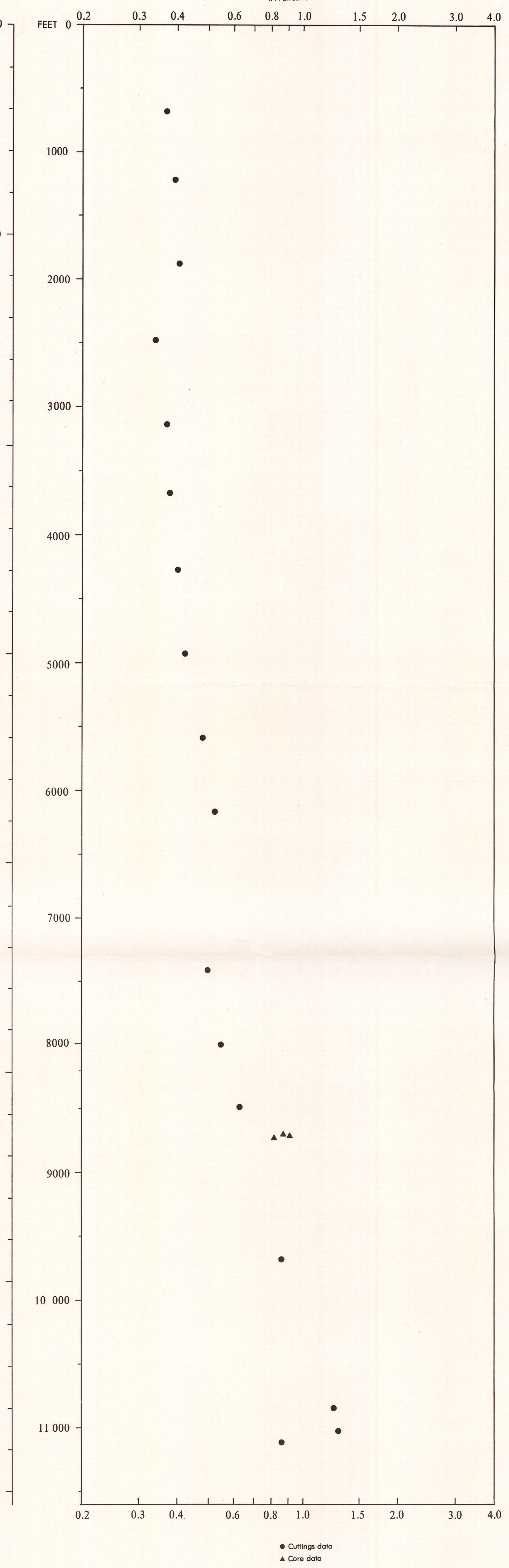
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

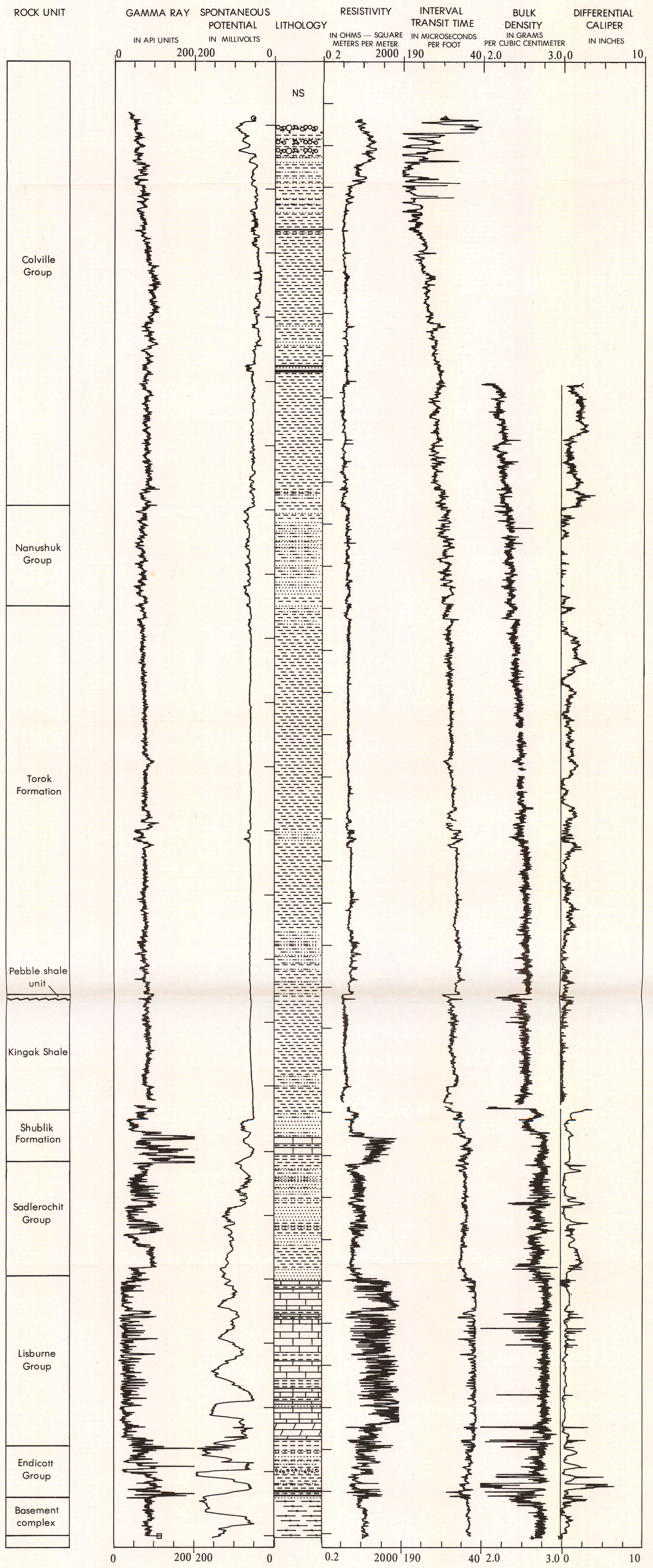
OIL AND GAS INVESTIGATIONS
CHART OC-98

ATIGARU POINT NO. 1

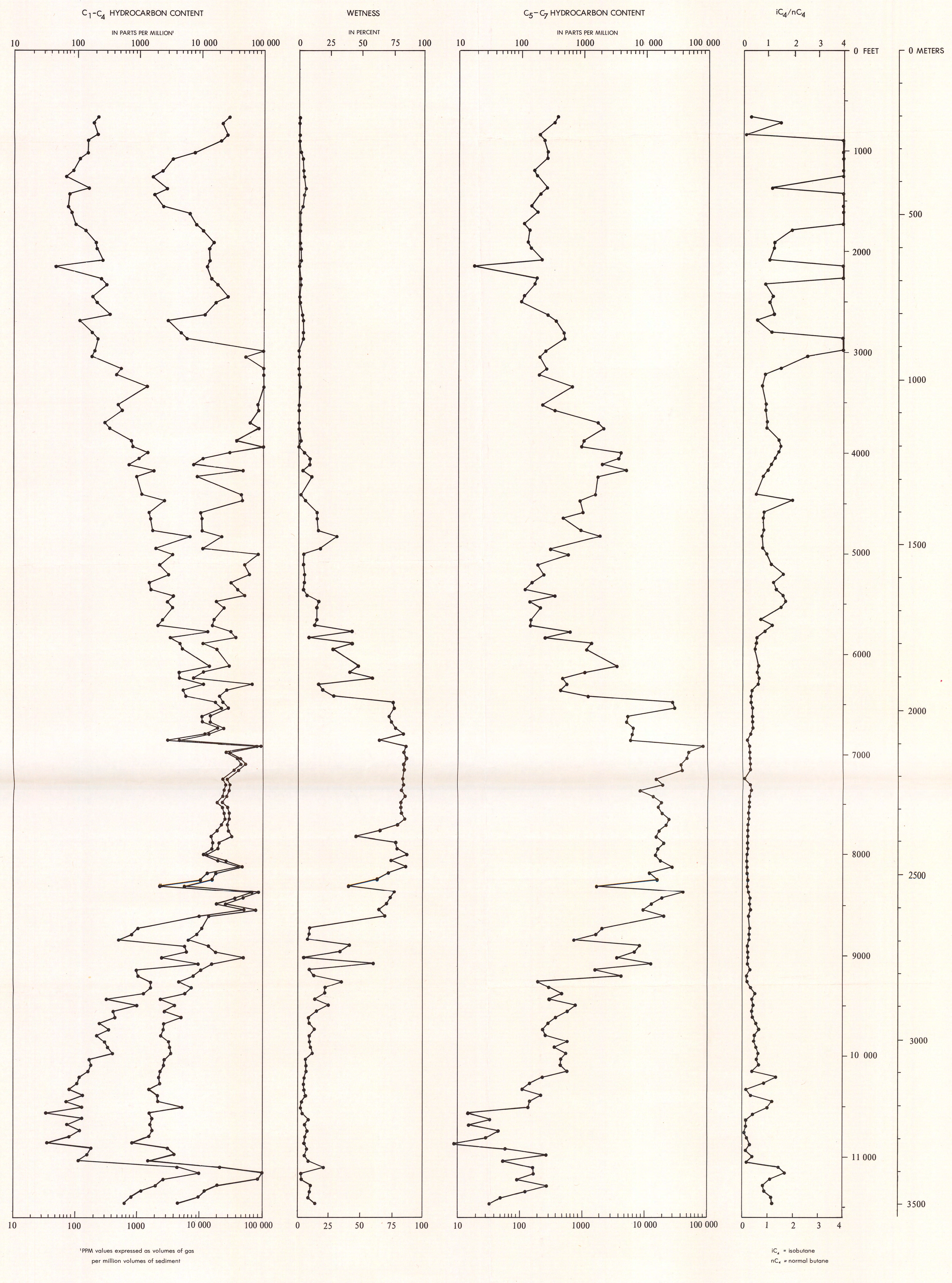
API No. 50-103-20008
Sec. 19, T. 14 N., R. 2 E., UM
Lat 70°33′22′′ N., long 151° 43′02′′ W.
Elev. KB 8.2 m (27 ft)
TD 3515.9 m (11,535 ft)

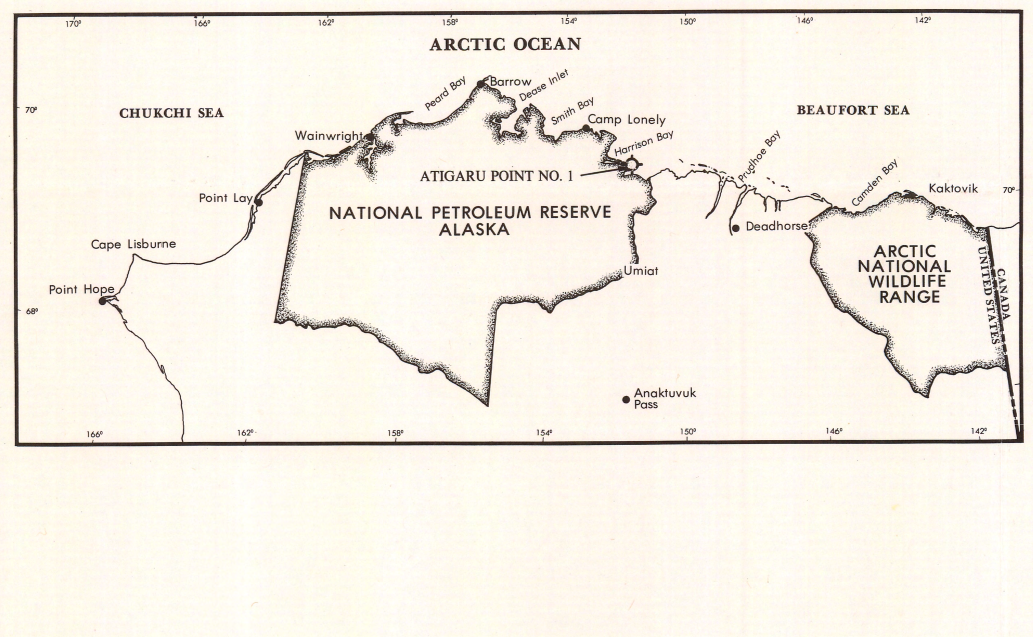
VITRINITE REFLECTANCE

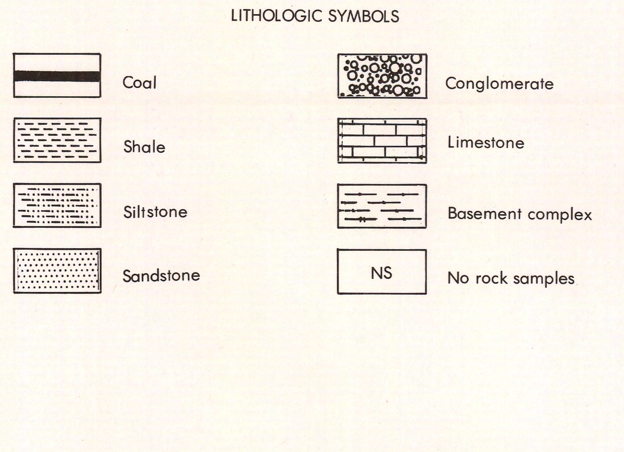




TOTAL C_1-C_7 HYDROCARBON HEADSPACE GAS PLUS CUTTINGS GAS







INTRODUCTION

This graphic display shows vitrinite reflectance, stratigraphic units, lithologies, wireline well-log curves, and C_1 to C_7 hydrocarbon gas data from the Atigaru Point No. 1 well. These initial vitrinite reflectance and hydrocarbon gas data are used to indicate degree of thermal maturity and, to a lesser extent, the level of organic richness of the rock units penetrated. Similar displays of basic data from many of the other wells that were drilled in NPRA (National Petroleum Reserve in Alaska) since 1975 are being made available in this format. The regional geochemical and geologic relations for each stratigraphic unit are being integrated from this well information.

ANALYTICAL PROCEDURE

At the well site drill cuttings are carefully washed with water to remove the drill fluid and are collected in quart cans. If enough cuttings are available, the can is filled to a depth of 3 inches. Water is added to submerge the cuttings and leave a 1/2-inch air space or headspace at the top of the can. A bactericide (zephiran chloride) is added to the water to prevent biological activity in the samples. The can is sealed airtight with a metal lid and 3 lid clips to insure that the samples will not be contaminated during shipment. The cans are shipped in cardboard boxes by air freight to Geochem Research, Inc. in Houston, Texas for analysis.

On receipt of the canned samples at Geochem Research, a silicone rubber septum is attached to the lid of the canned sample in preparation for the C_1 to C_7 headspace-gas analysis. Prior to analysis, the can is shaken by hand for one minute. A small hole is pierced through the septum, and degassed water is allowed to flow into the can until the pressure equilibrates to one atmosphere. The equilibration of pressure is necessary because a partial vacuum often exists inside the can after the warm drill cuttings cool to ambient temperature in the sealed cans. A sample of gas is withdrawn with a 2-ml syringe after a positive pressure is created in the can by injection of 2 ml of degassed water. This 2-ml headspace gas sample is injected into a standard 1-ml gas sample loop attached to the gas chromatograph.

A Varian Aerograph 1400 isothermal gas chromatograph equipped with a 1/8-inch by 8-foot alumina-packed column and flame ionization detector is used for analysis of headspace gas. This column resolves methane, ethane, propane, iso- and normal butane, and, if present, the C_2, C_3, and C_4 olefinic hydrocarbons. After the normal-butane peak elutes, the flow of carrier gas through the system is reversed with a back-flush valve, and the C_5 to C_7 hydrocarbons are eluted as a single composite chromatographic peak. The concentration of each hydrocarbon is computed from peak area by means of an electronic integrator with baseline correction. Before a suite of samples is analyzed, a light-gas standard containing 100 ppm each of methane, ethane, propane, iso-butane, and normal-butane is analyzed in triplicate. Analytical reproducibility is consistently within 2 to 3 percent of the observed value.

After the concentration of the hydrocarbon components in the headspace is determined, the quart can is opened and the volumes of air space, water, and rock drill cuttings are measured. These volumes are used to calculate the concentration of each hydrocarbon component in standard volumes of gas. Gas concentrations (ppm) are expressed as volumes of gas per million volumes of sediment.

After the can is opened, an aliquot of 10 ml of wet cuttings is placed in a specially designed blender for the C_1 to C_7 cuttings gas analysis. The sample is disaggregated in a blender for 2 to 3 minutes. A 2-ml sample of degassed water is injected with a syringe into the 10-ml air space at the top of the blender and an equal amount of the gas sample withdrawn. This 2-ml gas sample is analyzed in the same manner as the headspace gas. The 10-ml aliquot of cuttings and the 10-ml volume of air space are used for calculation of the standard volumes of C_1 to C_7 hydrocarbon components released per million volumes of rock disaggregated.

After the headspace gas and cuttings gas analyses are completed, the data are encoded and forwarded by mail to Petroleum Information Corporation (PI) in Denver, Colorado. At PI the data are keypunched and entered into the geochemical file for retrieval in tabular and graphic form. The display presented here is prepared from computer plots obtained from Geochem Research.

Before vitrinite reflectance and other kerogen analyses are performed, it is necessary to concentrate solid organic matter dispersed in the rock sample. A dried sample of drill cuttings is carefully inspected for contaminants under a microscope. When the sample does contain contaminants such as straw, walnut shells, or other material, they are removed by a density-separation method using a zinc bromide solution. After removal of contaminants, the rock sample is washed of the heavy liquid and air dried. A 30- to 50-g sample is impact crushed to 1- to 2-mm particle size and the <1 mm fraction removed by seiving. The sample is digested with excess amounts of 6N hydrochloric acid and 70 percent hydrofluoric acid. The resulting kerogen concentrate is separated from the inorganic residue and stored under water. A representative aliquot of the kerogen concentrate is mixed with bioplastic and mounted in a predrilled hole in a lucite plug. After the plug is cured overnight in a drying oven, the surface of the vitrinite plug is polished using different grades of coarse to fine alumina powder. The plug containing randomly oriented vitrinite is examined under reflected light, and the optical reflectance of first-cycle vitrinite is measured. Where the abundance of first-cycle vitrinite permits, 50 vitrinite readings are measured and recorded for each sample. If a sample contains little vitrinite, all the vitrinite particles are measured, even if they appear to be second- or third-cycle material. A description of the plug includes (a) polish quality, (b) ease of selecting first-cycle vitrinite, (c) list of all individual values, and (d) qualitative estimate of pyrite abundance.

After vitrinite reflectance values are acquired for each samples, the data are encoded and forwarded by mail to PI. At PI, the data are keypunched and entered into the geochemical file for mathematical calculations, tabular displays, and graphic displays. Information tabulated for this report from the observed values are (1) maximum, (2) minimum, (3) range, (4) mean, (5) standard deviation, and (6) 95-percent confidence limits. The mean reflectance value is computer plotted for this display.

GRAPHIC WELL DISPLAY

The graphic well display consists of three parts: vitrinite reflectance data, well information, and hydrocarbon gas results. All information is shown on a depth scale of 1:6,000. Vitrinite reflectance data are computer plotted mean values on a semi-log scale. The well information includes stratigraphic units penetrated, six wireline log curves--gamma ray, spontaneous potential, resistivity, interval transit time, bulk density, and caliper--, and lithology. The hydrocarbon gas results are a summation of the C_1-C_7 headspace gas and cuttings gas. Five curves of the gas data from left to right are C_2 to C_4, C_1 to C_4, gas wetness in percent (C_2 to C_4/C_1 to C_4 X 100), C_5 to C_7, and iso C_4/nC_4 ratio.

WELL INFORMATION

Atigaru Point No. 1 well was drilled from January 12, 1977 to March 13, 1977 to a total depth of 3,515.9 m (11,535 ft). The well was cased with steel pipe from the surface to the following depths: (1) 136 m (447 ft), (2) 765 m (2,509 ft), and (3) 2,483 m (8,147 ft). The name, age, hydrocarbon shows, and thickness of the stratigraphic units penetrated are as follows:

Name	Age	Shows	Thickness m	(ft)
Colville Group	Late Cretaceous	None	1,059	(3,475)
Nanushuk Group	Early Cretaceous	Oil stain, gas, and fluorescence	237	(777)
Torok Formation	Early Cretaceous	Gas and fluorescence	923	(3,028)
Pebble shale unit	Early Cretaceous	None	11	(35)
Kingak Shale	Jurassic	Gas	270	(885)
Shublik Formation	Triassic	Fluorescence	122	(400)
Sadlerochit Group	Permian and Triassic	Fluorescence and gas	272	(893)
Lisburne Group	Carboniferous	None	404	(1,327)
Endicott Group	Carboniferous	Black residue and gas	119	(390)
Basement complex	Pre-Carboniferous	None	93	(304)

Two conventional cores were cut through the following intervals: (1) 2,655.4 to 2,664.6 m, recovered 9.2 m (8,712 to 8,742 ft, recovered 30 ft), and (2) 3,511.3 to 3,515.9 m, recovered 4 m (11,520 to 11,535 ft, recovered 13 ft). Drill cuttings were collected and canned for each 18-m (60-ft) interval drilled from 171 to 3,511 m (560 to 11,520 ft). No drill-stem tests were run. Uncorrected bottom-hole temperatures (BHT) are (1) 79°C at 2,483 m (174°F at 8,147 ft), and (2) 121°C at 3,512 m (249°F at 11,523 ft). At 2,240 m (7,350 ft) diesel was added to the drilling-mud system. This well was plugged and abandoned March 15, 1977 as a dry hole.

RESULTS

Mean (MN) vitrinite reflectance values from 17 cuttings (CT) and three core samples (CO) range from 0.36 percent to 1.34 percent and a sample depth range from 207 to 3,395 m. Values tabulated below by sample depth (FT and M) and type (CT and CO) are from as many as 50 observed values (OB) from each sample and were statistically calculated to show (1) maximum, (MXR), (2) minimum (MIR), (3) range (RAN), (4) mean (MN), and (5) standard deviation (STD).

FT	M	SPL	OB	MXR	MIR	RAN	MN	STD
680	207	CT	50	0.50	0.27	0.24	0.37	0.07
1,220	372	CT	12	0.46	0.35	0.12	0.40	0.03
1,880	573	CT	50	0.46	0.33	0.13	0.41	0.03
2,480	756	CT	50	0.43	0.26	0.17	0.35	0.04
3,140	957	CT	50	0.46	0.25	0.21	0.38	0.04
3,680	1,122	CT	50	0.42	0.30	0.13	0.38	0.03
4,280	1,305	CT	50	0.53	0.34	0.19	0.41	0.05
4,940	1,506	CT	50	0.54	0.30	0.25	0.43	0.05
5,600	1,707	CT	48	0.63	0.36	0.23	0.49	0.06
6,180	1,884	CT	50	0.67	0.35	0.32	0.53	0.09
7,430	2,265	CT	50	0.69	0.35	0.34	0.51	0.10
8,020	2,444	CT	27	0.72	0.34	0.38	0.56	0.11
8,500	2,591	CT	8	0.72	0.54	0.18	0.64	0.07
8,713	2,656	CO	33	1.01	0.58	0.44	0.87	0.13
8,726	2,660	CO	33	1.05	0.58	0.48	0.91	0.13
8,742	2,665	CO	16	0.99	0.58	0.41	0.82	0.13
9,700	2,957	CT	2	0.90	0.81	0.10	0.86	0.07
10,870	3,313	CT	50	1.45	0.89	0.56	1.26	0.13
11,050	3,368	CT	46	1.47	0.90	0.57	1.30	0.13
11,140	3,395	CT	50	1.11	0.48	0.63	0.86	0.18

One hundred and fifty-two canned cuttings samples were analyzed for headspace gas and cuttings gas approximately every 18 m. The C_1-C_4 hydrocarbon content (headspace gas plus cuttings gas) is depicted with two curves; the left curve shows total C_2-C_4 content, and the right curve shows C_1-C_4 content. The distance between these curves is a measure of the methane (C_1) content. C_1-C_4 hydrocarbon content ranges from a low of 1,663 ppm at 372 m to a high of 369,607 ppm at 3,414 m. C_1-C_4 content varies significantly from 189 to 914 m but remains above 10,000 ppm from 914 to 2,637 m. C_2-C_4 hydrocarbon content increases from a low of 50 ppm at 660 m to a high of more than 10,000 ppm between 1,966 to 2,637 m. Below 2,637 m the C_2-C_4 content drops back to below 10,000 ppm.

Four zones of differing gas wetness (C_2-C_4/C_1-C_4 X 100), A through D, can be identified. Zone A, in which gas wetness is near zero, extends from near the surface to 1,220 m. Zone B, where gas wetness increases from zero to 50 percent, extends from 1,220 to 1,965 m. Zone C, where gas wetness exceeds 50 percent, occurs from 1,965 to 2,635 m. Zone D, where gas wetness drops toward zero from 50 percent wetness, is from 2,635 m to total depth.

C_5-C_7 hydrocarbon content increases and then decreases systematically. Gas content is less than 1,000 ppm from near the surface to 1,130 m. Between 1,965 and 2,635 m, the gas content ranges from 10,000 to 100,000 ppm. Below 2,635 m gas content drops from 10,000 to 100 ppm. The ratio of isobutane to normal butane is variable from the surface to 1,750 m and consistently less than 1.0 to 3,078 m. From 3,078 m the isobutane to normal butane content is so low that the ratio is again variable.

DISCUSSION

Vitrinite reflectance, minor hydrocarbon indications, and C_1-C_7 data suggest that zone A is thermally immature. Zone B is marginally mature as reflectance values range from 0.5 to 0.6 percent, oil and gas shows are present but are considered migrated oil. Liquid hydrocarbons are being generated in zone C. Reflectance values are 0.6 to 0.8 percent, C_1-C_7 hydrocarbons have peaked, and numerous hydrocarbon shows are present. Zone D is past peak liquid hydrocarbon generation, or the rock units contain little organic material. Reflectance values range from 0.8 to more than 1.0 percent, C_1-C_7 hydrocarbons are decreasing, and dead oil are present.

ACKNOWLEDGMENTS

The authors thank the people and organizations that contributed to this graphic display. Geochem Research provided the vitrinite reflectance data and the C_1 to C_7 hydrocarbon gas analyses and display. Petroleum Information provided the computer plot of the vitrinite reflectance data, and under the direction of Kenneth J. Bird of the U.S. Geological Survey provided the display for the six wireline well-log curves and lithology display. Kenneth J. Bird and Keith A. Kvenvolden critically reviewed this publication and provided many helpful suggestions that significantly improved the usefulness of this display. Brigitta V. Fulop and Jeanne A. Blank drafted the plates and Theresa A. Coit typed the text. Robert M. Egbert helped immeasurably in the early stage of the plate preparation.

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VITRINITE REFLECTANCE AND C_1-C_7 HYDROCARBON DATA FOR ATIGARU POINT NO. 1 WELL

NORTH SLOPE, ALASKA

By

Leslie B. Magoon and George E. Claypool

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