DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

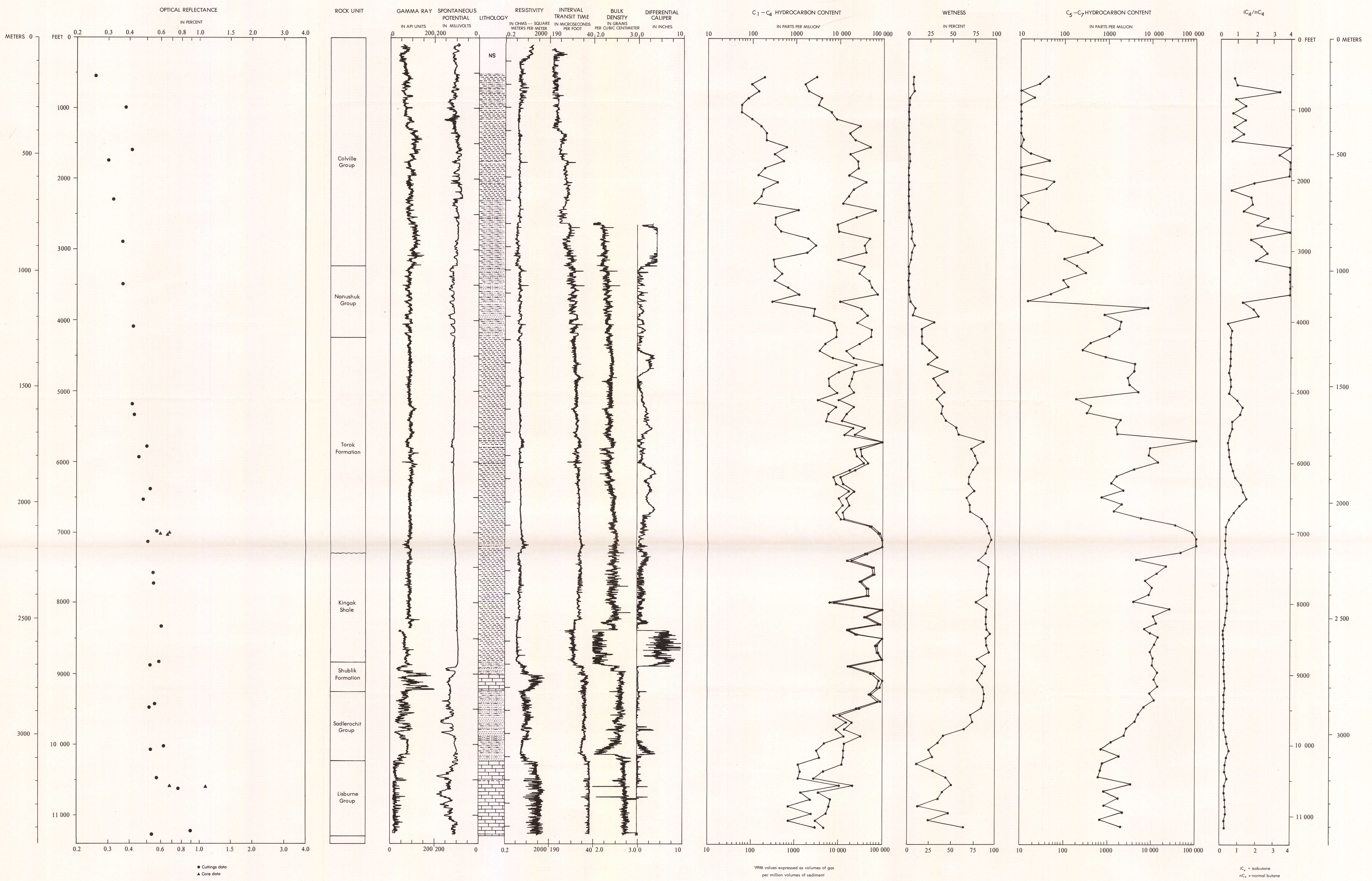
OIL AND GAS INVESTIGATIONS
CHART OC-93

SOUTH HARRISON BAY NO. 1

API No. 50-103-20007
Sec. 6, T. 12 N., R. 2 E., UM
Lat 70°25'29'' N., long 151°43'42'' W.
Elev KB 13.7 m (45 ft)
TD 3,441.2 m (11,290 ft)

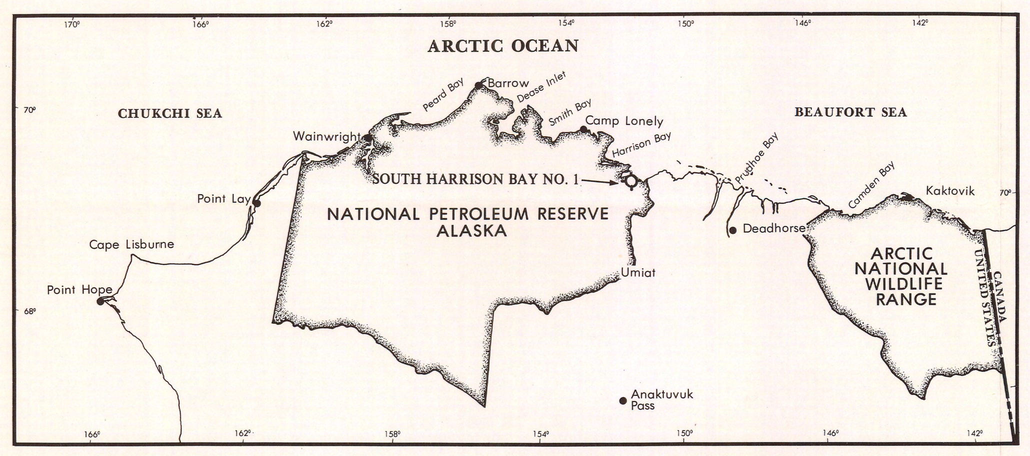
VITRINITE REFLECTANCE

TOTAL C_1-C_7 HYDROCARBON HEADSPACE GAS PLUS CUTTINGS GAS

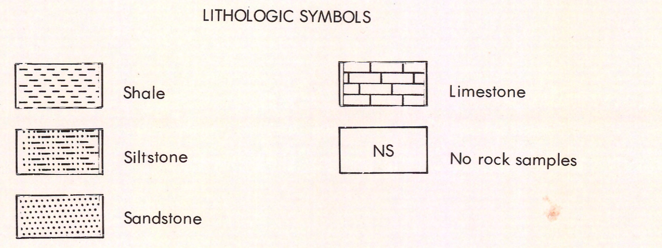


1PPM values expressed as volumes of gas per million volumes of sediment

iC_4 = isobutane
nC_4 = normal butane



LITHOLOGIC SYMBOLS



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 South Harrison Bay 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

South Harrison Bay No. 1 well was drilled from November 21, 1976 to January 28, 1977 to a total depth of 3,441.2 m (11,290 ft). The well was cased with steel pipe from the surface to the following depths: (1) 25 m (83 ft), (2) 792 m (2,600 ft), and (3) 2,661 m (8,730 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	Gas and dead oil	981	(3,220)
Nanushuk Group	Early Cretaceous	Fluorescence	303	(995)
Torok Formation	Early Cretaceous	Gas and fluorescence	937	(3,075)
Kingak Shale	Jurassic	Gas and fluorescence	474	(1,555)
Shublik Formation	Triassic	Gas and fluorescence	120	(395)
Sadlerochit Group	Permian and Triassic	Gas and fluorescence	302	(990)
Lisburne Group	Carboniferous	Dead oil	323	(1,060)

Two conventional cores were cut through the following intervals: (1) 2,140.3 to 2,149.5 m, recovered 4.2 m (7,022 to 7,052 ft, recovered 13.6 ft); and (2) 3,234.8 to 3,239.4 m, recovered 4.3 m (10,613 to 10,628 ft, recovered 14 ft). Drill cuttings were collected and canned for each 15-m (50-ft) interval drilled from 152 to 3,441 m (500 to 11,290 ft) except when a core was cut. Three drill-stem tests were run: (1) from 2,167 to 2,169 m (7,108 to 7,117 ft) with no fluid recovery; (2) from 2,170 to 2,222 m (7,120 to 7,290 ft) with no fluid recovery; and (3) from 1,731 to 1,765 m (5,680 to 5,790 ft) with recovery of very small amounts of gas and water. Temperatures from three drill-stem tests are: (1) 57°C at 1,711 m (134°F at 5,614 ft), (2) 76°C at 2,151 m (168°F at 7,057 ft), and (3) 77°C at 2,163 m (170°F at 7,095 ft). Uncorrected bottom-hole temperatures (BHT) are (1) 21°C at 804 m (70°F at 2,639 ft), (2) 69°C at 2,554 m (156°F at 8,380 ft), and (3) 117°C at 3,436 m (242°F at 11,274 ft). The well was plugged and abandoned February 28, 1977 as a dry hole.

RESULTS

Mean (MN) vitrinite reflectance values from 29 cuttings (CT) and five core samples (CO) range from 0.26 percent to 1.09 percent and a sample depth range from 168 m to 3,444 m. Values tabulated below by sample depth (FT and M) and type (CT and CO) are from as many as 50 observed values (OB) for 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
550	168	CT	50	0.35	0.21	0.14	0.26	0.03
1,000	305	CT	16	0.46	0.32	0.14	0.38	0.04
1,600	488	CT	7	0.49	0.31	0.18	0.41	0.06
1,750	533	CT	50	0.36	0.22	0.14	0.30	0.03
2,300	701	CT	43	0.42	0.27	0.15	0.32	0.04
2,900	884	CT	37	0.45	0.30	0.15	0.36	0.04
3,500	1,067	CT	10	0.46	0.30	0.16	0.37	0.07
4,100	1,250	CT	4	0.48	0.36	0.12	0.42	0.06
5,200	1,585	CT	6	0.45	0.38	0.07	0.41	0.03
5,350	1,631	CT	50	0.57	0.31	0.26	0.43	0.06
5,800	1,768	CT	29	0.56	0.39	0.17	0.50	0.04
5,950	1,814	CT	50	0.60	0.32	0.28	0.45	0.07
6,400	1,951	CT	11	0.69	0.41	0.28	0.53	0.10
6,550	1,996	CT	50	0.61	0.33	0.28	0.48	0.07
7,000	2,134	CT	33	0.71	0.35	0.36	0.57	0.09
7,022	2,140	CO	50	0.79	0.52	0.27	0.68	0.06
7,037	2,145	CO	48	0.72	0.44	0.28	0.60	0.06
7,052	2,149	CO	50	0.77	0.59	0.18	0.66	0.05
7,150	2,179	CT	37	0.63	0.35	0.28	0.51	0.09
7,600	2,316	CT	49	0.67	0.40	0.27	0.55	0.06
7,750	2,362	CT	37	0.67	0.35	0.32	0.55	0.10
8,350	2,545	CT	30	0.73	0.49	0.24	0.61	0.07
8,850	2,697	CT	14	0.72	0.47	0.25	0.59	0.08
8,900	2,713	CT	43	0.65	0.37	0.28	0.53	0.08
9,450	2,880	CT	21	0.74	0.42	0.32	0.56	0.11
9,500	2,896	CT	19	0.70	0.40	0.30	0.52	0.09
10,050	3,063	CT	15	0.83	0.44	0.39	0.63	0.14
10,100	3,078	CT	8	0.67	0.40	0.27	0.53	0.11
10,500	3,200	CT	28	0.72	0.42	0.30	0.57	0.08
10,650	3,246	CT	13	0.96	0.50	0.46	0.76	0.16
10,615	3,235	CO	50	0.80	0.50	0.30	0.28	0.06
10,626	3,239	CO	40	1.26	0.87	0.39	1.09	0.09
11,250	3,429	CT	9	1.11	0.65	0.46	0.89	0.14
11,300	3,444	CT	35	0.64	0.46	0.18	0.54	0.04

One-hundred and nine canned cuttings samples were analyzed for headspace gas and cuttings gas approximately every 30 m. The total 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, 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 1,640 ppm at 200 m to a high of 150,192 ppm at 2,195 m. Between the depth interval of 335 to 3,140 m the C_1-C_4 content is above 10,000 ppm. C_2-C_4 content ranges from a low of 63 ppm at 275 m to a high of 138,080 ppm at 2,195 ft. The C_2-C_4 hydrocarbon content is generally above 1,000 ppm at 1,140 m, and above 10,000 ppm from 1,660 m to 3,000 m. From 3,000 m the C_2-C_4 content drops 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 the surface to 1,145 m. Zone B, where gas wetness increases from zero to 50 percent, extends from 1,145 to 1,660 m. Zone C, where gas wetness exceeds 50 percent, occurs from 1,660 to 3,000 m. Zone D, where gas wetness drops toward zero from 50 percent wetness, is from 3,000 m to total depth.

C_5-C_7 hydrocarbon content changes generally correspond to changes of gas wetness. C_5-C_7 content is generally below 1,000 ppm to 1,145 m, and below 10,000 ppm to 2,075 m. Between 2,075 m and 2,880 m, the C_5-C_7 content averages 10,000 ppm. From 2,880 m to total depth the gas content drops below 10,000 ppm. The ratio of isobutane to normal butane is variable from 159 m to 1,220 m. From 1,220 m to total depth the ratio is near 1.0 or below.

DISCUSSION

Zone A is characterized by gas wetness near zero, reflectance values up to 0.4 percent, variable isobutane to normal butane ratio, and, on the mud log, minor hydrocarbon shows that probably migrated into these rocks. Zone B is characterized by an increase in gas wetness to 50 percent, reflectance values to 0.5 percent, isobutane to normal butane ratio below 1.0, and minor hydrocarbon shows. In zone C, gas wetness is above 50 percent, reflectance values are as much as 0.8 percent, and numerous hydrocarbon shows occur in shale or siltstone. Zone D is characterized by a decrease in gas wetness to below 50 percent, but this decrease can be attributed to the absence of organic material or, less likely, to a hot thermal history.

ACKNOWLEDGMENTS

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VITRINITE REFLECTANCE AND C_1-C_7 HYDROCARBON DATA FOR SOUTH HARRISON BAY NO. 1 WELL, NORTH SLOPE, ALASKA

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