UMIAT OIL FIELD REPORTS
(in this pdf document)

Arctic Contractors, (March) 1953, Exploration Report covering work done by Arctic Contractors under contract NOy-13360 from 1 January 1945 to 31 December 1953, pages included here: title & contents, 202-214, and 221-223.

Arctic Contractors, (June) 1953, Exploration Report covering work done by Arctic Contractors under contract NOy-71333 from 1 January 1945 to 31 December 1953, pages included here: title & contents, 87-91. [Good summary of all field size estimates.]

DeGolyer, and MacNaughton, 1952, Preliminary geological and engineerin study of the Umiat field, Naval Petroleum Reserve No. 4, Alaska: Unpublished report in the files of the U.S. Geological Survey, 9 pages and 4 enclosures.

Eggleston, W.S., and Woodward, A.F., 1951, Oil reserves of Umiat structure and report on Gubik structure, Naval Petroleum Reserve No. 4, Alaska: Unpublished report by Union Oil Company of California in the files of the U.S. Geological Survey, 4 pages, appendix, and 5 oversized plates.

Espach, R.H., 1952, Recoverable petroleum reserves in the Umiat structure, Naval Petroleum Reserve No. 4, Alaska (a revision of the 1951 report): U.S. Bureau of Mines Petroleum and Natural Gas Branch Open-File Report.

Gates, G.L., and Caraway, W.H., 1960, Well productivity related to drilling muds: Umiat field, Naval Petroleum Reserve No. 4, Alaska: U.S. Bureau of Mines Report of Investigations 5706, p. 21.

Mead, R.J., 1980, Memorandum to C.C. Livingston on Umiat development costs: Husky Oil memorandum of January 28, 1980, 7 pages.

(Reports not found.)

Lebsack (U.S. Navy), see page 88 of Arctic Contractors, June, 1953 report.

Milek, see page 88 of Arctic Contractors, June, 1953 report.

NAVAL PETROLEUM RESERVE NO. 4

BUREAU OF YARDS AND DOCKS

CONTRACT NOy-13360

EXPLORATION REPORT

COVERING WORK DONE BY ARCTIC CONTRACTORS

UNDER CONTRACT NOy-13360

FROM 1 JANUARY, 1946, TO 31 DECEMBER, 1953

p. 213 - 223

SUBMITTED BY

ARCTIC CONTRACTORS

FAIRBANKS, ALASKA

MARCH, 1953

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4. Oil Fields Discovered

a. Umiat

(1) Stratigraphy

The revised paleontological determinations on wells of the Umiat field are set forth in Special Report No. 29, Recent Developments in Paleontological Studies, November, 1951, by Harlan R. Bergquist of the Geological Survey. Dr. Bergquist states that,

> "At least 5 diagnostic fossil horizon markers can be traced through these wells. In the order of penetration they are as follows: A fauna dominated by Verneuilinoides F appears above the first productive sands, 300-460 feet below the base of Zone F; Ammobaculites F and Laevidentalium sp. appear about 100 feet below the top of Verneuilinoides F fauna; Ammobaculites tyrrelli appears 275-300 feet below the top of Verneuilinoides F fauna; Trochammina J appears at the same horizon or about 20 to 40 feet below the first Ammobaculites tyrrelli."

By reference to one or more of these fossil horizon markers, it has been possible to correlate all wells of the field. It has also been found possible to correlate the producing sands of the field by lithologic studies, and the results agree closely with the paleontology.

Within the field itself no pronounced erosional unconformities are in evidence; but upon comparing the Umiat stratigraphic column with that of the Titaluk, Square Lake, and Wolf Creek wells, erosion seems to have removed about 1,200 feet of Zone D-E sediments as a result of pre-Zone F uplift on the Umiat anticline. There are lithologic suggestions, without conclusive evidence, of an unconformity at the base of Zone G also.

Producing sands of the Umiat field are separately described below:

1. Immediately below the lowest shales bearing Zone F fossils and above the first Zone DE fossils a 90 foot sand yielded production for the first time in Umiat Test Well No. 10 at 655 to 745 feet, although it had been water-bearing in Umiat Test Well No. 7.

2. The "upper pay," or "first Ruby pay," of the Umiat field is a persistent oil sand throughout the field and was penetrated in Umiat Test Well No. 10 at 1,060 to 1,110 feet.

3. Thin lenticular sands at 1,214 to 1,225 feet and 1,310 to 1,323 feet in Umiat Test Well No. 10 have yielded some oil in various Umiat wells, but in others apparently are too thin and tight for production.

4. The principal producing sand of the Umiat field is the "lower pay," or "second Ruby pay," about 300 feet below the base of the "upper pay." It was penetrated in Umiat Test Well No. 5 from 730 to 1,060 feet.

(2) Structure

The surface structure as mapped by the U. S. Geological Survey is shown as Figure 1, accompanying Report No. 3, Stratigraphy and Structure of the Umiat Anticline, 1947.

The subsurface structure as presently interpreted is shown on the accompanying Drawing No. 1331-A. In respect to the subsurface faulting, other interpretations than that indicated on Drawing No. 1331-A are possible. The amount and extent of closure north of the main east-west fault is undetermined.

(3) Wells Drilled

Eleven wells have been drilled in the Umiat field. No. 1 was drilled to 6,005 feet in the west end of the field and was abandoned in 1946. It had good showings and some oil in cores, but production was not obtained. A core test (later called Umiat Test Well No. 3), drilled in 1946 on the southeast flank of the structure to a depth of 572 feet, was completed as a producer and made 25 bbls. per day on a test after some remedial work. Umiat No. 2, drilled to 6,212 feet in 1947, was located only a short distance southeast of the core test; and although saturated oil sands were cored at shallow depths, the well could not be made to produce. It was believed that the rotary method was the direct cause of sealing off the productive sands, for they are within the permafrost, and any water lost to the formations would freeze and form a barrier. To eliminate this possibility, the next well, No. 4, north of No. 2, was drilled with cable tools with only enough fluid in the hole to permit proper action of the tools. Oil was tried; but when it was found to be unsatisfactory, a brine was substituted of sufficient concentration that it could not freeze at the temperatures encountered. This well was completed in 1950 at a total depth of 840 feet. It was not drilled deeper; tools and junk in the hole to 802 feet prevented further penetration of the lower sand. With an average daily production of 90 bbls. of 36° API gravity oil, the results encouraged further exploration. No.5 was located down dip from No. 4 and very near to No. 2. It was drilled in a similar manner to 1,081 feet, and was completed with both zones open. A prolonged test showed the well capable of 350 to 400 bbls. per day. No. 6 was located in line with No. 4 and No. 5, but another location down the dip. While it had excellent showings while drilling and indicated on test that 80 bbls. per day of oil could be pumped from the upper sand, it was abandoned at a depth of 828 feet because of junk in the hole up to 761 feet, and because of excessive caving of the hole.

Instead of drilling another well close to No. 6, No. 7 was stepped out another location down the dip and was carried to 1,384 feet; but the sands appeared to be wet.

No. 9 was located at the east end of the field at a point estimated to be the equivalent stratigraphically to that of No. 5. In order to obtain information on connate water, it was drilled with oil-base mud. Completed in August, 1951, at a depth of 1,257 feet, on prolonged test the well produced at a rate of 250 to 300 bbls. per day. Later, casing was cemented on the bottom and the casing perforated by stages in an attempt to learn the exact location of the source of production. Apparently the cone-shot perforating was unsuccessful, and further testing was postponed until a bullet gun could be tried.

No. 8 was drilled near the axis of the structure to gain information on the thrust fault identified in No. 1. This well obtained 60 bbls. per day of oil production on a test at 1,080 feet; but when the lower pay sand was encountered at 1,230 feet and drilled to 1,327 feet, a flow of gas was encountered. After 8-5/8 inch casing was cemented at 1,231 feet, the well gauged 5,858,000 cubic feet on a flow test. The well was temporarily suspended. It is believed that this well is isolated from the rest of the field by two faults.

Because of the uncertainty of the true structural and stratigraphic picture, Umiat No. 10 was drilled to the northwest of No. 8 in an attempt to penetrate the main fault and test the sands on the north side. The fault was apparently penetrated at about 230 feet; and the upper sands on the north side of the fault are productive. Bailing tests indicated about 96 bbls. per day from a sand 650 to 740 feet and 220 bbls. per day from one at 1,060 feet to 1,112 feet believed to be the "upper pay" sand. The hole was cased off at 1,339 feet because of caving conditions, and the "lower pay" sand was encountered at 1,535 feet, but it had little oil down to 1,573 feet where the hole was suspended because of caving conditions. It was the intention to drill both No. 8 and No. 10 deeper with a Failing rotary at some later date.

Umiat No. 11 was located well north of the main fault; and because the pay sands were expected to be found deeper than the base of the permafrost, it was felt that a test drilled with rotary, using oil-emulsion mud, would give satisfactory results. Drilling had not commenced by the end of 1951.

(4) Drilling Methods

Umiat No. 1 and No. 2 were drilled with National 50 rotaries using water-base mud. Umiat No. 3 was drilled with a Failing rotary using water-base mud. Wells Nos. 4, 5, 6 and 7 were drilled with a Bucyrus Erie cable-tool rig, using enough brine in the hole to make the tools work properly. Umiat No. 8 and No. 10 were drilled in a similar manner with a Cardwell spudder. No. 9 was drilled with the Failing 1500 rig with oil-base mud, and No. 11 was planned for a Cardwell rotary with oil-emulsion mud.

(5) Production

Actual production tests gave the following rates: Umiat No. 3, 25 bbls. per day and Umiat No. 4, 92 bbls. per day in the upper sand with the top of the lower sand exposed. Umiat No. 5, 70 bbls. per day in the upper sand and 350 to 400 bbls. per day with both sands open. Umiat No. 9, 250 to 300 bbls. per day with both sands open.

Bailing tests showed indicated rates for the following wells: Umiat No. 6, 80 bbls. per day in the upper sand. The lower sand was not reached. Umiat No. 8, 60 bbls. per day at depth 1,080 feet. Umiat No. 10, 96 bbls. per day from a depth of 740 feet and 220 bbls. per day from 1,112 feet.

Well	Test	Depth	Bbls.Per Day	Test	Depth	Bbls.Per
Umiat No. 3				P.	572'	25
" No. 4				P.	802'	92
" No. 5	P.	615'	70	P.	1081'	350 ≁
" No. 9				P.	1257'	250 ≁
" No. 6				B.	828'	80 -
" No. 8				B.	1080'	60
" No. 10	B.	740'	96	B.	1112'	220
		Potential with present wells			-	1077

Potential on Basis of DeGolyer and MacNaughton's Acreage figures:

Acres	No. of Wells	Bbls. per Day	Bbls. per Day
250	10	350	8,750
250	10	320	8,000
750	75	300	22,500
1200	120	250	30,000
500	50	40	2,000
		Total	71,250

(6) Estimates of Reserves

A study of the Umiat Field was made by DeGolyer and MacNaughton, and a report was submitted under date of 4 June 1952. Assuming their estimates to be reasonable with respect to probable productive area, thickness, porosity, and connate water, we would like to point out that we believe a recovery factor of 30 to 40% could be expected by repressuring with gas from other sources, and this should not be less within the permafrost. A recapitulation follows:

	RECOVERABLE RESERVES	
	Probable Minimum	Probable Maximum
S.P. Sand - 500-1000 A., 45 ft. thick, 17% porosity, 45% water	4,696,000	9,393,000
#1 & 1-A Sands, 250-500 A., 18 ft. thick, 15% porosity, 45% water	795,000	1,590,000
#2 Sands (South Blk) 2250-4500 A., 18 ft. thick, 14% porosity, 40% water	7,790,000	15,580,000
#2 Sands (North Blk) 500-1000 A., 18 ft. thick, 14% porosity, 40% water	1,730,000	3,459,000
#3 Sands (South Blk) 1000-2000 A., 10 ft. thick, 15% porosity, 45% water	939,000	1,878,000
#3 Sands (North Blk) 250-500 A., 10 ft. thick, 15% porosity, 45% water	205,000	410,000
#4 Sand (South Blk) 2200-4400 A., 75 ft. thick, 16% porosity, 47% water	31,844,000	63,687,000
#4 Sand (North Blk) 250-500 A., 75 ft. thick, 16% porosity, 47% water	3,620,000	7,239,000
Totals	51,619,000	103,236,000

b. Simpson

(1) Stratigraphy

Shallow sediments present in the Cape Simpson area are typically exemplified in Simpson Core Tests Nos. 13 to 31, inclusive. They consist of unconsolidated gravel, sand, silt, and clay of the Gubik formation of Pleistocene age; shales with unimportant lenses of sand of the Colville group of Upper Cretaceous age; and alternating shales and locally oil-bearing sands of the upper part of the Nanushuk group of Lower Cretaceous age.

Deeper formations are typified in Simpson Test Well No. 1 below 980 feet as dark gray shale with unimportant thin lenticular sands of the lower Nanushuk group to 2,885 feet, dark grey Torok shale with sands in the basal 600 feet to 5,290 feet, black shale of basal Cretaceous age to 5,770 feet, Jurassic shale and sand to 6,265 feet, Triassic sands to 6,548 feet, and slightly metamorphosed pyritic shale of unknown age to 7,000 feet. No oil or gas occurs below the upper Nanushuk section in the Simpson field.

The interpretation of subsurface stratigraphy of the Simpson field is appropriately set forth in a Discussion of Geology by C. A. Everett in Section V of the Completion Report of Simpson Core Tests Nos. 13 through 24, and by C. L. Mohr in Section V of the Completion Report of Simpson Core Tests Nos. 25 to 31, inclusive. According to their interpretation (quoting from the latter report),

> "The seismograph results indicate the existence of a slightly deformed and nearly horizontal formation at depths of 1,000 to 6,000 feet with its upper surface locally truncated and incised by erosion at unusually steep angles and unconformably overlain by a younger formation differing somewhat in regional dip and strike from that below ...
>
> "Electric logs of core holes are capable of sufficiently good correlation and interpretation to confirm the existence of the unconformity suggested by seismograph evidence, and especially the uniform easterly dip of the underlying formation.
>
> "By micropaleontology the underlying formation is identified as Zone E of the Cretaceous, and the overlying beds are found to range from Zone F upward, possibly including Zones G and H. Thin remnants of Zone F are known to be present on the tops of some buried topographic highs, but it is not yet clear whether the rough topography was carved by pre-Zone F or post-Zone F erosion.
>
> "The Zone E section carries several remarkably clean, even-textured, porous, and permeable sands in which oil is found at shallow depths at and near the tops of buried hills. The simplest and most reasonable interpretation is that oil originated in Zone E and migrated westward up the regional dip through the sands in which it accumulated locally where the truncated edges of the sands were topographically high and overlain by the impervious Zone F and younger shales. So far as is known, no faulting or other structural deformation is present. Fracturing undoubtedly is prevalent in the permafrost and might have permitted the escape of oil and gas to the surface, forming the well known seepages of this area.
>
> "The magnitude of the relief of the buried erosion surface is much greater than commonly found in subsurface geology. It represents buried mountain sides sloping at the rate of 800 to 1,000 feet in a horizontal distance of three-quarters of a mile with over-all vertical relief of 2,000 to 3,000 feet."

An alternate interpretation to that quoted above is presented in U. S. Geological Survey Special Report No. 25 by Thomas G. Roberts and Florence Robinson, who support a theory postulated by Thomas G. Payne that an unconformity might have been developed under submarine conditions by erosion of unconsolidated Zone E sands by high-density turbidity or gravity currents subsequent to a slight elevation of the marine shelf at the close of Zone E time.

The seismograph picture of the Simpson area seems to conflict with the theory of submarine turbidity-current erosion and deposition, in that some 3,000 feet of regional east dip affects Zone E deposits, whereas little or no east component of regional dip is recognizable in the overlying Zone F and younger section.

(2) Structure

Seismograph mapping of the structure shows practically no departure from regional dip at and near the Simpson field. Electric log correlations of Zone E horizons in core holes of this area also show simple east dip. The oil accumulation is not accounted for by local faulting or folding but by a stratigraphic trap created by the deposition of impervious shales over rough topographic surfaces of Zone E sands and shales. Oil accumulation is in sands at or near the tops of buried hills and mountains.

(3) Wells Drilled

There were 35 wells drilled in the Cape Simpson area, 33 of which were core tests in the Simpson Seeps area. The depths varied from shallow holes of 200 to 700 feet to holes 2,505 feet deep in the Seeps area. Simpson Test Well No. 1 to the southwest drilled to 7,002 feet, and North Simpson Test Well No. 1 to 3,774 feet.

(4) Drilling Methods

Simpson Test Well No. 1 was drilled with a National 50 rotary rig. North Simpson Test Well No. 1 and Simpson Core Hole No. 28 were drilled with a Cardwell rotary. The rest of the core tests were drilled with a Failing rotary.

(5) Production

Production was obtained in only two wells in the area. Core Hole No. 26 was drilled to 1,171 feet but came in flowing from a depth of 306 feet. Core Hole No. 31 came in flowing from a depth of 355 feet. On flowing tests made at a later date, Core Hole No. 26 made 130 bbls. per day average, and No. 31 made 120 bbls. per day.

The oil was a 19° API gravity paraffin-base oil, but it had a high pour point and is not easily handled in cold weather.

(6) Estimates of Reserves

Because of the lack of knowledge of the structure or the trap from which these two wells produce, any estimate of the reserves would be hypothetical, and no attempt has been made here to make such an estimate.

c. Fish Creek

(1) Stratigraphy

The surface formation at Fish Creek Test Well No. 1 is the Gubik gravel of Quaternory age to a depth of 57 feet. Below the gravel a shale and sand section, probably representing both Zone H and Zone I, extends to the approximate depth of 1,000 feet. Below this depth Zone G sands and shales with at least one important coal bed extend approximately to 2,270 feet. Zone F shale extends from here to 2,890 feet, the supposed position of an unconformity separating the Colville group (Zones F through I) from the Nanushuk group.

The oil sand was found at 2,915 to 3,020 feet in the top of Zone E, the uppermost member of the Nanushuk group. Below this, shales and thin sands extend to 4,170 feet, then a shale to 5,330 feet, silty shales and thin sands to 6,200 feet, and shale to the total depth of 7,020 feet. Sediments from 2,915 to 7,020 feet belong to the Nanushuk group.

(2) Structure

In the area surrounding the Fish Creek well the regional dip of the producing horizon is about 50 feet per mile nearly due east, as shown by the seismograph data. The well is situated on a structural terrace which is very slightly developed, but immediately east of the well there is about 100 feet of east dip in one-half mile. Before the regional east dip was developed, there might have been a slight closure around the locality of the well, but no closure is mappable at present. For a distance of three miles west of the well the total amount of east dip does not exceed 50 feet.

The cause of oil accumulation at Fish Creek appears to be stratigraphic rather than structural, since the well know unconformity at the base of Zone F immediately overlies the pay sand, and a pinch-out may exist. The seismograph results do not depict conditions comparable to a stratigraphic trap, but neither do they present any contrary evidence.

Since the accumulation of oil at Fish Creek does not appear to be dependent on a local anticline or other well defined structural feature, the extent of the oil deposit cannot be estimated and might be very large. The importance of the discovery has not been adequately explored by drilling.

(3) Wells Drilled

One well was drilled in the Fish Creek area and carried down to a depth of 7,020 feet. The well was plugged back and redrilled from 2,550 feet to 3,018 feet to test a sand which had shown some oil on a drill-stem test. It was completed on the pump for the disappointing rate of 12 bbls. per day of very heavy asphalt-base crude oil of 13° to 14° API gravity.

(4) Drilling Methods

A National 50 rotary rig was used in drilling the well with water-base mud for circulating fluid.

(5) Production

On the pumping test the well produced at first at the rate of 12 bbls. per day, but dropped off to 8 to 10 bbls. per day with some entrained water and a little gas.

(6) Estimates of Reserves

No estimate of reserves has been made, as it is felt they probably are inconsequential.

5. Gas Fields Discovered

a. Barrow

This field, located about 4-1/2 miles southeast of the Barrow camp, was discovered in April, 1949, and since installation of lines and equipment by July of that year has supplied the camp with fuel. Starting with the firing of one boiler, the usage was increased as fast as it was possible to complete burner installations, until only a small part of the camp was left burning fuel oil.

The usage has varied seasonally from about one-quarter million to one-half million cubic feet of gas per day, and the service has been interrupted only a few times for short periods. One of these put the camp back on fuel oil for a month when the first well, South Barrow No. 2, was destroyed by fire before the stand-by well, South Barrow No. 4, could be completed. Before this happened, the tubing and casing in South Barrow No. 2 became plugged with the formation of hydrates during the coldest weather, and gas production was interrupted for a short time until the obstruction was cleaned out. Because of the mechanical condition of the casings and tubing on South Barrow No. 4, this has not held up production, because production is maintained through one of two annuli while the tubing is used only to blow the accumulated water from the bottom.

The discovery well, South Barrow No. 2, was drilled to a depth of 2,505 feet. The gas-producing sand was encountered between 2,330 and 2,440 feet, and the initial well head pressure was 1,020 p.s.i.

The second well, South Barrow No. 4, found the producing sand between 2,352 and 2,472 feet. It was drilled to 2,538 feet and encountered bottom water below 2,500 feet, but was not plugged back. The initial well-head pressure on this well was 1,010 p.s.i; and though it has been producing one-fourth to one-half million cubic feet of gas a day since it was put on production, 13 May 1950, the drop in pressure has been very little. In fact, it could be accounted for by variation of the gauges. Because of this, it seems likely that the field has a water drive.

b. Gubik

Two wells drilled on the Gubik structure near the mouth of the Chandler River proved this to be a gas field of major size.

The first well was drilled near the apex of the structure and proved gas to be present in commercial quantities in at least three sands by actual tests. A study of the electric log indicated at least ten other gas sands of equivalent value which were not tested. One of these, from 1,576 to 1,635 feet, is believed to be that which blew out in Gubik No. 2 with a flow estimated to be near 50,000,000 cubic feet per day. It was the only sand tested in Gubik No. 2 which showed evidence of gas in commercial quantities, although tests were made on nearly all sands in this well below 1,145 feet—15 successful tests in all.

c. Umiat

A gas zone of about 95 feet in thickness was discovered in Umiat No. 8 at 1,232 to 1,327 feet. It is believed that this gas is coming from the lower Umiat pay sand that is separated from the rest of the field by two faults and is therefore not a true gas cap in this sand. If this is true, it could be produced without affecting the productivity of the same sand in other parts of the field.

The closed-in well-head pressure built up to only 275 p.s.i., but on a flow test it produced at the rate of 5,858,000 cubic feet per day through a 1-1/2" orifice with a surface flow pressure of 85 p.s.i. On a flow test at 500,000 cubic feet per week, the casing pressures remained constant at 275 p.s.i.

d. Wolf Creek

Wolf Creek field, while gas is present in at least five sands which were tested, is not a field of major commercial importance. Of the sands tested, the highest volume of flow was 881,000 cubic feet per day through open hole. The highest volume through the 5/16" bean of the formation tester was 445,000 cubic feet. There are other sands that the electric log indicates might have about the same value, but there is no reason to expect any greater volumes or pressures from them.

This field would have considerable value for local use, but the volumes and pressures are too low for the field to be of any great value as a source of commercial supply.

e. Oumalik

Some sands in Oumalik No. 1 were found to contain gas under high pressure, but they were not located accurately nor tested.

High-pressure gas threatened to blow out when the well had reached a depth of 2,756 feet, and 10-3/4" casing was cemented at 2,762 feet to protect the hole. A formation test was made of the shut-off with the cement drilled out of the shoe, and a weak blow of gas reached the surface in 35 minutes and continued for the rest of the flow period (1 hour and 5 minutes). A bottom-hole pressure of 1,000 p.s.i. was reached when the valve was closed for 20 minutes.

Later with bottom at 3,244 feet the well started heading gas again; and after the rams had been closed for about 4-1/2 hours, the pressure at the well head had built up to 1,350 p.s.i., and it took 20 minutes to bleed the gas off through a 1/2" opening while pumping mud in the hole to replace it.

The electric log indicated possible gas sands 2,570 to 2,620 feet, 2,692 to 2,739 feet, and 2,740 to 2,785 feet. A formation test 2,762 to 2,851 feet took 55 minutes for the weak blow of gas to reach the surface.

All indications point to the probability of the gas zones being those above 2,762 feet, and that lack of a perfect cement job permitted gas to reach the hole around the shoe of the 10-3/4" casing. The electric log indicates that no gas is present in lower formations down to 10,000 feet. Below that depth to 10,824 feet there are streaks of sand that might contain gas, but the self-potential curve indicates very low permeability.

As no satisfactory flow tests were obtained on any of the sands in this well, the value of the field as a gas producer is questionable. It is believed that there is sufficient gas present in sands above 2,760 feet to furnish fuel for a camp and the rig boiler, but commercial production is doubtful.

f. Meade

No gas sands were recognized when drilling this well; but after the total depth of 5,305 feet was reached, the hole was plugged with cement to 3,038 feet and two formation tests were tried to test a zone of porosity found by the electric log at 2,949 to 2,975 feet. The packer failed to hold, and a bailing thes lowered the fluid to 650 feet, when gas entered in some quantity. A measurement indicated a flow of 300,000 cubic feet through a 1/2" orifice at 39 p.s.i. Later, after more fluid was bailed out, the flow increased to 718,000 cubic feet through a 1/2" orifice at 110 p.s.i. and 1,132,000 cubic feet through a 1" orifice at 35 p.s.i. A series of bailer runs showed considerable gas in the mud down to 2,100 feet, but little below 2,600 feet. 7" casing was cemented at 2,784 feet and gun perforated from 2,559 to 2,560 feet to test the shoe and again at 2,690 to 2,696 feet. With the packer set at 2,494 feet, two runs of the swab started a strong blow of gas, but the packer was pulled before any definite results were obtained, and the hole was junked following operations to remove the tester, which was stuck when a hammer was accidentally dropped down the hole.

There are a few sands in this well which contain gas; but like Oumalik No. 1, any estimate on possible potential would be highly conjectural. One was made, however, based upon few facts and many assumptions; and a possible reserve of 10,600,000,000 cubic feet for the one structure was estimated.

g. Square Lake

Some gas was encountered in the one well drilled in this field above 1,879 feet, but a test at 1,646 to 1,675 feet proved the sand to have low volume and pressure. A test 1,847 to 1,879 feet gave a strong blow of gas, but the water flowing with it prevented metering the gas flow with the equipment at hand. The lower part of this sand was undoubtedly water-bearing, but the top twenty feet at the well location was a good gas zone. The electric log indicates that the upper portion of a few other sands would be productive of gas, but volumes and pressures can be little better than rough estimates.

From the volume of gas and pressure on the test at 1,847 to 1,879 feet, it may be assumed that this field could be developed into one of commercial value.

h. Others

Sands in other wells in various parts of the Reserve contained gas, some associated with oil as at Fish Creek and Cape Simpson, while in others the gas was associated with water as at East Topagoruk. Titaluk No. 1 had a little gas at 3,000 feet, and the electric log indicated other possible gas zones, but the permeabilities in the sands of this well were so low that it is doubtful if production of value could be developed.

None of these areas showed sufficient volumes of gas to warrant development as a fuel source with the exception of the middle seep area at Cape Simpson, and this for local use only. Simpson Core Hole No. 16, when bailed down on a test for oil after the rig had been removed, flowed sufficient gas out of the bore hole that it prevented the hole being filled with water to stop the flow. It is known that this flow continued for at least a year. The actual volume and pressure were too small, however, to be of value except for local use.

Well	So. Barrow No. 4	Umiat No. 6	Umiat No. 6
Depth	Prod.-2538'	808'-825'	T.D. -825'
Date	3-2-52	8-31-50	9-6-50
Comment	Blown out as frozen chunks	Boiler sample	With oil
Calcium, p.p.m.	126	30	15
Magnesium, "	65	24	20
Sodium, "	5,320	11,600	2,450
Carbonate, "	--	--	--
Bicarbonate, "	744	1,900	3,350
Sulfate, "	42	60	685
Chloride, "	8,160	16,800	1,400
Iodide, "		1.3	2.6
Sulfide, "			
Silica, "		Not detected	5.2
Iron, "			
Total Solids, p.p.m.	14,457	30,415	7,927.8
Spec.Grav.@ 60° F.	1.009	?	?

7. Production Potential of Fields Discovered and Reservoir Estimates.

Oil has been found in the Reserve in only three areas. Of these the Umiat Field is the only one that can be considered as having commercial value at the present time. If produced by repressuring methods, it has a possible reserve of 50 to 100 million barrels of 36° API gravity oil. Its potential, with the wells that have been tested, is only about 1,000 bbls. a day, but by fully developing the field on a ten-acre spacing, the potential is estimated at 65,000 bbls. per day on the basis of DeGolyer and MacNaughton's minimum acreage figures.

Two wells at Simpson Seeps were completed, each flowing 120 to 130 bbls. per day, but the oil is too heavy (19° API) to ship by pipe line in cold weather, and the structure is highly problematical, as these were the only wells of 31 drilled in the area that had more than a few showings of oil.

Fish Creek discovered a small quantity of a very low gravity, 13° to 14° API, asphalt-base oil below 3,000 feet. The well pumped 8 to 12 barrels a day with some water and a little gas.

Gas had been found in many places in and near the Reserve. Three fields, South Barrow, Gubik, and Umiat, are of proven economic importance; two, Meade and Square Lake, are believed to be, though no accurate tests were made; and two others, Oumalik and Wolf Creek, showed sufficient gas flows to be of value for local use, but reserves are believed to be too small or the pressure too low for a major supply.

South Barrow field has an estimated reserve of 5,000,000,000 to 7,000,000,000 cubic feet and a potential with the one well of about

5,000,000 cubic feet per day, although sustained production seems to be limited to about 500,000 cubic feet per day, because of the formation of hydrates at higher rates. This field has supplied the Barrow Camp with the major part of its fuel since July, 1949.

A revised estimate of the reserves in the Gubik field places them at 222,000,000,000 cubic feet in the sands upon which successful tests were made and a possible 295,000,000,000 cubic feet if sands are included which appear on the electric log to have similar characteristics. With a probability of at least 15,000,000 cubic feet to 20,000,000 cubic feet per well per day, and a proven acreage for all sands of 3800 acres, a potential of 600,000,000 cubic feet on a 100 acre spacing is indicated.

Umiat No. 8 area is thought to be isolated from the rest of the field by two faults. The potential of the No. 8 Well is about 6,000,000 cubic feet and has been tested at 500,000 cubic feet per day for 11 days without showing a decline in pressures. The gas reserves in this sand have been estimated at 4,700,000,000 cubic feet, using the following data and computations:

Umiat No. 8 was completed as a gas well after penetrating the lower Umiat sand a distance of 91 feet. This sand is about 290 feet thick in Umiat No. 11, and we are assuming that about 200 feet of this would be effective in Umiat No. 8.

After casing was set at 1,231 feet, the well was blown daily for a few hours; and tests made of the flow on July 29, August 3, and August 14, showed a steadily increasing volume under identical conditions. These volumes were 1,893,000, 3,715,000, and 5,859,000 cubic feet respectively. The closed-in pressure built up to 275 p.s.i.

On a flow test of 11 days duration, 26 May 1952 to 6 June 1952, a continuous flow of 500,000 cubic feet per day was maintained; and the tubing pressure dropped only to 271 p.s.i. and remained constant thereafter to the end of the test. The casing pressure remained at 275 p.s.i.

Using a thickness of 200 feet, andarea of 419 acres as shown on Map 1331-A, a porosity of 14 percent, and a connate-water content of 35 percent, we have an available reservoir pore space of 324,688,000 cubic feet.

Then $324{,}688 \times \frac{520}{523}\left(\frac{300 \times 1.042}{14.4} - \frac{100 \times 1.014}{14.4}\right) = 4{,}735{,}000{,}000$ cubic feet

Using an average of 250,000 per day, $\frac{4{,}735{,}000}{250} = 18{,}950$ days - 52 year

While these calculations are believed to be conservative and are based upon a few known facts, there are a number of figures used which are conjectural and upon which assumptions necessarily had to be made. Any differences in these could alter the production considerably; although if we allow a contingency factor of 50 percent, the supply would still be 26 years at 500,000 cubic feet per day.

The Meade Well showed evidence that certain sands had valuable gas reserves, but the hole was lost because of mechanical trouble before adequate tests could be made. Estimates of gas reserves have been made on the five sands which appeared on the electric log to be gas sands, using assumed pressures equal to the hydrostatic head of fresh water. A revised estimate indicates a possible reserve of 19,600,000,000 cubic feet in the Meade No. 1 structure. If the areas in the East and West Meade structures, which are higher than the same contour in Meade No. 1, are included, there might be a reserve of as much as 249,000,000,000 cubic feet.

Square Lake had one sand at 1,835 feet which gave a strong blow of gas on a formation test, but water followed too soon to permit a measurement to be made with the critical flow prover. Another sand at 1,660 feet flowed some gas on a test but also pulled some water. An estimate on the reserves of these two sands was made, which totals 34,000,000,000 cubic feet.

Wolf Creek No. 1 and No. 3 showed some gas in a few sands, but the pressures were quite low, and it is believed the reserves here are not of major importance, although there is a sufficient reserve to be of value as a local supply for operations in the vicinity. The condition is somewhat similar to Gumalik, where the gas pressure is high but the sands are thin with low porosity. No attempt has been made at estimating the possible reserves in these two areas.

8. Pipe Line Studies

On 31 July, 1951, Arctic Contractors transmitted to the Officer in Charge of Construction a report on Crude Oil Transportation from NPR No. 4 covering cost estimates for a possible crude oil pipe line from Umiat to Valdes for 8-inch, 10-inch, 12-inch, and 16-inch sizes and for capacities of 10,000 to 20,000 barrels per day.

It was the intent of this report to enumerate the general cost factors and to arrive at costs which would be of a reasonable order of magnitude for the completed lines rather than that the report should be a final detailed hydraulic design. All basic factors were included, such as unit costs and transportation methods believed most efficient for delivery of the material in place.

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NAVAL PETROLEUM RESERVE NO. 4

BUREAU OF YARDS AND DOCKS

CONTRACT NOy-71333

EXPLORATION REPORT

COVERING WORK DONE BY ARCTIC CONTRACTORS

UNDER CONTRACT NOy-71333

FROM 1 JANUARY, 1952, TO 1 JULY, 1953

Reserve figures
for Umiat
Simpson
Gubik
Meade
So. Barrow

SUBMITTED BY

ARCTIC CONTRACTORS

FAIRBANKS, ALASKA

JUNE, 1953

LIST OF ILLUSTRATIONS
(In Pocket of Report)

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7. <u>Discoveries</u>

a. <u>Oil Deposits</u>

Umiat Test Well No. 10 discovered oil of 37 API gravity in a new sand of important aspect, but the extent of the productive area is undetermined. This sand was 95 feet thick and was penetrated at a depth of 640 to 745 feet, or at a sea-level elevation of plus 106 to plus 1 feet. The static fluid level of oil from this horizon was found to be 615 feet, or 141 feet above sea level.

Oil was first noted entering the hole at 655 feet. When the depth reached 753 feet, the hole was bailed 2 hours, recovering 2-1/2 barrels sand and 20 barrels of oil. The hole was allowed to stand idle 6 hours, after which the fluid level had risen to 615 feet. The hole was bailed dry in 2 hours, recovering 20 barrels of oil. The hole was then bailed dry at hourly intervals for 22 hours, recovering 88 barrels of oil. The rate of entry was therefore 96 barrels per day.

Considering that the static fluid level is only 25 feet above the top of the sand and 130 feet above the bottom of the sand, the formation pressure could not have exceeded 55 pounds per square inch; and this implies excellent permeability. Wells penetrating this oil deposit at a somewhat lower position on the structure should have much better productivity than Umiat Test Well No. 10.

The lateral extent of the oil deposit represented by the 640-745 foot sand discovery of Umiat No. 10 cannot be reliably stated because of the lack of structural control north of the main fault of the Umiat field. All that is known is that this deposit does not extend as far down the north flank as Umiat Test Well No. 11, which found salt water in the same sand. Taking the average of the maximum and minimum possibilities, or half the distance from No. 10 to No. 11 as the northern limit of the oil deposit, and assuming the subsurface structure to be as shown on accompanying Drawing No. 1331-3, the estimated productive area would be approximately as colored in green on this map, or 1,160 acres. This area probably should be considered as the maximum for evaluation purposes until additional wells are drilled to determine the actual conditions north of the fault.

Umiat Test Well No. 10 also obtained oil production which tested at an estimated rate of 140 to 190 barrels per day in a sand at 1,060 to 1,110 feet referred to in earlier reports of Arctic Contractors as the "upper Umiat pay." Owing to the fact that the 640-foot sand was not cased off, an accurate test of the productivity of the 1,060-foot sand was not obtained.

For evaluation purposes, the estimated areal extent of the oil deposit in the 1,060-foot sand north of the main fault may be based on reasoning anologous to that used for the 640-foot sand, resulting in a tentative maximum productive area of 1,160 acres.

One of the objectives of Umiat Test Well No. 10 was to test the "lower Umiat pay" north of the main fault, but a decision was reached to suspend operations before the well reached a depth sufficient to test this sand.

b. Gas Deposits

Square Lake Test Well No. 1 discovered gas deposits in sands at 1,660 to 1,692 feet and 1,835 to 1,880 feet. Formation water was produced in the drill-stem tests which yielded the gas in both of these sands. The electric log indicates the gas-water contact to be within the interval tested at both horizons. According to the seismograph data, the well appears to be located at least 40 feet structurally lower than the apex of the anticline, and since the structure is broad and flat on top, the two gas deposits probably cover an area of approximately 2,800 acres, or 4.4 square miles, as indicated on the accompanying seismograph map, U.G.C. Drawing No. 2481-A-1.

By locating wells higher on the structure, penetration of the gas-water contacts could be avoided, and production of gas in commercial quantities should be possible without early water encroachment.

Estimated gas reserves are discussed in this report under Topic IV-D-3, Estimates of Newly Discovered Reserves.

6. Production Testing

Oil-bearing horizons at 640 to 745 feet and 1,060 to 1,110 feet in Umiat Test Well No. 10 were tested only by bailing. The lower of these two horizons was tested without casing or packing off the upper; and consequently, no accurate determination of the productive capacity could be made. Complete details of the bailing tests are given under Topic IV-C-5, Test Wells. According to these tests the 640-foot sand produced at the rate of 96 barrels per day, and the 1,060-foot sand produced at a roughly estimated rate of 140 to 190 barrels per day.

Regarding the two gas horizons of Square Lake Test Well No. 1, it was not regarded as worth while to make prolonged tests of potential gas production because the sands were making considerable water. Adequate production tests of the gas could not be made without drilling another well higher on the structure.

D. Estimates of Reserves

1. Umiat Field

a. Summary of Earlier Estimates

At the Fifteenth Meeting of the Operating Committee in June 1951 the following estimates of recoverable oil reserves were submitted for the Umiat field:

(1)	Arctic Contractors	64,000,000/107,000,000 bbls.
(2)	Navy (Lebsack)	2,000,000/17,000,000
(3)	U.S. Bureau of Mines	151,000,000
(4)	DeGolyer and MacNaughton	57,000,000
(5)	Private industry	30,000,000 (+ 10,000,000?)
(6)	Milek	85,000,000

A reasonable average estimate of recoverable oil was considered to be 70,000,000 barrels for the Umiat field.

In their Exploration Report covering Contract NOy-13360, Arctic Contractors stated their estimate of recoverable oil in the Umiat field as 50,000,000 to 100,000,000 barrels if produced by repressuring methods. Without repressuring, their estimate would be 42,000,000 to 84,000,000 barrels.

b. Revisions of Earlier Estimates

The estimate of June 1951 by DeGolyer and MacNaughton regarding recoverable oil reserves of the Umiat field of 57,000,000 barrels was revised in their report of 4 June 1952 entitled Preliminary Geological and Engineering Study of the Umiat Field to a possible minimum of 18,800,000 barrels and a possible maximum of 37,600,000 barrels. Their revised figures include allowances for production north of the fault in the newly discovered shallow pay of Umiat Test Well No. 10 amounting to 1,300,000 to 2,600,000 barrels.

The U.S. Bureau of Mines estimate of 151,000,000 barrels of recoverable oil submitted in June 1951 was revised in a memorandum by Ralph H. Espach dated 15 January 1952, which stated as follows:

"As a result of new data, becoming available from analyses of cores from Umiat well 9, a re-evaluation of the reserve picture as given in the June 1, 1951 report was made. All data, excepting 'connate water,' bottom of page 5, remained the same. The recoverable reserves, using new connate water contents in the calculations, are 122,000,000 barrels. Pages 1a, 5a, 6a, 7a, and 8a, indicate changes made as a result of using Figure 6a, representing the new data. These pages and graph should be added to the original report."

Reference to the text of the original 1951 estimate by the Bureau of Mines discloses that the figure of 7,000 acres was used as the estimated size of the productive area of the Umiat field. Recent calculations by the Chief of Exploration indicated some variation in the areal extent of oil deposits in the various productive sands of the field, but a fair average for the principal sands was estimated to be 5,120 acres for the south flank of the structure south of the main fault. The size of the productive area north of the fault was estimated at 200 to 1,160 acres, but the productive area north of the fault is highly conjectural. On the basis of reduced acreage estimates from 7,000 to approximately 5,320 acres, the Bureau of Mines estimate should probably be reduced from 122,000,000 to approximately 93,000,000 barrels. Other undetermined variable factors pertaining to production practice might increase or decrease these estimates.

In his report of 18 May 1951 on estimated oil reserves of the Umiat field, Andrew Milek estimated 85,000,000 barrels of recoverable oil south of the fault, using a figure of 7,000 acres as the average productive area for all sands. Mr. Milek has not been requested to revise his estimate on the basis of more recent well data; but if the recent acreage estimate of 5,120 acres by the Chief of Exploration were used, Mr. Milek's recovery figure would be reduced from 85,000,000 to 62,000,000 barrels. Oil deposits discovered north of the main fault subsequently to Mr. Milek's estimate would perhaps raise his estimated recovery for the field to approximately 70,000,000 or 75,000,000 barrels.

A recent estimate of oil reserves in the Umiat field by the Chief of Exploration, gives a total of 480,000 acre feet of permeable sand south of the main fault, and he estimates the Umiat oil reserves as follows: Using the figure of 660 barrels per acre foot of oil in place, as indicated by George L. Gates for the more permeable sands of the Umiat field, a total of 316,800,000 barrels of oil in place is obtained. Using a recovery factor of Mr. Espach of 27% both in and below the permafrost gives 85,700,000 barrels of recoverable oil by normal gas-expansion and water-drive production methods. However, such methods of production were presumed not to function at full efficiency in the permafrost; but by using gas injection for re-pressuring and production of oil, the effect of the permafrost would probably be slight. An average increase in recovery of 20% for gas-injection over normal gas-expansion and water-drive methods of production was considered to be the minimum. On the assumption that the Umiat field should be produced only with gas injection, the recovery factor was raised from 27% to 32.5%, which gives an estimated 103,000,000 barrels of recoverable oil for the south flank.

c. Estimates of Newly Discovered Reserves

The discovery of oil in a new sand at 640 to 745 feet north of the main fault by Umiat Test Well No. 10 adds an undetermined volume to the estimated reserves of the Umiat field. This sand was regarded by the well geologist as having 88 feet of good permeability and 17 feet impermeable on the basis of the drilling rate and the aspect of 29.5 feet of cores recovered from 34 feet cut. Using productive acreage figures estimated above under Topic IV-C-7 Discoveries, the range of 200 to 1,160 acres north of the fault for this sand gives 17,600 to 102,000 acre feet. Assuming 15 percent porosity, 47 percent water saturation, the total oil in place should therefore range between 9,800,000 and 57,200,000 barrels. Using Mr. Espach's recovery factor of 27 percent gives 2,600,000 to 15,500,000 barrels recoverable by gas-expansion and water-drive production; or allowing an additional 20 percent for gas-injection, a range of 3,200,000 to 18,600,000 barrels recoverable is obtained.

Applying similar factors to the sand at 1,060 to 1,110 feet in Umiat Test Well No. 10, and assuming 28 feet of permeable sand, as indicated by the Micro-Log of Umiat Test Well No. 11, the estimated recoverable oil north of the fault in this sand would range between 800,000 and 4,900,000 barrels by ordinary production methods, or 1,000,000 to 6,000,000 barrels with gas injection.

Total recoverable reserves north and south of the fault would thus be estimated by the Chief of Exploration at 107,000,000 to 122,600,000 barrels.

2. Simpson Seeps Field

In a report of 21 May 1951, Andrew Milek estimated the Simpson Seeps oil field to cover a probable area of 710 acres. He estimated this area should contain roughly 12,000,000 barrels of recoverable oil. This estimate has not been revised.

3. Fish Creek Field

Previous evaluations have classified the Fish Creek area as noncommercial, and no estimates of recoverable oil have been recorded.

4. South Barrow Field

Previous evaluation of the South Barrow gas field has suggested a reserve of 5,000,000,000 to 7,000,000,000 cubic feet of gas.

5. Gubik Field

In their Exploration Report covering Contract NOy-13360, Arctic Contractors gave their revised estimate of recoverable gas in the Gubik field as 22,000,000,000 cubic feet in sands upon which successful tests were made and a possible 295,000,000,000 cubic feet if sands are included which appear on the electric log to have similar characteristics.

6. Umiat Test Well No. 8

The gas-bearing area surrounding Umiat Test Well No. 8 has an undetermined area. Arctic Contractors estimated that a reasonable recovery figure would be 4,735,000,000 cubic feet, assuming the productive area to be 419 acres; but this figure is very conjectural.

7. Meade Area

Recoverable gas on the Meade anticline was estimated by Arctic Contractors at roughly 19,600,000,000 cubic feet.

E. EVALUATION OF PROGRESS OF EXPLORATION

1. By Committee

At the March 1952 meeting of the Executive Operating Committee, the Officer in Charge of Construction appointed a committee "for the purpose of setting forth the objectives of future exploration in Naval Petroleum Reserve No. 4 and re-evaluating Navy's accomplishments to date." This committee consisted of Earle F. Taylor, Chairman, Commander M. V. Carson, Commander R. C. Jensen, John C. Reed, Ted C. Mathews, and Walter R. Fillippone.

The committee spent several weeks preparing a report which was submitted at the Sixteenth Meeting of the Advisory Committee, April 1952. The objective of the committee was stated as, "To make a reasonable evaluation of the petroleum potentialities of Naval Petroleum Reserve No. 4 and adjacent public lands." Its problem was defined as, "To accumulate sufficient data by drilling, geology, and geophysics to provide information necessary for the evaluation."

DeGOLYER AND MacNAUGHTON
CONTINENTAL BUILDING
DALLAS, TEXAS

PRELIMINARY

GEOLOGICAL and ENGINEERING STUDY

of the

UMIAT FIELD

NAVAL PETROLEUM RESERVE NO. 4

ALASKA

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Continental Building
Dallas, Texas

PRELIMINARY

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NAVAL PETROLEUM RESERVE NO. 4

ALASKA

FOREWORD

Scope of Investigation This report is a preliminary study of the Umiat oil field located in Naval Petroleum Reserve No. 4, Alaska. It contains geological and engineering data on the field and an appraisal of the total proved non-producing and semi-proven oil reserves under this field.

Authority This report is made at the request of Captain R. H. Meade, Director of Naval Petroleum Reserves.

Source of Information Information necessary for the preparation of this report was obtained from files in the offices of DeGolyer and MacNaughton in Dallas, Texas. This information was furnished DeGolyer and MacNaughton by various sources at the direction of the DNPR.

History Drilling operations in the Umiat area began with the spudding of Umiat Test Well No. 1 in June 1945. Although oil shows were encountered, this hole was abandoned as a non-producer in October 1946. The discovery well of the Umiat field was a core test, now called Umiat Test Well No. 3, which drilled through two oil sands between 248 and 360 feet. This test was drilled in November 1946 and made an estimated 24 barrels of oil per day on a 3-day pumping test. To date a total of 8 oil wells and 2 dry holes have been drilled on this structure. Except for testing of individual wells, this field has never been put on production.

GEOLOGY

The producing sand section in the Umiat field is believed to occur in the B-C zone interval of the Lower Cretaceous rocks. In the past it has been the custom to refer to the principal productive sands in the Umiat field as the upper or Ruby No. 2 sand and the lower or main sand. We have found this nomenclature to be inadequate and have prepared a type log (Enclosure II) showing a suggested revision in the naming of the various sands. Noted on the type log are the microfossils that serve to identify the sands.

As shown on the type log the youngest beds encountered at Umiat are "G" zone. No sand development of importance exists in this zone. The underlying "F" zone is principally shale; however, one thin sand, the "A" sand, is present in Umiat Nos. 1 and 10.

It is difficult to identify the contact between zones D and E hence they will be referred to as one unit. The first occurrence of Trochammina "P" and Gaudryina "A" is considered to mark the top of zone E and in general, the barren interval above the common occurrence of Verneuilinoides "F" identifies zone D. In some cases a rare occurrence of Verneuilinoides F marks the top of zone D.

The "salt and pepper" sand and the 1 and 1-A sands are classified as DE zone sands. As suggested above, common Verneuilinoides "F" is assumed to be at the top of zones BC, which have not yet been individually identified. This marker occurs just above the No. 2 sand. Ammobaculites "F" is recognized as the indicator for the No. 3 sand and Trochammina "J" occurring between the No. 3 and No. 4 sands is the No. 4 sand marker.

The No. 4 sand as penetrated in Umiat No. 1 is composed of some four separate members; however, in view of the general lenticularity of the sands at Umiat they will be considered as one sand body for the purpose of calculating reserves.

The lowest sand recognized so far in the Umiat wells is called the No. 5 sand, encountered from 2,775 to 2,810 in Umiat No. 1. This sand may form the basal member of the No. 4 sand group at positions higher on structure than Umiat No. 1.

A major fault is recognized in Umiat No. 1 at a depth of approximately 2,000 feet (-1,190) at which point some 750 feet of beds are duplicated as suggested by electric log correlation. In Umiat No. 2 the fault is apparently present at a depth of 2,360 feet (-2,000) on the basis of Schlumberger correlation. Although it is not conclusive, Umiat No. 10 may have encountered the fault plane at approximately 210 feet (+537) and Umiat No. 8 may have crossed the fault in the upper one or two hundred feet. Assuming that all of the above points are part of the same fault plane and not separate en echelon faults, the fault plane will have a dip of approximately 25 degrees in the vicinity of Umiat No. 2. We believe that the steep surface dips reported on the north flank of the structure are related to the fault zone and probably do not reflect structure. That this is a post-accumulation fault is suggested by the fact that in Test Well No. 4, the No. 4 sand was oil-bearing at a depth of -230 feet whereas it was gas-bearing at a depth of -500 to -575 feet in Test Well No. 8. This suggests further that a gas cap may have existed originally in the No. 4 sand in the south block (Enclosure I). We are tentatively placing the original gas-oil contact at approximately -200 feet. It is possible that this source of energy may have been responsible for the various seeps that exist in Umiat Lake. The effect of these seeps on the possible gas accumulation in the No. 4 sand is unknown.

<u>ESTIMATION of RESERVES</u>

Average basic data for these sands are shown on the type log. The net sand determinations were based primarily on the electric logs, and in the cable tool drilled holes where no electric logs are available we have used 50% of the gross sand logged as net sand.

For the purpose of calculating reserves that portion of the Umiat field lying south of the major east-west striking thrust fault will hereafter be referred to as the "south block" and that part of the field situated north of the fault will be referred to as the "north block".

In making reserve calculations we have placed the base of the permafrost at 800 feet below the surface as shown in Enclosure I and have calculated the reserves on the basis of a recovery of 8 percent from the sands in the permafrost and 12.5 percent from the sands below the permafrost.

In view of the results obtained from analyzing the cores of Umiat No. 9 as reported by George Gates in his memorandum dated March 18, 1952 we have used a connate water value of 40 percent for the No. 2 sand, 47 percent for the No. 4 sand and in the absence of representative data we have used 45 percent for the other sands.

RESERVES

"A" Sand

This sand is present only on the flanks of the Umiat structure and accordingly has been penetrated only by Umiat No. 1, 8 and 10 and perhaps in the very upper part of No. 7. The sand in the south block outcrops and therefore is assigned no reserves. A bailing test in Umiat No. 10 from a depth of 532 feet indicated the sand to be tight in that area and therefore we have not given the "A" sand any reserves for the north block.

"Salt and Pepper" Sand

Although core data are meager this sand is indicated to have a comparatively high porosity and permeability; however, inasmuch as the sand apparently outcrops in the area south of the fault it is considered to have no value in that area. As shown in Enclosure I there is apparently an accumulation in this sand north of the fault. Assuming 1) 500 acres to be semi-proven; 2) 45 feet of net sand; 3) 45 percent connate water; 4) 17 percent porosity; 5) volume factor of 1; and 6) 8 percent recovery, a reserve of the order of 1,300,000 barrels is present. Since no water level has been established it is reasonable to expect a maximum of 1,000 productive acres which might yield some 2,600,000 barrels.

No. 1 and No. 1-A Sands Very little data have been accumulated regarding these sands; however, in general the sands have low permeability and porosity and are not as widely developed as the Nos. 2 and 4 sands. There is also some question regarding the existence of a satisfactory reservoir seal over the high south block. In view of the poor tests that were made of this sand in Umiat Nos. 2, 3, 6 and 9 no producible reserves are believed to be present in the south block.

Although no porosity and permeability data are available from Umiat Nos. 8 and 10, approximately 127 barrels of oil per day were bailed from these sands in No. 8 and oil was recovered from both sands in No. 10. Accordingly, assuming 1) 500 acres to be semi-proven; 2) a total of 18 feet of net sand; 3) 45 percent connate water; 4) 15 percent porosity; 5) volume factor of 1; and 6) 12.5 percent recovery, a semi-proven reserve of some 700,000 barrels is present. A reasonable maximum of 1,400,000 barrels may be present.

No. 2 Sand On the basis of the recovery of salt water during a test of the No. 2 sand in Umiat No. 6, the water level is tentatively placed at 355 feet subsea; thus almost the entire accumulation in the south block lies within the permafrost and for this reason a recovery factor of only 8 percent is used. Using a porosity of 14 percent and a connate water value of 40 percent a recovery factor of only 52 barrels per acre foot results. An average of 18 feet of net sand is present in the wells south of the fault; thus if the entire area enclosed by the water level, amounting to 4,500 acres, is productive a maximum recoverable reserve of some 4,200,000 barrels exists. For the purpose of this report half of this amount will be classified as semi-proven.

An additional 1,000 acres may be productive in the north block below the permafrost. Assuming 18 feet of net sand and a recovery factor of 81 barrels per acre foot a reserve of some 1,400,000 barrels exists.

No gas cap has been observed in the No. 2 sand.

No. 3 Sand This sand is not well developed in all wells and appears to be rather lenticular. A review of the tests made in Umiat No. 9 suggests that while swabbing from a plugged back depth of 850 feet, approximately 120 barrels of oil per day were recovered from the No. 3 sand. Assuming 1) a maximum of 2,000 acres to be productive; 2) 10 feet of net sand; 3) 45 percent connate water; 4) 15 percent porosity; 5) volume factor of 1; and 6) 8 percent recovery, a reserve in the south block of 1,000,000 barrels is indicated, half of which can be considered semi-proven.

Using a recovery factor of 12.5 percent and assuming 500 acres to be productive, a reserve of 400,000 barrels may be present in the north block.

No. 4 Sand The largest accumulation of oil in the Umiat structure is present in the various members of the No. 4 sand, previously called the lower sand. Fairly good data indicate an average porosity of 16 percent and an average permeability of 94 md. As shown in Enclosure IV the crest of the No. 4 sand is slightly above 100 feet subsea. In view of the gas accumulation in Umiat Test Well No. 8 above 560 feet subsea and based on the previously mentioned thoughts concerning the Umiat fault, it is reasonable to expect that the sand contains gas above 200 feet subsea in the south block. This condition does not materially affect the reserve estimate. The oil reserves in the south block are based on 1) a maximum of 4,400 productive acres; 2) 75 feet of net sand; 3) 47 percent connate water; 4) 16 percent porosity; 5) volume factor of 1; and 6) 8 percent recovery in the permafrost and 12.5 percent recovery below the permafrost. A total of approximately 23,600,000 barrels is assigned to the No. 4 sand in the south block of which half or 11,800,000 barrels is considered semi-proven.

In the north block similar data give a possible maximum reserve of 3,000,000 barrels for a 500 acre productive area.

No. 5 Sand — No reserves are assigned to this sand since data from Umiat Test Well No. 2 indicate that the No. 5 sand is probably included as part of the No. 4 sand.

Total for Umiat Field

Sand	Possible Minimum Reserves	Possible Maximum Reserves
A	0	0
S & P	1,300,000	2,600,000
1 and 1-A	700,000	1,400,000
2	2,800,000	5,500,000
3	700,000	1,400,000
4	13,300,000	26,600,000
Total	18,800,000	37,600,000

CONCLUSIONS

As pointed out in our memorandum of May 25, 1951 we consider that it will not be commercially feasible to develop the oil reserves at Umiat until an amount of additional oil sufficient to support pipeline transportation to southern Alaska is proven to exist in N.P.R. 4 and adjoining areas.

In order to make a sound analysis of the productive capacity of a potential oil field it is necessary to obtain good representative cores and to make conclusive formation and/or production tests of all sands having favorable characteristics. In reviewing the core and testing data accumulated thus far at Umiat it is apparent that poor and often conflicting data have been obtained from the wells drilled with cable tools. A good example of this is the failure to recover more than one good core from Umiat No. 10. For this reason we believe that cable tools have been unsatisfactory for exploratory drilling here.

With the completion of drilling now approved for the Umiat area we feel that exploration in this field, as it is now known, can be terminated. New seismic data east of the Colville River or unusually encouraging results in Umiat Test Well No. 11 could alter the situation and our final opinion must await results of these operations.

Submitted,

DeGolyer and MacNaughton

DeGOLYER and MacNAUGHTON

June 4, 1952

SUMMARY OF TESTS

UMIAT NO. 1. Not Tested

2. Rec. Trace of Oil and Salt Water.
3. No. 4 Sand Not Penetrated.
4. Pumped Estimated 85 B/D From 3 and 4 Sands.
5. Swabbed 240 B/D From 3 and 4 Sands.
6. No. 4 Sand Not Penetrated.
7. Rec. Trace of Oil and Salt Water.
8. Produced at Rates Up to 5.9 MMCF at 85 psi.
9. Pumped 250 B/D, Mainly From No. 4 Sand.
10. Bailed 15 B/D. (Sand Not Completely Penetrated)

LEGEND

Well Number - 1 -491 - #2 Sand Datum (Subsea)
Elevation - 342 ● -827 - #4 Sand Datum (Subsea)
6000 - Total Depth
5400 - 7" Oil String
500 - (160)(Pf. or O.H.) - Top Interval Open (Length) Perf. or Open Hole.
I - 20 - 51 Completion Date
37.4 - Gravity
160 (P) Present Prod. Capacity in Bbls. (If Gas Show in Millions of Cu Ft.)

ENCLOSURE NO. IV
STRUCTURE MAP
SHOWING
CONTOURS ON TOP OF No 4 SAND
UMIAT FIELD
N.P.R. NO. 4 ALASKA

SCALE
2000 0 2000 4000
FEET

DEGOLYER AND MACNAUGHTON DALLAS, TEXAS
MAY, 1952

SUMMARY OF TESTS

UMIAT NO. 1. Rec. Trace of Oil.
2. Rec. Trace of Oil.
3. Pumped Estimate 20 B/D.
4. Pumped Estimate 15 B/D.
5. Pumped Estimate 75 B/D.
6. Pumped Estimate 25 B/D With Salt Water From 1-A and 2 Sands.
7. Bailed Trace of Oil With Salt Water
8. Pumped 60 B/D From All Sands Through The NO. 2 Sand.
9. Swabbed Trace of Oil.
10. Bailed Estimate 85 B/D From 1-A and 2 Sands.

ENCLOSURE NO. III

STRUCTURE MAP SHOWING CONTOURS ON TOP OF № 2 SAND

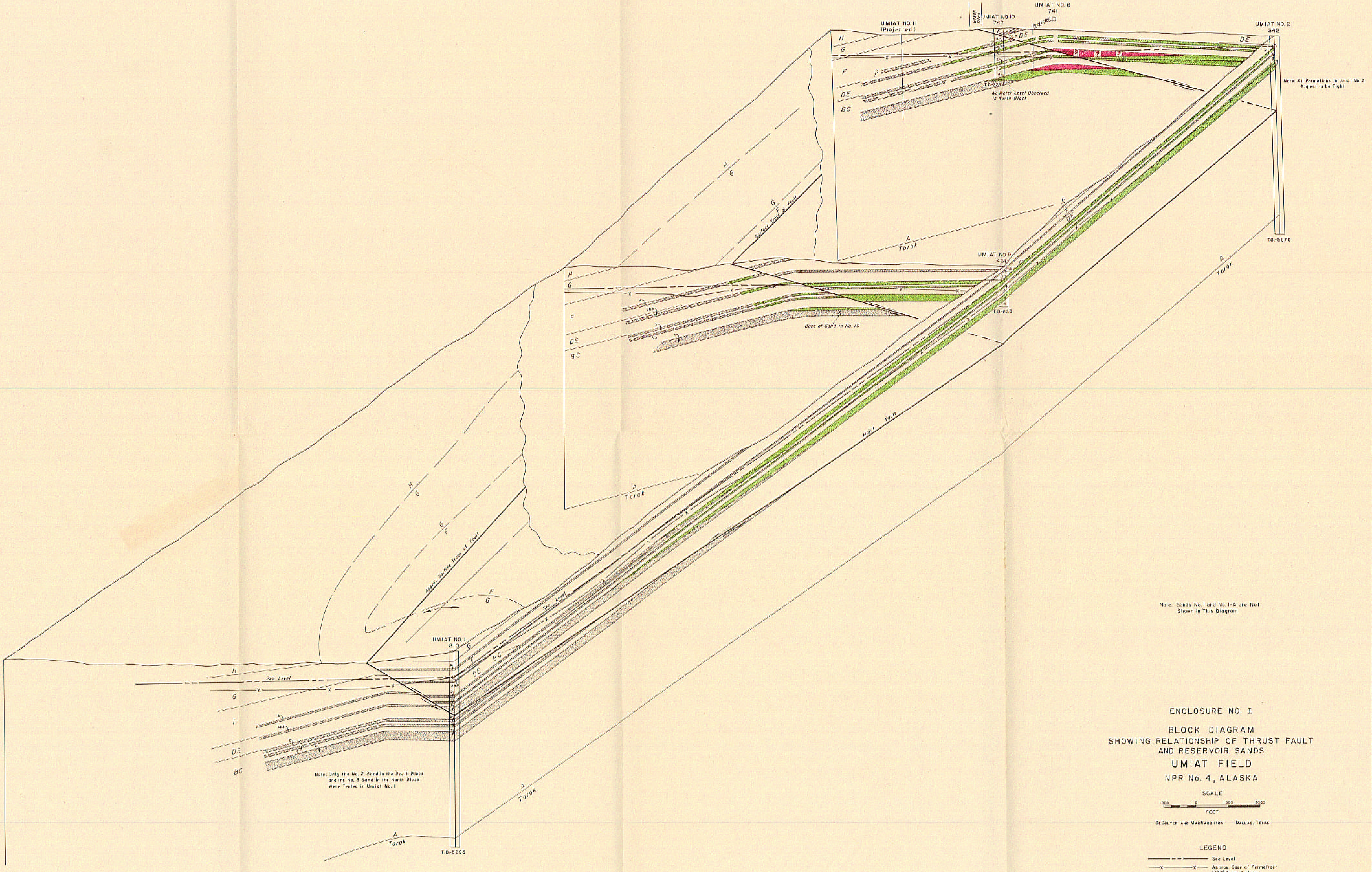
UMIAT FIELD

N.P.R. NO. 4 ALASKA

SCALE

DEGOLYER AND MACNAUGHTON DALLAS, TEXAS

MAY, 1952



ENCLOSURE NO. I

BLOCK DIAGRAM
SHOWING RELATIONSHIP OF THRUST FAULT
AND RESERVOIR SANDS

UMIAT FIELD

NPR No. 4, ALASKA

SCALE

1000 0 1000 2000

FEET

DeGolyer and MacNaughton Dallas, Texas

LEGEND

Sea Level

Approx. Base of Permafrost (600' Below Surface)

Oil

Gas

ENCLOSURE II

TYPE LOG
UMIAT FIELD

N.P.R. NO.4 ALASKA

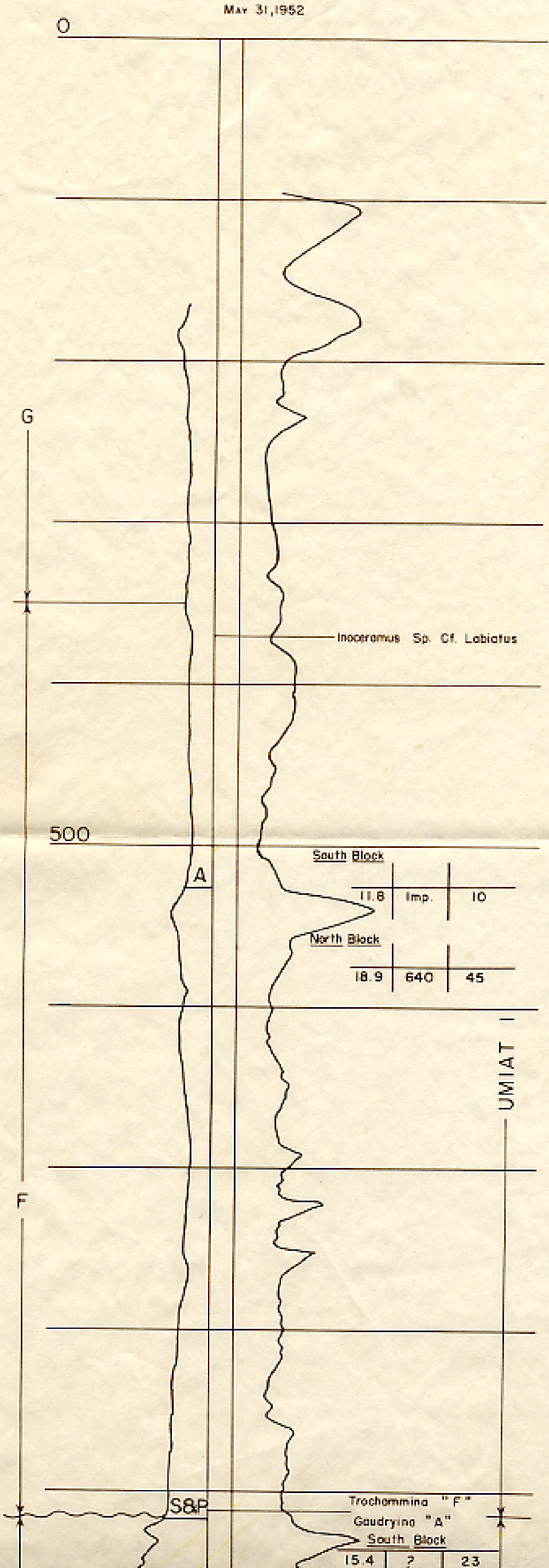
VERTICAL SCALE

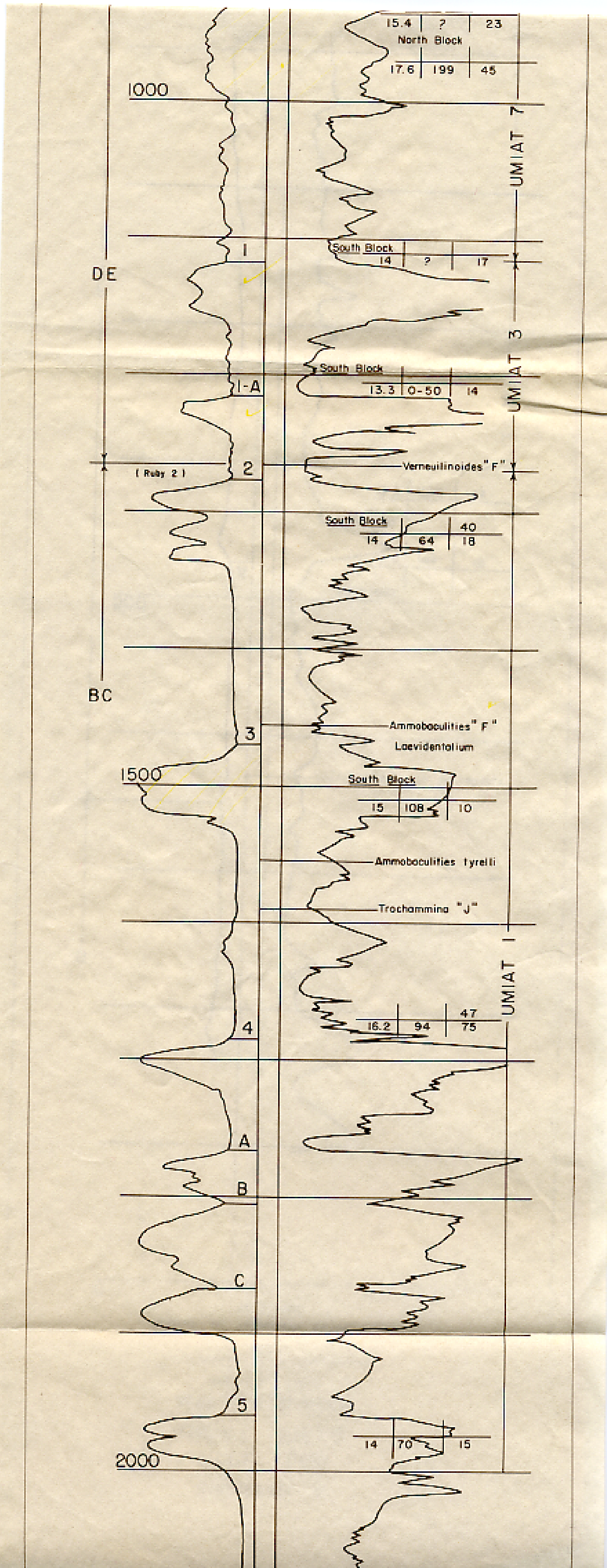
50 0 50 100

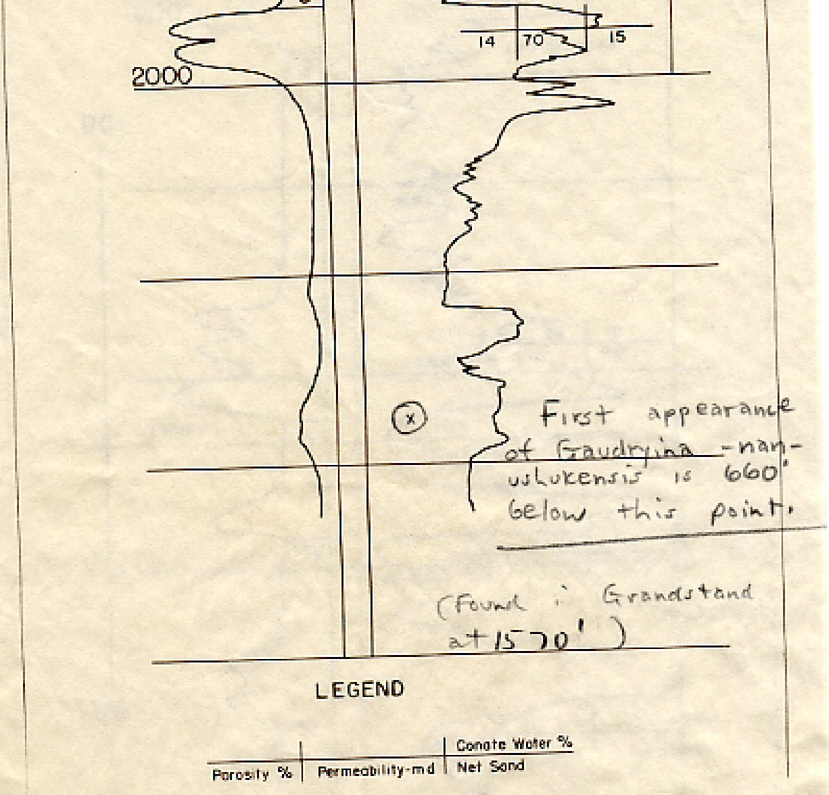
FEET

DeGolyer and MacNaughton Dallas, Texas

May 31, 1952




15.4 ? 23
North Block
17.6 199 45
1000
UMIAT 7
DE
1
South Block
14 ? 17
UMIAT 3
South Block
13.3 0-50 14
1-A
(Ruby 2)
2
Verneuilinoides "F"
South Block
40
14 64 18
BC
3
Ammobaculities "F"
Laevidentalium
1500
South Block
15 108 10
Ammobaculities tyrelli
Trochammina "J"
UMIAT 1
47
16.2 94 75
4
A
B
C
5
14 70 15
2000


2000
14
70
15
First appearance of Gaudryina -nan-uslukensis is 660' below this point.
(Found in Grandstand at 1570')
LEGEND
Connate Water %
Porosity %
Permeability-md
Net Sand

OFFICE OF CHIEF PETROLEUM ENGINEER
Union Oil Company of California

OIL RESERVES OF UMIAT STRUCTURE

REPORT ON GUBIK STRUCTURE

NAVAL PETROLEUM RESERVE NO. 4

ALASKA

Prepared For

DIRECTOR, NAVAL PETROLEUM RESERVES

By

W. S. EGGLESTON AND A. F. WOODWARD
Union Oil Company of California

October 25, 1951

October 25, 1951

Captain Robert H. Meade, CEC, USN
Director, Naval Petroleum Reserves
Mining Exchange Building
1030 Fifteenth Street
Denver, Colorado

SUBJECT: REPORT ON UMIAT AND GUBIK STRUCTURES
NAVAL PETROLEUM RESERVE NO. 4, ALASKA

Dear Sir:

Herewith is presented, in conformance with your instructions, a report as of October 15, 1951 of the extent of the crude oil reserves of the Umiat Structure and as to the oil possibilities of the Gubik Structure, Naval Petroleum Reserve No. 4, Alaska. Pursuant to your request, the Petroleum Engineering Department of the Union Oil Company of California has made an investigation of the crude oil possibilities of the area in question.

A summary of the report is as follows:

UMIAT STRUCTURE

Crude Oil Reserves

As of May 15, 1951, the Petroleum Engineering Department of the Union Oil Company of California made an appraisal of the extent of the crude oil reserves of the Umiat Structure as indicated in the following tabulation.

Estimated Recoverable Oil

(Proved Developed and Undeveloped crude oil reserves but uneconomic at today's prices and costs.) 30,000,000 barrels

Inferred Crude Oil "Reserves"

(Amount of crude oil that might be proved by additional exploratory development of the Umiat Structure, but that as yet has not been demonstrated.) 10,000,000 barrels

Developments subsequent to May 15, 1951 which include the production test of Umiat No. 5, and the drilling and testing of Umiat Nos. 8, 9 and 10 do not materially alter the former estimate. It is concluded that any revision of the estimate of May 15, 1951 would be purely academic and would be well within the limits of error inherent in making estimates of crude oil reserves. This statement applies to the totals and not to the detail of the component parts of the estimate.

(For detail refer to report by A. F. Woodward in the appendix.)

Both Umiat No. 5 and No. 9 indicate that favorable producing conditions exist in the lower sands south of the Umiat fault and below the permafrost zone over an area estimated to include some 2,650 acres.

The success that the operator has had in the use of artificial methods of production would indicate that it may be possible to reach an annual production comparable to oil fields more favorably located in which case a rate of 7,500 barrels per day might be realized for one or two years.

GUBIK STRUCTURE

To date, Gubik No. 1 drilled to a total depth of 6,000 feet and Gubik No. 2, drilling at a depth of 2,400 feet, have penetrated a series of sands in both the Upper and Lower Cretaceous having a net thickness in excess of 500 feet.

Oil Reserves

There is no evidence, to date, to indicate the presence of oil in the Gubik Structure, and it is unlikely that this structure contains oil in producible quantities. The only qualification to this statement applies to the sands in the Lower Cretaceous penetrated by Gubik No. 1 from 3,485 to 3,605 feet from which a gas sample was obtained that analyzed 94.7% methane and 5.3% ethane plus. The high content of methane indicates a dry gas condition in this sand but the lack of definite knowledge as to the composition of the ethane plus leaves some doubt. If the ethane plus includes propane but none of the heavier components such as hexane and pentane, then it is unreasonable to expect producible oil to occur in association with this gas.

Gas Reserves

None of the sands to a depth of 1,500 feet in Gubik No. 1 contain gas in producible quantities, although porous and permeable sands were encountered in the following intervals:

Sands penetrated in Gubik No. 1
to a depth of 1500 feet

Well Depths			
From	To	Total Interval	Net sands
890	940	50'	Sands silty
1065	1156	91	85'
1208	1238	30	30
1267	1345	78	60
1437	1490	53	45
Totals		302'	220'

All of these sands can be eliminated as producible of gas in quantities sufficient for consideration based upon tests in Gubik No. 1 and No. 2.

At depths below 1500 feet Gubik No. 1 penetrated a series of sands which were either cored or indicated on the Schlumberger and were tested in Gubik No. 1 and No. 2 as follows:

	Well Depths		Total	Net	
	From	To	Interval	Sands	Remarks
1)	1575	1630	55'	55'	Tested Gas in Gubik #2
2)	1680	1738	58	50	" " " " #1
	1840	1865	25	20	Test failed
	1903	1945	42	40	Not Tested
3)	3460	3605	145	120	Tested Gas in Gubik #1

In summary then there is positive evidence of gas production in only three sands out of a total of ten sand intervals indicated by coring or Schlumberger log.

An estimate of probable well head gas reserves per acre is as follows:

	Sand Interval From	To	Estimated MCF/Acre
1)	1575	1630	18,500
2)	1680	1738	19,000
3)	3460	3505	29,000
		Total	66,500 M.C.F. per acre

This estimate of gas reserves indicates the amount producible at the well head but is not indicative of commercial availability.

Well productivity, compression requirements, line losses and other intangible factors would all tend to materially reduce this reserve estimate when translated into amount of deliverable gas for commercial use.

It is impossible at this time to make a reasonable estimate of the number of productive acres due to the fact that the structure has only been indicated by seismic means and no data is available as to the areal extent of the sands.

CONCLUSIONS

It is not believed that further development of the Umiat Structure will materially change the present concept in regard to crude oil reserves. Such development would unquestionably change the detail of the estimates but should have proportionately little effect on the total.

Further drilling at Gubik is not likely to prove up any crude oil reserves. Gas analyses available at this time indicate that Gubik is a dry gas structure. If the gas analyses from formation tests in Gubik No. 2 are similar to those from Gubik No. 1 there is little likelihood that producible oil exists in this structure.

Respectfully submitted,

W. S. Eggleston

W. S. Eggleston
Chief Petroleum Engineer

WSE:ejd

APPENDIX

UMIAT STRUCTURE

REPORT BY A. F. WOODWARD

Cross - Section
Contour Maps

GUBIK STRUCTURE

CALCULATION SHEETS ON GAS CONTENT

Cross - Section
Contour Map

NAVAL PETROLEUM RESERVE NO. 4

ALASKA

As of May 15, 1951 a report on the Umiat Structure was submitted in which the details of the sources of information upon which the report was based were outlined.

In addition to the data collected at that time, subsequent reports of drilling and production tests were made available in the Fairbanks, Barrow, Umiat and Oubik offices of the Arctic Contractors.

Approximately two weeks were spent in the Fairbanks-Barrow area from October 1 to 14, 1951.

Well histories, logs, production data and related information obtained has not been included in this report. These data are omitted to avoid unnecessary duplication of facts readily available.

W. S. EGGLESTON

FORM 400 12-50 200M
PRINTED IN U.S.A.

Union Oil Company of California

IN REPLY GIVE NO.

Whittier, Calif. Oct. 25, 1951

Mr. W. S. EGGLESTON, Chief Petr. Engr. At Los Angeles, Calif.

Answering Letter { Date- File-

Att'n

Subject UMIAT STRUCTURE
NAVAL PETROLEUM RESERVE NO. 4
ALASKA

Estimated Reserves, as of October 25, 1951

The Umiat structure has been divided into several areas for the purpose of evaluating the oil sands found in different structural blocks as well as to differentiate between oil sands in the Permafrost Zone and those found below the Permafrost Zone. These areas or "Blocks", as shown on the accompanying maps, are as follows:

Block I	Crest of structure area, south of the Umiat Fault. Upper and Lower Zones in Permafrost.
Block II	South Central Area. Upper Zone in Permafrost and Lower Zone below Permafrost.
Block III	Area north of Umiat ? Fault. "Shallow" Zone and Upper Zone in Permafrost (part of Block may be below Permafrost in Upper Zone).

Estimated Recoverable Oil (Semi-proved, developed and undeveloped)

Block I	2,000 acres	8,440,000 barrels
Block II	2,650 acres	19,917,000 barrels
Block III	375 acres	1,050,000 barrels
		29,407,000 barrels

Umiat No. 8 proved up a limited area of Upper Zone production north of the Umiat ? Fault. The well pumped an average of 60 B/D of 37° gravity oil (clean) for 10 days. The well was deepened into what has been correlated as the upper part of the Lower Zone and tested 5,000 m.c.f. per day of dry gas (north of the fault).

Umiat No. 10 had reached a depth of 1124' on October 15, 1951 and was still drilling at the date of this report. An oil-bearing sand zone was encountered below 625' ("Shallow" sand) and although only 6 feet of actual oil sand was cored from 625' to 730', a productive thickness of 25' or more is suggested from the drillers' log. A 16 hour bailing test at 753' indicated a 96 B/D rate of 37° gravity oil. A second oil sand zone was found from 1061' to 1116'. This sand has been correlated tentatively as the "Upper" Zone. Bailing test at successive well depths of 1095' (27 hours), 1108' (5 hours) and 1124' (15 hours) gave an indicated initial production rate of over 200 B/D combined with the "Shallow" sand. Bailing tests are only comparative and seldom indicate the true productive capacity as established by a sustained pumping test.

The "Shallow" sand (625' - 670') might be rated at 60 B/D and the Upper Zone (1061' - 1116') at 80 B/D. The Upper Zone in Umiat No. 10 area at a depth of 1061', is very probably below the Permafrost Zone and accordingly has been given a slightly higher recovery factor than for the same sands in the Permafrost Zone.

Umiat No. 1, the original test well on this structure, found the Upper Zone oil bearing but extremely "tight". A 23 foot oil sand was cored from 1737'-60' with relatively good permeability. The main part of the Lower Zone, as correlated by R. G. Reese, was uncored and untested. According to Reese, a fault was encountered at ±2050' (presumably the Umiat Fault). Numerous low permeability oil sands were cored below this fault and are very probably a complete repetition of the Upper and Lower Zone north of the Umiat Fault. Gas shows were encountered below the fault in the upper to middle part of the Lower Zone, as correlated by R. G. Reese. This would approximate the same stratigraphic interval as the dry gas zone in Umiat No. 8, but over 1,000' structurally lower than No. 8. If this interpretation is correct, then both wells are north of the Umiat Fault in this interval, and therefore, prospecting for an oil belt down-structure from the Umiat No. 8 gas sand may be disappointing.

Low permeability oil sands were cored in Umiat No. 1 north (?) of the Umiat Fault in the Lower Zone below the gas shows. This might give some encouragement to the theory that oil should be found in the lower part of the Lower Zone at the Umiat No. 8 or Umiat No. 10 locations, however, all core evidence to date indicates an average permeability of 10 m.d. or less in this part of the Lower Zone.

An area unknown of size (designated as Block III) north of the Umiat Fault may prove to be productive in the Upper Zone for a considerable distance in close proximity to the Umiat Fault where the fractured condition of the reservoir rock may improve recovery considerably above the estimated 40 barrels per acre-foot.

The 23 foot oil sand cored in Umiat No. 1 at 1737' with permeabilities of 40 to 75 m.d. is below Permafrost and south of the Umiat Fault. This sand was untested but could be productive over a 300 to 400 acre area along the Umiat Fault, and if combined with some 100 feet of low permeability oil sand found below 2095' in Umiat No. 1, might yield over 1,000,000 barrels of oil (at ±3,500 bbls./acre recovery).

<u>Conclusion</u>:

Unproved prospective reserves of 1,000,000 bbls. for the Umiat No. 1 area added to semi-proved reserves of approximately 29,000,000 bbls. for the balance of the field, gives an estimated total of 30,000,000 bbls.

Very truly yours,

A. F. Woodward
A. F. WOODWARD
Staff Engineer.

AFW:ea
Encls. 2 maps
1 section

VOLUMETRIC ESTIMATES

BLOCK I

Upper Zone (In Permafrost)

Area = 400 acres
Net oil sand = 40 ft.
Estimated Recovery = 40 B/Ac.Ft.

40' x 40 bbls. = 1,600 bbls./acre

400 acres x 1,600 bbls. = 640,000 bbls.

Lower Zone (In Permafrost)

Area = 2,000 acres
Net oil sand = 60 ft.
Estimated Recovery = 65 B/Ac.Ft.

60' x 65 bbls. = 3,900 bbls./acre

2,000 acres x 3,900 bbls. = 7,800,000 bbls.

BLOCK I EST. RESERVES: 8,440,000 bbls.

BLOCK II

Upper Zone (In Permafrost)

Area = 1,020 acres
Net oil sand = 40 ft.
Estimated Recovery = 40 B/Ac.Ft.

40' x 40 bbls. = 1,600 bbls./acre

1,020 acres x 1,600 bbls. = 1,632,000 bbls.

Lower Zone (Below Permafrost)

Area = 2,650 acres
Net oil sand = 60 ft.
Estimated Recovery = 115 B/Ac.Ft.

60' x 115 bbls. = 6,900 bbls./acre

2,650 acres x 6,900 = 18,285,000 bbls.

BLOCK II TOTAL EST. RESERVES: 19,917,000 bbls.

BLOCK III

"Shallow" Sand (Found in Umiat No. 10, 625-730' in Permafrost)

Area = ± 300 acres
Estimated net oil sand = 25 ft.
Estimated Recovery = 40 B/Ac.Ft.

25' x 40 bbls. = 1,000 bbls./acre

300 acres x 1,000 bbls. = 300,000 bbls.

Upper Zone ? (In Permafrost in part of Block)

Area = 375 acres
Estimated net oil sand = 40 ft.
Estimated Recovery = 50 B/Ac.Ft.

40' x 50 bbls. = 2,000 B/acre

375 acres x 2,000 = 750,000 bbls.

Lower Zone

Gas (Reserves not estimated)

BLOCK III TOTAL ESTIMATED RESERVES: 1,050,000 bbls.

Summary of Estimated Reserves

BLOCK I	8,440,000 bbls.
BLOCK II	19,917,000 bbls.
BLOCK III	1,050,000 bbls.
TOTAL	29,407,000 bbls.

A. F. Woodward

A. F. WOODWARD
October 25, 1951

UMIAT STRUCTURE
Naval Petroleum Reserve Nº 4, Alaska
CONTOURS TOP UPPER ZONE
Based on Well Data, Surface Geology, Seismic Dips,
From: U.S.G.S. Report Nº 3 Fig. I by Stefanson & Whittington 1947,
U.S.G.S. Sp. Report Nº 16 Fig. I by Stefanson, Whittington & Keller 1950,
Seismic Dips from Prelim. Map by C.G.H. Feb. 1951 (Col. Kotick's Office.)
Geologic Surface Dips (U.S.G.S.)
Seismic Dips.
Scale 1" = 2000' (1:24,000)
UNION OIL CO. OF CALIFORNIA
EST. UPPER TRACE UMIAT FAULT
EST. LOWER TRACE UMIAT FAULT
Block III (375 Ac.) In Permafrost?
Block I (400 Ac.) In Permafrost
Block II (1020 Ac.) In Permafrost
Possible Permeability Barrier
Edge Water
Average Dip 8°
152°-00'
69°-22'-30"

Est. Upper Trace Umiat Fault
Est. Lower Trace Umiat Fault
Block I (2000 Ac.)
In Permafrost
Block II (2650 Ac.)
Below Permafrost
Fault
Edge Water
Section
152°-10'
152°-05'
152°-00'
69°-22'-30"
UMIAT STRUCTURE
Naval Petroleum Reserve Nº 4, Alaska
CONTOURS TOP LOWER ZONE
Based on Well Data, Surface Geology, Seismic Dips.
From: U.S.G.S. Report Nº 3, Fig. I by Stefansson & Whittington 1947,
U.S.G.S. Sp. Report Nº 16 Fig. I by Stefansson, Whittington & Keller 1950,
Seismic Dips from Prelim. Map by C.G.H. Feb. 1951 (Col. Kotick's Office.)
Scale 1" = 2000' (1:24,000)
UNION OIL CO. OF CALIFORNIA
A. F. WOODWARD 10-24-51
Drawn by

UMIAT STRUCTURE

Naval Petroleum Reserve No 4, Alaska

CROSS SECTION

Showing

UMIAT TEST WELLS Nos 2 THRU 9

Scale 1" = 500'

UNION OIL CO. OF CALIFORNIA

A. F. WOODWARD 10-24-51

Drawn By L. Lee 10-25-51

Appendix October 25, 1951

GUBIK STRUCTURE

The Gubik Structure located approximately 18 miles east of Umiat is an east-west trending structure estimated to contain some 21,000 acres within the closing contour as shown on the attached contour map.

Gubik No. 1 which was drilled near the crest of the structure, cored and logged a series of sands in both the Upper and Lower Cretaceous as shown on the attached cross-section.

The five sand intervals encountered from 890 to 1500 feet were tested in either Gubik No. 1 or No. 2 without successful gas production, although a gas sample was obtained in Gubik No. 1 from 1438 to 1490.

Sands encountered in Gubik No. 1 and No. 2 that could be productive of gas are listed as follows:

	Well Depths Logged By Schl. in Gubik No. 1 From	To	Total Interval	Net Sand Est. from Gubik No. 1 E-log	B.H.P. Measured by J. F. T.	B.H.T. Recorded	Well in which J. F. T. Made
1)	1575	1630	55	55	1000#	77°	Gubik No. 2
2)	1680	1738	58	50	1150#	78° Est.	Gubik No. 1
*	1840	1865	25	20	-	-	Test Failed
*	1903	1945	42	40	-	-	Sands pinch out
3)	3460	3605	145	120	1400#	150° Est.	Gubik No. 1

POROSITY PERMEABILITY & CONATE WATER

Well Depths From	To	Net Sand	Porosity %	Perm. MD	Conate Water
1575	1630	55	Est. 20%	?	Est. 40%
1680	1738	50	Ave. 20	39 Plus	Est. 40%
3460	3605	120	Ave. 12	29 to 265	Est. 40%

* Note: These sands were not tested in Gubik No. 1 but showed up on the Schlumberger. In Gubik No. 2 tests failed and lower sand 1903 to 1945 was missing.

Appendix October 25, 1951

Composition of Gas

Interval		
1433 - 1495	Methane	97.05%
	Ethane	1.25
	Propane +	1.57
	Nitrogen	0.13
1661 - 1738	Methane	97.05%
	Ethane	2.95
3488 - 3519	Methane	94.7%
	Ethane Plus	5.3

CALCULATION OF GAS RESERVES - GUBIK STRUCTURE

1) Sand interval in Gubik No. 1

1575 to 1630 net sand 55' estimated

B.H.P.	1000#
B.H.T.	77°
Deviation Factor	1.15

$$43560 \times .20 \times .6 \times \frac{460 + 60}{460 + 77} \times \frac{1000 + 14.7}{14.7} \times 1.15 =$$

398 M.C.F. per acre foot

estimated recovery factor 85%

398 x .85 x 55 = 18,500 M.C.F. per acre

2) Sand interval in Gubik No. 2

1680 to 1738 net sand estimated 50'

B.H.P.	1150#
B.H.T.	78°
Deviation Factor	1.16

$$43560 \times .20 \times .6 \times \frac{460 + 60}{460 + 78} \times \frac{1150 + 14.7}{14.7} \times 1.16 =$$

459 M.C.F. per acre foot.

estimated recovery factor 85%

459 x .85 x 50 = 19,000 M.C.F. per acre

3) Sand interval in Gubik #1

3460 to 3605 net sand estimated 120'

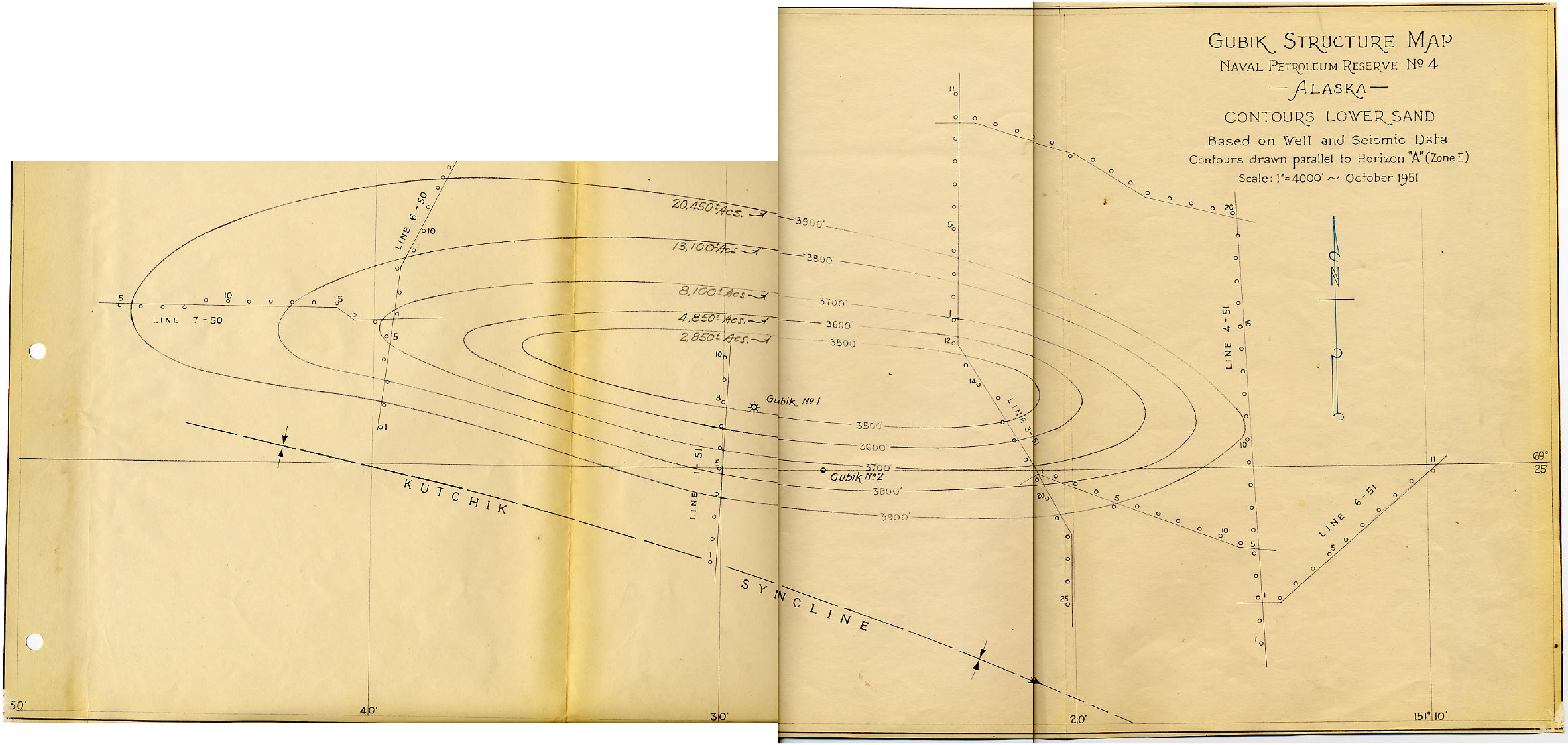
B.H.P.	1400#
B.H.T.	Est. 150°
Deviation Factor	1.11

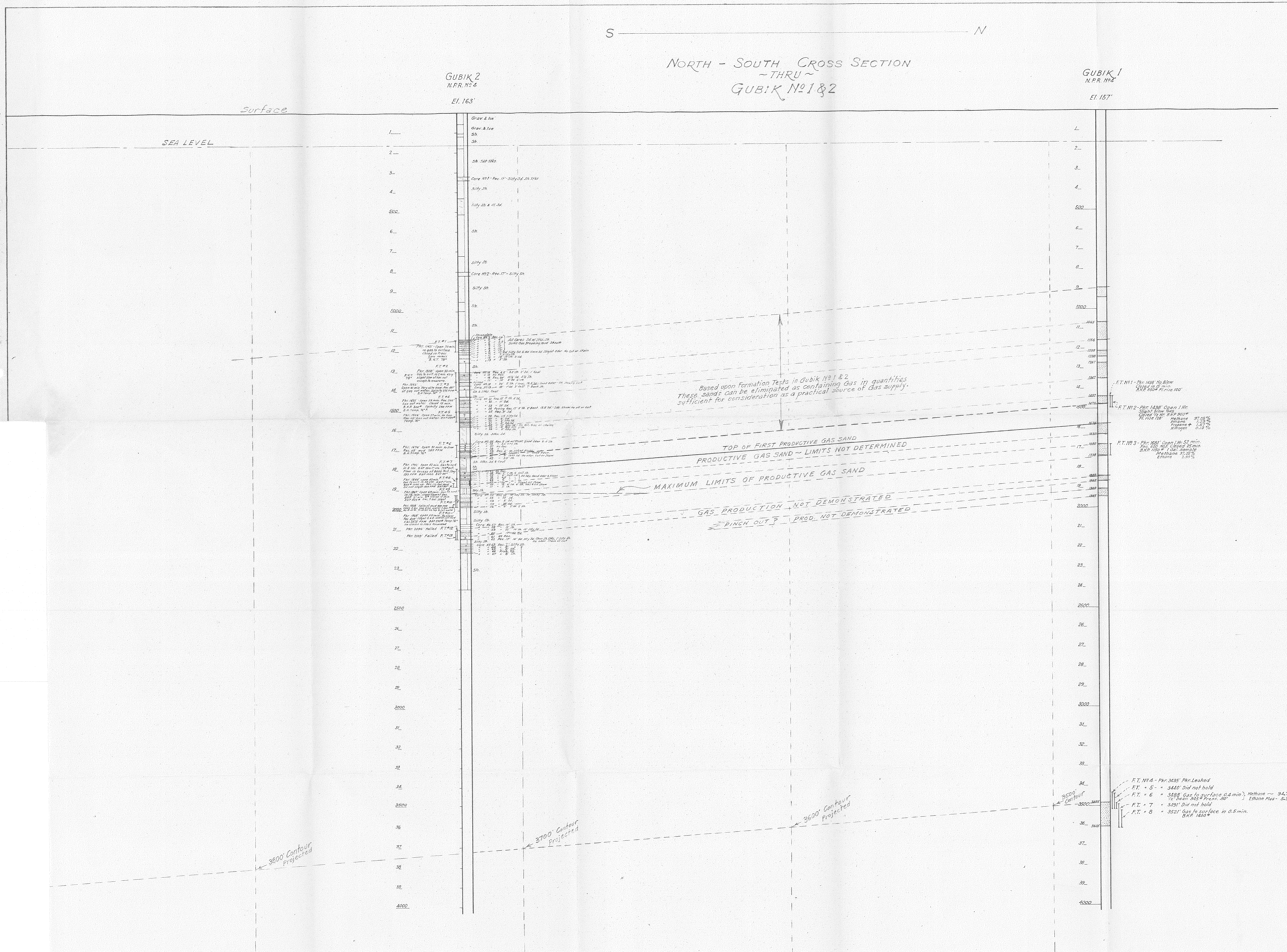
$$43560 \times .12 \times .6 \times \frac{460 + 60}{460 + 150} \times \frac{1400 + 14.7}{14.7} \times 1.11 =$$

284 M.C.F. per acre foot

estimated recovery factor 85%

284 x .85 x 120 = 29,000 M.C.F. per acre


GUBIK STRUCTURE MAP
NAVAL PETROLEUM RESERVE Nº 4
— ALASKA —
CONTOURS LOWER SAND
Based on Well and Seismic Data
Contours drawn parallel to Horizon "A" (Zone E)
Scale: 1" = 4000' ~ October 1951
20,450± Acs.
13,100± Acs.
8,100± Acs.
4,850± Acs.
2,850± Acs.
3900'
3800'
3700'
3600'
3500'
Gubik Nº 1
Gubik Nº 2
LINE 7-50
LINE 6-50
LINE 1-51
LINE 3-51
LINE 4-51
LINE 6-51
KUTCHIK SYNCLINE
N
69°
25'
50'
40'
30'
20'
151° 10'



GUBIK STRUCTURE
NAVAL PETROLEUM RESERVE No 4
—ALASKA—
CROSS SECTION
—THRU—
GUBIK No 1 & 2
SCALE: 1" = 200'

UNION OIL CO. OF CALIFORNIA
OFFICE OF CHIEF PETROLEUM ENGINEER
Drawn by: A.F.N. Oct. 23, 1951

7-15-76

RECOVERABLE PETROLEUM RESERVES IN THE UMIAT STRUCTURE, NAVAL PETROLEUM RESERVE NO. 4 ALASKA

by

Petroleum and Natural Gas Branch,
Bureau of Mines, Department of the Interior

June 1, 1951

Revised January 22, 1952

January 22, 1952

Subject: Revision of Report on Umiat Reserves

Captain Robert H. Meade
Director, Naval Petroleum Reserves
Mining Exchange Building
1030 Fifteenth Street
Denver, Colorado

Dear Captain Meade:

Following the meeting of the Naval Petroleum Reserves No. 4 Operators Committee, at which Mr. George L. Gates presented some results of core analyses from Umiat Well No. 9, we received a letter from Mr. Gates along with data relating to interstitial water in Well No. 9 core samples. Gates sent this information at your request and asked that we let you know what changes in our estimate these data would make.

In December I spent two days in your office and obtained appreciably more information on Well No. 9 with the thought that I wanted to assure myself that the formations in Well No. 9 were correlative to those in the wells upon which the report was based. Unfortunately, I have not had the time to satisfy myself on this and in order not to let the revision of the report hang fire much longer, I am sending you changes in the report that would result from the use of Gates' data. The revisions are prepared as a revised summary, pages 5a, 6a, 7a and 8a corresponding to pages 5, 6, 7 and 8 in the original report and figure 6a corresponding to the original figure 6. These sublettered pages and figure can be made a part of the original report. The new data indicate the reserves will be reduced to 122 million barrels.

Three copies of the revision are enclosed. Two copies will be sent to the Navy Oil Unit, Alaskan Section, U. S. Geological Survey, Washington and single copies will be retained by the Bureau of Mines in Washington and at Laramie. This corresponds to the distribution of the original report.

I am sorry for my delay in replying and I can only hope that it has not inconvenienced you.

Sincerely yours,

/s/ R. H. ESPACH

RALPH H. ESPACH, Chief
Pet. & Nat. Gas Branch

Copy to: George Gryc
R. A. Cattell
Writer
Files

Recoverable Petroleum Reserves in the Umiat Structure,
Naval Petroleum Reserve No. 4.

Summary

From information available as of June 1, 1951, when seven wells had been drilled on the Umiat structure, it can be concluded that a minimum of 100 acres have been proved productive of oil and that from those 100 acres 3-3/4 million barrels of oil could be recovered. A more likely picture of the potentialities of the structure, developed from evaluating the structure in terms of the known conditions as at Section A-A', Figures 1 and 2, reveals 7,000 acres as productive of oil and that from the 7,000 acres 151,000,000 barrels of oil could be recovered. The rate of recovery of this oil would be at a maximum at the time of full development or, according to a plan submitted, 21,333 barrels a day at the end of 6 years as shown in Figure 3. The life of the field would be somewhere between 25 and 50 years depending on the operations employed and economic and other considerations.

1/15/52

As a result of new data, becoming available from analyses of cores from Umiat well 9, a re-evaluation of the reserve picture as given in the June 1, 1951 report was made. All data, excepting "Connate water", bottom of page 5, remained the same. The recoverable reserves, using new connate water contents in the calculations, are 122,000,000 barrels. Pages 1a, 5a, 6a, 7a, and 8a indicate changes made as a result of using Figure 6a, representing the new data. These pages and graph should be added to the original report.

/s/ RALPH H. ESPACH

RALPH H. ESPACH
Bureau of Mines
Laramie, Wyoming

Volume of Oil in Umiat Structure

Figures 1 and 2 and the evaluation of the Ruby 2 sands are the bases for determining the oil in Umiat structure. ↑ Grandstand fm.

Acreages within the several contours are:

-491 to -400	837
-400 to -300	821
-300 to -200	989
-200 to -100	1,169
-100 to sea level	886
sea level to +100	1,028
+100 to +200	1,194
above +200	60
Total	6,984 acres

Surprising uniformity in sand thicknesses and intervals between sands permit the following generalizations for the structure.

Thickness of upper Ruby 2 sand	50 feet
Thickness of middle Ruby 2 sands	25 feet
Thickness of lower Ruby 2 sand	250 feet
Interval between top of upper Ruby 2 sand and top of middle Ruby 2 sands	94 feet
Interval between top of upper Ruby 2 sand and top of lower Ruby 2 sand	390 feet

By making use of all porosity determinations on Ruby 2 sands, (from whatever source) sample logs, Schlumberger logs and Figure 4, the sands were evaluated into good, medium and poor. Because of similarity the middle sands were grouped with the upper sand.

The evaluation is as follows:

		Grade	Porosity	Connate water	Permeability
75 feet of upper and middle sands	17'	good	17%	32%	160 md.
	22'	medium	15%	33%	65 md.
	36'	poor	8%	40%	1 md.
250 feet of lower sand	10'	good	18%	39%	210 md.
	20'	medium	16.5%	42%	100 md.
	151'	poor	12%	54%	5 md.
	57'	poor, not included, gas coming from about 15 feet of this near bottom of the sand			
	12'	Shale breaks, not included			

Oil in place is:

Upper and Middle sands:

17' x 1,319 bbls./acre foot x 70%	=	15,696				
22' x 1,241 bbls./acre foot x 67%	=	18,292				
36' x 621 bbls./acre foot x 52%	=	11,625		45,613		

Lower sands:

10' x 1,396 bbls./acre foot x 61%	=	8,516				
20' x 1,280 bbls./acre foot x 58%	=	14,848				
151' x 931 bbls./acre foot x 46%	=	64,667		88,031		133,644

133,644 x 6,984 acres = 933,370,000 barrels of oil in place, of which only that oil in good and medium grade sands is considered as available for production.

Or 400,546,000 barrels will respond to production procedures and

532,824,000 barrels will not.

Volume of Recoverable Oil in Umiat Structure

By expansion mechanism solely:

1\. 933,370,000 x .000458 (laboratory data) = 427,483 barrels

By gravity drainage solely:
(good and medium sands only of value)

(15,696 + 8,516) bbls/acre x 6,984 acres x .015 = 2,536,449

(18,292 + 14,848) bbls./acre x 6,984 acres x .01 (estimate) = 2,314,498
or 4,851,000 barrels.

By gas expansion solely: (if oil considered gas saturated)
(good and medium sands only of value)

400,546,000 (oil in place to respond to production procedures) x .27 (recovery factor) = 108,147,000 barrels.

This mechanism is very doubtful. See comment regarding Figure 8.

By water drive solely:
(good and medium sands only of value)

This mechanism is considered to be significant. Edge water working thru oil in permafrost provides energy at present wells. Aquifer surrounding Umiat structure large enough to supply energy and water to replace oil produced. Increased energy for increased rates of production could at a later date be furnished by injection of Colville River water into sands, particularly the lower Ruby 2 sand.

Water drive is considered effective to a point in the sand where the temperature is 32° F. (There is reason to consider that the water might be effective to a somewhat lower temperature point in the sand, say 30° F. or 30.5° F., which would permit 100 feet more of structural closure to be flooded by water.)

Subsurface temperatures at Umiat were established in well No. 1 in May, 1946, when 32° F. was determined to be at 900 foot depth (-100' elevation) with a gradient of 1.8° F. per 100 feet of depth and in well No. 6 in Jan. and May, 1951, when 32° F. was determined to be at 757 foot depth (420' elevation) with a gradient of 1.55° F. per 100 feet of depth. These data support the view that the 32° F. temperature plane over the Umiat structure will be an undulating one more or less paralleling the topography. From superimposing the topography over the structure map of Figure 1, these generalizations can be derived:

For upper and middle Ruby 2 sands 32° F. will be found at, or the edge water will drive to,

- the -400' contour wherever the surface elevation is below +400 feet.
- the -300' contour wherever the surface elevation is between 400 and 500 feet.
- the -200' contour wherever the surface elevation is between 500 and 600 feet.
- the -100' contour wherever the surface elevation is above 600 feet.

For lower Ruby 2 sand 32° F. will be found at, or the edge water will drive to, the same elevations as for the upper and middle sands but when these elevations on the lower sand are projected up to the upper sand, or contours of Figure 1, they become,

- the 0' contour wherever the surface elevation is below 400 feet
- the +100' contour wherever the surface elevation is between 400 and 500 feet
- the +200' contour wherever the surface elevation is between 500 and 600 feet.

From these considerations the area in the upper and middle sands that will permit water to move up into it is essentially that between the -200' to -400 contours, up to the -100' contour at Umiat Mountain and at the hill northwest of the air strip and the whole area west of 152° 15' or a total of 1,848 acres.

In a similar manner the area in the lower sand that will permit water to move up into it is essentially that of the whole structure with exception of 350 acres along Seabee Creek and above the 0 contour of Figure 1 or a total of 6,984 -350 or 6,634 acres.

The recoverable oil in the upper and middle Ruby 2 sands is:

(15,696 + 18,292) barrels x 1,848 acres x .55 (recovery factor) = 34,545,403

The recoverable oil in the lower Ruby 2 sand is:

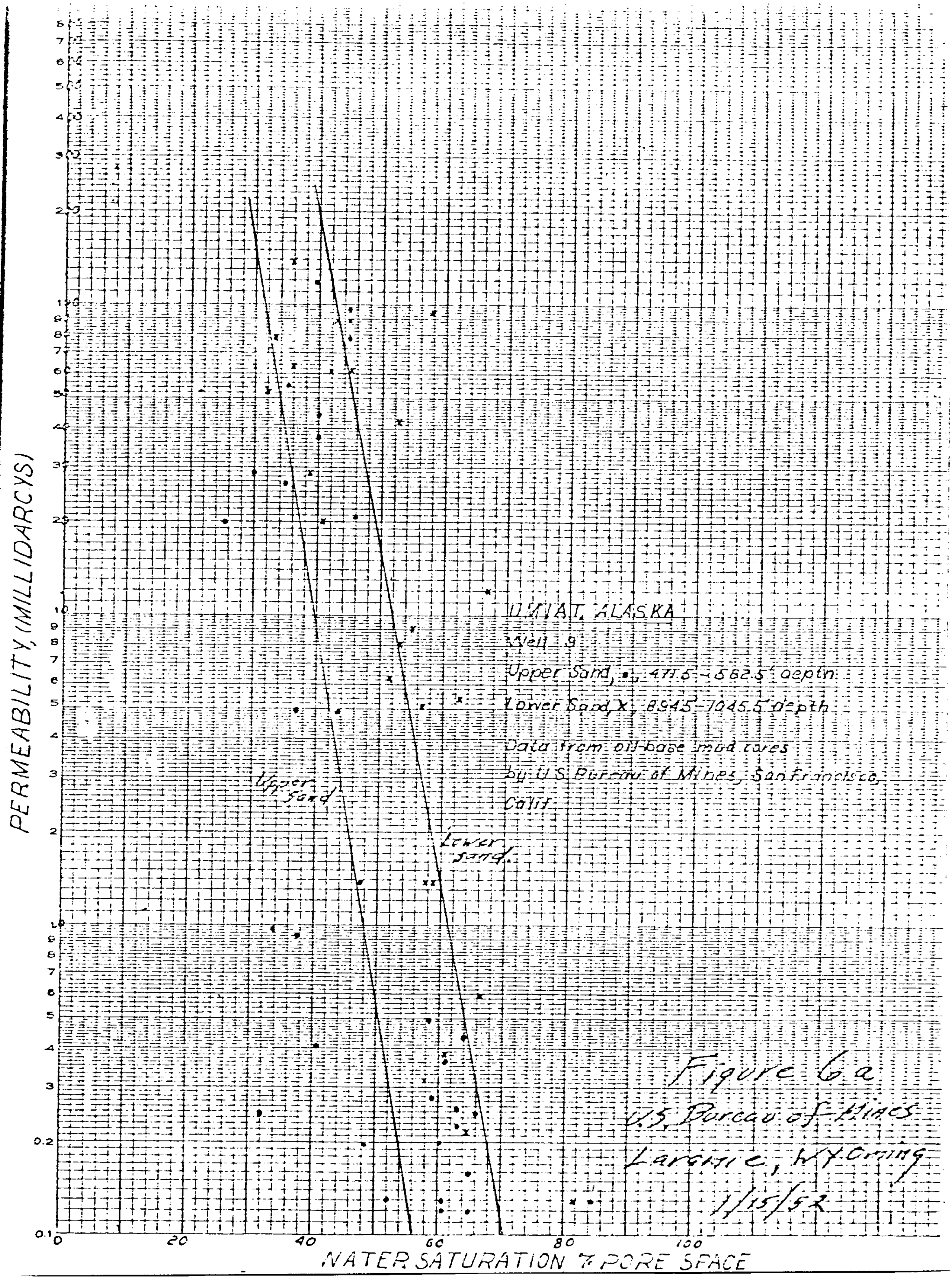
(8,516 + 14,848) barrels x 6,634 acres x .55 (recovery factor) = 85,248,227

Total recovery in all Ruby 2 sands by water drive is 119,794,000 barrels.

When water drive becomes ineffective in upper and middle sands, some gravity drainage can be effective in these sands while the lower sand is being water driven to exhaustion. This volume of oil will amount to:

(6,984 - 1,848) acres x 15,696 barrels x .015 = 1,209,220
(6,984 - 1,848) acres x 18,292 barrels x .010 = 939,477
or a total of 2,149,000 barrels by gravity drainage.

Total recoverable oil from structure equals 122,000,000 barrels.


PERMEABILITY, (MILLIDARCYS)
WATER SATURATION % PORE SPACE
UMIAT, ALASKA
Well 9
Upper Sand, •, 471.5 - 862.5' depth
Lower Sand, x, 894.5 - 1045.5' depth
Data from oil-base mud cores
by U.S. Bureau of Mines, San Francisco, Calif.
Upper Sand
Lower Sand
Figure 6a
U.S. Bureau of Mines
Laramie, Wyoming
1/15/52

Recoverable Petroleum Reserves in the Umiat Structure,
Naval Petroleum Reserve No. 4.

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Data and Information Developed from Laboratory Study of Cores from Wells 2 and 3

Samples were taken from cores stored at Fairbanks, Alaska to evaluate the Ruby 2 sands. Samples from cores from well No. 3 were used for the upper and middle Ruby 2 sands and samples from cores from well No. 2 were used for the lower Ruby 2 sand. Considerations relating to core recovery at time of drilling and core condition at time of sampling make the exact location of the samples not as finite as might be inferred from the location as given. The samples, their location, and porosity and permeability data that were later developed are given in the following table:

	Depth, feet	Porosity, percent	Permeability of cleaned plugs, md.	By visual inspection graded as
Well No. 3				
Upper sand	259	16.2	77	medium
do	274	8.6	0.5	poor
Middle sand	352	16.8	133	good
do	355	16.0	54	medium
Well No. 2				
Lower sand	796	18.6	291	good
do	797-1/2	17.0	77	good
do	805	16.9	127	medium
do	824	no plug cut from sample		good
do	831	14.4	22	poor

The Ruby 2 sands were evaluated by using the number of feet of good, medium and poor sand in each well (when possible to do so) and using appropriate porosity and permeability values for these gradings. The gradings as shown in the last column of the above table were given the samples at the time of sampling.

The 9 samples were analyzed and special tests performed, the results of which provided the data for Figures 4 to 7 inclusive.

Recovery factors were developed using pieces of Ruby 2 sand, graded as medium, or good, about 1-1/2" in diameter and several inches long. The factors are:

	Percent
By solution gas (oil saturated with gas to 100 p.s.i.) (at 26°F.)	27
By gas drive (following depletion by solution gas) (at 26°F.)	23
By water drive (at 70°F.)	57
By water drive (at 26°F.) estimated	55
By gravity drainage (at 70°F.)	1.6
By gravity drainage (at 26°F.) estimated	1.5

Figure 4 shows that a relationship does exist between porosity and permeability (air) for the Ruby 2 sands.

Figure 5 shows the relationship between permeabilities as determined on dry cleaned core plugs and cleaned plugs containing minimum water saturation (or connate water) for Ruby 2 sands.

Figure 6 shows the amount of water saturation to be expected according to the permeability of Ruby 2 sands.

Figur 7 shows the number of feet of Ruby 2 sand of various permeabilities required to give a yield of a given number of barrels of oil a day. Assumptions used were; 20 acre spacing, 7" hole, 5.9 cp. of oil viscosity (Umiat oil at 26°F.) and 100 pounds differential pressure.

Data and Information Developed from Laboratory Study of Crude Oil from Well No. 4

Coefficient of expansion at 25°F. = 4.58×10^{-6} vol./vol./p.s.i. or oil in reservoir will expand .000458 barrel for each barrel in the reservoir due to a drop in pressure of 100 pounds.

Figure 8, gas-in-solution curve, shows how much gas is necessary to saturate Umiat oil to various pressures. This has bearing on what might be expected as to the volume of gas that would be produced if the Umiat oil were gas saturated. The one gas analysis available from well No. 2 would indicate that a dry gas had bubbled up thru an oil column and that it was not gas that had been in solution in Umiat oil.

Figure 9 shows how the viscosity of Umiat oil changes with temperature. The line indicating change may be extended to lower temperatures.

Volume of Oil in Umiat Structure

Figures 1 and 2 and the evaluation of the Ruby 2 sands are the bases for determining the oil in Umiat structure.

Acreages within the several contours are:

-491 to -400	837
-400 to -300	821
-300 to -200	989
-200 to -100	1,169
-100 to sea level	886
sea level to +100	1,025
+100 to +200	1,194
above +200	63
Total	6,984 acres

Surprising uniformity in sand thicknesses and intervals between sands permit the following generalizations for the structure.

Thickness of upper Ruby 2 sand	50 feet
Thickness of middle Ruby 2 sands	25 feet
Thickness of lower Ruby 2 sand	250 feet
Interval between top of upper Ruby 2 sand and top of middle Ruby 2 sands	94 feet
Interval between top of upper Ruby 2 sand and top of lower Ruby 2 sand	390 feet

By making use of all porosity determinations on Ruby 2 sands, (from whatever source) sample logs, Schlumberger logs and Figure 4, the sands were evaluated into good, medium and poor. Because of similarity the middle sands were grouped with the upper sand.

The evaluation is as follows:

		Grade	Porosity	Connate water	Permeability
75 feet of upper and middle sands	17'	good	17%	22%	160 md.
	22'	medium	18%	27%	65 md.
	36'	poor	8%	57%	1 md.
250 feet of lower sand	10'	good	18%	19%	210 md.
	20'	medium	16.5%	25%	100 md.
	151'	poor	12%	45%	5 md.
	57'	poor, not included, gas coming from about 15 feet of this near bottom of the sand			
	12'	Shale breaks, not included			

Oil in place is:

Upper and Middle sands:

17' x 1,319 bbls./acre foot x 78% = 17,490				
22' x 1,241 bbls./acre foot x 73% = 19,930				
36' x 621 bbls./acre foot x 43% = 9,613				
	47,033			

Lower sand:

10' x 1,398 bbls./acre foot x 81% = 11,308		
20' x 1,280 bbls./acre foot x 75% = 19,200		
151' x 931 bbls./acre foot x 55% = 77,320		
	107,828	
		154,861

154,861 x 6,984 acres = 1,081,549,000 barrels of oil in place, of which only that oil in good and medium grade sands is considered as available for production.

Or 474,409,000 barrels will respond to production procedures

and 607,140,000 barrels will not.

Volume of Recoverable Oil In Umiat Structure

By expansion mechanism solely:

1,081,549,000 x .000458 (laboratory data) = 495,349 barrels

By gravity drainage solely:
(good and medium sands only of value)

(17,490 + 11,303) bbls./acre x 6,984 acres x .015 = 3,016,878

(19,930 + 19,200) bbls/acre x 6,984 acres x .01 (estimate) = 2,732,839
or 5,730,600 barrels.

By gas expansion solely: (if oil considered gas saturated)
(good and medium sands only of value)

474,409,000 (oil in place to respond to production procedures) x .27
(recovery factor) = 128,090,000 barrels.

This mechanism is very doubtful. See comment regarding Figure 8.

By water drive solely:
(good and medium sands only of value)

This mechanism is considered to be significant. Edge water working thru oil in permafrost provides energy at present wells. Aquifer surrounding Umiat structure large enough to supply energy and water to replace oil produced. Increased energy for increased rates of production could at a later date be furnished by injection of Colville River water into sands, particularly the lower Ruby 2 sand.

Water drive is considered effective to a point in the sand where the temperature is 32°F. (There is reason to consider that the water might be effective to a somewhat lower temperature point in the sand, say 30°F. or 30.5°F., which would permit 100 feet more of structural closure to be flooded by water.)

Subsurface temperatures at Umiat were established in well No. 1 in May, 1946, when 32°F. was determined to be at 900 foot depth (-100' elevation) with a gradient of 1.8°F. per 100 feet of depth and in well No. 6 in Jan. and May, 1951, when 32°F. was determined to be at 757 foot depth (-420' elevation) with a gradient of 1.55°F. per 100 feet of depth. These data support the view that the 32°F. temperature plane over the Umiat structure will be an undulating one more or less paralleling the topography. From superimposing the topography over the structure map of Figure 1, these generalizations can be derived:

For upper and middle Ruby 2 sands 32°F. will be found at, or the edge water will drive to,

the -400' contour wherever the surface elevation is below 400 feet.
the -300' contour wherever the surface elevation is between 400 and 500 feet.
the -200' contour wherever the surface elevation is between 500 and 600 feet.
the -100' contour wherever the surface elevation is above 600 feet.

For lower Ruby 2 sand 32°F. will be found at, or the edge water will drive to, the same elevations as for the upper and middle sands but when these elevations on the lower sand are projected up to the upper sand, or contours of Figure 1, they become,

the 0' contour wherever the surface elevation is below 400 feet
the +100' contour wherever the surface elevation is between 400 and 500 feet
the +200' contour wherever the surface elevation is between 500 and 600 feet.

From these considerations the area in the upper and middle sands that will permit water to move up into it is essentially that between the -450' to -400 contours, up to the -100' contour at Umiat Mountain and at the hill northwest of the air strip and the whole area west of 152°15' or a total of 1,848 acres.

In a similar manner the area in the lower sand that will permit water to move up into it is essentially that of the whole structure with exception of 350 acres along Bearpaw Creek and above the 0 contour of Figure 1 or a total of 6,984 -350 or 6,634 acres.

The recoverable oil in the upper and middle Ruby 2 sands is:

(17,490 + 19,930) barrels x 1,848 acres x .55 (recovery factor) = 38,033,688.

The recoverable oil in the lower Ruby 2 sand is:

(11,308 + 19,200) barrels x 6,634 acres x .55 (recovery factor) = 111,314,539.

Total recovery in all Ruby 2 sands by water drive is 149,348,000 barrels.

When water drive becomes ineffective in upper and middle sands, some gravity drainage can be effective in these sands while the lower sand is being water driven to exhaustion. This volume of oil will amount to:

(6,984 - 1,848) acres x 17,490 barrels x .015 = 1,347,430

(6,984 - 1,848) acres x 19,930 barrels x .010 = 1,023,604

or a total of 2,371,000 barrels by gravity drainage.

Total recoverable oil from structure equals 151,000,000 barrels.

Rate of Production at Umiat

Plan of development: 20 acre spacing or 350 wells (but before all drilled edge locations will be watered out). Possibility of using less wells, for example a 3 or 4 well wide ring of wells around sea level contour, may have merit but would reduce rate of take. Wells can be expected to produce 75 barrels a day from upper, middle and lower sands, half of this from the upper and middle sands and half from the lower sand. This shown by tests of present wells and by sand evaluations and use of Figure 7.

One drilling unit should complete a minimum of 6 wells a year. The use of 10 units would permit 60 completions a year.

Electrically driven pumping units might be expected to operate 320 days a year or each well produce 320 x 75 or 24,000 barrels a year.

With this plan the field would be developed in 6 years, followed by a period of 8 years of water drive on all sands, followed by a period of 10 years of water drive on the lower sand but gravity drainage on the upper and middle sands and followed by a period of water drive on the lower sand. The length of this last period will depend on whether energy is added to the sand to increase the 100 pounds available at present and maintained up to this last period. Figure 3 shows what might be expected in the production history of the field.

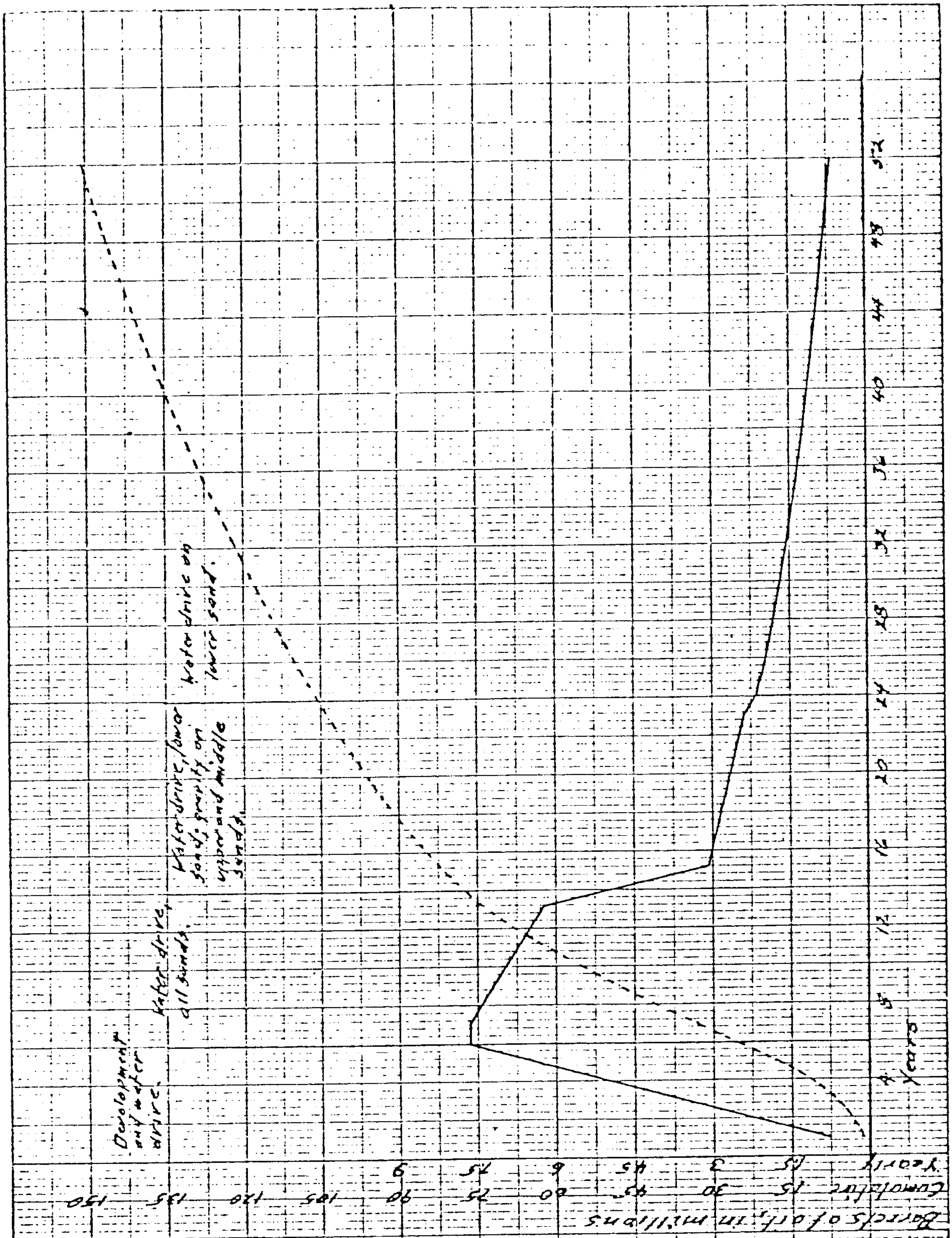


Figure 3
U.S. Bureau of Mines
Laramie, Wyoming
6/1/51

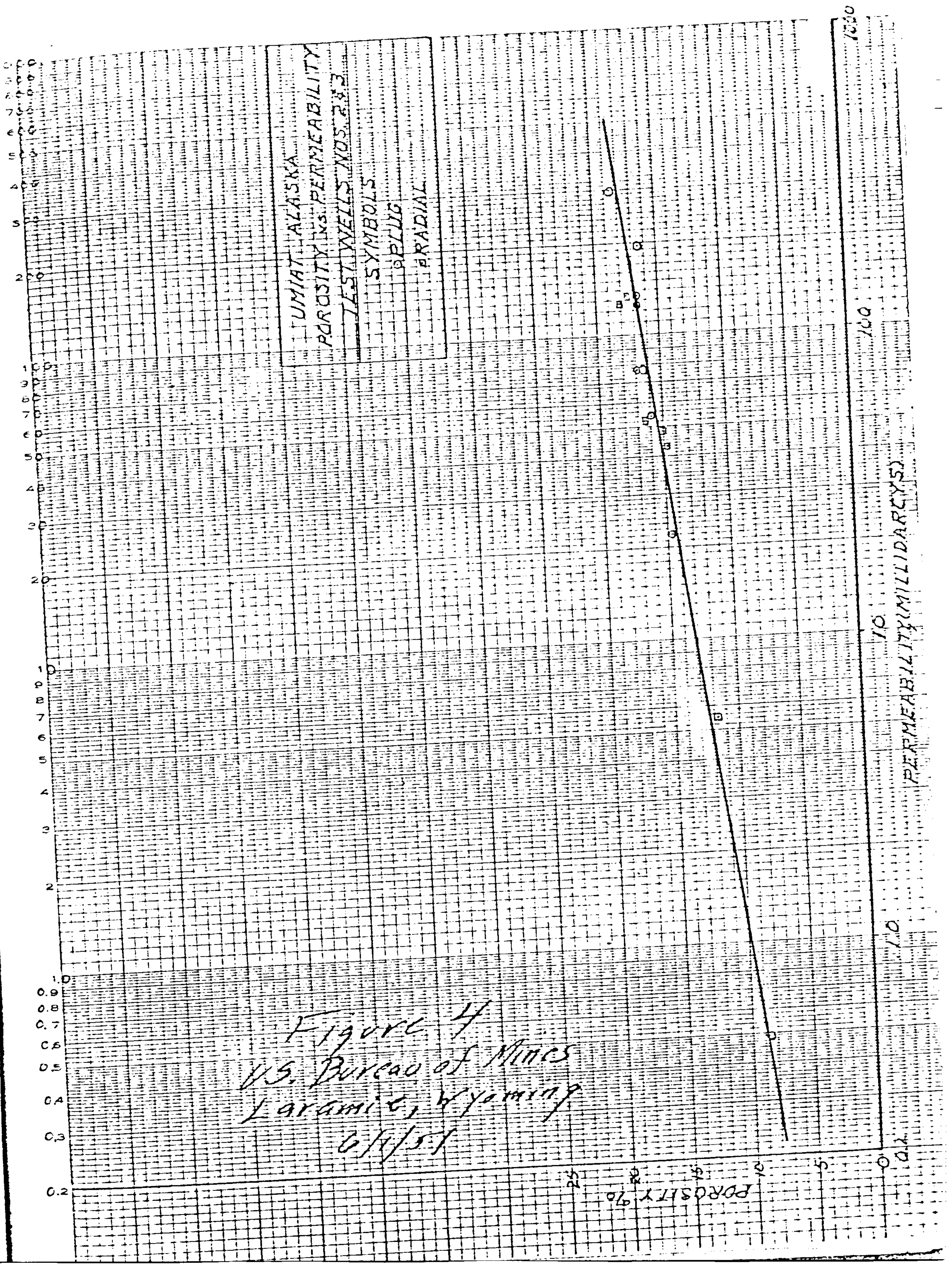
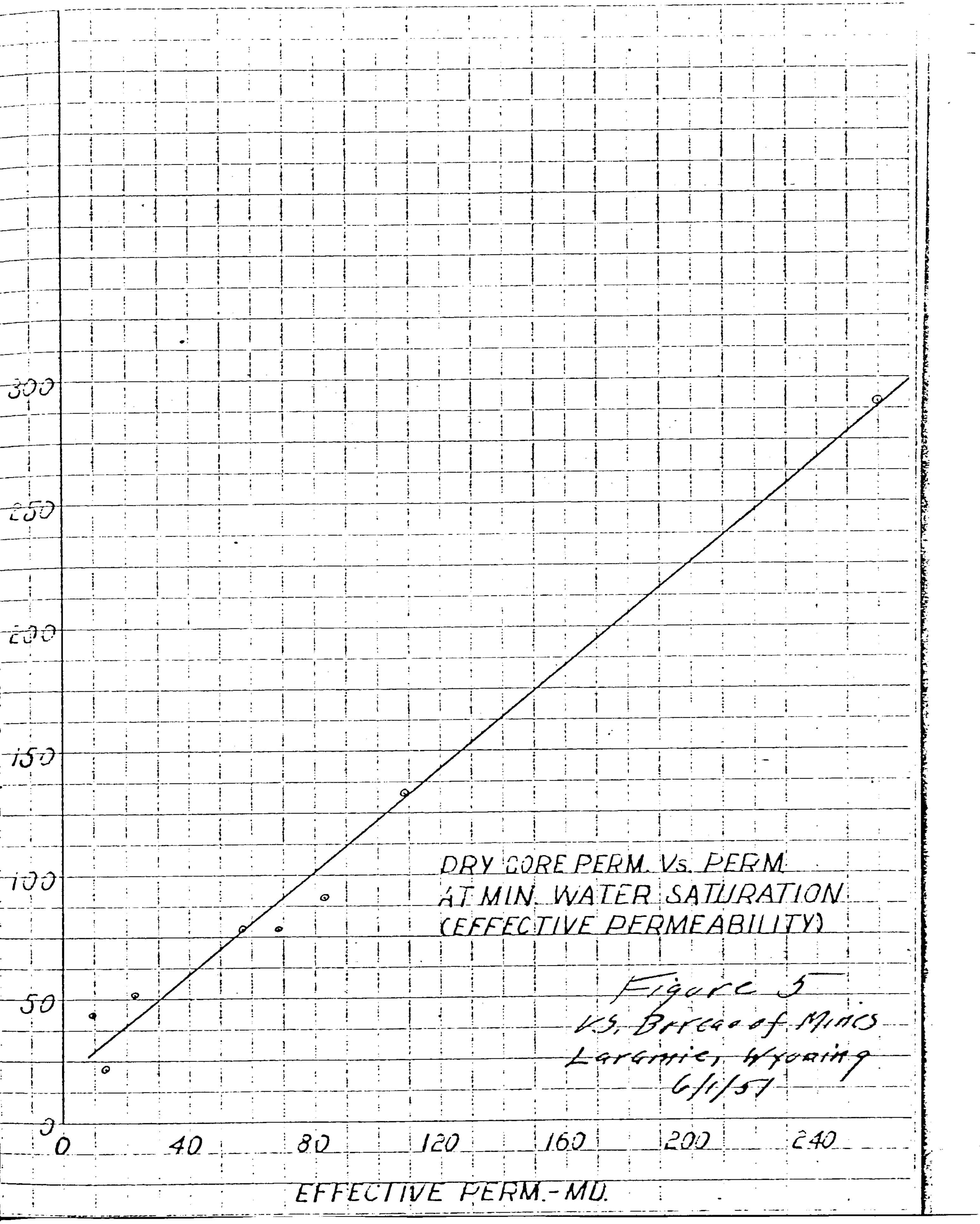
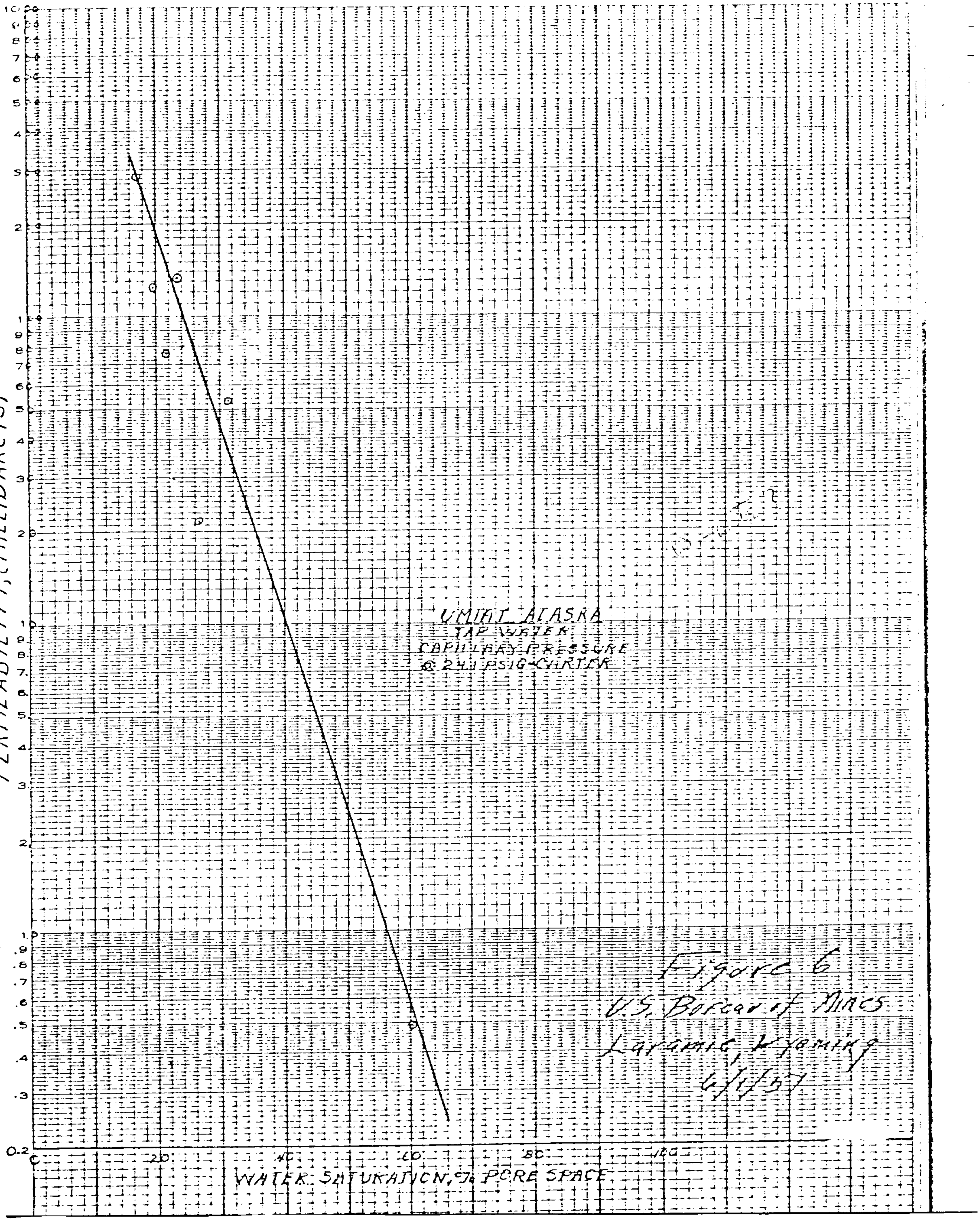


Figure 4
U.S. Bureau of Mines
Laramie, Wyoming
6/1/51


300
250
200
150
100
50
0
0
40
80
120
160
200
240
DRY CORE PERM. Vs. PERM AT MIN. WATER SATURATION (EFFECTIVE PERMEABILITY)
Figure 5
U.S. Bureau of Mines
Laramie, Wyoming
6/1/51
EFFECTIVE PERM.-MD.


UMIAT, ALASKA
TAP WATER
CAPILLARY PRESSURE
@ 241 PSIG-CARTER
WATER SATURATION, % PORE SPACE
Figure 6
U.S. Bureau of Mines
Laramie, Wyoming
6/1/57

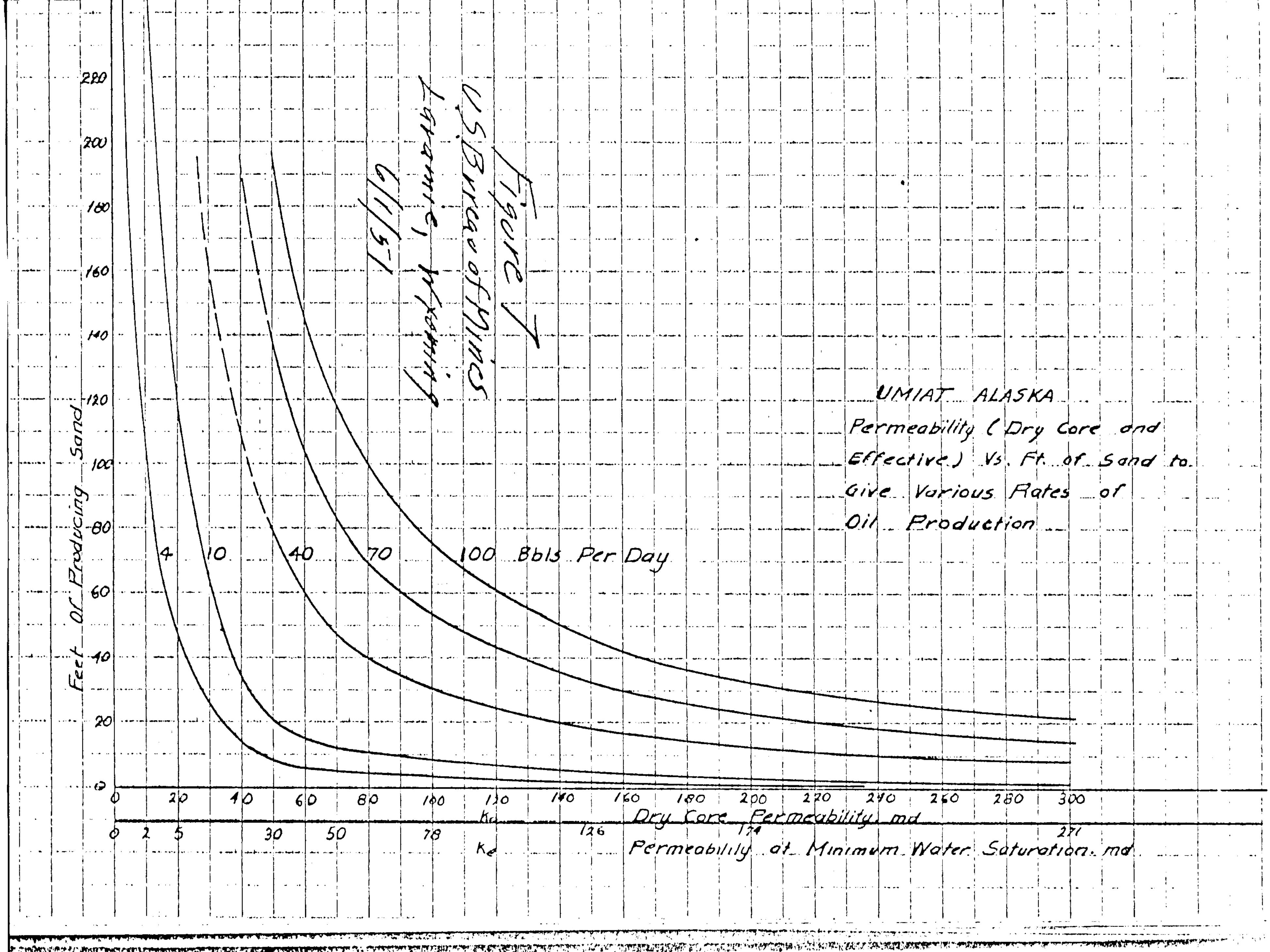
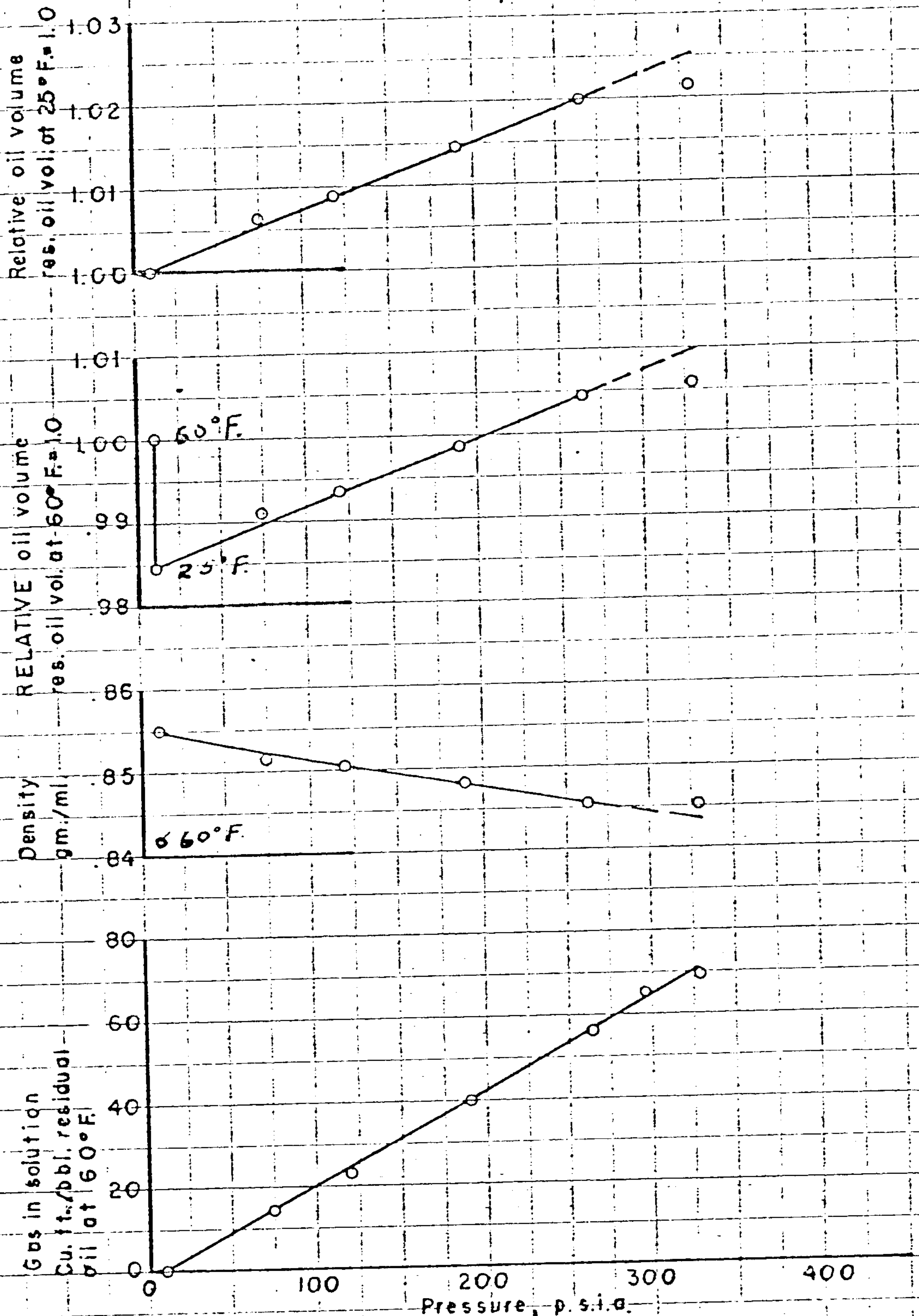
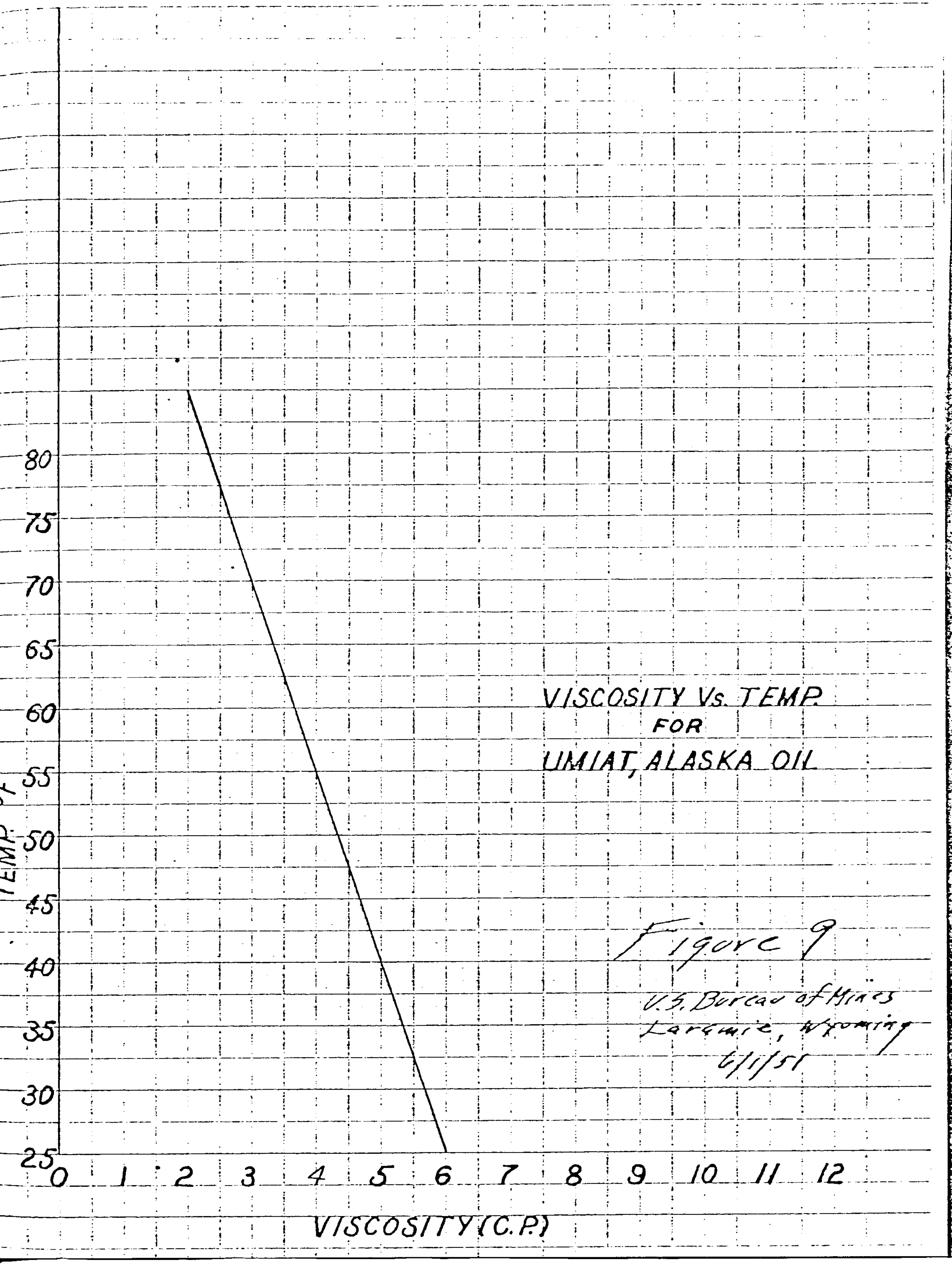


Figure 7
U.S. Bureau of Mines
Laramie, Wyoming
6/1/51
UMIAT ALASKA
Permeability (Dry Core and Effective) Vs. Ft. of Sand to Give Various Rates of Oil Production
4
10
40
70
100 Bbls Per Day
Feet Of Producing Sand
0
20
40
60
80
100
120
140
160
180
200
220
Dry Core Permeability, md
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300
Kd
Permeability at Minimum Water Saturation, md
0 2 5 30 50 78 126 174 271
Ke



RESULTS OF DIFFERENTIAL LIBERATION AT 25° F., RECOMBINED OIL SAMPLE WITH LINE GAS FROM UMIAT FIELD, ALASKA

Figure 8
U.S. Bureau of Mines
Laramie, Wyoming
6/1/51


VISCOSITY Vs. TEMP.
FOR
UMIAT, ALASKA OIL
TEMP. °F
80
75
70
65
60
55
50
45
40
35
30
25
0
1
2
3
4
5
6
7
8
9
10
11
12
VISCOSITY (C.P.)
Figure 9
U.S. Bureau of Mines
Laramie, Wyoming
6/1/51

NOTE:
The area to the north of dotted line is not included in the area of the potential reservoir because of the possibility of a fault existing along the north side of the structure at the location of the sharp flexure.

NOTE:
It is recognized that a transverse fault many in the area of Seabee Creek. However, its signific in relation to the volumetric contents of the reserv any, is minor, and is disregarded in the estimatior potential reservoir.

MAP OF UMIAT STRUCTURE

Scale – 1" = 2,000'

Datum – approximately sea level.
Contours – based on top of black "paper" shale member of zone 'F' but projected to top of upper Ruby 2 sand, using 1,000' interval.
Geology – by K. Stefansson, C.L. Whittington, S. Keller and T.G. Roberts, United States Geological Survey,

CROSS SECTION A-A', UMIAT STRUCTURE

Scale—horizontal—1" = 300'
vertical —1" = 100'

Log of wells 2 to 7 inclusive transposed to plane of section A-A'.

Well 1 is a composite well log derived from the repeated portions of this well and located as though the top of the upper Ruby 2 sand were transposed to the plane of section A-A'.

Cross section developed from map of Umiat structure and sample log of the wells, both by the United States Geological Survey.

For report on oil reserves at Umiat by Bureau of Mines
U.S. Dept. of the Interior, 6/1/51
Figure 2

WELL PRODUCTIVITY RELATED TO DRILLING MUDS: UMIAT FIELD, NAVAL PETROLEUM RESERVE NO. 4, ALASKA

By George L. Gates and W. Hodge Caraway

* * * * * * * * * * * report of investigations 5706

UNITED STATES DEPARTMENT OF THE INTERIOR
Fred A. Seaton, Secretary

BUREAU OF MINES
Marling J. Ankeny, Director

This publication has been cataloged as follows:

Gates, George L

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WELL PRODUCTIVITY RELATED TO DRILLING MUDS: UMIAT FIELD, NAVAL PETROLEUM RESERVE NO. 4, ALASKA 1/

by

George L. Gates 2/ and W. Hodge Caraway 2/

INTRODUCTION AND SUMMARY

This report presents an evaluation by the Federal Bureau of Mines of the effect of clay-water, brine, and oil-base drilling fluids on the productivity of test wells drilled on the Umiat anticline in U.S. Naval Petroleum Reserve No. 4 in northern Alaska. Eleven wells were drilled on the Umiat structure as part of the U.S. Navy's extensive exploration of the Reserve during 1944-53 to determine the possibilities for oil production. The Federal Geological Survey cooperated in the exploration program and has published a comprehensive report3/ on the geology of the area and case histories of the wells. The report also includes the results of special studies by the Bureau in connection with the drilling and coring of well 9 with oil-base mud in the hole and was the source of much of the information used in preparing this publication.

Of the eleven wells, four were drilled with rotary tools and water-base mud (one of the water-base muds was an oil-in-water emulsion mud), five were drilled with cable tools with brine in the hole, one was drilled with cable tools with brine in the hole and later reamed with rotary tools and crude oil, and one was drilled with rotary tools and oil-base mud. Although all of the wells penetrated sandstones that contained oil and gas, some were productive and others were not. The latter two wells, one completed with crude oil in the hole (with some added brine) and the other with oil-base mud, had the greatest productive capacities. The wells drilled with cable tools and brine in the hole had lower productive capacities. In contrast, two of three wells completed with rotary methods and fresh-water drilling mud and the well completed with rotary and emulsion mud were unproductive.

ACKNOWLEDGMENTS

Grateful acknowledgment is made to members of the Alaska Branch of the Federal Geological Survey, headed by George O. Gates, who supplied helpful information used in preparing this report.

1/ Work on manuscript completed November 1959.
2/ Petroleum engineer, Bureau of Mines, San Francisco, Calif.
3/ Collins, Florence Rucker, Bergquist, Harlan R., Brewer, Max C., and Gates, George L., Test Wells, Umiat Area, Alaska: Geol. Survey Prof. Paper 305-B, 1958, pp. 71-206.

GENERAL DESCRIPTION OF THE AREA

The Umiat area (fig. 1) is in the southeastern part of the Reserve on the Arctic slope. The arctic slope is bounded on the south by the crest of the Brooks Range and on the north by the Arctic Ocean. The Brooks Range, the Alaskan counterpart of the Rocky Mountains, comprises several groups of rugged, glaciated mountains having a relief of 3,000 to 6,000 feet and maximum altitudes of 3,600 to 9,200 feet. Anaktuvuk Pass (2,200 feet) is the highest elevation on the land route between Fairbanks and the Arctic plain.

The Arctic coastal plain is characterized by abundant lakes, swampy areas, wet tundra, meandering streams and--during the summer--hordes of hungry mosquitoes. Local relief rarely exceeds 100 feet; however, the surface of the Umiat anticline is marked by a maximum relief of about 500 feet.

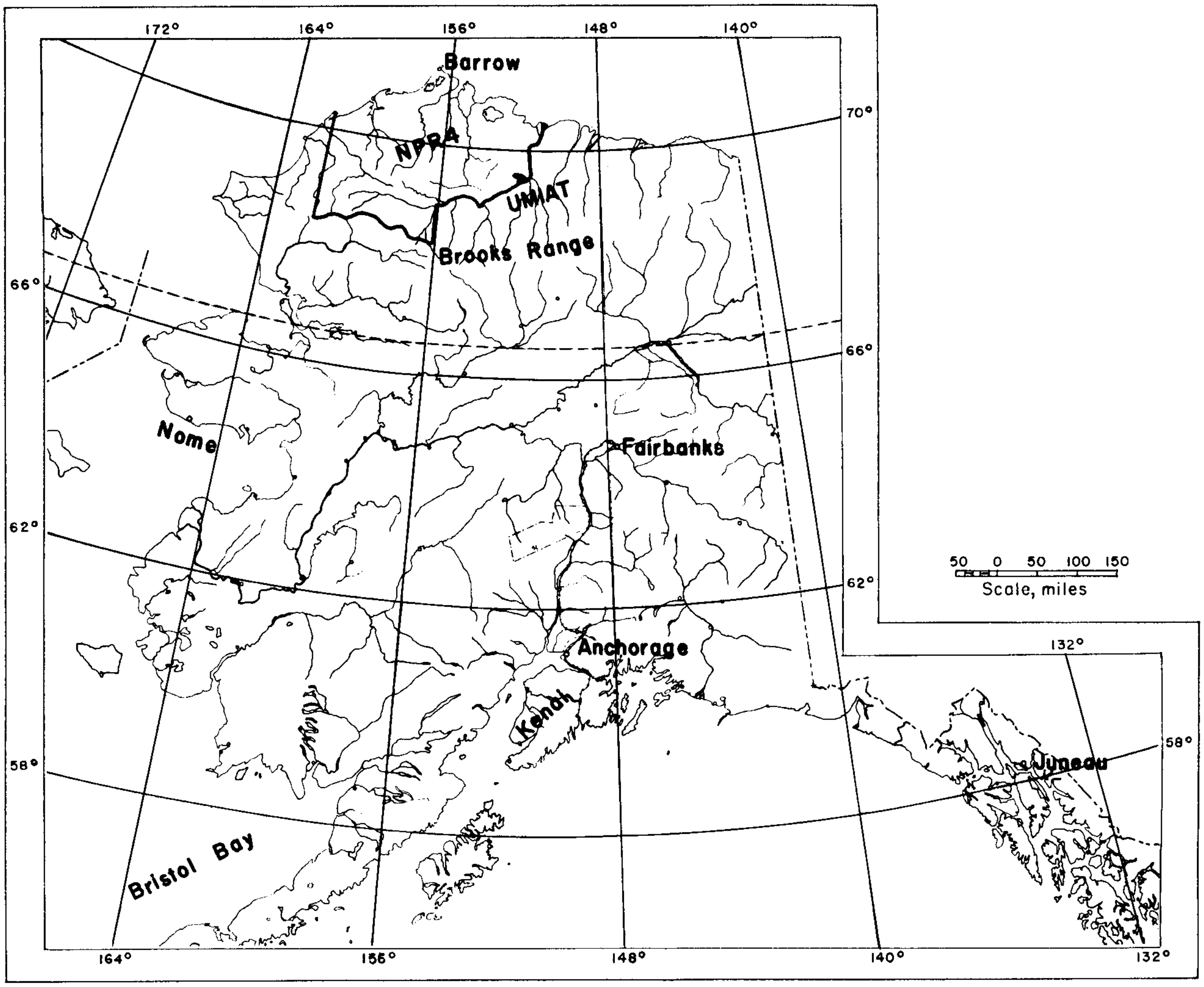


FIGURE 1. - Umiat Field and Naval Petroleum Reserve No. 4 in Northern Alaska.
(Adapted From Federal Geological Survey Outline Map.)

The Umiat anticline is about 150 miles southeast of Point Barrow (fig. 1). The anticline is about 10 miles long, 3 miles wide; the axis trends east and west and the structure has more than 800 feet of closure. It is the highest part in a structural trend extending many miles beyond the limits of the closed anticline and its limits were defined by field and photogeologic mapping. Seismic data on the region are also available.

The oil-productive sand in this area is the Grandstand formation of Cretaceous age. Most of this formation is within the designated zone of continuous permafrost. It is not known that all of the producing formation is colder than the freezing temperature of the interstitial brine. Nearly water-free oil, produced from this sandstone, indicates that the interstitial water is virtually immobile.

Climate

The climate on the Arctic slope is cloudy, cold, and sometimes windy. The annual mean temperature is 10.8° F. at Umiat. The maximum recorded temperature at Umiat is 79° F. and the minimum is -57° F. At Barrow the warmest month, July, has an average of 13 days with freezing temperatures. Mean annual precipitation is 5.4 inches at Umiat. Half of the precipitation is derived from rainfall during July, August, and September. Annual snowfall is about 33 inches at Umiat. Low temperatures, high humidities, and cloudy skies minimize the rate of evaporation and tend to conserve the small total precipitation for surface and ground-water supplies. In contrast to northern Alaska precipitation, the average annual precipitation in southeastern Alaska is about 100 inches.

Length of Day

At the Arctic Circle on the shortest day of the year the sun touches the southern horizon at noon, then drops from sight. Below the Arctic Circle the sun rises a correspondingly longer time, but farther north it stays below the rim of the horizon on this day. For instance, on December 21 at Fairbanks, about 2.5 degrees south of the circle the sun rises at 9:58 a.m. and sets at 1:40 p.m. At Barrow, about 4 degrees north of the circle, the sun is not seen from late November until late January. In summer the length of the days is the reverse of the winter.

Vegetation

The Arctic slope lies beyond the northern limit of the spruce. Small willows and scattered alders grow along the channels of some of the streams in the southern part of the region. Tundra consisting primarily of dwarf shrubs, grasses, sedges, lichens, and herbaceous plants cover a large part of the other areas.

Permafrost

One of the important characteristics of the region to be considered in drilling and producing operations is the permafrost. This area of subground-level ice is discussed in detail by Hopkins, Karlstrom, and others.4/

Permafrost has been defined by Muller5/ as "a thickness of soil or other surficial deposit or even of bedrock, at a variable depth beneath the surface of the earth in which a temperature below freezing has existed continuously for a long time (from two to tens of thousands of years)."

The four permafrost zones in Alaska (fig. 2) are not rigidly defined and their boundaries are arbitrarily drawn. The ground is perennially frozen nearly everywhere in the continuous-permafrost zone; unfrozen ground is found only at a few widely scattered sites. As shown in figure 2, the Umiat area is entirely within the continuous-permafrost zone. Perennially frozen ground is less widely distributed in the discontinuous-permafrost zone, and areas of unfrozen ground predominate in the southern part. In the sporadic-permafrost zone perennially frozen ground is confined to isolated sites where vegetation, topography, soil, and drainage permit its continued existence or its formation. Permafrost also is encountered locally in the no-permafrost zone, but it is so rare that it has little influence on the landscape or human activities.

Permafrost is affected locally by subsurface drainage and surface insulation. In the rigorous climate of northern Alaska local differences in these conditions generally result only in differences in the depth to permafrost. Permafrost is affected by lakes, ponds, and streams which have appreciable heat capacity.

Permafrost is present nearly everywhere beneath the Arctic slope of Alaska. Frozen ground generally extends to a depth of about 1,000 feet in this area. The permafrost lies at considerable depth or may be absent under major rivers, such as the Colville, which flows throughout the winter and has flood plains several thousand feet wide. Permafrost also lies at considerable depth or is absent beneath most lakes deeper than 8 feet and wider than 2,000 feet.

Geothermal Gradients

The geothermal profile or depth-temperature relation in well 6 is shown in figure 3. This survey was made by the Federal Geological Survey by placing thermistor cables in the bore for a period of about one year (10 months) after completion and abandonment of the hole.

4/ Hopkins, David M., Karlstrom, N. V., and others, Permafrost and Ground Water in Alaska: Geol. Survey Prof. Paper 264-F, 1955, pp. 113-146.

5/ Muller, S. W., Permafrost or Permanently Frozen Ground and Related Engineering Problems: J. W. Edwards, Inc., 1947, 231 pp.

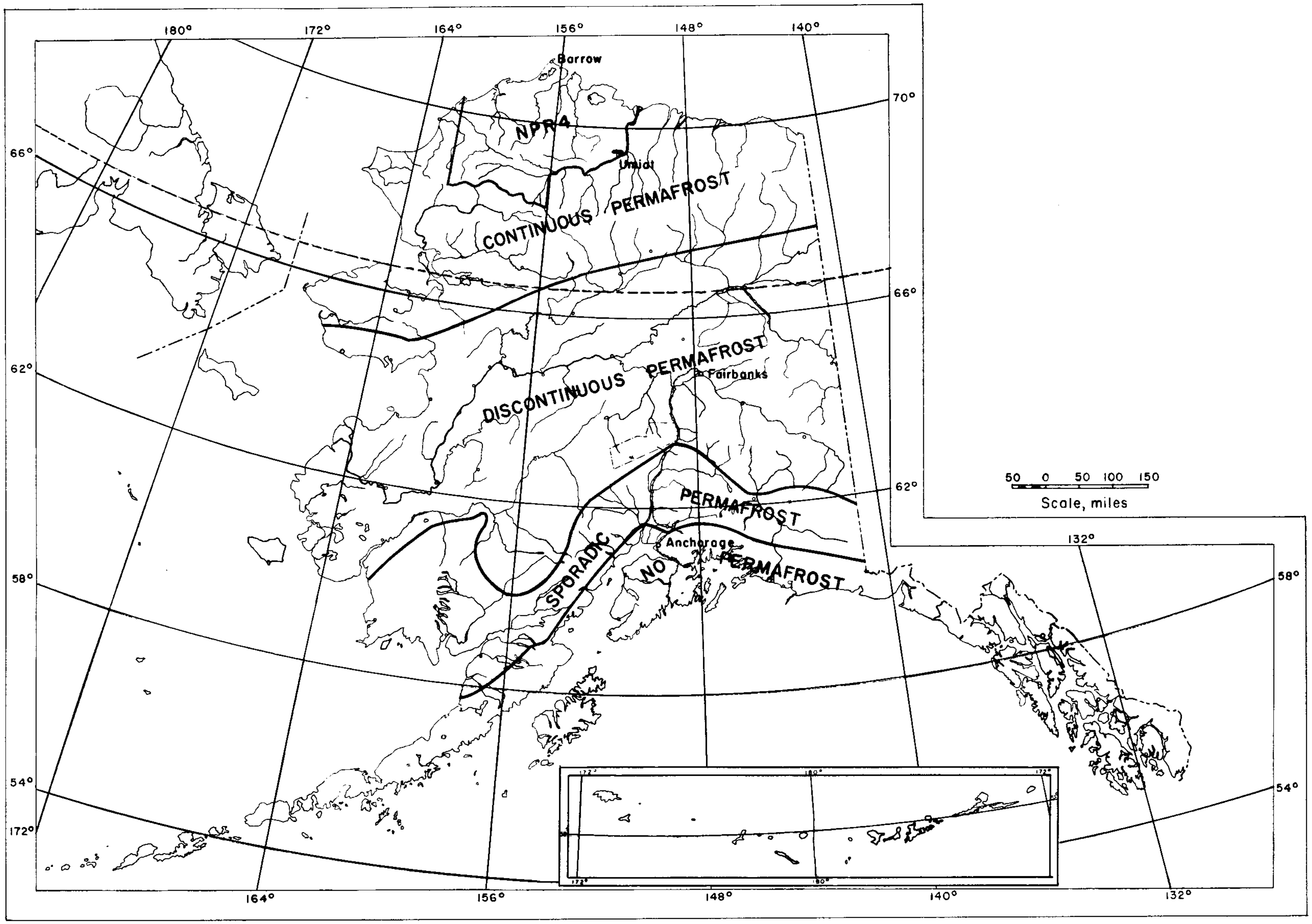


FIGURE 2. - Permafrost Zones in Alaska, Showing Location of Naval Petroleum Reserve No. 4 and Umiat Field.

(Adapted From Federal Geological Survey Prof. Paper 264-F.)

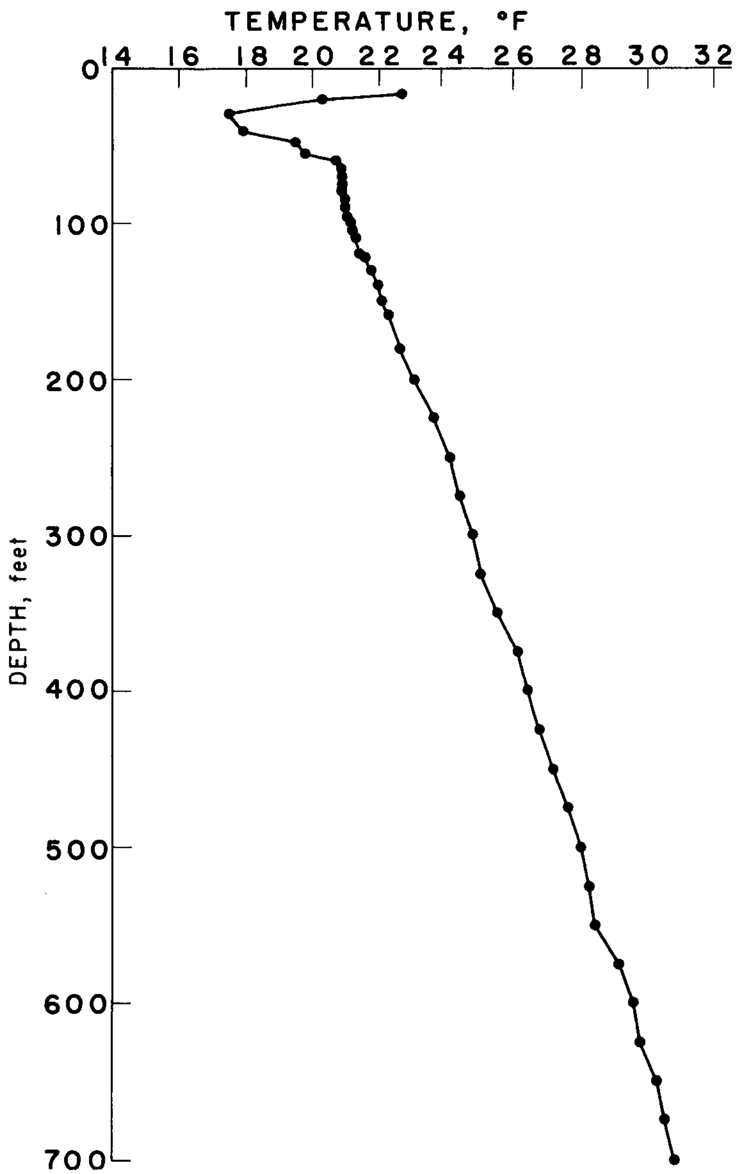


FIGURE 3. - Temperature-Depth Relation in Permafrost Zone of Well 6 (data from Geol. Survey).

The geothermal gradient in well 9 shows an increase of 1° C. per 135 feet (1.33° F. per 100 feet) of depth from approximately 100 to 870 feet. This is the largest gradient found in the Umiat area. The geothermal gradient at wells 4 and 6 is approximately 115 feet per degree Centigrade (1.56° F. per 100 feet) for similar depths.

A short extrapolation of the thermal profile in well 9 on Oct. 13, 1953 indicated a depth of permafrost of 1,055 feet. This thickness of permafrost is approximately 150 feet greater than that found at any of the other Umiat wells where temperature measurements have been made.

A Schlumberger temperature survey was run in well 2 when the final electrical log was run. The lowest recorded temperature was 40.5° F. at 260 feet. Above that depth the temperature was about 42° F. It fluctuated slightly around 43° F. between 310 and 525 feet and increased gradually with depth to 104° F. at 6,198 feet. These well temperatures are higher than the undisturbed temperatures found in a temperature study in a well drilled near Barrow, Alaska.6/ The warming of the formations is the result of friction developed in the drilling operation and the circulation of relatively warm mud during drilling.

The method used to obtain the temperatures has been described by Brewer.7/

6/ Lachenbruch, Arthur H., Brewer, Max C., Dissipation of the Temperature Effect of Drilling as Well in Arctic Alaska: Federal Geological Survey Bull. 1083-C, 1959, 109 pp.

7/ Brewer, Max C., Some Results of Geothermal Investigations of Permafrost in Northern Alaska: Trans. American Geophysical Union, vol. 39, No. 1, Feb. 1958, pp. 19-26.

The first U.S.S.R. oil deposits in permafrost were found in Nordvik, Siberia, where the permafrost was 540 meters (1,770 feet) deep and the rock temperature was -12.7° C. (+9.2° F.) at a depth of 56-60 meters (184-197 feet).8/

Transportation

Development of this area is greatly dependent on air travel. Point Barrow has a hard-surfaced airstrip and Umiat has a gravel airstrip. Lakes suitable for float planes are not abundant, however, a few such lakes are in the area. Ships can reach Point Barrow about three months of the year.

Tracked vehicles such as weasels are suitable for use in this region. In the winter sleds pulled by tractors on tracks are well suited for hauling equipment in the Arctic Coastal plain and the Arctic foothills when the ground is covered with snow.

DRILLING AND COMPLETION DATA ON TEST WELLS

The eleven wells drilled are considered in groups to point out important differences in drilling and completion practices that could have affected the productivity of the wells. A map of the well locations is shown in figure 4.

Water-Base Mud Completions--Wells 1, 2 and 3

The first and least productive group, comprising wells 1, 2, and 3, were drilled with rotary tools using water-base drilling mud. Well 1 was drilled about 5 miles west of 2 and 3, and oil-bearing formations were logged in each well. Formation tests were made either by bailing or running a packer on 2-1/2-inch tubing and swabbing. Wells 1 and 2 were dry and well 3 produced oil at a rate of about 24 barrels per day.

Evidence of the presence of petroleum in formations penetrated by these three holes was observed during drilling. Additional evidence of oil and gas in well 2 was obtained when the hole was being prepared for a temperature survey after it had been drilled to 6,212 feet. The Grandstand formation was found between 365 and 1,060 feet in this hole. Preparatory to the temperature survey, well 2 was bailed to 950 feet. When the blowout preventers were removed a small gas flow was noted. In preparation for a gas-flow test the hole was found to contain liquid at 730 feet. The hole was bailed to 1,075 feet and the gas flow, as measured by means of a Pitot tube and a water manometer, was estimated at 15,000 cubic feet per day. The gas contained 82 percent methane, 16 percent heavier hydrocarbons, and 1.7 percent carbon dioxide. Natural gas containing such a large quantity (16 percent) of hydrocarbons heavier than methane generally is associated with crude oil in the formation.

8/ Lappo, V. I. (Petroleum Occurrence in Nordvik (ÎURUNG-TUMUS): Neftîanoe mestorozhdenie Nordvik (Îûrung-Tumus): Nedra Arktiki, vol. 1, 1946, pp. 74-129.

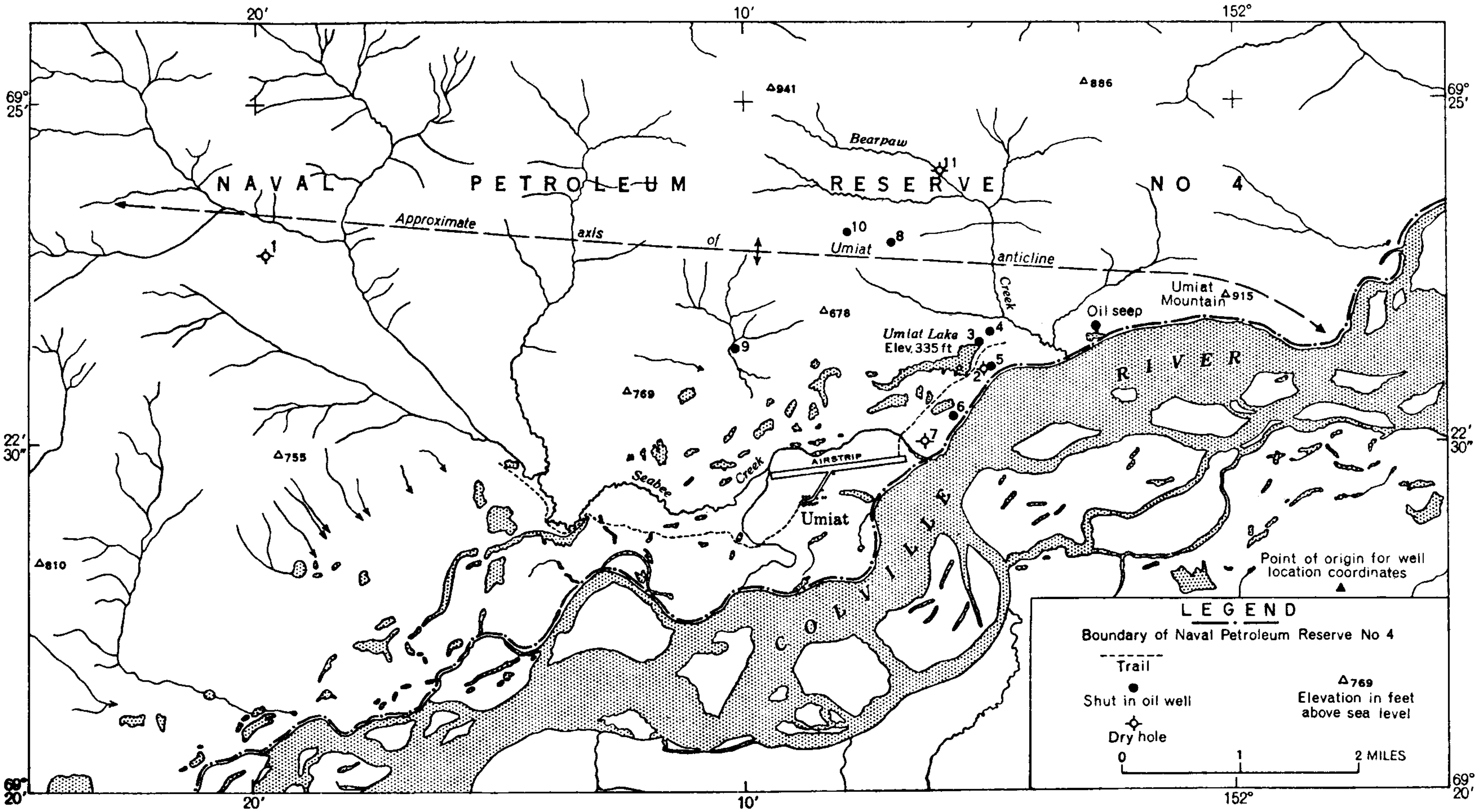


FIGURE 4. - Well Location Map, Umiat Field, Alaska.
(Adapted From Geol. Survey Prof. Paper 305-B, Test Wells, Umiat Area, Alaska.)

Well 2 is of particular interest because of its proximity to well 5 which had good productivity. This relationship is discussed in detail later in this report.

Description of Reservoir Rocks

A study[9/] of thin sections from cores from these wells showed that the fine Graywacke sandstone was not well sorted and that it was composed primarily of angular quartz grains. Authigenic illite was present, surrounding and partly replacing some quartz grains as coatings or elongate masses. An X-ray diffraction pattern of the material through 325-mesh sieve showed that it was composed of quartz and illite with small amounts of montmorillonite, albite, kaolinite, and chlorite. The pore space was lined with a thin coating of clay minerals, mostly illites.

Drilling Mud

The drilling mud used in wells 1, 2, and 3 was a water-base mud containing Wyoming bentonite, to which only a little lost circulation material and chemicals were added to control cement contamination. The density of the mud ranged from about 72 to 85 pounds per cubic foot. The API funnel viscosity ranged from about 33 to 40 seconds. The API filtrate volume ranged from about 17 to 7.0 milliliters.

Cable-Tool Completions--Wells 4, 6, 8, and 10

Several wells were drilled with cable tools after the first three holes drilled with rotary tools and water-base mud were unproductive (although oil and gas shows were observed). A sodium chloride brine was used to minimize the invasion of water into the formation and possible swelling of the clay minerals observed in the oil-bearing sandstones. Sloughing was common in drilling these holes and it retarded drilling. Good showings of oil and gas were observed in this group of wells and the average oil productivity was about 78 barrels per well per day. Most of the production testing was done by bailing which would result in lower than normal productivity when compared with testing by pumping.

Drilling Mud

The brine drilling muds were prepared by adding about 35 pounds of sodium chloride to each barrel of water. This lowered the freezing temperature of the solution below that of the minimum permafrost. The objective was to prevent freezing of the brine filtrate in the cold petroleum reservoir rocks and to minimize the swelling of clay minerals.

Well 7

Well 7 was drilled with cable tools and brine drilling mud. Sandstones containing oil and gas were penetrated and considerable water was produced in

9/ Work cited in footnote 3, p. 1.

the bailing tests. Small quantities of oil and gas were recovered by bailing. Based on the meager information available, some investigators believed this well to be below the edgewater in this reservoir.

Emulsion Mud Completion--Well 11

Well 11 was drilled to test the production possibilities of the sandstones of the Grandstand formation on the northern downthrow side of a fault that parallels the axis of the structure. The hole was drilled with rotary tools using an oil-in-water emulsion mud which had a water filtrate. Oil and gas shows were noted in the permeable sandstones penetrated, but no commercial production was indicated in eleven formation tests.

Drilling Mud

The drilling mud had an API filgrate volume of about 2.0 milliliter (ml), an API funnel viscosity of about 100 seconds, a weight density of about 85 pounds per cubic foot, and about 30 percent (by volume) of Umiat crude oil which had the fractions boiling below 325° F. removed.

Cable-Tool Completion Followed by Wall Scraping Using Crude Oil--Well 5

Well 5, 175 feet east and 97 feet north of well 2, was drilled with cable tools using 5-7/8-inch bits and brine drilling water. Bailing tests showed the presence of oil and gas. When the depth reached 615 feet a pump was installed to test the productive capacity of the well. In a test that lasted 15 days production averaged about 70 barrels of clean oil per day. Drilling with cable tools was continued to 1,075 feet, using a brine containing 40 to 50 pounds of sodium chloride per barrel of water.

Tubing was run for a swabbing test. A packer set at 630 feet was used to shut off liquids from sands that had been tested at a depth of 615 feet. After the drilling water was swabbed from the hole, oil flowed at the rate of 10 to 16 barrels per hour for short periods. Flow stopped several times; apparently resulting from restricted flow into the well bore or from the formation of ice in the tubing at shallow depths. The tubing was pulled, the rig removed in September 1950, and the well was shut in for the winter.

In April 1951 a rotary rig was moved in place. The hole was cleaned out and reamed in an effort to stimulate production. Circulation was lost and some brine was added to the crude-oil drilling fluid to restore circulation. The hole was reamed to 9-1/2 and 10-1/4 inches in the sandstone sections penetrated by the bit.

During alternate reaming and swabbing tests from May 21 to June 17 the first liquids recovered were brine and crude oil used for circulation while reaming. In the last part of the reaming operation, fresh crude oil was swabbed from the hole at an estimated rate of 400 barrels per day. One of the first samples of oil recovered contained 4.7 percent water and 0.1 percent sediment.

A pump with an electrical heater attached to the bottom of the tubing was set at 1,055 feet. In a 93-day pumping test the maximum production rate was about 400 barrels per day. However, the pump was too small to test the full productive capacity of the well. The water content of the 35.5° API gravity oil decreased from 1.35 to 0.4 percent. The temperature of the oil in the flow line ranged from 27° to 28° F.

Oil-Base Mud Completion--Well 9

Well 9, about two miles west of well 2, was drilled with a rotary rig. Core analyses indicated that this well penetrated a sandstone with appreciable porosity, permeability, and oil content.

Drilling Mud

Water-base mud was used to 209 feet. Below 209 feet to 1,257 feet, an oil-base mud was used to prevent the infiltration of water from a water-base mud into the formations penetrated and to provide cores uncontaminated by water from the mud. The mud contained a chemical tracer that was soluble in oil, insoluble in water, and unaffected by bacteria, to determine the volume of oil filtrate that entered the cores. The tracer was an organic chloride compound containing about 54 percent chlorine by weight. The method for following the volume of tracer-bearing filtrate has been described in detail.[10]

The oil-base mud was composed of diesel oil, a low-gravity crude oil from Fish Creek test well 1, Ken-Oil concentrate, and some unslaked lime. Addition of the concentrate and/or the heavy crude oil increased the viscosity of the mud, whereas, addition of diesel oil decreased viscosity. Gel strength was increased by adding the concentrate and lime, which also decreased the filter rate. The mud weight was kept low to minimize the flow of drilling mud filtrate into the formations. To keep the weight low, it was necessary to reduce the viscosity to less than 50 seconds API funnel viscosity at about 45° F. Cuttings would not drop from suspension otherwise, as no vibrating screen was available during drilling.

The properties of the drilling mud are listed in table 1.

Swabbing and Pumping Tests

Three formation tests in both the upper and lower sandstone sections in the Grandstand formation were made by swabbing through 2-1/2-inch tubing for about 4 hours. A cone packer set above different sections of the formation was used but no oil was produced. The Grandstand formation was found in this hole between 425 and 1,090 feet. The first swabbing test was made with the hole open from 476 to 533 feet. The second swabbing test was made with the hole open from 866 to 901 feet. The third test was made with the hole open from 959 to 1,017 feet.

10/ Gates, George L., Morris, Frank C., and Caraway, W. Hodge, Effect of Oil-Base Drilling Fluid Filtrate on Analysis of Cores From South Coles Levee, Calif., and Rangely, Colo., Fields: Bureau of Mines Rept. of Investigations 4716, 1950, 25 pp.

TABLE 1. - Properties of oil-base drilling mud used in Umiat well 9

Core No.	Core interval, feet	Drilling fluid								Drilling fluid filtrate	
		Filtrate volume, mg./30 min.		Weight density		Water content		API funnel viscosity, (1 quart out)		Water content, weight-percent	Tracer concentration, mg./ml.
		45° F.	75° F.	lb./gal.	lb./ft.^{3}	Weight-percent	Volume-percent	Time, seconds	Temperature, °F.		
	374-384	0	-	8.6	64.5	10.95	11.34	95	61	-	-
4	413-423	0	9	8.8	66.0	8.85	9.38	79	50	-	14.2
9	464-474	1.3	12	9.0	67.0	9.08	9.77	83	48	1.05	14.7
10	474-484	1.1	10	9.1	68.0	9.07	9.90	85	45	1.07	14.3
11	484-494	1.1	10	9.2	69.0	8.76	9.70	95	46	0.33	14.3
15	502-512	1.1	12	9.4	70.0	8.59	9.65	90	44	0.82	14.1
23	573-583	5.2	16	9.8	73.0	6.92	8.11	72	45	0.16	10.4
38	858-868	20.0	29	10.2	76.0	3.65	4.45	76	48	0	4.5
39	868-878	20.0	30	10.3	77.0	3.57	4.41	69	47	1/	18.5
40	878-888	20.0	27	10.3	77.0	3.64	4.50	69	47	do.	17.7
41	888-898	20.0	34	10.4	78.0	3.71	4.64	69	46	do.	21.7
42	898-901	20.0	33	10.4	78.0	3.72	4.65	69	46	do.	17.5
43	901-911	21.0	36	10.3	77.0	4.03	4.98	59	45	do.	15.6
48	949-959	21.0	38	10.4	77.5	4.02	5.00	60	46	do.	15.3
49	959-969	21.0	42	10.4	77.5	4.29	5.37	60	46	do.	14.6
50	969-979	6.4	12	10.4	78.0	4.33	5.42	59.5	46	do.	13.8
52	989.5-1,000	7.9	14	10.5	78.5	4.54	5.72	57.0	46	do.	13.4
53	1,000-1,010	7.9	10	10.5	78.5	4.67	5.88	57.0	46	do.	12.8
54	1,010-1,017	-	13	10.4	78.0	4.41	5.52	57.0	46	0	13.2
57	1,037-1,047	3.4	7	10.2	76.5	5.01	6.15	53.0	41	-	10.6
58	1,047-1,057	2.2	-	-	72.0	-	-	52.0	42	-	-
59	1,057-1,067	3.0	-	-	72.0	-	-	46.0	42	-	-
61	1,077-1,086	1.9	-	-	59.5	-	-	42.0	45	-	-
62	1,086-1,096	4.1	-	-	59.5	-	-	44.0	42	-	-
67	1,137-1,147	2.0	-	-	60.5	-	-	48.0	40	-	-

1/ The drilling-fluid filtrates from drilling fluid samples 39, 40, 42, 43, 48, and 49 were combined, and the water content of the combined samples was negligible.

After the third formation test, the hole was reamed with 7-7/8-inch bits to total depth of 1,257 feet. Two-inch tubing was run to 1,247 feet and the oil-base mud was swabbed from the hole and pumped into storage tanks. Shortly before all of the mud was swabbed from the hole, crude oil flowed into the hole. After twelve hours of swabbing no trace of oil-base mud was detected in the produced oil. Two hundred barrels of crude oil were swabbed in 15 hours. When swabbing was stopped, for lack of storage space, the liquid level rose to 50 feet from the surface. A subsequent pumping test of 6-1/2 weeks indicated a maximum productivity of approximately 300 barrels per day of clean oil.

Following the pumping test the well was plugged back, in stages, to 400 feet from the surface in an effort to determine the source of the oil. This procedure was partly successful in disclosing the productive sands. The cement plug was then drilled out to 1,077 feet using reverse circulation with oil as the drilling liquid. From that depth to bottom, 1,257 feet, brine containing 40 pounds of salt per barrel of water was used in drilling out the cement. Circulation was lost several times and cleaning the hole was difficult.

A string of 5-1/2-inch casing was cemented at 1,257 feet, total depth. The pipe was perforated repeatedly opposite the permeable sandstones but no oil entered the hole, even after swabbing, for periods longer than a week. The pore space around the well bore was blocked to the flow of crude oil and apparently the blocked area could not be penetrated by gun perforating.

Effect of Water on Permeability of Core Samples From Well 9

A series of tests was made to study the effect of water on the permeability of cores from the Grandstand formation. The effect of invasion of the sandstone by water from a fresh-water drilling mud was simulated. In this series of tests at room temperature one sample from each of four cores was selected. The cores had been sealed in cans at the well. The four selected samples containing the interstitial water and oil, present in the cores when they came from the core barrel, were mounted in low-temperature-setting plastic inert to both water and kerosine. The permeability of these four samples to kerosine was measured without cleaning the samples. The initial water and oil contents were not changed except that the crude oil was displaced by kerosine. The same unextracted core samples were then used in determining the permeability to fresh water. Note in table 2 that only one of the samples had measurable permeability to water. However, a small volume of water entered the three samples that were impermeable to the water. The samples were left in water overnight. Entrance of water into the core samples is analogous to exposure of the wall of the bore hole to fresh water from drilling mud during completion of the well. Following the contact of the cores with water, the permeability to kerosine was determined again and oil was flowed through the samples for several hours, apparently flushing part of the invasion water from the core sample. The results are shown graphically in figure 5 and are listed in table 2.

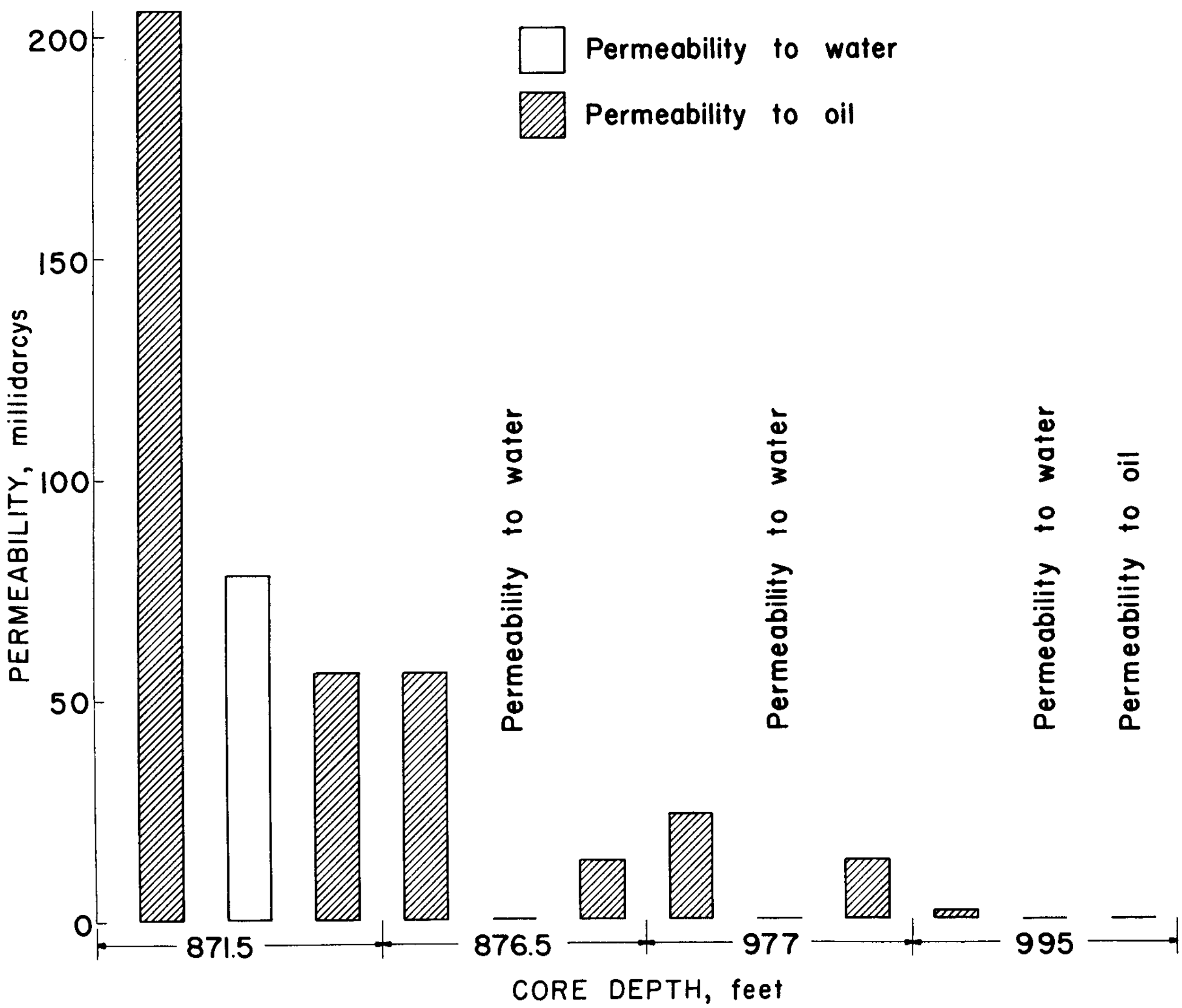


FIGURE 5. - Permeability of Core Samples to Oil and Water.

The observed reduction in permeability to oil after water invaded the core sample is believed to be, primarily, the result of the relative permeability changes.

When water entered the pore space the permeability to oil was reduced. Apparently when oil was flowed through the core some of the invasion water remained in the pore space. The core samples were left in water overnight so that the clays in the sandstone would have ample time to become fully hydrated. Overnight may not have been long enough for complete hydration because some clays required several days to reach equilibrium. In evaluation of drilling-mud clays the American Petroleum Institute Recommended Practice 29, May 1957, the minimum time for hydration of bentonite is 72 hours.

TABLE 2. - Permeability of well 9 core samples to oil and water

	Sample from--feet,			
	871.5	876.5	977	995
Permeability before soaking, md.				
Oil (water phase remained immobile)...........	206.0	56.5	24.0	2.1
Water (oil phase remained immobile)...........	78.1	.0	.0	.0
Oil permeability after soaking overnight in water, md.				
Immediately after removal......................	31.4	-	-	-
30 minutes after beginning test...............	37.9	-	10.8	-
1 hour after beginning test....................	-	8.9	-	-
2 hours after beginning test..................	-	-	-	0.3
2-1/4 hours after beginning test..............	-	13.4	-	-
3 hours after beginning test..................	-	-	13.4	-
4-1/2 hours after beginning test..............	56.6	-	-	-
6 hours after beginning test..................	-	-	-	.6

Six samples having a range of permeabilities were selected to determine the relative effects of air, oil, salt water, and fresh water on the permeability of extracted cores. The samples were cleaned by extraction with toluene to remove the water and oil simultaneously. The permeability to dry air was measured, cores were saturated with oil, and the oil permeability was determined. As shown in table 3 the two values were nearly the same. The core samples were cleaned of oil by toluene extraction again and then saturated with 0.5 N sodium chloride solution. The permeability to this solution was found to be less than the previously determined values. Finally the permeability to distilled water was measured and found to be less than any of the previous permeabilities. This change in permeability indicates that the fresh water entered the cores to lower the permeability as shown in figure 5. Similar reduction in permeability of Umiat cores was found by Yuster11/ and Baptist.12/ This permeability reduction is independent of reduction that may have been caused by freezing of fresh-water filtrate in the pore channels.

When the formation tests in well 9 indicated no producible crude oil although the cores contained crude oil and gas, a study was made to determine the effect of the low formation temperature on the filtrate from the oil-base mud. A sample of filtrate from the mud was blended with crude oil and placed in the camp refrigerator for several days. The refrigerator was maintained at 8° F., which is 10° F. below the lowest permafrost temperature measured in this hole. Neither the filtrate nor the blends of filtrate with crude oil gelled at this temperature, indicating that filtrate from the oil-base mud was not blocking the pore channels of the formation by the formation of a gel.

11/ Yuster, S. T., Oil and Gas Investigations Map OM 126 (in 3 sheets) sheet 2: Geol. Survey, 1951.

12/ Baptist, O. C., Oil Production From Frozen Reservoir Rocks, Umiat, Alaska: Jour. Petrol. Technol., vol. 11, No. 11, Nov. 1959, pp. 85-88.

TABLE 3. - Permeability of selected Umiat 9 cores to air, salt water, and fresh water

Depth (feet)	Permeability in millidarcys to--			
	Dry air	Oil	0.5 normal sodium chloride solution[1/]	Distilled water
866-867	22	18	15	13
867-868	31	34	32	30
873-874	270	260	250	200
875-876	150	160	140	120
880-881	140	150	130	100
907-908	54	54	35	26

1/ Samples were extracted and dried before permeability to salt water was determined.

Volume of Drilling Mud Filtrate in Cores From Well 9

A tracer was added to the drilling mud to obtain a quantitative measure of the volume of filtrate from the oil-base drilling mud that entered the pore space of the cores. This tracer was soluble in oil, insoluble in water, and not affected by bacteria. Analysis of the oil extracted from the cores was made by a chemical method that has been described previously.[13/] The results indicated that about 3 percent of the pore space in the permeable sections contained filtrate from the oil-base mud.

DISCUSSION OF RESULTS

Drilling and production data for the eleven test wells in the Umiat field are summarized in table 4 and shown in figure 6. The results indicate that the use of clay-water and clay-brine completion fluids damaged the productivity of some of the wells. This damage was a result of reduction in permeability of the sand at the well bore by the invasion of filtrates from the drilling fluids.

The two best wells in the field were completed with oil-base mud. These wells were approximately two miles apart. Four wells completed with brine mud (using cable tools) had a productivity of about 78 barrels of oil per day. In contrast, three wells drilled with water-base mud also penetrated oil-bearing (not necessarily oil-productive) sandstones, but none was completed as producers.

Information on the wells drilled indicates that all of the wells penetrated oil-bearing sandstones and the correlation between the type of drilling fluid used and the well productivity has been shown. However, any study of well completion practices is difficult because generally a well can be completed only once and the productivity attainable by any other method is a

13/ Gates, George L., Morris, Frank C., and Caraway, W. Hodge, Effect of Oil-Base Drilling Fluid Filtrate on Analysis of Cores From South Coles Levee, Calif., and Rangely, Colo., Fields: Bureau of Mines Rept. of Investigations 4716, 1950, 25 pp.

conjecture. It should be noted that wells 1 and 11 are located an appreciable distance from the producing wells. The lack of production from these holes may be due to lack of sufficient permeability of the reservoir rock. Also, lack of production from the other holes may be complicated by the lack of permeability. However, observed damage to wells 5 and 9 could not be the result of these factors.

TABLE 4. - Drilling and production data, Umiat field, Alaska, 1944-53

Well No.	Drilling method	Drilling mud	Production rate, barrels per day	Production test method	Length of test, days	Total depth, feet
1	Rotary..	Clay-water..	0	Formation..	<1	6,005
2	..do....	....do......	Trace	....do.....	<1	6,212
3	..do....	....do......	24	Pumping....	14 approx.	572
4	Cable...	Brine.......	100	....do.....	18	840
6	..do....	....do......	80 (wet)	....do.....	1 approx.	825
7	..do....	....do......	<1	Bailing....	1 approx.	1,384
8	..do....	....do......	60	Pumping....	14	1,327
10	..do....	....do......	70	Bailing....	1	1,573
5	..do....	Brine....... / Reamed, oil.	400+	Pumping....	93	1,077
9	Rotary..	Oil-base....	300+	....do.....	45	1,257
11	..do....	Oil-in-water emulsion	0	Formation..	1	3,303

Comparison of Wells 2 and 5

Comparison of the productivity of wells 2 and 5 indicates that damage results from completion practice in which water from the drilling fluid invades the reservoir formation. Well 2, completed with clay-water mud, was a dry hole and well 5, which was about 200 feet from well 2, was completed first with brine. Both holes penetrated oil-bearing sandstone with appreciable permeability. Well 5 then was reamed with oil as the drilling mud and a sustained production test indicated productivity to 400 barrels per day.

The brine drilling mud used in these holes had a freezing point below the formation temperature, therefore, the filtrate from these drilling muds reasonably would not be expected to be in the state of ice.

Study of the electrical log[14/] of well 2 indicated that the Grandstand formation might have been expected to be productive. The spontaneous potential and resistivity curves indicated that this formation might be expected to contain oil. However, very little oil was produced from this hole which was completed with water-base mud. Well 5, about 200 feet from well 2, was completed in this formation with oil-base mud and the productive rate was about 400 barrels per day.

14/ Collins, Florence Rucker, With Bergquist, Harlan R., Brewer, Max C., and Gates, George L., Test Wells Umiat Area, Alaska: Geol. Survey Prof. Paper 305-B, 1958, Pl. 11.

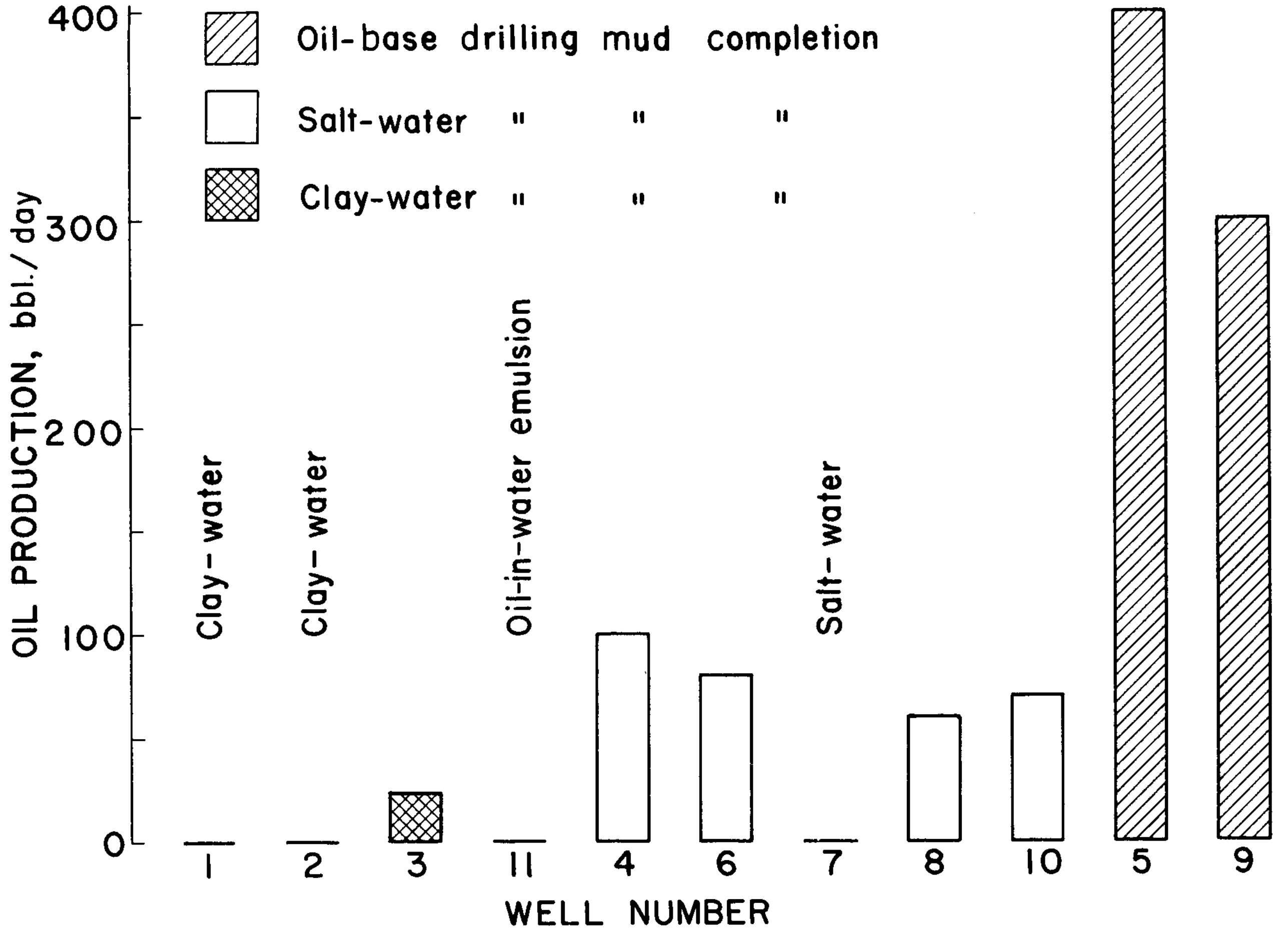


FIGURE 6. - Production Capacity of Umiat Wells Related to Drilling Mud.

Unusual Features of Well 9

Because of the time required to pump the oil-base mud from the mud pit into tanks the formation was exposed to a low pressure from the liquid column for about 6 hours. Why the crude oil came into the hole after this time interval and did not flow into the hole during the 4-hour formation tests is not understood. There is nothing in Darcy's law to indicate that time (several hours) is required for crude oil to flow from the formation into the bore hole.

Effect of Water on Relative Permeability to Oil

Where water from the drilling mud or any other source enters the pore space (especially if the water freezes) the channels available to the flow of oil are greatly reduced. A large decrease in permeability to oil with a small increase in water content has been established from relative permeability studies. Dunlap[15/] showed this relation in a laboratory study of the oil

15/ Dunlap, Eldon N., Influence of Connate Water on Permeability of Sands for Oil: AIME Petrol. Trans., vol. 127, 1938, pp. 215-225.

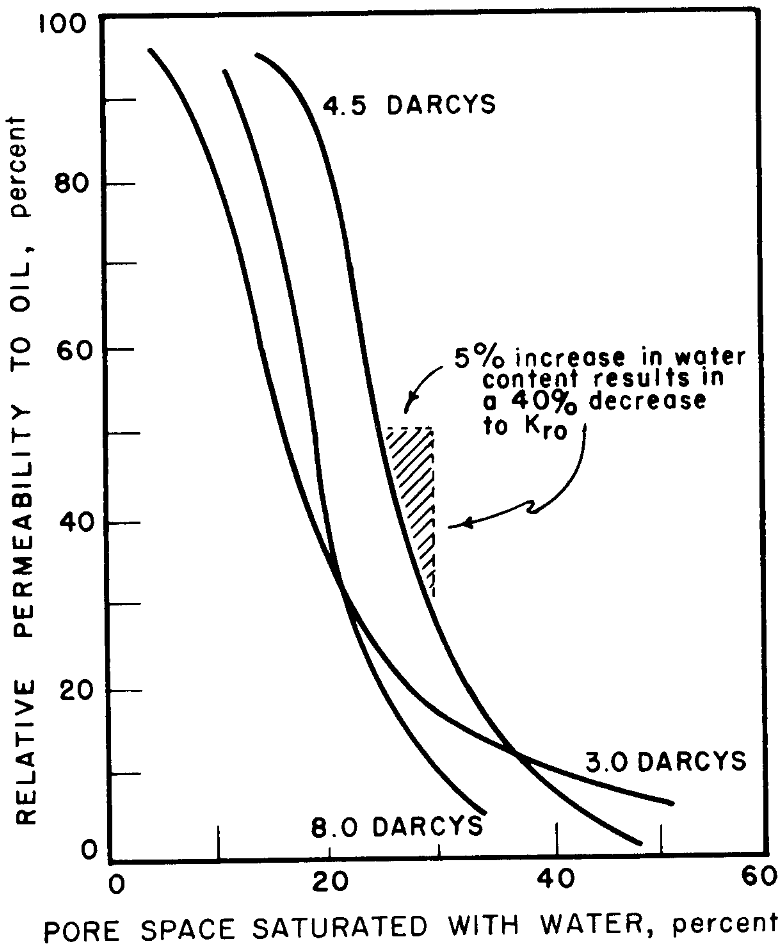


FIGURE 7. - Effect of Water Content of Sands on Permeability to Oil. *(Adapted From Dunlap, AIME Petrol. Trans. 1938).*

permeability of sands containing increasing volumes of water (fig. 7). The tests showed that a 5 percent increase in the water content of the sand resulted in a 40 percent decrease in permeability to oil. The permeabilities of the sands used in the laboratory tests were much higher than normal oil-reservoir sands. However, data are considered indicative of relative permeability trends.

Formation Pressure

Although few data are available regarding the formation pressure in the Grandstand sandstone in the Umiat field, some indication of the pressure may be obtained indirectly. Shut-in gas pressure at the surface of well 8 reached a maximum observed value of 270 pounds per square inch. The depth from which the gas was flowing and the liquid level in the well were unknown.

Wells 5 and 9 had liquid levels that reached nearly to the surface. Based on a crude oil specific gravity of 0.84 the pressure in well 9 at a depth of 900 feet was 900 x 0.84 x 0.43 lb./ft. of water = 325 pounds per square inch. The calculated pressure in the upper Grandstand sandstone at a depth of 470 feet was 170 pounds per square inch.

These pressures available to push water (brine) or ice from the pore channels are not large. The affinity of the clays in the reservoir rock also tends to hold water solutions in the pore channels thereby restricting the rate of flow of crude oil through the rock into the well bore.

Low Formation Temperatures

Wells in this field penetrated rocks at temperatures below the freezing temperature of water and some of the oil produced from these holes was shown to be flowing through rocks below 32° F. The measured oil flow temperature was about 26° F. indicating approximately the temperature of the oil-reservoir rock. Although this temperature is below the freezing temperature of fresh water in large containers, tests have shown that water solutions in small pores may have a freezing point at temperatures below 32° F.16/ The relative amounts of water in the liquid and solid states in ground at temperature below 32° F. depend on the physiochemical composition of the ground, on the presence of water-soluble particles, and on the temperature and pressure.

PROPERTIES OF THE CRUDE OIL

The produced crude oil has the following characteristics: API gravity, about 36°; pour point, -5° F.; sulfur, 0.1 percent, no hydrogen sulfide; Saybolt Universal viscosity at 100° F., 37 seconds; color, National Petroleum Association No. 4; and carbon residue, Conradson, weight percent, 0.1 to 0.2. The crude oil was relatively high in naphthene hydrocarbons. Analyses of some crude oils from Alaska have recently been published by the Bureau of Mines.17/

BASIC WELL DATA

Well 1 had a ground elevation of 801 feet and the elevation of the kelly bushing was 810 feet. The total depth from the surface was 6,005 feet. Sixteen feet of 24-inch conductor pipe was set 19 feet below the kelly bushing in a 30-inch hole. Sixteen-inch casing was cemented at 97 feet. A string of 11-3/4-inch casing was cemented at 685 feet.

Well 2 had a ground elevation of 333 feet and the kelly bushing was located at an elevation of 342 feet. Sixteen-inch conductor pipe was cemented at 103 feet. A string of 11-3/4-inch casing was cemented at a depth of 1,005 feet. The well was drilled to a total depth of 6,212 feet.

Ground elevation at well 3 was 351 feet and elevation of the kelly bushing was 360 feet. Seven-inch casing was cemented at a depth 72 feet below the kelly bushing. The well was drilled to a total depth of 572 feet.

The ground elevation of well 4 was 482 feet. Surface pipe was set at a depth of 33 feet. This hole was drilled to a total depth of 840 feet.

The ground level of well 5 was 334 feet and the rig floor was 335 feet above sea level. At a depth of 23.5 feet, 8-5/8-inch casing was cemented. The well was drilled to a total depth of 1,077 feet. After the 93-day pumping test, 5-1/2-inch casing was cemented at a depth of 1,068 feet with the top of the plug at 1,065 feet. The pipe was filled with Umiat crude oil and shut in.

16/ Nersesova, Z. A., (The Relative Amounts of Water the Solid and Liquid States Present in the Ground During Freezing or Thawing.) Fazovyy sostav vody v gruntakh pri zamerzanii i ottaivanii, Materialy po Laboratornym Issledovaniîam Merzlykh Gruntov, vol. 1, 1953, pp. 37-51.

17/ McKinney, C. M., Garton, E. L., and Schwartz, F. G., Analyses of Some Crude Oils From Alaska: Bureau of Mines Rept. of Investigations 5447, 1959, 29 pp.

Well 6 was at a ground level of 334 feet and the rig floor was at 337 feet. Surface casing was driven to a depth of 35 feet. The hole was drilled to a total depth of 825 feet.

Well 7 was spudded from a ground level of 326 feet and a derrick floor level of 330 feet. Surface pipe was driven to 52 feet. The hole was drilled to a total depth of 1,384 feet.

Well 8 was at a ground level of 735 feet and the derrick floor was 5 feet higher. Two joints of 11-3/4-inch casing were set at 50 feet. After testing promising sandstones, excessive caving of the walls of the hole resulted in setting 8-5/8-inch casing at a depth of 1,231 feet. The hole was drilled to a total depth of 1,327 feet.

Well 9 was at a ground level of 418 feet and the kelly bushing was 6 feet higher. A string of 8-5/8-inch surface pipe was cemented at a depth of 61 feet. After a sustained pumping test, 5-1/2-inch casing was run to bottom, cemented, and gun perforated. The total depth of this hole was 1,257 feet.

Well 10 was at a ground level of 741 feet and the derrick floor was 5 feet higher. A string of 11-3/4-inch casing was cemented at a depth of 70 feet. After caving and several fishing jobs, casing was cemented at a depth of 1,339 feet. The hole was drilled to a total depth of 1,573 feet.

Well 11 was at a ground level of 464 feet and the kelly bushing was 7 feet higher. The 13-3/8-inch casing was cemented at a depth of 89 feet, with 57.7 feet jacketed with 16-5/8-inch casing. The hole was drilled to a total depth of 3,303 feet.

c. Dale Ensign

MEMORANDUM

TO: C. C. Livingston January 28, 1980

FROM: R. J. Mead

SUBJ: Umiat Development Costs

Attached for your information is the estimatee costs to develope the Umiat field based on a 125 well 3 year development program.

It must be pointed out that a grand total of 12 man hours were spent on this report. For a frame of reference consider the original pipeline cost estimate of 800 million versus the finished cost of $8 billion.

To be off by a magnitude of 10 is a distinct possibility raising the development costs from 401 million to 4 billion dollars.

R. J. Mead

RJM/cds

Attachment

Rough estimate to build 90 miles of Emdi line to the TAPs line ± 176.5 m

CKE

UMIAT COST ANALYSIS

Assumptions

Average Depth - 1,200'
Spacing - 40 AC
Two Rig Program - 125 wells total
All pumping wells
Tank Battery - 4 for field
Development Time - 3 years
Inflation Rate - 14%/year
No Pipeline Costs Included

Estimated Drilling Time

Move In and Rig Up	4 days
Drill Surface Hole	3 days
Drill Main Hole	3 days
Complete	7 days
	17 days

Assumes no coring, testing, etc. since this is a development program.

Estimated Drilling Costs

Rig including catering, camp, extra labor	$16,000/day
Rig Support (including air)	14,000/day
Other Drill Costs (including casing)	18,000/day
	$48,000/day

$48,000/day X 17 days = $816,000/well - First year
930,000/well - Second year
1,060,000/well - Thrid year

Road and Location Costs

The estimated costs for the pads and road were based on a year-around program resulting in thicker pads and roads than used in a strictly exploratory program assuming ± 1/2 mile of road for each well site and a pad the cost average approximately $1.5 million per well site.

Maintenance and Operating Expenses

All wells will be elctrically powered and be serviced by "pumpers" who will monitor daily production. Repair and maintenance costs will include rod jobs, pump repair, lease road maintenance, and other related costs. These are estimated at $400/day/well.

Completion Costs

Estimated completion costs include all rods, tubing, pumping units, and associated equipment. In addition glycol injectors, and steam heaters were included to keep both the well base and flow line thawed out. This will require heat strings and heat "trace" lines on all flow lines. Additionally, all lines were assumed to be laid on the ground and insulated.

Generators were also included in these costs to provide electrical power for the units.

With these parameters in mind estimated completion costs are $420,000/well.

Tank Batterys

Four tank batteries were assumed for the entire field. These will be insulated with steam coil line, boiler, heater and lact units. Since only four batteries are required for the field the estimated costs on a per well basis is $80,000/well.

Cost Summary

Drilling Costs Per Well	$ 816,000	
Completion Costs Per Well	420,000	
Tank Batteries/Well	80,000	
Roads and Location	1,500,000	
	$2,816,000	per well First year
	3,210,000	per well Second year
	3,660,000	per well Third year

For an average the second year costs were used for the entire program.

$3,210,000/well X 125 wells = $401,250,000 Total Development Costs

Operating Expenses

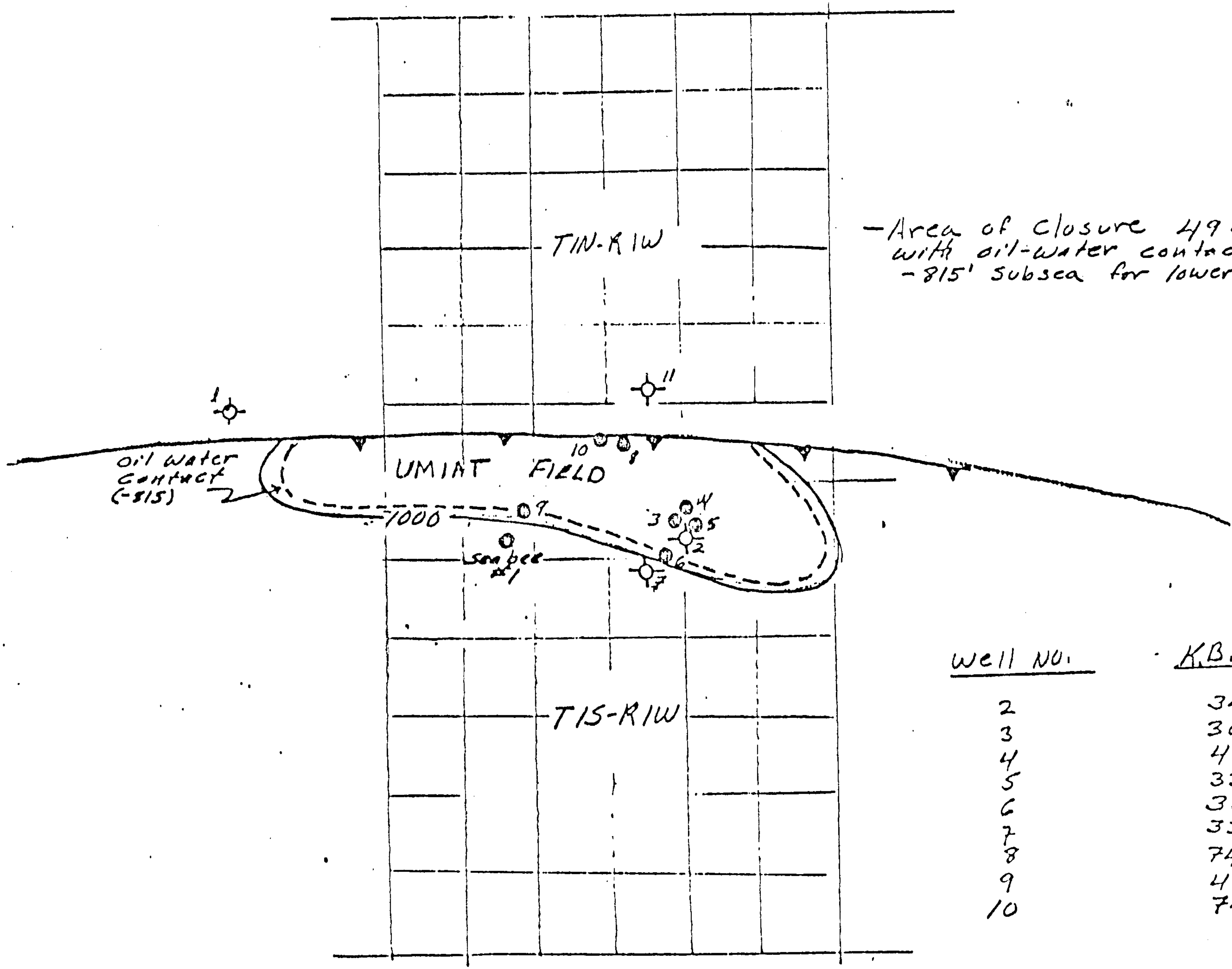
Based on $400/well/day the operating expense is $200 X 125 X $25,000/day X 365 days = $9,100,000/year. This is not included in the $401,250,000 total development costs.

Seabee Exploratory Well Costs (One Well)

With an estimated depth of 15,000' the following is the estimated cost to drill one Seabee "type" well.

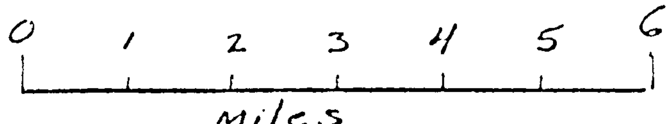
Drilling Subcontractor Costs	$4,496,000
Other Drilling Costs	4,200,000
Rig Support	2,600,000
Total	$11,296,000

FIELD MAP WITH OIL/WATER CONTACT

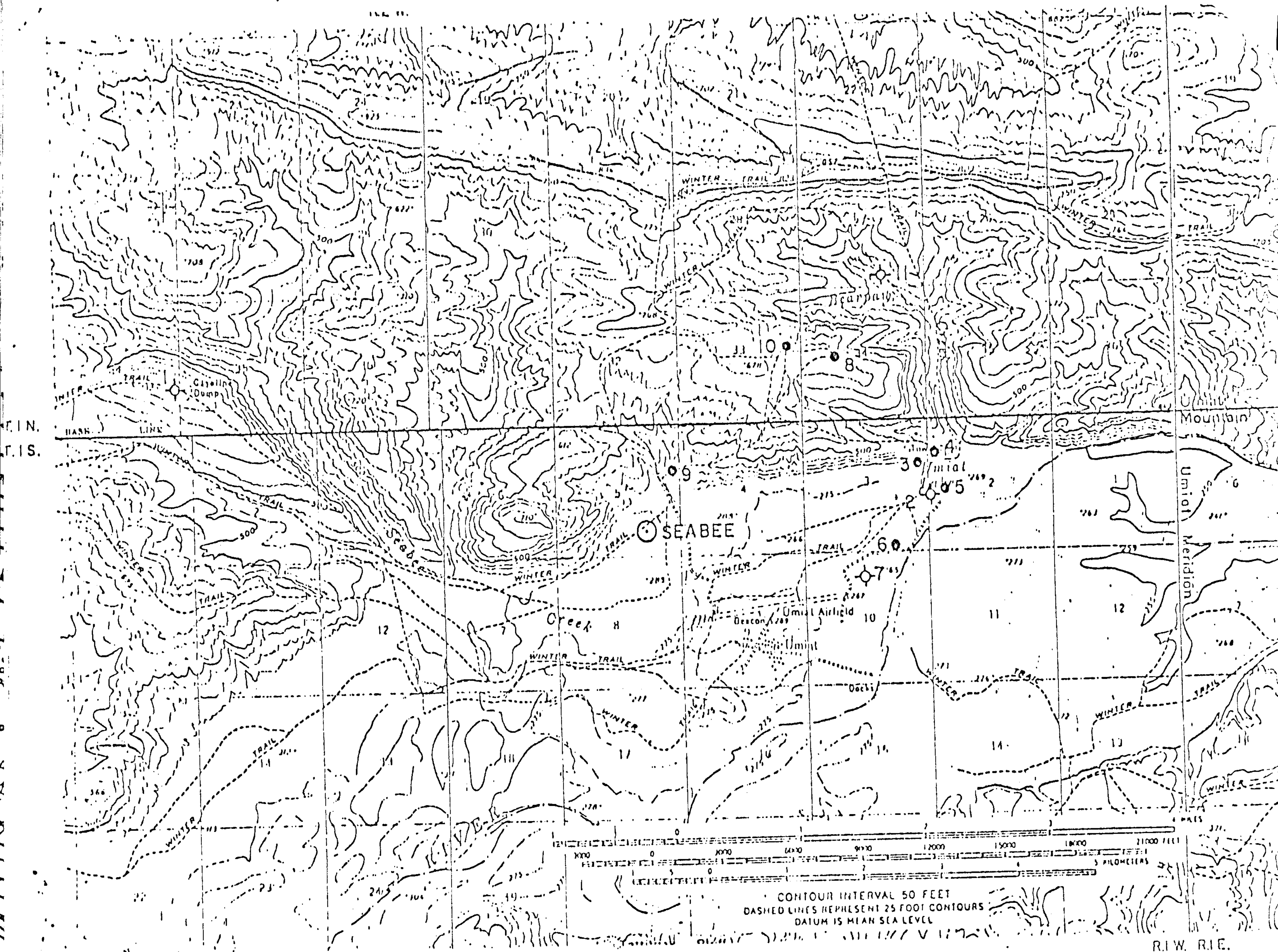


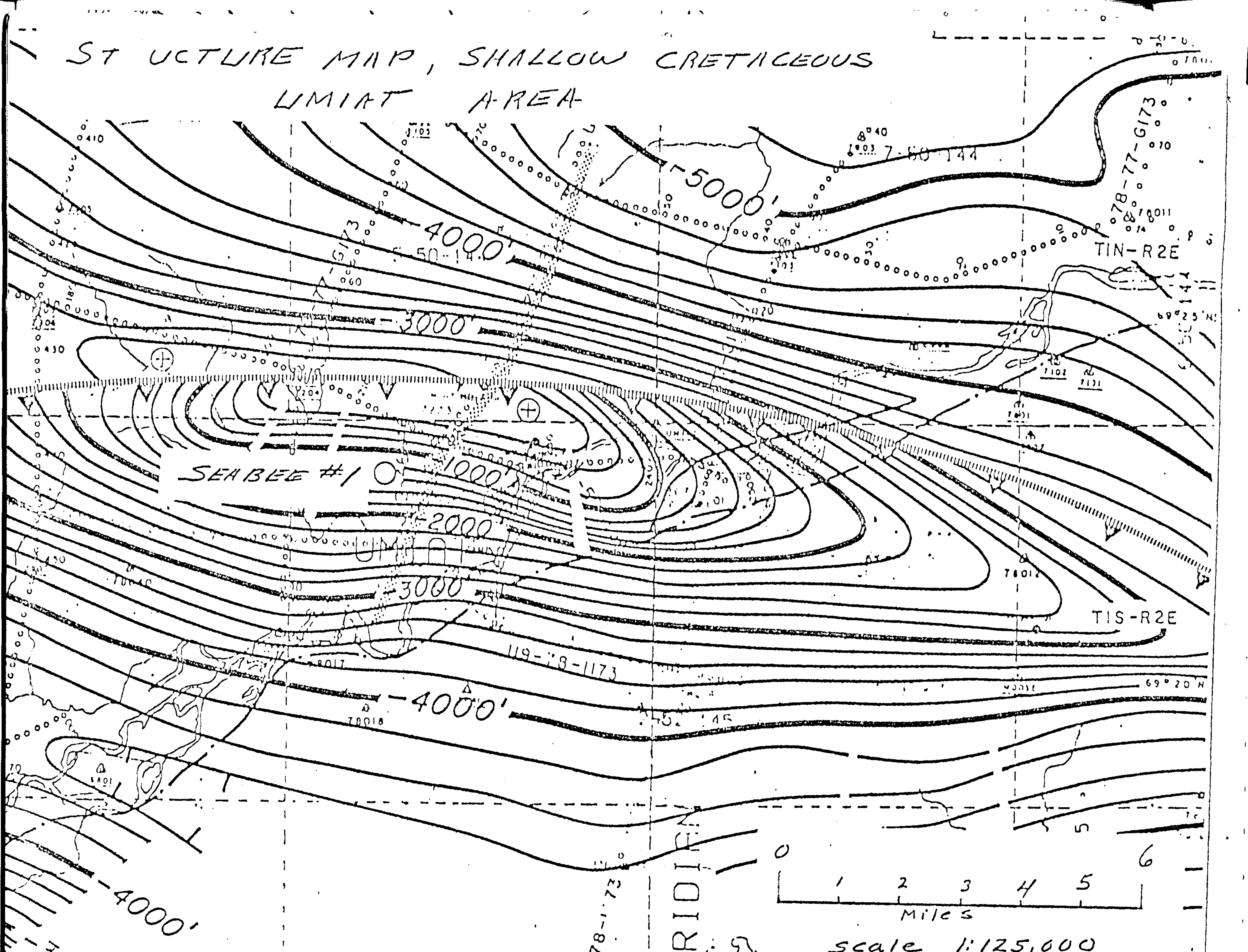
-Area of Closure 4964 acr
with oil-water contact of
-815' subsea for lower sand.

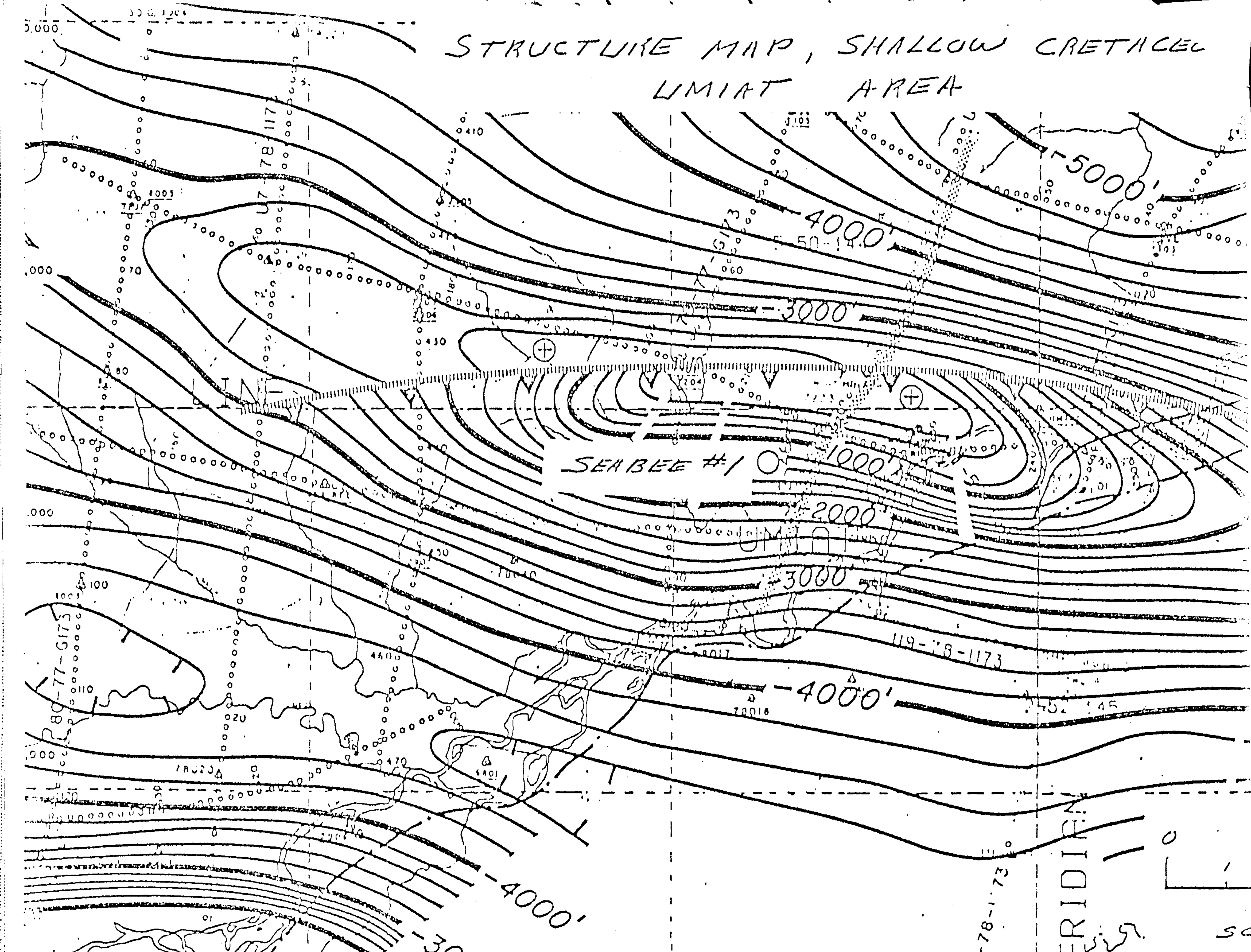
Well No.	K.B. Elve.
2	342
3	360
4	483
5	335
6	337
7	330
8	740
9	424
10	746



TOPOGRAPHIC MAP. UMIAT




ST UCTURE MAP, SHALLOW CRETACEOUS
UMIAT AREA
-5000'
-4000'
-3000'
SEABEE #1
-1000'
-2000'
-3000'
-4000'
-4000'
119-78-1173
78-77-G173
T1N-R2E
T1S-R2E
69°25'N
69°20'N
0 1 2 3 4 5 6
Miles
scale 1:125,000



STRUCTURE MAP, SHALLOW CRETACEC
UMIAT AREA
-5000'
-4000'
-3000'
SEABEE #1
-1000'
-2000'
-3000'
-4000'
-4000'
U9-78-1173