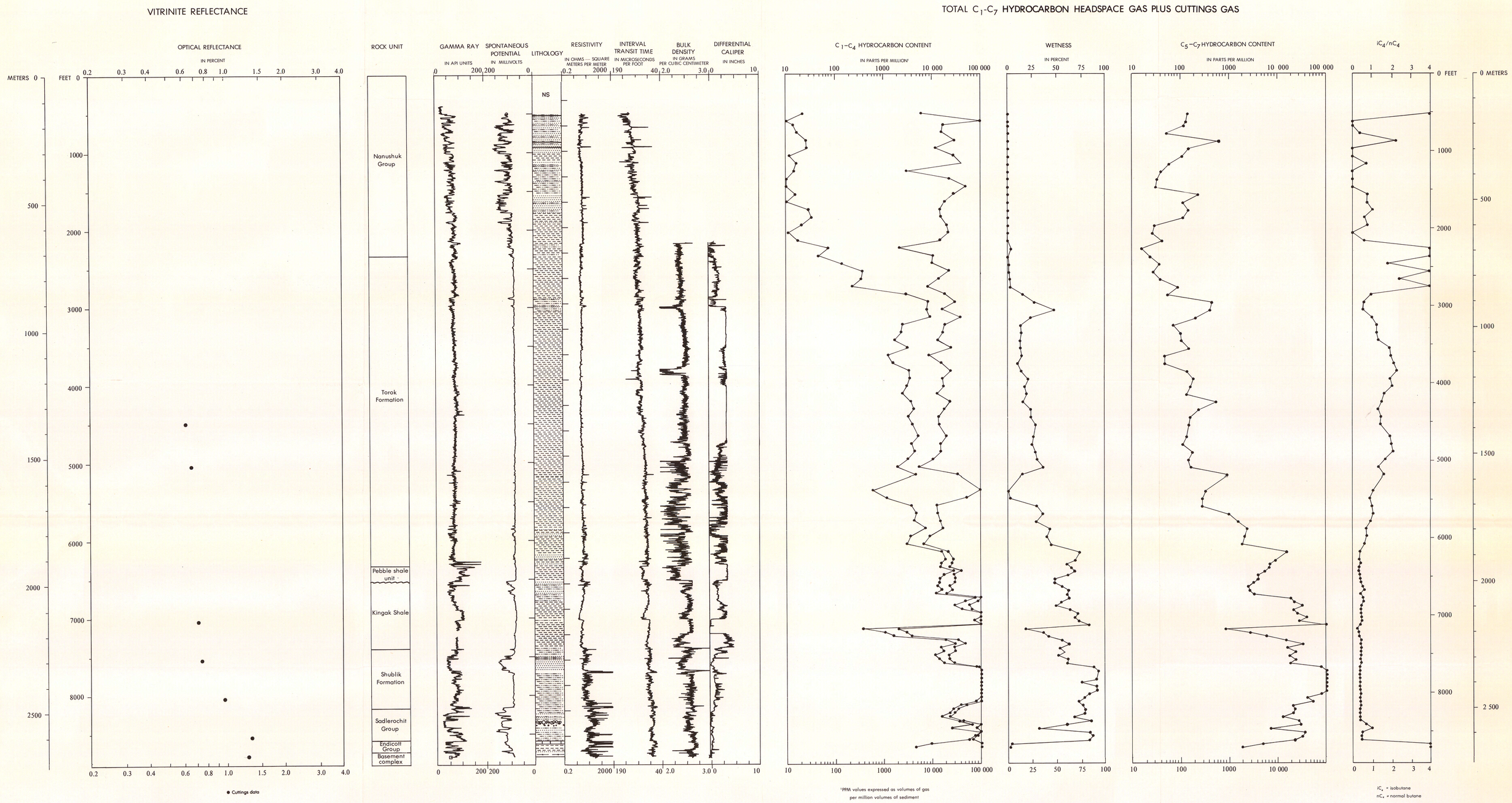
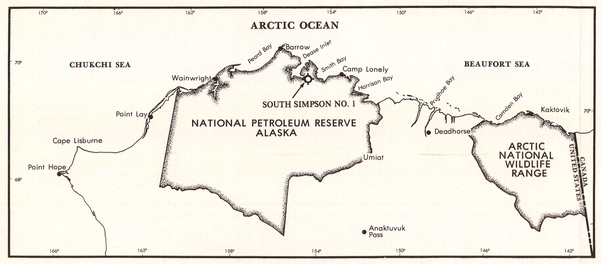
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

OIL AND GAS INVESTIGATIONS
CHART OC-92

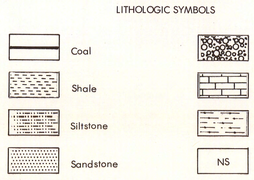
SOUTH SIMPSON NO. 1

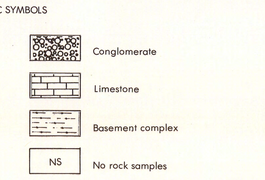
API No. 50-279-20001
Sec. 22, T. 17 N., R. 12 W., UM
Lat 70°48′25″ N., long 154°58′55″ W.
Elev. KB 7.6 m (25 ft)
TD 2,680.7 m (8,795 ft)





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 Simpson 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 (sephiran 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.

Upon arrival at 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_5, C_6, and C_7 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 deserved value.

After the concentration of the hydrocarbon components in the headspace is determined, the quart can is opened and the volumes of air spaces, 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_5 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_5 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 the geochemical file.

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 prerifled 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 sample, 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 includes 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_5 headspace gas and cuttings gas. Five curves of the gas data from left to right are C_1 to C_4, C_1 to C_5, 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 Simpson No. 1 well was drilled from March 9, 1977 to April 19, 1977 to a total depth of 2,680.7 m (8,795 ft). The well was cased with steel pipe from the surface to the following depths: (1) 151 m (495 ft), (2) 663 m (2,175 ft), and (3) 2,196 m (7,206 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	Fluorescence	713	(2,340)
Torok Formation	Early Cretaceous	Gas and fluorescence	1,218	(3,997)
Pebble shale unit	Early Cretaceous	None	56	(183)
Kingak Shale	Jurassic	Gas and fluorescence	264	(865)
Shublik Formation	Triassic	Gas and fluorescence	239	(785)
Sadlerochit Group	Permian and Triassic	Fluorescence	128	(420)
Endicott Group	Carboniferous	Gas	49	(160)
Basement complex	Pre-Carboniferous	None	14	(45)

No conventional cores were cut. Drill cuttings were collected and canned for each 15-m (50-ft) interval drilled from 155 to 2,681 m (510 to 8,795 ft). Three drill-stem tests (DSTs) were taken from three different depth intervals: (1) from 1,988 to 2,012 m (6,522 to 6,266 ft) gas flowed to the surface at an estimated rate of 75 MCFD (thousand cubic feet of gas a day) ten minutes after the final flow period started; at a rate of 75 MCFD (thousand cubic feet of gas a day); (2) from 1,862 to 1,957 m (6,108 to 6,420 ft) which recovered 785 ft of watery mud with some gas; and (3) 1,770 to 1,853 m (5,807 to 6,080 ft) with no recovery. Four gas analyses by Chemical & Geological Laboratories of Alaska, Inc. are from three DSTs; two samples were acquired from the first DST. The recorded temperatures for these three DSTs are 68°C (155°F), 54°C (130°F), and 51°C (123°F), respectively. Uncorrected bottom-hole temperatures from three log runs are (1) 27°C at 664 m (80°F at 2,180 ft), (2) 63°C at 2,195 m (145°F at 7,200 ft), and (3) 86°C at 2,682 m (187°F at 8,799 ft). This well was plugged and abandoned April 30, 1977 as a dry hole.

Component	Volume percent DST 1	DST 1	DST 2	DST 3
Oxygen	---	---	---	---
Nitrogen	87.88	88.24	89.40	76.28
Carbon dioxide	Trace	Trace	Trace	Trace
Hydrogen sulfide	---	---	---	---
Methane	10.297	10.73	9.50	22.21
Ethane	0.52	0.51	0.44	0.77
Propane	0.31	0.25	0.33	0.38
Iso-butane	0.05	0.04	0.05	0.06
N-butane	0.11	0.09	0.12	0.15
Iso-pentane	0.04	0.03	0.04	0.03
N-pentane	0.04	0.03	0.04	0.06
Hexanes	0.04	0.04	0.05	0.03
Heptanes and higher	0.04	0.04	0.03	0.03
Total	100.00	100.00	100.00	100.00

RESULTS

Mean (MN) vitrinite reflectance values from seven cuttings (CT) samples range from 0.42 percent to 1.14 percent, and a sample depth range from 1,372 m to 2,681 m. Reflectance values increase gradually from 0.42 percent to 0.74 percent then increase abruptly to 1.14 percent in the sedimentary rocks above basement. Values tabulated below by sample depth (FT and M) and type (CT) are from as many as 50 observed values (OB) 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
4,500	1,372	CT	50	0.78	0.46	0.32	0.62	0.09
5,050	1,539	CT	50	0.80	0.52	0.28	0.66	0.08
7,050	2,149	CT	10	0.84	0.50	0.34	0.71	0.10
7,550	2,301	CT	25	0.92	0.50	0.42	0.74	0.12
8,250	2,454	CT	34	1.14	0.41	0.53	0.98	0.12
8,550	2,606	CT	46	1.57	0.91	0.66	1.34	0.16
8,795	2,681	CT	43	1.55	1.22	0.33	1.29	0.16

One-hundred and eight canned cuttings samples were analyzed for headspace gas and cuttings gas approximately every 30 m to 1,920 m, then every 15 m to total depth. The total C_1-C_7 hydrocarbon content (headspace gas plus cuttings gas) is depicted with two curves; the left curve shows total C_1-C_4 and the right curve shows total C_5-C_7. 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 1,993 ppm at 2,195 m to a high of 603,477 ppm at 2,362 m. C_5-C_7 hydrocarbon content ranges from a low of 363 ppm at 2,195 m to a high of 561,284 ppm at 2,362 m. C_1-C_4 hydrocarbon concentration falls into three categories; concentrations below 1,000 ppm to a depth of 853 m, concentrations between 1,000 and 10,000 ppm to a depth of 1,875 m, and concentrations above 10,000 ppm to total depth.

Three zones of differing gas wetness (C_2-C_4/C_1-C_4 X 100). A through C, can be identified. Zone A, in which gas wetness is near zero, extends from the surface to 853 m. Zone B, where gas wetness increases from zero to 50 percent extends from 853 to 1,875 m. Zone C, where gas wetness exceeds 50 percent, occurs from 1,875 m to a depth of 2,667 m.

C_1-C_5 hydrocarbon content increases with increasing depth from values of less than a 1,000 ppm to 1,707 m to values over 1,000 to 2,667 m. The isobutane to normal butane ratio is generally above 1 to 1,700 m then remains below 1 (except for the last two samples) to total depth.

DISCUSSION

The gases analyzed in zone A are located in a zone of thermal immaturity. Gradual heating of the rock column is occurring in zone B. The vitrinite reflectance value of 0.6 percent is interpreted to be within zone B. Thermal maturity is complete through zone C where the gas wetness maximum is present. Postmature sediments were not found in this test with the possible exception of the basement rocks. The presence of shows (fluorescence) within the Shublik Formation, a shale and siltstone unit, and a noticable absence of shows in the Sadlerochit Group, predominantly a sandstone unit, suggest that the shows are indications of mature sediments and were not produced by migrated hydrocarbons.

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 the manuscript and made many helpful suggestions that significantly improved the usefulness of this display. Brigitta V. Pulop and Jeanne A. Blank drafted the plates and Theresa A. Cuit typed the text. Robert M. Egbert helped immeasurably in the early stage of the plate preparation.

DISCLAIMER

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

By
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