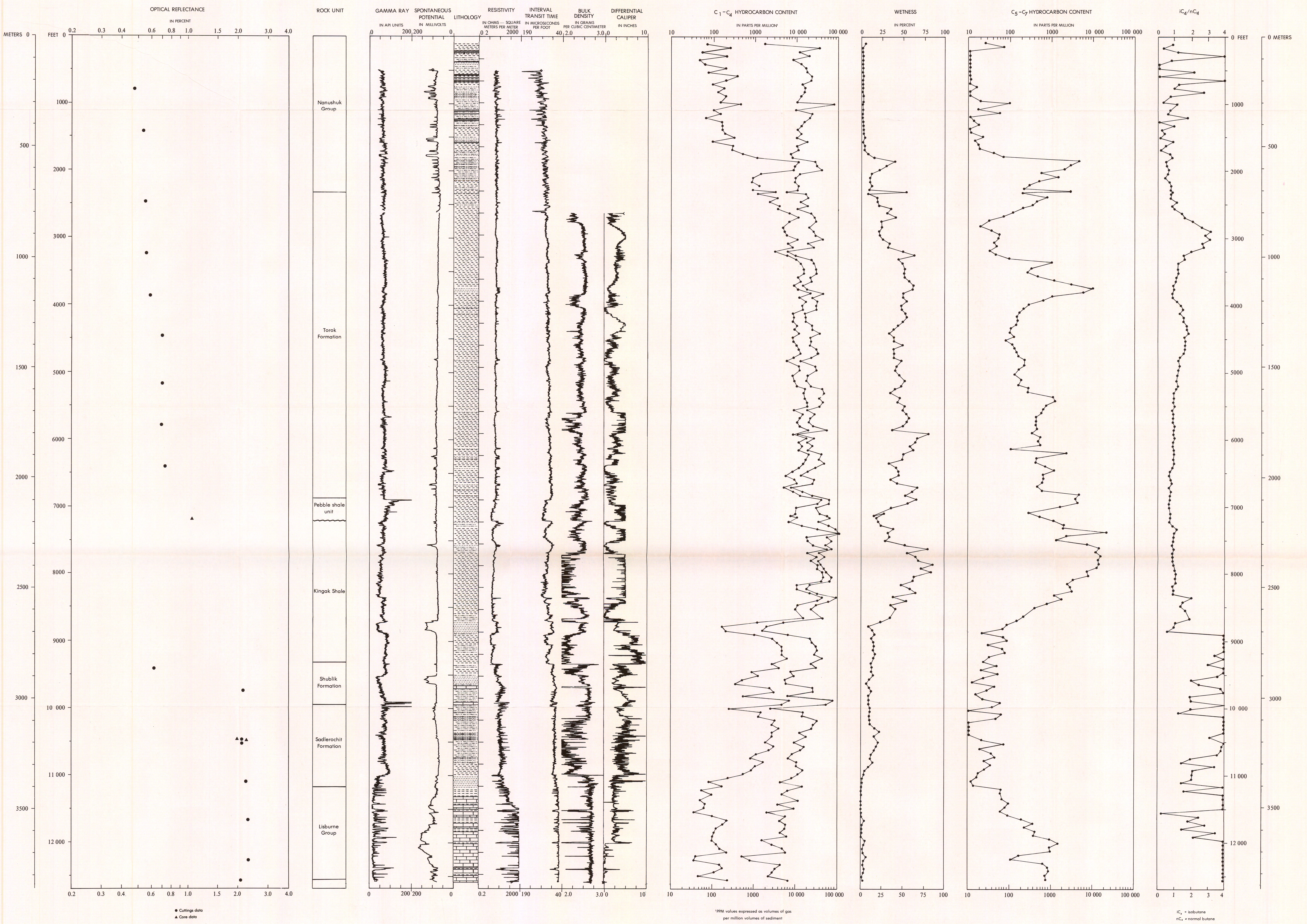
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

OIL AND GAS INVESTIGATIONS
CHART OC-101

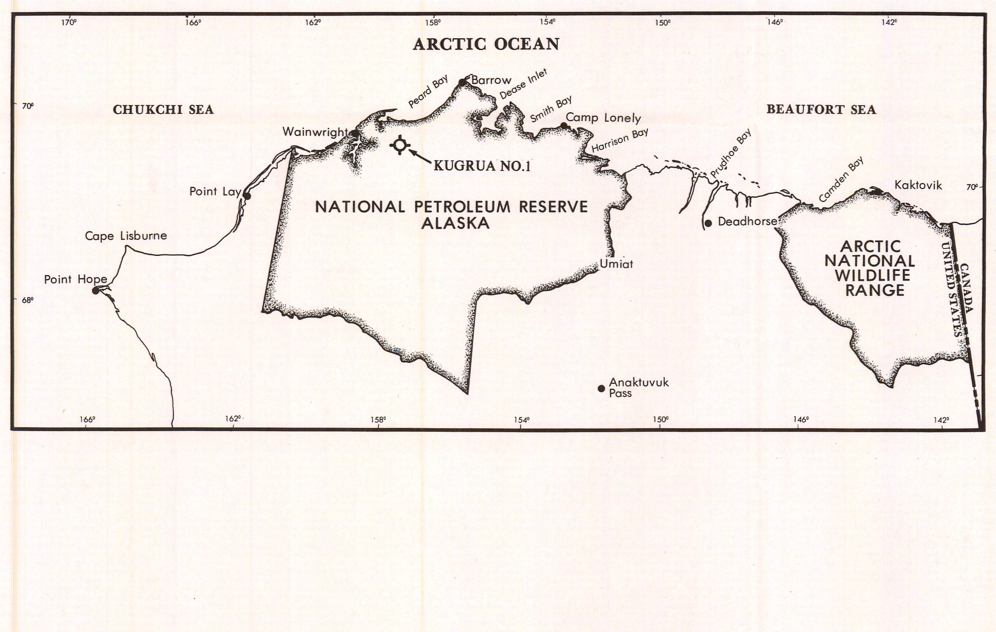
KUGRUA NO. 1

API No 50-163-20002
Sec. 8, T. 14 N., R. 26 W., UM
Lat 70°35'13'' N., long 158°39'43'' W.
Elev. KB 25.9 m (85 ft)
TD 3,836.8 m (12,588 ft)



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

iC_4 = isobutane
nC_4 = normal butane



LITHOLOGIC SYMBOLS

Coal
Shale
Siltstone
Sandstone
Limestone

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 Kugrua 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

Kugrua No. 1 well was drilled from February 12, 1978 to May 21, 1978 to a total depth of 3,836.8 m (12,588 ft). The well was cased with steel pipe from the surface to the following depths: (1) 28 m (93 ft), (2) 151 m (496 ft), (3) 795 m (2,611 ft), and (4) 2,653 m (8,704 ft). The name, age, hydrocarbon shows, and thickness of the stratigraphic units penetrated are as follows:

Name	Age	Shows	Thickness m	(ft)
Nanushuk Group	Early Cretaceous	Gas and fluorescence	710	(2,330)
Torok Formation	Early Cretaceous	Gas and fluorescence	1,390	(4,560)
Pebble shale unit	Early Cretaceous	Gas and fluorescence	95	(310)
Kingak Shale	Jurassic	Fluorescence and gas	650	(2,134)
Shublik Formation	Triassic	None	194	(636)
Sadlerochit Group	Permian and Triassic	Fluorescence	369	(1,210)
Lisburne Group	Carboniferous	Gas (H_2S)	429	(1,408)

Three conventional cores were cut through the following intervals: (1) 2,193.5 to 2,195 m, recovered 1.5 m (7,197 to 7,200 ft, recovered 5 ft); (2) 3,194.3 to 3,201.6 m, recovered 7.3 m (10,480 to 10,504 ft, recovered 24 ft); and (3) 3,362 to 3,363 m, recovered 1 m (11,030 to 11,033 ft, rcovered 3 ft). Drill cuttings were collected and canned for each 10-m (30-ft) interval drilled from 30 to 3,836.8 m (100 to 12,588 ft) except when a core was cut. No drill-stem tests were run. Bottom-hole temperatures (BHT) are (1) 38°C at 800 m (100°F at 2,624 ft), (2) 71°C at 2,652 m (160°F at 8,702 ft), and (3) 124°C at 3,837 m (255°F at 12,590 ft). The well was plugged and abandoned May 29, 1978 as a dry hole.

RESULTS

Mean (MN) vitrinite reflectance values from 18 cuttings (CT) and three core samples (CO) range from 0.47 percent to 2.30 percent, and a sample depth range from 58 to 3,839 m. Values tabulated below by sample depth (FT and M) and type (CT and CO) are from as many as 50 observed values (OB) and 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
190	58	CT	50	0.59	0.40	0.19	0.50	0.04
790	241	CT	50	0.62	0.36	0.26	0.47	0.07
1,420	433	CT	50	0.66	0.37	0.29	0.53	0.07
2,470	753	CT	42	0.71	0.40	0.31	0.55	0.07
3,240	988	CT	50	0.73	0.43	0.30	0.56	0.07
3,870	1,180	CT	50	0.77	0.40	0.37	0.59	0.07
4,470	1,362	CT	50	0.88	0.44	0.44	0.70	0.09
5,180	1,579	CT	50	0.83	0.53	0.30	0.70	0.08
5,800	1,768	CT	50	0.90	0.43	0.47	0.69	0.11
6,420	1,957	CT	50	0.90	0.44	0.46	0.73	0.12
7,198	2,194	CO	34	1.18	0.81	0.37	1.05	0.09
9,430	2,874	CT	14	0.79	0.49	0.30	0.62	0.09
9,760	2,975	CT	46	2.45	1.76	0.69	2.13	0.18
10,486	3,196	CO	45	2.27	1.79	0.48	1.96	0.13
10,490	3,197	CT	50	2.47	1.55	0.92	2.10	0.21
10,504	3,202	CO	48	2.50	1.77	0.73	2.24	0.16
10,550	3,216	CT	50	2.48	1.75	0.73	2.10	0.17
11,120	3,389	CT	50	2.61	1.72	0.89	2.22	0.18
11,690	3,563	CT	49	2.67	1.50	1.17	2.29	0.25
12,290	3,746	CT	50	2.77	1.62	1.15	2.30	0.23
12,594	3,839	CT	34	2.57	1.56	1.01	2.06	0.25

Two-hundred and six canned cuttings samples were analyzed for headspace gas and cuttings gas approximately every 18 m (60 ft). 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 content, and the right curve shows total 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 513 ppm at 3,720 m to a high of 308,899 ppm at 2,265 m. The C_1-C_4 content remains between 10,000 and 100,000 ppm from 50 to 3,350 m, where the gas content drops below 10,000 ppm. The C_2-C_4 hydrocarbon content increases from values near 100 near the surface to 520 m, where the gas content increases from 100 to 10,000 ppm around 1,005 m. Between 1,005 m and 2,590 m the C_2-C_4 content remains near or above 10,000 ppm. From 2,590 m to 3,350 m the gas content drops from 10,000 to 100 ppm and remains constant to total depth.

Five zones of differing gas wetness, A through E, can be identified. Zone A, in which gas wetness is near zero, lies between 30 m and 520 m. Zone B, where gas wetness increases to 50 perecent, extends from the bottom of zone A to 975 m. Zone C, in which gas wetness remains near or above 50 percent, is from 975 to 2,560 m. Zone D, where gas wetness drops from 50 percent to near zero, extends to 3,350 m. Zone E, where gas wetness returns to near zero, is found from 3,350 m to total depth.

C_5-C_7 hydrocarbon content depicts three significant gas peaks, of which only two peaks exceed 10,000 ppm. The shallowest peak occurs within zone B and may relate to migrated hydrocarbons that were reported when the well was drilled. The two deeper peaks occur within zone C at 1,220 m and 2,285 m. C_2-C_4 gas content drops below 100 ppm in zone D but increases to 1,000 ppm in zone E.

The ratio of isobutane to normal butane is variable to 550 m. Except for a large peak at 915 m, the ratio remains around 1.0 to 2,530 m. From 2,530 m to total depth, the ratio becomes variable.

DISCUSSION

On the basis of gas wetness, the rocks penetrated in this well can be divided into five zones of differing thermal histories, A through E. Zone A is considered thermally immature because the vitrinite reflectance values are about 0.5 percent. Zone B, a marginally mature zone in which gas wetness increases to 50 percent, has reflectance values of as much as 0.6 percent and one indication of hydrocarbon. Zone C, which represents thermal maturity, contains good indications of hydrocarbons with vitrinite reflectance values ranging from 0.6 to 1.5 percent. Hydrocarbon shows identified as the well was drilled indicate that the best shows occur in zone C. Zone D, a late stage of thermal maturity, is indicated by high reflectance values (1.5 to 2.5 percent) and a decrease in the number of hydrocarbon shows. Hydrogen sulfide (56 ppm) was encountered through zone E.

ACKNOWLEDGMENTS

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

By

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1980

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