33. GASES IN BASALTS FROM THE GULF OF CALIFORNIA, DEEP SEA DRILLING PROJECT LEG 65, HOLES 482B, 482C, 482D, 482F, 483, 483B, 483C, AND 485A[1]

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INTRODUCTION

Basalts from different structural provinces in the ocean basins, such as mid-ocean ridges, island arcs, and oceanic plateaus, show marked differences in major and minor element composition stemming from differences in magma source. In addition, there are variations even within individual provinces, based on such processes as crystal fractionation, secondary alteration, and hydrothermal alteration. It is also known that hydrothermal processes can cause changes in the gas composition of submarine basalts. For example, Zolotarev et al. (1978) have established that hydrothermal alteration frequently causes an increase in the CO_2 content of basalts. If the homogeneity in composition and concentration of organic gases in oceanic basalts is associated with degassing during epimagmatic alteration, it would be interesting to investigate the relative abundance of gas phases in young basalts from midoceanic ridges.

This chapter deals with the distribution of organic gases and CO_2 in young basalts recovered on Leg 65 from the Gulf of California. Our aim was to establish the relationship between gas composition and degree of alteration.

RESULTS AND DISCUSSION

Using standard analytical techniques, we studied the natural gas content of 85 basalt samples. (The distribution of samples is presented in Table 1.) Gas extractions were obtained from powdered 2-g samples in hermetically sealed steel chambers filled with argon. The gases were analyzed using an HL-108 gas chromatograph equipped with an oxygen-flame ionization detector. The threshold of sensitivity for individual hydrocarbons was $10^{-5}\%$ by volume, and analytical error was $\pm 5\%$ of the measured value. The sensitivity of the catarometer used to measure the low boiling-point gas content was $10^{-3}\%$ by volume for He; $10^{-3}\%$ for H_2; $10^{-1}\%$ for CO_2; and $10^{-1}\%$ for N_2. The analytical error was, again, $\pm 5\%$ of the measured value.

The measured gas contents are identical in many respects to those in basalts of the Kuril-Kamchatka Island arc (Voitov et al., 1970), the islands of the southwestern Pacific (Zolotarev et al., 1976), Iceland (Zolotarev et al., 1977), and also to those from the Mid-Atlantic Ridge obtained during DSDP Legs 45 and 49 (Zolotarev et al., 1978). In particular, all of the samples contain hydrogen and gaseous hydrocarbons.[2] Nevertheless, there are differences among gases from the different samples, as follows.

First, the CO_2 content in the samples we studied is always lower than the threshold response of the catarometer. Second, in most of the samples from Holes 482B and 483, the He content is anomalously high (up to 24.5 cm^3/kg). In fact, these values are higher than those observed in granite and crystalline basement rocks containing more uranium. Third, the total hydrogen content is 2–4 times higher than that in basalts recovered from the Mid-Atlantic Ridge on DSDP Legs 45 and 49.

Components ranging from methane to propane compose the hydrocarbons in these samples. The spectrum of hydrocarbons from basalts from Hole 482B is broader, however, in that these rocks typically contain butane, with normal butane being much more common than isobutane (Fig. 1). In terms of their relative amounts, the hydrocarbons in basalts we studied are similar to those associated with oil deposits.

We should also emphasize that the basalts from Hole 482B, which is situated near the intersection of the Tamayo Fracture Zone and the central paleomagnetic anomaly, also contained the highest concentrations of hydrocarbons, hydrogen, and helium.

CONCLUSIONS

The gases in basalts from the Gulf of California do not differ markedly from those from other areas of the ocean basins. Therefore, there appears to be no correlation between gas content and primary basalt composition. At the same time, the spectrum of hydrocarbons in basalts from Site 482 was wider than was that from other holes examined.

Since CO_2 content is extremely low at all sites, we conclude that hydrothermal alteration has been minimal. The relatively high concentration of hydrogen in the basalts from Hole 482B suggests that the hydrothermal solutions at this site may have been weakly mineralized and reducing.

[1] Lewis, B. T. R., Robinson, P., et al., *Init. Repts. DSDP*, 65: Washington (U.S. Govt. Printing Office).

[2] The nitrogen shown in Tables 1 and 2 is due to atmospheric contamination.

Table 1. Average chemical composition of gases in basalts from Holes 482B, 482C, 482D, 482F, 483, 483B, 483C, and 485A; Leg 65.

Hole	Number of Samples	CH_4	Total of Heavy Gases	He	H_2	N_2	Organic Gases Calculated on 100%						
							CH_4	C_2H_6	C_2H_4	C_3H_8	C_3H_6	$i\text{-}C_4H_{10}$	$n\text{-}C_4H_{10}$
482B	21	0.175/0.087	0.029/0.015	7.822/3.880	9.324/4.620	82.65/40.95	82.88	9.11	0.96	3.68	0.55	0.69	1.48
482C	8	0.153/0.079	0.019/0.010	—	4.729/2.440	95.10/49.06	89.02	7.27	0.73	2.32	0.09	—	0.58
482D	8	0.182/0.086	0.018/0.008	—	5.106/2.410	94.69/44.69	91.12	6.34	0.57	1.82	0.07	—	0.08
482F	1	0.223/0.065	0.026/0.008	—	5.968/1.750	93.78/27.50	89.68	7.43	0.89	1.95	—	—	—
483	11	0.136/0.073	0.030/0.016	3.415/1.840	2.357/1.270	94.06/50.68	82.64	4.99	1.61	10.63	—	—	0.15
483B	13	0.125/0.078	0.019/0.012	—	3.587/2.250	96.27/60.38	87.20	6.17	0.53	5.75	—	—	0.35
483C	1	0.176/0.089	0.015/0.008	—	5.929/3.00	93.88/47.50	92.02	5.84	0.44	1.70	—	—	—
485A	22	0.159/0.071	0.018/0.008	—	5.717/2.560	94.11/42.14	89.66	4.88	0.89	3.22	—	—	1.37

Note: Chemical composition of gases: numerator = average content, vol.%; denominator = average content, cm^3/kg. Dash = "not present."

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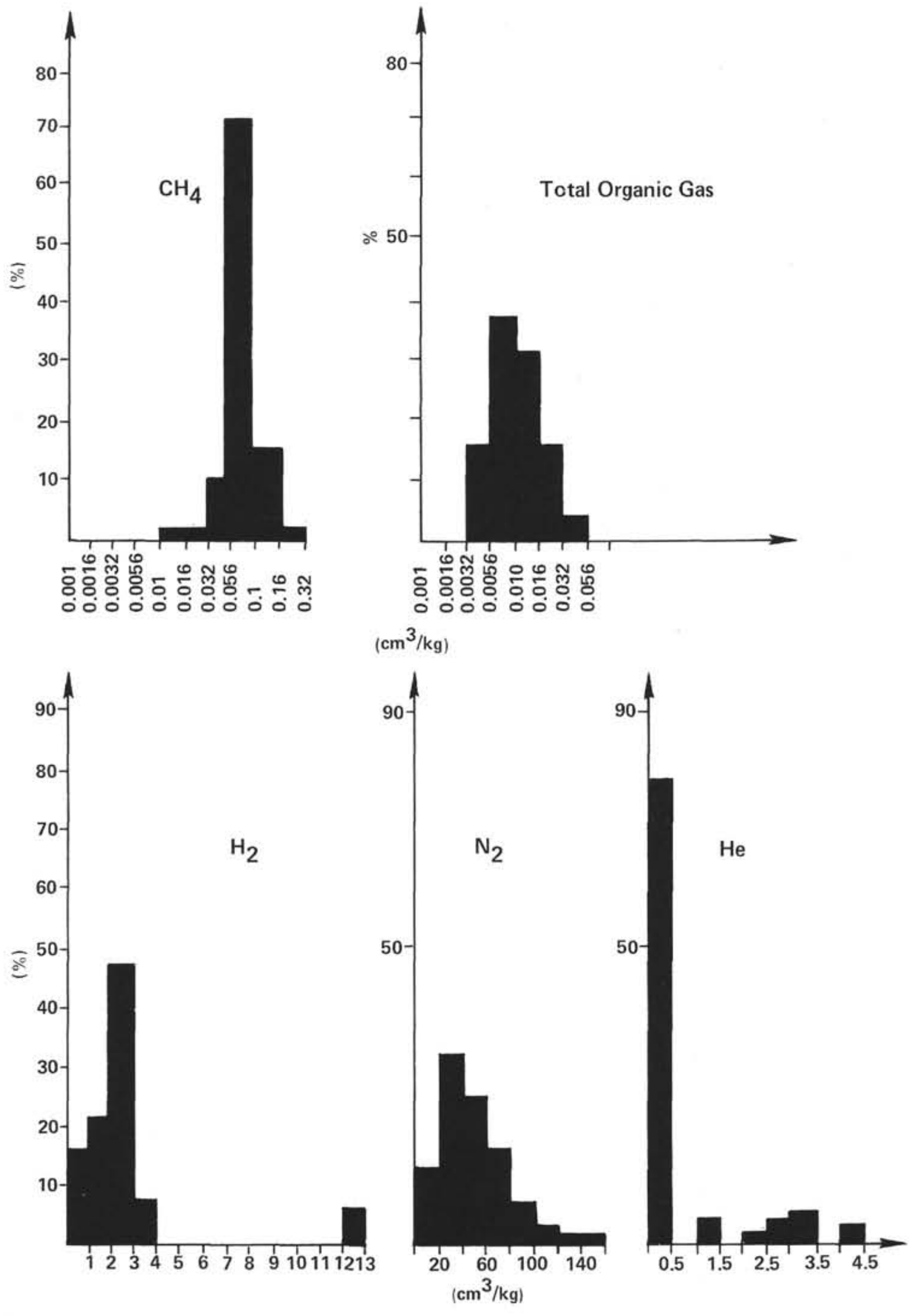

Figure 1. Histograms of gas content in basalt. Percentage of samples vs. content by volume (n = 85).

Table 2. Chemical composition of gases in basalts from Holes 482B, 482C, 482D, 482F, 483, 483B, 483C, and 485A; Leg 65.

Hole	482B																			
Core/Section (Interval in cm)	11-1 75-85		12-1 107-113		13-1 54-61		14-1 12-20		14-2 94-101		14-1 101-106		15-1 94-100		15-2 120-129		15-3 20-30		16-1 41-50	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
CH_4	0.095/0.066	77.58	0.132/0.065	83.69	0.042/0.068	73.49	0.143/0.059	82.42	0.114/0.055	83.56	0.052/0.055	84.69	0.017/0.020	62.17	0.252/0.081	85.02	0.242/0.101	86.72	0.284/0.113	86.52
C_2H_6		9.17		7.97		7.33		9.05		9.17		9.29		23.33		8.58		7.65		7.13
C_2H_4		2.79		1.09		1.39		1.19		0.99		1.00		2.05		0.68		0.73		0.65
C_3H_8		4.11		3.68		3.09		3.77		3.77		3.16		9.06		3.46		2.82		2.82
C_3H_6	0.019	1.76	0.013	1.44	0.025	1.21	0.013	1.58	0.011	0.80	0.01	0.58	0.01	—	0.014	0.79	0.015	0.64	0.019	0.85
$i-C_4H_{10}$		—		—		—		—		—		—		—		—		—		0.51
$n-C_4H_{10}$		1.97		2.14		1.50		1.97		1.71		1.27		3.55		1.47		1.43		1.51
C_4H_8		2.62		—		11.98		—		—		—		—		—		—		—
He	2.81/1.95		—		—		3.610/1.48		3.05/1.48		13.97/14.75		21.07/24.50		8.57/2.75		8.36/3.50		7.52/3.00	
H_2	3.35/2.33		3.94/1.95		0.93/1.50		28.80/11.75		24.33/11.75		0.71/0.75		10.11/11.75		36.61/11.75		1.79/0.75		29.46/11.75	
N_2	93.71/65.00		95.91/47.50		99.01/160.00		67.41/27.50		72.48/35.00		85.27/90.00		68.80/80.00		54.53/17.50		89.57/37.50		62.69/25.00	
CO_2	tr		—		—		—		—		—		—		—		—		—	

Note: A—chemical composition of gases: numerator = average content, vol. %; denominator = average content, cm^3/kg; organic gases, cm^3/kg. B—Organic gases calculated on 100%. Dash = "not present."

Table 2. (Continued).

Hole	482B																			
Core/Section (Interval in cm)	16-5 39-49		18-1 49-57		18-2 44-51		20-1 120-127		20-3 43-52		21-2 9-18		21-3 110-117		22-1 97-105		22-3 85-93		24-1 106-115	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
CH_4	0.245/0.089	85.26	0.539/0.104	82.53	0.361/0.226	93.95	3.013/0.233	95.13	0.192/0.066	87.59	0.224/0.071	87.99	0.289/0.072	86.15	0.224/0.073	86.12	0.364/0.118	76.35	0.062/0.017	63.59
C_2H_6		8.76		9.25		3.40		3.02		7.76		7.42		8.38		8.27		7.05		23.15
C_2H_4		0.62		0.67		0.27		0.35		0.56		0.52		0.78		1.00		0.69		1.63
C_3H_8		2.75		4.57		1.54		1.17		2.99		3.05		3.20		3.63		2.67		9.51
C_3H_6	0.015	0.72	0.022	0.89	0.016	0.31	0.012	—	0.009	—	0.01	—	0.012	—	0.073	—	0.036	tr	0.009	—
$i-C_4H_{10}$		—		0.53		—		—		—		—		—		—		12.33		—
$n-C_4H_{10}$		0.89		1.56		0.52		0.34		1.09		1.02		1.49		0.97		0.91		2.11
C_4H_8		—		—		—		—		—		—		—		—		—		—
He	67.39/24.50		18.06/3.50		—		—		—			—		—		—		—		—
H_2	32.32/11.75		3.87/0.75		3.60/2.25		32.28/2.50		5.10/1.75		5.50/1.75		9.06/2.25		7.67/2.50		6.93/2.25		5.66/1.50	
N_2	—		77.41/15.00		96.01/60.00		64.56/5.00		94.68/32.50		94.25/30.00		90.60/22.50		92.07/30.00		92.58/30.00		94.25/25.00	
CO_2	—		—		—		—		—		—		—		—		—		—	

Table 2. (Continued).

Hole	482B		482C																482D	
Core/Section (Interval in cm)	24-3 30-39		10-1 107-115		11-3 96-105		11-4 83-91		12-1 58-68		13-2 80-90		14-4 42-53		15-1 1-10		15-4 48-58		8-1 115-124	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
CH_4	0.253/0.068	90.04	2.469/0.044	91.83	0.046/0.062	86.61	0.218/0.093	85.36	0.109/0.079	87.12	0.076/0.084	88.28	0.215/0.076	91.17	0.353/0.091	92.99	0.192/0.103	88.79	0.240/0.090	90.12
C_2H_6		6.21		6.05	7.60		9.29		7.89			7.57		6.33		6.35		7.07		6.99
C_2H_4		0.56		0.88	0.91		0.60		0.71			0.68		0.78		0.66		0.56		0.65
C_3H_8		2.46		1.24		3.73		3.03		3.37		2.60		1.72		—		2.86		2.25
C_3H_6	0.007	—	0.004	—	0.009	—	0.016	0.69	0.010	—	0.011	—	0.007	—	0.007	—	0.013	—	0.010	—
$i-C_4H_{10}$		—		—		—		—		—		—		—		—		—		—
$n-C_4H_{10}$		0.73		—		1.15		1.03		0.90		0.87		—		—		0.71		—
C_4H_8		—		—		—		—		—		—		—		—		—		—
He	—		—		—		—		—		—		—		—		—		—	
H_2	6.52/1.75		97.31/1.75		1.12/1.50		5.87/2.50		3.11/2.25		5.25/2.50		7.13/2.50		12.57/3.25		6.09/3.25		6.65/2.50	
N_2	93.19/25.00		—		98.88/132.50		93.88/40.00		98.70/70.00		94.55/45.00		92.64/32.50		87.05/22.50		93.69/50.00		93.08/35.00	
CO_2	—		—		—		—		—		—		—		—		—		—	

Table 2. (Continued).

Hole	482D														482F		483			
Core/Section (Interval in cm)	9-1 59–68		9-2 130–139		10-1 133–139		11-1 110–118		12-1 80–87		12-3 104–108		13-1 59–70		5-1 100–108		14-1 13–21		15-1 121–130	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
CH_4	0.067/0.072	90.99	0.092/0.061	91.96	0.685/0.069	90.64	0.229/0.115	89.93	4.037/0.106	91.05	0.095/0.066	92.50	0.321/0.109	91.82	0.223/0.065	89.68	0.195/0.102	71.68	0.219/0.073	81.28
C_2H_6		6.38		5.86		6.63		6.56		6.73		5.47		6.09		7.43		5.59		3.05
C_2H_4		0.54		0.64		0.56		0.33		0.93		0.59		0.36		0.89		10.52		0.22
C_3H_8		2.09		1.54		2.17		2.25		1.06		1.44		1.73		1.95		11.61		15.45
C_3H_6	0.007	—	0.005	—	0.007	—	0.013	0.59	0.010	—	0.005	—	0.010	—	0.008	—	0.040	tr	0.017	—
$i-C_4H_{10}$		—		—		—		—		—		—		—		—		—		—
$n-C_4H_{10}$		—		—		—		0.43		0.24		—		—		—		0.59		—
C_4H_8		—		—		—		—		—		—		—		—		—		—
He		—		—		—		—		—		—		—	—		6.20/3.25		6.80/2.25	
H_2	1.64/1.75		2.62/1.75		24.81/2.50		4.51/2.25		95.57/2.50		3.22/2.25		11.07/3.75		5.97/1.75		2.86/1.50		2.27/0.75	
N_2	98.29/105.00		97.28/65.00		74.43/7.50		95.22/47.50		—		96.68/67.50		88.58/30.00		93.78/27.50		90.66/47.50		90.66/30.00	
CO_2	—		—		—		—		—		—		—		—		—		—	

Table 2. (Continued).

Hole	483																		483B	
Core/Section (Interval in cm)	16-1 71–83		17-2 120–128		20-1 118–127		21-2 43–51		22-4 117–127		23-2 92–103		25-1 48–58		26-2 140–149		26-3 98–108		4-5 13–23	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
CH_4	0.864/0.078	83.38	0.206/0.074	85.08	0.074/0.057	83.35	0.074/0.055	85.12	1.609/0.062	87.39	0.101/0.080	82.31	0.156/0.078	86.84	0.069/0.060	81.30	0.149/0.085	81.55	0.065/0.058	79.81
C_2H_6		5.61		6.23		5.67		5.40		3.87		5.17		4.76		4.74		4.83		5.07
C_2H_4		0.69		0.74		0.95		1.00		0.92		0.67		0.72		0.88		0.41		tr
C_3H_8		10.32		7.95		10.04		8.48		7.82		11.29		7.68		13.08		13.21		15.12
C_3H_6	0.016	—	0.013	—	0.012	—	0.010	—	0.009	—	0.017	—	0.012	—	0.014	—	0.019	—	0.015	—
$i-C_4H_{10}$		—		—		—		—		—		—		—		—		—		—
$n-C_4H_{10}$		—		tr		—		—		—		0.56		—		—		tr		—
C_4H_8		—		—		—		—		—		—		—		—		—		—
He	7.77/3.25		7.62/2.75		1.94/1.50		1.68/1.25		71.98/2.75		4.10/3.25		—		—		—		—	
H_2	2.39/1.00		2.08/0.75		0.97/0.75		1.01/0.75		26.17/1.00		1.26/1.00		4.99/2.50		2.02/1.75		3.93/2.25		1.68/1.50	
N_2	89.62/37.50		90.06/32.50		97.00/75.00		97.23/72.50		—		94.52/75.00		94.83/47.50		97.90/85.00		95.89/55.00		98.23/87.50	
CO_2	—		—		—		—		—		—		—		—		—		—	

Table 2. (Continued).

Hole	483B																			
Core/Section (Interval in cm)	7-2 8–19		8-3 26–35		12-1 40–46		13-3 64–74		17-1 138–146		19-2 21–30		22-2 13–23		25-1 103–114		27-2 10–21		27-3 15–25	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
CH_4	0.085/0.076	80.13	0.072/0.077	76.27	0.131/0.082	77.94	0.132/0.079	90.90	0.131/0.072	90.31	0.188/0.073	91.06	0.136/0.103	90.43	0.111/0.069	91.63	0.142/0.068	92.25	0.138/0.076	91.80
C_2H_6		6.15		5.81		6.33		6.71		6.33		6.84		6.31		6.21		5.77		6.38
C_2H_4		0.68		0.65		1.24		0.49		0.53		0.82		0.37		0.27		0.88		tr
C_3H_8		13.04		16.43		14.49		1.89		1.79		1.28		2.17		1.89		1.11		1.49
C_3H_6	0.019	—	0.024	—	0.023	—	0.008	—	0.008	—	0.007	—	0.011	—	0.006	—	0.006	—	0.007	—
$i-C_4H_{10}$		—		—		—		—		—		—		—		—		—		—
$n-C_4H_{10}$		—		0.84		—		—		1.03		—		0.72		—		—		0.33
C_4H_8		—		—		—		—		—		—		—		—		—		—
He	—		—		—		—		—		—		—		—		—		—	
H_2	1.96/1.75		1.64/1.75		3.61/2.25		3.76/2.25		4.54/2.50		2.59/1.00		4.28/3.25		2.65/2.25		6.24/3.00		4.10/2.25	
N_2	97.94/87.50		98.27/105.00		96.22/60.00		96.09/57.50		95.32/52.50		97.20/37.50		95.57/72.50		97.26/82.50		93.61/45.00		95.75/52.50	
CO_2	—		—		—		—		—		—		—		—		—		—	

Table 2. (Continued).

Hole	483B				483C		485A													
Core/Section (Interval in cm)	32-1 110–119		32-3 33–40		4-3 3–14		11-3 140–148		11-1 13–26		12-1 21–33		13-1 35–42		14-1 43–56		18-1 9–20		23-1 66–76	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
CH_4	0.283/0.086	89.88	1.258/0.101	91.23	0.176/0.089	92.02	0.208/0.110	80.58	0.209/0.084	87.16	0.161/0.061	92.90	0.142/0.090	91.60	0.154/0.106	91.27	0.183/0.097	84.85	0.118/0.053	91.90
C_2H_6		6.68		5.60		5.84		4.84		5.86		4.71		5.95		5.38		5.85		5.29
C_2H_4		0.44		0.58		0.44		0.47		4.41		0.65		0.43		0.73		0.37		0.58
C_3H_8		2.13		1.84		1.70		13.50		1.71		0.91		1.45		2.14		1.79		2.24
C_3H_6	0.010	—	0.010	—	0.008	—	0.027	—	0.012	—	0.008	—	0.008	—	0.010	—	0.017	—	0.006	—
$i{-}C_4H_{10}$		—		—		—		—		—		—		—		—		—		—
$n{-}C_4H_{10}$		0.86		0.74		—		0.60		0.86	—		—		—		—		—	
C_4H_8		—		—		—		—		—		0.83		0.56		0.48		7.20		—
He	—		—		—		—		—			—		—		—		—		—
H_2	5.87/2.50		36.99/3.00		5.93/3.00		5.65/3.00		6.24/2.50		7.88/3.00		1.57/1.00		4.75/3.25		5.65/3.00		3.93/2.25	
N_2	93.99/40.00		61.64/45.00		93.88/47.50		94.09/50.00		93.53/37.50		91.95/35.00		98.27/62.50		95.08/65.00		94.14/50.00		95.95/55.00	
CO_2	—		—		—		—		—		—		—		—		—		—	

Table 2. (Continued).

Hole	485A																			
Core/Section (Interval in cm)	23-2 38–50		23-3 60–72		24-2 77–87		25-1 63–74		29-3 118–130		30-1 121–134		30-2 116–129		31-1 98–119		34-2 78–89		35-1 21–31	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
CH_4	0.150/0.071	92.58	0.308/0.089	85.65	0.067/0.067	89.01	0.466/0.059	94.58	0.122/0.052	95.60	0.347/0.087	89.39	0.250/0.055	93.21	0.246/0.062	92.76	0.146/0.099	91.61	0.074/0.063	92.95
C_2H_6		5.57		4.32		6.25		3.44		3.61		5.81		4.65		4.39		5.01		4.02
C_2H_4		—		0.41		1.44		tr		0.79		0.44		0.73		tr		0.60		—
C_3H_8		1.86		2.39		2.21		1.98		tr		3.80		1.41		2.48		2.28		3.02
C_3H_6	0.006	—	0.015	—	0.008	—	0.003	—	0.002	—	0.010	—	0.004	—	0.005	—	0.009	—	0.005	—
$i{-}C_4H_{10}$		—		—		—		—		—		—		—		—		—		—
$n{-}C_4H_{10}$		—		7.23		1.10		—		—		0.57		—		—		0.51		—
C_4H_8		—		—		—		—		—		—		—		—		—		—
He	—		—		—		—		—		—		—		—		—		—	
H_2	4.75/2.25		12.99/3.75		2.50/2.50		19.90/2.50		5.32/2.25		9.96/2.50		8.02/1.75		9.97/2.50		4.75/3.25		2.94/2.50	
N_2	95.08/45.00		86.64/25.00		97.43/97.50		79.61/10.00		94.55/40.00		89.65/2.25		91.71/20.00		89.76/2.25		95.09/65.00		96.98/82.50	
CO_2	—		—		—		—		—		—		—		—		—		—	

Table 2. (Continued).

Hole	485A							
Core/Section (Interval in cm)	35-5 48–62		38-2 104–119		39-3 47–57		39-4 105–115	
	A	B	A	B	A	B	A	B
CH_4	0.236/0.084	93.80	0.390/0.059	93.03	0.157/0.072	91.81	0.059/0.048	92.84
C_2H_6		4.36		4.63		4.99		4.88
C_2H_4		tr		1.03		1.09		0.82
C_3H_8		1.84		1.31		2.11		1.45
C_3H_6	0.006	—	0.004	—	0.006	—	0.004	—
$i{-}C_4H_{10}$		—		—		—		—
$n{-}C_4H_{10}$		—		—		—		—
C_4H_8		—		—		—		—
He	—		—		—		—	
H_2	8.43/3.00		16.60/2.50		6.58/3.00		2.14/1.75	
N_2	91.32/32.50		82.98/12.50		93.25/42.50		97.79/80.00	
CO_2	—		—		—		—	