CRUISE REPORT R.D. CONRAD 23-05

June 18, 1982 Mark Langseth

The fifth leg of CONRAD cruise No. 23 was dedicated to the study of lateral distributions of geochemical gradients in sediment porewaters and geothermal gradients on the southern flank of the Costa Rica Rift. The underlying goal was to learn more about the circulation pattern of seawater in basement and its effects on chemistry and temperature. The study area is underlain by relatively young oceanic crust (circa 6 million years old) yet is rather thickly and uniformly covered by a blanket of sediment 250-280 m thick. This blanket of sediment traps most of the geothermal heat so that it must flow conductively through the sedimentary layer and can be measured easily at the seafloor. This conductive heat flow in the region is close to the theoretically expected value (200 mw/m^2).

Similarly significant chemical gradients have been established across the sedimentary layer between the underlying basement bottom seawater. DSDP drilling on Legs 68A and Leg 69 revealed a large lateral increase in the amplitude of these chemical gradients between drill holes 504B and 501. Thus our first study was in the vicinity of these drill holes to further map the variation chemical gradients and their correlation to the geothermal heat flux.

At hole 504B and 501 thermal observations indicated a significant down flow of seawater into basement. The pressure anomaly in basement that drives this flow is probably associated with water circulation systems within the basement. A basement outcrop about 15 to 20 miles southeast of the drilling site is one of the few in the area and consequently it was thought to be a likely place for the discharge of porewaters. Thus, a second study was undertaken near this basement outcropping.

The tools used for this study were: 1. the Pogo heat flow apparatus that can make closely spaced measurements of the temperature gradient on the seafloor, 2. long 16-17 m piston cores that

provided samples for porewater chemistry and physical properties measurements, and 3. single channel seismic profiling with water gun sources to map the accoustic reflectors in basement through out the region, and 4. accoustic bottom navigation system provided by Oregon State University.

The CONRAD left Callao, Peru to start the leg on May 30, 1982 and it ended in Quayaquil, Ecuador on June 18, 1982. The leg was shortened by approximately 8 days from the original plan because of time spent repairing the port main engine in Callao. This loss of time did not prevent us from achieving the major objectives of the leg. Two lesser objectives, one to study an area of very low heat flow measurements and the other to connect the high and low heat flow areas was dropped to allow time to study the 501/504 site and the site of basement outcrop more completely.

At site 501/504 ten three pipe cores (18 m long) were taken within an area 10 km by 3 km. Six of the cores, were taken along an E-W line that crossed the 504B to 501 sites. The other cores were taken off the line North or South to explore geothermal anomalies. Sixteen measurements of the geothermal gradient were made along the same E-W line extending from 5 km east of 504B to 8 km west of the site. A second line of 14 measurements was run south to north across the 504B site from 8 km south to 3 km north of the site. A third auxiliary line about 4 km long was run N-S across a geothermal and geochemical anomaly about 2 km west of 504B.

All of the cores and heat flow measurements were positioned using a bottom transponder accoustic net and a relay transponder on the core head. Physical properties including compressional wave velocity, thermal conductivity and gravimetric parameters were measured on several of the cores.

Lastly two short SCS lines were run over the E-W and N-S lines along which the measurements were made.

The results from the work are preliminary but the raw data are very suggestive:

1. The increase in certain geochemical gradients observed from drill hole 504B to 501 is associated with a geochemical and geothermal anomaly about 1.5 to 2 km west of these sites. The anomaly appears to be local and does not extend linearly in any direction for more than 1.5 km.
2. A second large geothermal anomaly about 1.3 kn south of 504B also has large calcium and magnesium gradients associated with it. This anomaly though close to the one mentioned above does not appear to be continuous with it.
3. A third geothermal anomaly was observed 7 km west of 504B, but no geochemical gradient was found associated with it; however, the core and thermal gradient measurement are separated by nearly 500 m.
4. Most of the area is characterized by heat flow close to the theoretically expected value and no significant gradients in calium or magnesium.

At the outcrop site we made two lines of Pogo geothermal measurements one in a N-S direction across the basement outcrops and the second east west along the crest of the highest scarp.

These measurements showed the heat flow in the vicinity of the outcrops to be anomalously low relative to the theoretically expected value. However, there were two spots along the crust of the scarp where high heat flow was measured. At one location the high was indicated by a single measurement, and several measurements nearby all yielded low values. At the second location the gradient was high (4 times the theoretically expected value) and two nearby measurement were 2 times and 3 times the theoretical value.

This was a genuine "warm spot". We took three 11 m cores all aimed at the "warm spot". Two of the cores showed a spectacular stratigraphy. At the top was a soft greenish-gray foraminferal ooze similar to that found every where at site 504B. The Worzel Ash, which occurred at 8-10 m at 504B, was at 2 meters at this site. Deeper in the core the greenish hues gave way to tans and yellows. This coloration change was not seen in 504B cores or in the DSDP drill cores. It represents an oxidation state change in the sediment. Deeper whitish and tannish chalk that is quite firm is found with thick bands of manganese material between. In core #20 there may be two ash layers in the chalk below the manganese layers. These manganase layers appear to have been formed in-situ.

Curiously the chemistry of the porewater is essentially that of seawater. We had expected to see a strong gradient reflecting the high temperature and highly altered basement at a relatively shallow depth. At one of the core sites (Core #22) we made simultaneous measurements of the thermal gradient which was high (0.66C^{o}/m) so that the core was definitely in the warm spot.

The significance of this lack of chemical signature is not known at this time. It may indicate that the warm spot developed rather recently and not enough time has elapsed to establish a chemical gradient which takes much longer than a temperature disturbance to diffuse thru the sediment. Alternatively seawater somehow has penetrated into the upper sediments. Much more has to be learned about these interesting cores before conclusions can be drawn.

A third core (Core # 21) which was also probably within the warm spot thermal anomaly contained 11 m of greenish gray ooze. No chalk or manganese was found. No chemical gradients were found in this core either.

Other studies that were carried out included 4 long N-S single channel seismic lines running from the high to the low heat flow area. These were made using the water guns and provided a good display of accoustic reflectors within the sedimentary layer. We hope that these can be used to trace temperature-related diagenetic zones over the area.

We made two sonobuoy experiments:

1. to obtain the far field signature of the water guns and
2. to obtain the crustal structure at site 504B. Both buoys were recorded digitally on tape.

This summarizes the results of the leg which we feel provided a valuable new insight into thermally driven water circulation in older (6-7 M.Y. old) oceanic crust and how it affects the chemistry of the sediments and basement. The thermal and chemical anomalies that we mapped in the vicinity of drill sites 501/504 most probably reflect upwelling zones of water circulating in basement. Our study shows that these anomalies are rather small in areal extent (11 cm diameter) and isolated.

The anomalies we think are associated with plume like upwelling of warmer water that results in higher temperatures and increased alteration in the upper part of basement. The circulation does not penetrate the sedimentary larger.

The large scarp where basement outcrops to the south of the site 501/504 is probably not the place where water that is drawn into the DSDP drill holes discharges. Rather the geothermal survey over the scarp shows that predominantly water is drawn into basement along the scarp as it is in many other regions of the ocean. However, we found two small areas along the brink of the scarp where much higher temperature water is being discharged.

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The "warm spots" were mapped in some detail with geothermal measurements. They are small in areal extent comparable to the zones in the 501/504 area and are surrounded by depressed heat flow suggesting draw down over these zones. The high temperature water brought up at the warm spots produce profound diagenetic charges in the sediments at shallow depth. These extraordinary features are rather similar to the mounds found much closer to the axis in Glapagos spreading center and deserve further detailed study.

SCIENTIFIC COMPLEMENT

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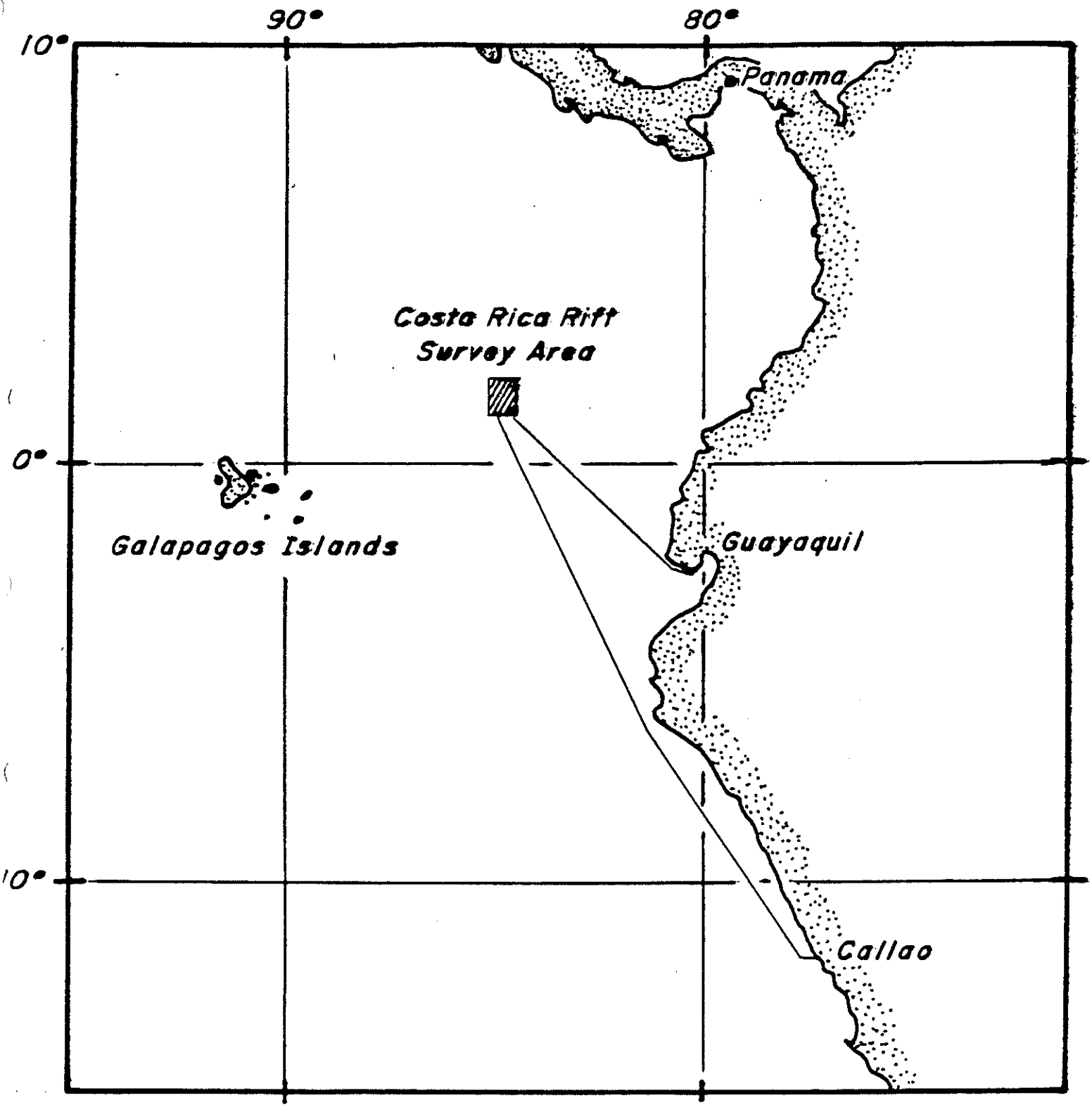
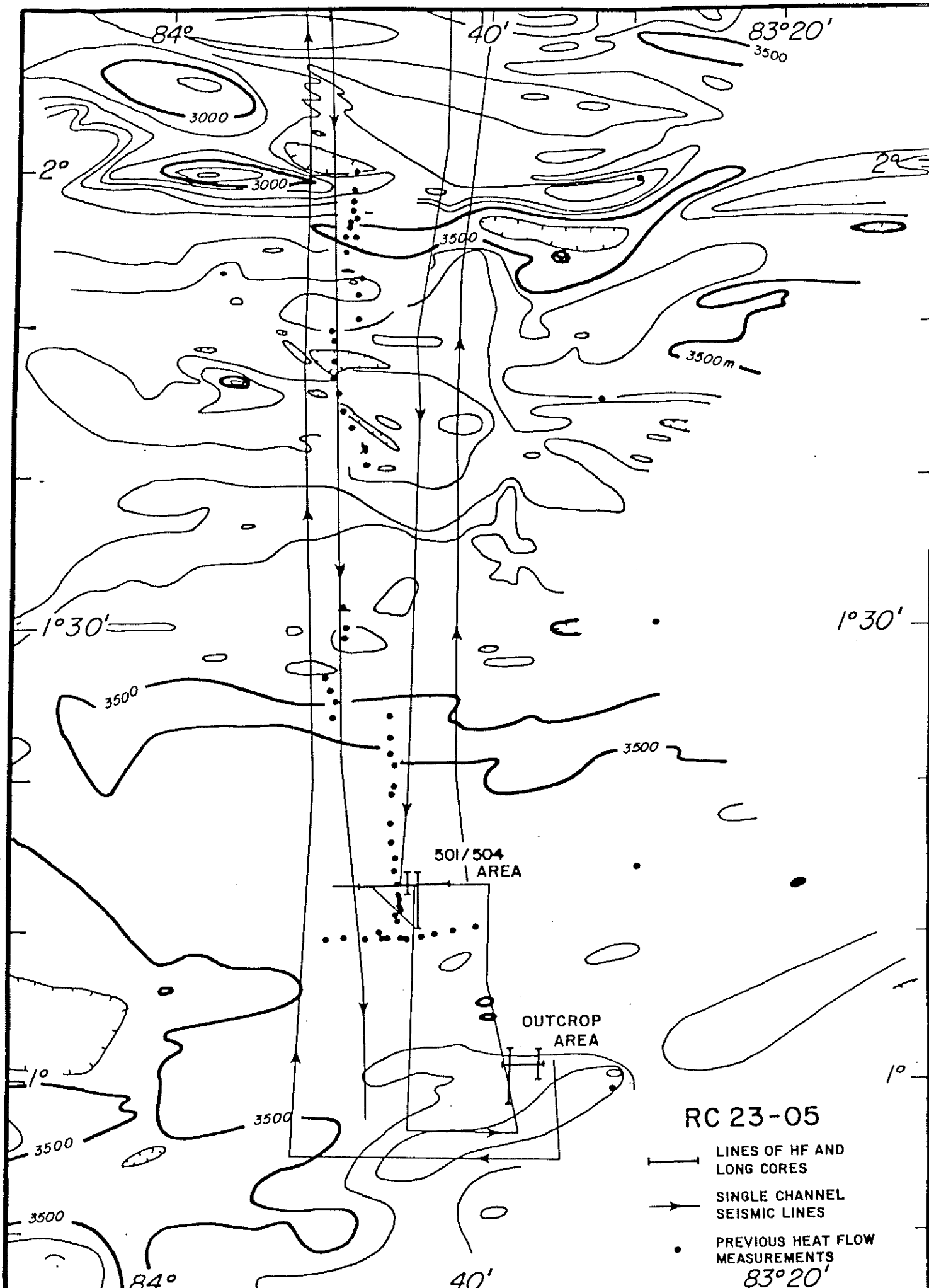
7.	Margaret Sulanowski	WHOI	Geochemistry
8.	Dale Goehringer	WHOI	Geochemistry
9.	Milo Clausen	Sonotech/OSU	Bottom Navigation
10.	William Rugh	OSU	Bottom Navigation
11.	Colin Bateman	L-DGO	Technician
12.	Emily Homonoff	L-DGO	Computer Specialist
13.	Martin Iltsche	L-DGO	Mechanical Specialist
14.	Ropate Maiwiriwiri	L-DGO	Oceanographic Technician
15.	Howard Giddy	L-DGO	Oceanographic Technician


90°
80°
10°
Panama
Costa Rica Rift
Survey Area
0°
Galapagos Islands
Guayaquil
10°
Callao


84°
40'
83°20'
3500
3000
2°
3000
3500
3500m
1°30'
1°30'
3500
3500
501/504
AREA
OUTCROP
AREA
1°
1°
3500
3500
3500
84°
40'
83°20'
RC 23-05
LINES OF HF AND
LONG CORES
SINGLE CHANNEL
SEISMIC LINES
PREVIOUS HEAT FLOW
MEASUREMENTS

RC23-05

Name Station list. No. Experiment No.
(Master)
Instructor Date

CUB 82

Ship STAT. #		Type		#		Date START	END		
16		CORE		10		JUN3			
		CORE		11 ✓		JUN4			
		HEAT FLOW		11 ✓		JUN 4	JUN 4		
17									
		CORE		12 ✓		JUN4			
		HEAT FLOW		12 ✓		JUN5	JUN6		
		CORE		13		JUN6			
		CURE		14		JUN7			
18		HEAT FLOW		13 ✓		JUN7	JUN 8		
		CORE		15 ✓		JUN8	JUN8		
		CORE		16 ✓		JUN8			
		HEAT FLOW		14 ✓		JUN8	JUN9		
19		HEAT FLOW		15 ✓		JUN9	JUN10		
		CORE		17 ✓		JUN 10			
		CORE		18 ✓		JUN 10			
		HEAT FLOW		16 ✓		JUN10	JUN 11		
20		CORE		19		JUN 11			
21		HEAT FLOW		17		JUN12	JUN 13		
22		HEAT FLOW		18		JUN 13	JUN 14		
		GORE		20		JUN 14			
		HEAT FLOW		19		JUN 14	JUN 14		
		CORE		21		JUN15			

RC 23-05

Name STATION LIST (CONT.) No. Experiment No.

Instructor Date

CUB 62

SHIP STA #		Type		#		Date		
						START	END	
23		CORE	~~22~~	22		JUN 16		
		HEAT FLOW (ON CORER)		20		JUN 16		

Name Seismic Lines No. Experiment No.

Instructor Sonobuoys Date

CUB 62

Line #		ON HOUR GMT	DAY	OFF HOUR GMT	DAY	REMARKS
1		0148	JUN 2	0500	JUN 3	RUN INTO SURVEY SITE.
2 & 3		0130	JUN 5	2000	JUN 5	Two N-S lines from 1° to 2°
4		1118	JUN 7	1742	JUN 7	Two lines SOUTH-NORTH ove OUT CROP AREA.
#5		0624	JUN 11	1230	JUN 11	CRISS CROSS SURVEY OF AREA 504B.
6		0445	JUN 15	0812	JUN 16	TWO N-S lines from 1° to 2
#7		2324	JUN 16	0306	JUN 17	Sonobuoy run at 504B AREA.
SB# 7		1500	JUN 2	1722	JUN 2	RUN for water gun for field signature
SB# 8		00	JUN 17	0300	JUN 17	2 AIR GUN SB ON E-W line cross 504B SITE