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CRUISE REPORT

Ship Name: ROBERT D. CONRAD

Cruise No: 21, Leg 17

Departure: December 16 at 1307 (Date) from Balboa (Port)

Arrival: December 31 at 1805 (Date) at Balboa (Port)

Days at Sea: 15
(Count day of departure but not day of arrival in port)

Days Foreign Port: 8
(number of days in arrival port before next leg)

Area of Operation: Southern flank of Costa Rica Rift, Gulf of Panama

Program Description:

Survey of drill sites in the Costa Rica Rift

Program supported by what contract: IPOD Scope L

Participants: (All L-DGO unless otherwise specified)

Name	Title
Marcus G. Langseth	Chief Scientist
Bruce M. Herman	Grad. Student
Michael A. Hobart	Heat Flow
David Holland	OBH Techn.
Martin Iltzsche	Air Gun Technician
Dwight Mossman	Electronic T.
Charles Salcedo	Gravity
Arnold Stein	Electronic Technician
Robert Suozzo	Computer Technician
Wm. Van Steveninck	Heat Flow

All inquiries regarding cruise should be made to the chief scientist.

Preliminary Science Report

R.V. CONRAD Cruise 21, Leg 17

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The objective of this leg was to survey an area on the flank of the Costa Rica Rift which will be drilled on Leg 68 of the GLOMAR CHALLENGER. The objective of Leg 68 is to drill into recent oceanic crust where the water circulation is completely cut off, or is confined to the crust beneath a sedimentary blanket. As a consequence, the emphasis of our geophysical program was on seismic reflection studies of the thickness and extent of sedimentary deposits, the distribution of seafloor heat-flow at the scale of one km or less, and the seismic properties of the upper crust.

The area of principal interest lies between the parallels of 1°10' and 1°30'N and the meridians 83°40' and 84°W. Our grid survey showed that the basement is irregular but with a low relief and is covered everywhere with a blanket of sediments about 250 meters thick. The seismic reflection profiles run along east-west courses showed strong side echos from the basement out to ranges of 7 to 9 seconds, whereas these were nearly absent on the north-south runs. This indicated that the basement topography is strongly lineated in an east-west direction, with numerous continuous scarps and ridges. Many of these scarps appear to be produced by normal faulting of the crust. The sedimentary cover is conformably draped over these basement scarps; and, in only a few instances, is its acoustic layering disrupted by the faults.

Geothermal Observations:

Lines of closely spaced heat-flow measurements in the area were the main focus of our survey. A north-south line, about 50 miles long, was surveyed and, at its southern end, this line was crossed by an east-west traverse about 16 km long. These measurements showed the gradients in the sediments to be about 0.25°C/m and extremely uniform along the traverses. At only four of the 29 penetrations did we find significantly higher values, up to 0.36°C/m. These were isolated occurrences. No relatively low gradients were observed.

The age of the oceanic floor in the survey area has been well established by particularly well developed magnetic lineations in the Costa Rica Rift. The area is located over the southern edge of Anomaly 3, which corresponds to an age of 5.5 to 6 m.y.b.p. Theoretical cooling models of the oceanic lithosphere predict a heat flow of 179 to 192 mW/m^2 in the area. The mean value in the survey area is about 182 mW/m^2, or almost exactly what is expected theoretically.

At each penetration five temperatures are measured in the sediments and at all of the stations the temperature profiles fitted a straight line within the limit of errors of temperature difference measurements. These results indicate that heat flows by conduction through the crust and the overlying sediments, and water circulation play a thermally insignificant role. The few high gradients (about 50% higher) may be due to the local upward flow of warmer waters along fractured zones in the crust to the base of the sediments. The geothermal regime in the survey area contrasts markedly with those recently surveyed on the flanks of the Mid-Indian Oceanic Ridge and the South Mid-Atlantic Ridge, where gradients in the sediments showed large and oscillatory variations with distance. In addition, many temperature profiles measured in the MIOR and MAR flanks were not linear; which has been interpreted as evidence of thermally significant water flow through the sediments. There is no evidence for a similar flow of water through the sediments on the flanks of the Costa Rica Fift.

Seismic results: Numerous sonobuoys were launched in the area using two Bolt airguns as a source. Profiles covering the lines of heat-flow stations were made and a series of sonobuoy refraction profiles parallel to the rift were shot along 1°10', 20', 30', 40', and 50' north latitude. Where the sedimentary cover was thick, the refraction results were exceptionally good with ground wave arrivals out to 15 seconds (probably mantle critical reflections) and very strong shear-wave arrivals. The results of these buoys should yield excellent information on the velocity of the crust for both P and S waves and an estimate of Poisson's ratio.

An Ocean Bottom Hydrophone was dropped at 1° 09'N and 83° 45'W. A 40 mile line including 20 miles of airgun shots and 20 miles of explosives at longer range was made over the instrument. The shooting line was from west to east and formed a split profile over the OBH. Two sonobuoys were also launched along the line. Unfortunately, the OBH did not return to the surface. The preset timer turned on the OBH's pinger at 2000 hrs but the unit remained on the bottom. Although the seafloor sediments are very soft in the area and there is the remote possibility that the pressure case and release umbilical were buried in the sediment, it seems more likely to me that the release mechanism did not fire properly. We were in the general area of the OBH nearly 24 hours after its scheduled release time and it was still forlornly chirping on the seafloor. This accident was a great loss of time, data and effort.

The Transition Zone:

The last few days of the leg were spent surveying an adjacent region to the north, closer to the active spreading axis where the sedimentary cover is much thinner and the basement relief much greater than in the prime area. We began work at about 2°N, see Figures 1 and 2. A north-south traverse of 22 temperature profile measurements yielded much lower values; some gradients were only 5% of those measured farther south and they were highly variable. Clearly, in this area the heat is being carried away by water circulation in the crust. The expected heat-flow in the region is about 220 mW/m^2; whereas, the average of 12 measurements along one line is 50 mW/m^2!

In other flank areas similar to this one we have seen evidence for water circulation upward through the sediments. However, at all penetration points in the survey area, the profiles of temperature in the sediments were linear within the errors of measurement. Two explanations can be put forward to explain the observations:

1) Water is advecting downward through the sediments at thermally significant rates of approximately 10^{-6} cm/sec, and/or
2) the lateral flux of seawater through the crustal rocks from areas of exposed rocks is great enough to maintain exceptionally low temperatures at the base of the sedimentary layer.

All of the temperature profile measurements in the survey area, when combined into a single profile show an extremely interesting pattern. At the southern end, i.e. within 20 km of 1°10'N, the agreement of the heat-flow values with what is theoretically expected indicates a heat transfer by conduction dominates and that the sediments have reached thermal equilibrium with the deeper mantle material. Fifteen km farther north, the heat-flow values begin to depart significantly from the theoretical and the discrepancy increases gradually northward. At the northern end of this segment of the line, values show that the sediment is clearly not in equilibrium with the lithosphere. The smooth transition between 20-45 km suggests a gradual reequilibration of the sediments from a highly disturbed thermal regime in younger crust to the north to the conductive region in the south.

The northern segment of the profile is characterized by large variations and values well below what is expected theoretically. Here water circulation in the oceanic crust and possibly through the sediments is dominating the heat transfer. This circulation and its effects must stop or at least be greatly reduced in the vicinity of 45-60 km. This gap unfortunately could not be filled due to time limitations.

We took two, two-pipe cores, Core #17 and #18 and detailed conductivity measurements, one every 20 cm, were made along the length of each. The conductivity was generally very uniform.

Sonobuoys launched in the region north of 30'N failed to yield the strong shear wave arrival that characterized those farther south. All buoys suffered more from topographic irregularity than those made in the more thickly sedimented region to the south. It is likely that the change in character of the sonobuoy records resulted from the change in sedimentary thickness than a change in the properties of the upper oceanic crust.

Geothermal surveying in the region between 1°N and 1°20'N reveals a place where young crust (about 5.5 m.y.) has been sealed against water flow. A reentry hole positioned anywhere between the position of DHF 14-F and DHF 15-H (from 12-15 km on Figure 2) should encounter good drilling conditions in the crust and pervasive mineralization in fractures and pores in the rock. Temperatures of about 65°C will be encountered at the base of the sedimentary layer and a vertical gradient of about 10°C/100m is expected in the crust.

Single-bit holes could be used to sample other attractive targets such as:

A 100-200 m crustal sample over a spot that has anomalously high heat-flow e.g. at 6 or 17 km. The objective would be to see if the crust is more porous and if higher temperature water of up to 90°C exists at the base of the crust. Is circulation continuing below these warm spots?

A deep single-bit hole should be drilled in the well determined low heat-flow region between 88 and 93 km on the profile. Here the crust should be porous and open and drilling difficulties may be encountered. Temperature measurements, in situ permeability measurements and water samples should be the major objectives of these holes.

A fourth hole in one of the relative heat-flow maxima, e.g. at 78 km or 63 km, should be made. Here crustal temperatures and the chemistry of interstitial water are the important objectives.

Lastly, a hole to sample the basement in the reequilibration zone would be extremely urgent to test the hypothesis that the heat-flow trend represents a transient condition. The rate of this reequilibration can set constraints on the processes of thermal recovery and the thickness of crust involved.

Operation of the Scientific Equipment on CONRAD Cruise 21, Leg 17

Underway geophysical gear (PDR's, magnetometer, gravimeter and the profilers) all seems and looks very old and tired, but generally it generated valid data . The chart recorder for the magnetometer is due for replacement. The mechanical parts and the slide wire potentiometer are worn to the hub and the amplifier is barely operating. The cable towing the sensor fish is too short and as a result there is a large ship effect.

The gravity equipment operated well during the leg. However, there is some question as to whether the cross-coupling sensors and circuitry were operating properly. The cross coupling effect is about 15% of the mean beam deflection. A check (recommended by Dan Hutchinson) of the surge-beam deflection multiplier and filtering circuit showed it to operate as expected. I do not remember the cross-coupling being such a strong function of the mean beam deflection and am still suspicious that something is not right.

The profilers operated normally (Profiler "A" occasionally gave a compressed stylus traverse) and the airgun and streamer gave few problems during the leg. The large airguns were used for sonobuoys and they operated well under Martin's intensive care. The sonobuoys also gave excellent results. In large part, this was because we were in an area of calm seas and good propagation characteristics in the crust. The PDR's are all but worn out. The mechanical operation is marginal, sticking stylii belts, sickly noises emerging from the inside and frequent stalls were some of the symptoms.

During the last few days, the 3.5 kHz gave very noisy records in very calm weather. Some of the noise sound is like water noise at the transducer.

We used the UGR recorder to good advantage for the digital heat-flow stations and also to make 5-second sweep profiles in the survey area. This seems like a very good piece of equipment. Sufficient spare parts for the UGR should be sent to the ship to keep it operating.

Data Logging and Computers:

During the last four days of the leg we logged data from maggie, gravity, and navigation on the Tectronix 4051 successfully. The problems of inputing the gravity and navigation parameters into the 703 interface have been solved by an additional interface box with differential and balanced inputs for each channel, designed and built by Wm Van Steveninck. Whether the system can be made to operate reliably day and night as part of the data acquisition

CORRECTIVE ACTION REQ'D

FOR FULL IMPLEMENTATION OF THIS SYSTEM

BY FEB 23 '79

JOHN LABRECQUE AND C? WINDISCH - WILL YOU PLS GENERATE A SCHEDULE system remains to be seen. At the least, the 4051 should be in a more favorable and better controlled environment. The interface box and the interface box <u>interface</u> needs layout design work

To date, no utilization of the data being acquired has been attempted. Operation came much too late to help us with the surveying. The utilization aspect of the computer operation should receive immediate attention, or it will become neglected and ignored <u>once again</u>. In my opinion, this system <u>does</u> appear to be something that we can build on. An effort in this area needs to be made <u>now</u>.

<u>Station Work</u> :

The ability to do station work continues to diminish leg by leg. The space for work on the afterdeck was further decreased and knee bruising obstacles increased by the addition of the MIT shack. The increasingly cramped conditions, not only subtract from the work space, but significantly increase the amount of time and effort to set out and reel in the gear for stations.

The trawl winch and coring apparatus are being well maintained by the 3rd mate, Howard Biddy. Right now, he is a one man show. For long stations, such as the POGO heat-flow measurements (about 12-15 hours) Howard does the whole job. If there is a core to be taken after a POGO, we are simply out of personnel. Although Howard says that he is willing to keep going until the job is done, the chief scientist is nonetheless limited on humanitarian grounds in what he can ask Howard to do. A second person to help with the heavy operation and who can also relieve on the core winch is required for closely spaced station work.

SAM - YOUR RECOMMENDATION PLS.

There are few supplies on board for handling or describing the cores. This situation would no doubt improve with a regular coring program and core describer on board. After considerable searching, I stumbled upon the stapling gun and coretube caps in the forward rocket magazine.

Large packets of storage space are being gobbled up by the MCS operation and/or ship supplies. It is very difficult to find space for other programs either on the deck or in the holds.

<u>Heat-Flow Equipment</u>: The digital heat-flow equipment again worked perfectly throughout the leg. The major problems with using the equipment effectively reside in maneuvering the ship to a desired location. This takes a long time, about 1.5 hours to move a mile, and accurate navigation of the measurement points.

The technical staff is leaving at the end of this leg with the exception of Charles Salcedo, so that there is not much need to assess their performance. They are all competent and agreable persons, eager to help and they keep the equipment as well as can be expected.

Buoys: We expected to use buoys as a secondary navigational aid during the heat-flow POGO station. Our plan before the cruise was to moor the buoys to the bottom using polypropylene line tied to junk automobile engine blocks. We bought the engine blocks in Panama at an inflated cost, $52 each. However, the long length of polypropylene line did not arrive; and, there was insufficient line on board to make even one buoy. Instead, we made drogue buoys, using some ancient sea anchors that were on board the CONRAD.

The buoys consisted of four sonobuoy cases, weighted with 25 lbs of cement on the bottom and sealed. An 18 inch wooden staff with radar reflectors was placed on top and at the bottom of the staff 300 ft of BT wire was secured, then 2400 ft of 1/4 in polypropylene line. The sea anchor and 100 lb lead weight were attached to the bottom. We launched two buoys and they set up quite well. Strong radar reflections could be seen out to 9.5 miles, despite considerable sea clutter. However, tracking of the buoys over a 24 hour period showed that they drifted much too fast (about 0.2 knots) to the SSW to be of much use for a three or four day program. We lost track of the southermost buoy after one day and decided not to chase it down. The other buoy fell over when the BT wire loop, at the base of the spar, chafed through and the sea anchor fell away. We retrieved and reset this buoy with 600 ft of BT wire; but, it seemed to drift faster if anything. Actually it drifted faster than the ship. This experience taught us a lot about making buoys. In some areas drogue buoys, if rugged enough, would work. But, in this equatorial region, the currents at all levels are just too fast. As a consequence, only for the first two stations were the buoys used as an aid to navigation. Their drift rates could not be predicted with enough accuracy to make them useful in real time as an aid. This was mainly due to the sparcity and inaccuracy of the satellite fixes.

Bottom moored buoys could probably be used with considerable success. But, bottom navigation is absolutely essential for precise positioning of heat-flow measurements and sampling.