R. Leyden

Lamont - Doherty Geological Observatory of Columbia University | *Palisades, N.Y. 10964*

Cable: LAMONT, Palisades, New York State

Telephone: Code 914, Elmwood 9-2900

Twx: 710-576-2653

CRUISE REPORT

Ship Name: R/V VEMA Cruise No: 3409

Departure: 2 November 1977 (Date) from Seychelles (Port)

Arrival: 7 December 1977 (Date) at Mauritius (Port)

Days at Sea: 35 Days Foreign Port: 2

No. of days in arrival port

Area of Operation: Crozet and Madagascar basins - Central Indian Ocean

Program Description:

see enclosed

Participants: (All L-DGO unless otherwise specified)

R. N. Anderson, Chief Scientist
Malakai Banuve, Core O.S.
Michael Hobart, Heat flow
Dallas Menke, Computer Tech.
William Menke, Computer Tech.
Brian Mossman, E. T.
Brian Ostrowski, E. T.
Robert Petersen, E. T.
Ropate Qali, Core Bosun
Mark Roth, Core Describer
HEctor Smith, Airgun
Wm. Van Steveninck, Heat flow

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

V34-09

PROGRAM DESCRIPTION

We have conducted four detailed surveys in the Indian Ocean (Fig. 1) in order to delineate the convection pattern and to determine the mechanisms responsible for the transition from convective to conductive heat flow in the sea floor.

Open Convection in 18 m.y. Crozet Basin Seafloor

Survey one is located on anomaly 6 in the northern Crozet Basin. An area of unusually smooth seafloor was chosen so that penetration of our heat flow instrument with its 5 m lance could be obtained in a sedimentary cover of only 5 to 10 fathoms of marl, clay and volcanic gravel. Measurements were made both along and across isochrons to test for three-dimensionality of the convection pattern. Nine heat flow measurements, each with an $\sim$1 km spacing across isochrons, yielded an oscillatory convection pattern with an approximately 5 km wavelength similar to that observed on the crest of the Galapagos Spreading Center (Williams et al., 1974). One measurement on the top of a small hill was non linear. All but one measurement were below the theoretically predicted heat flow value for this age seafloor. This observation indicates that more than half of the total heat flow into the oceanic crust is being convected directly to the water column and is simply not measured by our conductive experimental apparatus. Two surface probes measuring the thermal gradient in the upper 20 cm of the mud indicate that the linear thermal gradients do not deviate by as much as 005°C from linearity.

The second profile in survey area one was along strike of both the topographic relief and the isochrons. Again an oscillatory pattern was

measured but a) the amplitude is only one half that of the profile across the isochrons, b) the wavelength is 20 km, c) seven of eleven thermal gradient measurements were non-linear, and d) six have convex shapes - indicative of upward water discharge but one indicates flow of water downward through the sediments in a convective recharge area.

Closed Convection in 25 m.y. Crozel Basin Sea Floor

Survey two is in 25 m.y. old sea floor of the Crozet Basin in an area of subdued topography with 20 fathoms of clay and minor marl constituting the sediment cover. Seventeen measurements along a 30 km profile across isochrons shows an oscillatory pattern of heat flow of varying wavelength (5 to 15 km) with the mean of all the measurements approaching the theoretical prediction for this age of seafloor. Thus, the convection pattern appears closed to exchange of fluids between the oceanic crust and the bottom water. Yet seven non-linear gradients (all convex) indicate that some circulating fluid is discharging through the sediment cover. We interpret this survey area as one of predominantly closed convection in the oceanic crust with an impermeable lid of clay capping or isolating the crustal convection system from the ocean. Here, as in the earlier survey, the zones of upwelling and downwelling do not appear to correspond to topographic highs or lows but the non-linear gradients appear to occur in the transitions from high to low heat flow. The value of thermal gradient chosen for non-linear heat flow measurements is a straight line fit between the surface temperature and the deepest thermal probe value.

Closed convection in 45 m.y. Crozet Basin

Survey three is an area of rougher topographic relief near anomaly 17 in the central Crozet Basin. The sedimentary cover is 100 m of clay blanketing all basement relief. The convection pattern crudely outlined by this small survey of 8 measurements has a mean approaching the theoretical value for this age sea floor and a wavelength of $\sim$5 km. The two linear gradients recorded at this site were associated with small sea floor depressions.

Closed convection in 55 m.y. Madagascar Basin

The oldest survey area (four) is also the roughest and the most thickly sedimented. More than two hundred meters of deep sea clay blanket all basement. Here, thirteen measurements yielded four non-linear gradients, again in transitions between the high and low heat flow values of an oscillatory convection pattern with a mean equal to the theoretical and a wavelength of 20 km.

R N Anderson

Roger N. Anderson

Chief Scientist

S 193	12 NOV	C 136	TG 23A	
S 194	12 NOV	C 137	TG 23	
S 195	13 NOV	C 138	TG 24	
S 196	14 NOV	C 139	TG 25A,B,C.	
S 197	14 NOV			DHF 1
S 198	15 NOV			DHF 2
S 199	15 NOV			DHF 3
S 200	16 NOV			DHF 4
S 201	16 NOV			DHF 5
S 202	17 NOV	C 140	TG 25D	
S 203	23 NOV			DHF 6
S 204	23 NOV			DHF 7
S 205	24 NOV			DHF 8
S 206	25 NOV	C 141	TG 25	
S 207	25 NOV			DHF 9
S 208	28 NOV			DHF 10
S 209	28 NOV	C 142		
S 210	1 DEC			DHF 11
S 211	2 DEC	C 143	TG 26A	
S 212	2 DEC			DHF 12
S 213	3 DEC	C 144	TG 26	

SB 75A-82