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GEOPHYSICAL REPORT
ON THE
KOTANEELEE [illegible]

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August [illegible]

PROJECT NUMBER: 556-06-04-78-01

GEOPHYSICAL REPORT

ON THE

KOTANEELEE SEISMIC SURVEY, YUKON TY

FOR

COLUMBIA GAS DEVELOPMENT OF CANADA LTD.

BY

JLJ EXPLORATION CONSULTANTS LTD.

R. P. Jordan, P. Eng.
August 1979

LIST OF ENCLOSURES

MAPS 1:25,000 Scale

Time Structure - Nahanni

Time Structure - Mattson

Isochron Mississippian Limestone to Nahanni

Interval Velocity 1400' datum to Nahanni

Seismic Depth Map - Nahanni

SEISMIC SECTIONS - 3.75"/second

ABD 001, 002, 003, 005, 006, 007 and 008

AAV 001, 002, 003, 004, 005, 006

INDEX

PROJECT NUMBER: 556-06-04-78-01

REPORT NAME - GEOPHYSICAL REPORT - ON THE KOTANEELEE SEISMIC SURVEY, YUKON, YT.

TYPE OF SURVEY - SEISMIC REFLECTION

SURVEY AREA - 60° -04'N to 60° -11'N
124° -00'W to 124° -15'W

SURVEY PERIOD - May 27 to September 21, 1978

OPERATOR - COLUMBIA GAS DEVELOPMENT OF CANADA LTD.

GEOPHYSICAL CONTRACTOR: FAIRFIELD INDUSTRIES (CANADA) LIMITED

PERMIT NUMBERS: 411-68, 442 R-68, 443 R-68, 412-68, 444 R-68

LAND USE PERMIT NUMBER: YA 8B 194

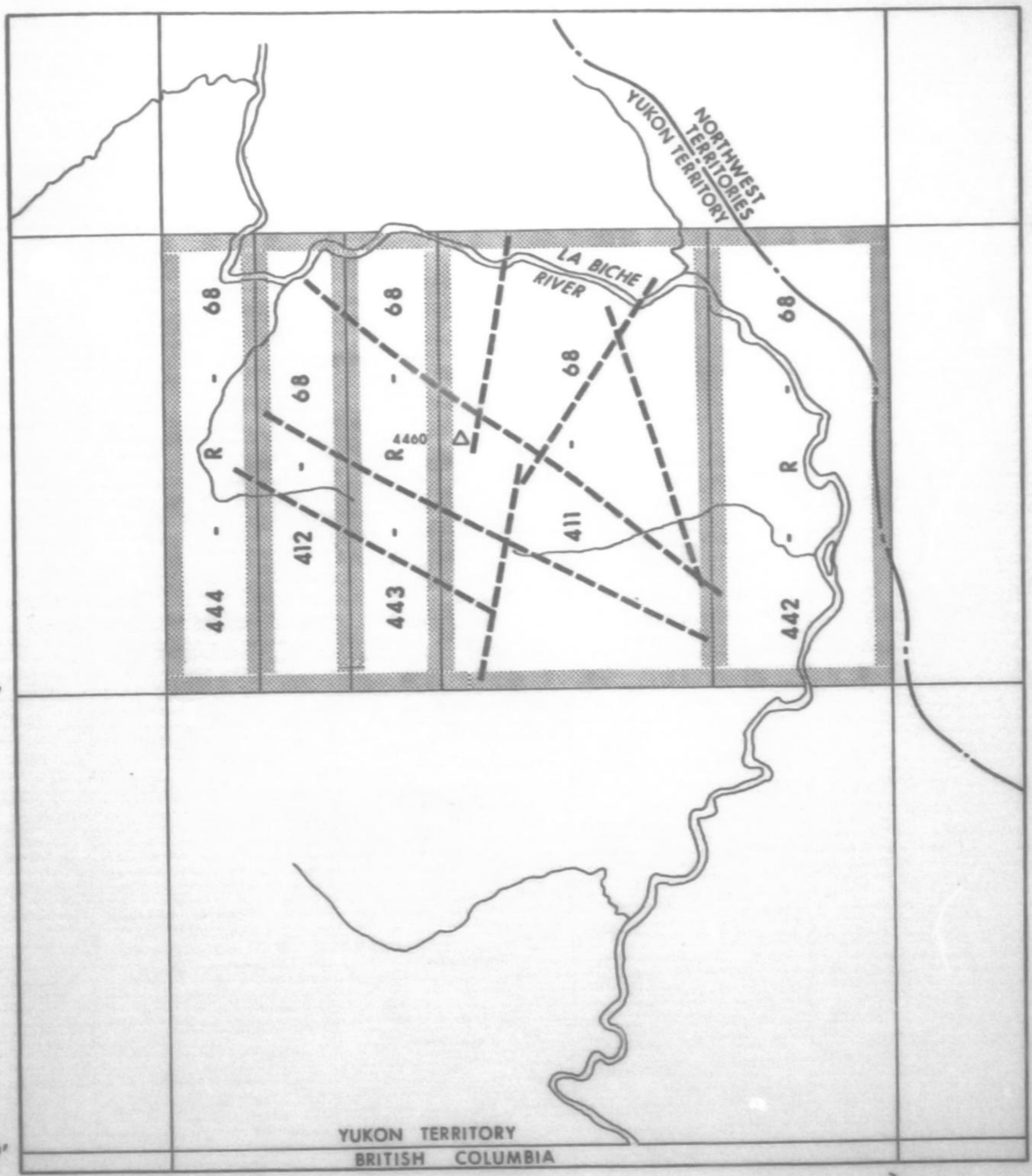
AUTHOR: R. P. JORDAN, P. ENG.

DATE: July 1979

INTRODUCTION

This report covers data collection, processing and interpretation of 43 kilometers of 400, 600 and 1200% reflection seismic data which was shot across Mount Martin in the summer and fall of 1978. This program was conducted by Fairfield Industries (Canada) Limited for Columbia Gas Development of Canada Limited.

The purpose of this survey was to obtain detailed seismic control across the crest of the Kotaneelee structure and to assist in the decision to locate additional development wells on the Kotaneelee structure.



LEGEND

- - - - SEISMIC LINE PROFILES

LOCALITY MAP

GEOPHYSICAL DISCUSSION

Data Gathering

Field procedures and statistics are discussed fully in Appendix 1. Because of rough terrain and extreme elevation differences across Mount Martin and environmental restrictions limiting use of bulldozed lines, this operation necessitated the use of unconventional field techniques. Past experience had indicated that a strong dynamite source was needed to obtain acceptable results so that use of a surface energy source such as primacord, air shots, or shallow multiple holes was not deemed to be feasible. At Mount Martin it was decided to use helicopter portable drills to be landed at hand cut clearings along the seismic lines. 23 kilogram (50 lb.) charges were used in 30 meter holes. Drills were severely limited as to mobility and in very steep terrain areas, notably along the east and north sides of Mount Martin, it was necessary to drill close spaced clusters of three or more holes for offset shots. These had a disconcerting tendency to all go off along with the initial shot resulting, in some cases, in a loss of CDP stack.

For data recording, individual groups of geophones were connected to Telseis FM transmitters operating in the VHF range. These units were self contained and battery operated and could be switched on either directly on the ground or by a remote triggering transmitted 'command' signal, in this program from the circling King Air recorder. Each telseis transmitter operates on one of approximately 52 crystal controlled channels separated by approximately 10 khz. A bank of FM receivers, each tuned to the appropriate 'Telseis' frequency is mounted in the overhead aircraft, the system is capable of recording, on DFS V digital instruments, all 48 geophone group signals, along with the break and up-hole times.

No insurmountable problems were associated with the use of the Telseis system except that it was occasionally difficult to command trigger individual telseis units in radio shadow zones (i.e. across steep hills or in gulleys) and these had to be triggered by ground control. Once the initial operational problems were solved, the program proceeded reasonably smoothly except for interruptions caused by poor flying weather. It should be noted that there is some loss in dynamic range of the DFS V system, nominally about 90 decibels, to about 72 decibels using the Telseis system. This was not considered to be detrimental in this specific program. There was some initial problem with static discharge noise from the aircraft wings, however, this was cleared up by installation of additional static discharge units on the trailing wing edges. There was also some considerable noise at about 100 hz caused by ghosting of incoming FM signals from the rotating propellor surfaces.

Recording Techniques:

Coverage: 1200% to 400% (variable)

No. of Traces: 48

Group Interval: 220'

Hole Depth: 100'

Charge Size: 50 lbs.

Geophones: 18 per trace, 14 hz

Sample rate: 2 ms.

Record Length: 6 secs

Filter: out/out

DATA PROCESSING

All reflection data from this survey were processed by Geophysical Service Incorporated (GSI) in their Calgary centre. Mr. Spence Chambers monitored the processing for Columbia Gas. Mr. Jim Haggedorn was responsible for GSI's processing. The processing sequence included the following:

1) True amplitude recovery
2) CDP gather
3) Deconvolution - spiking - 10% whitening - operator length 96 ms.
4) Gain equalization
5) Correlation static determination
6) Velocity analysis (scattergram)
7) Normal move-out application
8) Datum and weathering statics to a 427 m. above sea level datum using a 3050 m/s replacement velocity.
9) Application of correlation statics
10) First break suppression (mute)
11) CDP stack
12) Time variant 8-40/8-25 hz filter
13) Gain equalization
14) Migration

Except for poor near surface gain suppression, results of the GSI processing were generally satisfactory. It was hoped that GSI's sophisticated velocity analysis package could be used to help in preparation of the Nahanni depth map, however, overall poor record quality did not allow this.

As noted under 'Data Gathering', operational difficulties and high drilling costs precluded use of a 1200% stack as originally intended. Also premature detonation of some of the 'cluster' holes further degraded the stack. Lines ABD 002, 003, 005 were recorded as 600% CDP, lines ABD 001, 006, 007 and 008 were 400% CDP.

SEISMIC INTERPRETATION

Interpretation of this new data was integrated with the reprocessed data shot by Amoco Canada Limited in 1973 (lines AAV 001 through AAV 006) and with two Amoco 100% lines ABN 001 and ABN 003. Reliable horizon ties were obtained from velocity survey ties at the Kotaneelee YT [illegible] 50, YT E 37 and H 38 wells. Sonic log ties were used for ties at the Kotaneelee I-27 and Beaver River C27K wells. Interpretive maps were made for the Mattson time structure, Nahanni time structure, Isochron Mississippian Limestone to Nahanni, Interval velocity datum to Nahanni, and Nahanni Seismic depth map.

Section Discussion

ABD 001 - Interpreted on non-migrated display. Over-all quality is fairly good. Reflection coherence at the Nahanni level is fair. Evidence for the fault between SP's 63 and 69 is judged to be reliable.

ABD 002 - Interpretation on migrated section. Record quality south-east of SP 101 is fairly good. The remainder of the section is very poor. Reflection coherence at the Nahanni level is fairly good from SP 23 to the fault intersection at SP 97. There is evidence of complex faulting on the interpreted crest of the structure between SP's 73 and 93 northwest of the H 38 well. The I-48 well is located close to SP 81 on this line.

ABD 003 - Interpretation was done on the migrated section. Data quality west of SP 95 is good. Remainder of the line varies from poor to fair. Reflection coherence at the Nahanni level is extremely poor east of SP 95 even though the Nahanni can be identified with little or no problem on adjacent lines. (See Seismic depth map on Nahanni and compare SP 19 line ABD 003 with SP 19 on Line ABD 002).

Two possible solutions exist for this loss of a coherent Nahanni reflection:

1) Processing - this does not seem likely as continuity on shallow reflections seem reasonable.

2) The Nahanni has been broken by numerous small faults along the southwest flank of the La Biche anticline.

ABD 005, ABD 006 - Interpretation on ABD 005 migrated, ABD 006 non-migrated. These two sections cross the interpreted crest of the Kotaneelee structure just east of the Kotaneelee fault and are 'key' lines used in the location of the I-48 well. These lines should be joined at the tie (SP 10.5 ABD 006 and SP 73 ABD 005) and viewed as one line. Over-all reflection quality on both sections is reasonably good except for poor reflection coherence at the Nahanni level south of SP 33 on line ABD 006 (see Nahanni depth map). The Kotaneelee I-48 well is being drilled at SP 3 on line ABD 006.

ABD 007 - Non-migrated section used for interpretation. Record quality is generally poor. This line was shot in what turned out to be a rather unfortunate position along the trace of the Kotaneelee fault zone. Taken literally the interpretation on this section indicates that the crest of the Kotaneelee structure occurs just to the east of SP 41. The Nahanni at SP 9 at the P 50 well, correlates at 2.05 seconds which agrees with the velocity survey tie calculated at 2.047 seconds (see line AAV 002).

ABD 008 - Migrated section used for interpretation. Data quality is good west of the Kotaneelee fault at SP 43. Reflection identification is unreliable east of this point (see Nahanni depth map).

Interpreted copies of lines AAV 001 through AAV 006 are included with this report. These lines were discussed in last year's report, however, since that time changes have been made to conform to recently obtained velocity survey ties at the P 50 and Beaver River C27K wells and ties to the ABN 001 and ABN 003 sections and to the most recent shooting.

Map Discussion

Seismic Depth Map on Nahanni

This map was constructed using seismic time structure values on the Nahanni reflection and interval velocity values from the seismic datum to Nahanni. The interval velocity values were obtained by using the interval velocity slice method which was discussed in last year's report. High velocities along the boundary of the Kotaneelee fault have resulted in a south-easterly shift of the interpreted crest of the structure on the Nahanni from an apparent position in unit 49, to unit 38.

Note that on this interpretation it seems that a higher position on the structure is not likely west of the E 37 well. However, resolution of the Nahanni reflector is very poor in this area and some thought should be given to reprocessing of lines ABD 003, 006, and 008.

Interval Velocity 1400' datum to Nahanni

This map incorporates well tie data, and depths and velocities calculated along seismic lines using geologically related interval velocities. The high velocity zone along the Kotaneelee fault is caused by outcrop of the high velocity Mattson formation and fault related thickening between the Mattson and the Nahanni formations.

Mattson Time Structure

This map incorporates outcrop geology and selected Mattson time structure values from some of the better quality seismic sections. Note the south-easterly plunging anticlinal structure striking through units 26, 27, and 38 coincide with the 'pop-up' structure shown on the Nahanni time structure and depth maps.

Isochron Mississippian Limestone to Nahanni

This is a 'wonder' map constructed initially to check the validity of the Nahanni and Mississippian reflectors where data quality was reasonably good, however, it showed the effects of fault duplication so clearly that it was included with this report.

CONCLUSIONS AND RECOMMENDATIONS

Acquisition of additional data indicates that the crest of the Kotaneelee structure, at the Nahanni level, occurs in units 27, 37 and 38 where the La Biche and Kotaneelee structures intersect. Seismic resolution of the Nahanni reflection is particularly poor on the south-west side of the structure and along a two mile wide zone straddling the Kotaneelee fault. Well locations in these areas, including the present driller at I-48 are subject to considerable risk. Depending on the results of I-48 well, another location might be considered in the east half of unit 49, however, this would require acquisition of additional east-west control between I-48 and P-50 wells.

Reprocessing of lines ABD 003, 006 and 008 should be considered to try to improve reflection coherence south and west of the E 37 well.

The use of helicopter transportable drills proved to be costly and inefficient and if reasonable seismic results are to be obtained a return to higher CDP fold and to more conventional drilling and recording techniques should be considered.

PROFESSIONAL ENGINEER R. P. JORDAN ALBERTA

Respectfully submitted,

R. P. Jordan, P. Eng.

APPENDIX 1

Field Operations Report

FINAL REPORT

COLUMBIA GAS DEVELOPMENT

KOTANEELEE PROJECT Y.T. 1978

CONTENTS

I. EXECUTIVE SUMMARY

The exploration objectives of the SCAT-PAK crew was to acquire approximately 46 kilometers of seismic data around and over Mount Martin in the Yukon Territory. The difficulty of the terrain and the remoteness of the area offered Fairfield and Columbia Gas the opportunity to demonstrate the flexibility and mobility of the airborne concept of seismic data acquisition.

SCAT-PAK is a mobile self-contained seismic crew which utilizes telemetry seismic in an airborne configuration. This was the first time in the fifty year history of geophysical exploration that airborne seismic reflection recording had been accomplished. The system utilized a Beechcraft King Air 100 turbo-prop aircraft carrying a sixty channel seismic data receiving system, a computer control unit, and a Texas Instruments DFSV recording system. Fairfield's TELSEIS telemetry system transmitted the data via radio frequency from the ground to the recording system aboard the airplane.

II LINE CUTTING/SURVEYING

Line Cutting consisted of fourteen local labourers with one foreman. The men were split into groups of three or four and placed at various positions for the purpose of cutting a sight line for the surveyor and for the cutting of helicopter landing pads as required. Additional labor was required on ramp construction for helicopter landing in badly tilted areas. The sight line was constructed by cutting a minimum number of trees to allow short survey shots and to allow the line layout crew a path to walk when the recording operation began. Heliports were strategically placed to serve multiple purposes; first to pick up and let off surveyors and sawmen, second to serve as drill sites, and third as deployment points for the recording operation. In some cases the multiple use function was unworkable and additional helicopter landing areas were required though these were kept to a minimum.

A single survey crew, comprising a surveyor and rodman, worked with the line cutters in making sure the lines were cut as delineated on the map.

At the start of the operation the Alouette helicopter moved sawmen and surveyors as required. However, after the arrival of the Bell 212 the Alouette was terminated in favor of using the larger machine. The larger helicopter was more efficient since it handled the turbulent wind conditions. Flying hours were sufficiently reduced due to the large cabin which offset the higher hourly rate of the 212.

Production mileage varied depending upon the steepness of the terrain, the size of timber, weather, and the incidence of heliports or drill sites. The crew supervisors usually expected that a four-man saw crew would cut and clean .5 miles of line per 10 - 11 hour/day. A heliport usually took four sawmen four to six hours. If the men were obliged to construct a ramp for the helicopter to land this would add another two or three hours. Wet conditions slowed production and increased the chances for injury.

III DRILLING OPERATION

Drilling apparatus was composed of Big Indian Model 200 rotary drilling rigs designed to break down into flyable packages not exceeding 1200 kgs. each in weight. Each drill can operate, after assembly at the drill point, with either compressed air for solid rock drilling or with mud and water for unconsolidated conditions. A rock hammer was used where conditions warranted. The drills have a depth capacity exceeding 150 m. Four trips are required to move each drill from location to location, not including service trips to haul fuel, water, or drilling supplies. Supply trips were generally of the bus stop variety where-in a large metal basket loaded with on-site requirements stopped at each drill site and each crew took items they would need for the balance of the shift.

The drills operated efficiently from a mechanical point of view. A substantial on-site inventory of spares was carried along with a crew mechanic. A drilling supervisor was in attendance at all times.

The drilling apparatus was truck hauled to Ft. Nelson and then barged to the project landing site via the Nelson River - a trip of approximately 18 hours. Off-loading was accomplished by on-site cranes. Demobilization was exactly the reverse except that the time back to Ft. Nelson was longer by about 8 hours.

Drill strength was six (6) full units with a seventh as spare. Production statistics follow this short general comment. Drilling production failed to meet expectations. The requirement for a single hole to be drilled to 30m. depth every 100m, thru near surface rock was more difficult than anticipated.

Regardless of the efficienty of the crew or the equipment, the complications of operating a heliportable drilling project to the stated parameters in the project environment were enormous. The greatest single factor inhibiting drill production were unsuitable flying conditions. These conditions ranged from low wet clouds to clear days with high winds and resultant turbulence. Conditions as mentioned always delayed either drill start-up or drill moving and drill re-supply.

The second large factor in production was the drilling conditions themselves. Hard solid rock drilled well with compressed air and rock hammer only so long as no down-hole moisture was encountered. Moist conditions caused poor cutting returns with the danger of loss of drilling tools. Drill holes at sites with unconsolidated formations often had surface hole problems due to caving rock debris. It was not unusual to complete the hole to recommended depth only to find when loading the charge that a piece of rock had fallen from the wall of the hole and wedged into the bore at a shallow depth. Sometimes the hole was saved by tripping in and out at other times the hole did require re-drilling.

DRILL	MODEL #	DAYS	DRILLING PRODUCTION
# 30	Model 200	45	1067 m.
# 31	Model 200	43	975 m.
# 32	Model 200	38	762 m.
# 33	Model 200	52	1220 m.
# 34	Model 200	43	760 m.
# 35	Model 200	48	853 m.
		269	5637 m.

Average daily production per day 20.96 m.

As mentioned earlier, the drilling apparatus worked as efficiently as might be expected and poor production can be traced to areas removed from the equipment.

In the event the project is undertaken again with similar parameters, a basic drilling operational technique should be introduced. Each drill will be supplied with a mini-heliportable camp consisting of a fibreglass sleeping hut and a fibreglass eating hut each propane powered. The drills would be staffed with sufficient personnel for a 24-hour drilling operation which would continue to operate regardless of flying conditions. Drills using water for drilling would be supplied with extra quantities when flying conditions were suitable.

Drills waiting on helicopter service would not be entirely eliminated but it would be reduced to an acceptable level. The important point is that the ratio of drilling to time charged would be dramatically improved.

IV RECORDING - OPERATION

Heart of the system is a Beechcraft King Air 100 turboprop carrying a 60-channel seismic data receiving system, a computer control unit, and digital-data recording system. The aircraft equipment records data from succeding denotations in shot holes.

The TELSEIS telemetry system transmits data by radio frequency from the ground to recording units aboard the plane. The system can be used in swamp areas and mud flats as well as in mountainous area. Use of wheel or track-mounted vehicles and interconnecting cables between seismic detectors and recording units are eliminated. TELSEIS transmitters and detectors were transported by helicopter using a roll-a-long configuration. Ground crews laid out a 96-transmission unit in a straight line at selected intervals.

Using a 48-trace recording, data is recorded from units 1 through 48, followed by recordings from units 2 through 49, 3 through 50 etc. Once units 1 through 6 are no longer in use, a transmitter rack containing the transmitters is attached to a 140-ft. cable hanging from a helicopter hovering above treetop level. The helicopter then transports the transmitters to the front of the line for precise placement by a forward operating crew. The process is repeated until the entire seismic line is surveyed.

The geophysical equipment includes a Texas Instruments DFSV recording system with 96-position CDP switch and 96-position patch panel. Also included are a 48-channel TELSEIS system with 120 arrays of geophones with nine phones/array, a radio network operating on frequencies in the 50 Mhz range and two sets of input-output remote firing systems. Sixteen helicopter

TELSEIS transmitter racks designed to carry seven transmitters (including spares) with geophone arrays and battery chargers were provided. The system is operated by a 16-man crew.

V. HELICOPTERS

OPERATION	START	RELEASE	HOURS
1st Helicopter Alouette	78/5/25	78/6/27	67.9
2nd Helicopter Bell 212	78/6/4	78/7/25	249.5
3rd Helicopter Bell 206	78/9/2	78/9/19	91.4

R E C O R D I N G

Date September/78	Line No.	No. of Shots	Surface Kilometers	Operating Time	
1	1	-	-	-	weather
2	1	-	-	-	weather
3	1	6	2.4	3.5	weather
4	1	-	-	4.0	DFSV down
5	1	8	3.2	8	Static problems shooting box
6	1	1	-	6	Down - no spare
7	2	17	2.9	4	Standing by to modify
8	2	-	-	-	Weather
9	2	5	1.9	3	Bad weather backpacking
10	2	-	-	-	Weather
11	2	7	2.6	4	Weather backpacking shooting box down
12	2	15	3.4	4	Weather Ft. Nelson
13	3	29	3.4	7	Aircraft grounded by weather until 12 o'clock
14	3	26	6.0	7	Aircraft grounded by weather till noon
15	5	8	2.3	3	High winds
16	5/6	11/13	7.1	5	High winds
17	8	16	6.0	4.5	Helicopter maint. finish early
18	7	-	4.2	-	Weather
19	7	27	-	7	Recorder a/c down - oil leak
20					Project complete
		189	45.9	70.0	Project TOTALS