"In-Situ Sampling and Characterization of Naturally Occurring Marine Methane Hydrate Using the D/V JOIDES Resolution."

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COOPERATIVE AGREEMENT DE-FC26-01NT41329

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ABSTRACT

The primary accomplishments of the JOI Cooperative Agreement with DOE/NETL in this quarter were that: (1) follow-up logging of pressure cores containing hydrate-bearing sediment; and (2) opening of some of these cores to establish ground-truth understanding. The follow-up measurements made on pressure cores in storage are part of a hydrate geriatric study related to ODP Leg 204. These activities are described in detail in Appendices A and B of this report.

Work also continued on developing plans for Phase 2 of this cooperative agreement based on evolving plans to schedule a scientific ocean drilling expedition to study marine methane hydrates along the Cascadia margin, in the NE Pacific as part of the Integrated Ocean Drilling Program (IODP) using the R/V JOIDES Resolution.

TABLE OF CONTENTS

INTRODUCTION

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EXECUTIVE SUMMARY

The primary accomplishments of the JOI Cooperative Agreement with DOE/NETL in this quarter were that: (1) follow-up gamma attenuation density logging of pressure cores containing hydrate-bearing sediment; and (2) opening of some of these cores to establish ground-truth understanding. The follow-up measurements made on pressure cores in storage are part of a hydrate geriatric study related to ODP Leg 204. These activities are described in detail in Appendices A and B of this report.

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EXPERIMENTAL

The primary accomplishments of the JOI Cooperative Agreement with DOE/NETL in this quarter were that: (1) follow-up logging of pressure cores containing hydrate-bearing sediment; and (2) opening of some of these cores to establish ground-truth understanding. The follow-up measurements made on pressure cores in storage are part of a hydrate geriatric study related to ODP Leg 204. These activities are described in detail in Appendices A and B of this report. Please see these sections for details of the methods used and results obtained.

RESULTS AND DISCUSSION

The primary accomplishments of the JOI Cooperative Agreement with DOE/NETL in this quarter were that: (1) follow-up logging of pressure cores containing hydrate-bearing sediment; and (2) opening of some of these cores to establish ground-truth understanding. The follow-up measurements made on pressure cores in storage are part of a hydrate geriatric study related to ODP Leg 204. These activities are described in detail in Appendices A and B of this report. Please see these sections for details of the methods used and results obtained.

CONCLUSION

The primary objectives of the JOI proposal to DOE/NETL, which resulted in Cooperative Agreement #DE-FC26-01NT41329, were to sample and characterize methane hydrates using the systems and capabilities of the D/V *JOIDES Resolution* during ODP Leg 204, to enable scientists the opportunity to establish the mass and distribution of naturally occurring gas and gas hydrate at all relevant spatial and temporal scales, and to contribute to the DOE methane hydrate research and development effort. The goal of the work was to provide expanded measurement capabilities on the *JOIDES Resolution* for a dedicated hydrate cruise to Hydrate Ridge off Oregon (ODP Leg 204) so that hydrate deposits in this region are well characterized. This goal was accomplished along with many other aspects of this project, which have contributed to ongoing hydrate studies and joint industry project preparation to characterize hydrate deposits in the Gulf of Mexico.

In the past quarter, the primary accomplishments of the JOI Cooperative Agreement with DOE/NETL in this quarter were that: (1) follow-up logging of pressure cores containing hydrate-bearing sediment; and (2) opening of some of these cores to establish ground-truth understanding. The follow-up measurements made on pressure cores in storage are part of a hydrate geriatric study related to ODP Leg 204. These activities are described in detail in Appendices A and B of this report.

LIST OF ACRONYMS AND ABBREVIATIONS

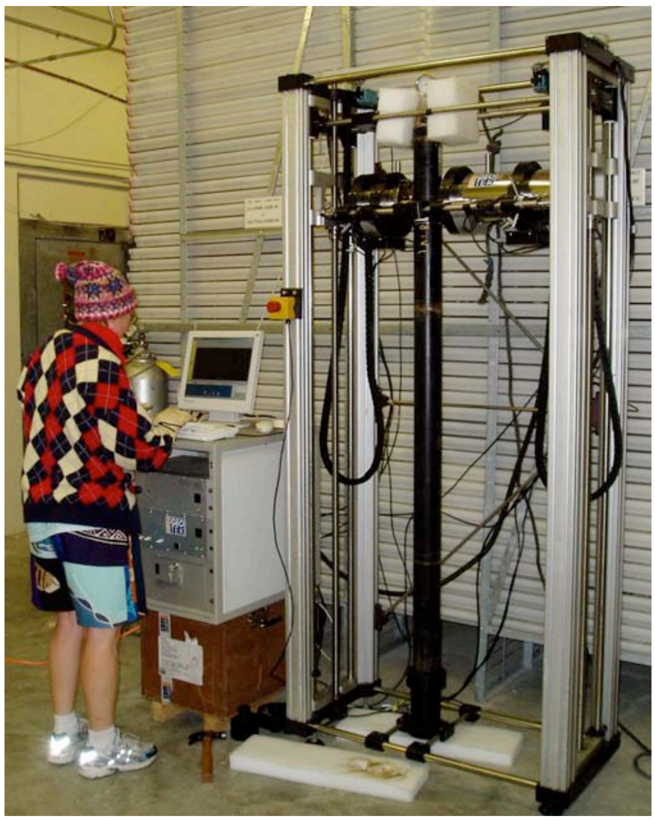
APC	Advanced Piston Corer
APC-M	Advanced Piston Corer-methane tool
APC-T	Advanced Piston Corer-temperature tool
BHA	Bottom Hole Assembly
BSR	Bottom Simulating Reflector
DOE	Department of Energy
DVTP	Davis Villinger Temperature Probe
DVTP-P	Davis Villinger Temperature Probe with Pressure
FMMG	Fugro-McCleland Marine Geosciences
FPC	Fugro Pressure Corer
GHSZ	Gas Hydrate Stability Zone
HR	Hydrate Ridge
HRC	HYACE Rotary Corer
HYACE	Hydrate Autoclave Coring Equipment
HYACINTH	Deployment of HYACE tools In New Tests on Hydrates
IR-TIS	Infrared Thermal Imaging System
JOI	Joint Oceanographic Institutions
JOIDES	Joint Oceanographic Institutions for Deep Earth Sampling
LDEO	Lamont Doherty Earth Observatory (Columbia University)
L/L	Liters per Liter
LTC	Laboratory Transfer Chamber
LWD	Logging While Drilling
MBRF	Meters Below Rig Floor
MBSF	Meters Below Sea Floor
MH	Methane Hydrate
MPa	Mega-Pascals
MSCL-V	Multi-Sensor Core Logger - Vertical
NETL	National Energy Technology Laboratory
NSF	National Science Foundation
ODP	Ocean Drilling Program
ODP-LC	Ocean Drilling Program – Logging Chamber
PCS	Pressure Core Sampler
PSI	Pounds per Square Inch
RAB	Resistivity at the Bit
RAB-c	Resistivity at the Bit with Coring
RCB	Rotary Core Barrel
R/V	Research Vessel
TAMU	Texas A&M University
XCB	Extended Core Barrel

APPENDIX A

GAMMA DENSITY RE-LOGGING OF COLD, PRESSURIZED HYDRATE CORES FROM ODP LEG 204

Gamma Density Re-Logging of Cold, Pressurized Hydrate Cores from ODP Leg 204

October 2004



Logging cores with the MSCL-V in the reefer at IODP College Station

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Gamma Density Re-Logging of Cold, Pressurized Hydrate Cores from ODP Leg 204

In October 2002 we logged the steel pressure vessels containing repressurized gas hydrate cores recovered on Ocean Drilling Program (ODP) Leg 204 in Aug/Sept 2002 (see original report, "Gamma Density Logging..."). This logging exercise provided detailed density profiles of all the cores stored in the pressure vessels at a 0.5 cm spatial resolution. The cores were recovered at the end of ODP Leg 204 from the summit of Hydrate ridge (Site 1249) and were rapidly transferred into the steel pressure vessels and repressurized with bottle methane to an initial pressure between 500 and 600 psi and then stored at 4-5˚C. Although some dissociation of the gas hydrates will inevitably have occurred during the core recovery and transfer process, significant amounts of gas hydrate were observed in the cores prior to insertion into the pressure vessels. The pressure and temperature of storage was quite close to the hydrate phase boundary, but within the field of hydrate stability. It was reasoned that at these conditions–and because they were stored under methane–the gas hydrates would be stable and might be stored for some time without any significant further dissociation.

All the cores have been carefully stored upright in a cold 'HAZMAT' container over the past 2 years at ODP/IODP (Integrated Ocean Drilling Program) in College Station, Texas A&M University (TAMU). Only 3 of the pressure vessels have been depressurized and opened (PV3, PV14 and PV20). Apparently, none of these contained any obviously visible gas hydrates but there was significant evidence, in the form of disturbed sediments and 'vuggy' structures, that hydrate had once existed. In addition, a number of gas samples were taken from some pressure vessels, with the conclusion that no evidence of gas hydrate dissociation could be discerned from the $\partial^{13}C$ analysis.

These observations raise a number of immediate questions:

a) Had the gas hydrate in the 3 opened cores all dissociated prior to being placed in the pressure vessels or had it dissociated during storage?

b) Was there, in fact, any natural gas hydrate in the cores where gas samples had been taken?

c) Did any of the cores contain any gas hydrates?

d) What changes had occurred to the cores during the 2 years of storage?

e) Had any of the bottled methane gas formed gas hydrates during the storage period?

f) Is the storage technique used appropriate for storing samples containing gas hydrates?

As part of the investigation to help answer some of these questions all the cores in the pressure vessels were again logged in a similar manner and with the same equipment as had been done 2 years earlier. This would determine if any density changes had occurred during that time period which might indicate either if any gas hydrate had dissociated–or formed–during the storage.

The Presure Vessels stored upright in the HazMat container

This 2nd logging exercise took place between the 8th and 13th of October, 2004 exactly 2 years after the cores had been logged previously (7th – 14th October, 2002, about 6 weeks after the samples had originally been recovered). Logging took place in the main core store at around 4-5˚C at ODP-TAMU using the GEOTEK vertical logging system (MSCL-V) in exactly the same way as had previously been done.

A summary table of the known pressure history of the vessels is shown at the end of this report. Unfortunately, the exact pressures inside the bottles after pressurizing on the ship were not recorded, nor is a detailed pressure record over the past 2 years available. The pressures recorded are taken from the pressure gauges and are probably only accurate to about +/- 10 psi. With the benefit of hindsight, it is clear that a more accurate and detailed record might have helped significantly in understanding the nature of the changes that have occurred. Both dissociation and formation of hydrate will have been accompanied by some pressure change.

Each core section was logged from the top down at 0.5cm intervals. A standard gamma count time of 25 seconds was used throughout the logging process which results in density values that have a precision of about 1-2%.

The data are plotted as two density profiles for each core. The first profile is the data obtained in October 2002; the other is the data obtained in October 2004.

When comparing the two density profiles for each core it should be remembered that the gamma density values represent the average density of a 5 mm diameter horizontal 'pencil beam' through the center of the core. The gamma density calibration was conducted using standard linear techniques with aluminium and water. This optimizes the accuracy of the measurement in the sediment-water range but introduces an error at very low densities. Consequently, pure gas apparently has a density of less than zero.

Core densities have been divided into the same three zones as in the original report:

Zone A) Density values lower than 0.95 g/cc (the approximate density of pure methane hydrate) that show the core must contain some gas.

Zone B) Density values in the range 0.95 to 1.4 g/cc, which are quite abundant in the cores and are most likely to be sediment with sub-horizontal gas cracks, but could also include some hydrate and small amounts of gas.

Zone C) Densities greater than 1.4 g/cc, that are likely to be mainly sediment but could still contain small amounts of gas or hydrate.

There is no definitive method of ascertaining the existence of methane hydrate at any location in a given core from these density measurements. However, the general nature of the density profiles in each core may act as a good guide to the occurrence of hydrates, especially as more information is gathered.

If it is assumed that no mass has been lost from the pressure vessels (apart from the small amount of gas that was taken from some of the vessels for analysis) then any differences in the two profiles can be assumed to occur as a result of one or more of the following processes:

a) Dissociation of any original natural gas hydrate

b) Methane hydrate formation from bottled gas

c) Vertical movement of the core inside the liner within the pressure vessel

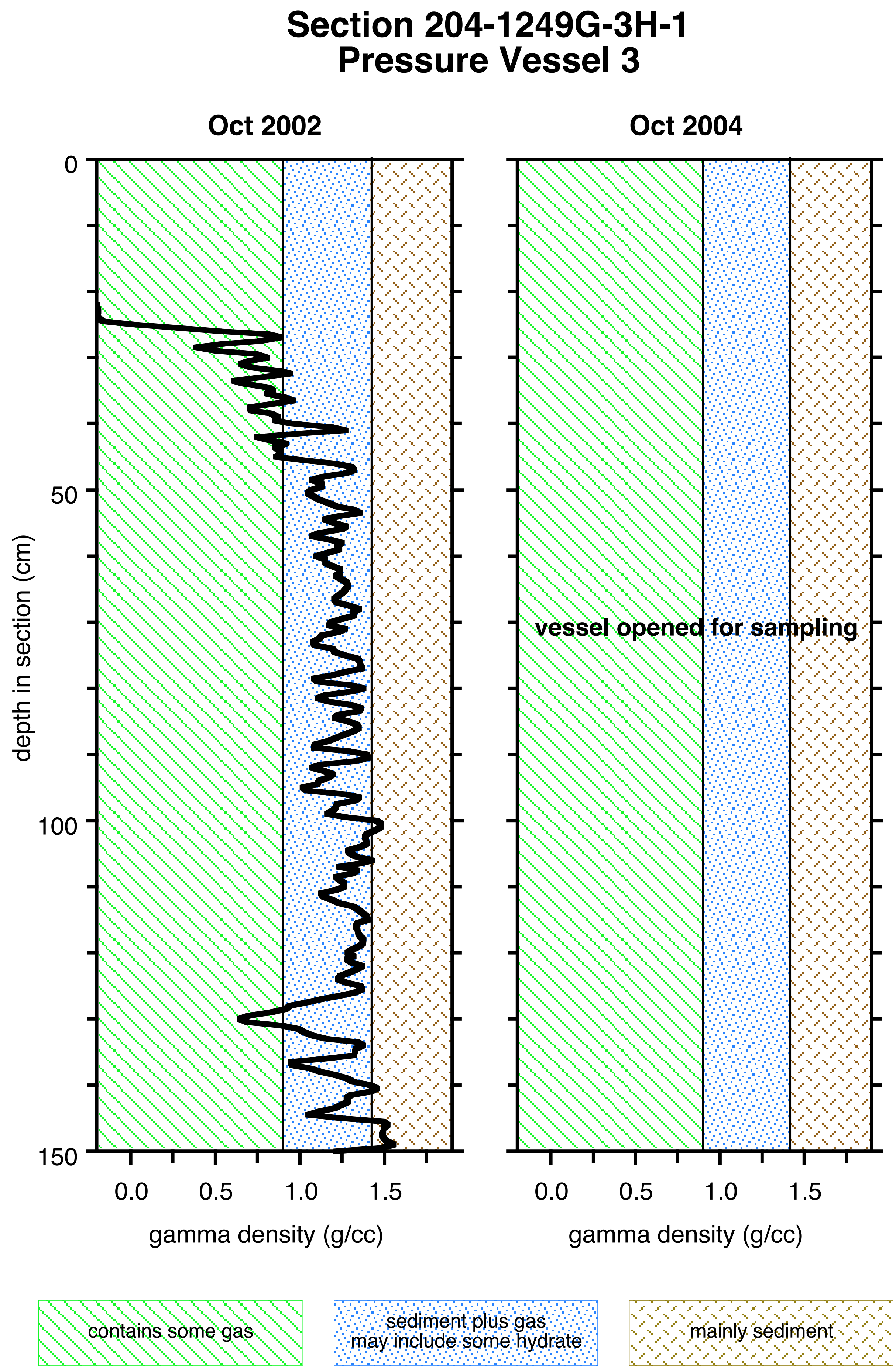
d) Rotation of the core within the pressure vessel

Note that the pressure vessels were logged in the same orientation, but this does not preclude the possibility of some relative rotation of the core inside with respect to the pressure vessel. This will change the character and position of small sub-horizontal cracks containing gas inside a sediment core.

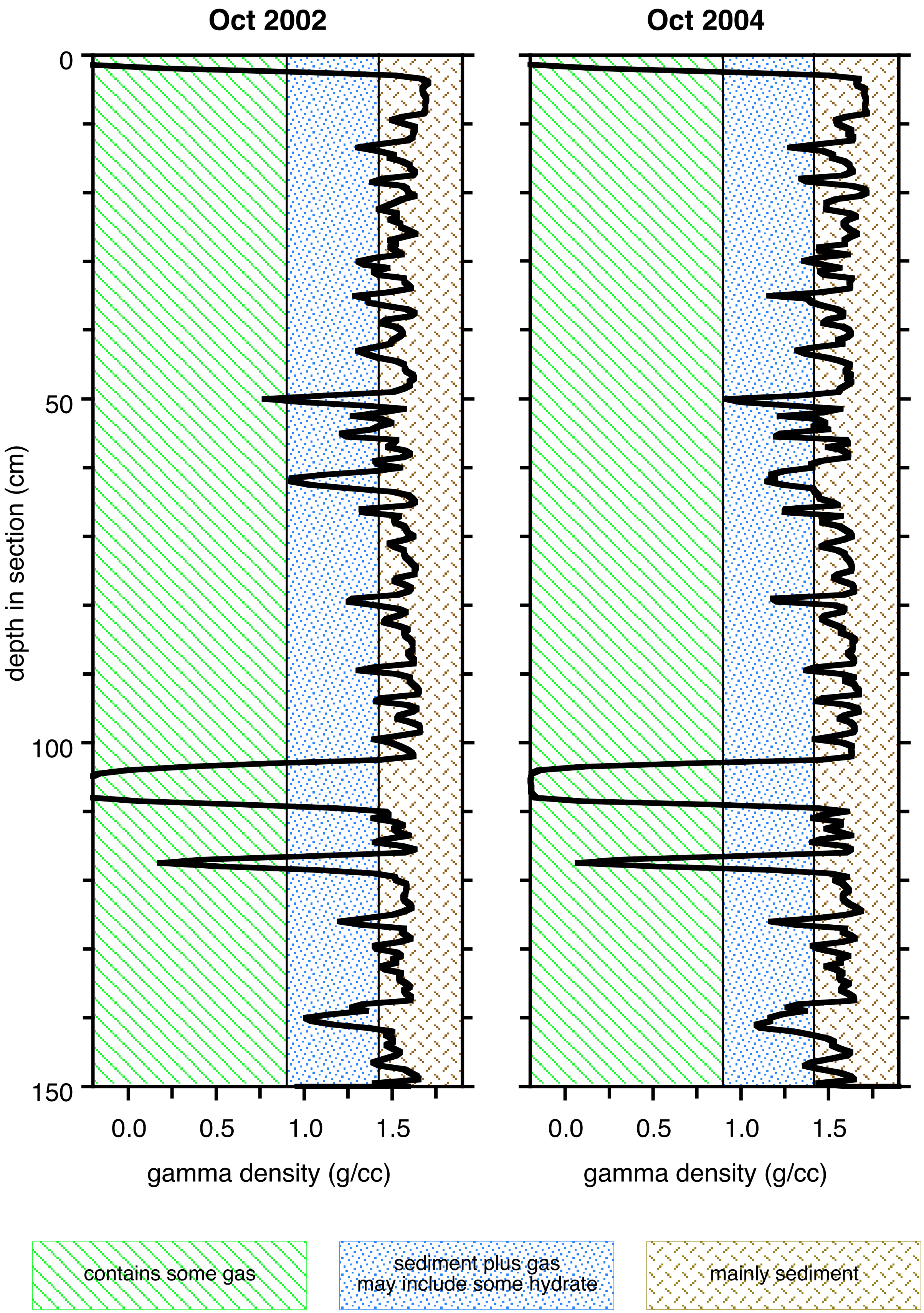
The first impression, looking quickly through the data and comparing the profiles from 2002 and 2004, is that they are generally quite similar. The most obvious feature is the movement of gas upwards and sediment blocks downwards. Where there is little or no change in the low density gas spikes between the two logs, then the amount of gas at the top of the core is also unchanged, indicating no large vertical movements of gas and sediment. This is the most common situation and is observed for Pressure Vessels 4-9,11-13,16,18, 23, 26, 28-32, 34, 37, 38 and 40.

Where there is a significant change in the gas spikes between the 2 logs, there is invariably more gas (a longer low density interval) at the top of the core, showing that core intervals have fallen within the liner. This is observed for Pressure Vessels 10,17,19, 22, 25, 27, and 36. Pressure Vessel 22 shows some particularly large differences where gas has obviously migrated upwards and sections of sediment have moved downward. A detailed analysis is beyond the scope of this data report and will be best be done when more pressure vessels are opened and the density logs can be ground truthed.

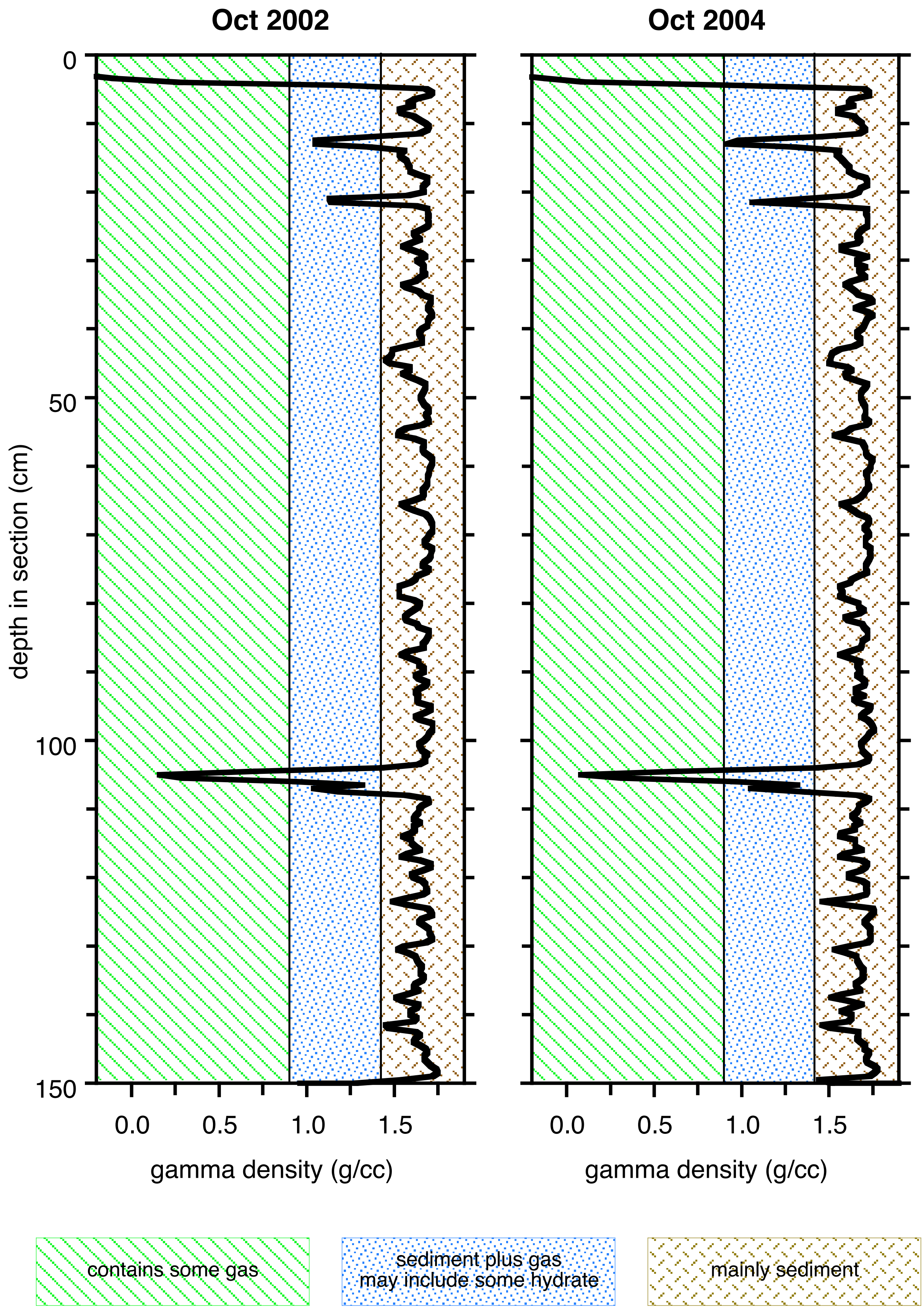
Pressure Vessel #	Core	Pressure PSI	Pressure PSI	Pressure PSI	Sampled for Gas Analysis
	204-1249-	Oct 2002	30 Jul 04	Oct 2004	
1	EMPTY	EMPTY	EMPTY	EMPTY	
2	EMPTY	EMPTY	EMPTY	EMPTY	
3	G-3H-1	560	OPENED	OPENED	G & Al
4	H-3H-4	630	625	630	
5	H-6H-3	510	500	510	
6	H-3H-1	590	590	580	G & Al
7	H-5H-3	570	525	550	
8	H-6H-6	600	560	590	
9	H-4H-3	550	550	550	
10	H-4H-4	610	550	560	Al
11	H-6H-1	600	590	580	
12	H-5H-1	570	550	530	
13	H-5H-2	590	600	590	
14	H-6H-4	500	OPENED	OPENED	
15	EMPTY	EMPTY	EMPTY	EMPTY	
16	H-6H-5	560	500	540	
17	J-2H-1	650	625	600	
18	J-3H-4	660	600	690	Al
19	J-3H-1	640	600	640	
20	I-4H-3	640	OPENED	OPENED	
21	EMPTY	EMPTY	EMPTY	EMPTY	
22	K-3H-2	540	460	550	G & Al
23	K-3H-1	540	510	590	
24	K-3H-5	560	560	590	
25	K-4H-1	550	515	550	
26	K-5H-4	530	510	520	
27	K-4H-2	650	600	640	
28	K-5H-1	500	440	440	
29	I-4H-6	700	650	690	G
30	I-4H-2	570	560	570	
31	K-5H-2	490	490	490	
32	L-2H-2	600	590	590	
33	L-2H-3	590	590	580	
34	L-2H-1	520	500	530	
35	EMPTY	EMPTY	EMPTY	EMPTY	
36	L-4H-1	560	550	560	
37	L-4H-2	570	560	560	
38	L-3H-1	500	500	500	
39	EMPTY	EMPTY	EMPTY	EMPTY	
40	L-3H-3	540	500	540	


Section 204-1249G-3H-1
Pressure Vessel 3
Oct 2002
Oct 2004
0
50
100
150
depth in section (cm)
vessel opened for sampling
0.0
0.5
1.0
1.5
gamma density (g/cc)
gamma density (g/cc)
contains some gas
sediment plus gas
may include some hydrate
mainly sediment

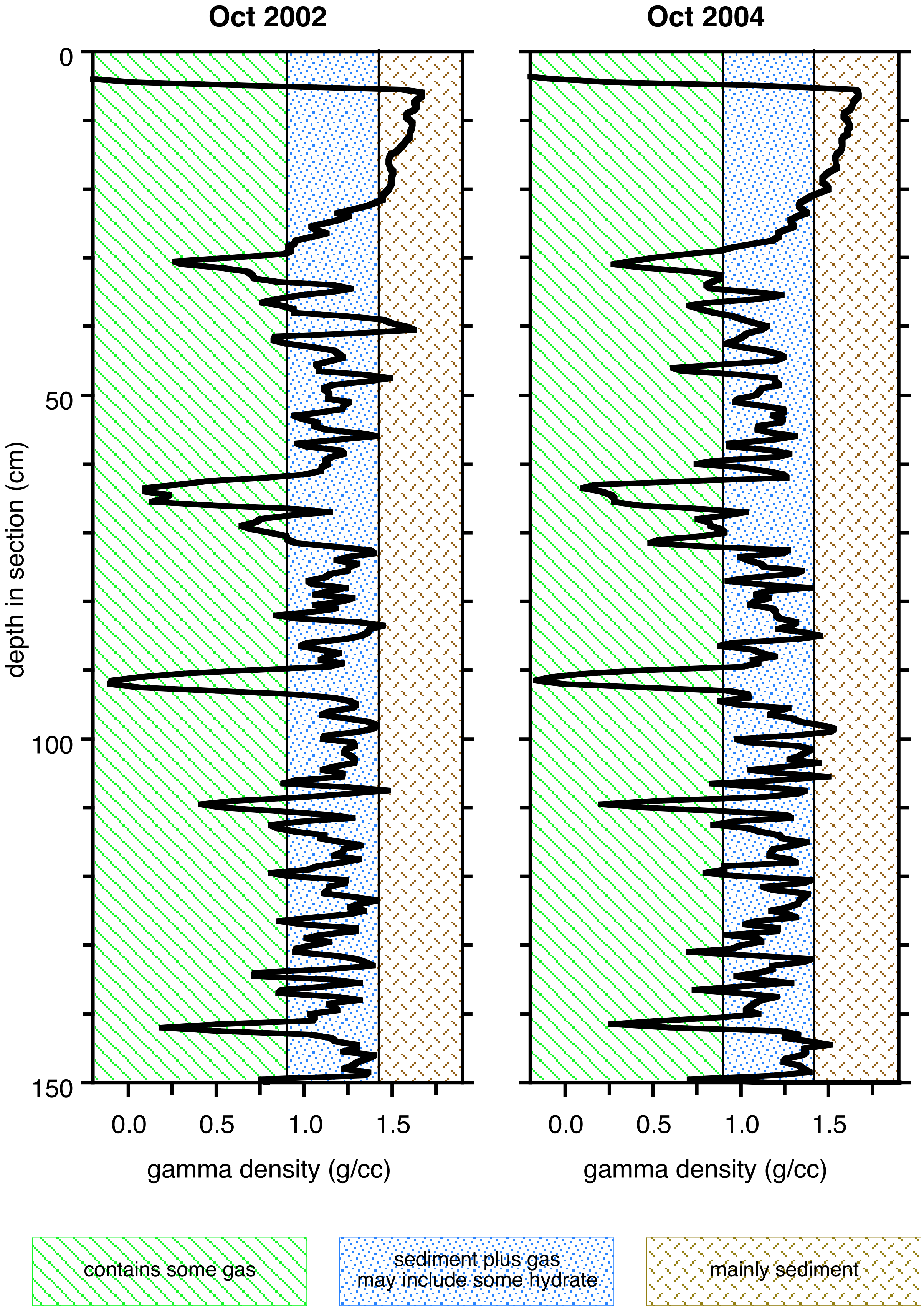
Section 204-1249H-3H-4
Pressure Vessel 4



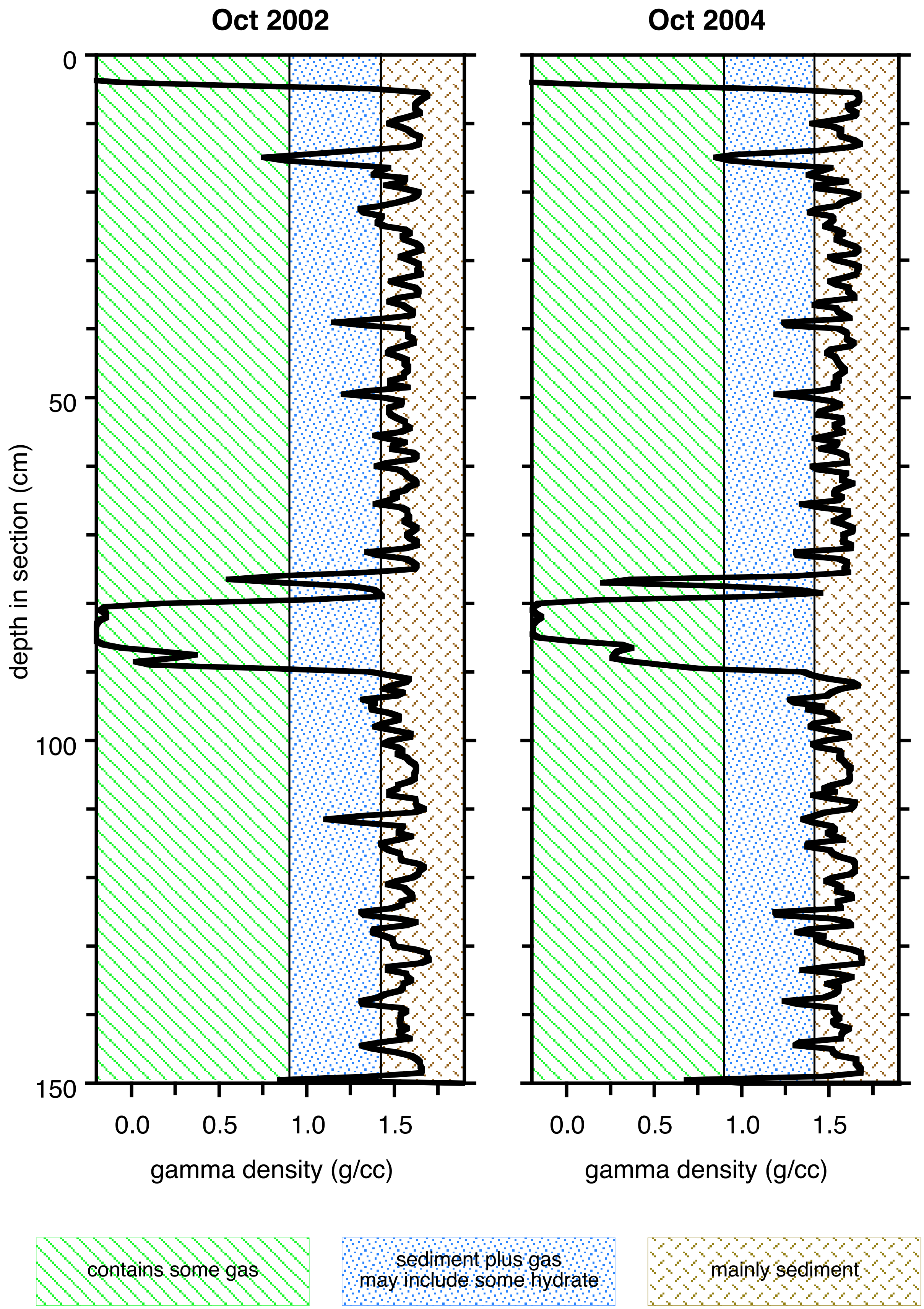
Section 204-1249H-6H-3
Pressure Vessel 5

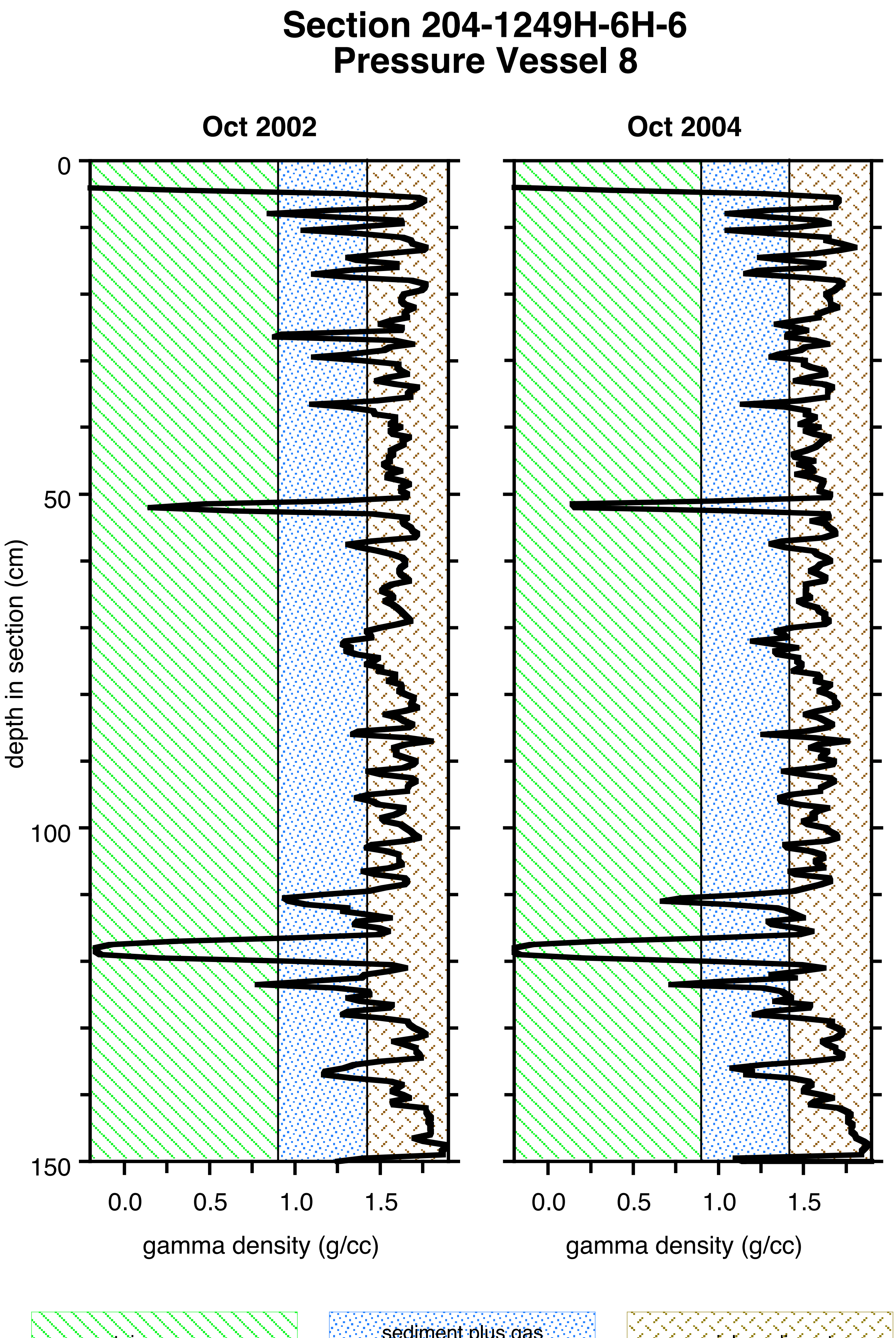


Section 204-1249H-3H-1
Pressure Vessel 6



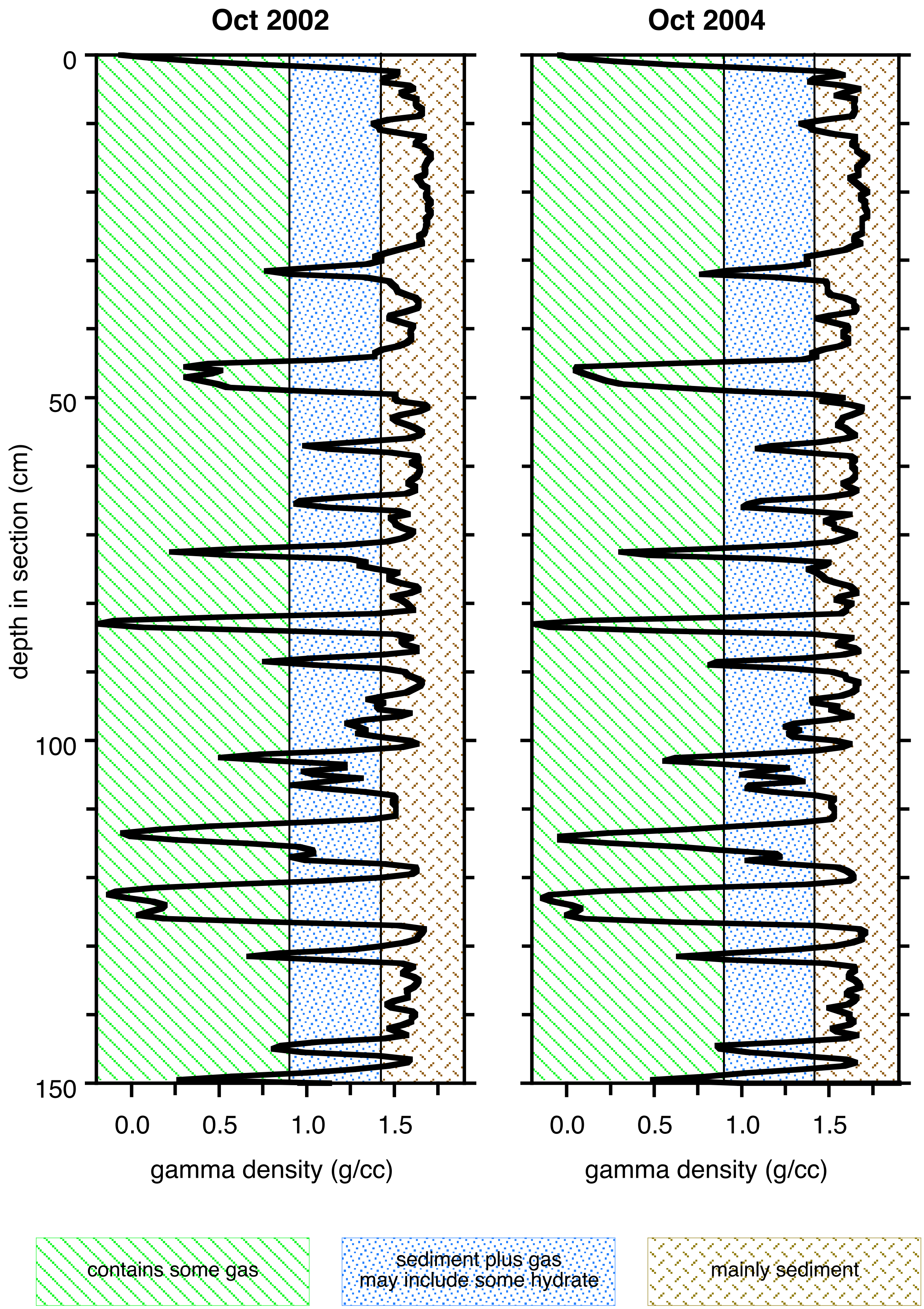
Section 204-1249H-5H-3
Pressure Vessel 7



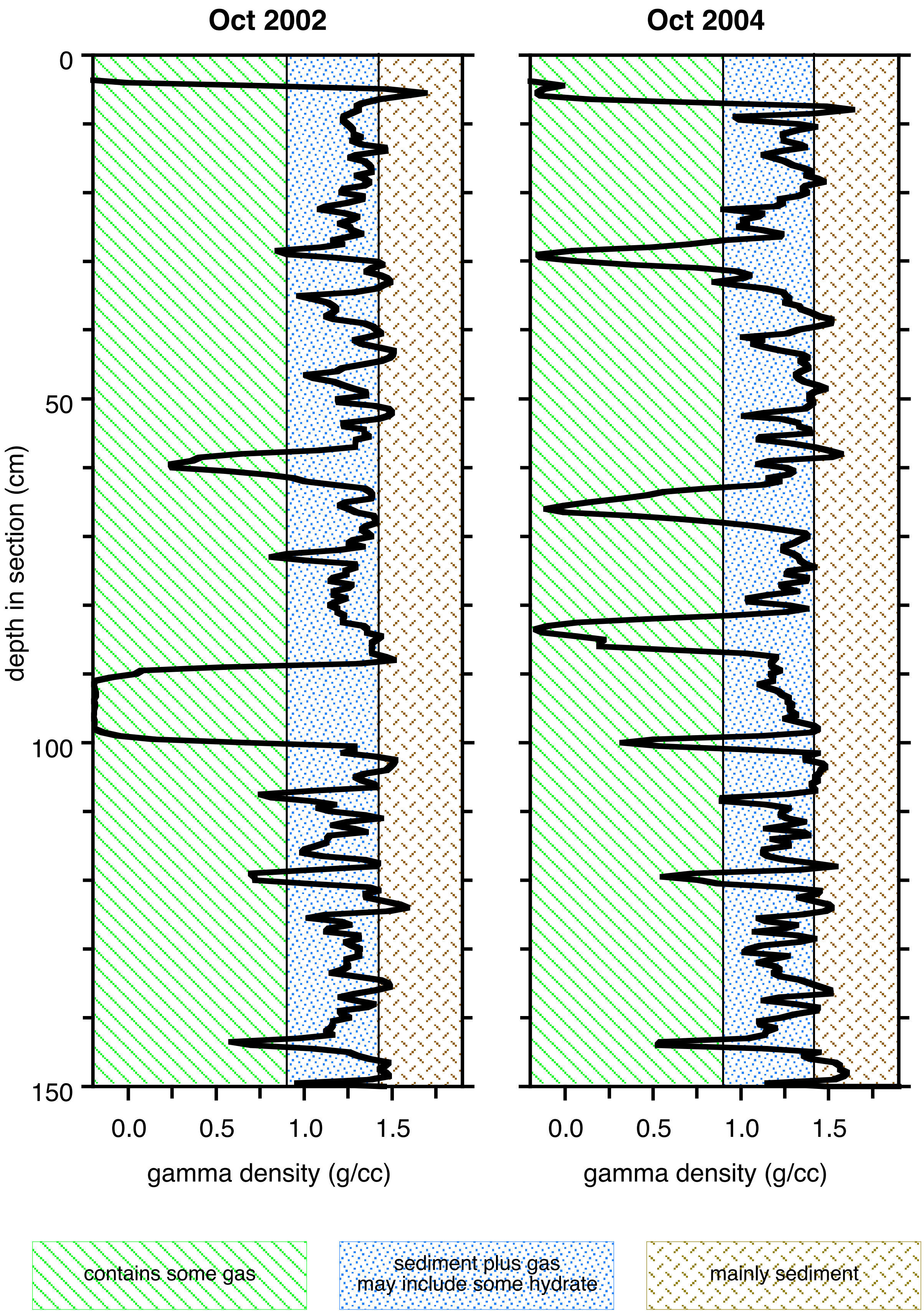


Section 204-1249H-6H-6
Pressure Vessel 8
Oct 2002
Oct 2004
depth in section (cm)
0
50
100
150
0.0
0.5
1.0
1.5
gamma density (g/cc)
contains some gas
sediment plus gas
may include some hydrate
mainly sediment

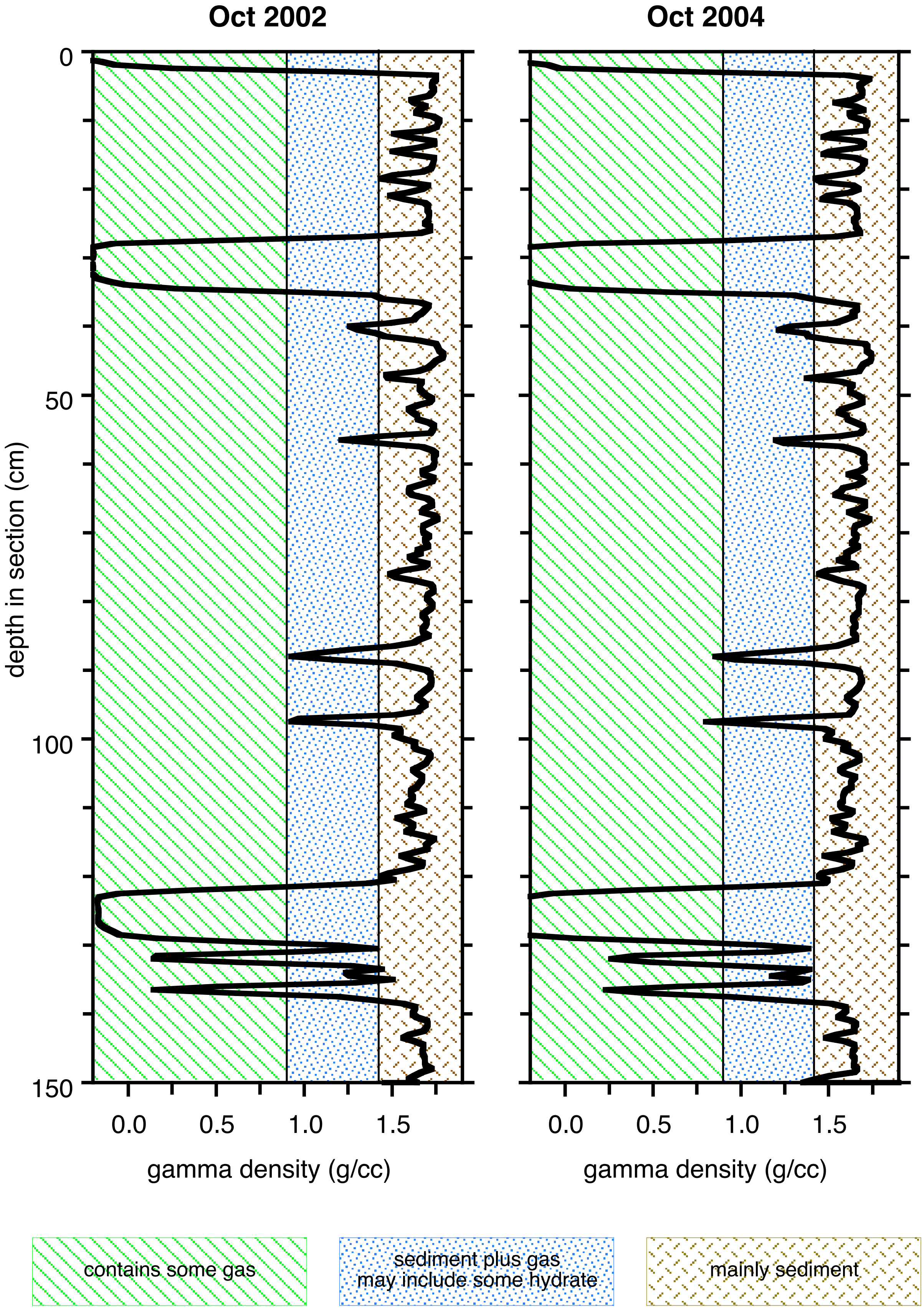
Section 204-1249H-4H-3
Pressure Vessel 9

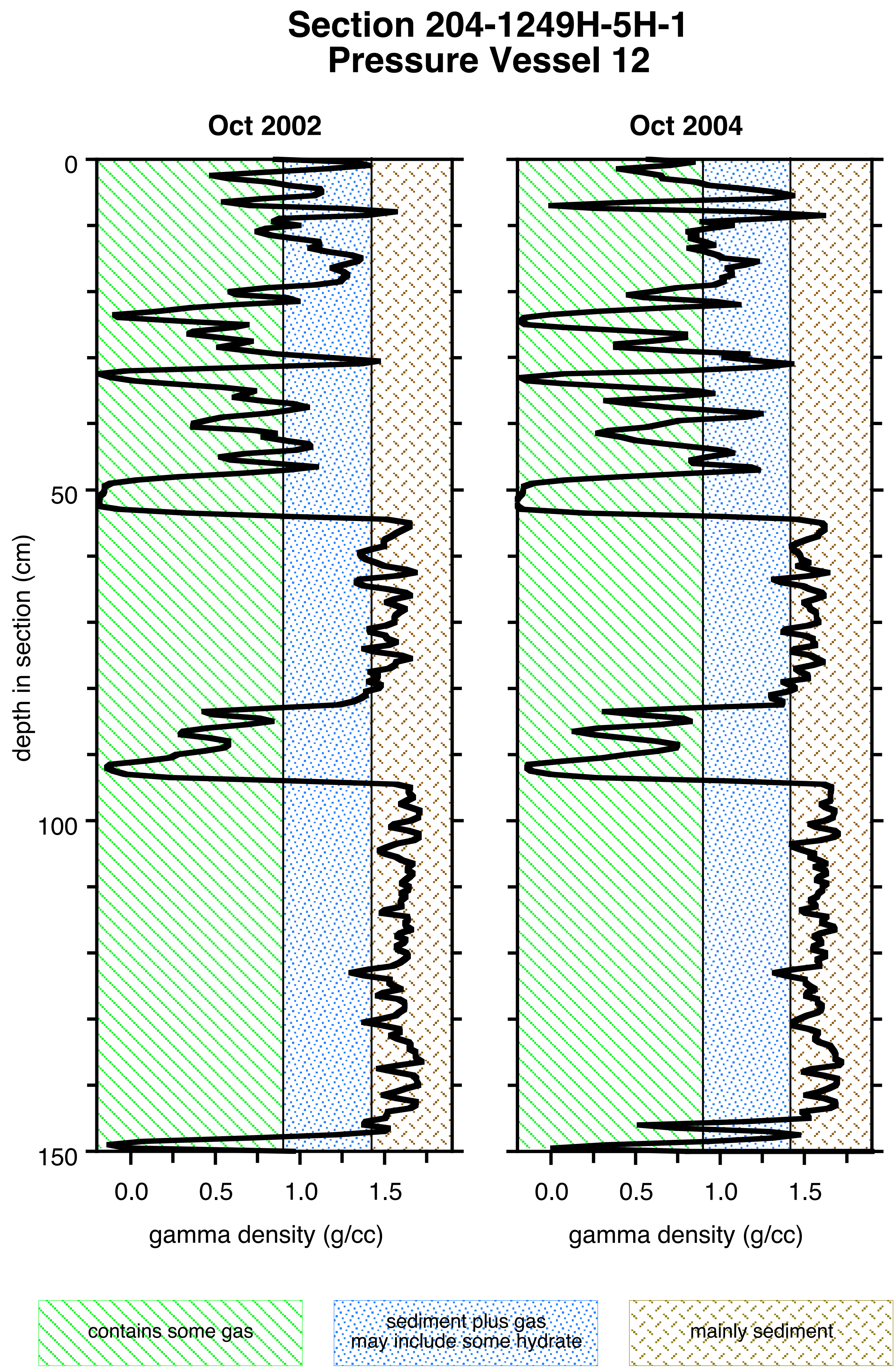


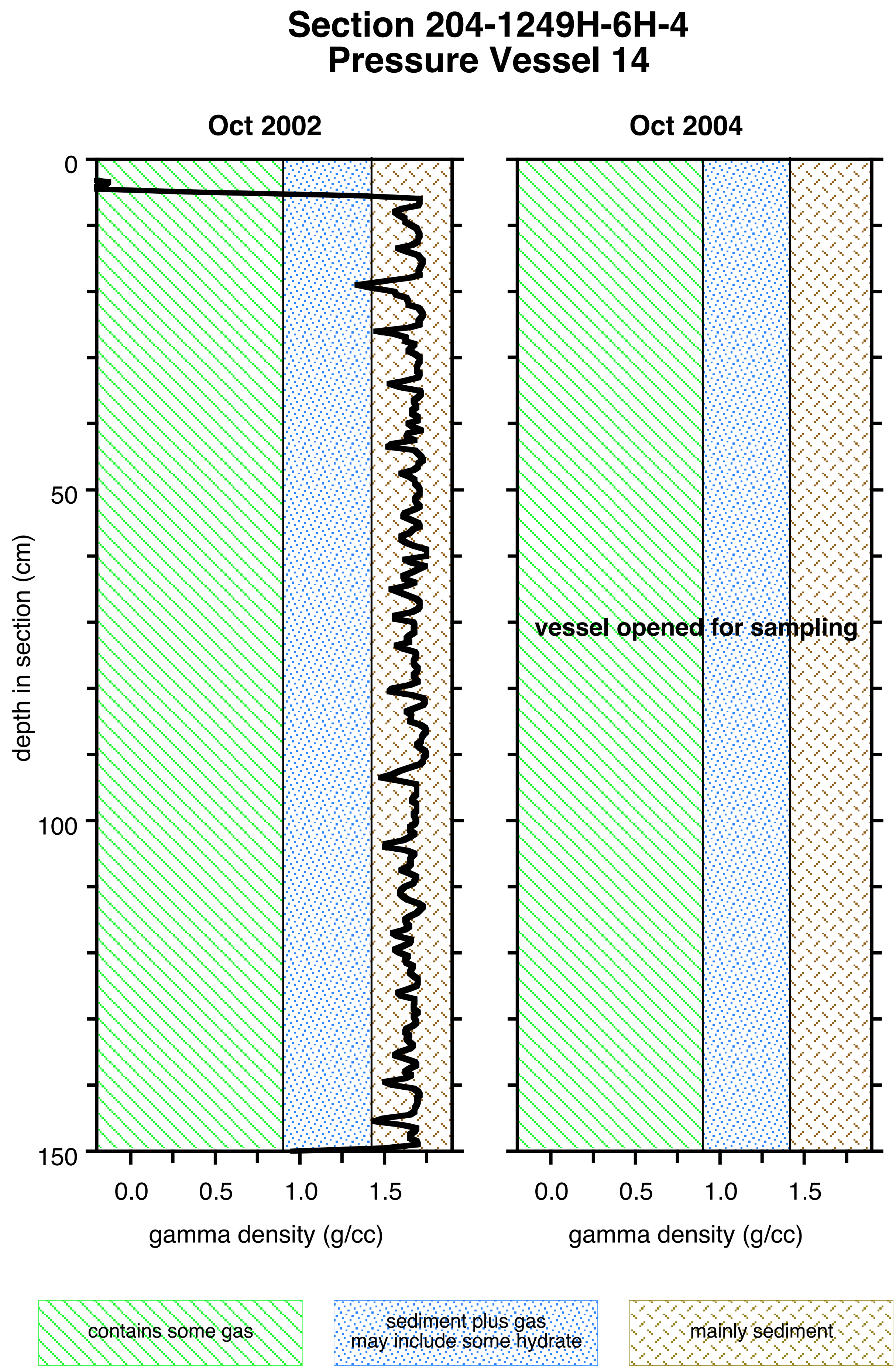
Section 204-1249H-4H-4
Pressure Vessel 10



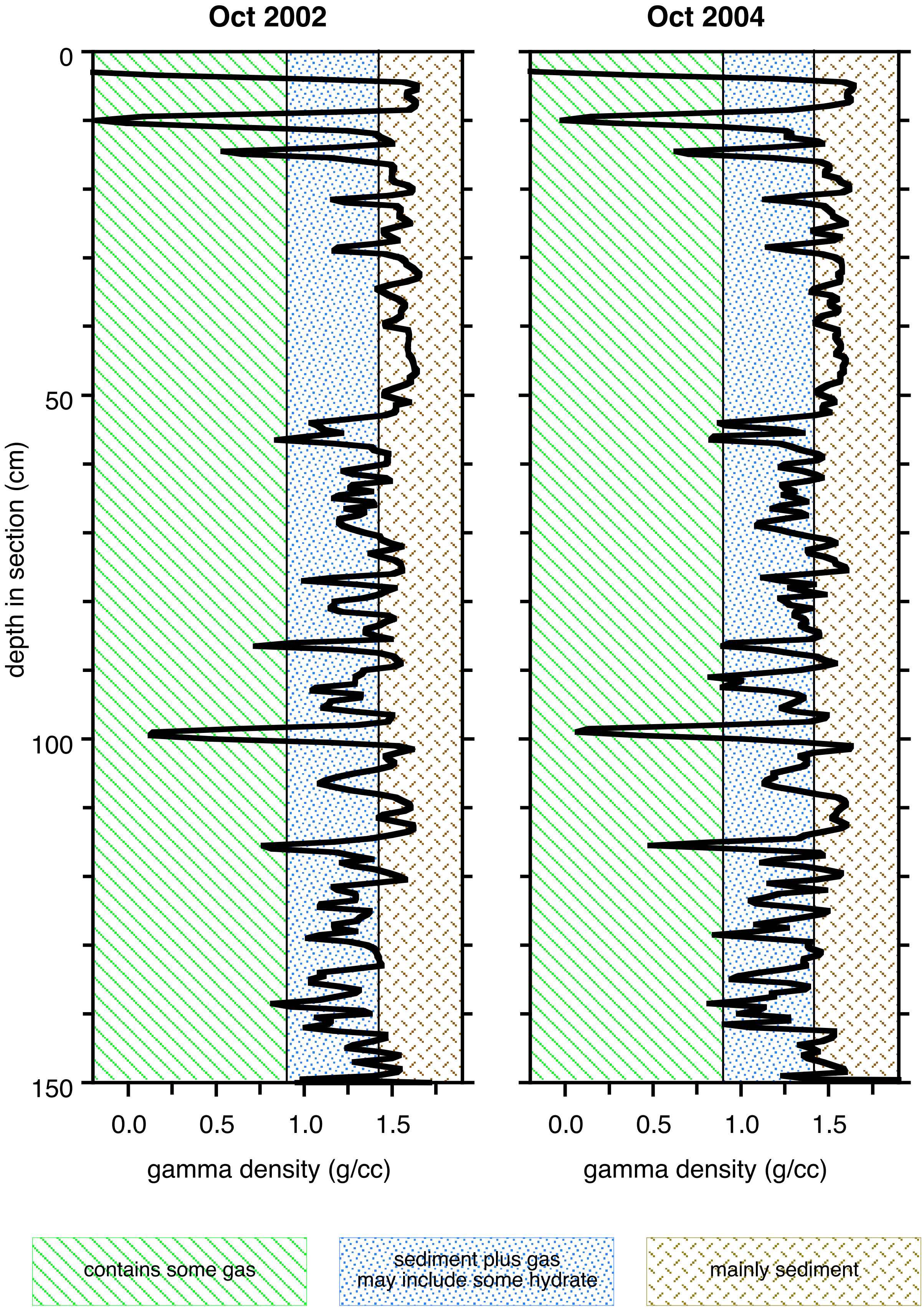
Section 204-1249H-6H-1
Pressure Vessel 11



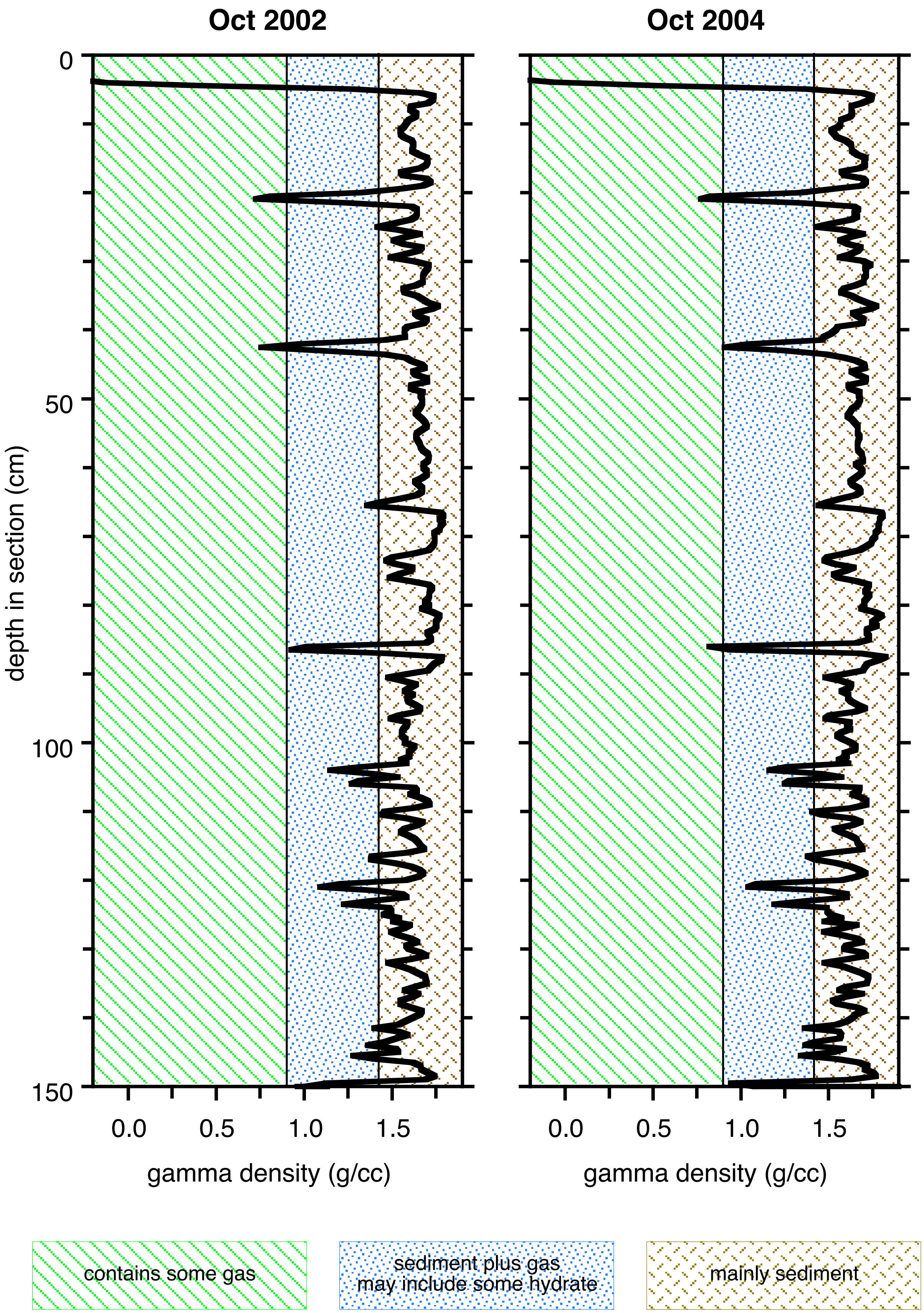

Section 204-1249H-5H-1
Pressure Vessel 12
Oct 2002
Oct 2004
depth in section (cm)
0
50
100
150
0.0
0.5
1.0
1.5
gamma density (g/cc)
gamma density (g/cc)
contains some gas
sediment plus gas
may include some hydrate
mainly sediment

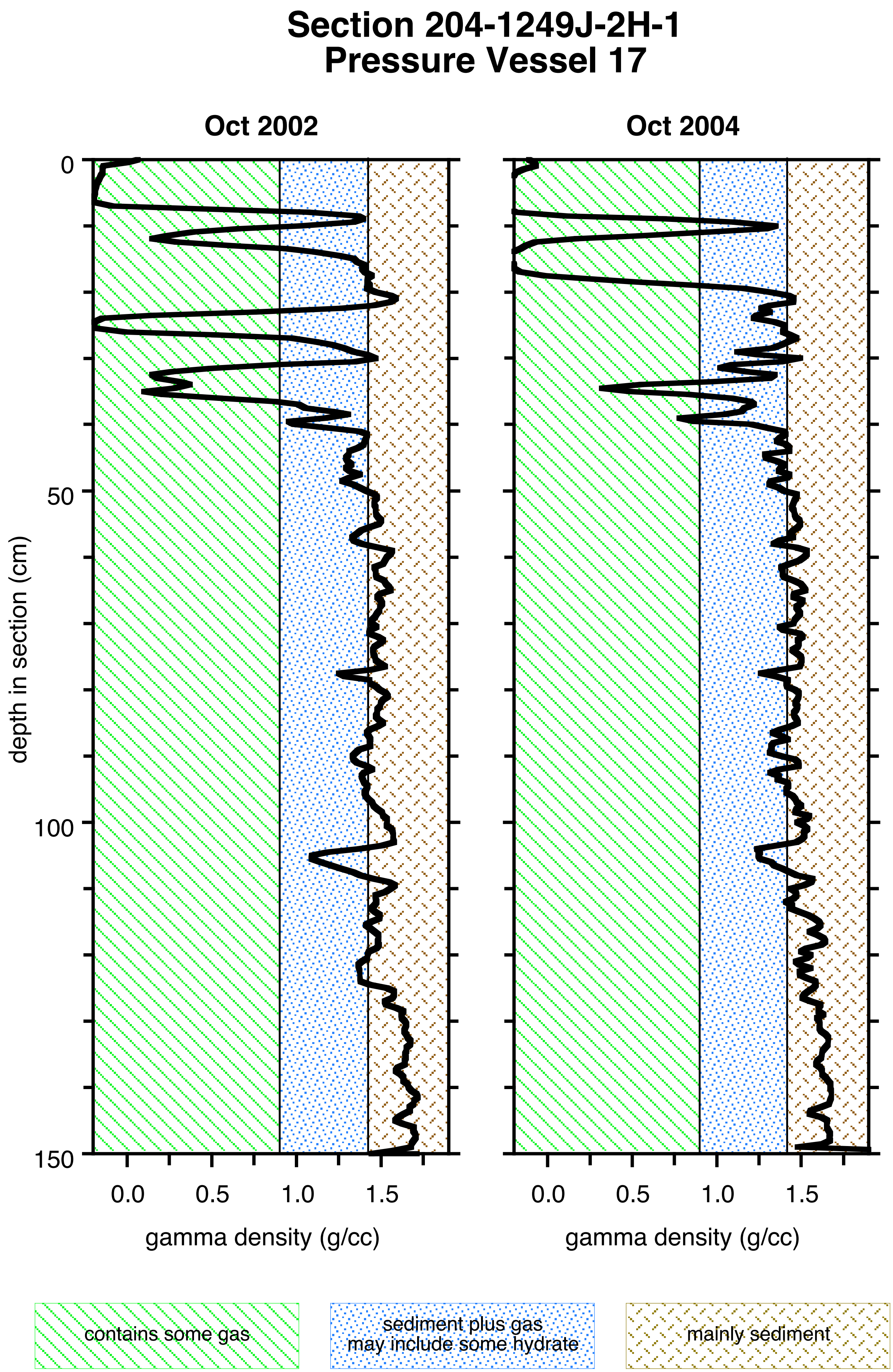

Section 204-1249H-6H-4
Pressure Vessel 14
Oct 2002
Oct 2004
0
50
100
150
depth in section (cm)
0.0
0.5
1.0
1.5
gamma density (g/cc)
vessel opened for sampling
contains some gas
sediment plus gas
may include some hydrate
mainly sediment

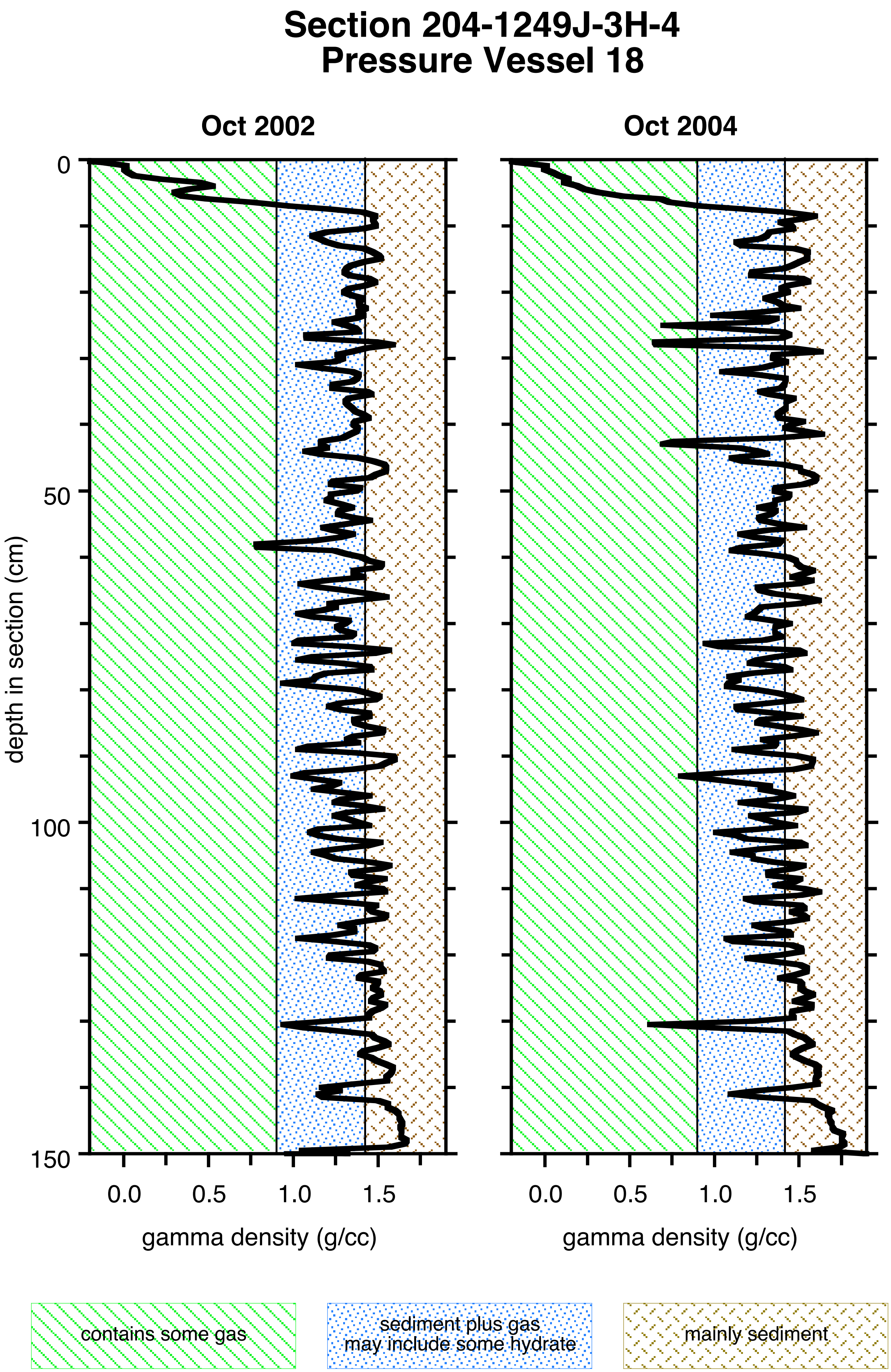
Section 204-1249H-5H-2
Pressure Vessel 13

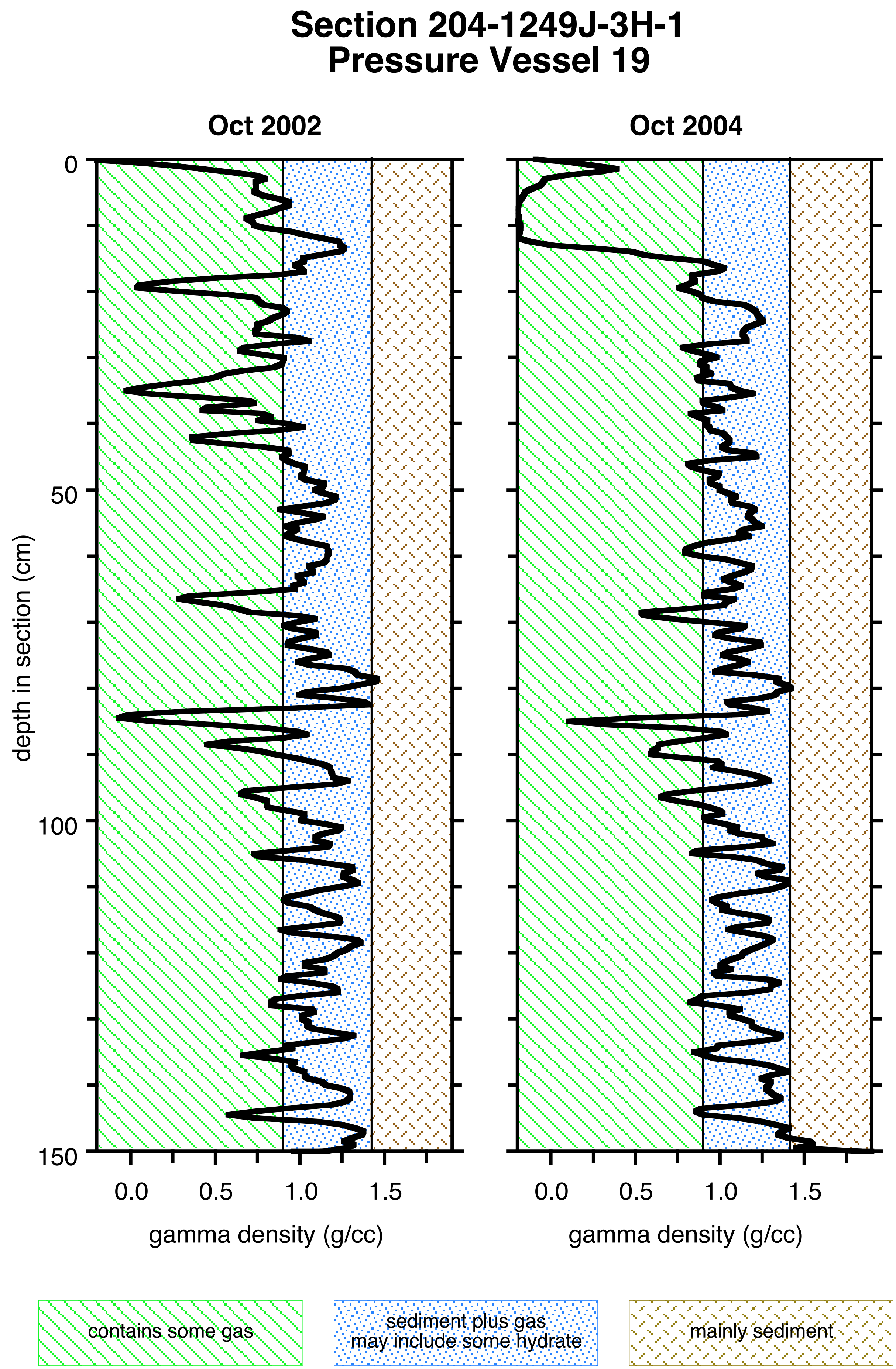


Section 204-1249H-6H-5
Pressure Vessel 16

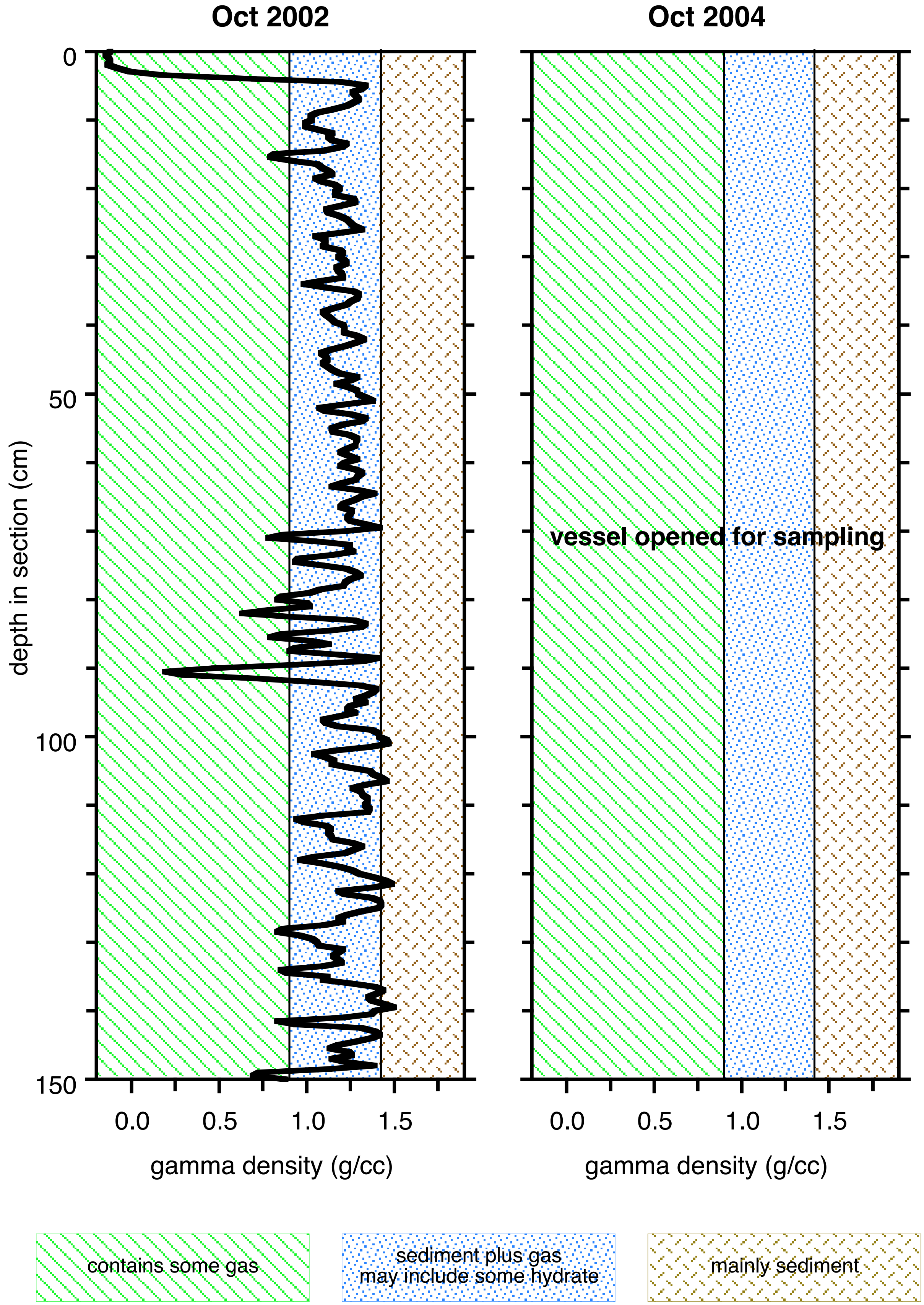



Section 204-1249J-2H-1
Pressure Vessel 17
Oct 2002
Oct 2004
0
50
100
150
depth in section (cm)
0.0
0.5
1.0
1.5
gamma density (g/cc)
0.0
0.5
1.0
1.5
gamma density (g/cc)
contains some gas
sediment plus gas
may include some hydrate
mainly sediment

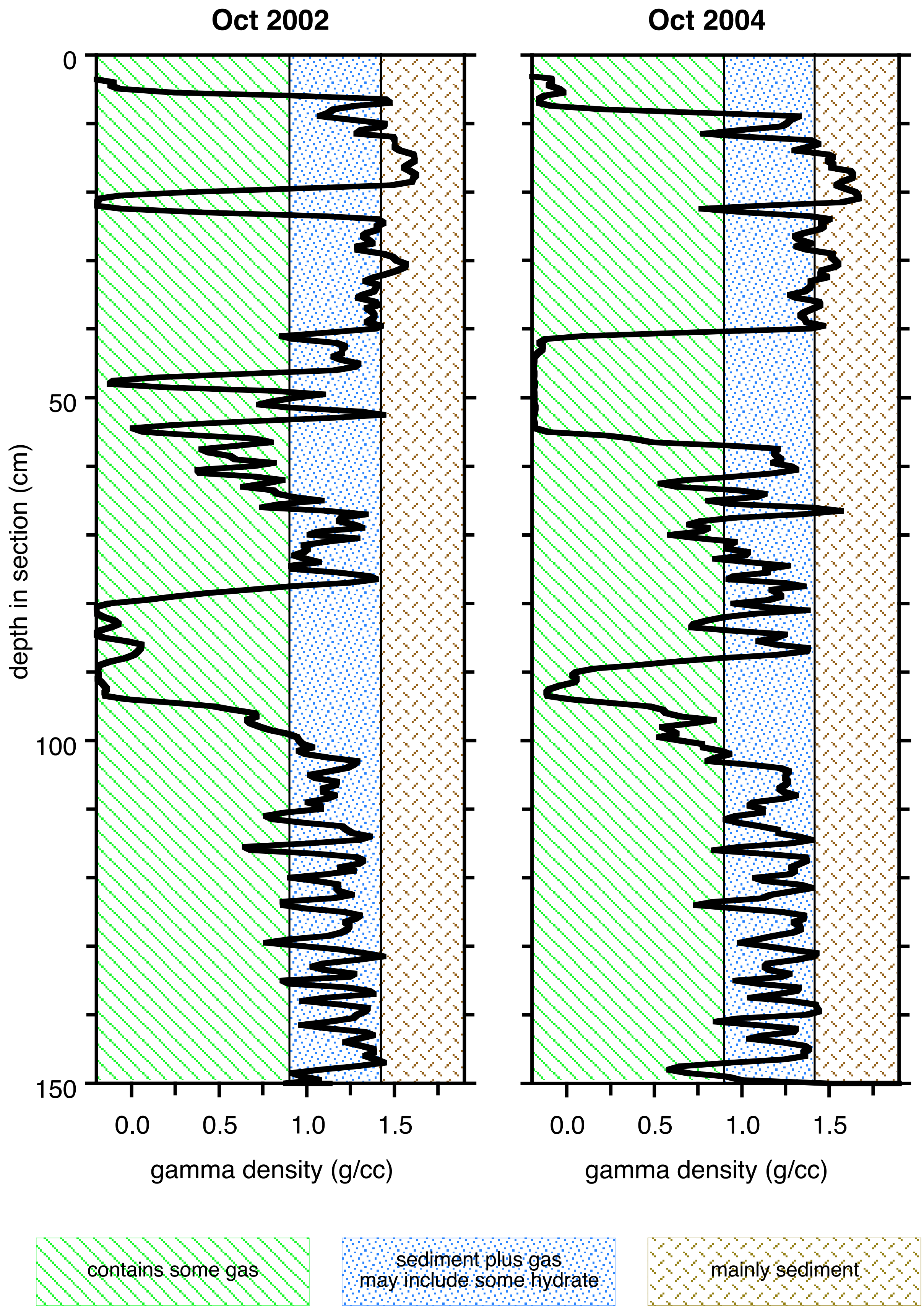

Section 204-1249J-3H-4
Pressure Vessel 18
Oct 2002
Oct 2004
0
50
100
150
depth in section (cm)
0.0
0.5
1.0
1.5
gamma density (g/cc)
contains some gas
sediment plus gas
may include some hydrate
mainly sediment

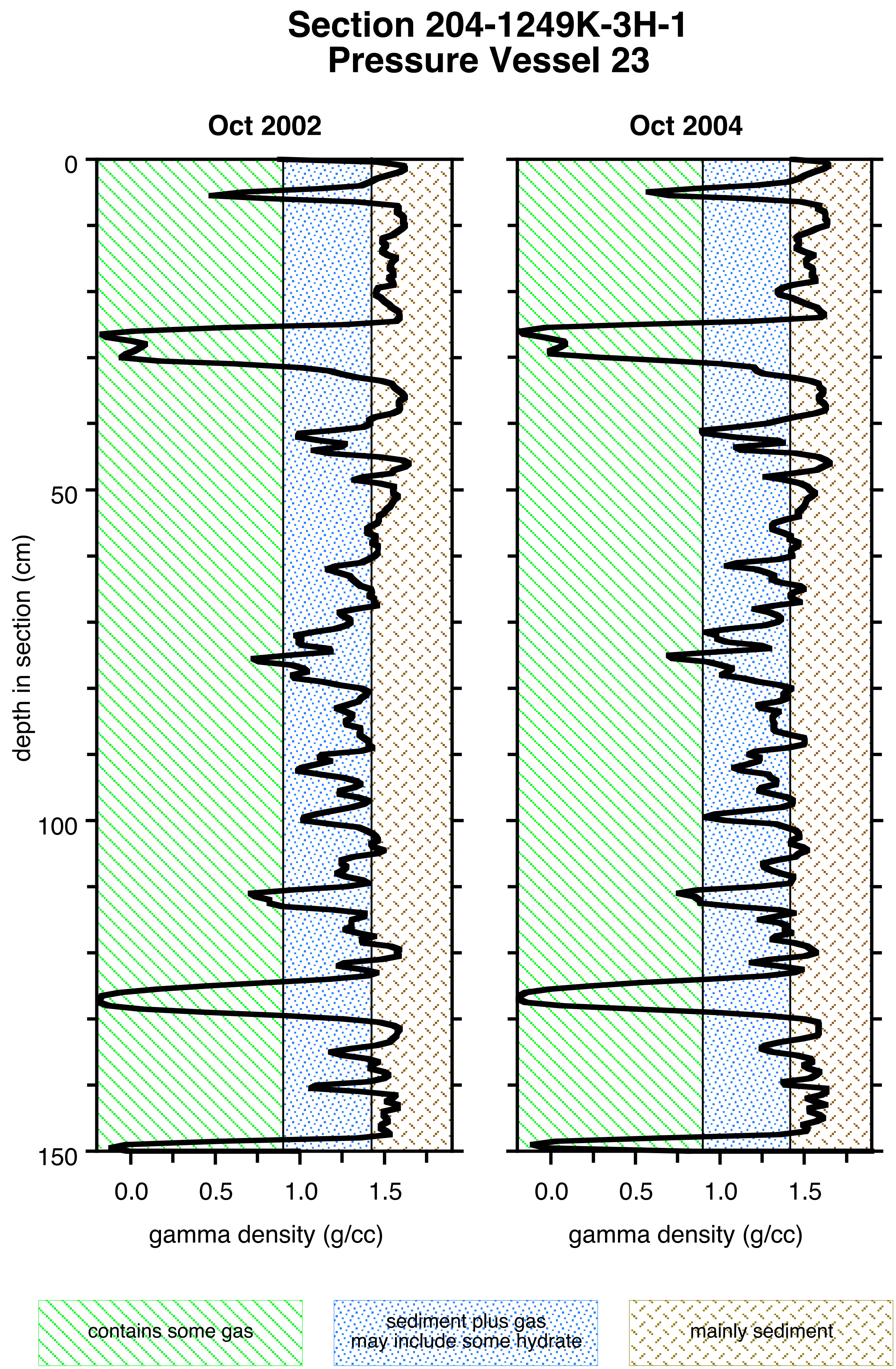

Section 204-1249J-3H-1
Pressure Vessel 19
Oct 2002
Oct 2004
depth in section (cm)
0
50
100
150
0.0
0.5
1.0
1.5
gamma density (g/cc)
gamma density (g/cc)
contains some gas
sediment plus gas
may include some hydrate
mainly sediment

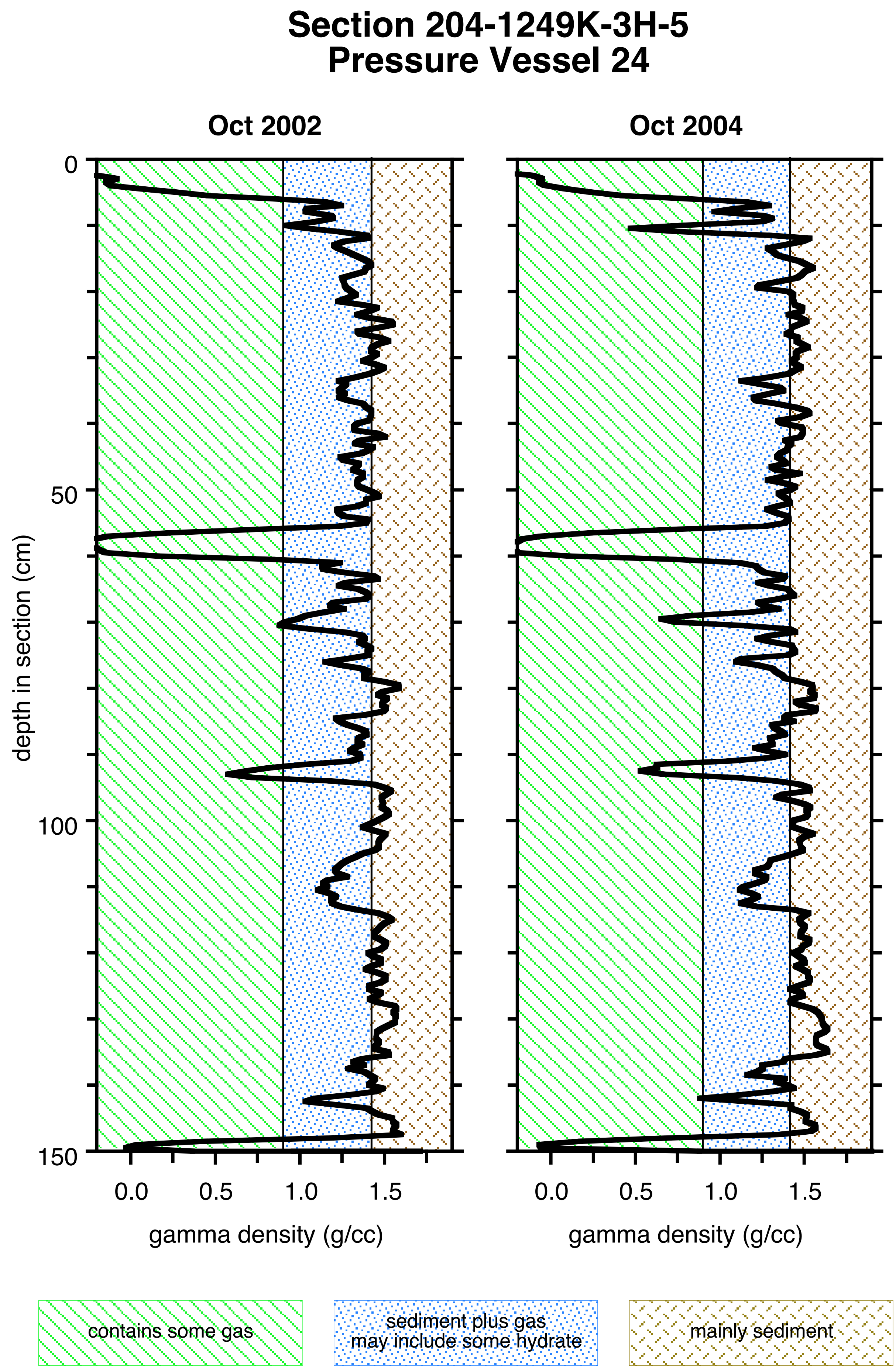
Section 204-1249I-4H-3
Pressure Vessel 20



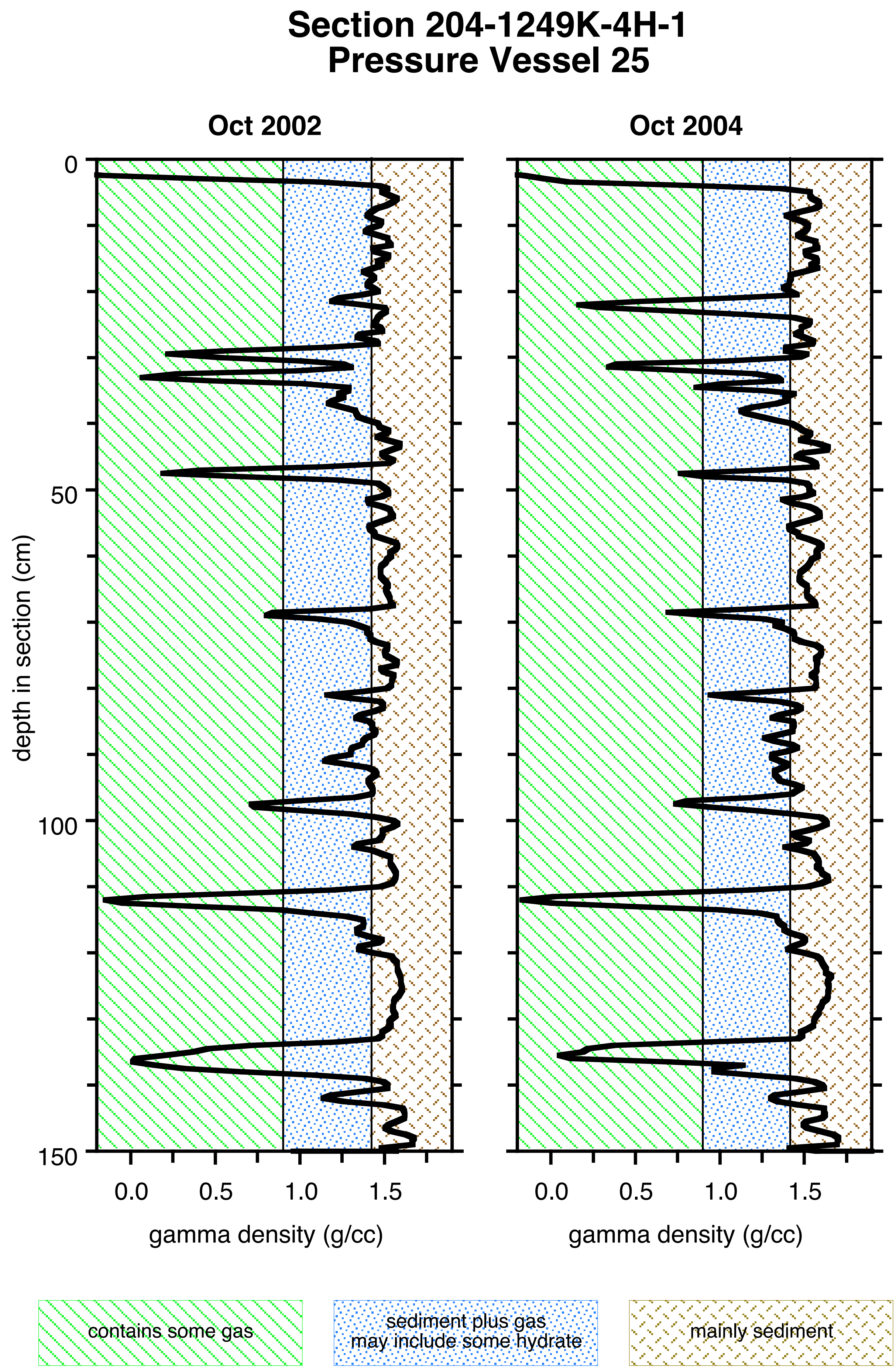
Section 204-1249K-3H-2
Pressure Vessel 22




Section 204-1249K-3H-1
Pressure Vessel 23
Oct 2002
Oct 2004
depth in section (cm)
0
50
100
150
0.0
0.5
1.0
1.5
gamma density (g/cc)
contains some gas
sediment plus gas
may include some hydrate
mainly sediment

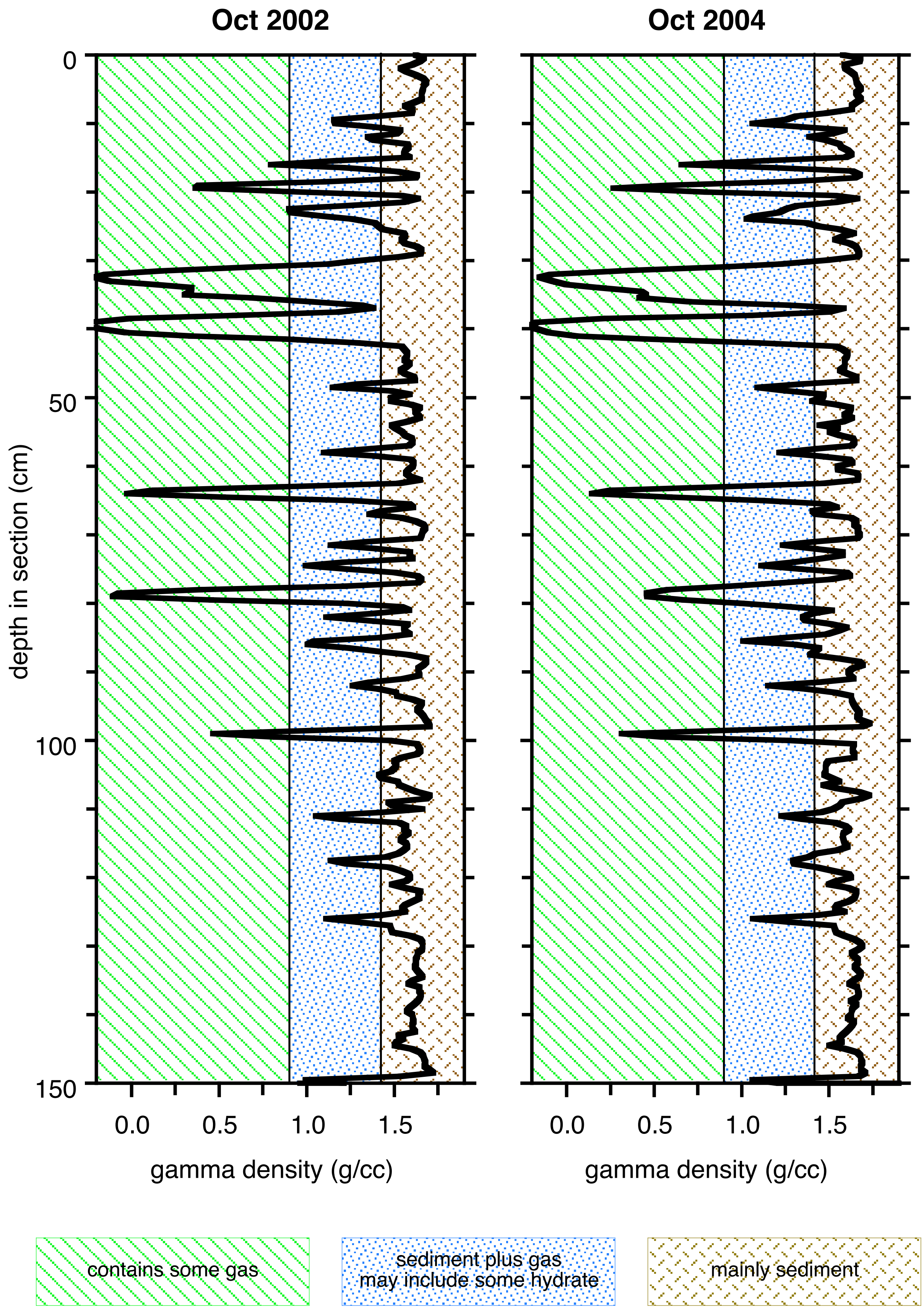


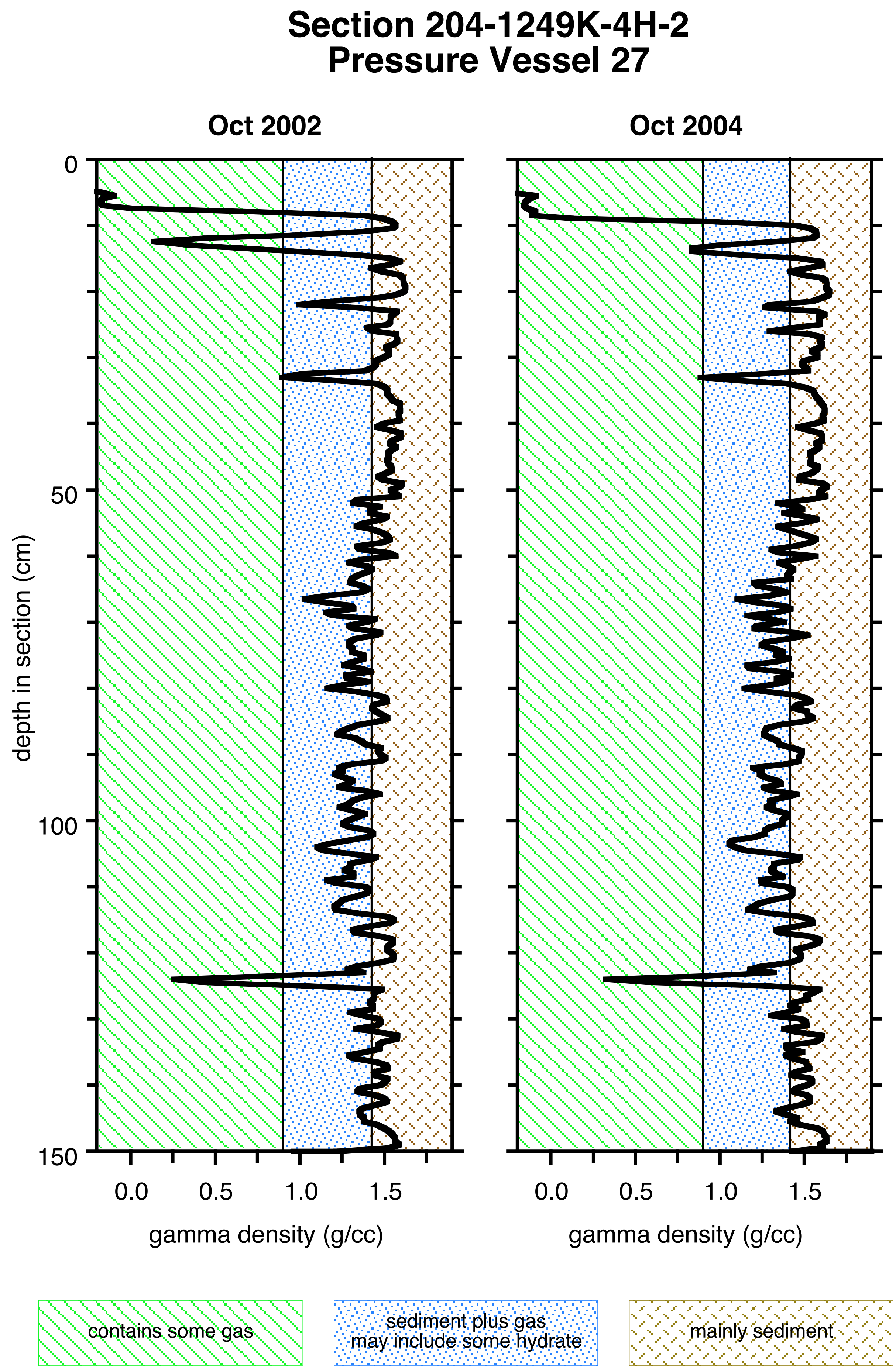
Section 204-1249K-3H-5
Pressure Vessel 24
Oct 2002
Oct 2004
0
50
100
150
depth in section (cm)
0.0
0.5
1.0
1.5
gamma density (g/cc)
0.0
0.5
1.0
1.5
gamma density (g/cc)
contains some gas
sediment plus gas
may include some hydrate
mainly sediment



Section 204-1249K-4H-1
Pressure Vessel 25
Oct 2002
Oct 2004
depth in section (cm)
0
50
100
150
0.0
0.5
1.0
1.5
gamma density (g/cc)
gamma density (g/cc)
contains some gas
sediment plus gas
may include some hydrate
mainly sediment

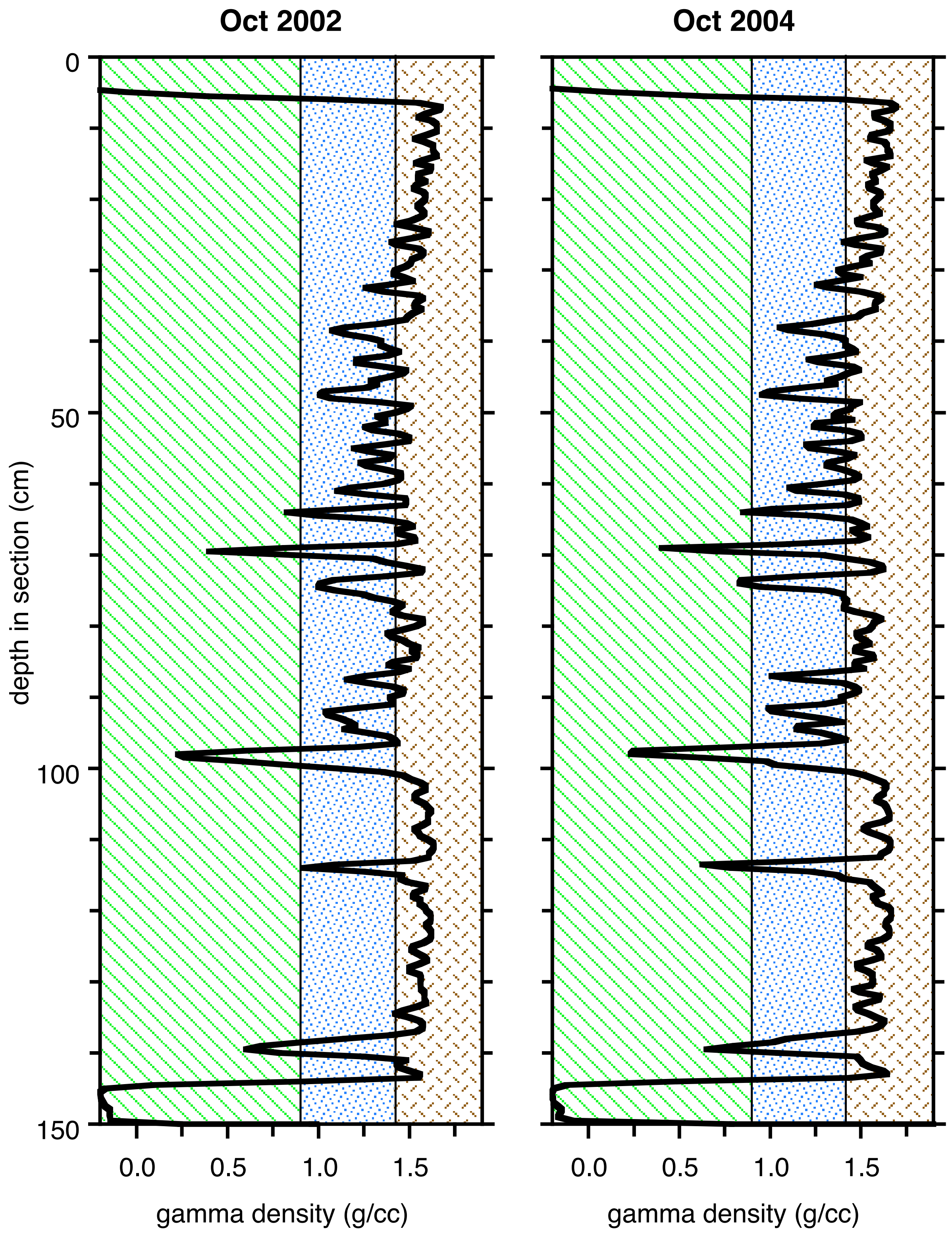
Section 204-1249K-5H-4
Pressure Vessel 26





Section 204-1249K-4H-2
Pressure Vessel 27
Oct 2002
Oct 2004
depth in section (cm)
0
50
100
150
0.0
0.5
1.0
1.5
gamma density (g/cc)
gamma density (g/cc)
contains some gas
sediment plus gas
may include some hydrate
mainly sediment

Section 204-1249K-5H-1
Pressure Vessel 28



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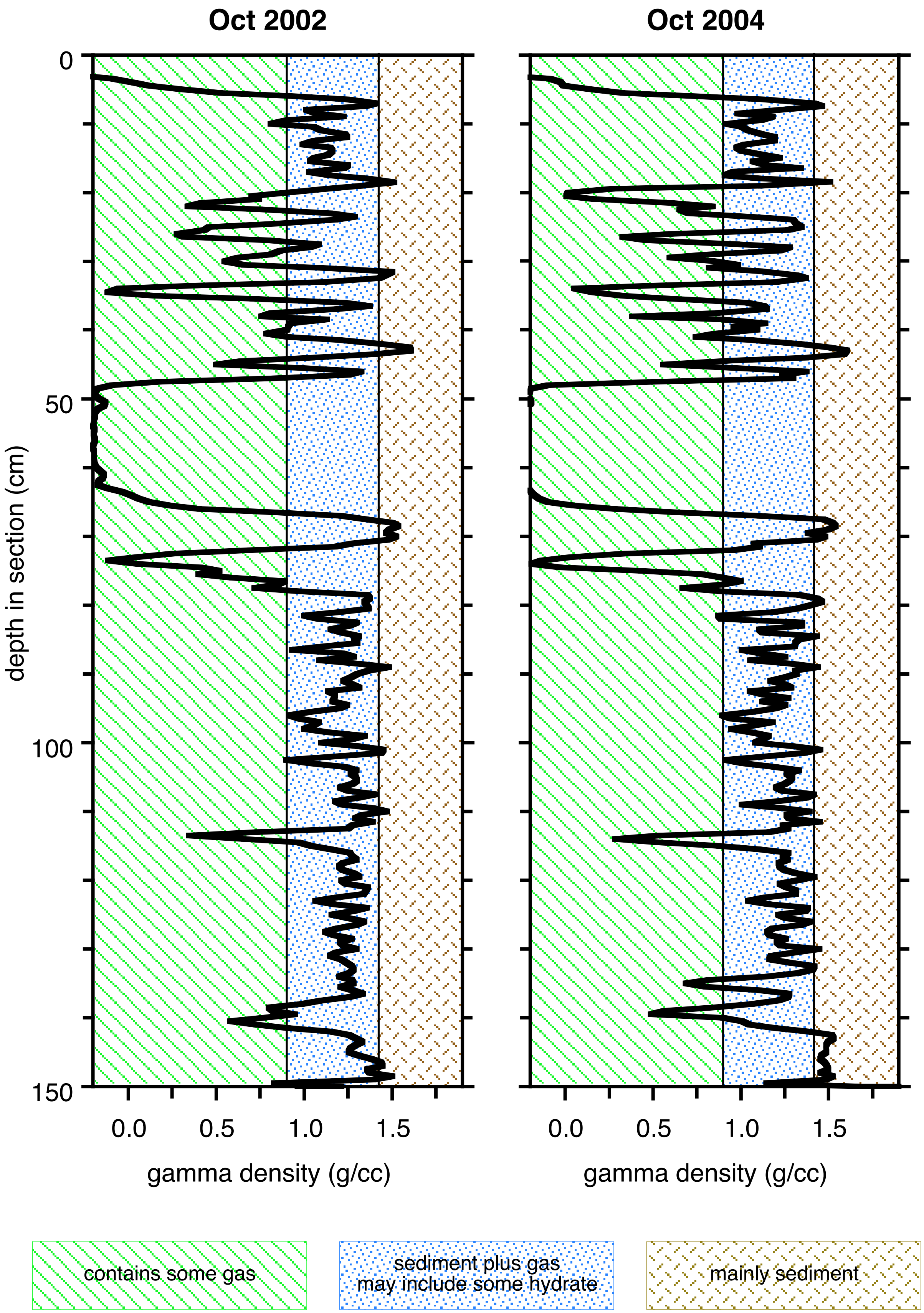
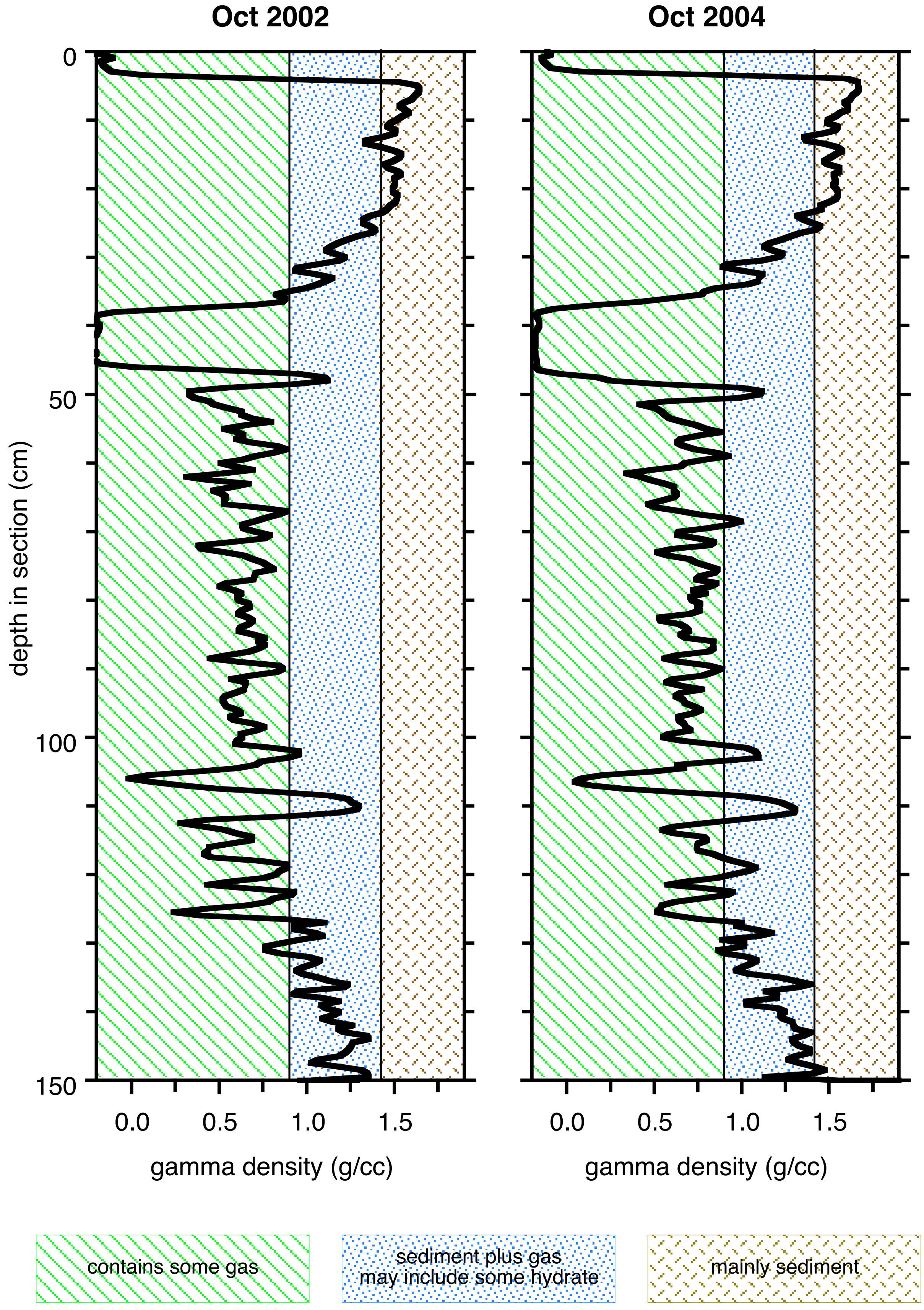
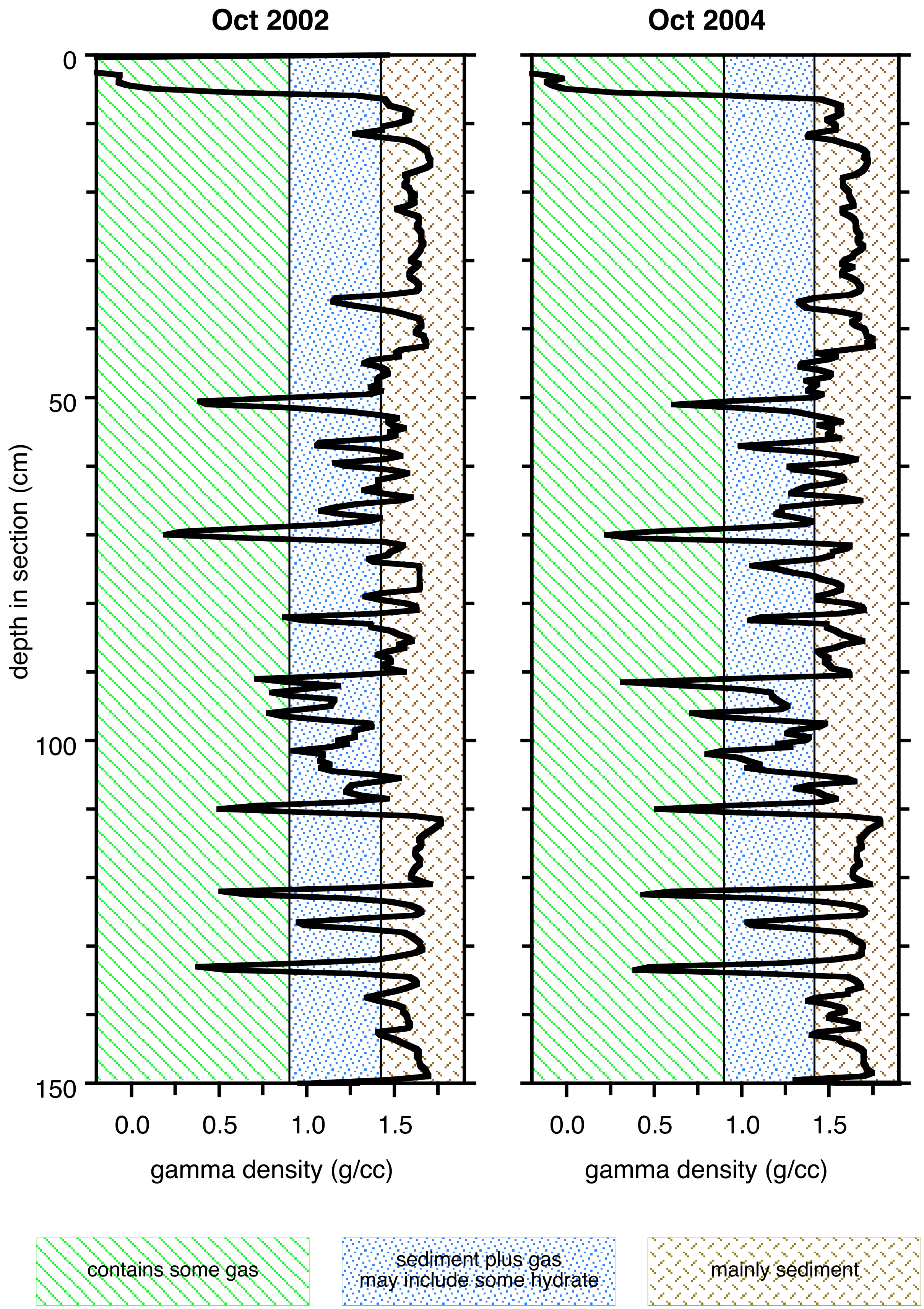
Pressure Vessel 29



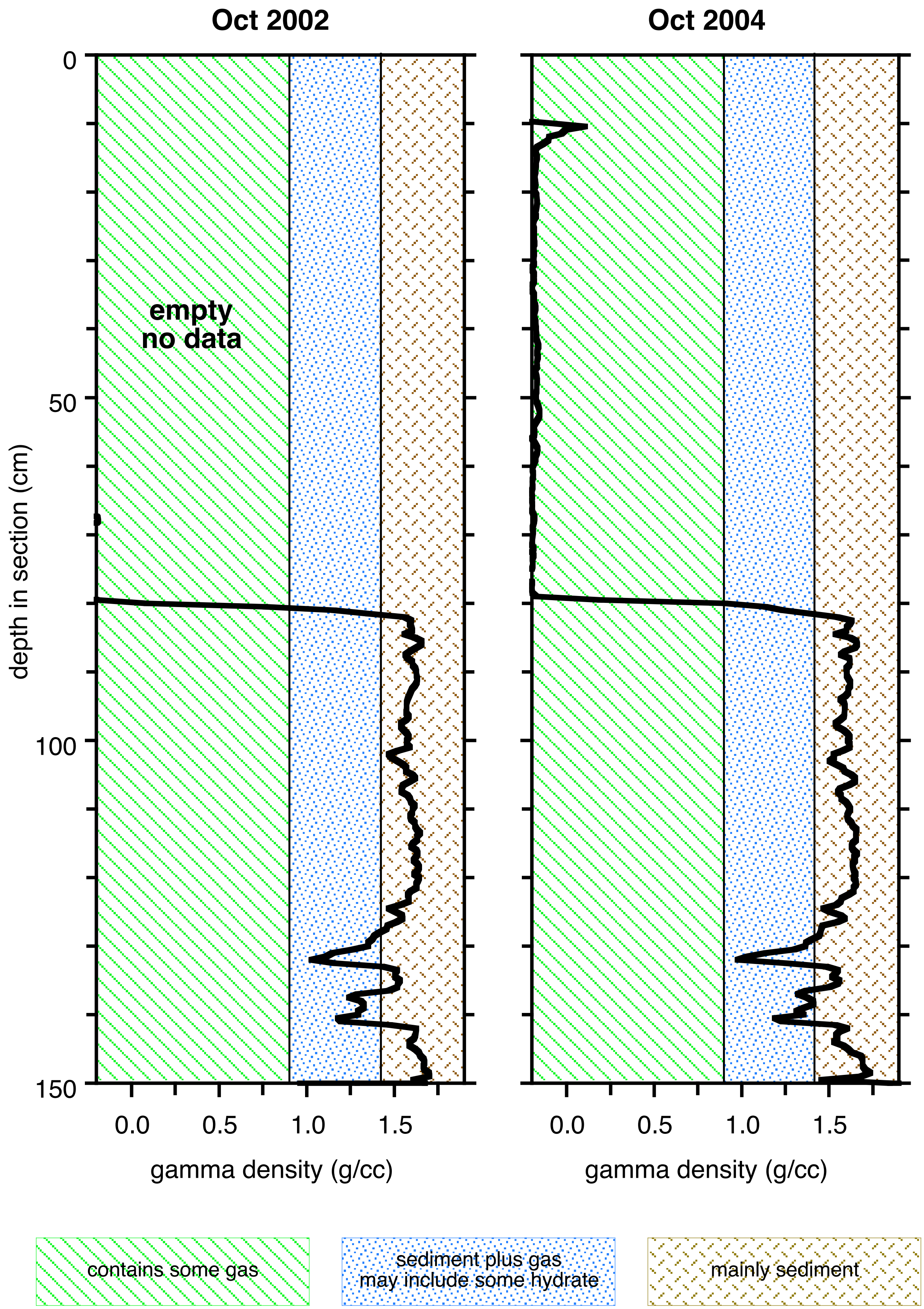
Section 204-1249I-4H-2
Pressure Vessel 30

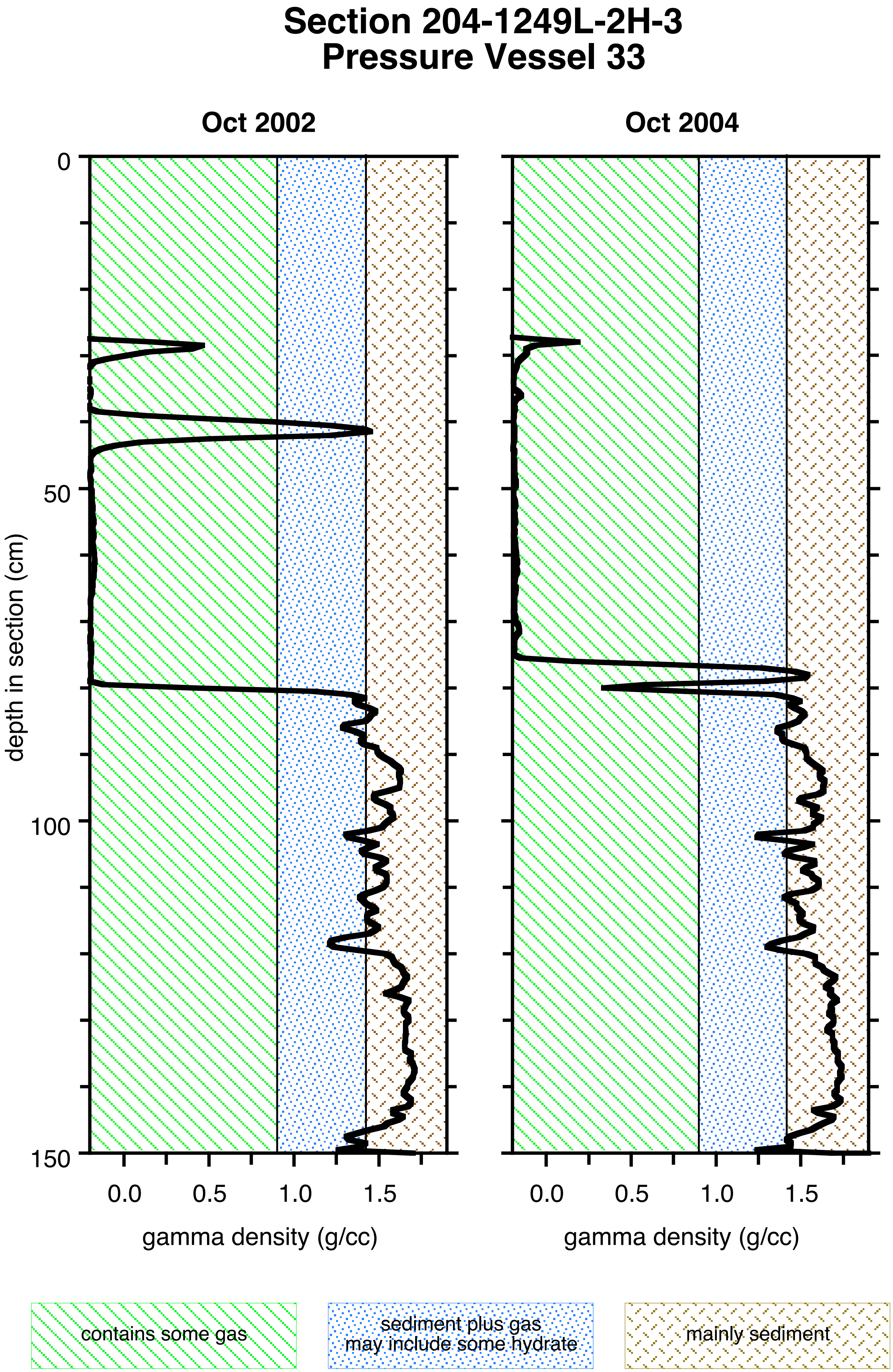


Section 204-1249K-5H-2
Pressure Vessel 31



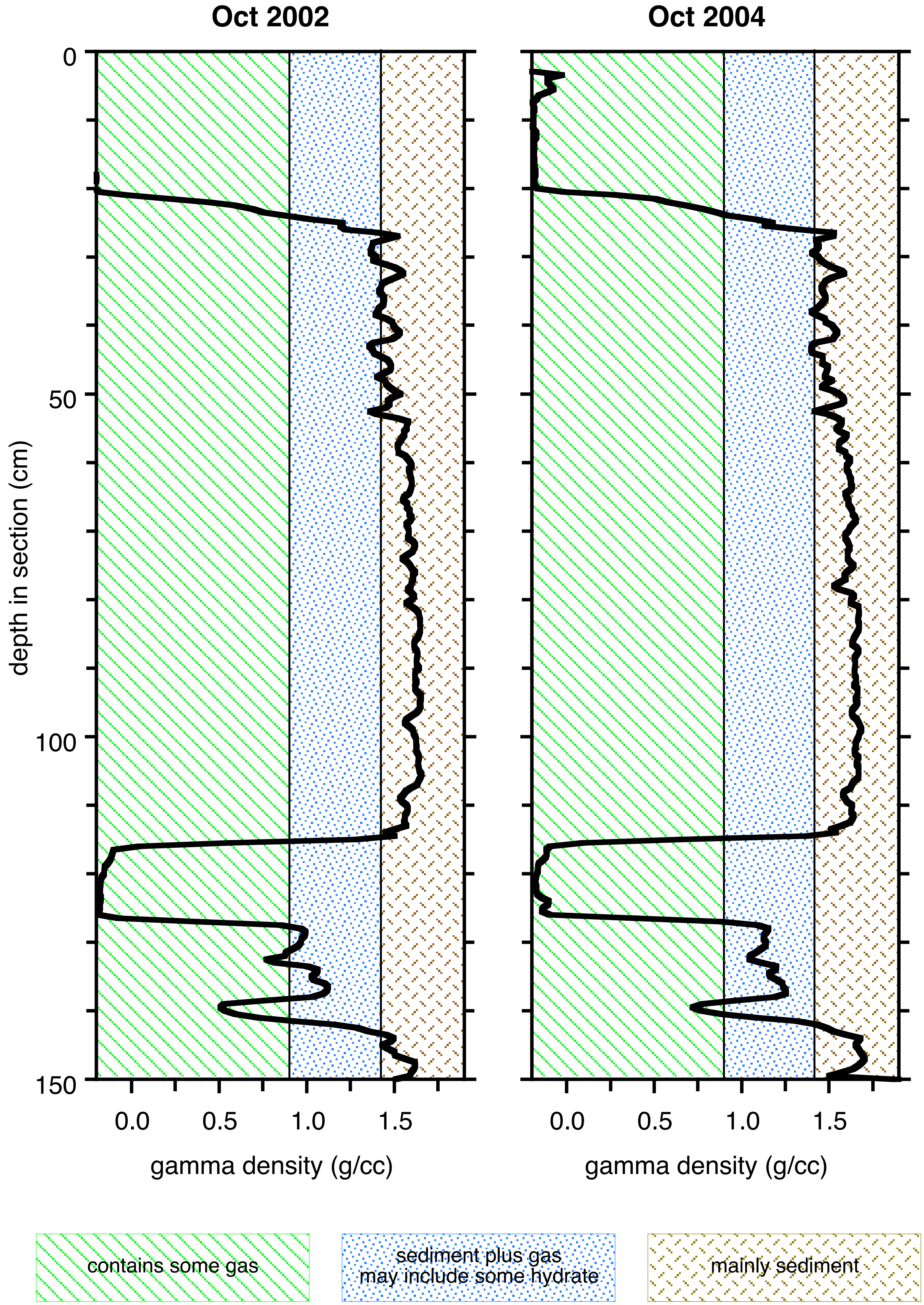
Section 204-1249L-2H-2
Pressure Vessel 32



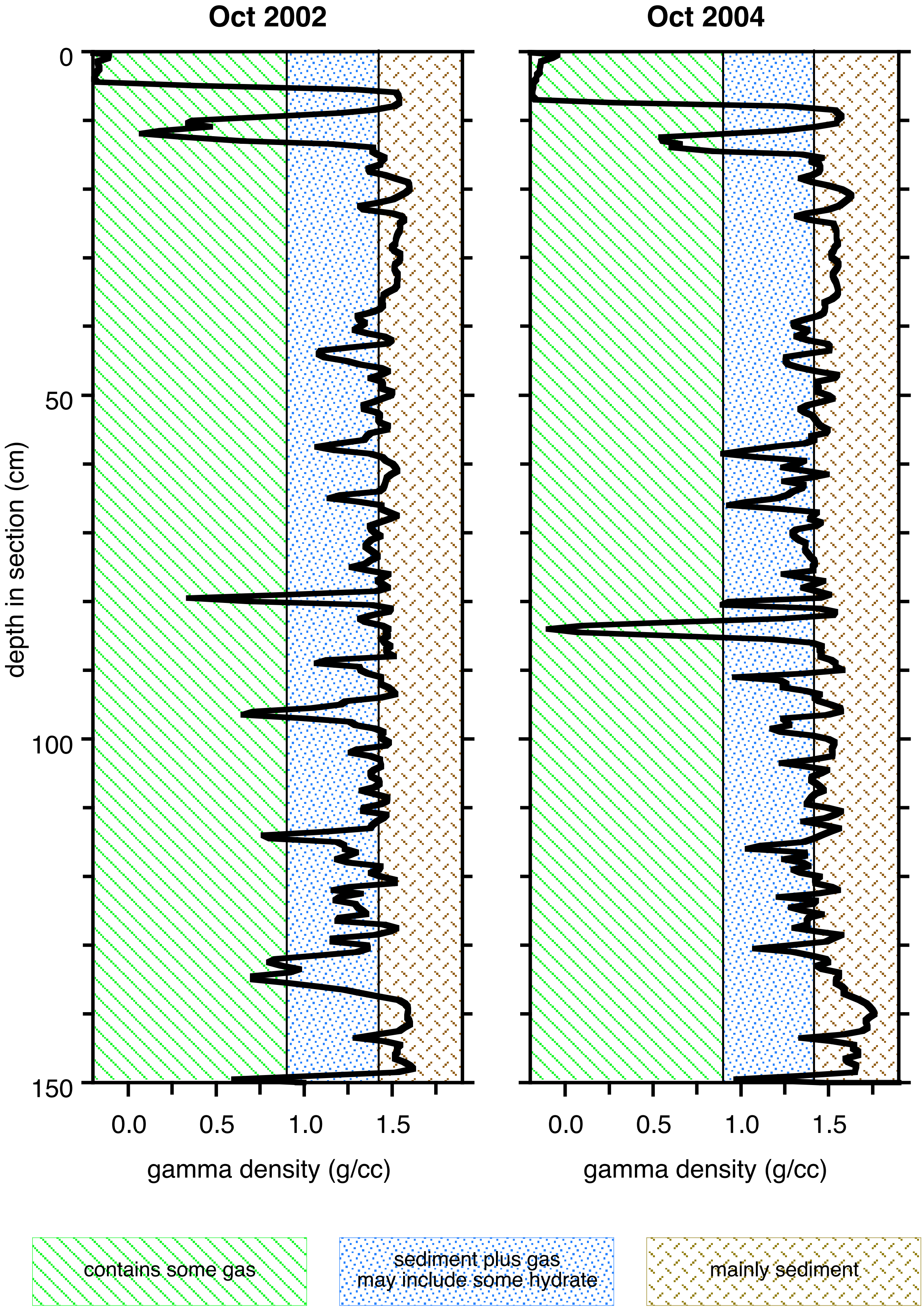


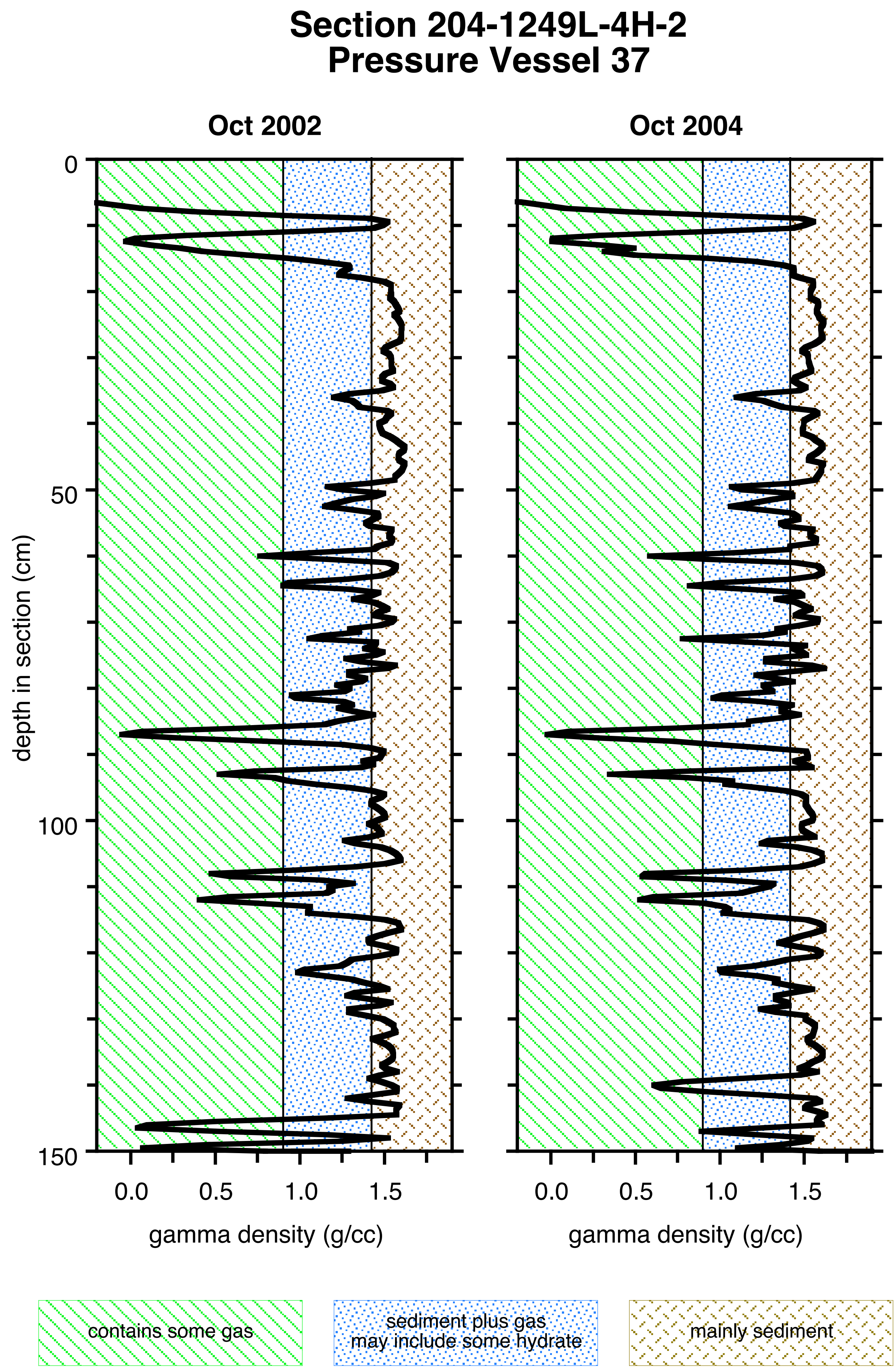
Section 204-1249L-2H-3
Pressure Vessel 33
Oct 2002
Oct 2004
depth in section (cm)
0
50
100
150
0.0
0.5
1.0
1.5
gamma density (g/cc)
gamma density (g/cc)
contains some gas
sediment plus gas
may include some hydrate
mainly sediment

Section 204-1249L-2H-1
Pressure Vessel 34



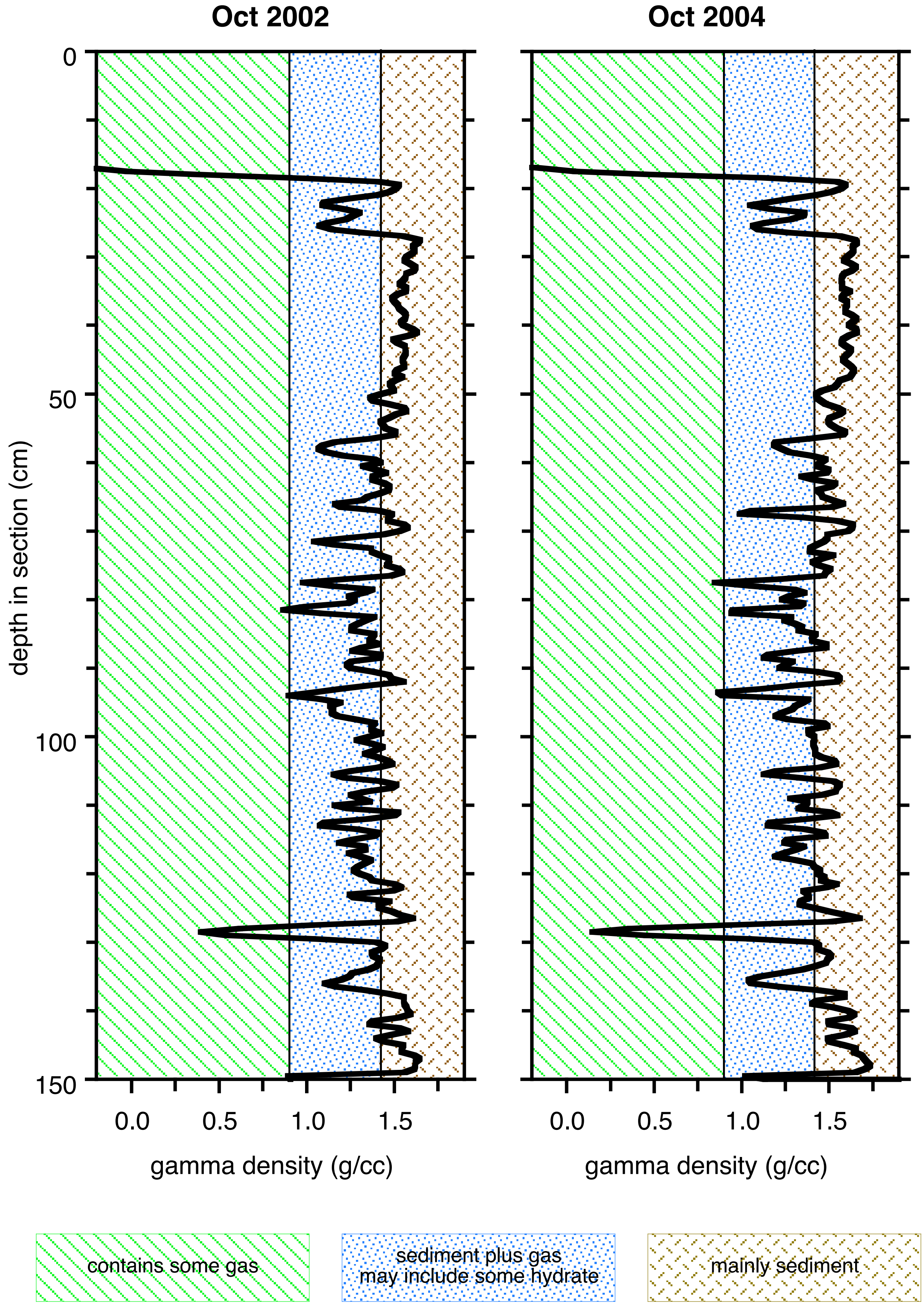
Section 204-1249L-4H-1
Pressure Vessel 36



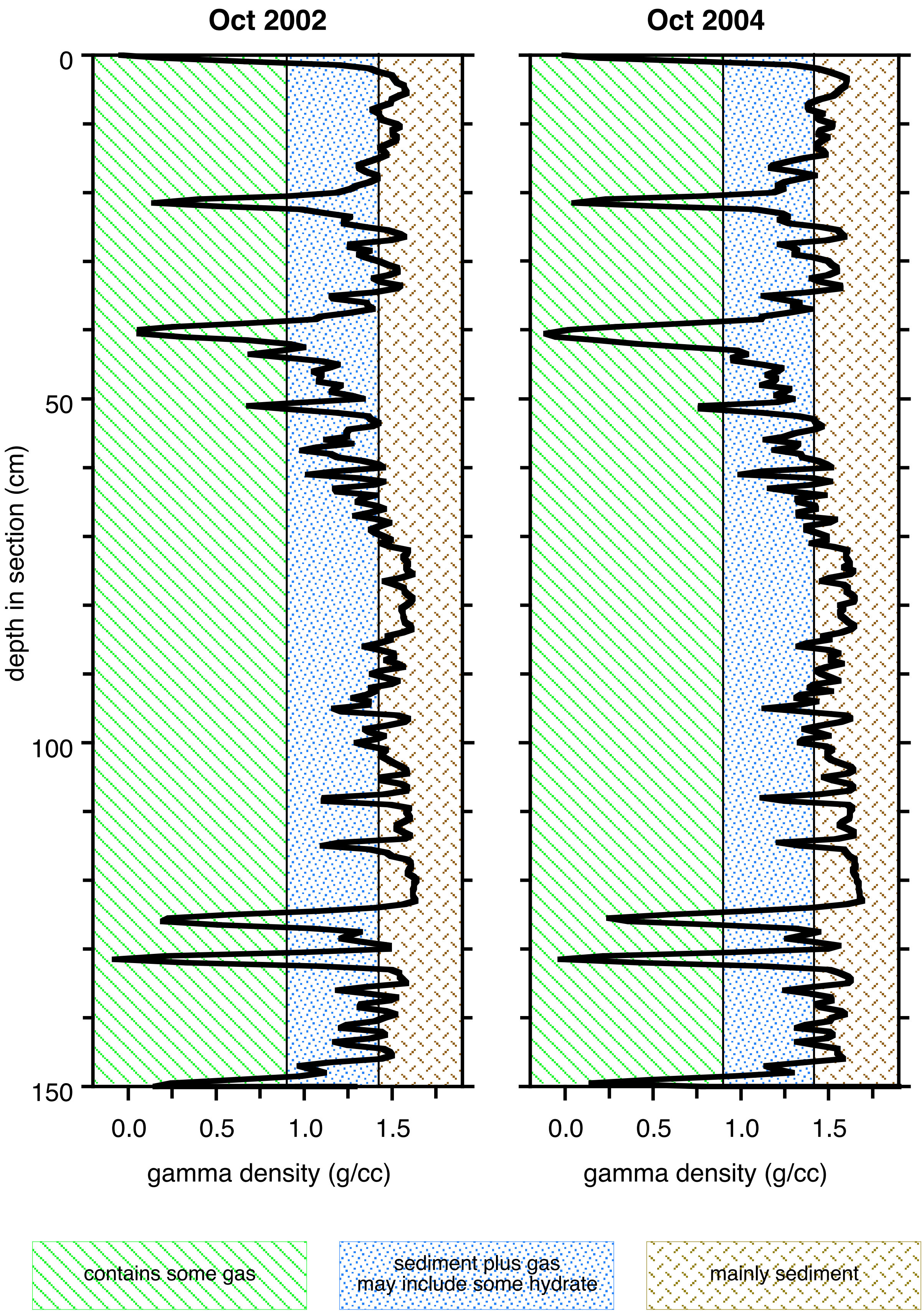


Section 204-1249L-4H-2
Pressure Vessel 37
Oct 2002
Oct 2004
0
50
100
150
depth in section (cm)
0.0
0.5
1.0
1.5
gamma density (g/cc)
gamma density (g/cc)
contains some gas
sediment plus gas
may include some hydrate
mainly sediment

Section 204-1249L-3H-1
Pressure Vessel 38



Section 204-1249L-3H-3
Pressure Vessel 40



APPENDIX B

NOTES ON: OPENING COLD, PRESSURIZED HYDRATE CORES FROM ODP LEG 204 – NOVEMBER 22-23, 2004

Notes on: Opening Cold, Pressurized Hydrate Cores from ODP Leg 204 November 22nd/23rd 2004

Peter Schultheiss / Melanie Holland

In October 2002 and October 2004 we logged the steel pressure vessels containing repressurized gas hydrate cores recovered on Ocean Drilling Program (ODP) Leg 204 in Aug/Sept 2002. This logging exercise provided detailed density profiles of all the cores stored in the pressure vessels at a 0.5 cm spatial resolution and showed how some of the cores had changed over the 2 year period (see previous reports).

Only 3 of the pressure vessels had previously been depressurized and opened (PV3, PV14 and PV20). Apparently, none of these contained any obviously visible gas hydrates but there was significant evidence, in the form of disturbed sediments and 'vuggy' structures, that hydrate had once existed. In addition, a number of gas samples were taken from some pressure vessels, with the conclusion that no evidence of gas hydrate dissociation could be discerned from the $\partial^{13}C$ analysis. It should be noted that these samples were not opened and analyses in any detail and it is possible that small amounts of hydrates may have existed in the samples.

These observations raised a number of immediate questions:

a) Had the gas hydrate in the 3 opened cores all dissociated prior to being placed in the pressure vessels or had it dissociated during storage?

b) Was there, in fact, any natural gas hydrate in the cores where gas samples had been taken?

c) Did any of the cores contain any gas hydrates?

d) What changes had occurred to the cores during the 2 years of storage?

e) Had any of the bottled methane gas formed gas hydrates during the storage period?

f) Is the storage technique used appropriate for storing samples containing gas hydrates?

The data from the 2 gamma density logging had shown that the profiles from 2002 and 2004, were generally quite similar. The most obvious feature is the movement of gas upwards and sediment blocks downwards in some of the cores. Where there is little or no change in the low density gas spikes between the two logs, then the amount of gas at the top of the core is also unchanged, indicating no large vertical movements of gas and sediment. This is the most common situation and is observed for Pressure Vessels 4-9,11-13,16,18, 23, 26, 28-32, 34, 37, 38 and 40.

Where there is a significant change in the gas spikes between the 2 logs, there is invariably more gas (a longer low density interval) at the top of the core, showing that core intervals have fallen within the liner. This is observed for Pressure Vessels 10,17,19, 22, 25, 27, and 36. Pressure Vessel 22 shows some particularly large differences where gas has obviously migrated upwards and sections of sediment have moved downward.

To understand further the reasons for the changes in the density profiles and to determine the nature of the gas hydrate in the pressure vessels a number of them were opened in the cold reefer for further observation. The vessels were first depressurized by opening the valve (this takes about 1 minute) and then unscrewing the pressure vessel base and removing the core in its liner. The core was then quickly split and examined for signs of gas hydrates using visual observation and an IR camera to look for cold spots.

The following table summarizes our observations:

Pressure Vessel Core ID	**Observations / Comments**
PV05 204-1249H-6H-3	The gamma density profile of this core indicated that the core was mainly sediment with 3 small cracks and had not changed at all during the 2 years of storage. Visual observation confirmed the above interpretation. In addition no thermal anomolies were observed indicating that this core did not contain any gas hydrate.
PV11 204-1249H-6H-1	The gamma density profile of this core was similar to PV05 indicating that the core was mainly sediment except there was a little more cracking. But there had been no change over the 2 years of storage. Visual observation confirmed the above interpretation but there were indications of 2 small (5cm) thermal anomolies below the 2 larger voids. It is possible that there may have been small amount of disseminated hydrate at these locations but there were no other indications. It was thought at the time that these cold anomolies may have been associated with differential cooling effects from the expanding gas during depressurization at these locations.
PV04 204-1249H-3H-4	The gamma density profile of this core showed a number of lower density layers as well as 2 significant cracks. Only very small changes could be detected between the 2 profiles collected over the 2 years of storage. Visual observation confirmed the above interpretation but yet again there were indications of significant thermal anomolies which again seems related to the larger cracks. Again it is possible that there may have been small amount of disseminated hydrate at these locations but at the time it was thought that these cold anomolies could be caused by gas expansion effects.

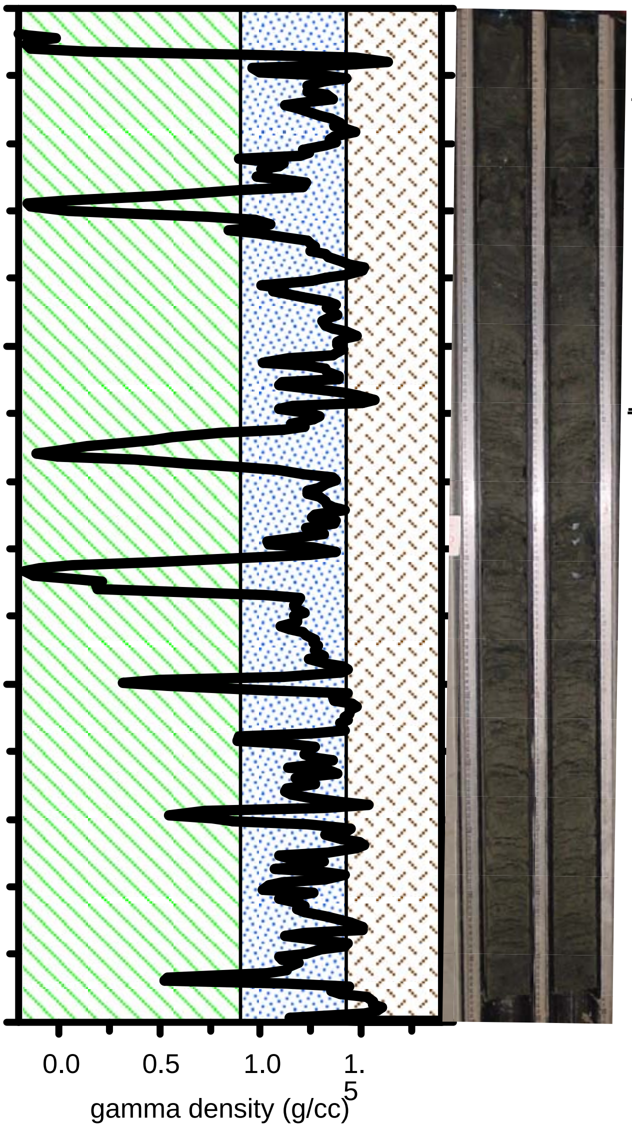
PV08 204-1249H-3H-4	The gamma density profile of this core showed a region of lower densities in 2 locations (one near the top and one near the base) again with 2 significant cracks. Some small changes can be seen near the top of the core around 20-30 cm. Visual observation again confirmed the overall interpretation but significantly a thermal anomaly existed in the same area as the differences in the gamma profiles had been observed (20-30 cm). This time the anomaly was not adjacent to any significant cracks or voids. This led us to believe that small amounts of disseminated hydrate may be responsible for the anomolies rather than gas expansion effects. Still there was no visual evidence of any gas hydrates.
PV10 204-1249H-4H-3	The gamma density profile of this core showed that most of the core had lower average densities than the previously opened cores and also had 2 significant cracks. There was also a more significant change between the 2 density profiles collected 2 years apart with some obvious downward shifting of parts of the sediment. As the core was removed from pressure vessel it was immediately obvious that this core contained small nodules (1-3 mm) of gas hydrate in several locations. After splitting the core visual and IR observations confirmed this and significant thermal anomolies were recorded at 20 cm, 40 cm, and 56 cm down core. The following day we observed some expansion of this core and confirmed that the thermal anomolies had decayed.
PV19 204-1249J-3H-1	The gamma density profile of this core was similar to PV10 but exhibited even lower overall densities and more significant changes between the 2 density profiles and with more pronounced downward shifting of sediment sections. A gas sample was collected at the start of the depressurization process. It was a slight surprise therefore that when removed and split there was no visual or thermal evidence of any existing gas hydrates.
PV22 204-1249K-3H-2	The gamma density profile of this core showed was similar to PV19 but exhibited even larger cracks/voids that had shifted between the 2 gamma profile measurements. As with the core from PV10 it was immediately obvious that this core contained small gas hydrate nodules. Unfortunately the splitting process didn’t go so smoothly but we did collect both gas hydrate nodules (118-120 cm and 123 – 125 cm) and sediment samples from regions that showed distinct thermal anomolies (82-102 cm and 140-146 cm. We also collected a gas sample when the pressure vessel was first depressurized. The whole process took around 18 minutes.

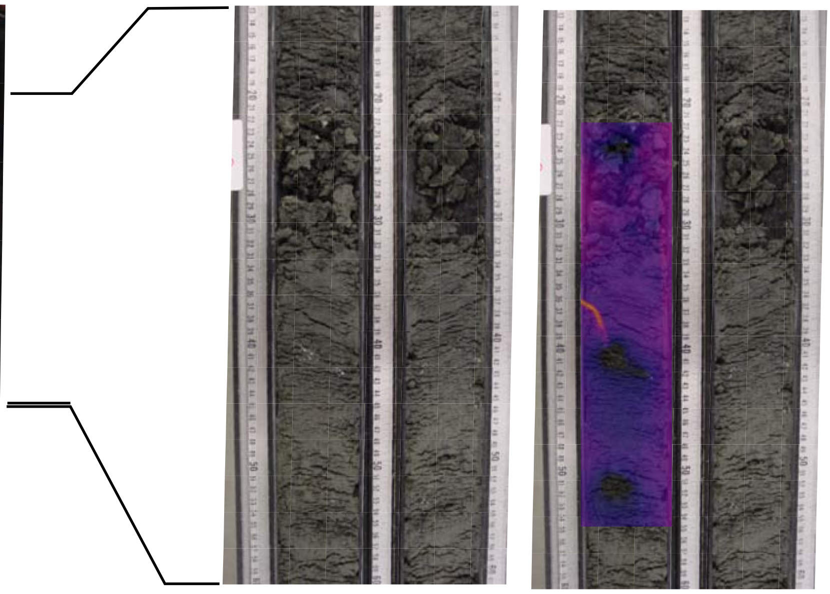
Conclusion

Some of the cores do contain gas hydrates in the form of small (millimeter sized) nodules. There is some thermal anomaly evidence to indicate that non-visible disseminated hydrate zones may be relatively common but it is quite possible that large chunks of massive hydrate do not exist. It should be noted that any immediately obvious massive hydrate was removed and stored in LN at the time the core was recovered. The samples collected (free gas, hydrate nodules and sediment samples) should answer the questions about the origin of the gas hydrate. Is it naturally formed hydrate? Is it hydrate formed from bottle gas? or is it a mixture of sources indicating that some methane exchange has occurred?

We will wait for the results of the gas analysis to throw further light on our initial observations. However, the possible existence and survival of naturally occurring fine grain, disseminated gas hydrate could be an interesting observation. If gas hydrate does exists in this low concentration disseminated form in fine grained sediments it is possible (or even likely) that it may have fully dissociated during the initial coring and core recovery process but may have fully or partially reassociated when repressurized and cooled.

To explore these observations and thoughts further we will propose to open some of the other pressurized cores and collect time-lapse images of the split core archive surfaces with the IR camera. In addition further samples of sediment both in and around thermal anomolies will be collected. Together these data will allow us to quantify the nature and amount of gas hydrate present. To do this we will propose to set the IR camera up on a track whereby it will automatically collect the time-lapse images. In addition we will also propose setting up a track that will collect detailed line scan digital images of the core at the same time.

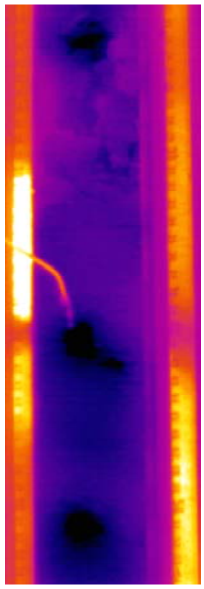


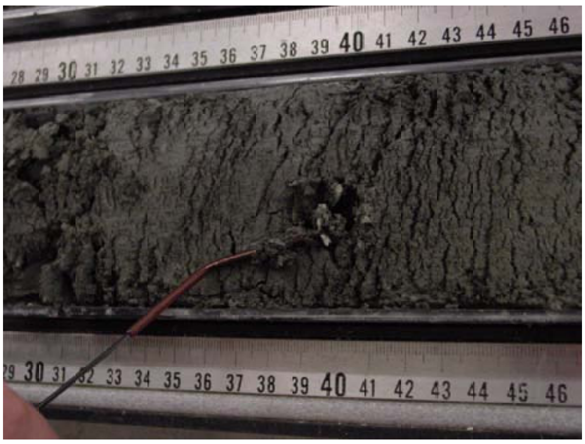


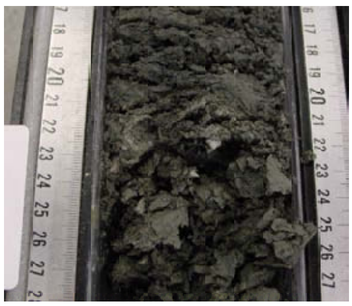
Visual image

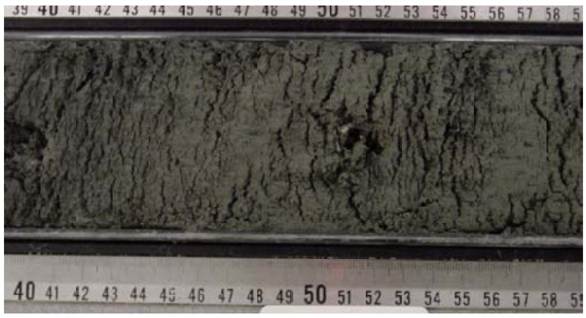
Superimposed IR image

Original IR image

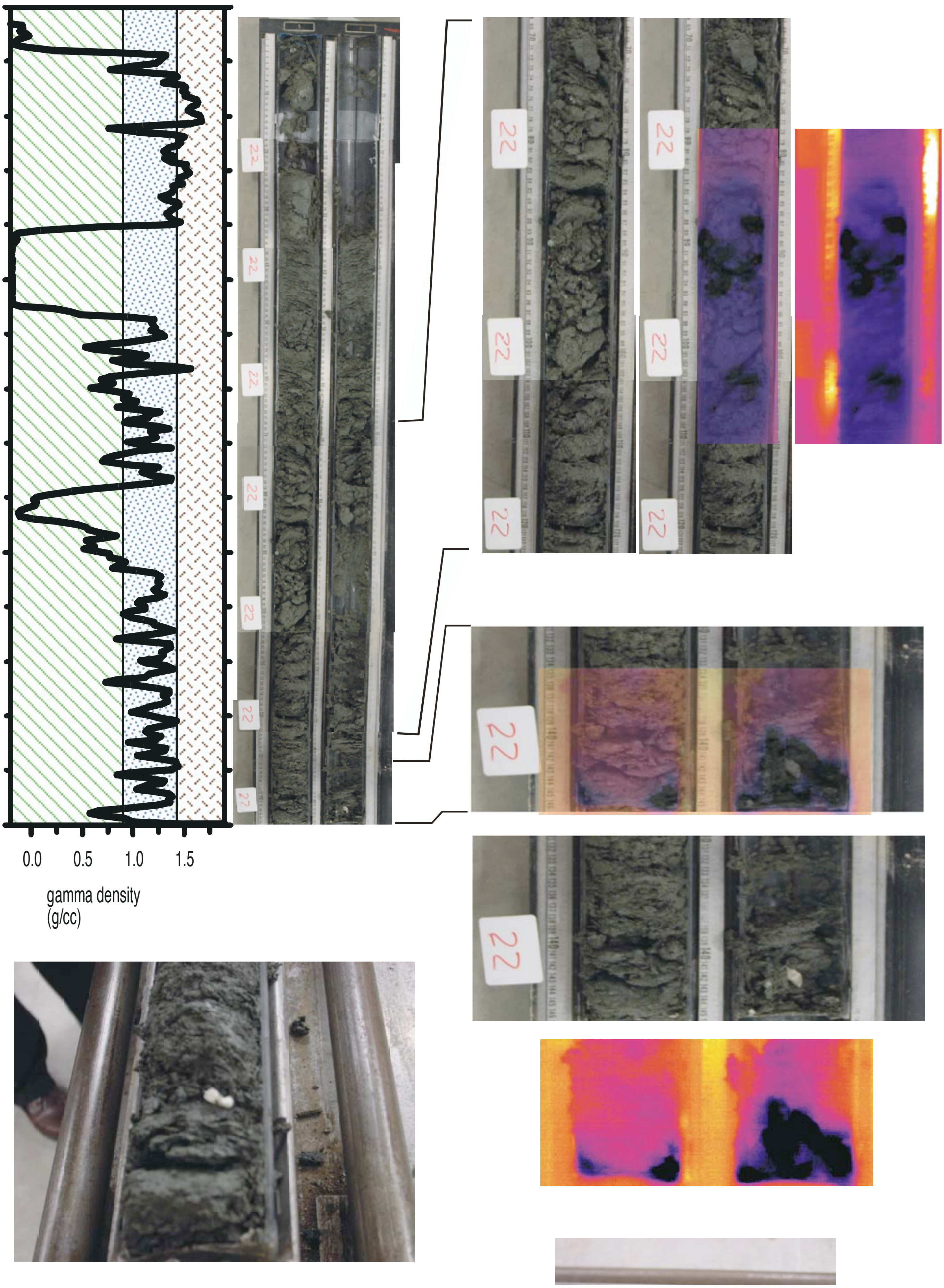








PV10


0.0
0.5
1.0
1.5
gamma density
(g/cc)