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43. *DATA REPORT:* ADDITIONAL SHIPBOARD INFORMATION FOR THE PRESSURE CORE SAMPLER (PCS)[1]

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INTRODUCTION

The pressure core sampler (PCS) is a tool designed to recover a 1385-cm^3 cylindrical sediment core at in situ pressure (Pettigrew, 1992). Quantity and composition of gas in a sediment sample at depth can be determined by releasing gas from the PCS at the surface. Shipboard data collected from PCS deployments on Leg 164 are of great interest to the scientific community because they provide the only direct information concerning in situ gas quantities and composition in deep-sea sedimentary sequences (Dickens et al., 1997). A portion of total data collected from the PCS was published in "Downhole Tools and Sampling" sections of site chapters in the Leg 164 *Initial Reports* volume (Paull, Matsumoto, Wallace, et al., 1996). Here we present the shipboard PCS data not included in the *Initial Reports* volume because of time constraints. Suggested improvements for future PCS data collection also are noted here. Interpretations based on PCS data are discussed elsewhere in this volume and by Dickens et al. (1997).

DATA COLLECTION

Forty-two deployments (runs) of the PCS on Leg 164 were recovered at a pressure greater than 780 psi (5.5 MPa; Table 1; Paull, Matsumoto, Wallace, et al., 1996). These runs are of interest because significant quantities of hydrocarbon gas are probably not released from the PCS above this pressure (Paull, Matsumoto, Wallace, et al., 1996, pp. 195 and 265). The reason is that essentially all methane exists as solid hydrate or dissolved in water at pressures greater than a threshold pressure of ~5.5 MPa (and at temperatures less than 5°C; Dickens et al., Chap. 11, this volume).

Data collection for PCS runs generally proceeded as follows (with the notable exception of two "sediment only" cores at Site 997 that were deployed to collect gas hydrate specimens; Paull, Matsumoto, Wallace, et al., 1996, pp. 295–296). The PCS was retrieved, separated from the drill string, and placed in an ice bath. A gas manifold system and sampling chamber were attached to a port on the PCS. Incremental volumes of gas then were released over time until the inside of the PCS was at atmospheric pressure (or a port or manifold became clogged with sediment). The PCS was removed from the ice bath and warmed to ambient temperature (~15°C). Any additional volumes of gas were then collected. Aliquots of gas were taken from numerous gas volume increments for compositional analyses. After measuring gas volumes and taking gas samples, the PCS was opened, and the sediment core was examined for length and overall condition and sampled for physical properties measurements. Data collection configurations and manifold designs are described by Paull, Matsumoto, Wallace, et al. (1996, pp. 24–26). Deviations to these general procedures are noted in Tables 2–5.

An important aspect of understanding PCS data collection concerns sampling ports on the PCS. The PCS has an inner chamber and an outer chamber with a sampling port to each. The inner chamber contains the sediment core and borehole water with a total volume of ~1.3 L. The outer chamber contains borehole water with a volume of ~2.7 L. The two chambers are connected inside the PCS. Gas release experiments on Leg 164 prior to Core 164-995A-18P exclusively used the port to the inner chamber because this was the original design for use of the PCS. The problem with this configuration, however, is that sediment at high pressure (especially shallow and unconsolidated sediment) can be extruded into the port (or worse, the manifold), clogging the system and preventing gas release. Starting with Core 164-995A-27P, the manifold was connected to the port of the outer chamber (1) after sediment clogging of the port to the inner chamber, or (2) at the start of a gas-release experiment (see notes in Tables 2–5). Sediment clogging was not a problem with this alternative configuration; apparently, the connection between the PCS chambers or borehole water in the outer chamber serves to limit sediment extrusion. Because the path of gas flow is different for each port, there may be "port dependent" variations in how gas volumes or compositions are released from the PCS with drops in pressure over time. However, the total amount of gas and its bulk composition should be independent of its path through the PCS.

Measurements of PCS data were necessarily simple for multiple reasons, including PCS configuration and manifold-design problems, insufficient high-pressure components aboard the *JOIDES Resolution*, and the absence of a shipboard "Downhole Tools" scientist with appropriate time and experience. Time was recorded with a watch and rounded to the nearest half minute. Pressure was determined with a pressure transducer on the PCS. Gas volumes for PCS runs retrieved after Core 164-994C-66P were collected by: (1) attaching an inverted 1-L graduated cylinder immersed in water saturated with NaCl to the gas manifold system, (2) purging the gas-manifold system and bubbling chamber with He at 1 atm pressure, and (3) releasing incremental gas volumes from the PCS through the gas-manifold system and into the bubbling chamber (Paull, Matsumoto, Wallace, et al., 1996, p. 25; Dickens et al., 1997). The length of the sediment core inside the PCS was determined with a meter stick. Temperature inside (or outside) of the PCS was not recorded.

Uncertainties in individual pressure and volume measurements are within 10 psi and 10 mL, respectively. Uncertainties in measured sediment core length are within 1 cm. However, the error in reported core length (Table 1) likely exceeds 1 cm, and the error in total gas volume (Table 1) likely exceeds the cumulative error of incremental volumes.

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Table 1. Description of PCS deployments retrieved at pressure.

Core	Depth (mbsf)	Recovered pressure** (psi)	Total gas volume (mL)	Core recovered (cm)
164-991B-				
1P	10.0	2550	Not taken†	0
164-994C-				
9P	70.9	1500	Not taken†	23
18P	147.9	3260	Not taken†	0
27P	222.5	3657	Not taken†	7
36P	299.4	4438	Not taken†	23
45P	376.5	4988	Not taken†	0
48P	395.6	4900	Not taken†	15
53P	434.1	5030	Not taken†	15
60P	491.9	5166	Not taken†	28
66P	540.1	5205	Not taken†	22
70P	568.9	4266	720‡	20
164-995A-				
0P*	–73.0	2760	140‡	0
9P	68.2	4126	Not taken†	100
18P	136.7	3176	555‡	70
27P	223.9	4045	4215	100
36P	301.3	4740	1430‡	75
45P	378.6	4635	4370	58
48P	397.8	4712	860††	23
52P*	423.7	4892	85	0
52P	426.7	4788	2365	18
60P	494.1	4238	1310	9
70P	589.2	3680	285	3
164-995B-				
7P	308.5	2769	2330‡	93
10P	320.5	3284	980	65
164-996A-				
7P	47.5	3326	5415	20
164-996D-				
7P	51.2	2998	8100	0***
164-996E-				
8P	61.3	946	575	0***
18P	146.9	4290	450	42
164-997A-				
25P	202.4	4501	7485	88
29P	231.3	4621	Not taken‡‡	0
33P	317.7	4783	290	0†††
49P	394.9	3660	7050	64
51P	404.5	3987	Not taken‡‡	47
55P	433.3	780	6380	50
164-997B-				
10P	462.2	4460	5125	14
15P	501.8	4485	3190	30
21P	549.9	4578	3455	94
29P*	606.5	4832	110	0
32P	635.3	4755	70‡	0
36P	664.1	5122	120	0
40P	693.0	4944	70	0
44P	721.8	4808	80	0

Notes: mbsf = meters below seafloor; ** = some pressures are different than those reported by Paull, Matsumoto, Wallace, et al. (1996). The reason is twofold: pressure changes rapidly over the first minute, and certain pressures were recorded by more than one individual. † = the total volume of gas was not determined because of manifold problems. ‡ = the total volume of gas is a minimum because the PCS was not equilibrated. * = cores designed to collect water without sediment. †† = total volume is a minimum because a gas aliquot was vented before recording. ‡‡ = the total volume of gas was not determined because of immediate PCS opening. *** = a small volume of hydrate and sediment likely existed in the PCS prior to tool opening. ††† = a small volume of sediment likely existed in the PCS prior to tool opening.

Core lengths may be longer than reported in Table 1 by perhaps 3 cm. Certain cores contained "moussey" and "soupy" intervals. Although such intervals were compressed after opening the PCS, the length of these wet sections is difficult to measure accurately because a circumference similar to that of dry sections cannot be established. Small (but unknown) quantities of sediment also can be lost during gas venting when pressurized sediment passes through the manifold, or during extrusion of the sediment core from the PCS.

Total gas volumes may be greater than reported in Table 1; in some cases, by up to 300 mL. The primary source of this error is the volume of gas remaining inside of the PCS after reducing pressure to 1 atm. This unknown "residual" volume depends on temperature, initial gas volume (and composition), and the pressure, time, and volume history of the core prior to opening the PCS. Sediment cores that are kept inside of the PCS at ambient temperature (~15°C) for greater than 7 hr can release upwards of 300 mL of gas after reaching 1 atm (e.g., Core 164-997A-55P). Cores that were not given sufficient time to equilibrate at ambient conditions may therefore contain more gas than reported in Table 1 (see Dickens et al., Chap. 11, this volume). Small volumes of gas may have escaped when the inner port became clogged, and the manifold was removed during a PCS run (see Tables 2–5). However, this volume loss was minimal because the manifold was kept at 1 atm pressure for the entire PCS run (at least those where incremental volumes were collected). The principal effect of removing the manifold at 1 atm, therefore, was to change the composition of gas from primarily methane to air or helium.

DATA PRESENTATION

Shipboard data collected during PCS gas-release experiments at Sites 994, 995, 996, and 997 are presented in nine columns in Tables 2–5. The nine columns are: Eastern Standard Time, run time, gauge pressure, corrected pressure, PCS opening number, gas release volume, gas sample number, gas split volume, and cumulative gas volume. The columns are discussed below because the meaning of the data in the columns is not immediately obvious, and because there is no precedent for PCS data documentation. Basic information concerning time, pressure, or gas volumes was not collected for Cores 164-991B-1P, 164-994C-9P, 164-994C-18P, and 164-997A-51P.

The Eastern Standard Time column lists watch time in hour, minutes, and seconds to the nearest 30-s interval. Dates can be found in "Operations" sections of site chapters in the Leg 164 *Initial Reports* volume (Paull, Matsumoto, Wallace, et al., 1996). The run time column lists the time in minutes since core recovery.

The gauge pressure column lists discrete measurements of pressure in psi using the pressure transducer. The corrected pressure column lists the pressures in megapascals such that a transducer reading for the PCS at atmospheric pressure is 14.7 psi (the transducer was variably set between 0 and 15 psi for atmospheric pressure). Most cores retrieved prior to Core 164-994C-70P do not have corrected pressures because pressure inside the PCS could not be reduced to atmospheric pressure. However, the pressure transducer gave values between 0 and 15 psi after opening the PCS for the cores. No pressure measurements are associated with initial time recordings (run time = 0) because it takes at least 7 min to connect the pressure transducer after core retrieval aboard the *JOIDES Resolution*. The thermal history of a PCS core from core recovery at depth to connection of the transducer on ship is unknown. Initial recorded pressures (Tables 2–5) cannot be used as in situ pressures.

The PCS opening number column indicates each occurrence, in numerical order, when the valve between the PCS and manifold was opened to release an incremental volume of gas from the PCS. When the valve was opened for longer than a minute or in successive minutes, the opening number is kept the same but given a letter designation. The gas release volume column lists the amount of gas released for each valve opening.

The gas sample number column indicates samples in numerical order collected from the bubble chamber of the manifold for chemical analyses. In most cases only a fraction (5–60 mL) of total gas entering the bubbling chamber from a PCS core was sampled. Also, in many cases, multiple gas volume increments were accumulated in the bubbling chamber prior to gas sampling. The gas split volume column indicates the amount of gas in the bubble chamber when each gas sample was collected.

Table 2. Time, pressure, and volume measurements of PCS deployments at Site 994.

Core	EST (h:m:s)	Run time (min)	Gauge pressure (psig)	Corrected pressure (MPa)	PCS opening number	Gas released (mL)	Gas sample number	Gas split (mL)	Cumulative volume (mL)	Notes
164-994C-27P										
	10:00:00	0								Core recovery
	10:11:00	11	3657							No ice; connect to inner port
	10:15:00	15	3664							
	10:16:00	16	423		C0		G1			
	10:20:00	20	444							
	10:26:00	26	312		C1		(G2)			
	10:27:00	27	332							
	10:34:00	34	91		C2		(G2)			
	10:38:00	38	111							

Note: EST = eastern standard time.

This is a sample of the table that appears on the volume CD-ROM.

Table 3. Time, pressure, and volume measurements of PCS deployments at Site 995.

Core	EST (h:m:s)	Run time (min)	Gauge pressure (psig)	Corrected pressure (MPa)	PCS opening number	Gas released (mL)	Gas sample number	Gas split (mL)	Cumulative volume (mL)	Notes
164-995A-0P*										
	10:15:00	0†	2760	19.07					0	No time recorded for core recovery
	10:18:00	3	2786	19.25					0	On ice at 22:18:30
	10:20:00	5	2660	18.38					0	
	10:21:00	6	2537	17.54					0	
	10:23:00	8	2424	16.76					0	
	10:24:00	9	2386	16.49					0	
	10:26:00	11	2325	16.07					0	
	10:31:00	16	2217	15.33					0	
	10:34:00	19	2175	15.04					0	

Notes: EST = eastern standard time. * = core designed to collect water without sediment. † = arbitrary core recovery.

This is a sample of the table that appears on the volume CD-ROM.

Table 4. Time, pressure, and volume measurements of PCS deployments at Site 996.

Core	EST (h:m:s)	Run time (min)	Gauge pressure (psig)	Corrected pressure (MPa)	PCS opening number	Gas released (mL)	Gas sample number	Gas split (mL)	Cumulative volume (mL)	Notes
164-996A-7P										
	14:15:00	0							0	Core recovery
	14:35:00	20	3326	23.01					0	On ice at 14:35:00; connect to inner port
	0:32:00	617	2529	17.52					0	
	0:38:00	623	2528	17.51					0	
	0:39:00	624	2049	14.21	C0	10	G1	10	10	
	0:40:00	625	2061	14.3					10	
	0:53:00	638	2063	14.31					10	
	0:55:00	640	2036	14.12	C1A				10	
	0:56:00	641	1175	8.19	C1B	20	G2	20	30	

Note: EST = eastern standard time.

This is a sample of the table that appears on the volume CD-ROM.

Table 5. Time, pressure, and volume measurements of PCS deployments at Site 997.

Core	EST (h:m:s)	Run time (min)	Gauge pressure (psig)	Corrected pressure (MPa)	PCS opening number	Gas released (mL)	Gas sample number	Gas split (mL)	Cumulative volume (mL)	Notes
164-997A-18P										
	17:10:00	0							0	Core recovery
	17:20:00	10	4290	29.65					0	On ice at 5:20:00; connect to inner port
	19:45:00	155	3458	23.92					0	
	19:46:00	156	3457	23.92					0	
	19:46:30	156.5	3068	21.23	C0	10	(G1)		10	
	19:47:00	157	3071	21.26					10	
	19:48:00	158	3071	21.26					10	
	19:48:30	158.5	2820	19.53	C1	10	(G1)		20	
	19:49:00	159	2825	19.56					20	

Note: EST = eastern standard time.

This is a sample of the table that appears on the volume CD-ROM.

The cumulative gas volume column lists the sum of incremental gas volumes collected in the bubble chamber per incremental valve opening. Cumulative volumes only increase after the valve between the PCS and manifold is opened.

Not all PCS cores recovered at pressure have values in all nine columns. Moreover, not all data in the columns is of similar quality. For example, gas volumes at Site 994 only were determined for Core 164-994C-70P, and total gas volumes determined for early cores were not given sufficient time to equilibrate at ambient conditions. In general, the best overall PCS data was collected at Site 997 because this was the last site to be drilled on Leg 164 and we had gained considerable experience using the tool.

SUGGESTED DATA COLLECTION IMPROVEMENTS

Ideally, from a scientific perspective, four sets of continuous (rather than discrete) measurements should be recorded during gas-release experiments and core recovery for each successful PCS run: (1) time since core collection, (2) pressure inside the PCS, (3) temperature inside the PCS, and (4) incremental gas volume released from the PCS. These information sets were not collected on Leg 164 for three reasons. First, shipboard redesign of gas-manifold systems and placement of the PCS in a confined location prevented automated and continuous data collection. Second, the PCS was not equipped with a pressure transducer to record pressure inside the tool during core recovery. Third, the PCS was not equipped with a thermocouple or probe to determine temperature inside of the tool at any time. Of additional use would be a controlled temperature bath connected to the mounting sleeve, and a valve for controlled gas release. Two complete manifold systems and mounting sleeves should be available for cases where PCS cores are collected within short time intervals. Future drilling proposals that include plans for using the PCS should consider modifying the instrument prior to sailing such that the above improvements can be made. The most useful and successful set-up for Leg 164 operations is shown in Figure 1.

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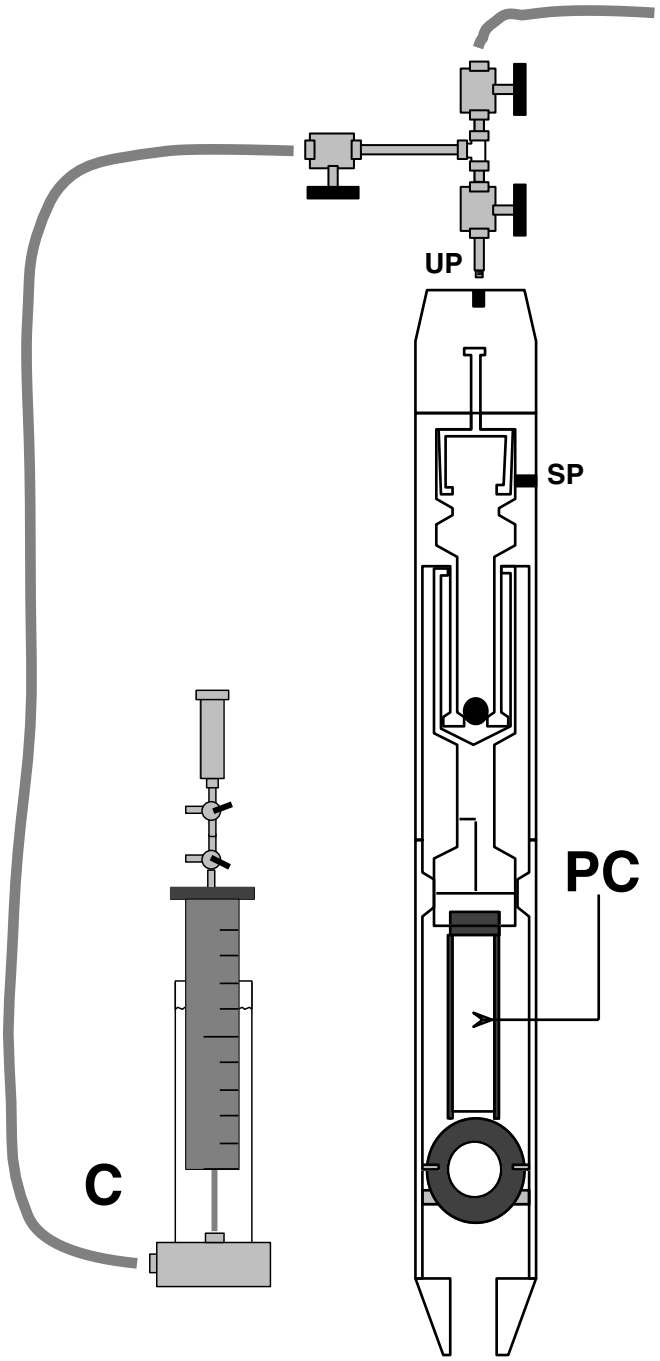

Figure 1. Diagram showing the pressure core sampler (PCS) after recovery of a sediment core (PC) with the attached manifold, and bubble chamber (C). Configuration shows connection to the outer chamber of the PCS through the upper port (UP) rather than connection to the inner chamber through the side port (SP). This represents the best set-up for operations during Leg 164.