K-1
SHELL MOBIL ALEXANDRIA #6
60° 18' 45" N. LAT.
119° 18' 45" W. LONG.

K-2
SHELL ALEXANDRA #7
60° 21' N.
118° 43' W.

K-3
BRIGGS WEST TATHLINA LAKE #1
60° 37' 21" N. LAT.
117° 53' 08" W. LONG.

K-4
BRIGGS WEST TATHLINA LAKE #2
60° 38' 18" N. LAT.
117° 47' 27" W. LONG

K-5
BRIGGS TATHLINA LAKE #3
60° 40' 30" N. LAT.
117° 30' 40" W. LONG.

K-6
WILKINSON WEST TATHLINA LAKE #4
60° 41' 33" N. LAT.
117° 40' 6" W. LONG

21 Miles | 54 Miles | 3.5 Miles | 3 Miles | 2.5 Miles

DATUM LOG MARKER Nº 4 — TROUT RIVER

INTERBEDDED SHALY LIMESTONES - SILTS & SHALES

FORT SIMPSON FORMATION
REF.: G.S.C. PAPER 61-29

HAY RIVER FORMATION
REF.: G.S.C. PAPER 61-29

UPPER SLAVE POINT
SLAVE POINT FORMATION
LOWER SLAVE POINT
10/40% PSEUDO OOLITE
20 % FRAGMENTAL
BIOCLASTIC LIMESTONE
MUDSTONE WITH STROMATOLITES
INNER BANK LOW ENERGY CARBONATES
WATT MOUNTAIN
INNER REEF FACIES DOLOMITE
MUSKEG CARBONATE
INNER REEF FACIES DOLOMITE
BACK REEF OR INNER REEF DOLOMITE
KEG RIVER FORMATION
INDICATES DOLOMITE
KEG R. REEF
KEG R. PLATFORM
INNER REEF FACIES (Limestone)
KEG RIVER PLATFORM
SLAVE POINT-ELKTON SANDS
PRE-CAMBRIAN
TATHLINA HIGH
CHINCHAGA

K.B. 1257
T.D. 4751
K-1

K.B. 970
T.D. 3110
K-3

K.B. 930
T.D. 3435
K-4

K.B. 939
T.D. 2890
K-5

K.B. 911
T.D. 3198
K-6

INDEX MAP
1" = 8 MILES

1 of

FORT SIMPSON FORMATION

REF.: G.S.C. PAPER 61-29

HAY RIVER FORMATION

REF.: G.S.C. PAPER 61-29

INTERBEDDED SHALY LIMESTONES - SILTS & SHALES

UPPER SLAVE POINT

SLAVE POINT FORMATION

LOWER SLAVE POINT

BIOCLASTIC LIMESTONE

INNER BANK LOW ENERGY CARBONATES

WATT MOUNTAIN

INNER REEF FACIES DOLOMITE

MUSKEG CARBONATE

BACK REEF OR INNER REEF DOLOMITE

KEG RIVER FORMATION

INDICATED DOLOMITE

KEG RIVER PLATFORM

INNER REEF FACIES (Limestone)

PRE-CAMBRIAN

TATHLINA HIGH

K.B. 1632
T.D. 5451
K-1

K.B. 1257
T.D. 4751
K-2

K.B. 973
T.D. 3110
K-3

K.B. 930
T.D. 3435
K-4

K.B. 939
T.D. 2890
K-5

K.B. 911
T.D. 3198
K-6

INDEX MAP
1" = 8 MILES

KAMISA AREA

THE CALGARY & EDMONTON CORPORATION LIMITED

N.W.T. & NORTHERN ALBERTA

STRATIGRAPHIC CROSS-SECTION

SHOWING CHINCHAGA - KEG RIVER ONLAP
AND KEG RIVER OVERLAP

Geology By: R.C. Sweerett	Date: Oct., 1963	Drawn By: K. Cornelius
Revised	Date	Map No. 138
	Scale: Not to scale	Base

2072

MAR 11 1965

28-1-4-2

K-5

FINAL REPORT
PERMIT NOS. 3520 & 3519
KAKISA RIVER PROSPECT

Prepared by:
THE CALGARY & EDMONTON CORPORATION LTD.

Abstracted for
Geo-Science Data Index

Date

FINAL REPORT

PERMIT NOS. 3520 & 3519

Abstracted for
Geo-Science Data Index

Date

KAKISA RIVER PROSPECT

GEOLOGICAL & EVALUATION
RESOURCES DIVISION
APR 12 1965
OTTAWA, CANADA
Dept. of Northern Affairs & National Resources

Prepared by:

THE CALGARY & EDMONTON CORPORATION LIMITED

March, 1965

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MAP — ISOPACH TROUT RIVER TO SLAVE POINT

MAP — TROUT RIVER TO CHINCHAGA ISOPACH

MAP — SLAVE POINT ISOPACH

MAP — KEG RIVER ISOPACH

GENERAL

Permit Nos. 3520 and 3519, comprising a total of 127,168.00 acres, are located in The District of MacKenzie, Northwest Territories, about 11 miles north of the Alberta-Northwest Territories boundary.

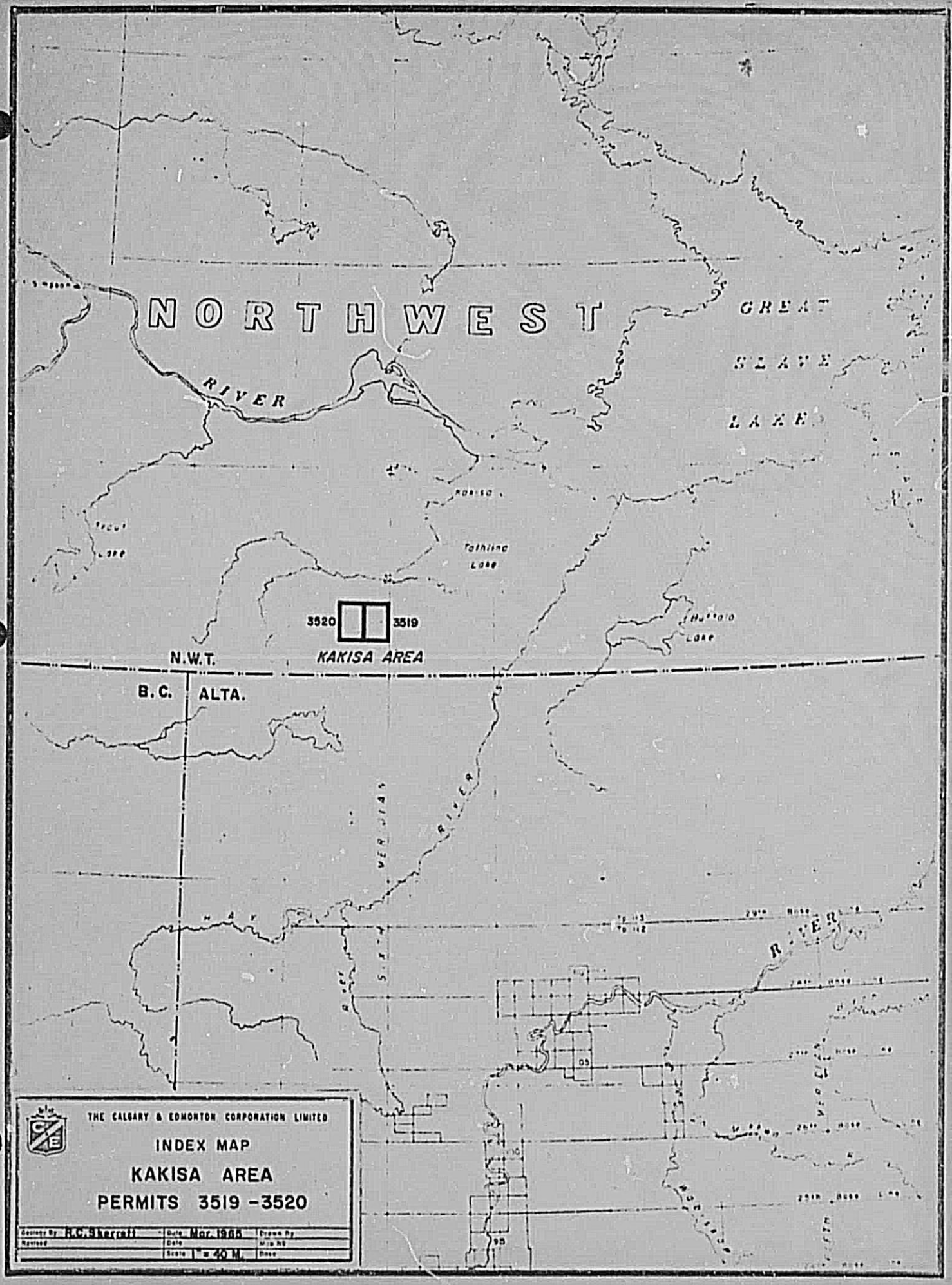
GEOLOGY

Permit Nos. 3520 & 3519 are located in the lowlands of The District of MacKenzie, Northwest Territories, about 11 miles north of the Alberta-Northwest Territories boundary. The area is of gentle relief with muskeg in the lows. The Permit area lies adjacent to the northwest flank of the Cameron Hills. Locally intermittant drainage trends north and west to Tathlina Lake and the Kakisa River. A narrow strip of muskeg lies between the Kakisa River and the northwest sector of the Permit area. Access would be limited to winter conditions. Within the Permit and general area, Cretaceous clastics are exposed. Glacial drift of variable thickness probably occurs in the area but was not observed locally. Palaeozoic outcrops first appear approximately 36 miles northeast of the Permit area along the northeast shore of Tathlina Lake. Lower Cretaceous sediments underly the area of the Permit and unconformably overly Upper Devonian carbonates of the Wabamun, Winterburn and Woodbend groups. The lower formations of the Upper Devonian comprise open marine carbonates and clastics of the Hay River and Slave Point formations. An unconformity may occur at the base of the Hay River formation. Locally the unconformity is represented by a black bituminous shale. The word "unconformity" as used here is tentatively inferred. The total Upper Devonian preserved is approximately 3,200 feet and dips to the southwest about 20 feet per mile and appears to maintain a relatively uniform thickness over a broad area. Anomalous changes in isopach interval may suggest structure.

The Upper Devonian overlies, with apparent unconformity, the Elk Point group. Locally, and in the area of the Permit, the total Elk Point is approximately 600 feet thick. South and west of the Permit area the Elk Point thickens to a maximum of 1,500 feet. The Elk Point formations in descending order are: the Sulphur Point, Muskeg, Keg River and Chinchaga formations. The Basal Palaeozoic sand, that underlies the Chinchaga, has been included with the Elk Point group. The Sulphur Point formation is between 75 to 100 feet thick and appears as a low energy carbonate. The Muskeg formation is essentially a biostromal dolomite with thin beds of evaporite. The evaporite strata appear to lense out north of the Permit area. The Muskeg is approximately 75 to 200 feet thick. Separation of the Sulphur Point and Muskeg formations by Log and Lithologic character is subjective. The Keg River formation consists of biostromal dolomite and fine grained, low energy limestone. Locally this formation represents approximately 50% of the Elk Point group. The Chinchaga formation is present and consists of interbedded anhydrite and anhydritic dolomite. Locally the Chinchaga is 200 feet thick but appears to lense out north and west of the Permit area as it onlaps the Tathlina high. The Basal Palaeozoic sands suggest probable outwash from a pre-Chinchaga shore line to the northeast.

SUBSURFACE WORK

No Geophysical or Geologic work, other than subsurface isopach structure and facies mapping was done on and in the Permit area.



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INDEX MAP
KAKISA AREA
PERMITS 3519 -3520

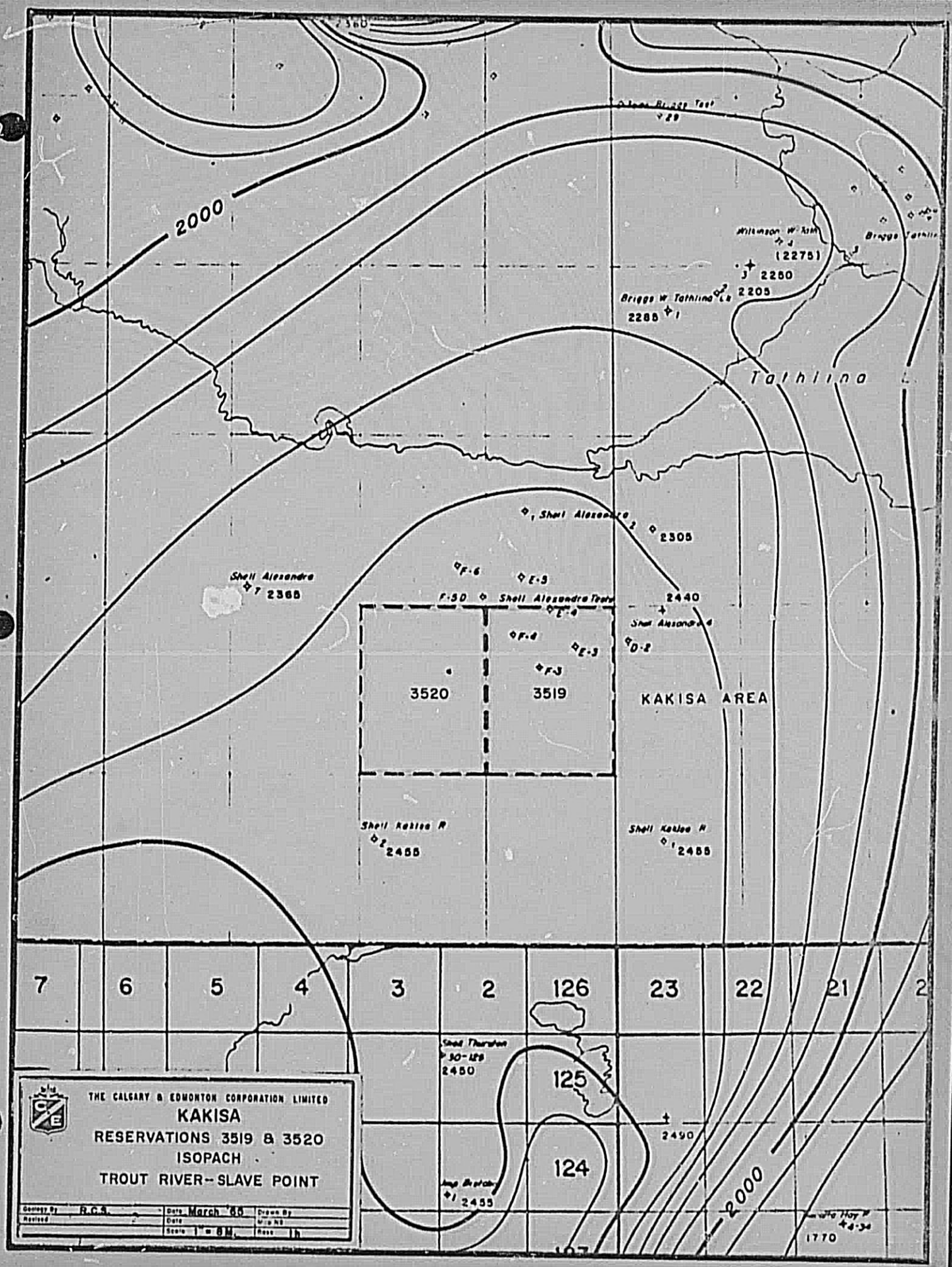
Surveyed By: R.C. Skerratt	Date: Mar. 1965	Drawn By	
Revised	Date	Mile Sq	
	Scale: 1" = 40 M.	Base	

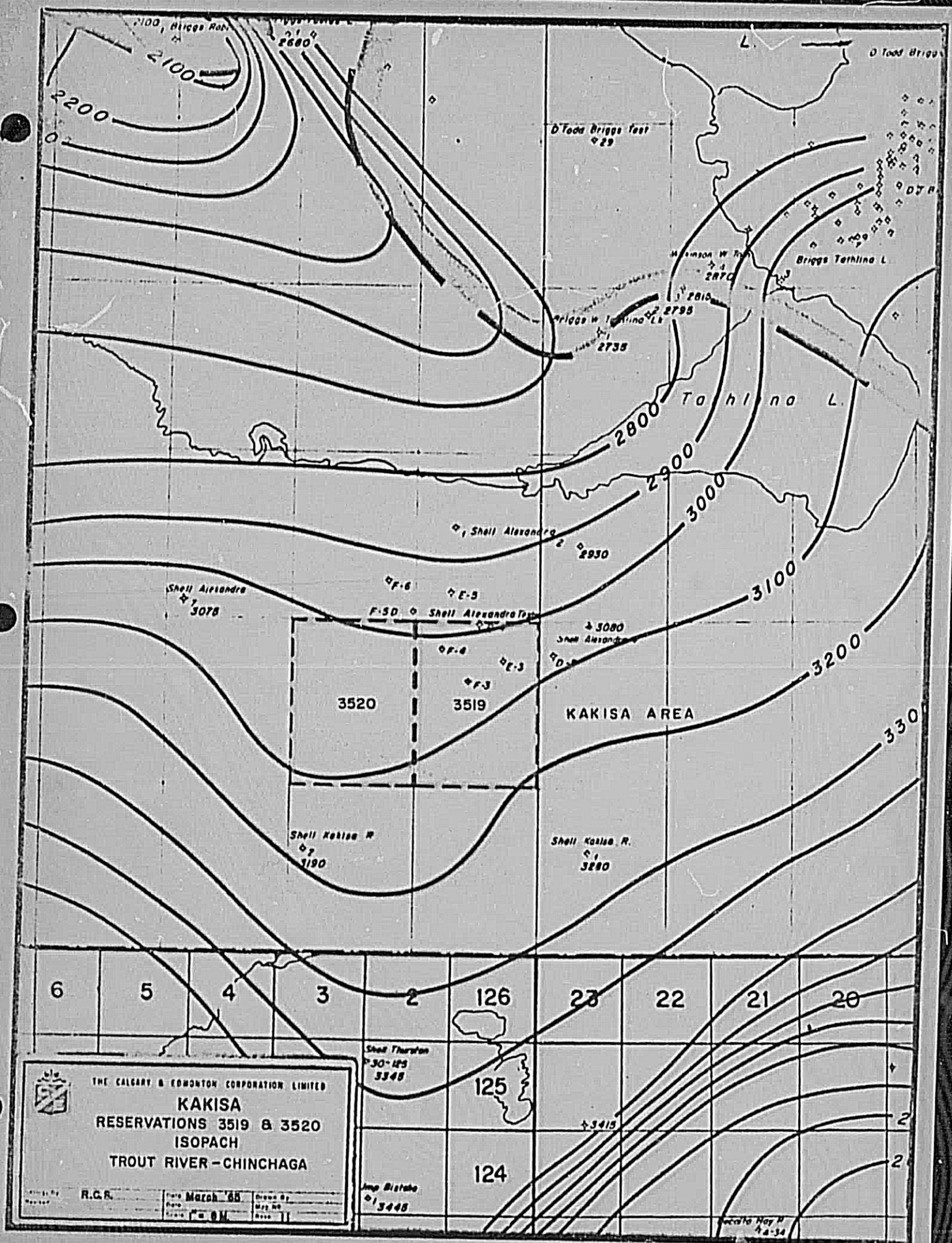
CONCLUSIONS

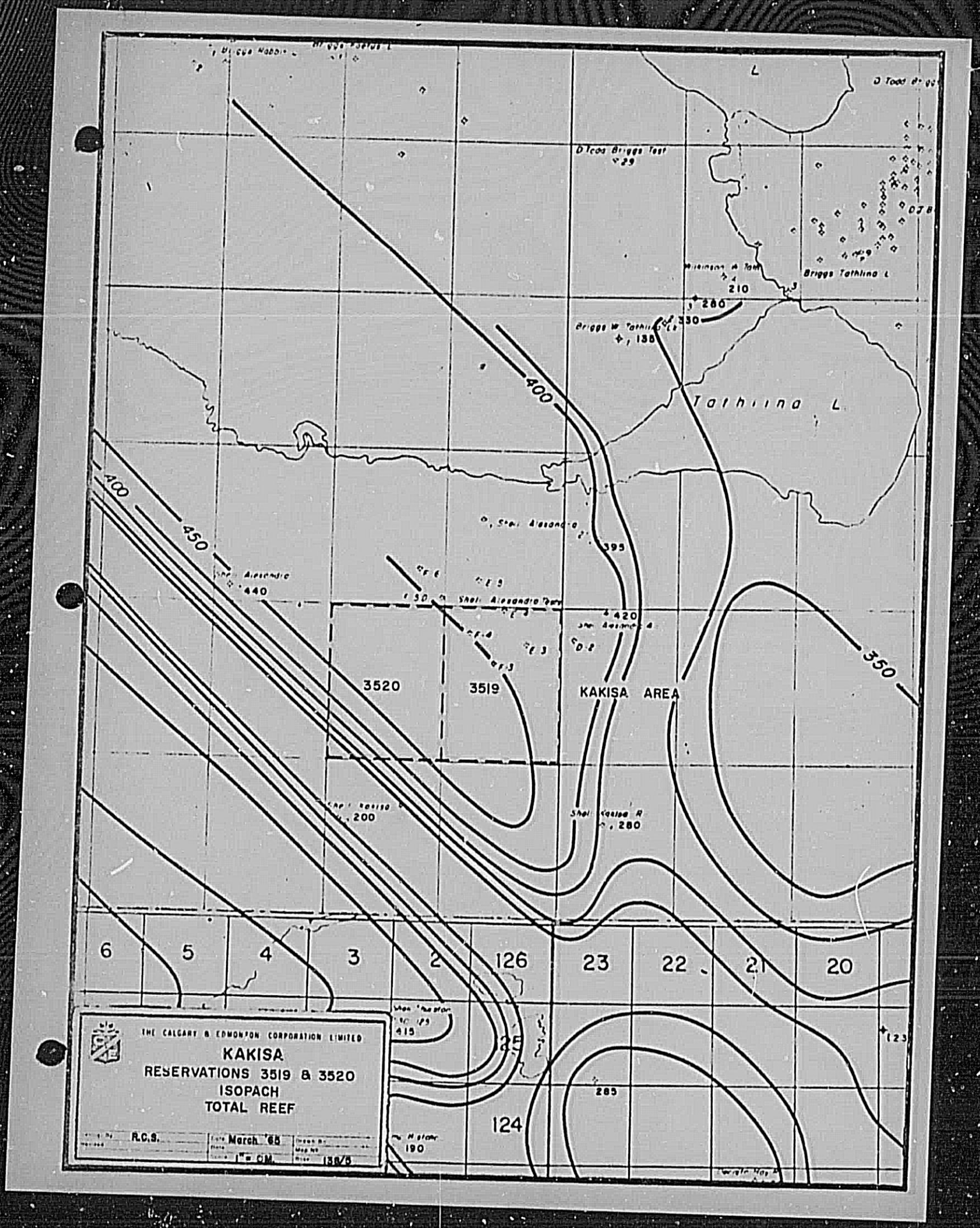
The primary zones of interest underlying Permits 3520 and 3519 are the Keg River, Muskeg complex.

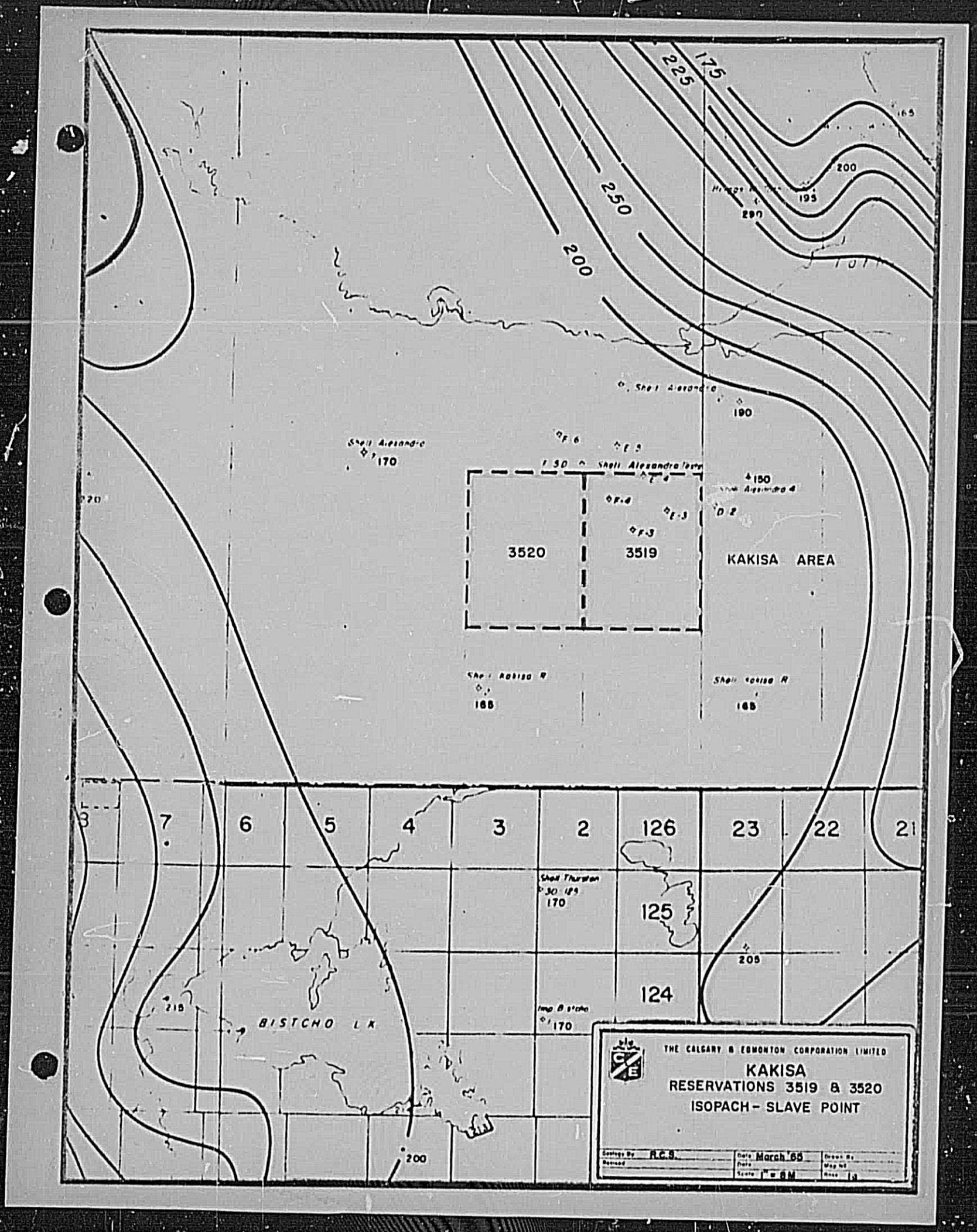
From subsurface data no local stratigraphic or structural closures are interpreted.

As a result of the completed subsurface study, it was decided to terminate the Permits.


2000
Talhiino
Shell Alexandra 2
2305
Shell Alexandra
T 2365
F-6
E-5
F-5D
Shell Alexandra Trah
2440
Shell Alexandra 4
D-2
F-4
E-3
F-3
3520
3519
KAKISA AREA
Shell Kaslea R
2 2455
Shell Kaslea R
1 2455
7
6
5
4
3
2
126
23
22
21
125
124
2490
2455
2000
1770
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KAKISA
RESERVATIONS 3519 & 3520
ISOPACH
TROUT RIVER - SLAVE POINT
Geology By R.C.S.
Date March '65
Drawn By
Revised
Date
Scale 1" = 8M.
Rose


2100
2200
2680
D Todd Briggs
D Todd Briggs test
29
Briggs Tathlina L
2795
2735
Tathlina L.
2800
2900
3000
3100
3200
330
Shell Alexandra
2930
Shell Alexandra
3078
F-6
E-5
F-5D
Shell Alexandra Test
3080
E-6
E-3
F-3
3520
3519
KAKISA AREA
Shell Kakisa R
3190
Shell Kakisa R.
3280
6
5
4
3
2
126
23
22
21
20
125
124
Shell Thurston
3348
3415
Jmp Bistcho
3448
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KAKISA
RESERVATIONS 3519 & 3520
ISOPACH
TROUT RIVER - CHINCHAGA
R.C.R.
March '65
1" = 1 M.


Tathlina L
400
450
350
3520
3519
KAKISA AREA
210
280
330
395
420
440
200
280
415
190
285
6
5
4
3
2
126
23
22
21
20
125
124
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KAKISA
RESERVATIONS 3519 & 3520
ISOPACH
TOTAL REEF
R.C.S.
March '65
1" = 1M.
138/5


175
225
250
200
165
200
195
290
190
Shell Alexandra
170
150
3520
3519
KAKISA AREA
Shell Kakisa R
165
165
7
6
5
4
3
2
126
23
22
21
125
124
205
215
BISTCHO LK
200
THE CALGARY & EDMONTON CORPORATION LIMITED
KAKISA
RESERVATIONS 3519 & 3520
ISOPACH - SLAVE POINT
Geology By R.C.S.
Revised
Date March '65
Date
Scale 1" = 8M

GEOLOGICAL REPORT OF FIELD WORK
STRAND FIORD AREA - AXEL HEIBERG IS. NWT
JULY 1971

V. W. Sutherland
R. G. Metherell

OIL & GAS OPERATIONS UN
Oil and Mineral Division
JUN 29 1972
OTTAWA CANADA
Dept. of Indian Affairs & Northern Dev.

GEOLOGICAL REPORT OF FIELD WORK

STRAND FIORD AREA - AXEL HEIBERG IS. N.W.T.

JULY 1971

Abstracted for
Geo-Science Data Index
Date

V. W. Sutherland

R. G. Metherell

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INTRODUCTION

The area examined during the brief field trip carried out from July 23 to July 29, 1971 is located between latitudes 78° 50' and 79° 05' N. and longitudes 92° 45' and 94° 15' W. This is on the south side of Strand Fiord, Axel Heiberg Island N.W.T., in the vicinity of the Good Friday Anticline and the Vantage Point West Gypsum Diapir.

The nearest permanent airstrip is at Eureka, Ellesmere Is. approximately 105 miles to the northeast. Access to Eureka is by chartered aircraft from Resolute.

The base of operations was the Compagnie Generale de Geophysique seismic camp on the Skraeling Pt. eastern Axel Heiberg Island approximately 90 miles northeast of the area examined. Access to the area was by Bell 205 helicopter via the Eureka Pass.

The outcrop section examined at Vantage Point is exposed on several sharp north west trending ridges formed by the resistant parts of the section and in stream valleys eroded into the recessive weathering shales. Exposure is poor to fair with a considerable part of the section covered by scree. Approximately 1000 feet of relief is present. This outcrop section was examined to obtain stratigraphic control and to aid in the mapping of Canadian Superior's permit located on the Good Friday Anticline.

Bedrock exposures in that portion of the Good Friday Anticline that was examined are found in the main stream valley and on the crests of the ridges separating the streams. A traverse was run along the major stream trending northwest through the anticline. Apart from the steep walled valley mentioned above, the terrain in the area of the anticlinal culmination is moderately rolling and should pose no insurmountable problem to the operation of tracked vehicles.

SUMMARY & RECOMMENDATIONS

This one day surface study has provided additional information on an anticlinal closure with photogeologic measurements of 12 miles by more than 3 miles all on Canadian Superior-Superior acreage. The stratigraphic closure east and west (perpendicular to the axis) is more than 10,000' as indicated by regional isopachs. Gentle south dip was noted on the surface but the photogeology must still be relied on for much of this evidence. Faulting, transverse to the axis of the anticline, enhances the south closure which from displacement of formations must measure more than 2000'. The northern plunge is more poorly controlled but from photogeology must exceed 1000'.

It was found that the Savik is exposed in the core of the anticline (previous mapping showed only Awingak) and that the primary horizon of interest, the Heiberg, should be encountered 1650' below the surface in the culmination of the structure. The Heiberg at the nearby Vantage Point exposure is 3150' thick but has reservoir properties impaired by silicification. It can be theorized however that the same sand in the anticline should be less severely altered and under these circumstances would provide an excellent reservoir. Analyses of the shales above this potential reservoir indicates that an adequate source of hydrocarbons is present.

Surface mapping cannot predict the section below the Heiberg but unknown and possible great thicknesses of shale may be encountered before penetrating any basal Triassic sands. Weak evidence for potential deeper reservoirs was noted at the Vantage Point Diapir but whether they can be reached by the drill is another question.

The presence of intrusions in the Mesozoic section was confirmed but their relative abundance cannot be ascertained without further "on the ground" study.

This structure must be ranked as the best of the prospects presently held by Canadian Superior in the Arctic Islands and ranks geologically behind only the broad gentle structures present in less tectonically active parts of the Sverdrup Basin where the Mesozoic targets such as the Heiberg have been found productive. The Good Friday Anticline can be considered as prospective as any structure on either of the islands of Axel Heiberg or Ellesmere and negotiations of either a farm-out nature or involving spreading of interest should recognize this. It should also be recognized however, that the prospect is 65 miles from the nearest well which, incidentally, was dry and abandoned and on which information is not available. Beyond this it is another 45 miles to a similarily classified well. The third well in greater than a 30,000 square mile area therefore has obvious risk which can only be partly reduced by further detailed geological surface studies and a comprehensive geophysical program.

STRATIGRAPHY AND STRUCTURAL GEOLOGY

Vantage Point West Gypsum Diapir Area

An intrusion of Permo-Penn. gypsum and anhydrite at Vantage Point has uplifted a section of Triassic, Jurassic and Cretaceous rocks, (1) which have been exposed by subsequent erosion. The bedded sediments were measured to strike N 60° W to N 55° W and dip to the northeast at 60°. However due to the erratic magnetic compass behavior at high latitudes it was decided to use the strike of N 40° W derived from the photo mosaic in the calculations of formation thicknesses. A table of formations and generalized stratigraphy is presented below.

(1) See Columnar Section and Cross Section A-B.

ERA	PERIOD	FORMATION	THICKNESS(Ft.)	LITHOLOGY
MESOZOIC	Lower Cret. -U. Jurassic	Deer Bay	Not Measured	Basal Part: dk. gy. shale w/10% silty shale.
	Jurassic	Awingak	600	Brown sandstone
		Savik	1980	Black to brown shale.
	Triassic	Heiberg	3150	Grey & brown sandstone.
		Blaa Mtn.	600+	Grey shale & minor dk. brn. & grey siltstone.
	PIERCEMENT CONTACT			
PALEOZOIC	Permian or Older			Gypsum, anhydrite, limestone.

The enclosed Section A-B illustrates the structure and stratigraphy of the Vantage Point area. The oldest rocks exposed are the gypsum and anhydrite diapiric intrusion found on the west side of the section on the tip of Vantage Point. They are believed to be of Permian or older age. The intrusion is composed of 80% Gypsum, white, fine crystalline and 20% Anhydrite, grey banded, fine to micro crystalline. The weathering color is buff to brown and the topography is extremely rough and craggy. No intrusions were found in the diapir. One hundred feet east of the diapir, however, a 20 foot bed of grey gypsiferous limestone was noted. It is coarsely crystalline, appears recrystallized, and has vuggy, fair to good porosity. This limestone band is believed to be of Permian or older age and to have been dragged up and emplaced by the gypsum intrusion. There are indications that the gypsum body may have been intruded in blocks that are now separated by Triassic Blaa Mountain or older shales. Such an intrusion has been described by E.F. Roots (G.S.C. Memoir #320; Geology of the North-Central Part of the Arctic Archipelago Northwest Territories: Fortier et al: p.p. 491 to 494).

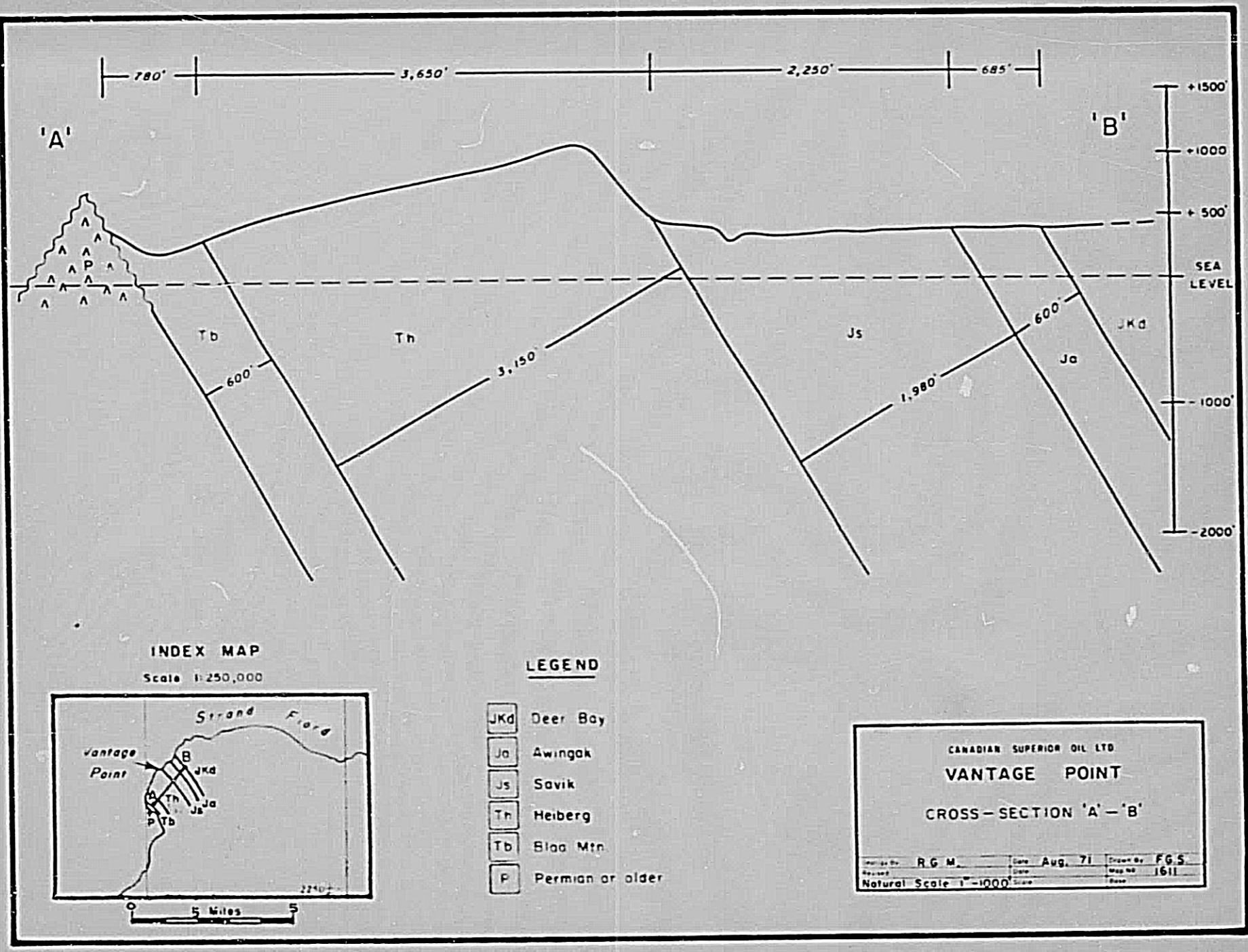
The beds overlying the gypsum intrusion belong to the Triassic Blaa Mountain formation. They are 600 feet thick and occur as a recessive weathering unit. The Blaa Mountain is predominantly grey to black, calcareous, blocky to fissile shale, with minor dark brown siltstone. The Blaa Mountain-Heiberg contact was not exposed,as scree from the overlying Heiberg Sand had covered it.

The Triassic Heiberg sand overlies the Blaa Mountain. The outcrop is composed mainly of rubble covered slopes with the only truly in place outcrop encountered at the top of the high ridge near the center of Section A-B. The Heiberg is predominately fine grained sandstone, buff to grey brown, subangular, well sorted. Limonite staining and carbonaceous material is common. The thickness of the Heiberg is approximately 3150 feet of which perhaps 20% has poor to fair porosity. Occasional silty shale inclusions were noted at the base of the Heiberg. Bedding varies from 2" to massive. Ripple marks are common. The upper part of the Heiberg is well rounded, well sorted sandstone with better porosity but becomes increasingly silty and shaly near the contact with the overlying Savik shale.

The Heiberg is overlain by the Savik shale of Jurassic age. The Savik is a 1980 foot thick recessive weathering, dk. brn. to black fissile shale. Two gypsum sills were found in the Savik. The lower one overlies a five foot sand and silt bed. The gypsum beds appear to be intruded along strike as far as they are visible. They are highly contorted and badly weathered. Some sulphur crusts were noted. A gabbro sill was observed between the two gypsum sills. The Savik contains common concretion ranging in size from 2 inches to 3 feet in diamater. Some concretions contain ammonites. The upper portion of the Savik contains sandstone stringers which become more common toward the top as the Savik grades into the overlying Awingak Sand.

The Awingak formation is of Jurassic age and is composed of 600 feet of fine to coarse grained, light brown, subangular, poorly sorted, carbonaceous porous sandstone. The lower part of the Awingak is interbedded with Savik shales. The Awingak exhibits a characteristic buff weathering color. The upper contact of the Awingak with the overlying Deer Bay shales is very sharp and occurs in a small gully. The abruptness of this contact suggests the possibility of a fault and the attendant thinning of the section.

Only the base of the Deer Bay formation was observed on this section due to time limitations. The Deer Bay is Upper Jurassic to Lower Cretaceous in age and a predominately dk. grey, fissile to platy, calcareous shale. Approximately 10 per cent of that part of the lower Deer Bay that was examined is composed of silty shale stringers up to 4 inches thick, exhibiting cross bedding.



INDEX MAP

Scale 1:250,000

LEGEND

JKd	Deer Bay
Ja	Awingak
Js	Savik
Th	Heiberg
Tb	Blaa Mtn
P	Permian or older

CANADIAN SUPERIOR OIL LTD

VANTAGE POINT

CROSS – SECTION 'A' – 'B'

Drawn by R G M.	Date Aug. 71	Drawn by F.G.S.
Revised	Date	Map No. 1611
Natural Scale 1"=1000'	Scale	Base

-9 AUG 1971

Good Friday Anticline Area

Approximately ten miles southeast of the above described Vantage Point area, a structure known as the Good Friday Anticline is mapped. Photogeologic mapping shows the structure to be a north trending box anticline, quite flat on top and dipping steeply on the limbs. The anticline has been mapped as plunging to both the north and south, thus effecting structural closure. At the culmination of the structure, Awingak Sand outcrop had been mapped by photogeology. Several hours were spent running a traverse along the prominant stream valley parallel to and slightly west of the axis of the Anticline. (The geological stations where observations were made are marked on the accompanying sketch map and the field notes are recorded in Appendix I).

It was found that the photogeologic map is not correct in mapping Awingak Sand outcrop over the entire anticlinal culmination. In fact, Savik shale outcrops for several miles along the banks of the traversed creek (Stations 1, 2, 3, 6, 10, 11, 12, 13, 14). Awingak Sand caps the uplands (Stations 4, 5, 10, 11, 13). An estimated 350 feet of Savik shale has been eroded in the traversed stream valley. Therefore, it is believed that 1630 feet of Savik remains capping the potential reservoir beds - the Heiberg Sand. The Heiberg is not breached.

A diabasic diorite sill is exposed in the traversed creek bed (Stations 7, 8, 11, 12, 13). The intrusion is believed to be a sill rather than a dike because the stream has cut into it and the igneous rock often outcrops on both stream banks and does not appear to have affected the stream's course. The base of the sill was not exposed and it is estimated to be at least 200 feet thick. Cooked Savik shales were observed in proximity to the sill (Stations 9, 10) and upstream where it is believed to lie beneath the stream bed (Stations 1, 2, and 6). The visual metamorphism of the shales occurs only within approximately 100 feet of the intrusion. The sill appears to have been folded with the surrounding beds.

DISCUSSION OF LABORATORY STUDIES

Source Rock Evaluation

Samples from four distributed parts of the Savik section and from one point in the Blaa Mountain were submitted for analysis. All were from the area of the Vantage Point Diapir since there is evidence indicating local alteration of at least the exposed section of the Savik by a diabase sill in the area of the Good Friday prospect. This local alteration need not however represent the entire section of the Savik over the anticline.

After consultation with the University of Calgary and with Geoservices three different source rock parameters were requested:

1. Total Organic Carbon
2. Total Soluble Organic Carbon
3. Maturation

Results of the "Total Organic Carbon" analysis indicate that four of the five samples were about 20% below the significance threshhold of 1.14% and one sample was considerably above the threshhold. Calculations for "Soluble Organic Carbon" show four of the five samples to be above the minimum of 3% of total organic carbon but all samples are in the low range. The "Maturation" studies show all but one sample to be ranked as definitely high, as would be expected from the geologic history of the area, and to favor gas generation. We should also note that an analysis of the soluble extracts shows an abundance of "mono and poly-cyclic aromatic hydrocarbons and the presence of hetero-compounds possibly containing sulfur.

The Blaa Mountain although slightly different in facies (grey calcareous Blaa Mountain shale as compared to black and dark grey fissile Savik shale) is remarkably similar in source rock qualities to the Savik as determined by the analysis that was conducted on this formation.

The chemical analyses which in summary classify the shales as on the low end of "acceptable" is considerably more pessimistic than opinions gathered from a study of the micofossils present. Dr. Loranger states, "the fauna is abundant with approximately 500 individuals being recovered. Such a high number of individuals from a standard sample is highly significant since it is an indication of the type and abundance of organic matter that was present at the time of deposition. The hydrocarbons derived from this type of environment are believed to provide the essential elements for the production of wet gas when a sufficient degree of maturation has been achieved." Some difference of opinion therefore exists between these two disciplines.

In addition to the contribution of the Savik formation and the uppermost Blaa Mountain formation as a source for generating hydrocarbons, an unknown thickness, possibly very great, of Blaa Mountain and probable Blind Fiord shales underlie the Heiberg Sand. This raises the questions of vertical verses horizontal migration and distance of migration but this will not be entered into in this note. Suffice it to say however that in light of existing discoveries of gas in the Heiberg under apparently similar stratigraphic conditions; and because of the at least marginal acceptability of the shales analyzed and the unknown thickness of underlying shales, source rocks should not be considered a problem in this prospect.

Porosity & permeability Calculations

Six samples of the Heiberg Sand collected throughout the section were analyzed for porosity and permeability. Porosities ranged from a low of 5.4% to a high of 15.6% and permeabilities from .12 Md to 13.2 Md. Reservoir properties at the outcrop therefore must be considered marginal as was apparent from visual examination. Petrographic studies indicate a very compact rock fabric with interlocking grain contacts and a high degree of probable contact solution greatly impairing porosity and permeability. The cause of the solution is unknown and whether it represents conditions in the subsurface is an important question. Since rim cementation is not recognized the possibility of surface alteration by meteoric waters is improbable. Instead, a heat and/or pressure route is preferred. Since the Heiberg is not normally as highly silicified in other areas of similar stratigraphic history, deep burial is not considered a likely cause. The fact however that the one outcrop studied is associated with high dips and an anhydrite intrusive may be significant, and a diagenesis created by the same forces that resulted in the forming of a major fold system with associated faulting and the movement of evaporites is a definite possibility. It is suspected that some of these forces existed throughout Mesozoic time but the main pulse is the Middle Tertiary "Eurekan" Orogeny. It was not until Tertiary times therefore that the Good Friday anticline and the Vantage Point Diapir were formed as we know them today and since the forces forming the anticline could be less severe than those forming the 60° dips associated with the diapir the degree of diagenesis could be less severe. In addition it is evident that under most conditions Triassic hydrocarbons will have formed and moved into traps long before Tertiary time. If such occurred we would hope that a Heiberg gas accumulation existed in a gentle anticlinal trap at Good Friday before the "Eurekan" Orogeny. This could conceivably serve to protect the reservoir from the degree of diagenesis affecting other areas. The same is true for diagenesis associated with the heat and pressure of the placement of the igneous intrusions. This latter factor is considered last however because from the section examined at Vantage Point, igneous intrusions do not form a significant part of the section.

Petrographic Study - Igneous Rock

A sample collected from the igneous sill which in the field notes is referred to as grano-diorite was submitted for "expert" opinion. From this work we learn that the rock should be correctly referred to as a "diabasic diorite" which commonly constitutes the dikes and sills of the western Arctic Islands.

Micropaleontology

Two composite samples representing the Savik at the Vantage Point Diapir and the Savik at the prospect were submitted. This latter sample was composed of what appeared as the less "cooked" parts of the Savik outcrop on the anticline but apparently the visual appearance is not indicative of the true character since Dr. Loranger found all microfossils to be completely carbonized. The Vantage Point Savik formation displayed an unusual abundance of foraminifera dated as Middle to Lower Jurassic and confirming a shallow water marine environment of normal sea water salinity.

APPENDIX 1

Field Notes Vantage Point West Gypsum Diapir Section

July 27/71 - 12 Noon - Strand Fiord
W. Gypsum Diapir - East Side.

Permian or Older -
- Photo #1 - 80% Gypsum - white fi/crs. x/n.
- Badly fract.-weathers buff to brown, craggy topography - thick weathered surface
- 20% anhydrite - gray, banded, fi. to micro xl.
- No inclusions identified
- Topography indicates movement by blocks averaging one acre in area with depression 25' deep separating.

Blaa Mountain - 100' east of diapir (Sample #1) 20' of ls, gypsum, gy/wht, crs. crystalline, vuggy porosity fair to good. Also sh. gy. hard, blocky fract., calcareous, banded in pt. Grading to siltstone, gy. blk., sl. calc.

225' east - shale, black, brown, fissile.

525' east of Diapir (Sample #2) Shale becomes interbedded with siltstone est. at 50%. Slt. is dk. brn. with Fe staining.

725' - Shale 100% - gy. blk., badly weathered, forms west side of first ravine.

Base Heiberg - 925' east (Sample #3) Sh. as above becomes more interbedded with slt. and Ss. to total sandstone from talus reading. Ss. f./crs. gr., brn. gy., mod. sorting med. well rounded, tight, limonite stain, inclusions of silt.

1500' east of diapir (Sample #4) Ss. fi. gr. gy/brn., subangular, well sorted, limonitic poor to fair porosity, poss. arg.
Rubble of this continues.

4000' Approx. (Sample #5) Ss. brn./buff/gy. fi. gr/v. fine gr., sil. cem., bedding 2" to 4" with ripple marks, tite, carb. mat. common, limonite st.
Strike N 60° W, Dip 60° N.

Heiberg - 4300' (Sample #6) Ss. lt. gy. to bf. F. gr. well rounded, well sorted, med. por., coarse bedding to mass., carb. mat.

(Sample #6A) Slt. V. arg. at top of Heiberg unmeasured top of Heiberg at base of scree slope measured at 40°. Talus becomes increasingly silty. and then shaly to a fissile,

Base Savik - gy. shale. (Sample #7) Too weathered to describe.

300' from base of slope - 5' Ss. gy., fi. gr., sil., grading to slt. overlies: 2' of gypsum, badly weathered.
- Concordant with bedding for 1000' and over horizon.

425' from base of slope (Sample #8 Photo) sill, gabbro, 5' thick, follows bedding in part.

450' from base of slope - 2nd sill of gypsum intruded along strike of bedding, contorted banding, badly weathered, sulphur crusts.

Savik at base of Ravine (Sample #9) Sh., blk. to brn., fiss., non calc., non silty, weathers very crumbly- Fossils: Ammonite and Belemnite. Strike N 60° W, Dip 60° N.

Farther down Ravine - (Sample #10) Shale as above.

On east side of Ck. (Sample #11 Photo) Shale as above, concretions to 3 feet in diameter.

Savik = 350 paces @ 5'/pace.

Base of Awingak - Front of first knoll east of 2nd Ravine (Sample #12) Ss. fi. gr. brn. poorly sorted, subangular, good porosity, carb. mat. abundant.
- Stringers of sand increasing in top of Savik.
- Weather buff-distinctive !
- Ss. becomes more varied and approaches grit size.

Awingak - 800' topography from Awingak base (Sample #12A) sudden abrupt change in facies to sh. with interbedded Ss. Strike N 55° W, Dip 60° N. Fracture of Awingak Ss. gives appearance of an east dipping fault but this is not the interpretation given. Ss. at top of Awingak med. gr., subangular, lt. gy. sil. tight - mafic minerals.

Base Deer Bay - (Sample #13) Sh. dk. gy. fissile to platy, calc., silty sh. stringers 10% with beds up to 4" finely lam. & X bedded in pt.

Field Notes for Good Friday Anticline Traverse - Traverse #2-July 27/71

Station 1 - Sample 14 - sh. dk. gy. fi. lam., sl. slty.
- Bank on west side of Axial Stream is made up of 50' of exposed black shale.
- Looks like Savik but is harder.
- No attitude avail.

Station 2 - (1150' from Station 1) - Sample 15 sh. aa. but is more indurated - weathers chippy.
- Speckled in part.
- Otc continues for 500' and remains constant in lith.
- Looks burnt from weathered surface.

Strike N 40° E, Dip 6° S.

Station 3 - (1400' from Station 2) Sample 16 Black shale between Station 2 & 3 weathers very soft to form a smooth bank & decomposed black outcrop. Strike N 45° E, Dip 6° S.

Station 4 - Scree appears to cover slopes which at base must have Savik unless faulting. Looking north a mesa is forming with Awingak Cap- (Photo taken) est. at 350' in hieght.

Station 5 - Sample 17 - Scree of Awingak-origin must be only 200' to 300' up slope. Area is continuous Awingak scree as far as eye can see. Hills show 300' of relief visable ½ mile to south and east in ravines.

Station 6 - Beds of Savik shale more resist. (indurated) and forming cap to mesa-like hill.
- beds are badly slumped so attitude is rough. Strike N 45° E, Dip 9° N.
- attitude from beds below at base of hill. Strike N 30° W, Dip 6° W.

Station 7 - Sample 18 - Rubble from dike or sill of light gy. xl. igneous rock, feldspar and mafic minerals - granodiorite.
- No topo. relief.

Station 8 - Granodiorite on both sides of stream.

Station 9 - Sample 19 - Granodiorite continues but one exposure on east bank of slate. Previously Savik.

Station 10 - Sample 20 - Sh. blk. gy., slaty on east bank - west bank - Awingak scree from top of slope at 150'. Scree below is Savik shale cooked. Strike N 20° E, Dips west.
- float of one piece of anhydrite noted.

Station 11 - Re-appearance of Granodiorite in stream bed-Savik shale continuous on both sides from Station 10 except covered in part on west by Awingak-Scree outcropping 100' up. No good exposure.

Station 12 - 50' high exposure of granodiorite on west side - Savik shale with granodiorite scree on east. Photo.

Station 13 - East Bank - Savik shale on outcrop on hill 100' up - less comp. shale interpreted both above and below totalling 200'. Granodiorite in stream. Some Awingak in talus indicating not all Savik.
- 200' downstream from Station 13. Strike N 30° E, Dip 8° W.

Station 14 - Savik shale exposed on hillside 100' high. Savik comes in 500' to east on top.

APPENDIX 2



Figure No. 1

Phantom Lake



Figure No. 2

Crusoe Glacier



Figure No. 1

Phantom Lake



Figure No. 2

Crusoe Glacier



Figure No. 1

West End of Kanguk Peninsula



Figure No. 2

Vantage Point and South Shore
Strand Fiord



Figure No. 1

West End of Kanguk Peninsula



Figure No. 2

Vantage Point and South Shore
Strand Fiord



Figure No. 1

Vantage Point



Figure No. 2

Gypsum Incrusive (Permo-Penn)
Vantage Point



Figure No. 1

Vantage Point

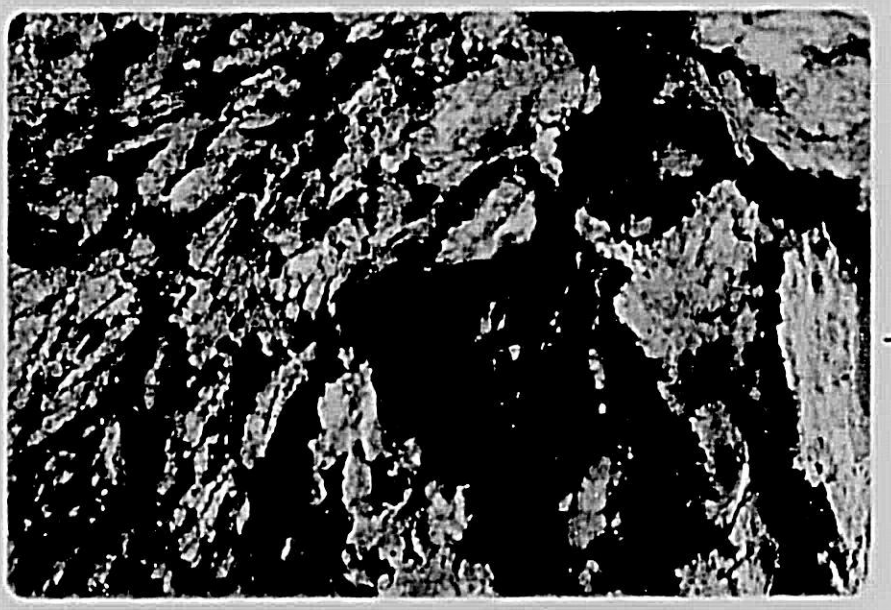


Figure No. 2

Gypsum Incrusive (Permo-Penn)
Vantage Point



Figure No. 1

Heiberg (Triassic) at Vantage Point



Figure No. 2

Heiberg (Triassic) at Vantage Point



Figure No. 1

Heiberg (Triassic) at Vantage Point



Figure No. 2

Heiberg (Triassic) at Vantage Point



Figure No. 1

Igneous Intrusion - Vantage Point



Figure No. 2

Savik (Jurassic) with Concretions
Vantage Point



Figure No. 1

Igneous Intrusion - Vantage Point



Figure No. 2

Savik (Jurassic) with Concretions
Vantage Point

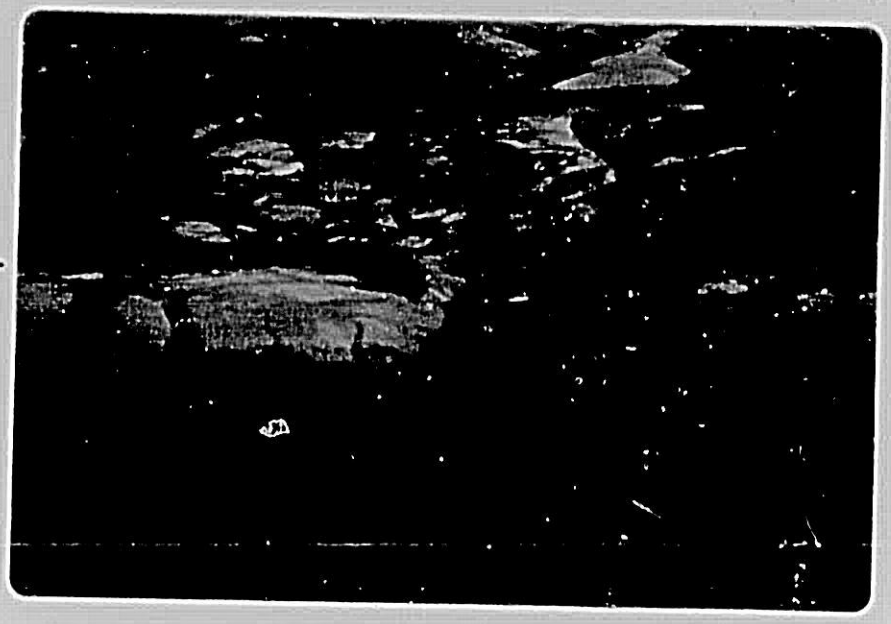


Figure No. 1

Eastward View from above Good Friday Prospect - indicates east dip



Figure No. 2

Savik Shale - Good Friday Prospect



Figure No. 1

Eastward View from above Good Friday Prospect - indicates east dip



Figure No. 2

Savik Shale - Good Friday Prospect



Figure No. 1
Savik Shale with Awingak Cap
Good Friday Prospect



Figure No. 2
Savik Shale with Awingak Cap
Good Friday Prospect



Figure No. 1
Savik Shale with Awingak Cap
Good Friday Prospect



Figure No. 2
Savik Shale with Awingak Cap
Good Friday Prospect



Figure No. 1

Awingak Scree Covered Slopes
Good Friday Prospect



Figure No. 2

Diorite Sill - Good Friday Prospect



Figure No. 1

Awingak Scree Covered Slopes
Good Friday Prospect



Figure No. 2

Diorite Sill - Good Friday Prospect

APPENDIX 3

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SOURCE ROCK EVALUATION

GEOSERVICES

GC-W058

OCT- 71

SOURCE ROCK EVALUATION

I. METHOD OF INTERPRETATION

The purpose of this paragraph is to outline the principles which we use to interpretate the results of analyses. The whole process of interpretation is summarized on the flow chart following these pages.

A. MAIN PARAMETERS

(1) Organic Carbon (symbol : Ct% ; index (Ct - C)/C)

The main parameter is the amount of organic material contained in the sediment. It is expected that, all conditions being the same, a sediment with a low content in organic material will have produced smaller quantities of hydrocarbons than a sediment rich in organic matter.

The content in organic material is measured in terms of percentage of organic carbon equivalent (symbol : Ct%).

We have selected the following criteria :

To be significant, the organic carbon content must be higher than 0.24% for carbonated sediments or 1.14% for shaly sediments. The significance is indicated by the ratio (Ct - C)/C.

(2) (Chloroform) Soluble Organic Carbon (symbol : Cs/Ct%)

It is remarkable that only a small fraction of the hydrocarbons which have been generated in a source rock, have been expelled out of the sediment through primary migration. Therefore, the second main parameter is the amount of hydrocarbons remaining in the sediment. These hydrocarbons are extracted with a solvent specific to hydrocarbons and lipids, namely : Chloroform.

The content in chloroform soluble material is expressed in terms of percentage of carbon equivalent (symbol : Cs) relatively to the total amount of organic carbon (symbol : Cs/Ct%).

We have selected the following criterium :

To be significant, the amount of chloroform soluble material must be so that the ratio Cs/Ct is equal to or larger than 3% but smaller than 30%.

.../...

(3) Maturation (or Carbonization) index (symbol : CR/CT%)

The maturation (carbonization) of the organic matter is mainly due to the effect of thermal diagenesis and, to a certain extent, to the catalytic properties of the argillaceous sediments.

Of course, maturation is not the only factor of hydrocarbon genesis, other factors such as the very nature of the organic material itself and the depositional environment are equally important.

The degree of maturation (evolution, carbonization) is measured by the CR/CT ratio where :

-) CT is the amount of carbon equivalent to the organic matter unsoluble in chloroform,

-) CR is the amount of carbon equivalent to the organic residue remaining after the unsoluble material has been pyrolized at 800°C.

Since all organic materials except graphite are volatile at 800°C, a CR/CT of 100% is indicative of a completely carbonized graphite-like organic matter.

It should be noted that a very high CR/CT could be obtained under two completely different sets of conditions :

Rob. →

-) a thorough thermal diagenesis will be responsible for a high CR/CT by producing, as end products, methane and carbon (graphite).

-) a strongly oxydizing depositional environment will eliminate the hydrogen from the original organic material, thereby conducing to a carbon (graphite) deposit and an eventual methane production.

However, when the depositional environment is favorable, it is expected that a mature organic material has generated, with time, a whole "spectrum" of hydrocarbons.

We have selected the following criteria :

A suitable CR/CT ratio is comprised between 45 and 75%. A high maturation index (favorising gas over oil) is around 80% or higher. However, it is known that, in young formations (Miocene), oil has been formed in formations having a CR/CT of 20%.

B. SECONDARY PARAMETERS

(1) Sorbed Gases (symbol : Cg/Ct%)

The light (viz. gaseous) hydrocarbons are lost during the chloroform extraction of the samples. To compensate for this defect, the so-called "sorbed" gases are extracted. These gases are those which are retained by or on the organic material and the inorganic matrix of the sediment.

The sorbed gases are extracted by acid digestion of the sediment in a vacuum at a temperature of 80°C. By no means do we analyze the free gases which are in the porosity of the sediments.

The content in sorbed gases is expressed in terms of carbon equivalent (symbol : Cg) relatively to the total amount of organic carbon (symbol : Cg/Ct%).

Since the gases are in a less condensed state than the liquids and solids, the ratio Cg/Ct is expressed by a much smaller index than the homologous Cs/Ct ratio.

The interpretation of the sorbed gases is hindered by several drawbacks which are :

-) the amount of sorbed gases extracted from a sediment depends not only on the amount which is actually present but also on the retention properties of the sediment and the ability (or efficiency) of the desorption process to extract the gases.

-) the gas extracted from a sample can be of migratory origin or in-situ or both.

-) the sorbed gases have been less studied than the liquid and/or solid organic materials in sediments.

In view of the above, we do not have set criteria to interpretate the Cg/Ct ratios. However, we tend to regard a Cg/Ct ratio equal to or smaller than 0.005% as not significant, a Cg/Ct ratio larger than 0.005% but smaller than 0.050% as average to significant, a Cg/Ct ratio larger than 0.050% as very significant.

(2) Composition of the sorbed gases (symbols : C2/C1, C3+/C1)

A valuable indication furnished by the study of the sorbed gases is the relative amount of methane extracted from the sediment.

We represent the gas composition by the ratios C2/C1 and C3+/C1 that is the ratio of the amount of ethane to the amount of methane and the ratio of (propane + butanes) to methane.

Unusually low C3+/C1 ratios associated to very high CR/CT ratios tend to characterize an organic material which was oxydized when it was deposited.

C. ANALYSIS OF THE CHLOROFORM EXTRACT

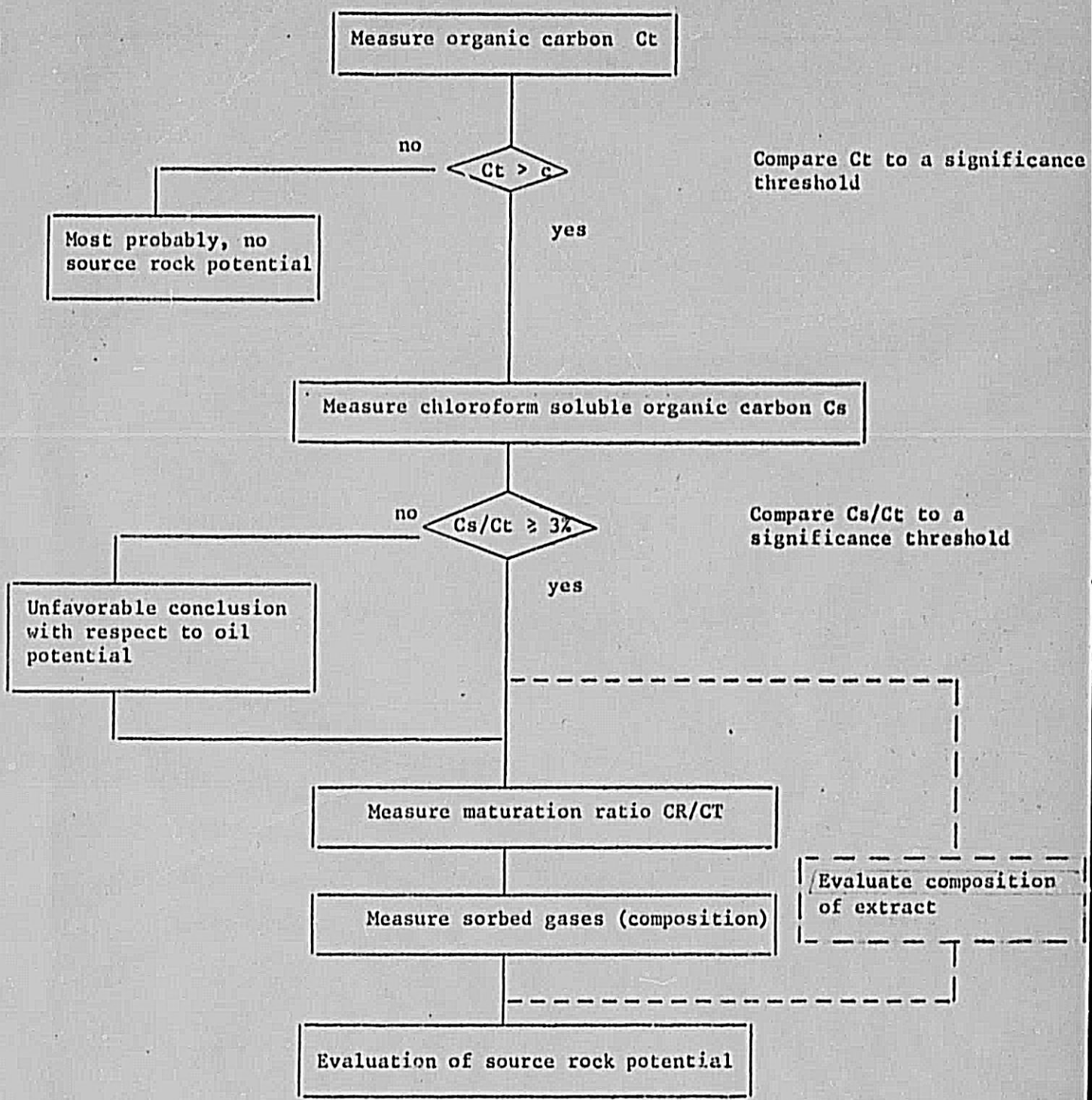
An analysis of the chloroform extract indicates the type of hydrocarbons which remains entrapped in the source rock.

D. SUMMARY

The interpretation process can be summarized by the attached flow chart.

It should be emphasized that the results presented hereafter constitute the first stage of the interpretation. To obtain the full results, the geological environment and the past geological history of each sampled formation should be taken into account.

(see overleaf)


Measure organic carbon Ct
no
Ct > c
Compare Ct to a significance threshold
Most probably, no source rock potential
yes
Measure chloroform soluble organic carbon Cs
no
Cs/Ct ≥ 3%
Compare Cs/Ct to a significance threshold
yes
Unfavorable conclusion with respect to oil potential
Measure maturation ratio CR/CT
Evaluate composition of extract
Measure sorbed gases (composition)
Evaluation of source rock potential

II. RESULTS OF INTERPRETATION

The amount of sample submitted for analysis was not sufficient to allow us to extract the so-called sorbed gases. However, we were able to measure the organic carbon content, the fraction of organic material which is soluble in chloroform and the maturation ratio. The results of analyses are summarized on table N° I and figures N° 1 to 6.

TABLE N° I

SAMPLE	Ct %	(Ct-C)/C %	Cs/Ct %	CR/CT %	Carb %
Blaa Mtn 2	0.93	- 18	4.3	81	0
Bs. of Sauk 7	0.95	- 17	2.6	82	0
Mid Sauk 9	0.97	- 15	5.2	84	0
Sauk 10	0.95	- 17	9.0	69	0
Top Sauk 11	1.98	+ 74	5.9	81	3

C = 0.24 when Carb ≥ 45%

C = 0.52 when 20% ≤ Carb < 45%

C = 1.14 when Carb < 20%

(1) Samples N° 2, 7, 9 and 10 do not contain enough organic material to qualify as good source rocks. Their content in organic matter is slightly below the significance threshold.

(2) However, the chloroform soluble fraction of the organic matter contained in samples N° 2, 9 and 10 is well above the significance threshold.

A UV spectrophotometric analysis of these extracts shows an abundance of mono- and poly-cyclic aromatic hydrocarbons and the presence of hetero-compounds possibly containing sulfur.

(3) It should be noted that the carbonization (maturation) ratio of samples N° 2, 9 (and 7) is very high, i.e. about 80% of the organic material which is not soluble in chloroform is composed of graphite-like carbon.

We shall conclude from this remark and remark (2) above, that the organic material contained in samples N° 2, 7 and 9 has evolved considerably.

.../...

(4) Sample N° 10 shows a somewhat lower maturation. However, the carbonization ratio of 69% of this sample is still indicative of a well mature organic matter.

(5) Sample N° 11 is the only sample which contains an above average amount of organic matter. It is interesting to note that a significant fraction of this organic material is soluble in chloroform.

(6) An UV spectrophotometric analysis of the chloroform extract (see fig.5) shows the presence of mono- and poly-cyclic aromatic hydrocarbons, alkylated naphtalenes, asphaltenes and possibly of hetero-compounds containing sulfur.

A chromatographic analysis of the concentrated extract shows the presence of benzene, toluene, xylenes, n-heptane and n-octane. There is no indication of significant amount of hydrocarbons in the range of xylenes to n-C16 (naturally, hydrocarbons heavier than n-C16 are present in significant amounts).

Conclusion

It is remarkable that samples N° 2, 7, 9 and 10 have practically the same content in organic material. The UV spectrum of the chloroform extract is nearly identical for these four samples (with the exception of overall concentration, of course). If we except sample N° 10 these samples also show the same degree of maturation.

The higher percentage of soluble material shown by sample N° 10 is consistent with the above remarks.

We shall conclude that samples N° 2, 9 and 10 could have been good source rocks if they had contained more organic material.

Sample N° 7 would have been an acceptable source rock of lower potential if its organic carbon content had been higher.

Sample N° 11 is the only one which shows good source rock characteristics. Tentatively, we suggest that very light oil and/or gas has been generated by this very mature organic matter.

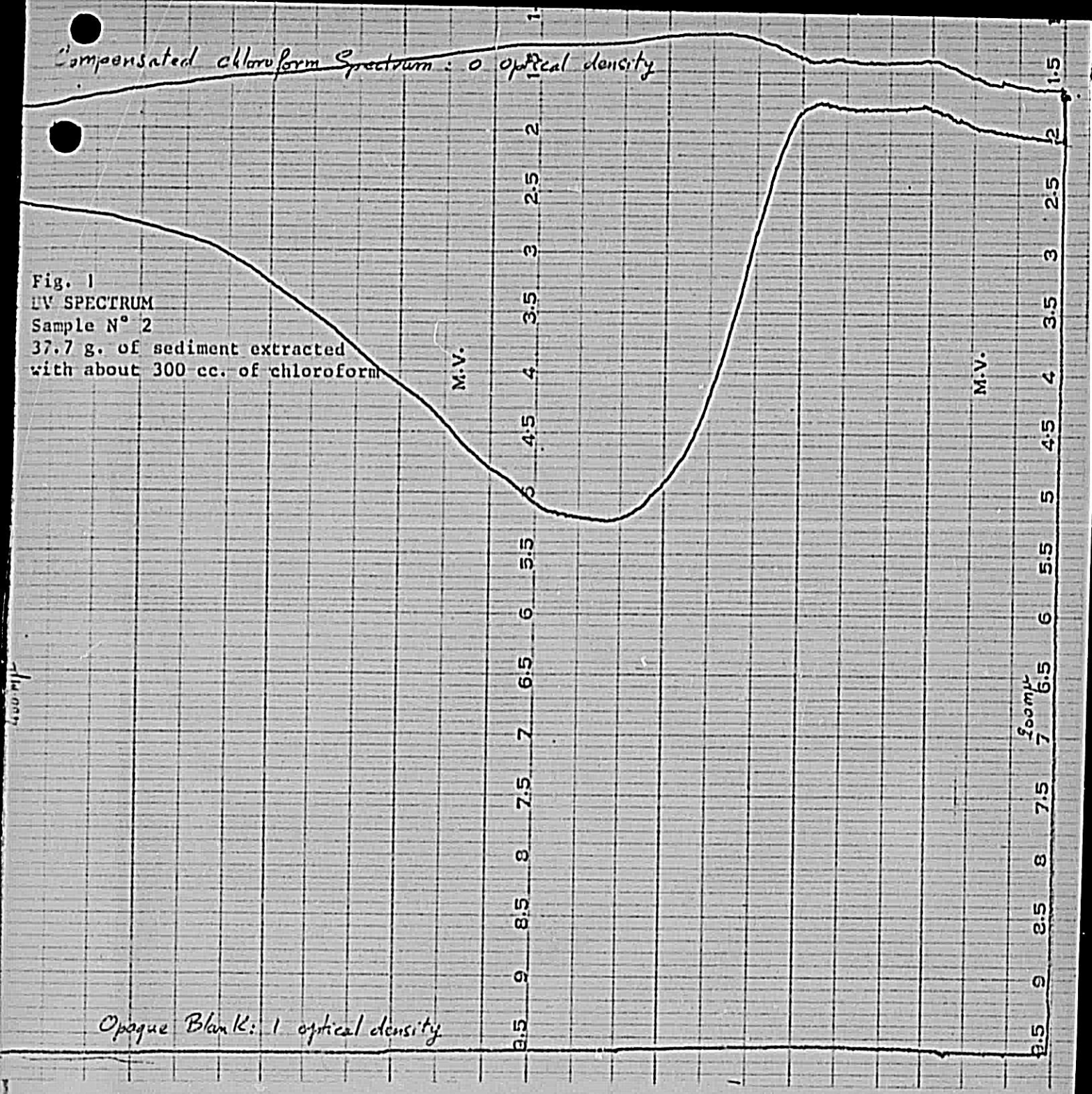


Fig. 1
UV SPECTRUM
Sample N° 2
37.7 g. of sediment extracted
with about 300 cc. of chloroform

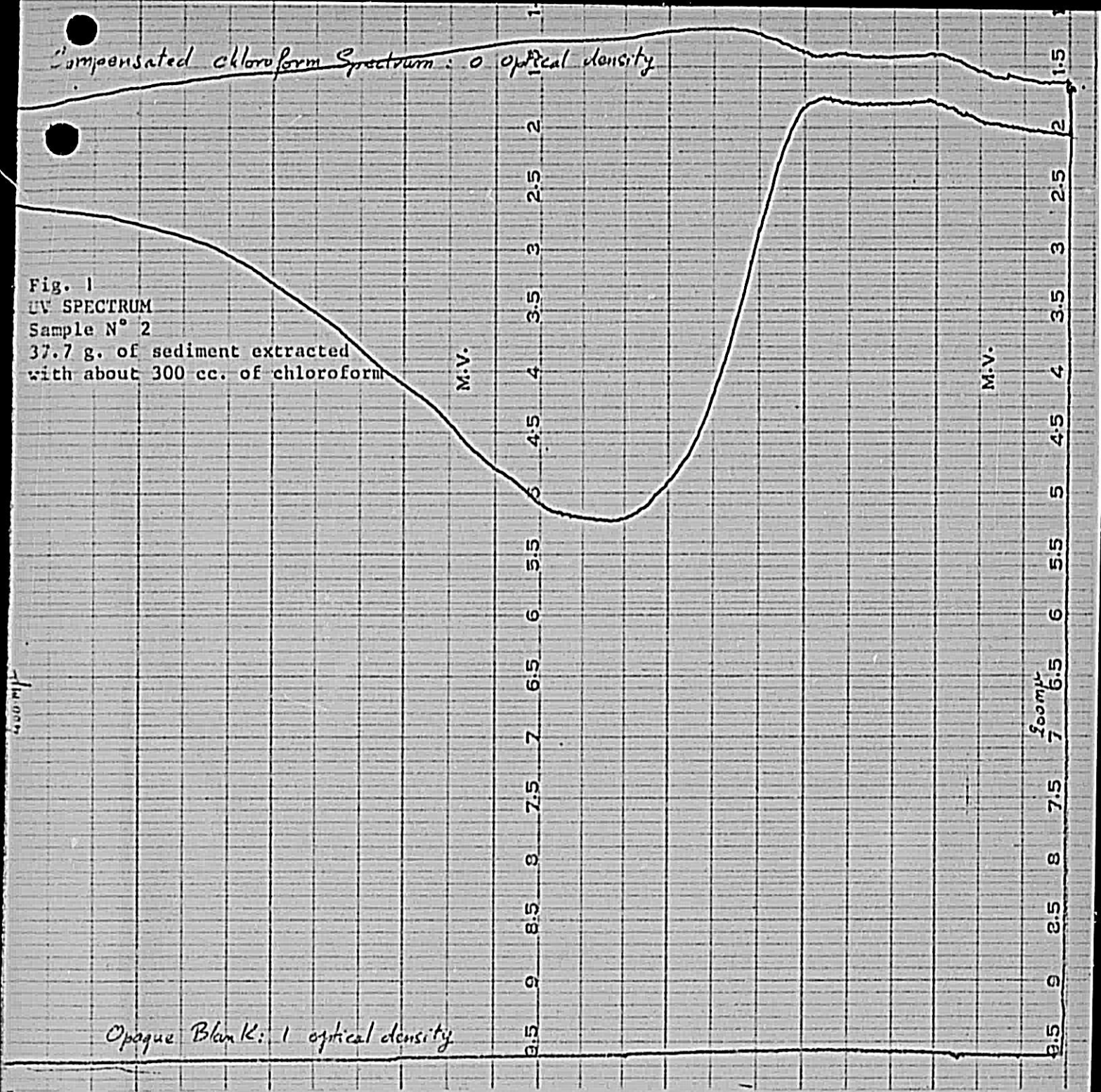


Fig. 1
UV SPECTRUM
Sample N° 2
37.7 g. of sediment extracted
with about 300 cc. of chloroform

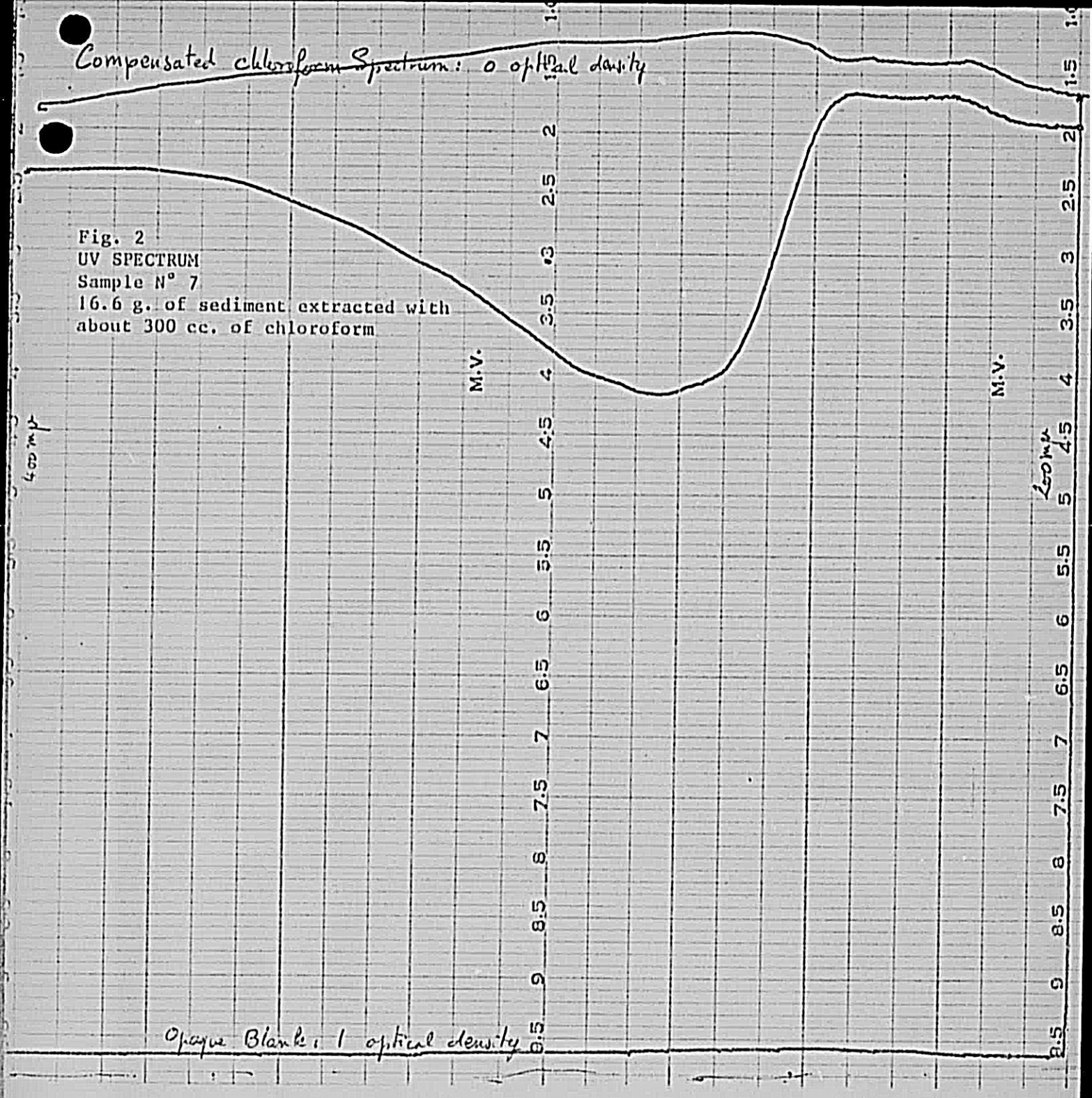
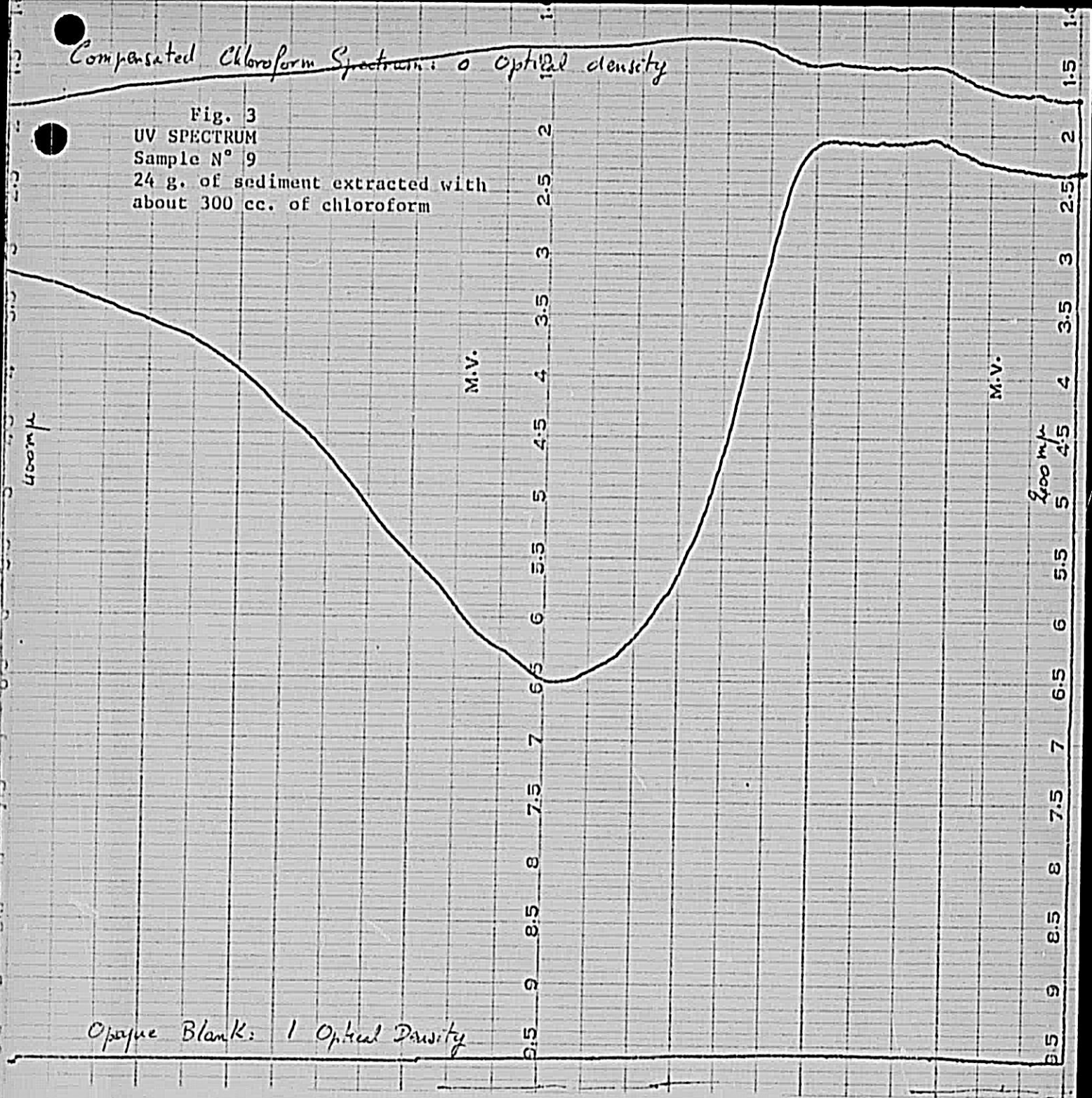


Fig. 2
UV SPECTRUM
Sample N° 7
16.6 g. of sediment extracted with
about 300 cc. of chloroform

Compensated Chloroform Spectrum: 0 Optical density

Fig. 3
UV SPECTRUM
Sample N° 9
24 g. of sediment extracted with
about 300 cc. of chloroform



Opaque Blank: 1 Optical Density

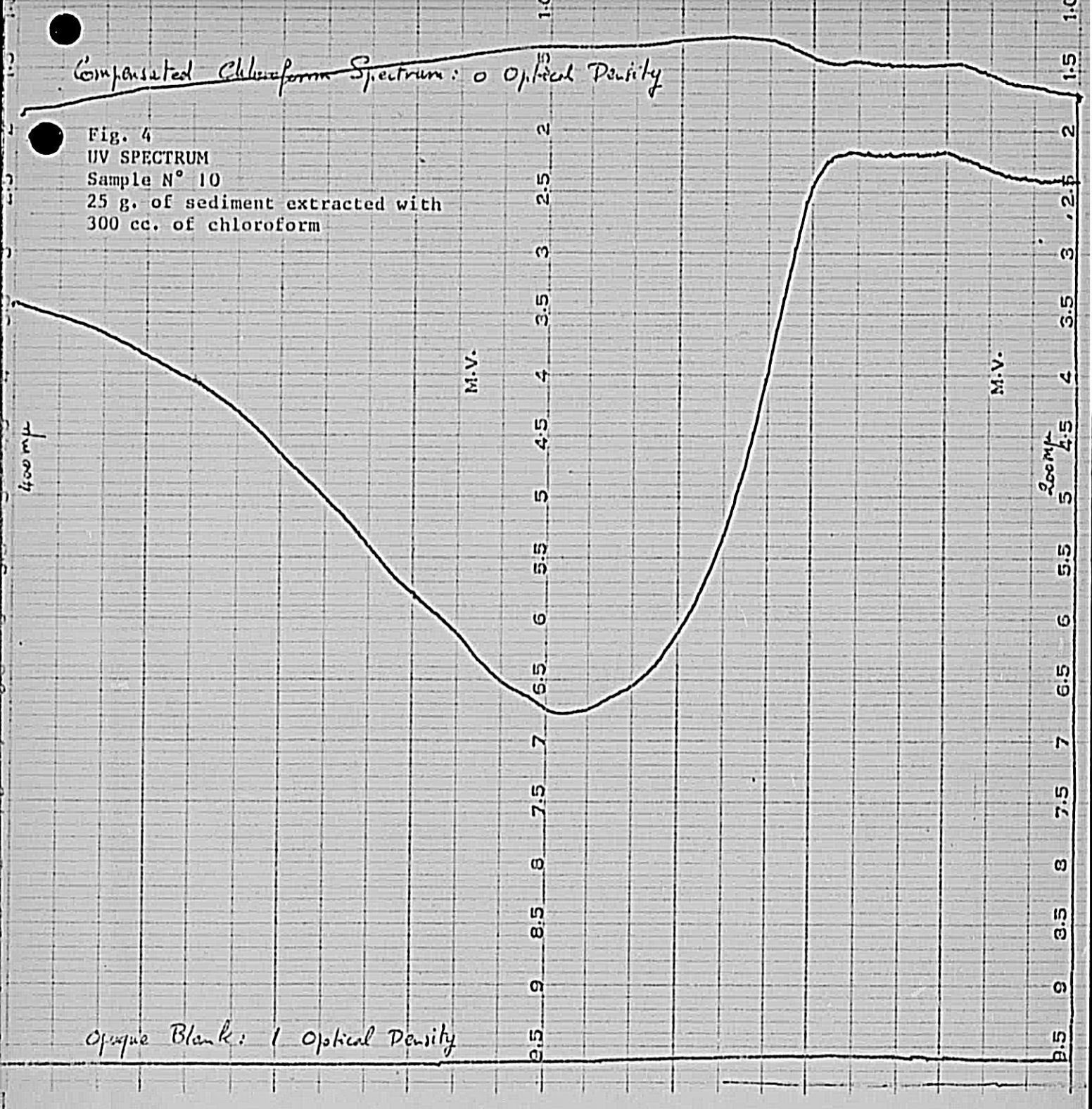


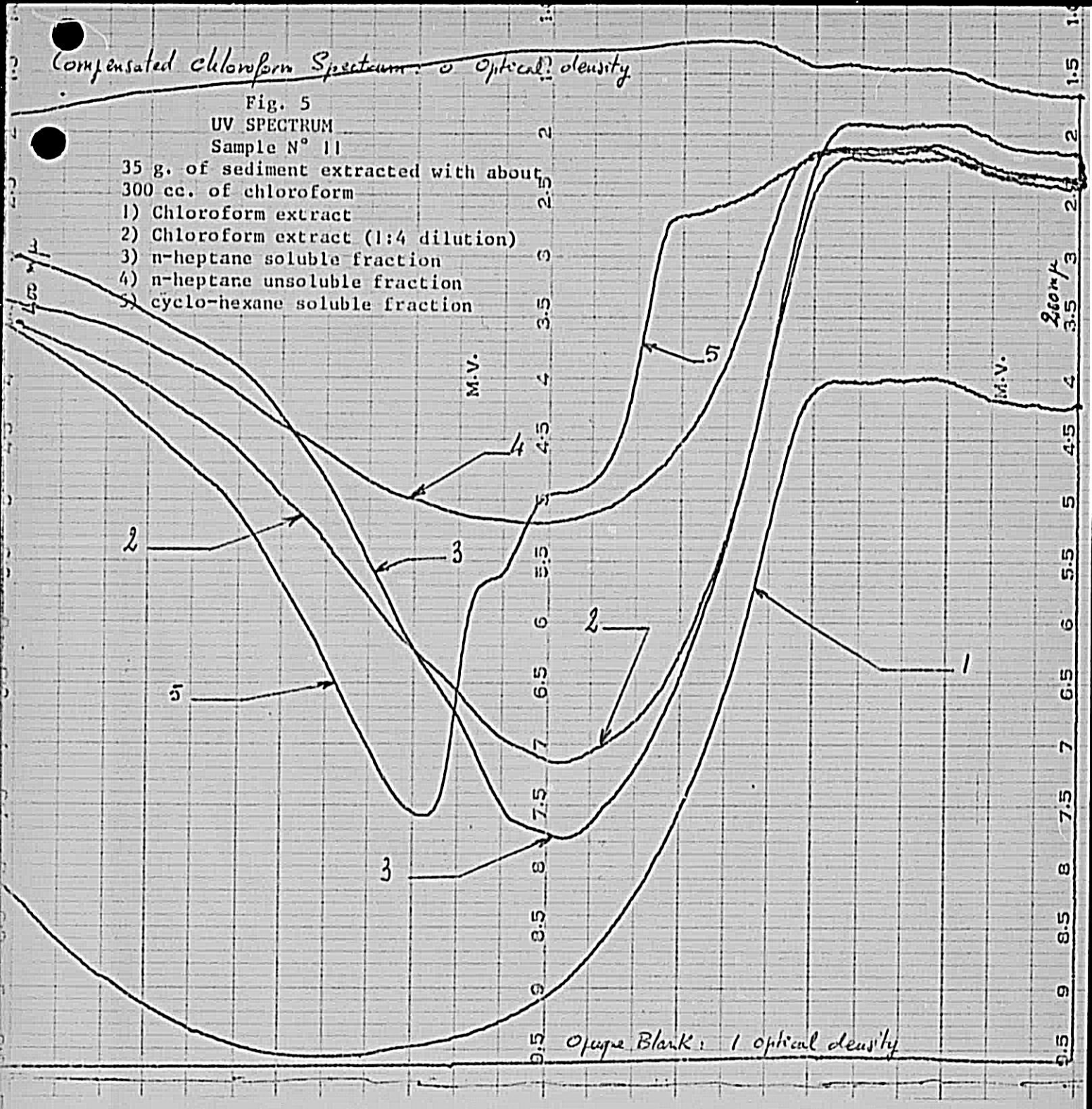
Fig. 4
UV SPECTRUM
Sample N° 10
25 g. of sediment extracted with
300 cc. of chloroform

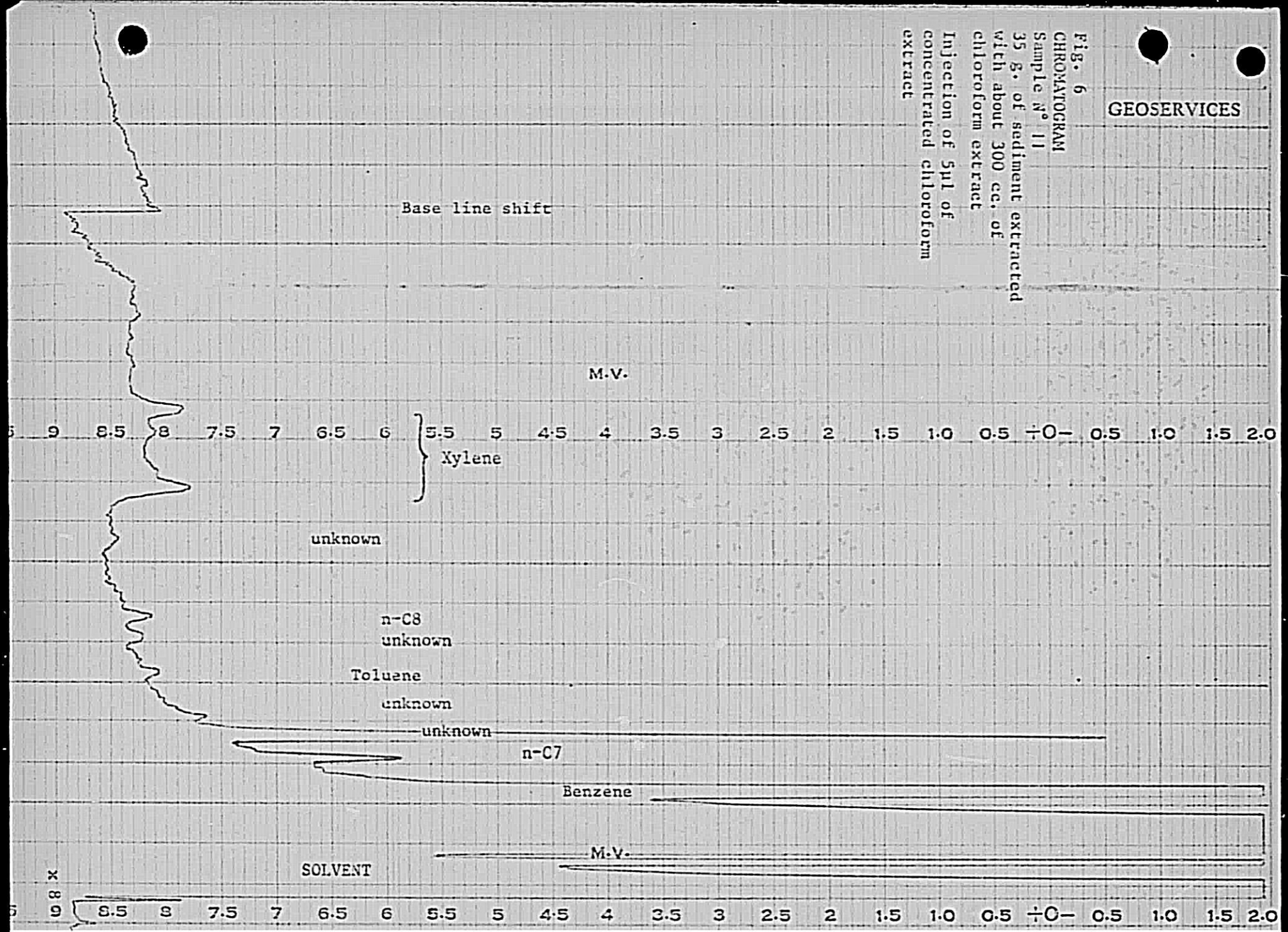
Compensated chloroform Spectrum: 0 Optical density

Fig. 5
UV SPECTRUM
Sample N° 11

35 g. of sediment extracted with about 300 cc. of chloroform

1) Chloroform extract
2) Chloroform extract (1:4 dilution)
3) n-heptane soluble fraction
4) n-heptane unsoluble fraction
5) cyclo-hexane soluble fraction




GEOSERVICES
Fig. 6
CHROMATOGRAM
Sample N° 11
35 g. of sediment extracted with about 300 cc. of chloroform extract
Injection of 5µl of concentrated chloroform extract
Base line shift
M.V.
9 8.5 8 7.5 7 6.5 6 5.5 5 4.5 4 3.5 3 2.5 2 1.5 1.0 0.5 +0- 0.5 1.0 1.5 2.0
Xylene
unknown
n-C8
unknown
Toluene
unknown
unknown
n-C7
Benzene
M.V.
SOLVENT
x 8
9 8.5 8 7.5 7 6.5 6 5.5 5 4.5 4 3.5 3 2.5 2 1.5 1.0 0.5 +0- 0.5 1.0 1.5 2.0

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WELL OUTCROPS
FIELD
LOCATION

FORMATION
DRILLING FLUID
ELEVATION
ANALYSIS SMALL PLUG
REMARKS

PAGE 1 of 1
FILE 913-1227
DATE REPORT SEPT. 1/71
ANALYSTS MH

SAMPLE NUMBER	INTERVAL REPRESENTED, FEET		HORIZ. PERM TO AIR, MILLIDARCYS	PERMEABILITY FEET	POROSITY, PER CENT	POROSITY FEET	RESIDUAL SATURATIONS, PER CENT PORE SPACE		VISUAL EXAMINATION
	DEPTH	THICK					OIL	TOTAL WATER	
A	Hudson Land Samples		1.12		11.8				I FEW PPV F
B	Vantage Pt. Area		0.29		15.6				I PPV
C	Cent Hilbery.		0.12		5.4				I

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ANALYSIS
REMARKS

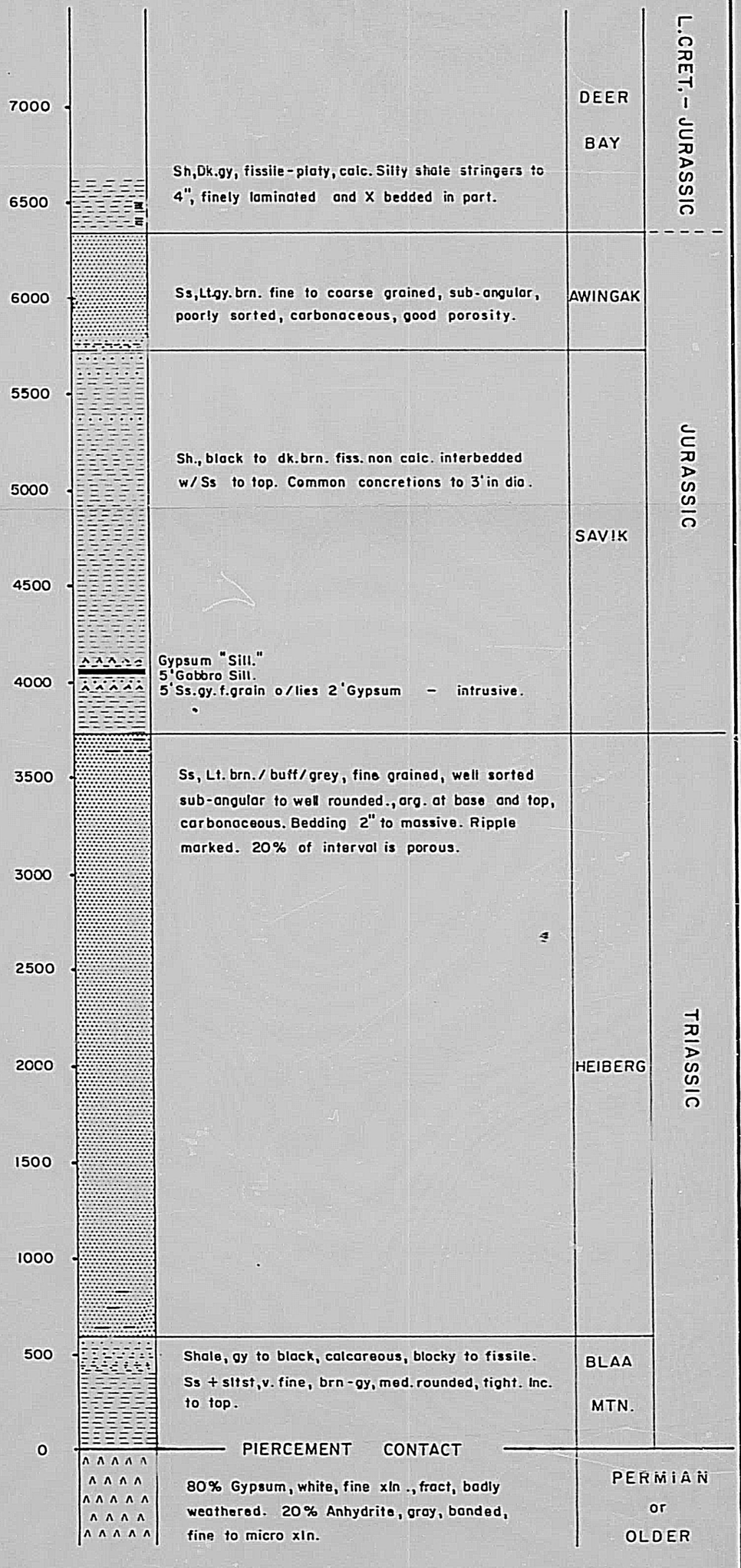
PAGE 1 of 1
FILE 913-1218
DATE REPORT DEC. 3/71
ANALYSTS MH

SAMPLE NUMBER	INTERVAL REPRESENTED, FEET		HORIZ. PERM TO AIR, MILLIDARCYS	PERMEABILITY FEET	POROSITY, PER CENT	POROSITY FEET	RESIDUAL SATURATIONS, PER CENT PORE SPACE		VISUAL EXAMINATION
	DEPTH	THICK					OIL	TOTAL WATER	
4			5.22		15.2				FS
5			0.12		7.9				FS
6			13.20		12.8				FS

Form B2

COLUMNAR SECTION

VANTAGE POINT WEST GYPSUM - DIAPIR AREA



Compiled by: R.G. Metherell

MAP Nº: 1611/2

-9 AUG 1971

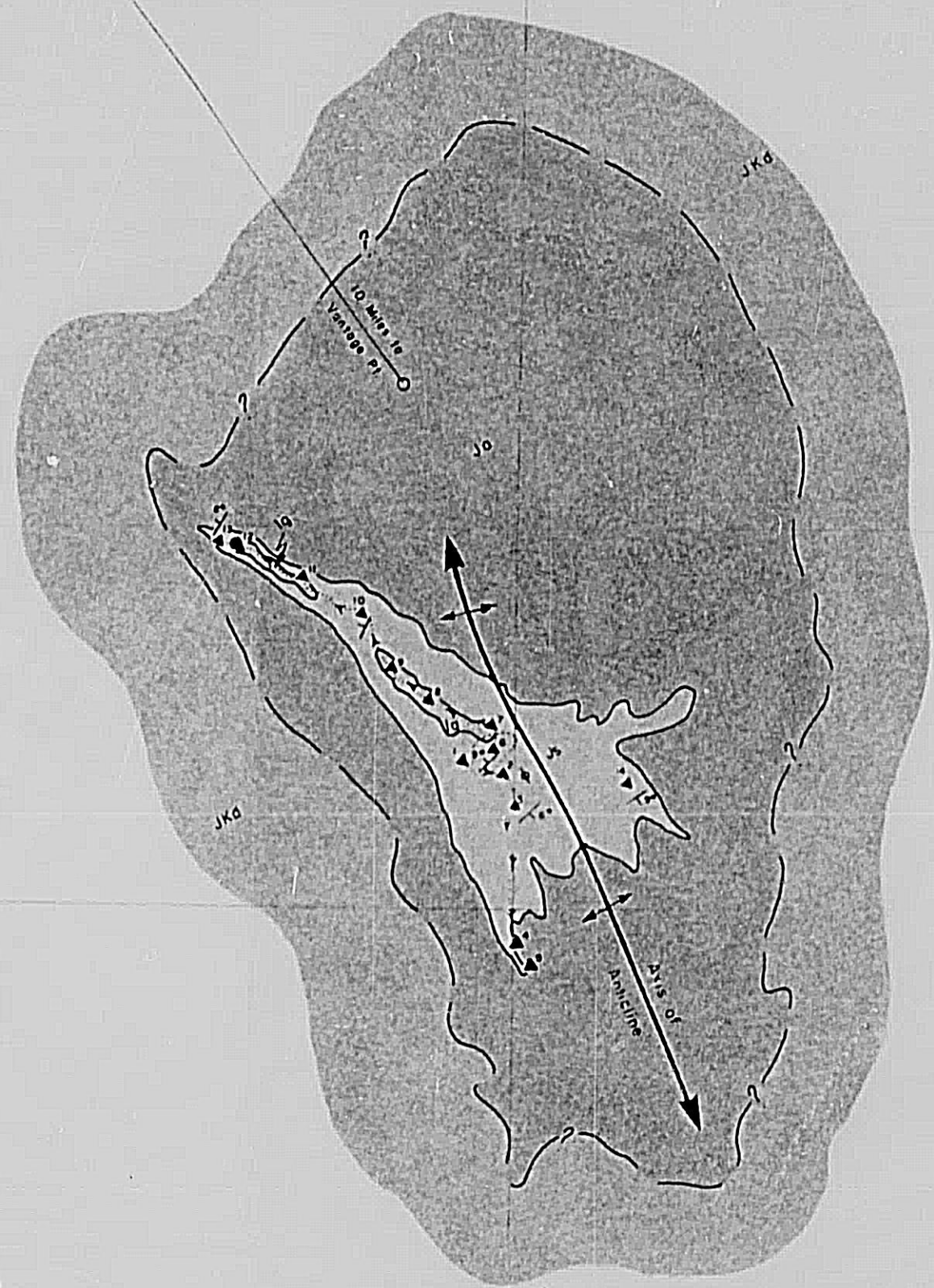
93°30'

93°15'

93°00'

92°45'

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OIL & GAS OPERATIONS UNIT
Oil and Mineral Division
JUN 19 1972
Ottawa, Canada

PETROGRAPHIC REPORT

3 SANDSTONE SPECIMENS

4, 5, 6 OH

25-7-10-23

Abstracted for
Geo-Science Data Index
Date

Prepared for

Canadian Superior Oil Ltd.

Calgary

By

George A. Wilson Geological Consultants Ltd.

Calgary

INTRODUCTION

This petrographic report is the result of petrographic examination of the sandstone specimens labelled 4, 5, 6. It was made at the request of Canadian Superior Oil Ltd. who provided the specimens.

Colours are defined according to the rock colour chart published by the Geological Society of America.

Proportions of constituents including porosity are based on visual estimate only. This method is much less reliable than point counting.

CONCLUSION

The three sandstones are very similar in that all are well sorted, all have a significant proportion of clay mineral, and all have zircon and tourmaline as accessory minerals.

There are also some recognizable differences between the three specimens. Specimen 4 (Figs. 1, 2, 3, 4) is or was entirely angular and specimens 5 (Figs. 5, 6, 7, 8) and 6 (Figs. 9, 10, 11, 12) were subangular to subround. Original shape in all cases is obscured by post depositional packing which resulted in solution of silica at points of contact with simultaneous deposition at other places. Nevertheless original shape is discernible.

Specimen 4 (Figs. 3, 4) had a significant amount of feldspar, mostly microcline, a mineral unnoticed in specimens 5 and 6. Specimen 4 also has, or had, a higher proportion of mafic minerals.

They differ even in the size and proportion of accessory minerals, zircon and tourmaline. They tend to be less round in specimen 4. There is a greater abundance of zircon and tourmaline in 5. Accessory minerals are larger in 6. Apatite was found in 4 but was not found, although it may exist in them in very small amounts, in 5 and 6.

Porosity ranges from an estimated 5% in specimen 4 to 3% in specimen 5 and 7% in specimen 6. Porosity has been reduced by compaction and pressure solution at points of contact (Figs. 5, 6). It may also have been reduced by redeposition of the products of weathering. Surface weathering may also have created some porosity by removal of mafic material.

The lack of roundness, the mafic mineral fragments, and the feldspar all seem to indicate that the constituents are reasonably

close to their place of origin. The quartz could be second generation although some of it should be more rounded than it is to be of second generation. The lack of deformed quartz except in specimen 6 is not consistent with its being derived from gneissic terrains. Mafic minerals do not survive long. All of them have good cleavage and all are broken down fairly easily by atmospheric agents.

It is strongly suggested therefore that unless several areas contributed material it is first generation and has not been moved far.

SPECIMEN DESCRIPTIONS

Specimen: Canadian Superior #4
Location: Not specified.

MACROSCOPIC EXAMINATION:

Weathered Surface:
Colour: weathered surface is composed of 2 layers. The outer layer is medium light grey (N6) flecked with light grey (N7). The inner layer is moderate yellowish brown (10YR 5/4).
The inner layer is exposed where the outer friable layer has been rubbed off.

Fresh Surface:
Colour: 70% light grey (N7) with 30% flecks of moderate brown (5YR 4/4).
Texture: grain is fine, and homogeneous lamination is absent.
Minerals: quartz, muscovite, mica, and mafic mineral.

MICROSCOPIC EXAMINATION:

Composition:
Quartz 65%; feldspar, orthoclase and plagioclase 5%; mafic minerals 20%; porosity 5%; cement 5%.
Approximately 70% of the grains are between 0.14 and 0.2 mm across (fine sand). An estimated 10% are between 0.10 and 0.14 mm (very fine sand to fine sand). An estimated 20% of the grains are between 0.2 and 0.3 mm (fine sand to medium sand).

Quartz: almost entirely monomineral although a few grains appear to have been derived from chert or very fine quartz siltstone. Extinction is generally sharp without evidence of strain. It is all angular. Boundaries range from straight to arcuate. In some cases there is evidence that grains penetrated one another in ways that must be due to solution at points of mutual contact. Enlargement of grains at points without pressure is present but minor.

Feldspar: mostly orthoclase adularia but microcline and plagioclase are also present. Feldspar is clear with limited alteration to kaolinite. Some grains (e.g., microcline near N.E. corner) have been crushed somewhat during post deposition compaction.

Mafic Minerals: The identity of the mafic minerals deposited as original sediments is hidden by post depositional alteration. All are converted to masses of kaolinite and very fine quartz, stained greyish orange (10YR 7/4) to moderate reddish brown (10R 4/6) by iron oxides. In a few places the shape of the altered material is that of mica.

Accessory Minerals:
Zircon: trace, .05 x .025 mm, clear, rounded.
Tourmaline: trace .03 x .01 mm subhedral, pleochroic, O = greyish green (5G 5/2), E = light greenish grey (5G 8/1).
Apatite: trace, 0.03 mm, hexagonal, subhedral.

Cement:
Quartz deposited in optic continuity with some grains and probably made available through solution at points of contact is a minor constituent.
There is fairly abundant very fine mosaic quartz deposited generally with iron oxides in zones which were probably interstitial to original quartz. This material may have been made available during alteration of the mafic minerals.
Most grain boundaries are marked by a thin film of iron oxides. This material probably originated during alteration of mafic minerals.

Porosity: 5%. The pores have the same size and shape as the grains comprising the rock. Permeability would be poor.

Comment (Figs. 1, 2, 3, 4)
This rock is composed of angular mineral fragments, dominantly quartz. Compaction has resulted in slight increase in angularity together with minor fracturing of minerals with cleavage. The few grains found with clear silica cement deposited in optic continuity with the clast were originally angular.
Cementation appears to have taken place in two stages. The first during compaction and the later during alteration of mafic minerals. This made available for deposition in pores silica, iron oxides and kaolinite. The silica was deposited as mosaic quartz with kaolinite and iron oxides. Much of the kaolinite and silica occur as masses in the position of the altered grain.
The processes by which the mafic minerals were altered are probably surface weathering. In any case it is clear that surface weathering has created iron oxides (see macroscopic description).

Deposition seems to have involved sedimentation of angular quartz, feldspar and mafic minerals in a zone sufficiently agitated to

permit removal of clay and fine silt size particles and to assist in packing of the grains. Deposition has taken place sufficiently close to the source of the material that the quartz is not rounded and the feldspars not altered.

---------- (George A. Wilson Geological Consultants Ltd.)

Specimen: Canadian Superior 5
Location: Not specified.

MACROSCOPIC EXAMINATION:

Weathered Surface:
Colour: very pale orange (10YR 8/2) with extensive growth of black lichen. Some partly weathered surfaces are moderate reddish brown (10R 4/6). This deposit of iron oxides is thin. A similarly coloured zone less than 1 mm thick occurs beneath the pale orange outer surface on parts of the specimen.

Fresh Surface:
Colour: pale pinkish grey (5YR 9/1) with lenticular continuous to zig zag broken black laminae to 0.25 mm thick.
Texture: homogeneous, very fine grained with traces of bedding laminae near one surface. The bedding laminae are very thin, black, argillaceous, carbonaceous material. Adjacent to some of them there is a suggestion of fine ripple marks on a partly weathered surface. The zig zag broken lines are formed of blebs of black carbonaceous, argillaceous material similar to the bedding laminae
Minerals: quartz 70%; mafic material 20%; argillaceous material 5%; porosity 5%.

MICROSCOPIC EXAMINATION:

Composition:
Quartz 75%; mafic minerals 12%; accessory minerals 1%; matrix 9%; porosity 3%. It is estimated that 80% of the grains are 0.15 to 0.2 mm in diameter (fine sand), 10% are 0.6 to 0.15 mm in diameter (very fine to fine sand), and 10% are from 0.2 mm to 0.35 mm in diameter (fine sand to medium sand).

Quartz; almost entirely monomineral but some grains composed of microscopic silica and a few grains contain twinned quartz. Approximately 20% of the quartz has undulose extinction indicating strain. Approximately 80% of the quartz is subangular, 10% is angular and 10% is subrounded.
Boundaries are straight to arcuate. Solution at contact points is more extensive than in specimen 4 as is deposition of quartz in optic continuity with grains.

Mafic Minerals: Size is similar to the size of quartz. All have been oxidized and altered to masses of kaolinite, fine mosaic quartz and iron oxide. Muscovite mica comprised a significant proportion of dark minerals. A few flakes of it remain. All are crushed and bent during compaction.

Accessory Minerals:
Zircon, 0.015 mm in diameter, equant, to 0.09 x 0.18 oblong. Most are rounded but at least one is euhedral and obviously tetragonal. Colour ranges from colourless through pale brown to greyish pink (5R 8/2). Some zircon has prismatic inclusions.
Tourmaline: 0.07 to 0.12 mm, generally equant angular. Pleochroic O = greyish yellow green (5GY 7/2), E = greyish olive (10Y 4/2). Some of the tourmaline grains have a more blue colour.

Matrix: Consists of clay sized clasts of clay mineral and quartz, all stained light brown (5YR 6/6), e.g., iron oxides. Matrix occurs as film occupying interstices between grains and as streaks and lenticles (not all parallel) as wide as 1/2 mm and as long as 5 mm.

Porosity: 3%, 0.15 to 0.3 mm, shaped similarly to grains and at least some of them are due to removal or decomposition of grains.

Comment (Figs. 5, 6, 7, 8)
This rock is composed of subangular mineral fragments in which quartz is dominant with a clay matrix. It was well packed. During diagenesis or post diagenesis metamorphism solution has taken place at points where grains were in contact. Silica deposition has taken place as grain enlargement to a noticeable but minor extent.
Cementation as in specimens 4 and 6 seems to have been a two stage process. One took place due to pressure and was dominantly a transfer of silica from points of contact to points not in contact. The second results from deposition of iron oxides along grain boundaries and in spaces. It may be due to meteoric waters.
Deposition involved sedimentation of subangular to subrounded mineral grains in an environment sufficiently agitated to eliminate most of the clay sized material and to result in close packing.
---------- (George A. Wilson Geological Consultants Ltd.)

Specimen: Canadian Superior #6.
Location: Not specified.

MACROSCOPIC EXAMINATION:

Weathered Surface:
Colour: light grey (N7) with patches of greyish orange (10YR 7/4) within which there are small patches and flecks of moderate reddish brown (10R 4/6). These colours represent various layers in the weathered part of the rock. The outer layer, light grey in colour, grades to reddish brown through greyish orange.
Texture: homogeneous.

Fresh Surface:

Colour: light olive grey (5Y 6/1), near center of specimen. It may simply be the least weathered part of the rock. The sawn surface shows that the light olive grey grades out to reddish brown through a yellowish grey (5Y 8/1) zone 3 to 4 mm wide. The reddish brown zone then grades to light grey through greyish orange over a thickness of 1 mm.

Texture: The rock is homogeneous, fine grained without evidence of sedimentary structures in hand specimens.

MICROSCOPIC EXAMINATION:

Composition: Quartz 85%; mafic minerals 8%; accessory minerals, trace; porosity 7%. Approximately 70% of the grains are between 0.18 and 0.25 mm (fine sand), 20% of the grains are between 0.1 and 0.18 mm (very fine sand), and 10% are between 0.25 mm and 0.30 mm (fine to medium sand).

Quartz: almost entirely monomineral. Some multiple grains occur. Most of the quartz has sharp extinction but 10% has undulose strain extinction and some is clearly derived from quartzose gneisses in which the quartz has been considerably strained.

Most of the quartz is subround to subangular, a small proportion was angular, and a small proportion was rounded. The degree of rounding is obscured by solution of quartz at points of contact with simultaneous deposition in pores. Grain enlargement is recognizable but is not extensive.

Mafic Minerals: Mafic minerals except for a few flakes of muscovite have been converted to masses of micrograined quartz and kaolinite stained dark yellowish orange (10YR 6/6) to moderate brown (5YR 4/4) by iron oxides. The iron oxides have also been deposited along most grain boundaries.

Recognizable phlogopite mica flakes have been deformed during compaction or dynamic metamorphism. Alteration of them to clay minerals is extensive.

Accessory Minerals:

Zircon occurs in traces as rounded to subrounded grains as large as 0.12 mm in diameter.

Tourmaline of similar size has the following pleochroism: O = greyish olive; E = moderate greenish yellow. The tourmaline is rounded to well rounded.

Matrix: Traces of matrix as clay mineral occur between some quartz grains. It is not clear whether this material is original clay mineral matrix or whether it was transported and redeposited during surface weathering.

Comment: Minor quartz deposition in optic continuity with grains of quartz probably contemporaneous with pressure solution. A much later cement in the form of iron oxides also occurs between nearly all grains.

Comment (Figs. 9, 10, 11, 12):
This rock is composed of subangular to subrounded quartz with minor mafic minerals. It appears to have been deposited in conditions with sufficient agitation to remove clay material and to facilitate initial packing.
Pressure due to loading or deformation has resulted in closer packing and reduction of porosity.
The conversion of mafic constituents seems to be the result of surface weathering and is probably recent.
Porosity is fair, permeability is probably poor. At least some porosity is due to removal of original grains.

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Legend: All Figures

Porosity	Po
Pressure Solution	P
Overgrowth	O
Mosaic Quartz	M
Feldspar	F
Microcline	Mi
Tourmaline	T
Zircon	Z

On all figures very dark grey to black represents mafic constituents altered to clay mineral and quartz.

Dark film surrounding grains is iron oxides probably deposited during weathering of mafic constituents.

Porosity is represented by finely stippled areas in plane polarized light and opaque areas with crossed polarizers.

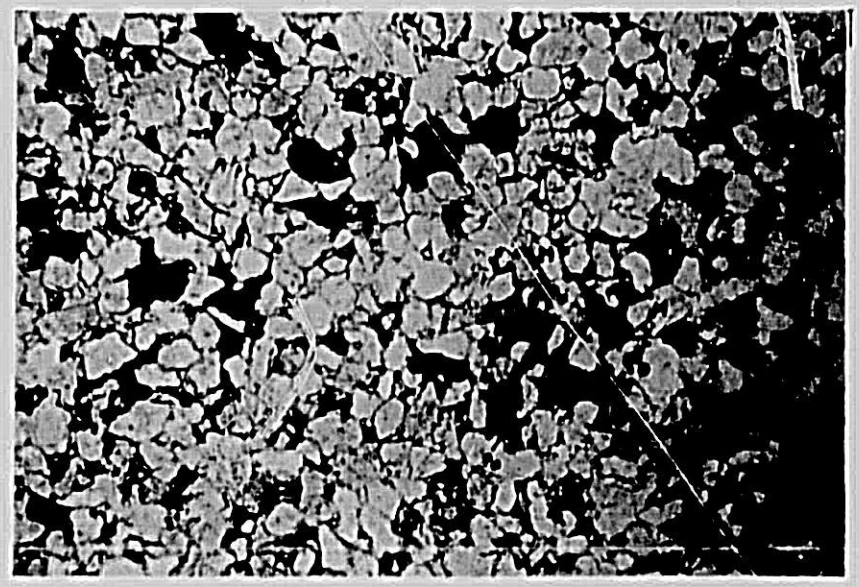


Figure 1. Specimen 4. Original angularity has been accentuated by solution of grains at points of contact accompanied by deposition of quartz elsewhere. Plane polarized light X 30

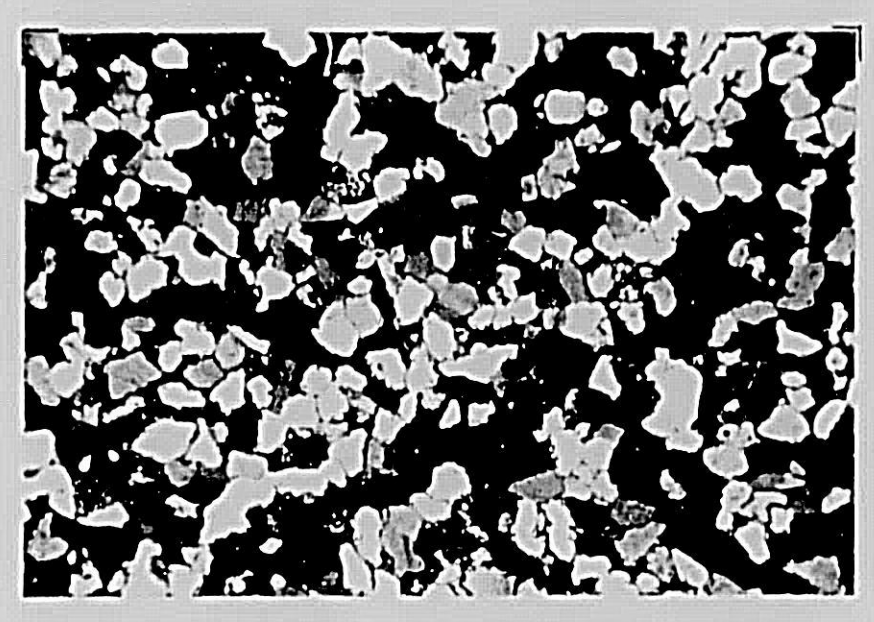


Figure 2. Specimen 4. As a bove with crossed polarizers.

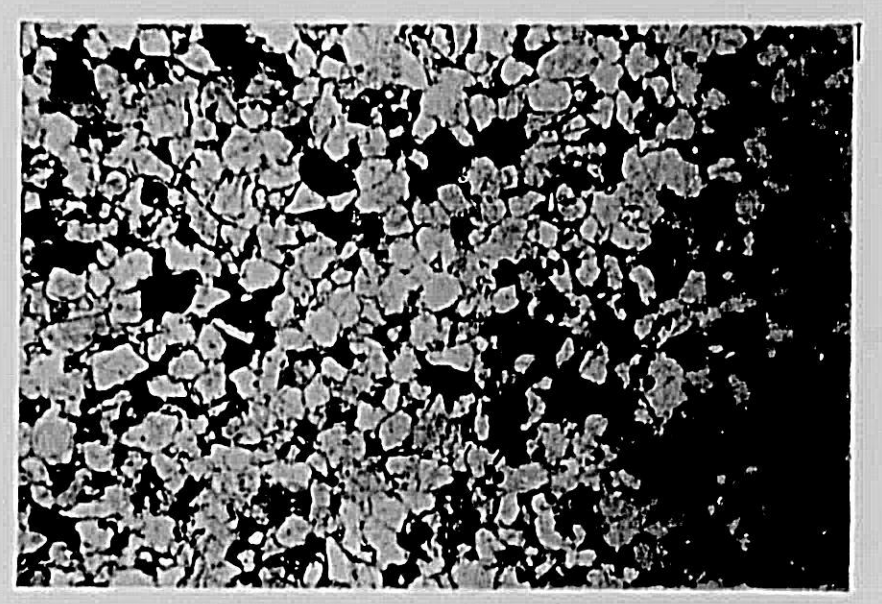


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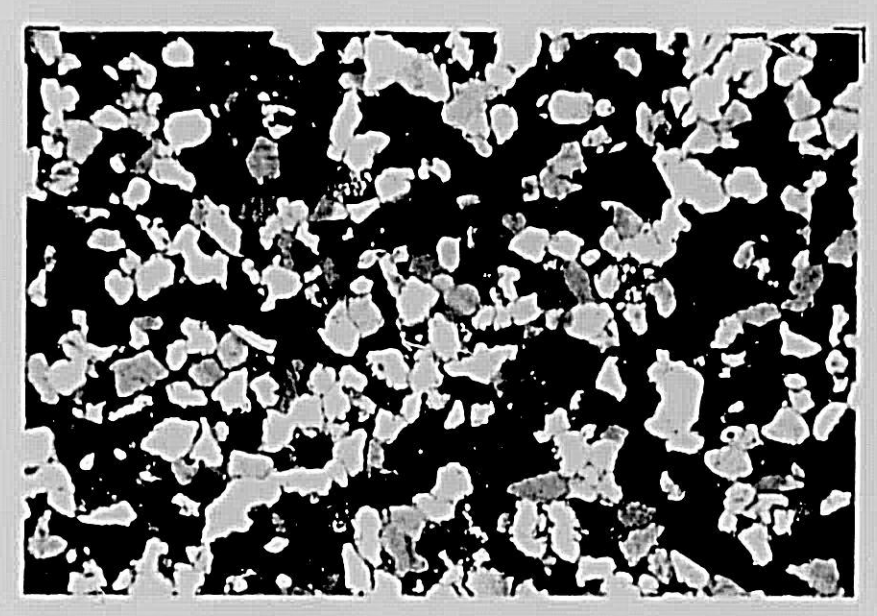


Figure 2. Specimen 4. As a bove with crossed polarizers.

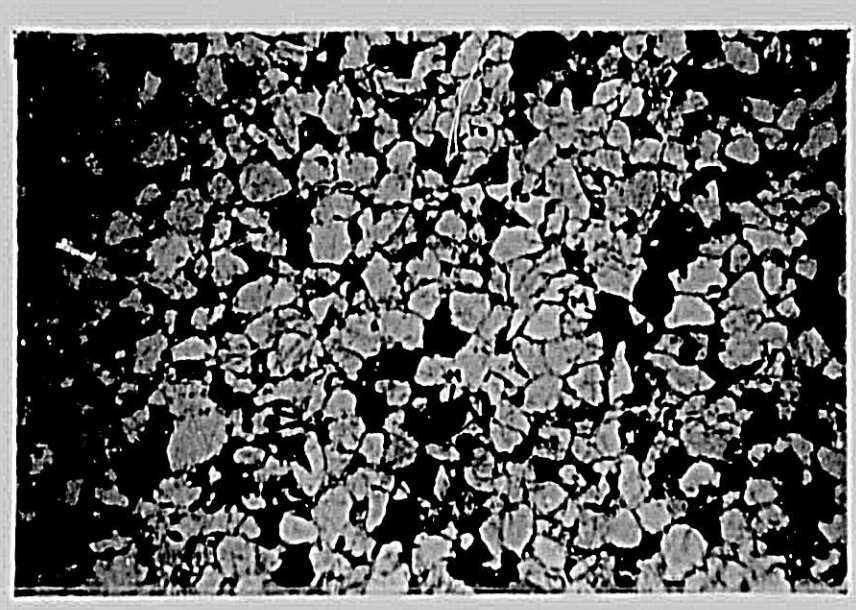


Figure 3. Specimen 4. Similar features as Figure 1 but with microcline. Note angular wedge shaped in center. Surrounded by opaque iron stained matrix. Plane polarized light X30.

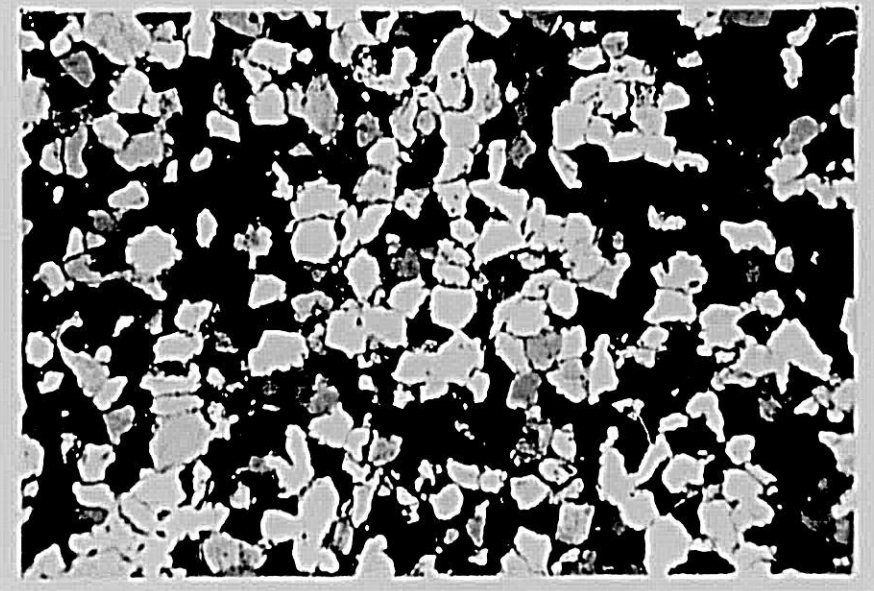


Figure 4. Specimen 4. As above with crossed polarizers.

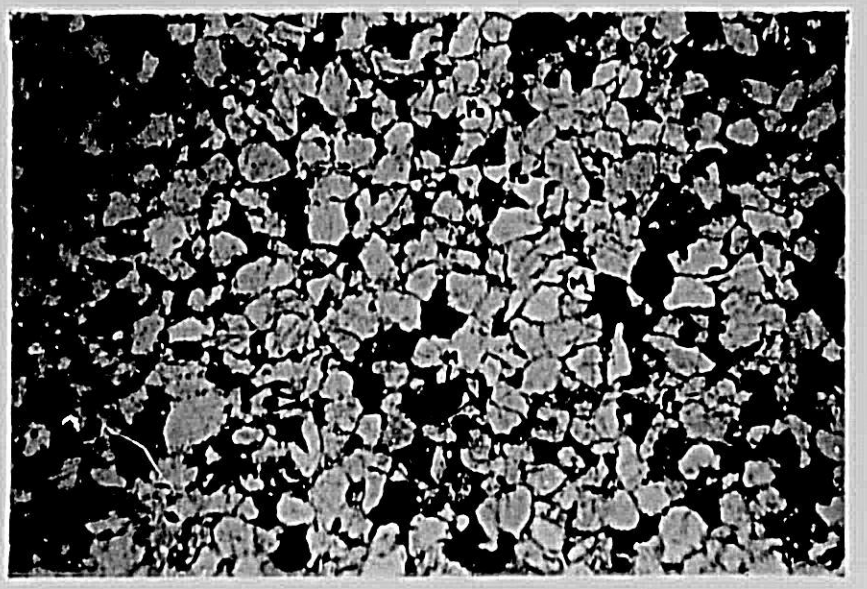


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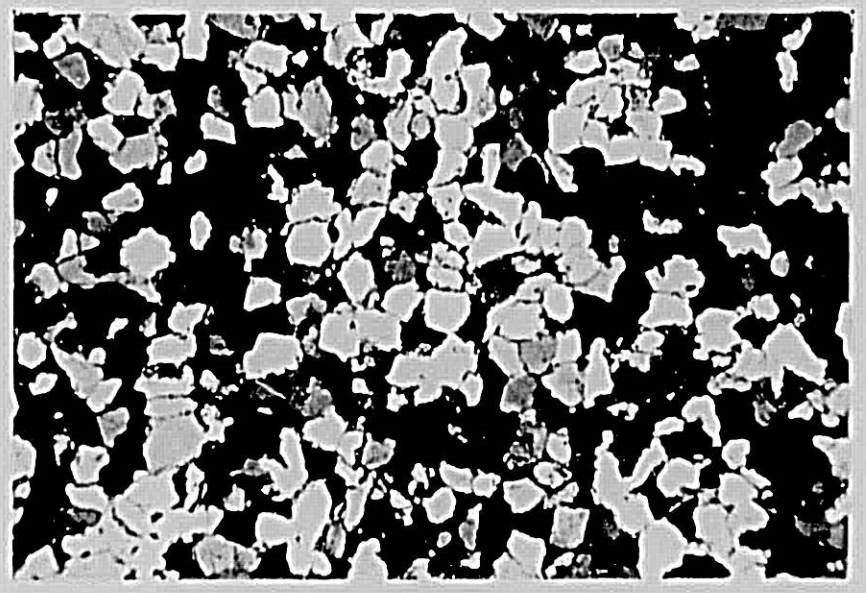


Figure 4. Specimen 4. As above with crossed polarizers.

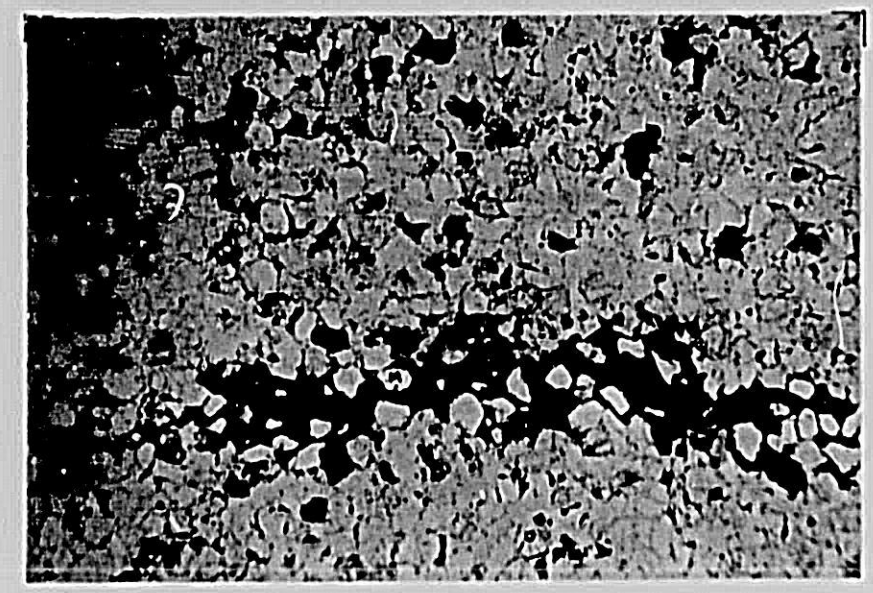


Figure 5. Specimen 5. Subangular quartz made more angular by grain contact solution effects. Note subangular to subrounded clasts in iron stained matrix. Plane polarized light X30.

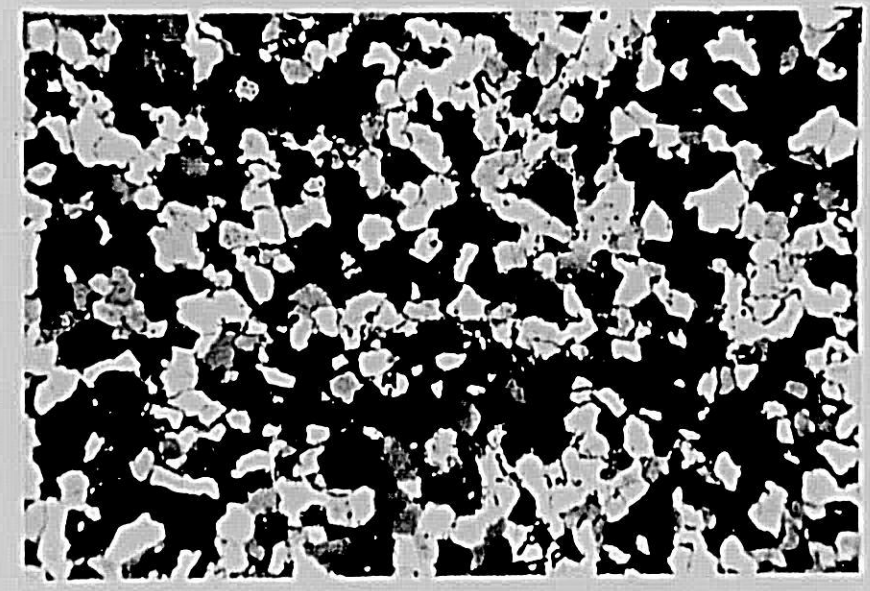


Figure 6. Specimen 5. As above. Crossed polarizers X30

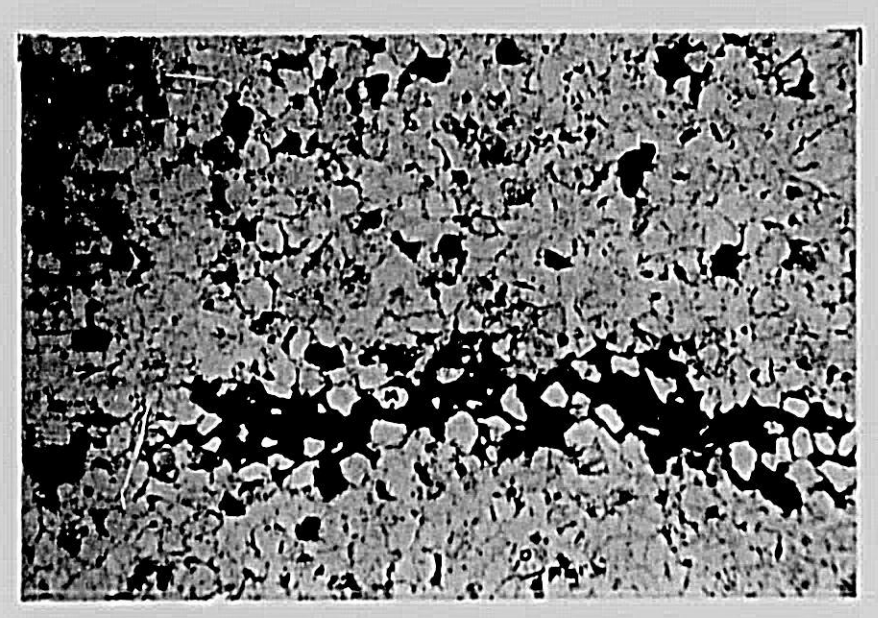


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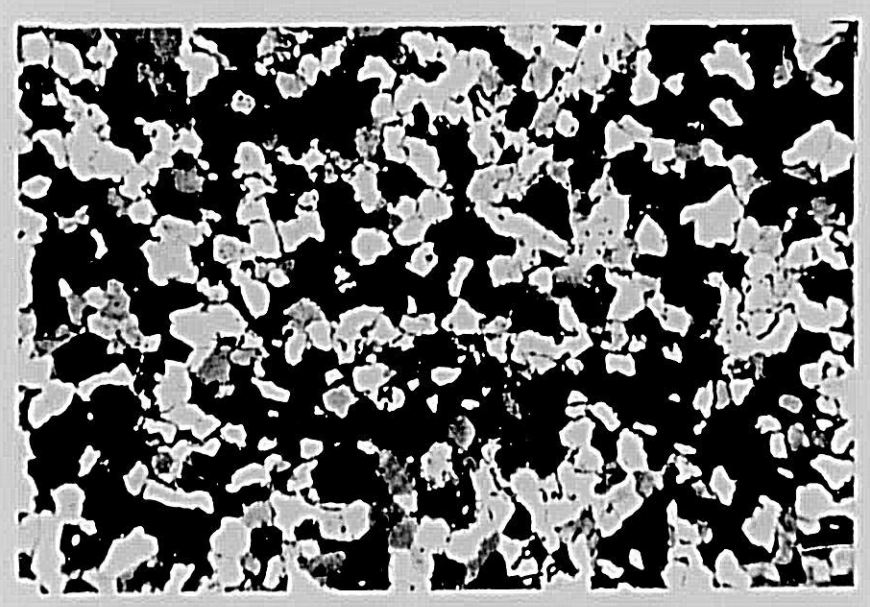


Figure 6. Specimen 5. As above. Crossed polarizers X30

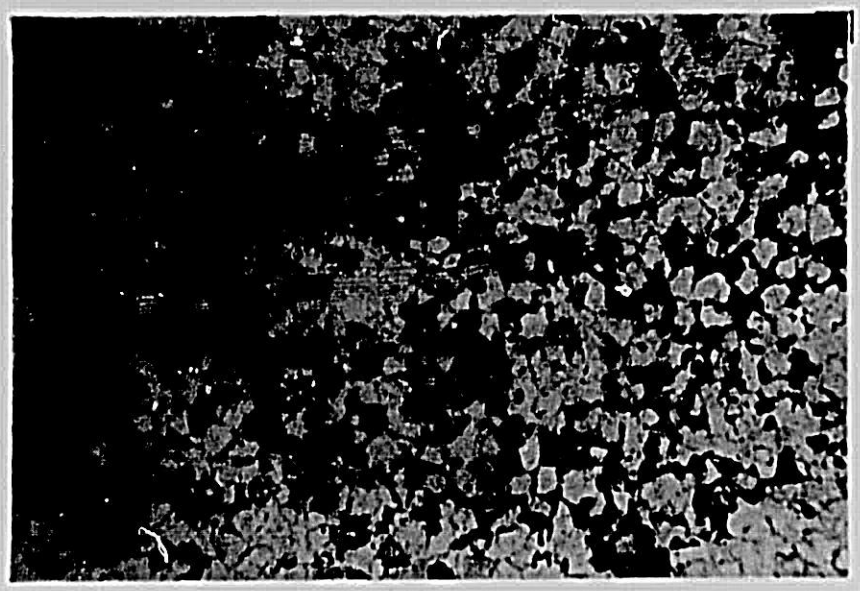


Figure 7. Specimen 5. Subangular clasts with grain contact solution. Matrix is stained with iron oxides. Plane polarized light X30

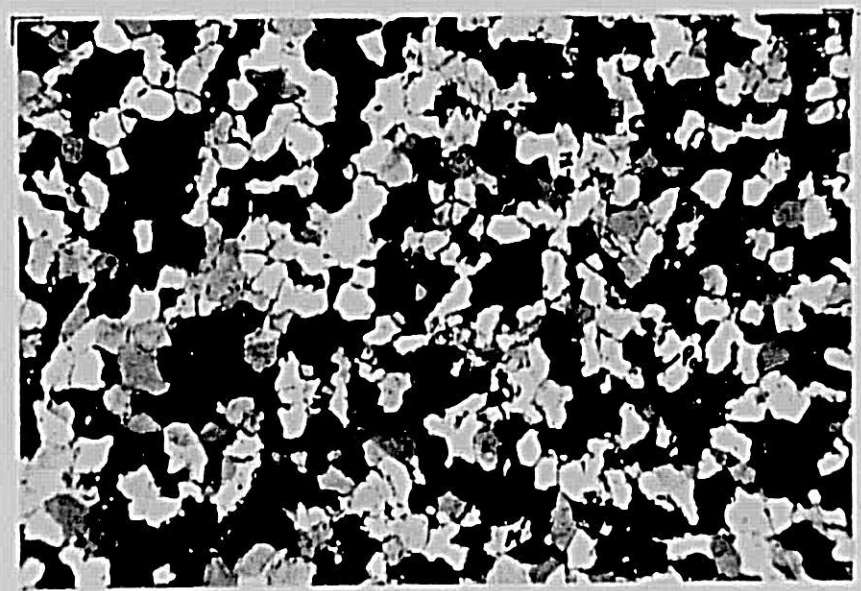


Figure 8. Specimen 5. As above. Crossed polarizers X30

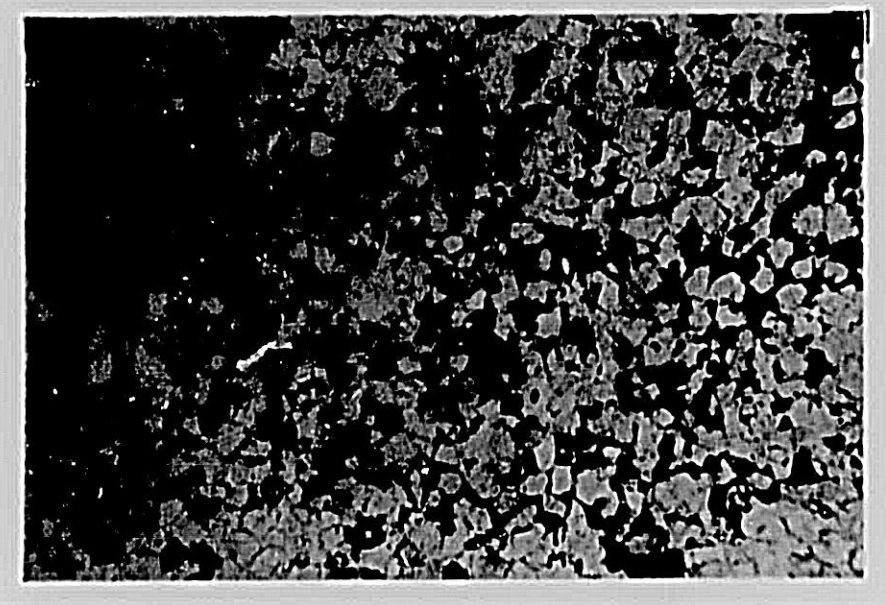


Figure 7. Specimen 5. Subangular clasts with grain contact solution. Matrix is stained with iron oxides. Plane polarized light X30

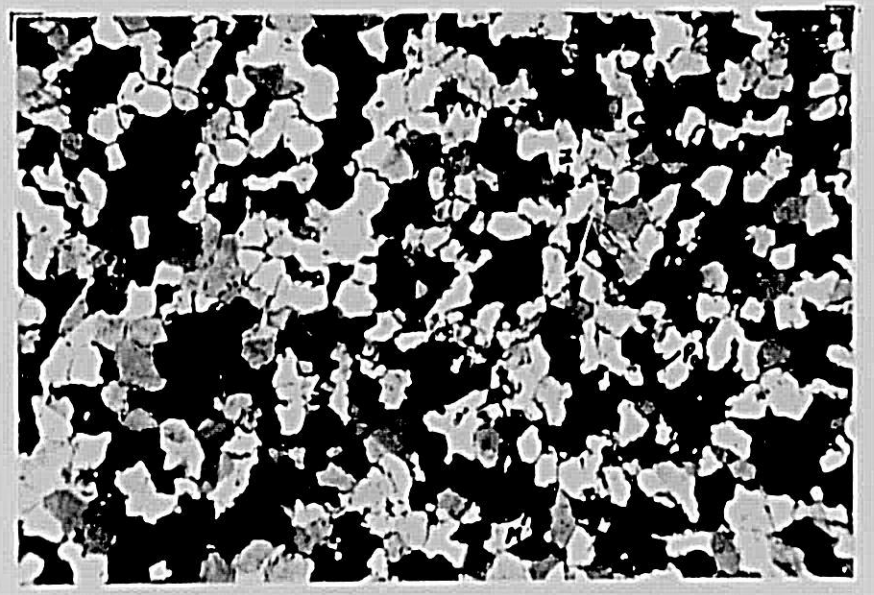


Figure 8. Specimen 5. As above. Crossed polarizers X30

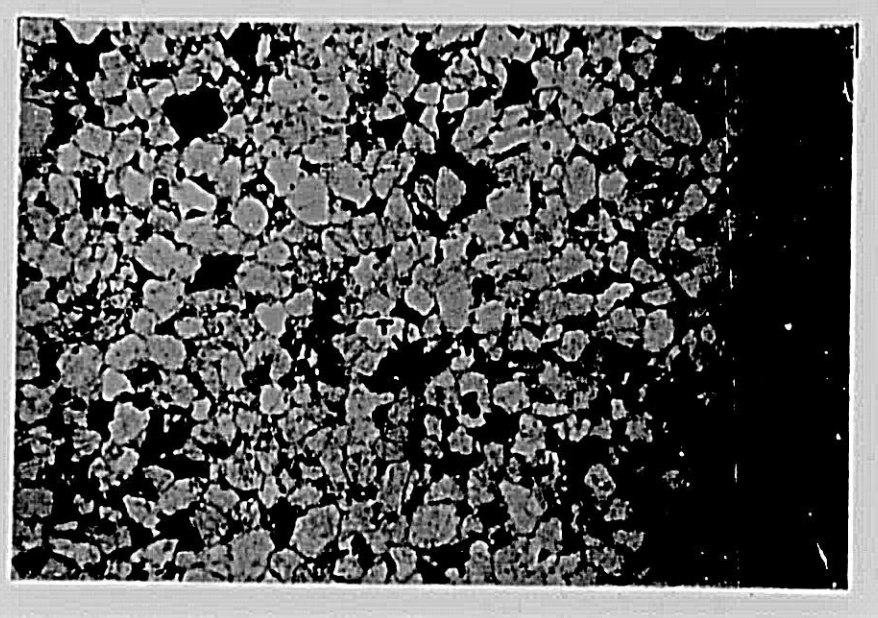


Figure 9. Specimen 6. Subrounded to subangular quartz made more angular by contact solution and redeposition of quartz elsewhere. Plane polarized light X30

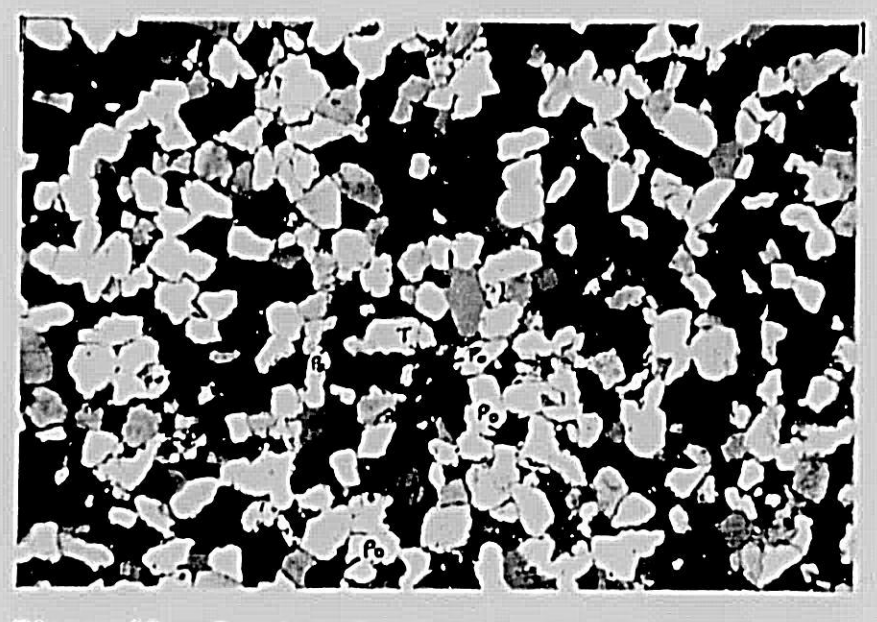


Figure 10. Specimen 6. As above but with crossed polarizers. X30

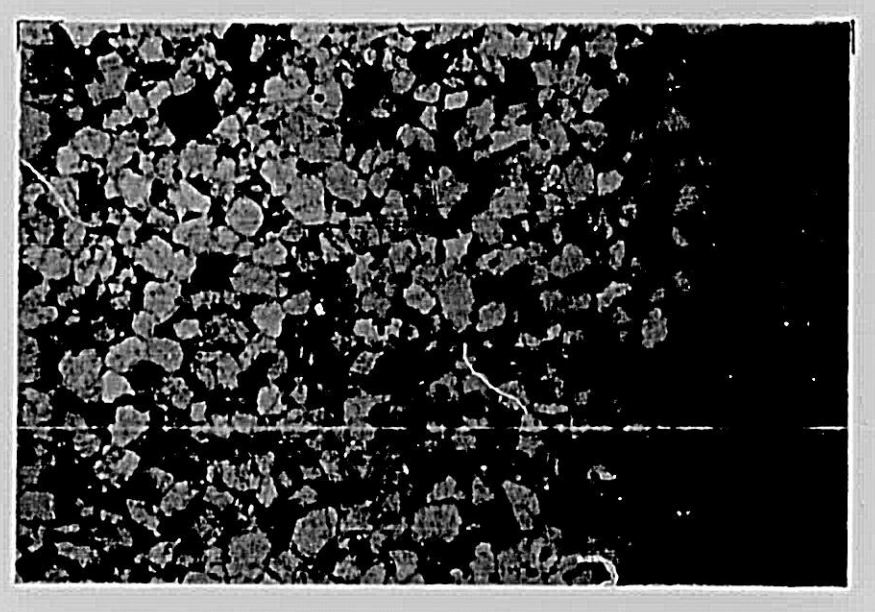


Figure 9. Specimen 6. Subrounded to subangular quartz made more angular by contact solution and redeposition of quartz elsewhere. Plane polarized light X30

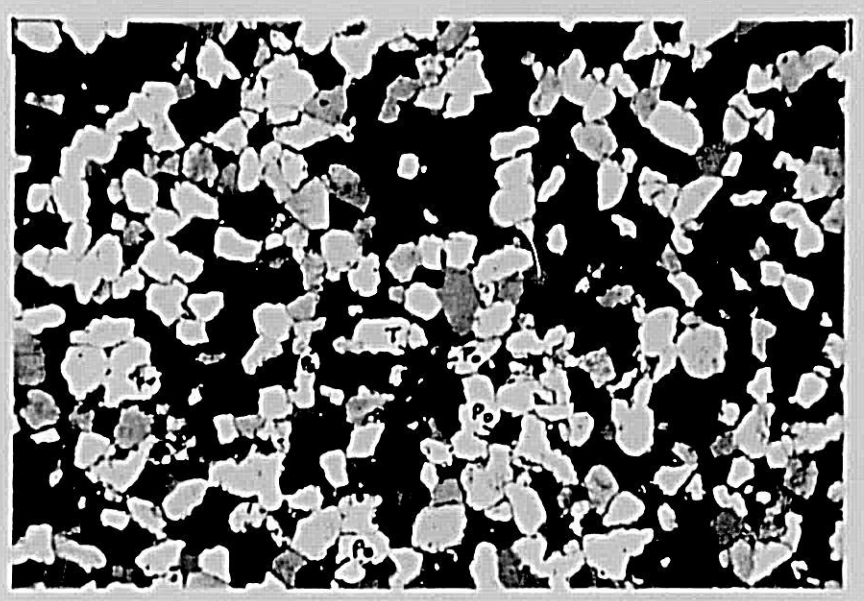


Figure 10. Specimen 6. As above but with crossed polarizers. X30

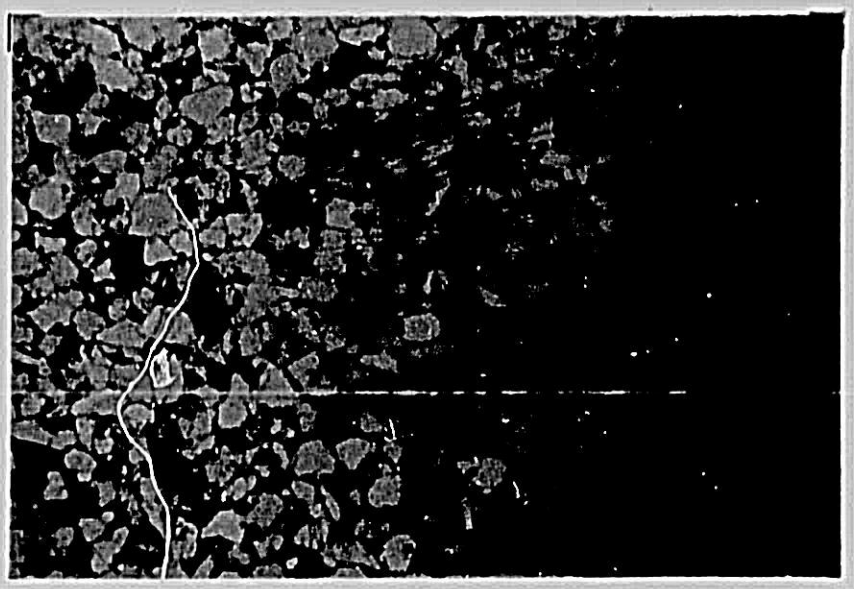


Figure 11. Specimen 6. Subrounded to subangular quartz made more angular by solution at points of contact with redeposition elsewhere. Plane polarized light. X30

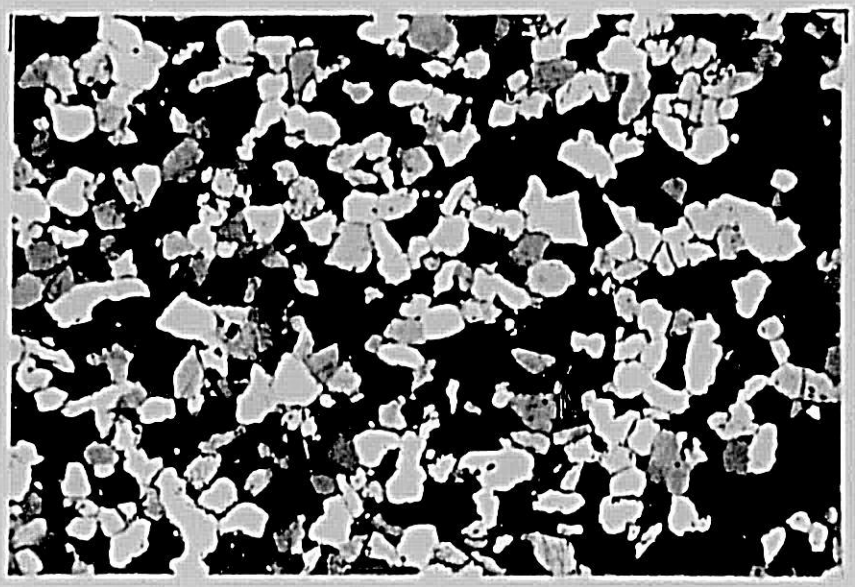


Figure 12. Specimen 6. As above. Crossed polarizers X30

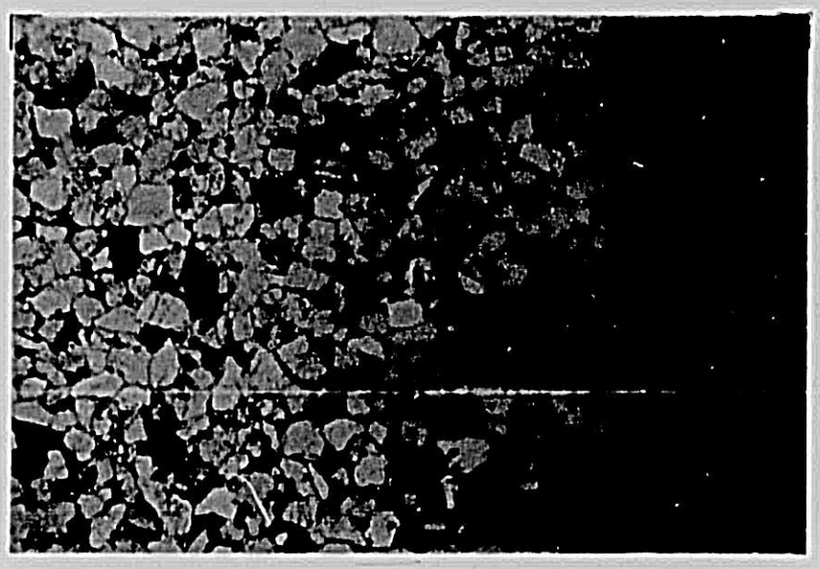


Figure 11. Specimen 6. Subrounded to subangular quartz made more angular by solution at points of contact with redeposition elsewhere. Plane polarized light. X30

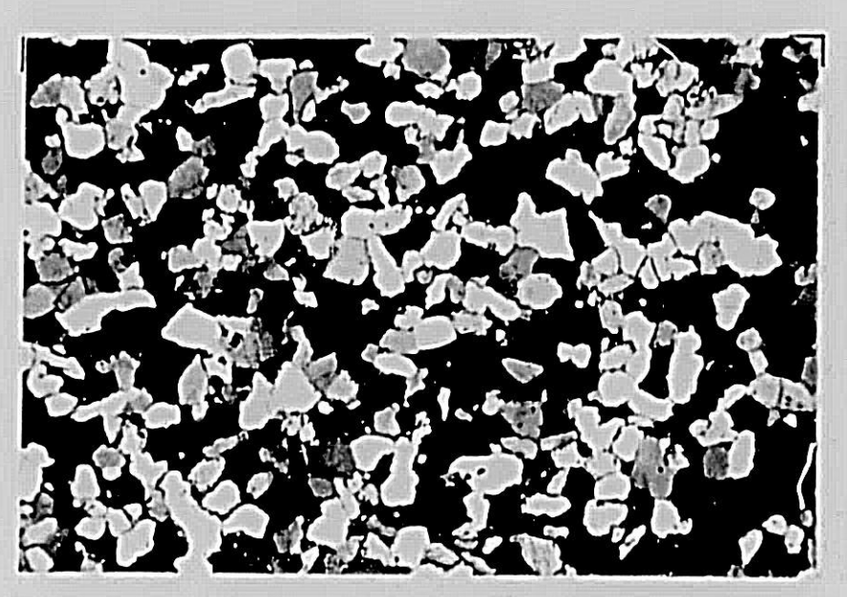


Figure 12. Specimen 6. As above. Crossed polarizers X30