

RESEARCH CRUISE REPORT

RC-23-06

Ship Name: R/V ROBERT CONRAD

Clearance Country: Peru

Project Title: "PERU SHELF GEOCHEMISTRY"

Dates/Port Calls: 23 Jun 82 - 4 July 82
Guayaquil-Guayaquil

Chief Scientists: William C. Burnett
Philip N. Froelich

Description of Scientific Program:

Investigation of phosphorite genesis by collection and geochemical analyses of seawater, sediment, and interstitial waters from the Peruvian shelf and upper slope in areas of intense coastal upwelling.

Observations and Samples:

Standard hydrographic measurements, bottom sampling (box cores, grab cores, gravity and piston cores), pore water geochemistry, atmospheric measurements of reduced sulfur compounds and aerosols.

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INTRODUCTION

The continental margin of Peru is a unique site of biogenic sediment accumulation. Sediments rich in organic carbon, silica, and phosphorus are deposited in response to the extremely high biological productivity which is maintained by coastal upwelling processes. Although the physical and biological aspects of coastal upwelling have already been addressed in some detail during the CUEA program, there are few detailed geological-geochemical studies of these environments. Our intention during cruise RC-23-06 was to investigate the geochemistry of organic-rich sediments at selected sites on the shelf and upper slope of the continental margin of Peru. Particular attention was given to identifying the diagenetic reactions which lead to the formation of the phosphatic minerals characteristic of these areas.

It may not be scientifically valid to consider the upwelling zone off Peru a modern-day analog for the "giant" sedimentary phosphate deposits of the geologic past. We feel, however, that a significant contribution to our understanding of the genesis of ancient deposits may be made by refinement of the geochemical processes operative during modern phosphorite formation. Presumably, the same types of diagenetic reactions would have operated in the past. Differences between the ancient and modern sea floor deposits may really only be a reflection of varying degrees of physical reworking of the sediments.

The Peruvian upwelling zone is considered ideal for this study because of its persistently high organic productivity and the fact that a considerable amount of background information has already been accumulated on the phosphate nodules which occur on the Peruvian shelf and upper slope. These studies have documented the geochemical characteristics of the phosphate nodules and proven by radiometric dating that the nodules are geologically

youthful. In addition, an open leg before an equatorial Pacific geochemical cruise provided a "leg of opportunity" to study sedimentary diagenesis and phosphorite formation in this area.

Our rationale in planning this expedition was to combine detailed pore water chemistry investigations with collection of undisturbed sediment cores and oriented nodules. Studies in the past have emphasized study of the phosphate nodules and sediments or have concentrated on analysis of the interstitial water chemistry. We believe that our combined approach will enhance the potential of adding significantly to our knowledge in this field.

SCIENTIFIC PROGRAM/RATIONALE

Our cruise plan was designed to study four areas along the Peruvian margin where previous studies have indicated the presence of phosphate nodules of varying ages. Study areas were chosen at approximate south latitudes of 7° , 10° , 12° , and 15° . The first station within each study area was taken in relatively deep water (~ 1000 m) in order to characterize the water column in terms of nutrients (phosphate, silica, and nitrogen species) and dissolved oxygen. The depth intervals for sample collection were then selected so as to include both the top and bottom of the oxygen minimum intersection with the continental margin. In most cases this resulted in sampling depths of between 100 to 500 m. The study areas at 12°S and 15°S were considered to be the most important in view of our previous measurements which indicated modern phosphorite formation at these locations. The 10°S site has been shown by radiometric dating to be characterized by phosphate nodules having ages on the order of tens of thousands of years before present while extremely old (greater than hundreds of thousands of years) samples have been reported from the 7°S site. It

was thus of interest to determine if other discernible differences would be evident in the sediment or pore water chemistries between these sites. The locations of these study areas relative to the coastline of Peru is shown in Fig. 1.

Our main sampling objective during this cruise was to recover undisturbed sections of organic-rich sediment with associated phosphate nodules in place. Recent studies in our laboratory have indicated that phosphate nodules from the Peru shelf grow slowly (on the order of millimeters per thousand years) relative to the accumulation rates of the associated sediment (millimeters per year). Nevertheless, phosphate nodules are thought to occur at or near the sediment-seawater interface and not buried deeply within the mud. This situation is reminiscent of the manganese nodule paradox except the relative rates involved are all about three orders of magnitude faster thus providing an opportunity to study the authigenic concretion/sediment relationship with considerable more detail than possible in the case of deep-sea manganese nodules and pelagic sediments.

To this end, we decided to employ the Soutar-designed box and grab coring devices. The Soutar box core has been shown in many cases to be capable of retrieving sediment cores of 50 cm or more length with a well-preserved sediment-seawater interface. The Soutar "grab corer" is positioned in the same type of frame as the box core and is also hydraulically lowered into the mud but has a pair of heavy jaws which bit into the bottom upon impact rather than simply sliding in as in the case of the box core. The grab corer was thought to be a better device for sampling in an area where there was a mixture of soft mud and hard nodules. In fact this turned out to be the case as we encountered situations where the box core failed because the lids became jammed with nodules while the grab corer was able to recover

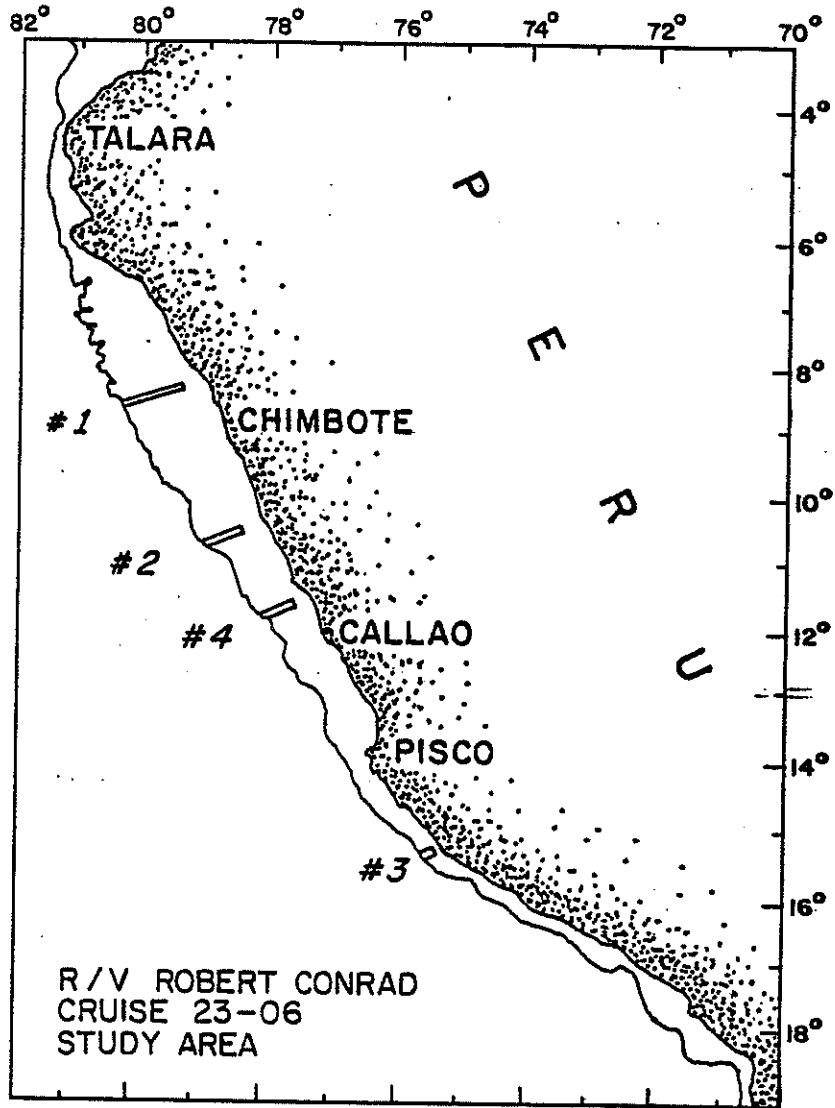


Fig. 1. Index map of Peru showing the locations of the four study areas occupied during cruise RC-23-06. The 1000 m isobath is shown for reference.

both nodules and associated sediment.

In addition to the detailed sampling by box and grab coring, we occasionally deployed gravity and piston cores in order to obtain samples from deeper horizons. We also supplemented our nodule collection by occasional rock dredging in areas determined to be nearly free of sediment.

Although the main emphasis of this expedition was a geochemical study of the organic-rich phosphatic sediments, several ancillary programs were being run simultaneously. Some of these programs included a study of reduced sulfur compounds both in the ocean and the atmosphere, collection of aerosol samples for later elemental analysis, and measurements of tin and germanium species in the water column.

MEASUREMENTS, SAMPLES COLLECTED, & PRELIMINARY RESULTS

A summary of the activities and samples collected during RC-23-06 is given together with location and depth information in Table 1. Samples for hydrographic analysis were taken in 2- ℓ Niskin bottles attached to a 12-bottle rosette sampler. All of these samples were analyzed for nutrient species by AutoAnalyzer techniques and for dissolved oxygen by a colorimetric technique specifically designed for low oxygen waters. Additional hydrographic samples were taken by special Go-Flow and Vane samplers for trace element and sulfur work. The standard hydrographic data is tabulated in the appendix of this report. Profiles of dissolved phosphate and oxygen from each study area are shown in Figs. 2-5.

All samples for pore water chemistry were expressed by centrifugation from slices of subcores taken by hand immediately after the corer came back on deck. All handling of these subcores was done in a glove box under nitrogen atmosphere in a refrigerated van kept at in situ temperatures ($\sim 10^{\circ}\text{C}$). Individual pore water samples were stored in a refrigerator until analyzed. All analyses were performed as soon after collection

Table 1. Locations, water depth operations and samples at all stations occupied during cruise RC-23-06.

Station	Latitude °S	Longitude °W	Depth (m)	Operations	Samples	Remarks
<u>STUDY AREA #1</u>						
1-1	7° 43.3'	80° 41.1'	1057	hydrocast	water column samples	analyzed for DO, nutrients
1-2	7° 36.3'	80° 38.0'	480	hydrocast grab samples	bottom water, sediment, rock, oriented samples	2 cm thick crust (dolomite, phospho- rite?) under ~ 10 cm mud
1-3	7° 38.2'	80° 33.8'	425	gravity core	26 cm core, <u>GC-1</u>	pore water chemistry
<u>STUDY AREA #2</u>						
2-4	10° 42.4'	78° 45.8'	1000	hydrocast	water column samples	analyzed for DO, nutrients
2-5	10° 35.1'	78° 38.8'	472- 433	hydrocast gravity core rock dredge	bottom water, chips from core, <u>GC-2</u> ~ 8 dark phosphate nodules in dredge <u>0-1</u>	1st try on GC came up empty, 2d try only fragments of phosphorite in nosecone
2-6	10° 34.2'	78° 36.4'	271	gravity core	22 cm core <u>GC-3</u>	nosecone contained phosphorite chips - encountered buried layer (?)
2-7	10° 26.3'	78° 29.3'	204	gravity core	core empty	hard bottom(?)
2-8	10° 24.0'	78° 29.3'	223	gravity core	30 cm core, <u>GC-4</u>	sediment disturbed
			221	box core	some sediment, nodules, <u>3X-1</u>	box core lid pried open with nodules
	10° 22.7'	78° 31.1'	216	box core	10-15 cm sediment/ layer of nodules/ layer of sticky green mud, <u>3X-2</u>	4 subcores taken; light & dark nodules present; <u>3X-2</u> sampled for org. geochemistry
<u>STUDY AREA #3</u>						
3-9	15° 26.5'	75° 30.4'	840	hydrocast	water column	analyze for DO, nutrients
3-10	15° 16.9'	75° 23.9'	387	gravity core	~ 10 cm green mud <u>GC-5</u>	samples for pore water & radiochemistry
				hydrocast box core	bottom water sediment <u>3X-3</u>	<u>3X-3</u> good undisturbed core, white bacterial mat on surface
3-11	15° 15.7'	75° 23.5'	133	hydrocast box core	bottom water sediment <u>3X-4</u>	bottom water ~ 12 m off bottom <u>3X-4</u> : excellent interface, good undis- turbed core
3-12	15° 12.4'	75° 19.9'	80	gravity core	~ 4' sediment <u>GC-6</u>	
			86	hydrocast box core	water column sediment <u>3X-5</u>	<u>3X-5</u> : excellent interface, undisturbed
3-13	15° 17.3'	75° 24.6'	303	grab sampler	all mud <u>GS-2</u>	1 bulk sample, fish debris from screen
3-14	15° 15.1'	75° 23.2'	159	grab sampler	mud, nodules <u>GS-3</u>	large nodules occur just under surface & gravel layer under nodules, oriented nodules, short (~ 6 cm) subcore
3-15	15° 16.6'	75° 24.0'	405	piston core	~ 3' sediment <u>PC-1</u>	disturbed sediment
<u>STUDY AREA #4</u>						
4-16	12° 06.4'	77° 49.17'	1058	hydrocast	water column	analyze for DO, nutrients
4-17	12° 06.5'	77° 38.9'	186	piston core	~ 20' piston core <u>PC-2</u>	core penetrated to weightstand; cut into seven sections
4-18	12° 05.1'	77° 40.0'	201	grab sampler	sediment, nodules, <u>GS-4</u>	small nodules washed out of mud on screen
			204	grab sampler	lg. nodules, sediment <u>GS-5</u>	nodules caught in jaws
			203	grab sampler	sediment, nodules <u>GS-6</u>	grab filled with mud, nodules found buried in sediment. Sampled oriented nodules & subcores
				gravity core	sediment <u>GC-7</u>	
4-19	12° 03.1'	77° 32.0'	142	grab sampler	lg. nodule <u>GS-7</u>	very lg. nodule caught in jaw of grab, some disturbed sediment
				grab sampler	sediment, nodules <u>GS-8</u>	small nodules (8-10 cm) beneath sur- face; sample subcores
4-20	12° 05.0'	77° 42.0'	277	grab sampler	nodule, sediment <u>GS-9</u>	lg. nodule in jaws of grab with ~ 10 cm sediment cover
			272	grab sampler	sediment <u>GS-10</u>	completely filled with mud; screen sediment for fish debris
4-21	12° 05.0'	77° 39.5'	183	box core	sediment <u>3X-6</u>	complete full and undisturbed core
4-22	11° 58.6'	77° 16.5'	100	hydrocast	water column	samples for sulfur work
4-23	12° 06.9'	77° 41.9'	340- 314	rock dredge	large nodules <u>0-2</u>	9 lg bags of phosphate nodules
4-24	6° 12.1'	81° 16.9'	3140	hydrocast	water column	samples for sulfur work

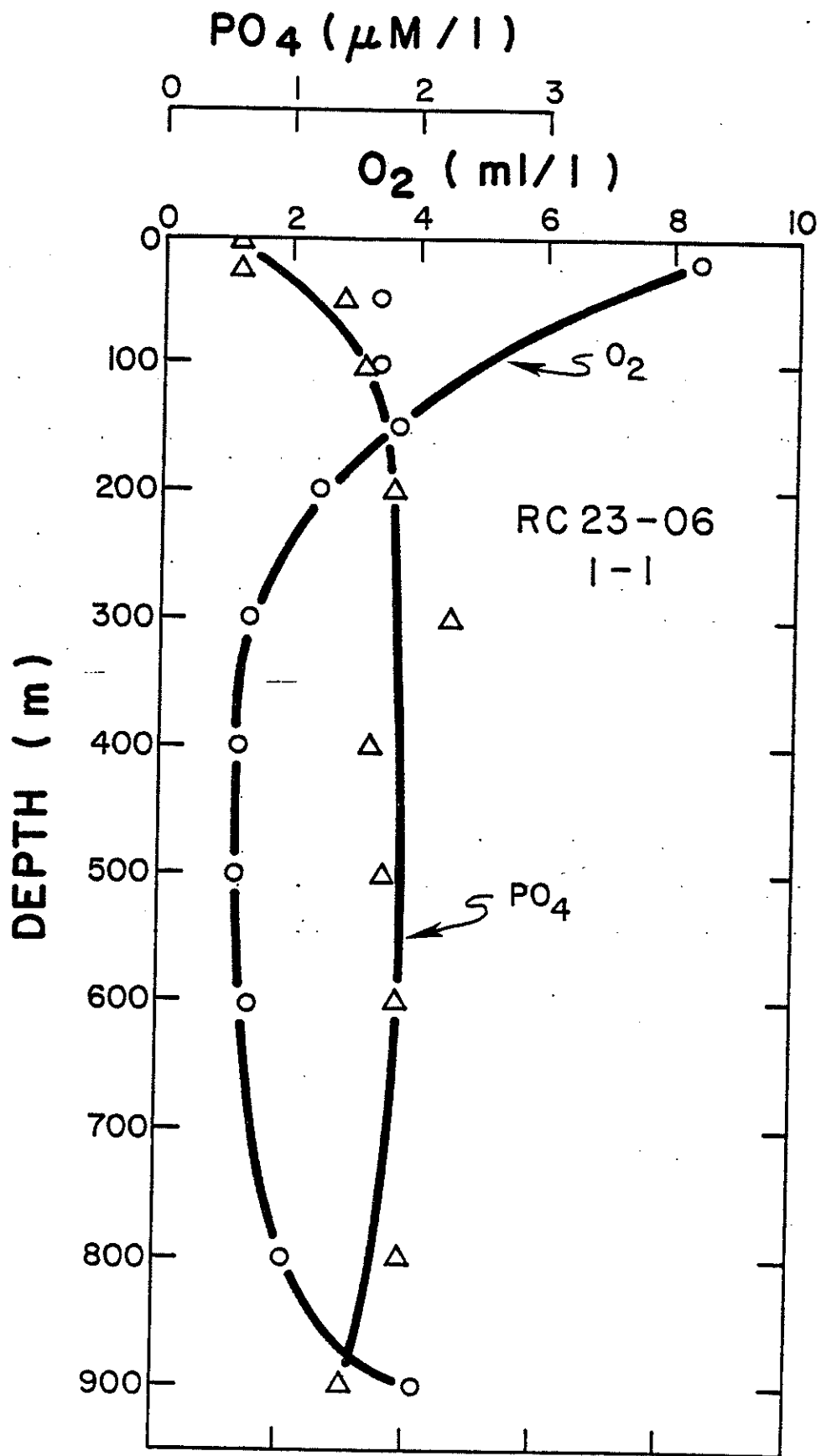


Fig. 2. Dissolved oxygen and phosphate data from station 1-1.

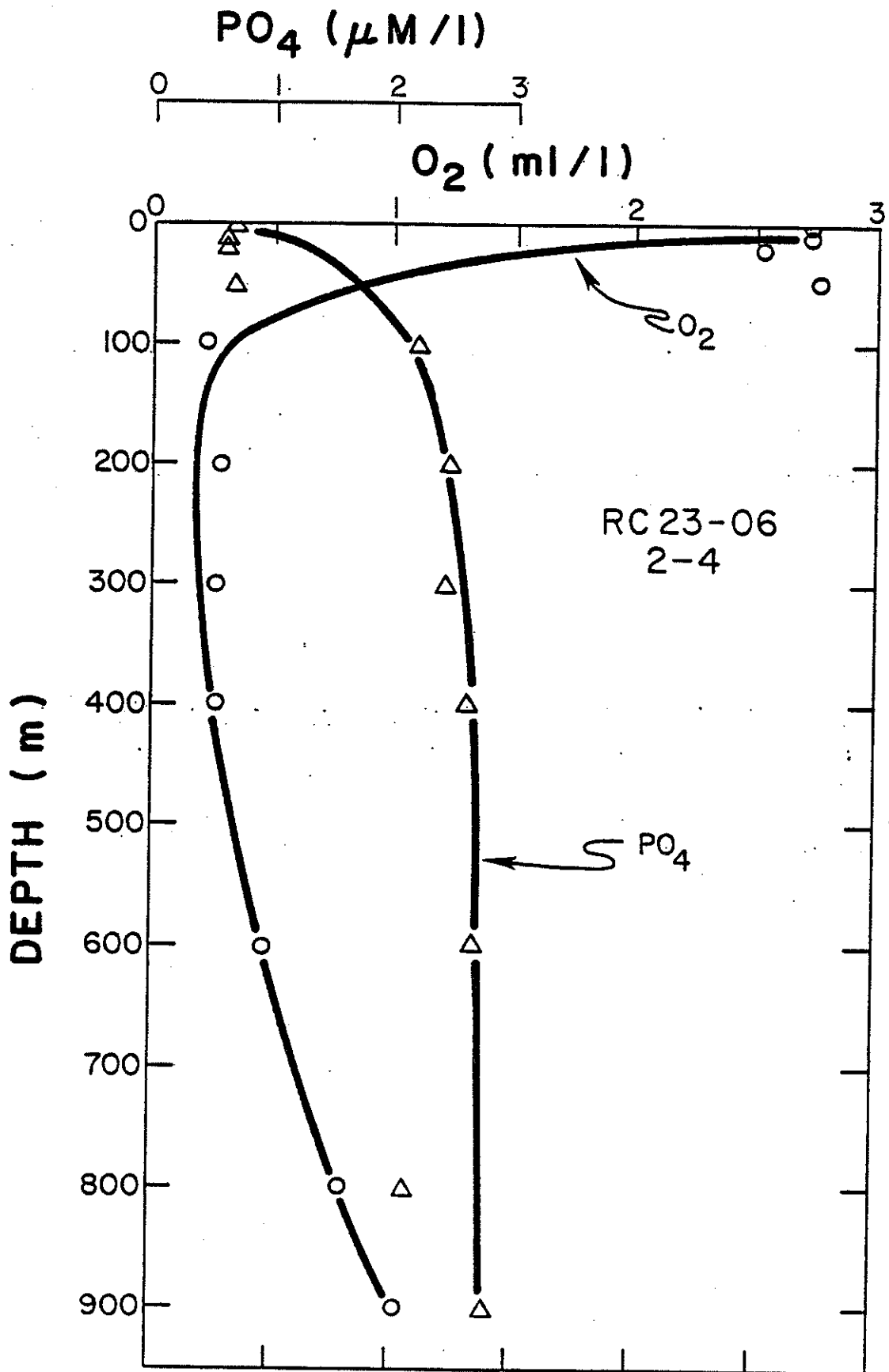


Fig. 3. Dissolved oxygen and phosphate data from station 2-4.

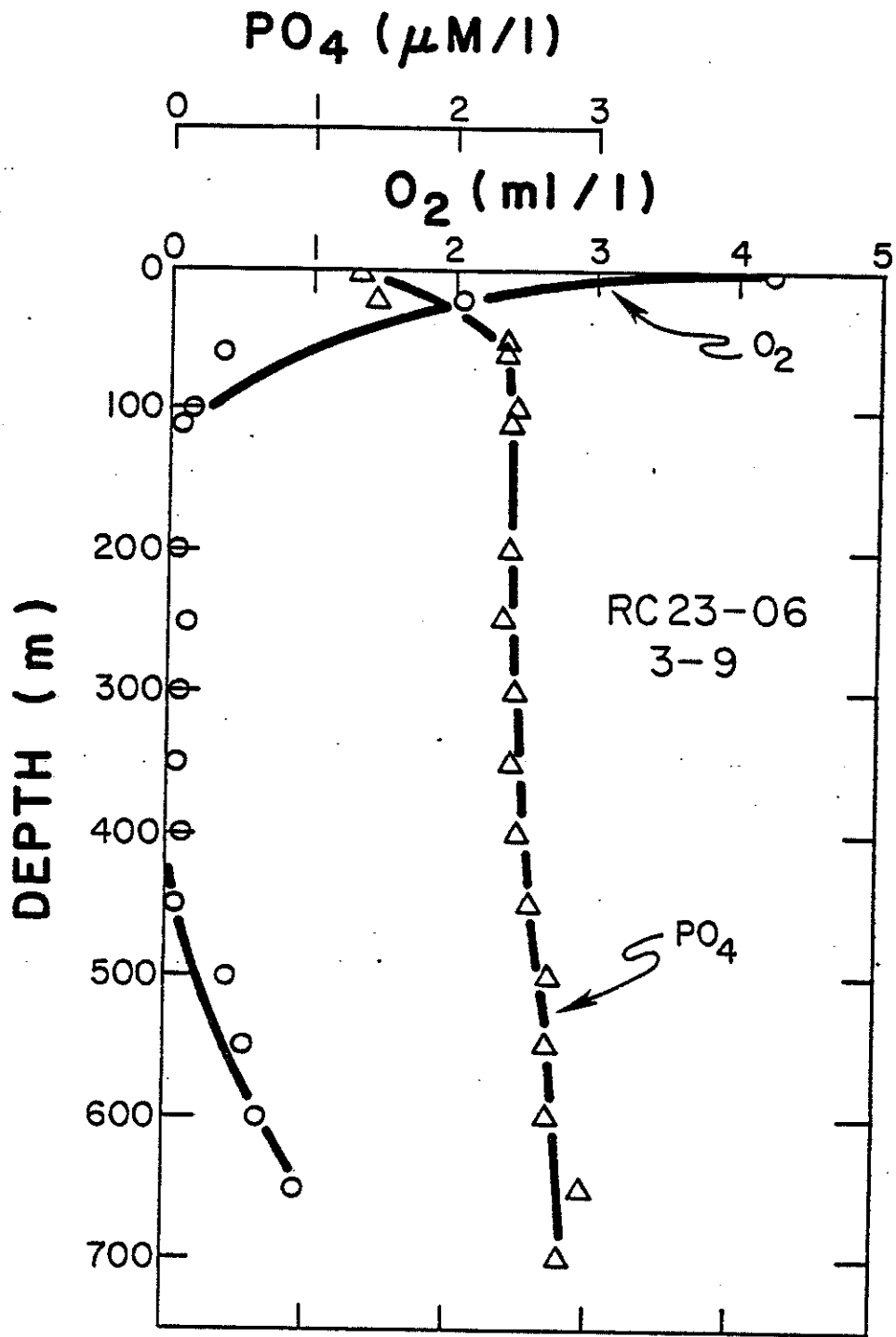


Fig. 4. Dissolved oxygen and phosphate data from station 3-9.

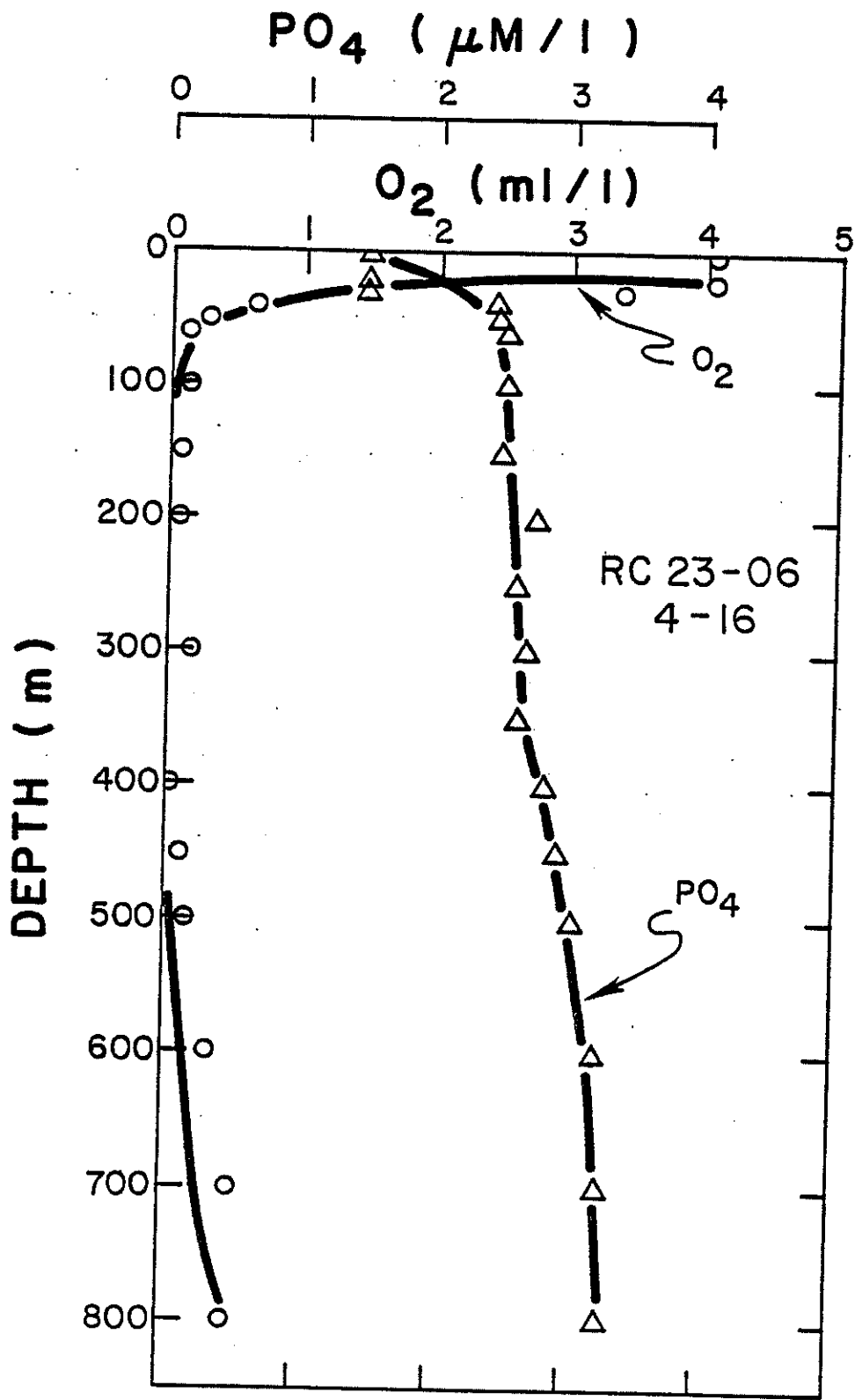


Fig. 5. Dissolved oxygen and phosphate data from station 4-16.

as possible.

The nutrient species PO_4^{3-} , NO_3^- , NO_2^- , NH_4^+ , and Si were measured in every core by modified AutoAnalyzer techniques. Cl^- was measured by Coulometric titration. Two techniques were used to measure F^- , an ion specific electrode and a spectrophotometric procedure. The cations Ca^{2+} and Mg^{2+} were analyzed in selected samples by an EGTA/EDTA titration. The redox species SO_4^{2-} and H_2S were determined by turbometric and colorimetric procedures respectively. Mn^{2+} and Fe^{2+} were analyzed for in selected samples using spectrophotometry. The carbon system parameters were also measured--pH by a glass electrode, alkalinity via a potentiometric titration and total dissolved inorganic carbon (ΣCO_2) samples were taken for later analysis.

The shipboard results of these pore water analyses are presented in the appendix of this report. The data indicate a complex situation with respect to phosphate consumption (precipitation). Several of the cores show exceedingly high dissolved phosphate just under the sediment-seawater interface implying an as yet undefined regenerative process operating right at or just below this interface. Phosphate is very often higher than would be predicted on the basis of regeneration of organic matter. Several cores also show significant gradients of F^- implying consumption of this species within the sediments. The F^- profiles, however, do not mimic the PO_4^{3-} profiles as might be expected if apatite precipitation was the main reaction influencing these species. A complete discussion of the significance of these results will have to await the analysis of the sediment solid phases which is now in process.

During this expedition, we recovered 6 box cores, 7 gravity cores, 2 piston cores, 10 grab core samples, and 2 rock dredges. Subcores were

taken in plastic liners from the box core and grab corer. These cores as well as sections of the gravity and piston cores and nodule samples have all been shipped to Florida State University (FSU). Lengths and descriptions of cores which weren't totally devoted to pore water studies are given in Table 2. These sediment samples are currently undergoing several different types of geochemical and radiochemical analysis.

One of the main priorities in the sampling program was to recover samples of oriented nodules from the sea floor. This objective was very successful as the grab corer provided several samples of soft mud with associated nodules in place. In addition, 3 subcores opened after arrival at FSU contained buried nodules. A list of these oriented samples is given in Table 3. Since not all the cores have been opened as yet, there is a good possibility more oriented nodules may be found.

SHORE-BASED INVESTIGATIONS

Detailed study of sediment and nodules sampled during cruise RC-23-06 will be conducted in our laboratories at FSU as well as in the labs of cooperating scientists. Nodules will be examined by standard mineralogical techniques to characterize their main components. Selected samples will be analyzed by uranium-series techniques for age determinations. Stable carbon and oxygen isotopes will also be run on some nodule samples by H. W. Yeh (University of Hawaii) and M. Arthur (University of South Carolina). Samples of oriented nodules will be sectioned into as many slices as possible perpendicular to the growth axis for growth rate studies (Burnett, FSU). Since these samples have been collected in place, the tops and bottoms are known unequivocally. This will enable a major advance since all other growth rate determinations have been performed using nodule samples whose orientation

Table 2. List of cores sampled during cruise RC-23-06 available for further study. Cores which are included in Table 1 but not here were entirely dedicated to pore water chemistry.

Station	Core/Subcore Number	Length (cm)	Description
1-2	GS-1	14	non-laminated dark green mud with scattered light-colored pellets, nodule collected just under core, 54-60% H ₂ O
2-8	BX-2	21	dark, dense sediment, black pellets, buried phosphate nodule @ 15-18 cm, 30-85% H ₂ O
3-10	BX-3	40	non-laminated to weakly-laminated dark green mud; sharp contact @ 20 cm with light sticky green mud below 0-20 cm 80-88% H ₂ O 17-21% LOI 20-40 cm 57-67% H ₂ O 9-13% LOI
3-11	BX-4	39	light to dark green laminated mud, very soupy to 9 cm, good laminae from ~ 12 cm to bottom, phosphate nodule occurs @ 35-39 cm, 75-86% H ₂ O, 15-20% LOI
3-12	GC-6	129	-*
3-14	GS-3	9	-
3-15	PC-1	106.5	-
	PC-1 pilot	12.5	
4-17	PC-2	~700	very stiff laminated dark clay throughout
4-18	GS-6	19.5	gritty dark mud grading into stiffer clay with depth, gravel layer at bottom, small nodules encountered in pore water subcore
	GC-7	41	
4-19	GS-8	16	non-laminated dark green mud, 0-5 cm, very soupy, no visible pellets, 33-80% H ₂ O
4-20	GS-9	19	-
	GS-10	29	dark green, non-laminated mud, contact @ 22 cm; darker & soupy above, 64-79% H ₂ O
4-21	BX-6	54	very well-laminated ooze, 0-9 cm very soupy, laminae best developed from ~ 20-40 cm, light-colored layers @ 22 and 38 cm (phosphate pellets ?) 71-84% H ₂ O

*Core not opened thus far.

Table 3. Oriented nodules collected during cruise RC-23-06.

Station	Sample	Description
1-2	GS-1 (A,B,& C)	3 oriented nodules, 1 from bottom of subcore GS-1
2-8	BX-2 (14-20 cm)	buried nodule
3-11	BX-4 (35-39 cm)	buried nodule
3-14	GS-3 (A,B,& C)	4 oriented nodules
4-18	GS-6 (A,B,& C)	3 oriented nodules

had to be implied. Radiometric ages and growth rates will be determined by measurement of uranium and thorium isotopes, ^{231}Pa , and ^{226}Ra .

Seven sediment cores were flown back to FSU from Guayaquil immediately after this cruise so samples could be processed for determination of short-lived decay-series isotopes. Of particular interest is the determination of ^{234}Th ($t_{1/2} = 24.1$ days) in these Recent sediments for an evaluation of the extent of biological mixing. These seven cores were opened and described (see Table 2) soon after arrival at FSU and measurements for ^{234}Th as well as ^{210}Pb , and ^{226}Ra are underway by Burnett's group. Selected sediment samples will also be analyzed for U and Th isotopes and ^{231}Pa . From these measurements, we hope to assess accumulation rates, fluxes of ^{234}Th , ^{230}Th and ^{231}Pa to the sea floor, and depth of biological mixing. The mixing models and accumulation rates are necessary to assist in the evaluation of the pore water chemistry.

Another important aspect of the shore-based work will be the geochemical analysis of the solid phases of the sediment. These analyses will include the determination of inorganic and organic phosphorus, organic carbon, biogenic silica, and other components. This work, which is being performed by Froelich's group (FSU) will be used to supplement the fluid phase chemistry of these cores done onboard the ship.

Finally, M. Arthur (University of South Carolina) will be doing laboratory determinations of total inorganic carbon (ΣCO_2) and $\delta^{13}\text{C}$ in pore water samples from box cores BX3, 4, and 5. These data will be very useful in our attempt to decipher the $\delta^{13}\text{C}$ record of the structural carbonate in the associated phosphorites.

SCIENTIFIC PARTY

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marine geochemistry, radiochemistry, origin of phosphorites

Dr. Philip N. Froelich - Co-Chief Scientist

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Ms. Lisa Wells

marine geochemistry, nutrient cycles

Mr. James Byrd

marine chemistry, tin in seawater

Mr. Kee Hyun Kim

marine geochemistry, radioisotopes in sediments

Mr. Gordon Hambrick

marine chemistry, germanium in seawater

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APPENDIX 1: Data tables of hydrographic results from cruise RC-23-06.

Station 1-1: Hydrocast; 7°43.33'S, 80°41.09W; 1057 m.

Depth (m)	Temperature (°C)	Si ($\mu\text{M}/\text{l}$)	PO ₄ ($\mu\text{M}/\text{l}$)	NO ₃ ($\mu\text{M}/\text{l}$)	NO ₂ ($\mu\text{M}/\text{l}$)	O ₂ ($\mu\text{M}/\text{l}$)
1	-	2.95	0.59	7.4	0.69	-
10	-	-	-	-	-	-
20	-	2.95	0.60	7.4	0.68	-
50	-	9.76	1.44	21.0	0.12	-
100	-	11.5	1.59	22.8	0.03	-
150	-	-	-	-	-	-
200	-	14.6	1.84	26.6	0.01	-
300	12.67	22.4	2.29	27.8	0.60	-
400	-	36.8	1.67	35.2	0.26	-
500	7.83	40.1	1.78	40.1	0	-
600	-	48.4	1.90	43.2	0	-
800	6.92	57.4	1.91	43.3	0	-
900	-	22.1	1.56	22.4	0.35	-

Station 2-4: Hydrocast; 10°42.35'S, 78°45.78'W; 1000 m

Depth (m)	Temperature (°C)	Si ($\mu\text{M}/\text{l}$)	PO ₄ ($\mu\text{M}/\text{l}$)	NO ₃ ($\mu\text{M}/\text{l}$)	NO ₂ ($\mu\text{M}/\text{l}$)	O ₂ ($\mu\text{M}/\text{l}$)
1	-	1.93	0.70	7.2	0.68	111
10	20.02	1.71	0.63	7.2	0.73	112
20	-	1.71	0.62	7.4	0.74	106
50	-	1.71	0.70	8.0	0.80	115
100	-	13.4	2.22	25.7	0.12	8.5
150	-	-	-	-	-	-
200	-	21.5	2.48	21.3	3.8	13.5
300	11.12	24.7	2.45	25.3	4.4	12.0
400	-	28.7	2.62	36.5	0.15	12.2
500	-	(6.33)	-	(12.1)	(0.85)	(51.8)
600	-	37.8	2.71	39.0	0.25	19.7
800	5.40	31.1	2.15	29.3	0.64	35.2
900	-	60.5	2.81	30.4	0.08	44.2

Station 3-9: Hydrocast; 15°26.53'S, 75°30.37'W; 840 m

Depth (m)	Temperature (°C)	Si ($\mu\text{M}/\text{l}$)	PO ₄ ($\mu\text{M}/\text{l}$)	NO ₃ ($\mu\text{M}/\text{l}$)	NO ₂ ($\mu\text{M}/\text{l}$)	O ₂ ($\mu\text{M}/\text{l}$)
1	-	0	1.32	9.18	0.60	176.7
20	-	0.14	1.45	10.7	0.61	84.6
50	14.29	14.2	2.40	19.8	0.11	5.5
60	-	12.6	2.37	23.1	0.02	15.3
100	-	21.9	2.46	12.1	4.15	6.7
110	-	22.5	2.42	10.4	6.01	3.2
150	12.85	-	-	-	-	6.6
200	-	24.0	2.40	11.0	9.45	1.5
250	-	23.8	2.38	18.6	4.39	6.6
300	11.37	24.2	2.45	25.1	0.27	4.0
350	-	26.2	2.44	26.9	2.44	3.0
400	-	28.5	2.49	30.9	1.53	4.9
450	-	29.6	2.58	36.7	0	3.7
500	7.93	33.1	2.72	39.7	0.01	18.7
550	-	36.6	2.70	40.7	0.04	23.6
600	-	39.2	2.72	41.9	0.04	27.2
650	5.81	46.3	2.96	43.1	0.05	38.5
700	-	50.9	2.81	43.6	0.03	27.0

Station 3-12: Hydrocast; 15° 12.4'S, 75° 19.9'W; 80 m.

Depth (m)	SiO ₂ (μM/l)	PO ₄ (μM/l)	NO ₃ (μM/l)	NO ₂ (μM/l)	O ₂ (μM/l)
0	15.4	1.87	18.9	0.61	69.0
10	15.9	2.24	18.9	0.61	84.8
20	20.9	2.34	18.1	0.77	33.3
30	21.1	2.37	18.1	0.80	38.3
40	21.1	2.34	18.7	0.80	34.0
50	20.2	2.37	19.2	0.73	42.6
60	19.2	2.37	19.9	0.77	28.3
70	19.8	2.34	19.7	1.21	12.2

Station 4-16: Hydrocast; 12°06.44'S, 77°49.17'W; 1058 m

Depth (m)	Temperature (°C)	Si ($\mu\text{M}/\text{l}$)	PO ₄ ($\mu\text{M}/\text{l}$)	NO ₃ ($\mu\text{M}/\text{l}$)	NO ₂ ($\mu\text{M}/\text{l}$)	O ₂ ($\mu\text{M}/\text{l}$)
1	-	1.53	1.47	14.9	0.62	167
20	-	1.50	1.47	14.4	0.57	169
30	-	1.19	1.47	13.6	0.56	140
40	15.75	10.7	2.43	25.0	0.25	26.5
50	-	12.1	2.45	27.0	0.23	11.7
60	-	16.2	2.52	26.1	0.45	5.0
100	-	20.1	2.52	25.1	0.29	6.2
150	-	18.6	2.48	25.9	0	4.0
200	11.38	26.4	2.77	6.6	8.0	3.5
250	-	22.7	2.61	19.8	3.32	(8.6)
300	-	24.0	2.70	19.0	5.59	0.8
350	11.57	25.8	2.65	25.4	2.77	(8.6)
400	-	29.0	2.83	31.0	0.88	1.0
450	-	31.7	2.95	35.5	0.11	4.8
500	8.18	36.7	3.06	38.2	0	6.8
600	-	43.9	3.24	42.8	0	13.7
700	-	47.6	3.29	43.2	0.06	21.1
800	-	54.3	3.30	44.2	0.01	20.2
900	-	-	-	-	-	-

Station 4-22: Hydrocast; 11° 58.6'S, 77° 16.5'W, 100 m

Depth (m)	SiO ₂ (μM/l)	PO ₄ (μM/l)	NO ₃ (μM/l)	NO ₂ (μM/l)	O ₂ (μM/l)
0	0.27	1.20	13.0	0.67	202
10	0.15	1.24	13.8	0.68	173
20	3.94	2.06	20.1	0.77	63.2
30	12.9	2.31	23.1	0.58	25.9
40	14.2	2.37	25.7	0.56	24.8
50	22.9	2.72	19.3	0.62	8.2
70	24.2	2.77	17.6	0.73	3.9
90	25.1	2.77	15.8	1.13	10.0

APPENDIX 2: Data tables of pore water results from cruise RC-23-06.

Key to Pore Water Data

Core: Sequential number designating each coring device.

RC = ROBERT D. CONRAD
23 = year 23 (1982)
06 = leg 6
4-21 = transect 4, station 21
BX = box core (Soutar 12"x12"x36")
PC = Piston core (Lamont)
GS = grab sample (Soutar)
GC = gravity core (Froelich's Benthos)

Lat: latitude

Long: longitude

Water Depth: uncorrected sounding

Bottom Water Temp: from bottom bottle of hydrostation

Reefer Temp: Temperature in refrigerated pore water lab during extrusion and centrifugation

Supernatant Temp: Temperature of water overlying mud inside box core immediately after landing

Core Onboard: time between landing and initiation of extrusion and centrifugation

PW No: sequential sample number assigned to each centrifuge tube and pore water sample

Depth, cm: depth interval in core

SO₄, mM: dissolved sulfate concentration (turbidimetric analysis of BaSO₄ + gelatin)

TA, meq/l: total alkalinity; gran titration

Cl, mM: chloride concentration, coulometric titration with Ag, amperometric endpoint

Ca, mM: dissolved calcium, EDTA titration

Mg, mM: dissolved magnesium, EGTA titration

Fe, μM: dissolved iron, ferrozine spectrophotometry

Mn, μM: dissolved manganese, formaldozime spectrophotometry

NO₃, μM: dissolved nitrate, CuCd reduction, diazotization, spectrophotometry (AutoAnalyzer)

NO₂, μM: dissolved nitrite, diazotization, spectrophotometry (AutoAnalyzer)

NH₄, μM: dissolved ammonia, salicylate, spectrophotometry

PO₄, μM: dissolved phosphate, molybdate-blue spectrophotometry (AutoAnalyzer)

Si, μM: dissolved silica, molybdate-blue spectrophotometry (AutoAnalyzer)

H₂S, μM: dissolved sulfide, methylene blue spectrophotometry

F_C, μM: dissolved fluoride, lanthanum-alizarin complexone spectrophotometry

F_e, μM: dissolved fluoride, potentiometric F-electrode (LaF crystal)

R, ohm: resistivity of mud, Mannheim probe

P_S, μmol/cm³: acid-soluble solid phase phosphorus (inorganic), Hot 1N HCl for 3 hours

Core RC-23-06-1-3-(X)1

Lat 7-38.2 S Long 80-33.8 W Water Depth 425 m

Bottom Water Temp ~ 14°C Reef Temp ~ 14°C Supernatant Temp Core Onboard ~ 10 hrs

PW No.	Depth cm	SO4 mM	TA mcg/l	Cl mM	*Ca mM	*Mg mM	Fe μM	Mn μM	NO3 μM	NO2 μM	NH4 μM	PO4 μM	Si μM	H2S μM	F μM	F μM	R olum	P5 μmol/cm3	
Supernatant																			
Bottom Water		28.25	2.36	562	11.06	57.07			27.7	0.03		2.70	44.9		72				
1	0-4	28.3	2.37	563	11.90	53.16	3.3	1.2	0.5	0.11		17.9	266	No odor	67.1				
2	4-8	27.8	2.65		10.86	52.72	2.4	1.7	0.4	0.07		10.1	373		64.1				
3	8-12	27.6	2.75		10.69	52.58	5.5	6.0	0.1	0.02		12.6	390		63.9				
4	12-16	27.6	2.85		10.78	52.44	1.7	6.5	0.1	0.02		6.6	375		66.3				
5	16-20	27.5		561			4.7		2.9	0.11			358		68.4				
6	20-26	27.4	2.94		10.78	52.96	0.2	1.6	3.7	0.11		5.19	332						

Description: Grey-black silty mud, no H2S, no pellets or agglomerates, no laminae or banding.

*TA-samples: values suspect

Core RC-23-06-2-8-BX2 Lat 10-22.7 S Long 78-31.1 W Water Depth 216 m

Bottom Water Temp ~ 14°C Reef Temp 9-18°C Supernatant Temp Core Onboard ~ 2 hrs

FW No.	Depth cm	SO ₄ mM	TA meq/l	Cl mM	Ca mM	Mg mM	Fe μM	Mn μM	NO ₃ μM	NO ₂ μM	NH ₄ μM	PO ₄ μM	Si μM	H ₂ S μM	F ₁ μM	F ₂ μM	R olum	P _S μmol/cm ³	
Supernatant																			
Bottom Water		28.1																	
7	0-3.5	28.2	2.36		10.02	55.66	<0.5		5.5	1.05	30	53.1	78	No odor	70.4	65.6		126	
8	3.5-6.9	27.8	2.65	559			<0.5	0.7	3.6	0.82	48	67.2	174		63.1	61.9		211	
9	6.9-10.1	28.3	3.11		9.39	56.22	<0.5	2.0	0.8	0.61	86	44.9	215		53.8	50.0		759	
10	10.1-13.2	27.9	3.27						0.5		90	26.0	217		50.0	48.4		790	
11	13.2-16.3	28.3	3.58						0.2		101	15.6	270					640	
12	16.3-19.2	27.7	3.56						1.4		105	10.1	316					663	
13	19.2-20.9	28.1	3.37						1.4		115	9.3	359					692	
14	20.9-23.2	27.9	3.57	560	10.08	56.09			1.0		154	6.2	360		49.6	46.9		412	

Description: 0-15 cm = grey-black silty mud

15-18 cm = gravel layer containing large phosphorite "chunks" and "pellets" ~ 3-5 cm thick

18-23 cm = bright green, very stiff clay, sharp contact @ ~ 18 or 19 cm with overlying gravel layer

Core RC-23-06-3-10-BX3 Lat15-16.9 S Long 75-23.9 W Water Depth 387 m

Bottom Water Temp 10.5°C Reeler Temp 9-13°C Supernatant Temp 14.2°C Core Onboard 54 hrs

PW No.	Depth cm	SO ₄ mM	TA meq/l	Cl mM	Ca mM	Mg mM	Fe μM	Mn μM	NO ₃ μM	NO ₂ μM	NH ₄ μM	PO ₄ μM	Si μM	U ₂ S μM	F μM	Fe μM	R ohm	P μmol/cm ³
Supernatant		28.1	2.36		11.17	55.10	0.0		26.8	2.70	8	2.59	31.2	0.0	69.3			
Bottom Water									27.6	3.19	11	2.50	29.2					
77	0-0.8	26.5	5.14	552	11.23	54.01	0.8		34.5	0.2	350	87.5	801	224	65.0	66.6	238	0.8
78	0.8-1.9	27.2	5.80	564	11.52	56.68	0.5		17.2	0.03	386	67.8	965	238	66.3	67.1	238	0.4
79	1.9-2.9	27.1	5.50		11.27	55.90	0.4		8.6	0.06	352	58.5	910	355	66.8	67.9	251	0.3
80	2.9-4.0	26.9	5.54		11.31	55.44	0.4		1.9	0	306	57.2	899	394	67.8	68.5		0.3
81	4.0-5.0		5.33		11.24	55.80		0.4	0.6		289	51.9	872	354	67.9			1.0
82	5.0-6.1		4.95		11.05	55.52					265	45.8	910	356	68.4	69.9	255	0.5
83	6.1-7.2	27.2	4.97		11.24	58.21			0.3		262	41.0	865	334	69.5	68.5	269	0.4
84	7.2-8.2		4.70		11.81	54.57					253	40.7	806	181	69.3	70.7		0.6
85	8.2-10.3	27.3						0.3	0.3		249	34.2	821	294	71.0	69.6	273	1.0
86	10.3-12.3	28.4	4.29		11.39	54.96		0.3	0.3		228	29.8	804	246	71.7	68.8		1.0
87	12.3-14.4	28.5									214	25.7	777	294	71.7	68.8	265	2.0
88	14.4-16.5	28.5									196	25.0	749	263	71.0	69.0		4.6
89	16.5-18.6	28.7	3.97		11.32	54.97		0.2	0.2		186	22.8	713	129	70.6	68.5	329	2.3
90	18.6-20.7			565				0.8	0.8		119	19.9	884	129	70.7	70.7		40.9
91	20.7-22.4	28.7					1.6	2.2	2.2		187	19.0	706	31.5	72.0	71.6	443	40.0
92	22.4-24.4		4.03		11.20	55.16		7.3	7.3		205	17.8	730	16.8	(65.0)	66.6	476	21.9
93	24.4-26.3	28.7	4.03		11.20	55.16					205	21.6	730					20.5
94	26.3-28.5	28.7	4.03				0.4											20.5
95	28.5-30.6																	23.7

Description: Black gelatinous mud grading down to dark olive green very stiff clay; 10-20 cm may be weakly laminated. Sharp contact at 20 cm with underlying very stiff, dry bright-green clay which continues to bottom. Worm burrow at 12-14 cm.

*TA samples, values suspect

Core RC-23-06-3-11-BX4 Lat 15-15.7 S Long 75-23.5 W Water Depth 133 m

Bottom Water Temp 13.5°C Reef Temp 10-15°C Supernatant Temp 13.5°C Core Onboard ~ 7 hrs

PW No.	Depth cm	SO ₄ mM	TA meq/l	Cl mM	Ca mM	Mg mM	Fe μM	Mn μM	NO ₃ μM	NO ₂ μM	NH ₄ μM	PO ₄ μM	Si μM	H ₂ S μM	F ₂ μM	F ₂ μM	R ohm	P _s μmol/cm ²
Supernatant		28.3			10.48	53.92	0.0		13.4	7.4	2.8	2.48	25.9		68.1	67.1		
Bottom Water									13.5	6.0	9.7	2.35	23.1					
23	0-1.2	27.5	3.02	557	10.91	54.89	10.8		102	1.6	189	105	537	< 2	63.4	72.4		0.1
24	1.2-2.4		3.29				8.1		21.9	0.6	195	45.8	560		67.0	70.2		1.3
25	2.4-3.5	27.4					4.9		7.2	0.4	195	35.5	658	< .4	67.1	70.4		0.6
26	3.5-4.4	27.6*					2.5		86	13.2		39.9	733		69.4	68.4		0.3
27	4.4-5.2	27.7					1.6		11.4	1.2	281	39.4	752		65.1	68.7		0.8
28	5.2-6.3	27.7*					0.8		4.7	0.4	306	38.0	777	< 4	65.6	70.7		303
29	6.3-7.4	26.9					0.3		3.3	0.4		39.8	794		64.5	69.5		300
30	7.4-8.5	27.4*					0.3		4.1	0.4		39.2	789		64.0	68.2		298
31	8.5-10.5	27.0					0				388	39.8	738	< 2	68.1	68.1		286
32	10.5-12.4						0.7				418	40.5	738	< 2	65.9	67.4		296
33	12.4-14.3	27.9					0.4		0.2		445	41.8	754	12.2	64.6	68.2		301
34	14.3-16.3	27.3*					1.2		0.1		455	40.5	746	21.7	64.6	68.7		313
35	16.3-18.2 (28.5)						1.2		0		486	40.0		25.1	64.9	65.3		316
36	18.2-20.2	27.4*					1.6		0.1		502	39.4	738	34.2	65.9	67.9		326
37	20.2-22.2	26.3					1.5		0		520	37.9	773	38.6	60.5	65.2		328
38	22.2-24.2						1.5		0		530	36.8	770	18.3	66.5	65.2		319
39	24.2-26.2	26.4					1.3		0.1		549	30.6	759	27.5	65.4	66.0		310
40	26.2-28.3						0.7		0.1		550	29.2	763	25.5	64.4	67.4		293
41	28.3-30.4	27.1*					0.8		0.1		559	28.1	742	34.4	64.4	65.8		292
42	30.4-32.4						0.8		0.3		560		777		64.6	66.6		310
43	32.4-34.4	26.1					0.8		0.4				770	20.9	64.6	66.5		310
44	34.4-35.2						0.8		0.3		577		747	< 4.0	67.8	69.0		383

Description: 0-14 cm: dark greyish-brown gelatinous mud at surface grading downward to slightly stiffer brown mud
 14-20 cm: dark brown clay, still gradational color change
 20-26 cm: dry dark brown clay
 26-36 cm: gradational (26-28 cm) to more greenish clay, stiff at base; laminations visible in reference subcore, beginning at ~ 12 cm to bottom of core. A phosphorite nodule occurs in this subcore at 35-39 cm (sample "oriented nodule-BX4")

*Second batch calibration suspect; values perhaps .6 mM too high.

Core RC-23-06-3-12-BXS Lat 15-12.4 S Long 75-19.9 W Water Depth 86 m

Bottom Water Temp 14.20C Recfcer Temp 12-16° Supernatant Temp 14.2°C Core Onboard ~ 24 hrs

PW No.	Depth cm	SO4 mM	TA meq/l	Cl mM	Ca mM	Mg mM	Fe μM	Mn μM	NO3 μM	NO2 μM	NH4 μM	PO4 μM	Si μM	TPS μM	Fc μM	Fg μM	R olum	PS μmol/cm3
Supernatant			2.34		10.49	54.25					5							
Bottom Water		29.3	2.34								19							
45	0-1	23.2	3.65	572			24.6	17.4	32.5	1.8	271	24.3	730	<.1	69.1	69.6		1.9
46	1-2				9.74	56.91	24.7	13.1	36.2	1.9	221	27.0	821	<.1	71.4	67.7	250	0.8
47	2-3	24.9	3.84	568	9.42	57.04	18.2	12.4	36.6	1.5	214	24.5	891	<.1	68.0	67.4		1.0
48	3-4-1						6.4	4.8	7.2	1.1	115	22.5	773	<.4	68.3	67.4	273	1.6
49	4.1-5.2	27.3	3.48	565			3.3	2.5	1.8	0.8	184	20.2	716	<.3	65.9	70.4		2.6
50	5.2-6.4						3.9	4.6	0.6		170	21.8	704	<.1	66.6	61.5	274	3.1
51	6.4-7.5	29.3	3.37				2.7	2.6	0.8		158	19.9	658	<.1	66.2	62.2	303	5.1
52	7.5-8.5						3.2	3.7	1.1		136	17.7	682	<.5	64.7	61.2		3.0
53	8.5-9.7	28.6	3.35				2.4	3.3	0.2		226	18.7	661	<.1	65.1	62.0	333	4.7
54	9.7-10.7						3.2	3.9	0.2		160	23.3	625	<.7	64.2	62.0		4.8
55	10.7-12.9	29.1	3.70				2.4	4.0	0.4		218	22.6	653	2.4	61.4	64.3	342	5.8
56	12.9-14.8						2.3	3.9	0.1		372	24.4	632	4.0	59.2	60.5		7.2
57	14.8-17.1		4.07				1.7	3.7	0.8		353	30.2	713	2.8	57.4	57.0	331	6.8
58	17.1-19.1	29.4					1.1	2.7	0.1		400	32.7	776	9.7	52.4	52.4		
59	19.1-21.1		5.11				1.3	2.8			738	36.3	747	11.9	50.8	50.8	316	12.0
60	21.1-23.0						1.2		0		870	37.4	773	11.9				
61	23.0-24.9						1.1	1.5				40.6	785	26.9	44.2	44.7	318	4.0
62	24.9-26.9	27.0					1.6	4.4	0		901	40.6	785	26.9	44.2	44.7		
63	26.9-28.8		8.02				1.4	5.4	0		1021	42.9	759	38.3	47.4	47.4	318	4.0
64	28.8-30.8						1.8	0.1			1076	44.9	807	62.7	41.5	43.6	325	9.8
65	30.8-32.8	26.7					1.0	3.2	0		1058	44.1	728	62.7	41.9	41.9		
66	32.8-34.7		8.67				0.9	2.7	0		1173	45.2	783	81.6	38.9	40.8	330	6.6
67	34.7-36.9						0.4	2.5	0		1355	42.9	730	102	39.8	39.8		
68	36.9-38.9	26.3	9.36						0		1439	45.4	781	104	38.4	41.1	345	8.4
69	38.9-40.9				8.62	56.52	0.3	2.1	0		1218	49.7	744	115	37.3	36.9	345	8.4
70	40.9-44.0						0.2	1.4	0		1077	49.7	807	125	36.7	36.9	365	8.2
71	44.0-47.0						0.1		0		1187	50.2	776	176	36.7	36.7	365	8.2
72	47.0-50.0		10.94				0		0		1120	50.9	802	201	37.3	37.3	307	5.1
73	50.0-53.2						0.1	1.4	0		1218	49.7	802	300	36.7	37.9		
74	53.2-56.0	24.9	11.44						0		1249	52.5	809	347	36.7	36.7	293	
75	56.0-59.1			570			0.2		0		1353		795	383				
76	59.1-60.9	24.7	12.09						0		1578		826	380	36.4	37.6		4.9

Description: Gelatinous black mud grading downward into dark olive green clay, no silt or gravel or pellets; continuous sedimentation. Shell fragments at 40-44 cm; very stiff clay below 44 cm.

Core RC-23-06-4-17-PC2+IW2 Lat 12-06.5S Long 77-38.9W Water Depth 186 m

Bottom Water Temp 14.0°C Reefer Temp 10-18°C Supernatant Temp

Core Onboard 66-80 hrs

PW No.	Depth cm	SO ₄ mM	TA meq/l	Cl mM	Ca mM	Mg mM	Fe μM	Mn μM	NO ₃ μM	NO ₂ μM	NI ₄ μM	PO ₄ μM	SI μM	H ₂ S μM	***F μM	F _e μM	R ohm	P _s μmol/cm ³	
Supernatant																			
Bottom Water																			
TW2:																			
111	0-6	24.4*		574			1.4				992	58.9	589	0	55.1	55.0		1.4	
112	6-11.6	22.6*	8.73	576	9.21	55.28	1.3		0.61		1596	60.3	736	120	51.1	51.4			
113	11.6-17.7	18.6*					1.0		0.6			72.6	741	120	48.6	48.6			
114	17.7-23.1	14.4*					2.1		0.9			84.5	764	95	47.2	47.8		11.0	
IC2:																			
116	3-6	12.4*					0.5		0.9			89.7	783	150	45.2	45.9			
117	6-9.1	10.6*	(13.25)		4.95	57.02			0.9		1413	102	857	252	53.9	45.4		9.9	
118	9.1-12.1	7.2*			3.65	55.22			0.7			97.7	857	2350	62.0	44.5		746	
119-	30.1-	8.9*									1901	27.6	762	430	39.8	31.3		542	
121	39.6	6.8**																128.2	
122-	55.4-	6.0*										24.8	828	1660	42.1	32.1		544	
124	66.4	3.6**																162.0	
125-	95.3-	4.5*										31.6	809	1930	43.8	32.7		530	
127	105.1	1.9**																162.0	
128-	132.2-	3.1*			2.50	53.53					1661	31.6	826	2500	43.9	33.1		510	
130	142.3	1.1**																168.7	
131-	169.3-	3.8*										25.0	826	3060	48.7	36.7		496	
133	179.4	.8**																232.1	
134-	206-	2.9*			42.40	563					1510	35.9	821	2162	48.8	33.7		525	
136	216.3	1.1**																159.4	
137-	243.3-										2732							571	
139	253.8																	164.3	
140-	279.9-	4.0*			41.01	49.31					3758	40.0	849	2195	42.2	34.5		580	
142	288.9	1.3**																133.6	
143-	320-	1.5*			41.95	561					3623	31.1	856	2458	43.7	33.7		559	
145	329	1.1**																129.8	
146-	357-				41.68	49.67					3775	31.2	851	2276	45.3	33.9		571	
148	366	0.9**																123.7	

(Continued next page)

Core RC-23-06-4-17-PC2+TW2 (continued)

PN No.	Depth cm	SO ₄ mM	TA mcg/l	Cl mM	Ca mM	Mg mM	Fe μM	Mn μM	NO ₃ μM	NO ₂ μM	NH ₄ μM	PO ₄ μM	SI μM	H ₂ S μM	F ₂ μM	F ₁ μM	R ohm	P _s μmol/cm ³
149-151	395-404	0.7**	42.55		1.71	54.17					3990	41.3	905	2385	45.4	33.8	527	137.3
152-154	433-442	0.7**	42.98	567	2.06	52.07					3910	28.7	921	2604	45.7	34.1	612	139.0
155-157	471-480	0.7**	43.78		2.31	52.07					4148	25.3	882	2326	42.8	33.5	507	115.8
158-160	509-518	0.7**	41.86								4148	28.1	854	2684	43.6	33.7	593	140.6
161-163	548-557	0.7**		569	3.29	52.20					4119	31.9	875	2757	43.8	33.7	505	114.4

Description: very stiff black clay throughout, laminated.

*diluted 100X/25 ml
**diluted 500X 25 ml

***turbidity blank on samples 137-139, 149-151, 161-163, show absorbance equivalent to 3.5 mU: deep values are too high by at least that much.

Core RC-23-06-4-18-NS6 Lat 12-05.1 S Long 77-40.0 W Water Depth 203 m

Bottom Water Temp 14.0°C Recorder Temp 8-13°C Supernatant Temp Core Onboard ~48 hrs

PW No.	Depth cm	SO4 mM	TA meq/l	Cl mM	Ca mM	Mg mM	Fe μM	Mn μM	NO3 μM	NO2 μM	NH4 μM	PO4 μM	Si μM	HS μM	F μM	F μM	R olm	P S μmol/cm ³
96	0-1	27.3		581					1.4		279	27.3	558	No	65.4	63.5		1670
97	1-2.1	26.6		574					1.3		265	27.3	575	odor	64.9	60.8	579	567
98	2.1-3.3	28.1		575					2.0		257		570		64.1	60.3		947
99	3.3-4.5	28.0							0.8			25.7	556		62.6	58.2	685	748
100	4.5-5.5	27.9										23.9	525		56.2	54.1	805	1592
101	5.5-6.7	28.1										23.3	575		60.8	57.5		1719
102	6.7-7.7	28.4										23.2	577		60.4	57.9		1710
103	7.7-8.8	28.2										20.0	561		59.5	56.3	865	1348
104	8.8-9.8	27.9										16.4	558		56.6	53.0		916
**105	9.8-11.0	27.4		562					1.7		202	15.5	549		56.0	52.2	960	990
*106	11.0-13.1	27.8									182	14.9	544		53.3	50.8		1149
107	13.1-15.2	27.0										14.4	535		51.7	49.6	1127	1199
*108	15.2-17.3	27.8		572					1.5		157	12.7	514		50.2	48.2		1106
109	17.3-18.8	27.8									157							1670
*110	18.8-21.0			572							157							1628
111																		

Description: Wet, gritty, sandy black mud at surface grading into gritty stiffer clay with depth; gravel layer at bottom of core (~22 cm); containing P-pellets. Small nodules encountered at 11 cm and at 15 cm. 6-7 cm slice contained phosphatized fish bone. 10-12 cm slice contained fish debris. 18-20 cm slice contained several small P-nodules.

**fish debris - black
*nodules

Core IR-23-06-4-21-IRX6 Lat 12-05.0 S Long 77-39.5 W Water Depth 183 m

Bottom Water Temp 14.0°C Keel Temp 9-15°C Supernatant Temp Core Onboard 56 hrs

PN No.	Depth cm	SO ₄ mM	TA meq/l	Cl mM	Ca mM	Mg mM	Fe μM	Mn μM	NO ₃ μM	NO ₂ μM	NI ₄ μM	PO ₄ μM	Si μM	Al ₂ S ₃ μM	F ₂ μM	F ₁ μM	R olum	P _s μmol CH ₃	
Supernatant																			
Bottom Water																			
164	0-1-1	27.9	3.040		10.96	54.69	0.8		40.2	0.77	180.2	37.8	302	< 8	67.0	62.0		1.43	
165	1.1-2.3	28.0			10.55	54.66	0.8		29.2	0.60	226.8	19.7	419	< 8	66.7	61.5		1.23	
166	2.3-3.3	27.3	4.137		10.83	54.77	0.3		58.4	3.08	320.1	17.7	504	< 8	63.8	59.8	269	1.04	
167	3.3-4.3	27.1			10.29	54.87	0.3		26.3	0.78	381.6	19.0	560	< 8	63.5	58.2	265	1.58	
168	4.3-5.3	27.0			9.76	55.23	0.3		15.1	0.67	477.0	22.8	596	< 8	61.3	56.5		2.61	
169	5.3-6.4		5.699		9.95	54.34	0.1		10.6	0.48	530.0	26.3	633	< 8	59.2	53.9	275	2.61	
170	6.4-7.3	25.8			9.70	54.81	0.1		7.1	0.75	616.9	29.3	629	< 8	57.7	53.3		2.65	
171	7.3-8.2										701.7	32.8	698	< 16	57.4	55.0	281	3.46	
172	8.2-9.2	25.1	7.477		9.89	54.11			0.2		773.8	37.5	704	71	54.9	53.5		3.54	
173	10.2-11.1				9.51	55.00					867.0	37.5	718	170	55.5	55.2	274	2.17	
174	12.2-13.2	24.7			9.68	53.88			0		913.7	43.3	711	245	54.8	52.0		6.21	
175	13.2-14.2										1034.5	44.6	725	308	51.4	50.0		3.39	
176	16.1-17.1	23.8	10.058		9.75	53.20					1002.7	47.7	753	521	49.6	49.4	280	2.62	
177	20.0-21.0				9.34	54.15					1045.1	53.0	681	529	47.8	48.4	280	1.60	
178	23.0-23.9	22.0			9.16	54.74					1456.4	49.7	808	884	48.7	47.2	278	1.22	
179	25.8-26.8		13.867		9.61	53.81					1573.0	56.9	849	1114	47.9	46.9		1.47	
180	28.8-29.9	19.4			8.61	53.46					1679.0	65.3	820	1501	49.8	45.9		1.75	
181	31.9-33.1				7.95	54.70					1901.6	56.2	856	1564	49.4	45.2	268	0.53	
182	35.2-36.2	19.1	16.406								1992.7	67.0	854	1833	48.8	46		1.45	
183	38.2-39.2				9.51	51.85					1920.6	72.9	868	1857	47.0	46	277	0.51	
184	41.3-42.2	17.4			7.05	55.74					1986.4	76.8	856	2156	55.2	46		11.50	
185	44.3-45.3										2361.6	83.2	856	1951	53.0	46	326	8.89	
186	47.4-48.5	16.5	20.279		8.85	52.80					2408.2	83.3	808	2394	50.3	46		12.79	
187	50.6-51.6										2476.1	78.0	854	1967	51.6	46	342	11.43	
188	53.6-54.6		22.268		9.56	52.23					2119.9	90.6	859	2236	49.6	46		5.46	
189	56.6-57.6	14.3			7.91	54.04					2565.1	94.8	856	2504	50.1	46	364	9.12	
190	59.4-60.4				7.07	53.30					2741.0	94.8	838	2536	49.6	46		10.10	
191	62.5-63.8	13.3	24.615		9.64	52.55					2777.1	103.6	854	2267	52.9	46		12.99	

Description: 0-8 cm: black gelatinous mud, very soupy. 8-64 cm: grades downward into slightly stiffer, dark olive green/brown clay with obvious lamellations below 20 cm. 23-24: white flecks in mud, wispy appearance, sandy texture + elemental sulfur? (Reference subscore had white-colored layer at ~22 and ~38 cm.)