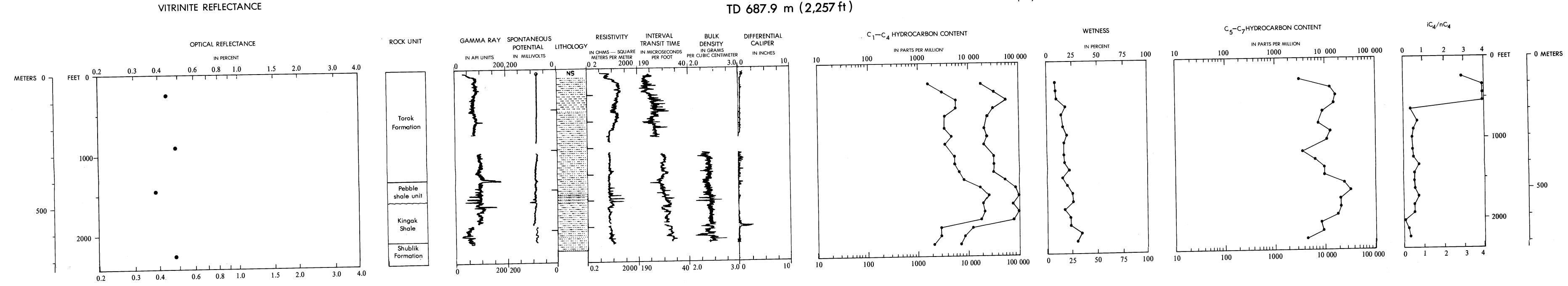
API No. 50-023-20009 Sec. 25, T. 22 N., R. 17 W., UM Lat 71°13′59" N., long 156°18′11" W. Elev. KB 9.5 m (31 ft)

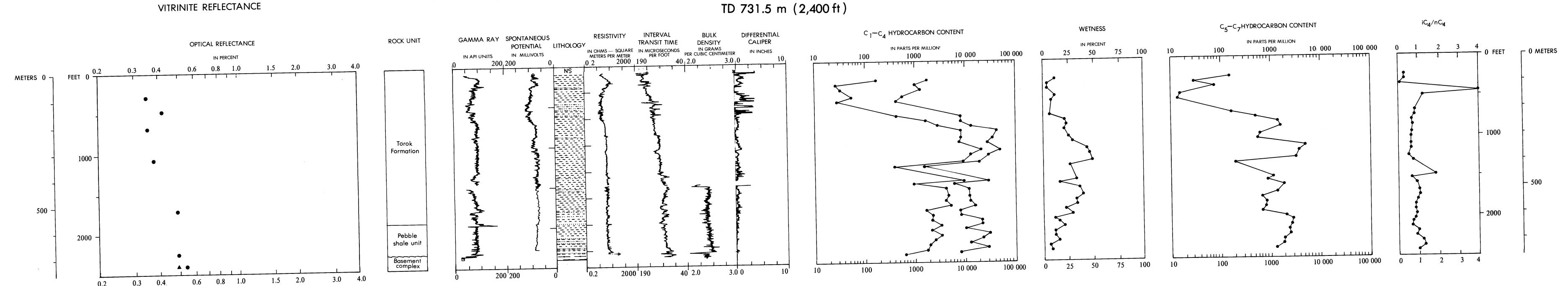
TOTAL C1-C7 HYDROCARBON HEADSPACE GAS PLUS CUTTINGS GAS



SOUTH BARROW NO. 16

API No. 50-023-20010 Sec. 1, T. 22 N., R. 18 W., UM Lat 71°16′57′′ N., long 156°32′47′′ W. Elev. KB 9.1m (30 ft) TD 731.5 m (2,400 ft)

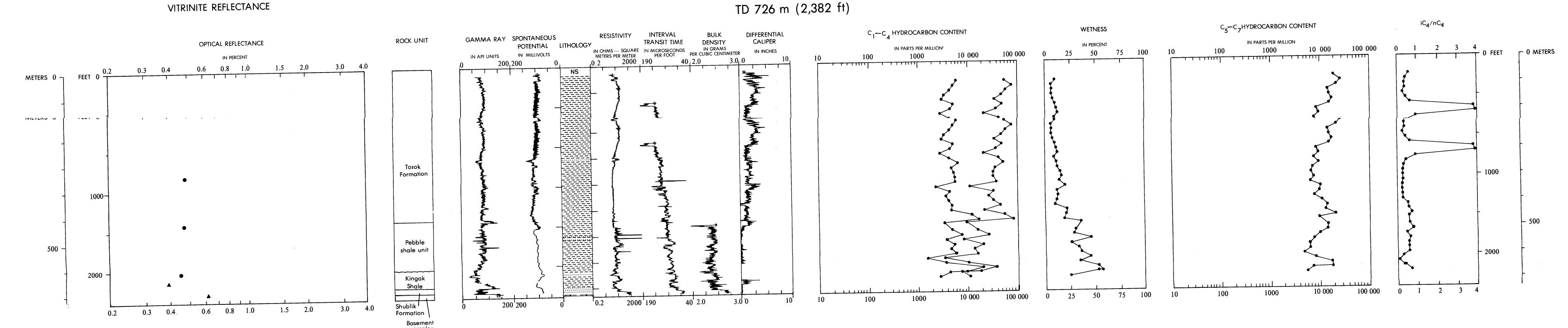
TOTAL C1-C7 HYDROCARBON HEADSPACE GAS PLUS CUTTINGS GAS



SOUTH BARROW NO. 17

API No. 50-023-20011 Sec. 30, T. 22 N., R. 16 W., UM Lat 71°14'01'' N., long 156°15'34'' W. Elev. KB 10.1 m (33 ft)

TOTAL C1-C7 HYDROCARBON HEADSPACE GAS PLUS CUTTINGS GAS



SOUTH BARROW NO. 19

API No. 50-023-20012 Sec. 23, T. 22 N., R. 17 W., UM Lat 71°14'29'' N., long 156°20'02'' W. Elev. KB 9.1 m (30 ft) TD 701 m (2,300 ft)

TOTAL C1-C7 HYDROCARBON HEADSPACE GAS PLUS CUTTINGS GAS

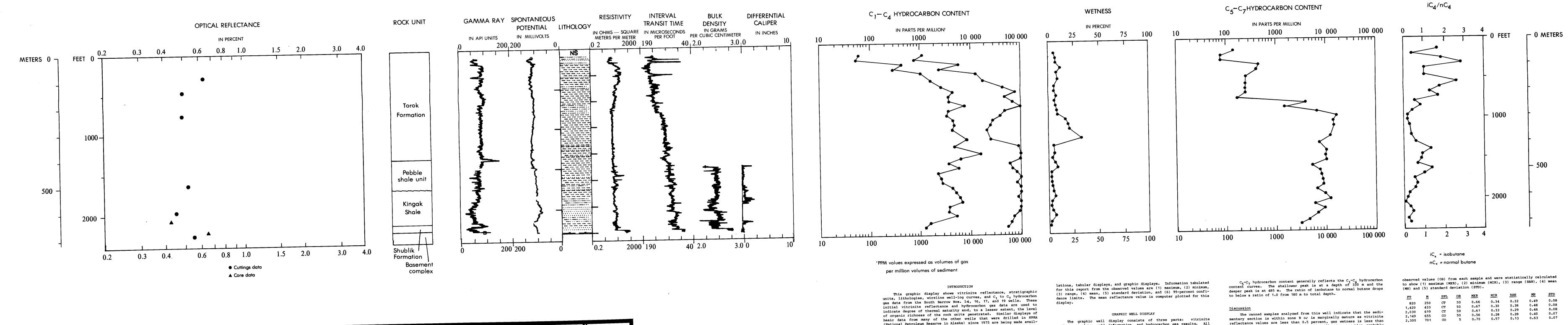
GRAPHIC WELL DISPLAY

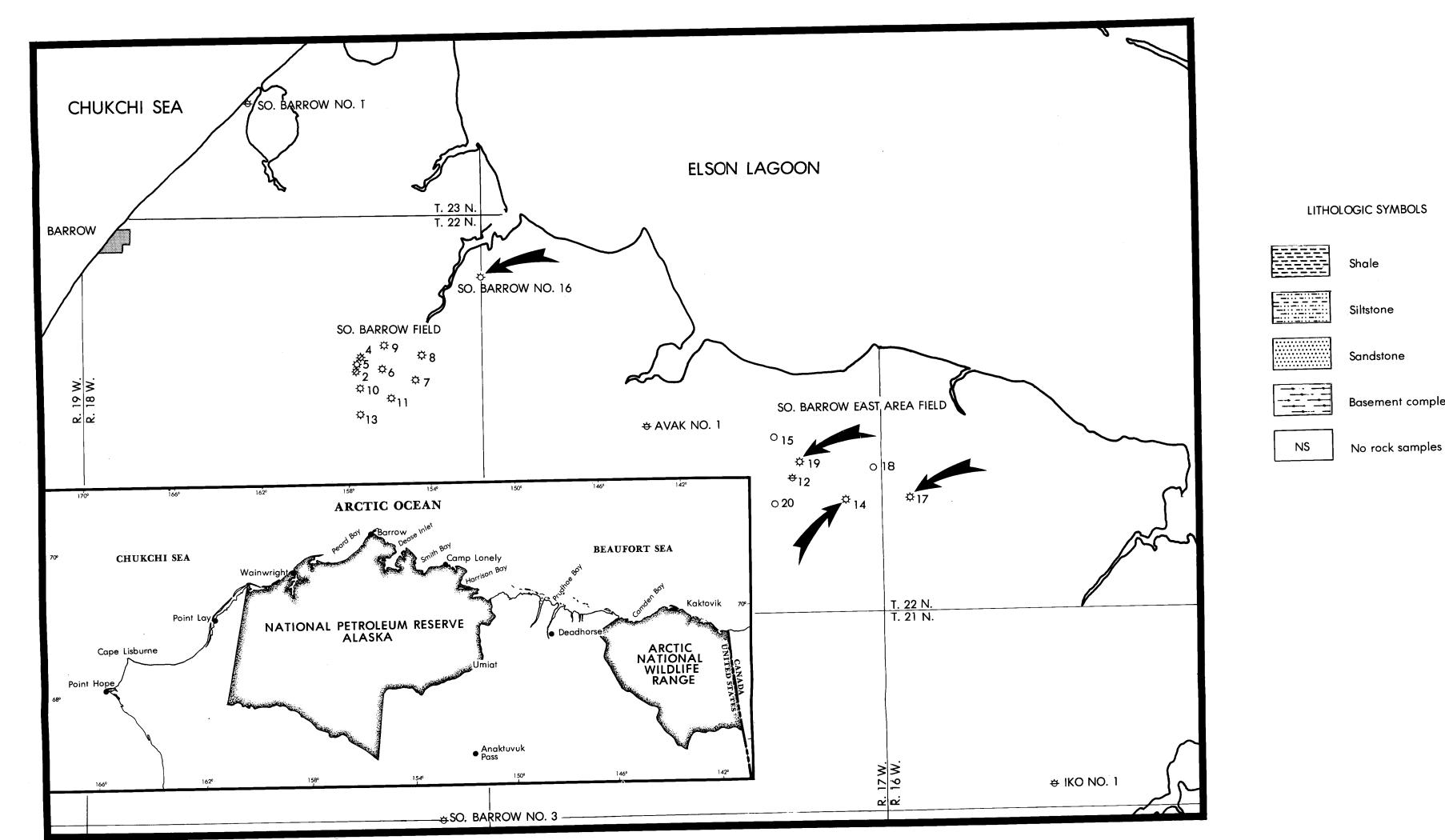
reflectance data, well information, and hydrocarbon gas results. All

information is shown on a depth scale of 1:6,000. Vitrinite reflectance

U.S. Geological Survey, Box 25286, Federal Center, Denver, CO 60225

The graphic well display consists of three parts: vitrinite





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 ANALYTICAL PROCEDURE 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. 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 Well Information South Barrow No. 14 well was drilled from January 28, 1977 to in cardboard boxes by air freight to Geochem Research, Inc. in Houston, February 14, 1977 to a total depth of 687.9 m (2,257 ft). The well was cased with steel pipe from the surface to the following depths: (1) 318 On receipt of the canned samples at Geochem Research, a silicone rubber septum is attached to the lid off the canned sample in preparation shows, and thickness of the stratigraphic units penetrated are as for the C₁ to C₇ 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 m (ft) Shows 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 pres-Oil stain Early Cretaceous Torok Formation Oil stain Gas and Pebble shale unit Early Cretaceous sure 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 Oil stain No conventional cores were cut. Drill cuttings were collected and 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, canned for each 15 m (50 ft) interval drilled from 61 m (200 ft) to 686 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 m (2,250 ft). One drill-stem test (DST), run from 593 m to 640 m (1,947 to 2,100 ft), recovered 200,000 cubic feet of gas. A gas sample from flow of carrier gas through the system is reversed with a back-flush this DST was analyzed by Chemical & Geological Laboratories of Alaska, valve, and the C_5 to C_7 hydrocarbons are eluted as a single composite chromatographic peak. The concentration of each hydrocarbon is computed Inc. and contains the following gas components: from peak area by means of an electronic integrator with baseline correction. Before a suite of samples is analyzed, a light-gas standard Component percent 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 head-space is determined, the quart can is opened and the volumes of air Carbon dioxide Hydrogen sulfide 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 C₁ to C₇ cuttings gas N-butane analysis. The sample is disaggregated in a blender for 2 to 3 minutes. N-pentane A 2-ml sample of degassed water is injected with a syringe into the 10ml air space at the top of the blender and an equal amount of the gas trace 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 Uncorrected bottom-hole temperatures (BHT) are 16° at 589 m (60°F at $\mathbf{C_1}$ to $\mathbf{C_7}$ hydrocarbon components released per million volumes of rock 1,934 ft) and 16° C at 653 m $(60^{\circ}$ F at 2,144 ft). The well was shut-in disaggregated. After the headspace gas and cuttings gas analyses are completed, February 23, 1977 as a gas well. 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 Mean (MN) vitrinite reflectance values from four cuttings samples form. The display presented here is prepared from computer plots ob-(CT) range from 0.38 to 0.49 percent and a sample depth range from 76 to Before vitrinite reflectance and other kerogen analyses are per-686 m. The mean value from the shallowest sample, 76 m, is 0.44 percent; that from the deepest sample, 686 m, is 0.49 percent. Values tabulated below by sample depth (Ft and M) and type (CT) are from as formed, 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 conmany as 50 observed values (OB) and were statistically calculated to show (1) maximum (MXR), (2) minimum (MIR), (3) range (RAN), (4) mean taminants such as straw, walnut shells, or other material, they are removed by a density-separation method using a zinc bromide solution. (MN), and (5) standard deviation (STD). After removal of contaminants, the rock sample is washed of the heavy FT M SPL OB MXR MIR RAN MN STD 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 250 76 CT 50 0.55 0.30 0.25 0.44 0.06 900 274 CT 50 0.63 0.39 0.24 0.48 0.06 1,450 442 CT 50 0.50 0.27 0.23 0.39 0.05 2,250 686 CT 50 0.62 0.32 0.30 0.49 0.07 is digested with excess amounts of 6N hydrochloric acid and 70 percent hydrofluoric acid. The resulting kerrogen 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 Twenty cuttings samples were analyzed for headspace gas and cuta drying oven, the surface of the vitrinite plug is polished using diftwenty cuttings samples were analyzed for headspace gas and cuttings gas 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 content, and the right curve shows C_1 - C_4 content. The distoral C_2 - C_4 content, and the right curve shows C_4 - C_4 content. ferent 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 tance between these curves is a measure of the methane (C₁) content. abundance of first-cycle vitrinite permits, 50 vitrinite readings are tance between these curves is a measure of the mediane (c) contents.

C₁-C₄ hydrocarbon content ranges from a low of 7,800 ppm at 670 m to a high of 122,245 ppm at 550 m. C₂-C₄ hydrocarbons range from a low of 1,702 ppm at 60 m to a high of 25,932 ppm at 485 m. Both curves have 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 intwo peaks, the shallowest at 120 m and the deepest from 485 to 580 m.

Gas wetness increases gradually from a low of 9 percent to a high of 34 percent near the bottom of the hole. In the bottom two samples cludes (a) polish quality, (b) ease of selecting first-cycle vitrinite, (c) list of all individual values, and (d) qualitative estimate of pyrite abundance. from below the 593 m casing point wetness exceeds 25 percent. Zone B, After vitrinite reflectance values are acquired for each samples, in which gas wetness is above zero but below 50 percent, is represented in this well. Zone A, in which gas wetness is near zero, is not present.

The canned samples analyzed from this well indicate that the sedimentary section is within zone B or is marginally mature as vitrinite reflectance values are less than 0.5 percent, gas wetness is less than 50 percent. Erosion of the overlying sedimentary section probably removed zone A. The overall gas richness from the samples in this well compares with that in South Barrow Nos. 17 and 19. The hydrocarbon shows in this well have probably migrated into the South Barrow area, because the rocks are not capable of generating hydrocarbons. SOUTH BARROW NO. 16 Gas wetness increases down the borehole from 10 percent at 190 m to 58 percent at 645 m, below which gas wetness decreases to 25 percent. C_5-C_7 hydrocarbon content ranges from a low of 4,572 ppm at 590 m to a high of 16,676 ppm at 625 m. This curve generally reflects the C_1-C_4 hydrocarbon content curve which indicates three peaks at depths of 75 m, 440 m, and 625 m. The ratio of isobutane to normal butane is below 1.0 Well Information South Barrow No. 16 well was drilled from January 28, 1978 to Pebruary 13, 1978 to a total depth of 731.5 m (2,400 ft). The well was cased with steel pipe from the surface to the following depths: (1) 30 m (99 ft), and (2) to 453 m (1,487 ft). The name, age, hydrocarbon shows, and thickness of the stratigraphic units penetrated are as fol-Shows Torok Formation Early Cretaceous Gas 588 (1,930) Gas and Pebble shale unit Early Cretaceous fluorescence 123 (402) Basement complex Pre-Carboniferous Fluorescence 20 (67) One conventional core was cut from 730.6 m (2,397 ft) to 731.5 m (2,400 ft), and 1 m (3 ft) of core was recovered. Drill cuttings were collected and canned for each 10-m (30-ft) interval from 61 to 731.5 m (200 to 2,400 ft). No drill-stem tests were run. Uncorrected bottom-hole temperatures (BHT) are too low to measure (less than 75°F). The well was plugged and abandoned February 16, 1978 as a dry hole. Mean (MN) vitrinite reflectance values from seven cuttings (CT) mean (MM) vitilities tellectains state from 0.35 percent to 0.55 percent and a sample depth range from 88 to 731 m. The value from the shallowest sample, 88 m, is 0.35 percent; that from the deepest unit above the basement complex is 0.50 percent at 686 m. Two values from the basement complex, one of which is from a core, are 0.55 percent and 0.50 percent. The thermal maturity of the basement complex is unknown as only 12 vitrinite(?) macerals from the core were found. Values tabulated below by sample depth (FT and M) and type (CT and CO) 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 290 88 CT 50 0.45 0.30 0.15 0.35 0.03 470 143 CT 38 0.54 0.31 0.23 0.42 0.06 470 143 CT 38 0.54 0.31 0.23 0.42 0.06 680 207 CT 50 0.42 0.28 0.14 0.35 0.03 1,070 326 CT 50 0.49 0.30 0.19 0.38 0.05 1,710 521 CT 30 0.65 0.36 0.29 0.50 0.08 2,250 686 CT 38 0.64 0.35 0.29 0.50 0.06 2,398 731 CO 12 0.58 0.42 0.16 0.50 0.04 0.35 0.29 731 CT 13 0.60 0.42 0.18 0.55 0.05 Thirty-one canned cuttings were analyzed for headspace gas and cuttings gas approximately every 18 m (60 ft). C_2 - C_4 hydrocarbon content ranges from a low of 23 ppm at 80 m to a high of 20,129 ppm at 326 m. C₁-C₄ hydrocarbon content ranges from a low of 400 ppm at 140 m to a high of 50,000 ppm at 326 m. Two peaks are observed, a shallower peak with a C_1 - C_4 maximum at 326 m and a deeper peak at 649 m.

Gas wetness increases from 2 percent at 80 m to a maximum of 48 percent at 370 m then decreases to 6 percent at 705 m. The wettest gas correlates with the shallower peak. Zone B is present as none of the wetness values exceeds 50 percent. C_r-C₇ hydrocarbon content generally reflects the C,-C₄ hydrocarbon content curves. The peak of the shallower curve is at 317 m and the peak of the deeper curve is at 613 m. The ratio of isobutane to normal butane is generally around 1.0 except for two shallow samples and one deeper sample. The thermal maturity in this well is marginal (zone B) where gas wetness is between 0 and 50 percent and vitrinite reflectance values are less than 0.5 percent.

SOUTH BARROW NO. 17 Well Information South Barrow No. 17 well was drilled from March 2, 1978 to April 2, 1978 to a total depth of 726 m (2,382 ft). The well was cased with steel pipe from the surface to the following depths: (1) 24 m (80 ft), (2) 461 m (1,512 ft), and (3) 674 m (2,212 ft). The name, age, hydrocarbon shows, and thickness of the stratigraphic units penetrated are as Shows Early Cretaceous None Torok Formation Pebble shale unit Early Cretaceous Oil stain and fluorescence Oil stain and Kingak Shale fluorescence Shublik Formation Triassic Basement complex Pre-Carboniferous None Four conventional cores were cut through the following intervals. Drill cuttings were collected and canned for each 10-m (30-ft) interval drilled from 58 to 726 m (190 to 2,382 ft). Four drill-stem tests (DST) were run. One production test conducted through the interval 640 to 648 m (2,101 to 2,127 ft) had a calculated absolute open flow (CAOF) of 7.2 million cubic feet of gas per day (MMCFD) with 200 barrels of water per day (BWPD). Bottom-hole temperature (BHT) was too low to measure. This well was shut in April 13, 1978 as a gas well. m (ft) m (ft) 639-648 (2,096-2,126) 9 (30) 648-654.7 (2,126-2,148)

700-708 (2,295-2,322) 1 (3) 708-716 (2,322-2,349) 8 (27) DST m (ft) Recovered 461-523 (1,512-1,715) Gas-cut drilling fluid DST m (ft) Recovered 461-523 (1,512-1,715) Gas-cut drilling fluid 674-715 (2,212-2,345) 24 barrels of gas and very slightly

Below by sample deben /17 mm ... --- -11

 FT
 M
 SEL
 OB
 FAX
 FAX
 FAX
 SEL
 CE

 280
 85
 CT
 11
 0.78
 0.48
 0.30
 0.63
 0.12

 460
 140
 CT
 50
 0.66
 0.30
 0.50
 0.09

 760
 232
 CT
 50
 0.63
 0.31
 0.32
 0.49
 0.06

 1,630
 497
 CT
 22
 0.62
 0.41
 0.21
 0.53
 0.06

 1,960
 597
 CT
 50
 0.64
 0.35
 0.29
 0.46
 0.07

 2,069
 631
 CO
 50
 0.59
 0.35
 0.24
 0.43
 0.05

 2,213
 675
 CO
 13
 0.85
 0.41
 0.44
 0.66
 0.14

 2,255
 687
 CT
 8
 0.70
 0.37
 0.33
 0.56
 0.13
 Thirty-four canned cuttings samples were analyzed for headspace gas m (ft) and cuttings gas approximately every 18 m (60 ft). C₂-C₄ hydrocarbon content ranges from a low of 49 ppm at 50 m to a high of 16,230 ppm at 440 (1,443) 415 m. C_1 - C_4 hydrocarbon content ranges from a low of 778 ppm at 50 m to a high of 275,289 ppm at 415 m. Both curves have low values at shallow depths, then build to the first shallow peak at 230 m. The second peak is located at the top of the pebble shale unit at 415 m. The deepest and broadest peak starts at the base of the pebble shale and persists through the Kingak Shale. Gas wetness increases from 5 percent at 30 m to 33 percent at 360 m (at the base of the Torok Formation), then abruptly drops to less than 10 percent to total depth. C₅-C₇ hydrocarbon content is less than 1,000 ppm to 220 m, but below this depth most values are between 3,000 and 20,000 ppm. The ratio of isobutane to normal butane is greater than 1.0 to 220 m and generally less than 1.0 to total depth. The thermal maturity of the sedimentary rocks in this well is marginally mature (zone B) where gas wetness is between 0 and 50 percent as vitrinite reflectance values are less than 0.5 percent. The thermal maturity compares favorably with South Barrow Nos. 14 and 17. The authors thank the people and organizations that contributed to this graphic display. Geochem Research provided the vitrinite reflecpetroleum Information provided the computer plot of the vitrinite reflectance data, and under the direction of Kenneth J. Bird of the U.S. 642-654 (2,105-2,147) 1.09 million cubic feet of gas per day
674-708 (2,212-2,322) Highly gas-cut, slightly oil-cut mud
674-715 (2,212-2,345) 24 barrels of gas and very slightly 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. this graphic display. Geochem Research provided the vally in the early tance data and the C₁ to C₂ hydrocarbon gas analyses and display.

Petroleum Information provided the computer plot of the vitrinite re-642-654 (2,105-2,147) 1.09 million cubic feet of gas per day 674-708 (2,212-2,322) Highly gas-cut, slightly oil-cut mud flectance 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.

Thirty-five canned cuttings samples were analyzed for headspace gas

and cuttings gas approximately every 18 m (60 ft). C₁-C₄ hydrocarbon content ranges from a low of 3,421 ppm at 590 m to a high of 83,864 ppm

content ranges from a low of 3,421 ppm at 590 m to a high of 20,618 ppm at 625. Background for the C_2 - C_4 hydrocarbon content ranges from a low of 1,572 ppm at 590 m to a high of 20,618 ppm at 625. Background for the C_2 - C_4 hydrocarbon content ranges from 3,000 to 7,000 ppm. Methane (C_1) content below a depth of 440 m drops abruptly from concentrations well above

25,000 ppm to below 15,000 ppm.

Gas wetness increases down the borehole from 10 percent at 190 m to

The thermal maturity in this well is considered transitional (zone

B) where gas wetness is above zero but below 50 percent. The three

samples above 50 percent are considered spurious because gas wetness

from nearby wells (South Barrow Nos. 14 and 19) is below 50 percent. Vitrinite reflectance values are below 0.5 percent. The gas and liquid

hydrocarbon have probably migrated into the area from thermally mature

SOUTH BARROW NO. 19

South Barrow No. 19 well was drilled from April 18, 1978 to May 6,

1978 to a total depth of 701 m (2,300 ft). The well was cased with

steel pipe from the surface to the following depths: (1) 24 m (80 ft),

(2) 455 m (1,492 ft), and (3) 659 m (2,161 ft). The name, age,

hydrocarbon shows and thickness of the stratigraphic units penetrated

405-415 (1,330-1,360)

621-631 (2,039-2,069)

673-676 (2,209-2,217)

680-684 (2,230-2,245)

Drill cuttings were collected and canned for each 10-m (30-ft)

Mean (MN) vitrinite reflectance values from six cuttings samples

(CT) and two conventional cores (CO) range from 0.43 to 0.66 percent and a sample depth range from 85 to 675 m. The values from the shallowest

sample, 85 m, is 0.65 percent with only 11 observations. Reflectance

values with 50 observations are 0.5 percent or less. 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 cal-

(4) mean (MN), and (5) standard deviation (STD).

culated to show (1) maximum (MXR), (2) minimum (MIR), (3) range (RAN),

FT M SPL OB MXR MIR RAN MN STD

Coit typed the text. Robert M. Egbert helped immeasurably in the early

interval drilled from 30 m (100 ft) to 701 m (2,300 ft). One drill-stem

test (DST) was run from 659 to 684 m (2,161 to 2,245 ft) with an esti-

mated rate of 800 MCFD (thousand cubic feet per day) of gas and 7 gal-

lons of gas and slightly oil-cut mud. Bottom-hole temperatures are too

low to measure. This well was shut in May 16, 1978 as a gas well.

676-680 (2,217-2,230)

Early Cretaceous

Pebble shale unit Early Cretaceous

are as follows:

Torok Formation

VITRINITE REFLECTANCE AND C1-C7 HYDROCARBON DATA FOR SOUTH BARROW NOS. 14, 16, 17, AND 19 WELLS NORTH SLOPE, ALASKA

Interior-Geological Survey, Reston, Va.-1980

NORTH SLOPE, ALASKA

the data are encoded and forwarded by mail to PI. At PI, the data are keypunched and entered into the geochemical file for mathematical calcu-

of organic richness of the rock units penetrated. Similar displays of

(National Petroleum Reserve in Alaska) since 1975 are being made avail-

basic data from many of the other wells that were drilled in NPRA

able in this format. The regional geochemical and geologic relations

for each stratigraphic unit are being integrated from this well infor-