162

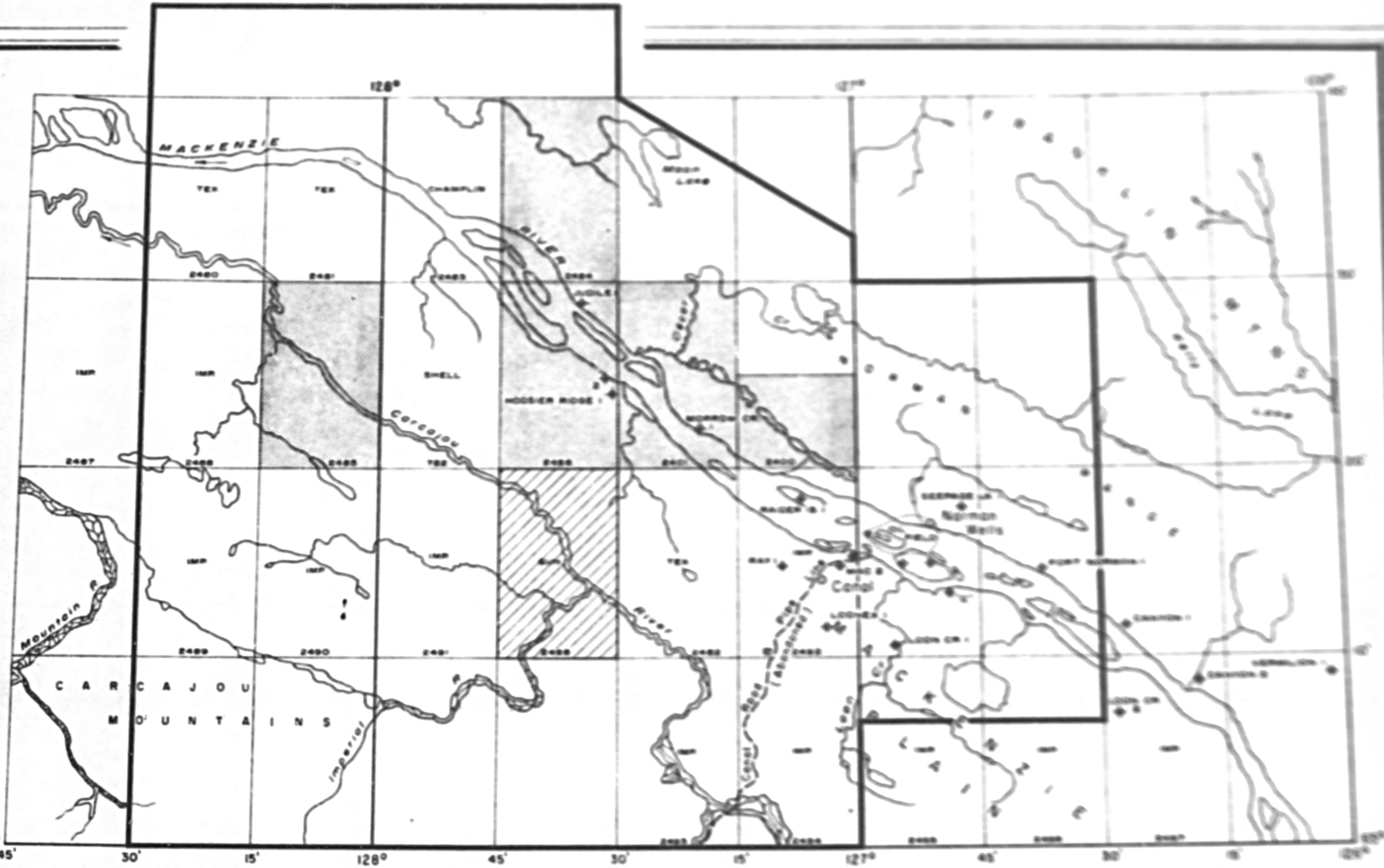
GEOLOGIC SURVEY
of the
NORMAN WELLS REGION, N.W.T.

by T. P. STOREY
CANADIAN HUSKY OIL LTD.

edited by P. B. GREIG, JR.

Calgary, Alberta
July, 1960

CONTENTS



Dominion Government Oil & Gas Permits
Can. Husky 100%

Sun Oil Co. 100%

FIGURE I:

Index Map Showing Area Covered
By Reconnaissance Mapping.

HUSKY OIL & REFINING LTD.	
NORMAN WELLS - N.W.T.	
SCALE: 1 IN. - 8 MLS.	DATE:

GEOLOGIC SURVEY OF THE NORMAN WELLS REGION

INTRODUCTION

This report is based on the data gathered in the course of a geological reconnaissance survey by J. C. Scott and T. P. Storey in June, 1959, using a helicopter for transportation. The survey covered Crown Permits #2400, 2401, 2484, 2485 and 2486, issued to Canadian Husky, Permit #2498, issued to Sun Oil of Canada, and areas adjacent to these permits (Fig. 1). A total of eight days was spent in the field.

The field data have been supplemented by photogeology and library research. Particularly useful in this regard were several publications of the Geological Survey of Canada and the reports of the Canol project. In addition Warren and Stelk (1949, 1950, 1956) provided data on faunas and unconformity relationships which are the principal basis for the interpretation presented here. The work of Crickmay, (1954), Law, (1955), and Van Hees, (1956, 1958), has also been considered. Several differing stratigraphic interpretations have been made by these authors, but these interpretations can be reconciled by close examination of each author's detailed work. The writer's own experience on the Canol project and with the subsurface Devonian across Western Canada has assisted materially in evaluating the published data.

STRATIGRAPHY

Sedimentary rocks of Cretaceous, Devonian, Silurian, and Cambrian age crop out in the area here under consideration. The composite succession of exposed rocks is shown in the following table:

Eocene	- unconsolidated sand, clay, lignite
- unconformity	
Upper Cretaceous	East Fork formation
	Little Bear "
	Slater River "
Lower Cretaceous	Sans Sault "
- unconformity -	
Upper Devonian	Imperial sandstone
- ? unconformity ? -	
	Fort Creek formation Upper Fort Creek shale Kee Scarp reef (locally) Lower Fort Creek shale Beavertail limestone

(Table cont'd next page)

- ? unconformity ? -

Middle Devonian	Ramparts formation Upper Ramparts limestone Middle Ramparts (Hare Indian River) shale Lower Ramparts limestone

- unconformity -

Lower (?) Devonian	Bear Rock dolomite

- unconformity -

Silurian	Ronning group

- unconformity -

Cambrian	Macdougal group Katherine group

Inasmuch as the Devonian section is thought to have the greatest hydrocarbon potential, exploratory work in this preliminary survey was concentrated on Devonian rocks. The information contained herein on beds of Cretaceous, Silurian, and Cambrian age is almost entirely from published data.

CAMBRIAN

Katherine group
Macdougal group

Rocks of Cambrian age were reported by Hume (1954, p. 9 ff) on the Imperial River in the southwest portion of the map area, where approximately 2000' of sediments of the Katherine and Macdougal groups form the core of the Carcajou Mountains. This area was not visited in the course of Husky's field work. According to Hume, the Cambrian beds consist of varicolored shale, quartzite and tight sandstone, gypsum, and dense limestone, none of which gives much encouragement to the petroleum geologist. Cambrian outcrops are unknown elsewhere in the map area.

SILURIAN

Ronning group

Lying unconformably on the Cambrian sequence is a Silurian section more than 1100' thick known locally as the Ronning group, consisting of bedded limestone, dolomite, and cherty dolomite. These beds have a wide lateral distribution, underlying most of the map area and cropping out as the core of the Norman (Discovery) Range, Morrow Mountain, Thomas Mountain, and Paige Mountain. A coral zone in the upper part of the Silurian sequence is locally very porous and could serve as an excellent oil reservoir.

LOWER DEVONIAN (?)

Bear Rock formation

The Bear Rock formation is assigned to the Lower Devonian, partly on fossil evidence but primarily because its basal contact with the Silurian represents a greater unconformity and stratigraphic hiatus than does the upper contact with the Ramparts formation. Shell Oil geologists (Jan. 12, 1960) claim faunal proof of the formation's Lower Devonian age. Furthermore, the relatively more intense metamorphism exhibited by Silurian rocks below the Bear Rock at some places suggests that the Bear Rock formation was deposited after the deformation caused by the late Silurian Caledonian orogeny.

The Bear Rock is characterized by penecontemporaneous carbonate breccias. It is locally porous and vuggy and in one well flowed large quantities of sulfurous water on drillstem test. This formation is an excellent potential reservoir for oil and gas.

MIDDLE DEVONIAN

Ramparts formation

The Ramparts formation ranges in thickness from 250 to 1500 feet and contains fossils of Middle Devonian age. Where the formation is thickest it is divisible into the Lower Ramparts limestone, the Middle Ramparts or Hare Indian River shale, and the Upper Ramparts limestone. These form a dense sequence generally devoid of porosity.

In consideration of the underlying unconformity, the age of the "Lower Ramparts" limestone may differ from place to place. The upper boundary of the Lower Ramparts may be a facies boundary so that the "Lower Ramparts"limestone of some areas may be stratigraphically equivalent to part of the basal portion of the Middle Ramparts shale in the thickest sections.

The Middle Ramparts or Hare Indian River shale has a maximum thickness of about 800 feet and is commonly much thinner. On the Imperial anticline, on the structures south of Fort Good Hope, and along the Mackenzie River northwest of Fort Good Hope, the Middle Ramparts shale is highly calcareous and contains stringers of thin, highly fossiliferous limestone. It weathers buff to grey in color. Bituminous shales occur in the lower part of the interval in some areas.

The Middle Devonian index fossil stringocephalus has not been reported this low in the Ramparts section.

The Upper Ramparts limestone appears to be a distinct stratigraphic unit which is commonly identified by the presence of the fossil Stringocephalus. This limestone is known from the

Hanna River basin east of Carcajou Ridge, on the Imperial anticline, and to the north and northwest of these areas. Exposures of Upper Ramparts have not been reported to the south, although in the subsurface it may extend to the Hoosier Ridge structure (

The Upper Ramparts is thought to have been removed by pre-Lower Fort Creek erosion south of the Hanna River basin and along the southern extension of the Imperial anticline. The Upper Ramparts is considered to be stratigraphically equivalent to the Presqu'ile, the Methy dolomite, Crickmay's Winnipegosan (1954) of the subsurface across Western Canada, Baillie's subsurface "Dawson Bay" (1953) of southwestern Saskatchewan, and may be equivalent to Law's Keg River formation (1955) of northern Alberta's subsurface.

In the Norman Wells region little porosity has been observed within the Upper Ramparts proper. Reefs, and reefoid structures have been reported, but these may well be in the Beavertail limestone, which has been included with the Upper Ramparts by many authors but which here is placed just above the postulated unconformity between the Lower Fort Creek and the Upper Ramparts.

UPPER DEVONIAN

Fort Creek formation

This formation lies unconformably on truncated Ramparts strata and on progressively older strata northwestward from the Norman Wells region. Where present, the Kee Scarp reef member divides the formation into Upper and Lower Fort Creek, the entire sequence ranging in thickness to more than 1800 feet. The thickness of the Lower Fort Creek ranges from 100 to 600 feet; but where eroded by recent pre-Cretaceous and pre-Imperial erosion, lesser thicknesses occur. Over most of the region the Lower Fort Creek shale is commonly non-calcareous, locally containing limestone bands like those in the Hare Indian River shale. It is black and bituminous and weathers to bright yellow, orange, or red in color. The basal unconformable contact is generally overlain by 20 to 80 feet of Beavertail limestone, which herein is considered to be the basal transgressive carbonate facies of the Lower Fort Creek unit.

The Beavertail limestone may locally be represented by shale, but both shale and limestone facies contain the fossil *Caryorhynchus castanea* (sensu strictu), which is considered to correspond to the *Cyrteria panda* zone. Thus *Caryorhynchus castanea* (sensu lata) as suggested by Warren and Stelck (1950) does not seem warranted. Basal Lower Fort Creek strata lie on pre-*Stringocephalus* beds both at Norman Wells and on the Imperial anticline near the Carcajou River, but occupy a post-*Stringocephalus* position at Carcajou Ridge, East Mountain, Beavertail Point, and on the Imperial anticline on Mountain River. (The occurrence of *Stringocephalus* at the latter locality is confirmed by McLearn, who identified the fossil in collections made there by two major oil companies.)

The Beavertail limestone is reefoid and porous at some localities. It is rubbly and very shaly at Norman Wells, where is it only about 15 feet thick. The unit also contains bitumen at some localities, and in Hoosier No. 2 a slight oil show was reported. The Beavertail is here regarded as the stratigraphic equivalent of the Slave Point or basal Beaverhill Lake limestone of northern Alberta. Locally it has a highly reefoid development similar to that in the Swan Hills member south of Lesser Slave Lake in Alberta.

The Upper Fort Creek shale is 1000 to 1800 feet thick near Norman Wells, where locally in the subsurface (Canyon No. 1, Loon Creek No. 1 and 2, and Loonex No. 1) the sub-Imperial unconformity shows erosion at the top of the Upper Fort Creek shale. Along most of the length of the Imperial anticline, at Carcajou Ridge, and westward there is a large area where the Upper Fort Creek is absent due to erosion prior to and during the deposition of the Imperial sandstone. Near Norman Wells the basal Upper Fort Creek contains limestones and black, bituminous shales which represent facies of reef deposition. The reef itself is called the Kee Scarp reef after the ridge formed by its outcrop on the southwest flank of the Discovery Range. It is recognized at only two other localities: 1) at Hoosier Ridge, and 2) in the Norman Wells oil field.

The general symmetry and surface configuration of the Norman Wells reef known from well and seismic data suggests that this reef is a depositional rather than an erosional feature. General faunal correlations suggest the Kee Scarp reef interval to be equivalent to the Ireton (Leduc, or D-3) reefs of central and west-central Alberta. There is in fact very little known about Kee Scarp reef distribution and alignment, and in much of the region north of 65° 35' N, the Kee Scarp reef or shale interval is probably absent due to pre-Imperial erosion. South of this area, the reef facies may be involved in structural and/or erosional conditions which may provide possibilities for oil entrapment. There is little or no information that would suggest the occurrence of reefs south of the Norman Wells oil field, but the Canyon sandstone in outcrops and in wells near Norman Wells is probably a stratigraphic equivalent of part of the Kee Scarp interval.

Where the sandstone, black shale or reef lithologies are absent in the basal Upper Fort Creek, it is difficult to distinguish between the Upper and the Lower Fort Creek shales, which are both fine-grained and medium grey in color. The Upper Fort Creek shale described herein is believed to be the stratigraphic equivalent of the Woodbend group and the Nisku formation of the Winterburn group as defined by the Imperial Oil geological staff (1950).

Imperial formation

The Imperial sandstone is the youngest Devonian deposition in the Norman Wells area. It varies considerably in thickness because of pre-Cretaceous and recent erosion. The formation ranges from very sandy to very shaley both laterally and vertically. The basal Imperial contact is a regional unconformity which truncates the Fort Creek section from an overall thickness of 1800 feet at Norman Wells to 100 feet or less on the Imperial anticline near Mountain River and at the west end of Carcajou Ridge. The Imperial is considered to be equivalent to the Wabamun and Graminia units of central Alberta.

Oil staining and minor oil flows have been reported from the Imperial sandstone in the Norman Wells field area. The Imperial is not as widely distributed as is the Fort Creek formation, and this relationship certainly does not suggest that the two are contemporaneous facies as interpreted by Martin (AAPG Oct. 1959). Hume (1954, sheet 1) mapped the Upper Fort Creek shale as "Imperial sandstone", from Norman Wells southeastward to Prohibition Creek, but the subsurface data from the Canyon No. 1 and 2 wells suggest that the Imperial is not as widespread as indicated on Hume's map.

CRETACEOUS

Beds of Cretaceous age are found throughout the Norman Wells region. At first glance at most maps of the region the Cretaceous appears to have been deposited in pre-Cretaceous inter-montane basins, but this concept is untenable in view of the fact that the Cretaceous strata appear to have been affected equally with older Devonian strata by post-Cretaceous earth movements. Cretaceous rocks range from very sandy to very shaly. Oil stains or seepages from Cretaceous strata have not been reported in the region, although porous potential reservoir beds do occur.

STRUCTURE

The main positive structural features of the Norman Wells region are the Discovery Range, Morrow, Cleaver, Paige and East Mountains, the Imperial anticline, Carcajou Ridge and the Mackenzie Mountains. Minor positive structures include the Loon Creek anticline, Hoosier Ridge, and secondary anticlinal axes which appear to strike out of the Imperial anticline toward the Mackenzie River. The small syncline between the Imperial anticline and the Mackenzie Mountains appears to have two enechelon axes whose relationships are not fully understood. Most of the positive structures appear to be asymmetrical folds. Some are breached along their axes and are characterized by fault-like escarpments which are probably the results of thrusting and faulting. The en-echelon pattern of the structures suggests complex tangential earth-movements.

Discovery Range

The Discovery Range extends northwestward from Norman Wells to Oscar Creek and is a broad southwest-dipping monocline, probably faulted and containing many secondary flexures. Such flexures can be seen in Ramparts strata along Schooner Creek north of the Kee Scarp outcrop, in Ramparts, Beavertail, and Lower Fort Creek strata in the bed of Bosworth Creek, and in Ramparts strata on the flank of the Discovery Range at helicopter stop T-18 (see accompanying map). The Vermilion Gorge anticline described by Hume (1954, p. 64) is another such flexure.

The crest along most of the length of the Discovery Range is formed by Silurian rocks cropping out as a steep northeast-facing escarpment 1000-1800 feet high. Successively younger Devonian strata occur down the flank toward the Mackenzie River. The scarp appears to be the result of faulting, perhaps along the crest of what originally was a huge anticline, or it may be the result of the removal by erosion of the steep flank of the anticline. (Hume, 1954, p. 60). Down-faulting may have occurred on the northeast side of the range, possibly associated with some transverse movement, as is suggested by the structure at Morrow Creek. At this locality the Discovery Range is buckled and faulted - possibly as a result of northwestward horizontal movement relative to Morrow Mountain. The fault bordering the northeast flank of the Discovery Range apparently continues northwestward along the southwest flank of Morrow Mountain. Northwest of Cleaver Mountain, which is an asymmetrical anticline, the extent and direction of the fault is uncertain. It may continue northwestward along the flank of the north-plunging nose of Cleaver Mountain anticline to join the fault flanking Thomas Mountain, or it may veer westward from Cleaver Mountain and die out. Whatever the explanation, it is noteworthy that the Discovery Range and Morrow Mountain scarps, both of Silurian rocks, are in almost perfect alignment but face in opposite directions.

Faulting is prominent in many of the structures, although some apparently major faults have only small stratigraphic displacement locally - probably because of transcurrent movement (e.g. north end of Discovery Range). Thrust faulting in the closely compressed strata of asymmetrical folds may also occur, or the steep flank (as exhibited by the south flanks of Thomas Mountain and Carcajou Ridge) may have been eroded and/or removed by glacial scour, leaving the gentler flank and the inner core of resistant Silurian strata. Pronounced glacial grooving and striated granitic boulders found on the mountain peaks indicate that the mountains were largely covered by glacial ice. Concealed beneath glacial debris and muskeg at the base of the Silurian escarpments, the truncated beds on the steep flank could continue to some depth, perhaps with some faulting and/or overturning, and flatten out basinward from the fold axis. Overthrusting may be present at depth, grading upward into asymmetrical folding.

The removal of the steep flank by glacial abrasion would be facilitated by glacial movement paralled to the strike of the structure. Deep furrows and ridges, ranging from 10 to 30 feet in amplitude occur on Kee Scarp, Hoosier Ridge, Carcajou Ridge, and elsewhere in the area and are considered to be "striations" of glacial origin. These striae strike generally southeastward at an angle to the axes of Hoosier and Carcajou Ridges, where the steep flank of the structure is exposed.

Imperial anticline

This enormous structure is by no means a simple anticline and should probably be classified as an anticlinorium. It embraces a number of anticlinal axes, the principal one of which plunges and rises along a total length of more than 35 miles, exposing strata of Bear Rock to Cretaceous age, all of which were deformed by post-Cretaceous earth movement. Structural deformation also occurred after Ramparts and Fort Creek deposition and prior to Fort Creek and Imperial deposition. The thinning and thickening of these formations along the Imperial Anticline is interpreted as the result of erosional truncation of Ramparts below Fort Creek and of Fort Creek below Imperial. Following the anticline westward, the Ramparts section below the Fort Creek near the Carcajou River is believed to be of Lower Ramparts age. Three to four miles further west the broad featureless area on the aerial photographs is believed to consist mainly of the Middle Ramparts or Hare Indian River shale, with a remote possibility of some basal Fort Creek shale. Still farther west the Upper Ramparts limestone underlies the Lower Fort Creek shale.

Miscellaneous Structural Data

The Halfway anticline (Hume, 1954, p. 63) and the Loon Creek anticline may be component parts of a single post-Cretaceous structure. This structure appears to have ancestral components, inasmuch as the Upper Fort Creek in Loon Creek #2 is notably thinner than in Canyon #1 and Loon Creek #1, suggesting structural uplift and erosion of these strata at Loon Creek #2 in post-Fort Creek pre-Imperial time.

There is some meagre support for the hypothesis that the Kee Scarp reefs were deposited on incipient "highs" formed by post Ramparts upwarping in the Norman Wells area and in the area northwest of Fort Good Hope concurrent with downwarping between Carcajou Ridge and the Imperial anticline on Mountain River. The upwarped areas were subjected to more erosion than the downwarped area between the "highs". Later, during final Lower Fort Creek deposition, further upwarping may have occurred to favor carbonate shoal and reef deposition in the Norman Wells area. The understanding of these paleo-structural effects has an important bearing on exploration for areas of reef deposition and oil accumulation.

<u>Editor's Note</u>: It should be pointed out that there is a difference of opinion among geologists familiar with the area regarding the correlation of the Devonian sections on Carcajou Ridge and the

Imperial anticline with that in the vicinity of the Norman Wells field. Opposed to the view presented herein by Storey that truncated Middle Devonian Ramparts is overlain unconformably by Upper Devonian Fort Creek is the view that the Ramparts-Fort Creek sequence represents a continuous lithologic sequence of Middle Devonian age in which lateral variation of facies accounts for the apparent truncation and overlap. Recently revised and as yet unpublished paleontological data would seem to support the continuous sequence concept.

CONCLUSIONS

Rocks of Cretaceous, Devonian, Silurian and Cambrian age crop out within the area mapped. These rock systems are separated by regional angular unconformities. In addition, one and possibly two regional unconformities occur within the Devonian section.

Porous zones which could serve as hydrocarbon reservoirs occur in Lower Cretaceous sandstones, the Upper Devonian Imperial sandstone, Kee Scarp reef, and (to a lesser extent) Beavertail reef, the Lower Devonian Bear Rock dolomite, and a coral zone in the upper part of the Silurian section. The Kee Scarp reef, which produces oil at Norman Wells, is the primary prospect.

followed in importance by the Bear Rock dolomite, the most widespread porous rock in the area, and the Beavertail reef.

The rock sequence in the Norman Wells area has been subjected to several periods of structural deformation, resulting in a complex system of faults and structural axes striking generally west to northwest and resulting in a structural environment which, when combined with the above-discussed stratigraphic conditions, is ideal for the entrapment of oil and gas. A continuation of exploratory work in the area is therefore recommended.

July 1960

REFERENCES

Baillie, A.D., 1953: "Devonian system of the Williston basin area", Manitoba Mines Branch, Publication 52-5, 105 pp.

Cooper, G.A., et al., 1942: "Correlation of Devonian sedimentary formations of North America", Geol. Soc. Am., Bull., vol. 53, pp. 1729-1794.

Crickmay, C.H., 1954: "Paleontological correlation of Elk Point and equivalents", Am. Assoc. Petrol. Geol., Western Canada Sedimentary Basin, Symposium, pp. 143-148

Hume, G.S., 1954: "The lower Mackenzie River area, Northwest Territories and Yukon", Geol. Surv. of Canada, Memoir 273, 118 pp.

Law, J., 1955: "Geology of northwestern Alberta and adjacent areas", Am. Assoc. Petrol. Geol., Bull., vol. 39, pp. 1927-1975.

Layer, D.B., et al., 1950: "Devonian nomenclature in Edmonton area, Alberta, Canada", Am. Assoc. Petrol. Geol., Bull., Vol. 34, pp. 1807-1825.

Link, T.A., and others, 1943-44: "Reports on the Canol Project", 40 unpublished reports available in the files of the Geol. Surv. of Canada.

Martin, L.J., 1959: "Stratigraphy and depositional tectonics of north Yukon-lower Mackenzie area, Canada", Am. Assoc. Petrol. Geol., Bull., vol. 43, pp. 2399-2455.

Van Hees, H., 1956: "Elk Point group", Alberta Soc. Petrol. Geol., Jour., vol. 4, pp. 29-37.

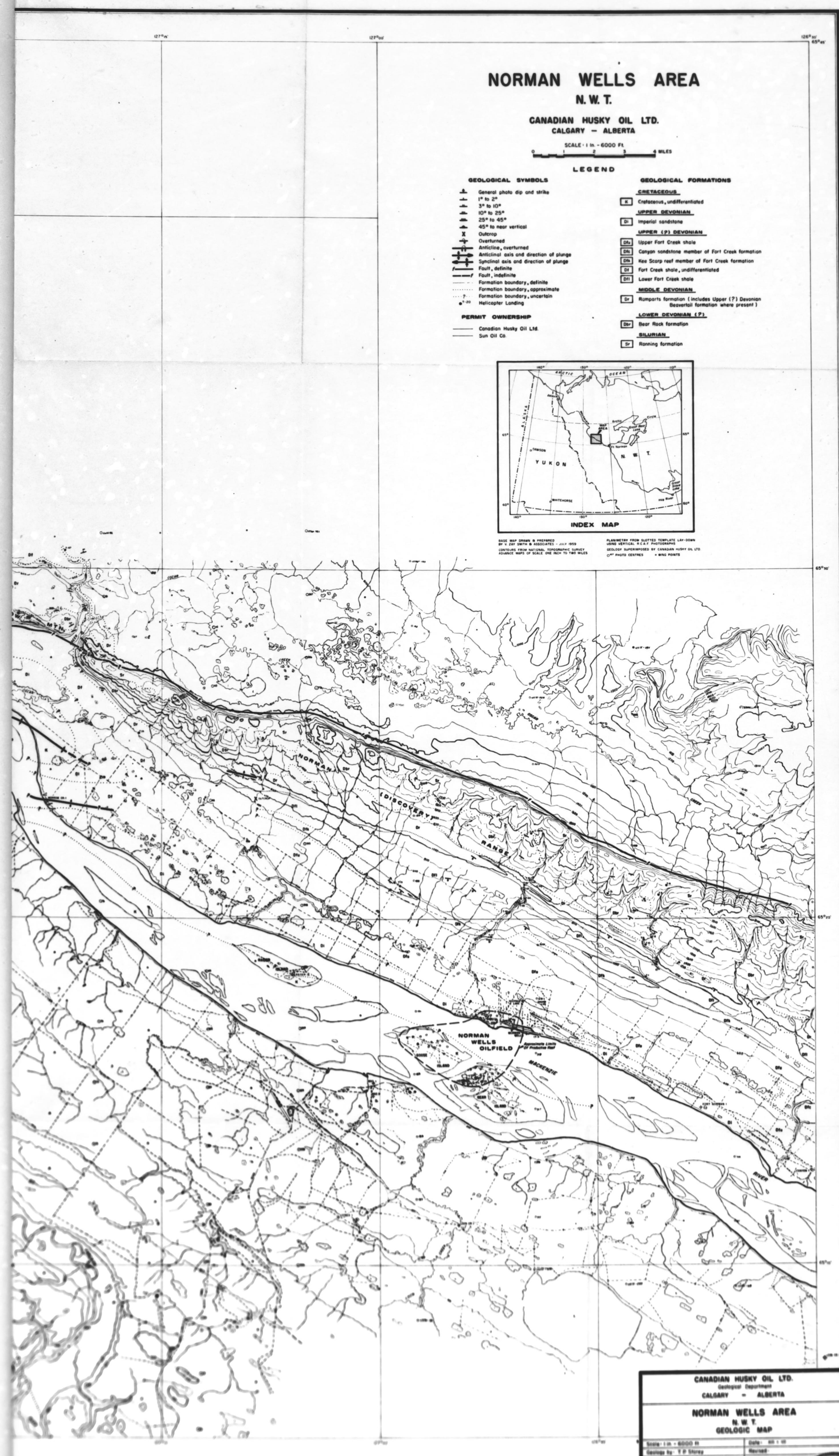
_______ , 1958: "The Meadow Lake escarpment - its regional significance to Lower Paleozoic stratigraphy", N. Dak. Geol. Soc. & Sask. Geol. Soc., Williston Basin Symposium, pp. 70-78.

Warren, P.S., and Stelk, C.R., 1949: "The late Middle Devonian unconformity in northwestern Canada", Royal Soc. Canada, Trans., 3rd ser., vol. 43, sec. 4, pp. 139-148.

__________ ,1950: "Succession of Devonian faunas in western Canada", Royal Soc. Canada, Trans., 3rd ser., vol. 44, sec. 4, pp. 61-78.

__________ , 1956: "Devonian faunas of western Canada", Geol. Assoc. Canada, Special Paper No. 1.


GREENHORN ANTICLINE
HOOSIER RIDGE
MACKENZIE
RIVER
IMPERIAL
ANTICLINE
RAINBOW
ANTICLINE
SAMMONS
ANTICLINE
IMPERIAL
ANTICLINE
CARCAJOU
RIDGE
MACKENZIE
RIVER



NORMAN WELLS AREA
N. W. T.
CANADIAN HUSKY OIL LTD.
CALGARY — ALBERTA
SCALE: 1 In. - 6000 Ft.
0 1 2 3 4 MILES
LEGEND
GEOLOGICAL SYMBOLS
General photo dip and strike
1° to 2°
3° to 10°
10° to 25°
25° to 45°
45° to near vertical
Outcrop
Overturned
Anticline, overturned
Anticlinal axis and direction of plunge
Synclinal axis and direction of plunge
Fault, definite
Fault, indefinite
Formation boundary, definite
Formation boundary, approximate
Formation boundary, uncertain
Helicopter Landing
PERMIT OWNERSHIP
Canadian Husky Oil Ltd.
Sun Oil Co.
GEOLOGICAL FORMATIONS
CRETACEOUS
K Cretaceous, undifferentiated
UPPER DEVONIAN
Di Imperial sandstone
UPPER (?) DEVONIAN
Dfu Upper Fort Creek shale
Dfc Canyon sandstone member of Fort Creek formation
Dfk Kee Scarp reef member of Fort Creek formation
Df Fort Creek shale, undifferentiated
Dfl Lower Fort Creek shale
MIDDLE DEVONIAN
Dr Ramparts formation (includes Upper (?) Devonian Beavertail formation where present)
LOWER DEVONIAN (?)
Dbr Bear Rock formation
SILURIAN
Sr Ronning formation
ARCTIC OCEAN
ALASKA
YUKON
N. W. T.
MAP AREA
INDEX MAP
NORMAN RANGE
DISCOVERY RANGE
NORMAN WELLS OILFIELD
MACKENZIE
RIVER
CANADIAN HUSKY OIL LTD.
Geological Department
CALGARY — ALBERTA
NORMAN WELLS AREA
N. W. T.
GEOLOGIC MAP
Scale: 1 in. = 6000 ft
Geology by: T.P. Storey
Contour interval:
Date:
Revised:
File No:

286

SEISMIC SURVEY

JUDILE WELL AREA

NORTHWEST TERRITORIES CANADA

submitted to

HUSKY OIL AND REFINING LTD.

by

GEOPHYSICAL SERVICE INTERNATIONAL
Corporation

CALGARY ALBERTA

P. J. FARRELL PARTY CHIEF

PARTY 406

JULY 29 to AUGUST 28, 1959

ABSTRACT

The interpretation has been limited to the preparation of time sections for the lines worked.

INTRODUCTION

Prospect:	Judile No. 1 Area
Territory:	Northwest Territories, Canada
Surveyed for:	Husky Oil and Refining Ltd.
	Client Representatives: Mr. J. Scott and Mr. T. Storey
Surveyed by:	Geophysical Service International Corporation
	Party 406, P. J. Farrell, Party Chief
Party Headquarters:	Tent camp approximately 28 miles north of Norman Wells, Northwest Territories, on the Mackenzie River.
Dates of Shooting:	August 7, 1959 to August 23, 1959
Detailed Location:	See Plate 1

PURPOSE

The purpose of the survey was twofold:

(1) To obtain good quality seismograms using only the parameters of hole depth, charge size, and electrical filtering;

(2) to investigate the subsurface attitude of all recorded events, notably the reef limestone member.

GEOLOGY

The log of the Judile No. 1 well is shown to list the components of the local geologic column.

Formation	Lithology	Depth in Feet
Recent	Sands, silts	0 to 60
Cretaceous	Shales	60 to 315
Imperial	Sandstone	315 to 653
Fort Creek	Upper shale member	653 to 1252
	Bituminous shale member	1252 to 1305
	Reef limestone member	1305 to 1835
	Lower shale member	1835 to 2306
Ramparts	Beavertail limestone member	2306 to 2500
	Lower shale member	2500 to 2608
Bear Rock	Dolomitic limestone and anhydrite	2608 to 2815

The above log is taken from "The Geological Survey of Canada" Paper 45-29, by J. S. Stewart.

The dip of the formations in the area is generally southwest. Surface outcrops which occur approximately two miles northeast of the Judile No. 1 location can be correlated to the Ramparts formation which lies below the reef limestone in the well. Thus, between these two points the reef has disappeared by truncation, faulting, or its surface expression cannot be recognized.

PHYSICAL CONDITIONS

Surface Conditions

The surface cover consists of muskeg with occasional sand ridges. Permafrost is present within two feet of the surface in the muskeg areas and only slightly deeper in the sandy portions.

The growth is mainly spruce and birch which, in places, grow very thick and average five inches in diameter. Portions of Line One proved very difficult to clear, and made it necessary to use a power saw on trees too large for the bombardier to push over.

Availability of Roads

The program shot was evenly divided between previously cut line, and line the crew cleared for the purpose of the survey. The previously cut line was in good condition.

Transportation

Equipment and supplies were moved from Edmonton to Hay River by truck and transported along the Mackenzie River to the project by barge.

The personnel were flown to Norman Wells by commercial aircraft.

A 30-foot cabin cruiser was used for transportation of men and supplies between Norman Wells and the field.

Weather Conditions

From August 1 to August 12, cold rainy weather predominated, however, conditions were favourable during the rest of the month.

FIELD METHODS

Surveying

The horizontal and vertical control was referenced to the Judile No. 1 well location.

All elevations and shot point locations were obtained using a chain, plane table and alidade.

For the magnetic horizontal survey, a declination of North 38 degrees East was chosen.

The vertical survey was re-run and tied within allowable limits.

Drilling

One Sewell wet auger drill, mounted on a muskeg tractor, was used to drill the holes. Forzen sandy and silty clay was present with some holes bottoming in fresh unfrozen blue clay.

The holes were preloaded shortly after being drilled to avoid ice forming and plugging the hole.

Water was readily available at all times.

Shooting

Standard 60% high velocity geogel, and No. 8 seismocaps with 60-foot leads were used throughout the shooting. Experimental variations in the shooting technique consisted of varying the charge size and/or its position in the hole. No optimum charge could be found, since ground conditions varied from hole to hole.

Recording

Spread Details - See Plate 11

Split continuous profiles with normal 600-foot spacing were shot throughout the survey.

The recording apparatus consisted of 12 high resolution amplifier channels, in conjunction with a 24-trace camera, to record the energy from 12 seismometer groups. All seismograms were recorded on both straight and mixed circuits. Traces 1 to 12 represent the straight, and traces 13 to 24 represent the mixed circuits.

Experimental variations, using several different filter settings in conjunction with differing charges and depths, appeared to be inadequate to successfully obtain good quality records. Since the reflection frequency is close to 60 cycles per second, a base filter of 30K to 90K seemed the best choice. In some cases an improvement could be noted by raising the low cut-off to 50 cycles per second, and, when holes could be loaded back, a second shot using this filter selection was taken.

Single marsh-type seismometers, which could be pushed down to contact the permafrost, were used on shot points 1 to 27. The remainder of the program was laid out with 9 seismometers per group spread over 100 feet. Each of these seismometers was dug down and planted on solid ground or ice. The improvement noted using the multiple arrangement was slight, but considered sufficient to warrant their use.

METHOD OF CALCULATION

Record corrections were computed by the up-hole method, using a replacement velocity of 10,000 feet per second and a level datum 200 feet above sea level.

Cross Sections

Vertical time sections were prepared for each line worked. The scale used was 1 cm. = 0.02 seconds vertically, and 1 cm. = 100 feet horizontally.

The correlations were generally poor over the area, however, jump correlations between better quality seismograms were used to confirm doubtful points.

Mapping

Two maps are presented on a scale of four inches equals one mile.

(1) Reef horizon

(2) Reef - Ramparts interval

The discussion of the maps will be facilitated if they are considered together.

The thin areas on the interval map appear to coincide with low areas on the structure map. This would indicate that the thin areas represent less reef and, on this basis, the thinning between shot points 35 - 40, together with the corresponding low on the structure map, could indicate truncation of the reef in this direction.

Reliable west dip was found between shot points 15 and 16. This does not have any anomalous counterpart on the interval map, and must be interpreted as a general structural build-up to the east.

Discounting local variations, the regional strike appears to be north northwest, and the regional dip to be west southwest.

DISCUSSION OF RESULTS

The quality of the records was poor, and any consideration of the maps and sections must be made on that basis.

Reflected energy was evident on most of the records. This was picked and plotted on the time sections, but the correlations between records were seldom certain and, although jump correlations across several shot points were made, the possibility of an alternate correlation must be considered.

In areas of uncertainty the horizons were phantomed to obtain a continuous horizon from which map values could be picked.

The west dip between shot points 15 and 16 can be considered reliable. The north dip between shot points 36 and 39 is interpreted on very poor data and should be considered much less reliable.

SUMMARY AND CONCLUSIONS

The records obtained are of poor quality. It is felt, however, that enough reliable data was obtained to provide evidence of higher reef elevation east of the Judile No. 1 well, and less reliable evidence of reef truncation to the north.

ACKNOWLEDGEMENTS

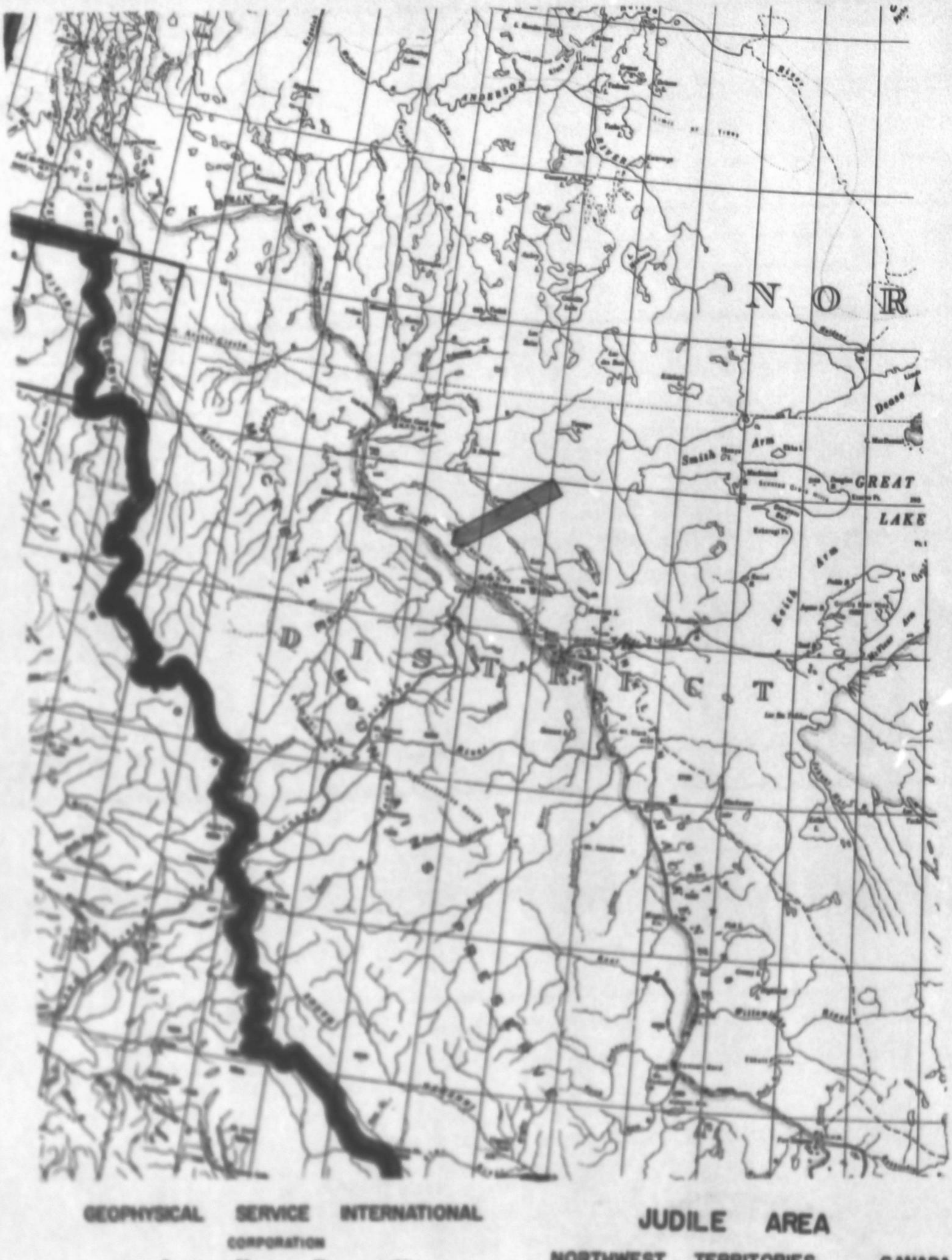
The author wishes to acknowledge the valued assistance given by Messrs. J. Scott and T. Storey of Husky Oil and Refining Ltd.

Respectfully submitted,

GEOPHYSICAL SERVICE INTERNATIONAL
Corporation

P. J. Farrell
P. J. Farrell, Party Chief

D. F. Brennan.
D. F. Brennan, Area Manager



GEOPHYSICAL SERVICE INTERNATIONAL
CORPORATION

SCALE MILES

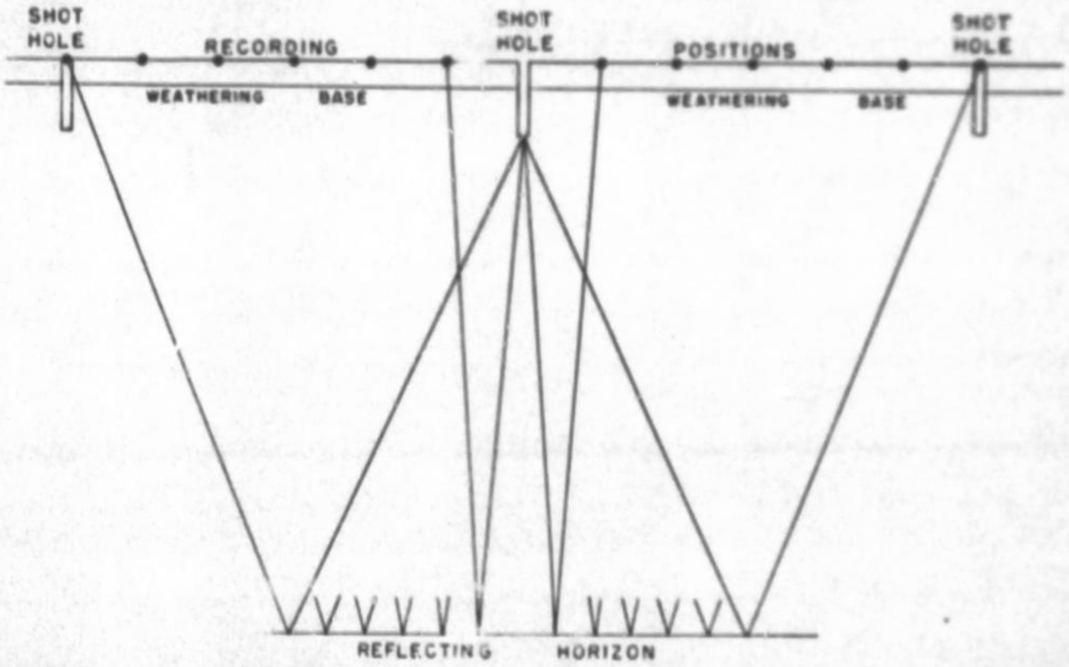
JUDILE AREA

NORTHWEST TERRITORIES CANADA

G.S.I. Party 406

P.J.Farrell

Plate 1



SPREAD ARRANGEMENT FOR CONTINUOUS CORRELATION

SPLIT SPREAD

12 CHANNEL EQUIPMENT

DESCRIPTION OF SPREAD

Seismometers per spread	12 or 108
Seismometer groups	12
Seismometers per group	1 or 9
Normal distance between groups	100'
Distance to centre of first group	100'
Distance between seismometers in group	11'
Normal distance between shot holes	600'

INSTRUMENTAL DETAIL

Seismometer series	28 cps
Amplifier series	H. R.
Camera	Ser. 8
Circuit	straight & mixed

TYPICAL CONDITIONS

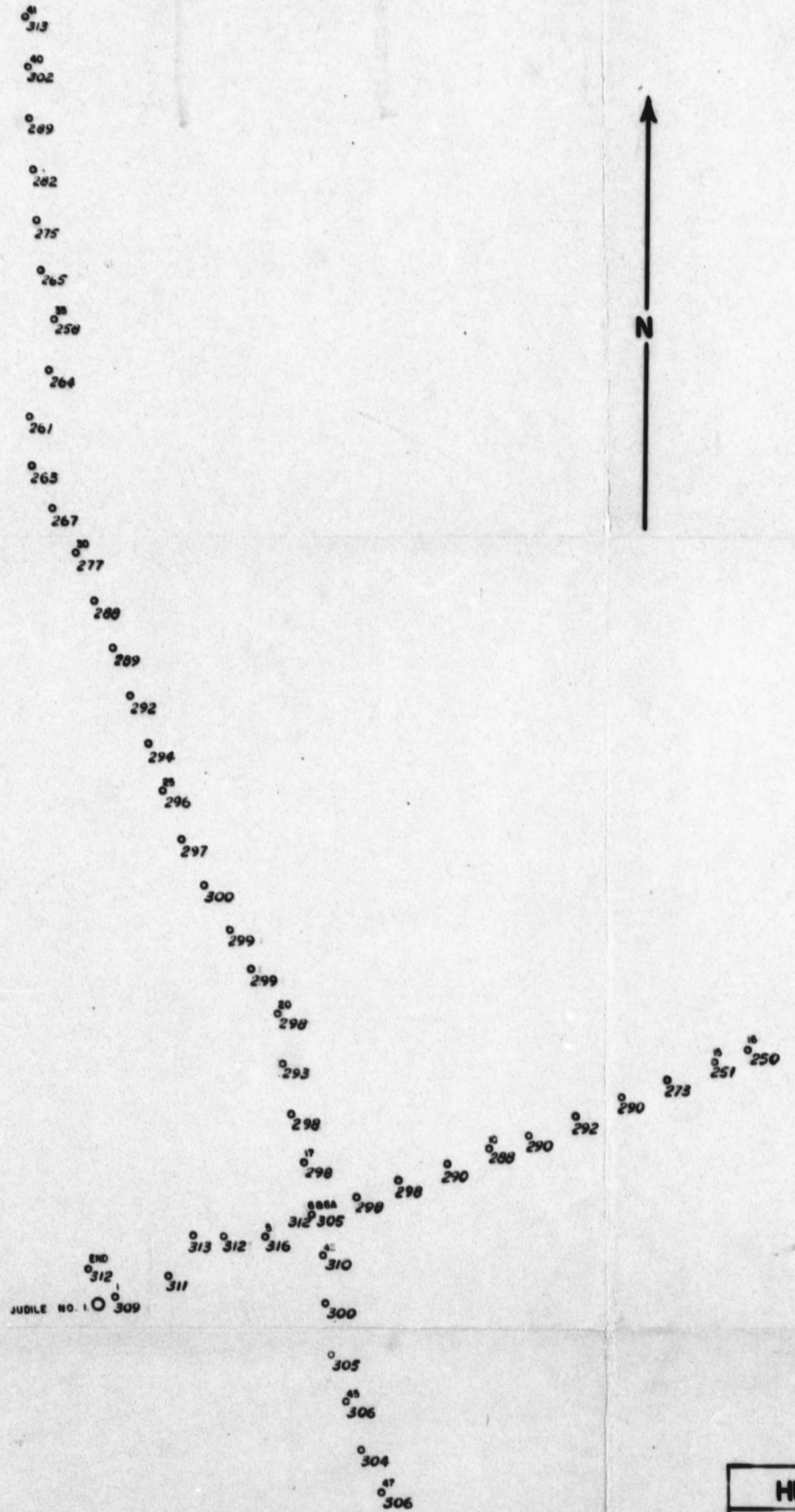
Average hole depth (ft)	40
Average charge (pounds)	1 1/4
Optimum filter	K30 - K90
Shooting medium	silty clay

JUDILE WELL AREA

P. J. Farrell - Party Chief

GSI Party 406

Plate 11.



SPR

HUSKY OIL & REFINING LTD.

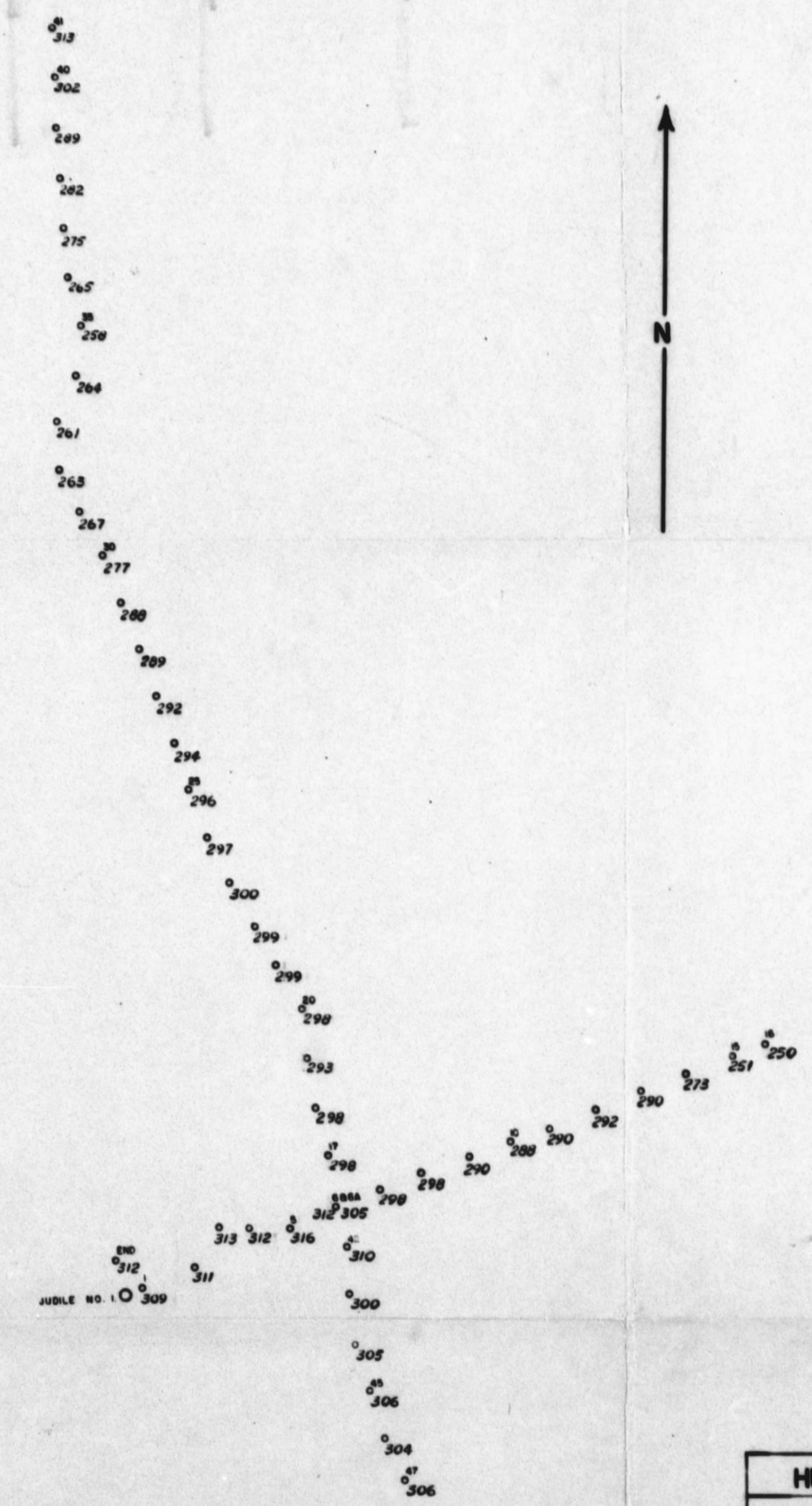
SHOT POINT ELEVATION MAP

JUDILE AREA

SCALE: 4" = 1 MILE

GEOPHYSICAL SERVICE INTERNATIONAL
CORPORATION

PARTY 406 AUGUST, 1959.



SPR

HUSKY OIL & REFINING LTD.

SHOT POINT ELEVATION MAP

JUDILE AREA

SCALE: 4" = 1 MILE

GEOPHYSICAL SERVICE INTERNATIONAL
CORPORATION

PARTY 406 — AUGUST, 1959.