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CRUISE REPORT
R/V CONRAD 28-06

SCHEDULE: The original schedule was to be from June 7, Recife, Brazil to July 11, Fortaleza, Brazil. Because of a mechanical breakdown and a medical emergency the cruise schedule ended up to be:

Leg 1	Depart	June 7,	1987	Recife, Brazil
	Return	July 3,	1987	Recife, Brazil
Leg 2	Depart	July 4,	1987	Recife, Brazil
	Depart	July 21,	1987	Fortaleza, Brazil

INCLUSIVE DATES: June 6 to July 22, 1987

DAYS AT SEA: 44

DAYS IN PORT: 3

RESEARCH IN FOREIGN WATERS: Sixteen dredge stations recovering volcanic rocks, high resolution bathymetric surveying (Seabeam) and underway gravity data were collected within a radius of 200 nautical miles of St. Peter and Paul's Rocks, Brazil, in the period of July 10 to 15, 1987.

PARTICIPATING PERSONNEL:

(1) Scientific Party:

Schilling, Jean-Guy	Chief Scientist	U.R.I.
Botros, Mona*	Graduate Student	U.R.I.
Riebesell, Ulf*	Graduate Student	U.R.I.
Quigley, Joseph C.*	Geologist	Brown Univ.
Botros, Peter, F.*	Student	Queen's University, Canada
Senglet, Martine**	Student	Univ. of Geneva, Switzerland
McCully, Brian, L.	Geologist	U.R.I.
O'Rourke, Mark, E.	Technician	U.R.I.
Cambon, Pierre, M.	Chemist	IFREMER, France
Edwards, Randy	Technician	U.R.I./NECOR Seabeam
Thekkethala, John, V.	Technician	U.R.I./NECOR Seabeam
Smith, James, A.	Science Officer	LDGO
Maiwiriwiri, Ropate, Q.	Technician	LDGO
Dibernardo, John, G.	Technician	LDGO
Blaes, Robert, J.	Technician	LDGO
Robinson, Frank	Technician	LDGO

* Disembarked July 3 in Recife because of extension of the cruise.
**Disembarked July 3 in Recife for medical reason.

(2) Ship's Company:

Roberge, Patrick, R.	Master	LDGO
Mello, Lewis, J.	Second Mate	LDGO
Young, Ian, W.	Second Mate	LDGO
Collins, Edmund, M.	Third Mate	LDGO
Santini John, J.	Bosun	LDGO
Heinze, Blaine, A.	A/B	LDGO
Bagwell, Samuel, W.	A/B	LDGO
Nolan, Timothy, J.	A/B	LDGO
Bugeuno, Herman, E.	A/B	LDGO
Olander, Hans, P.	O/S	LDGO
Berg, Niels, E.	Obs. Ch. Eng.	LDGO
Nissen, Paul, A.	First Asst./Engr.	LDGO
Tucke, Mathew, S.	2nd Asst./Engr.	LDGO
Peterson, Michael, A.	3rd Asst./Engr.	LDGO
Uribe, Guillermo, F.	Oiler	LDGO
Brow, Robert, F.	Oiler	LDGO
Spruill, Michael, L.	Oiler	LDGO
Price, Pamela, W.	Steward/Cook	LDGO
Paloney, Frank	Galleyman/Cook	LDGO
Moqo, Luke	Messman	LDGO
Mitchel, Susan J.	Messman	LDGO

PROJECT TITLE: Petrological and geochemical variations along the Mid-Atlantic Ridge in the Equatorial Region (3°S to 7°N)

PRINCIPAL INVESTIGATOR: Jean-Guy Schilling, Graduate School of Oceanography, University of Rhode Island, Kingston, RI, 02881

FUNDING AGENCY: National Science Foundation, Division of Oceanography, Marine Geology and Geophysics.

GRANT NUMBER: NSF: OCE 8608626

PRIMARY OBJECTIVES: Rock sampling along the axis of the Mid-Atlantic Ridge from 3°S to 7°N, including segments within and between the mega equatorial fracture zones. The petrology, geochemistry and isotopic composition of these rocks will subsequently be studied in the laboratory for the purpose of :

(1) Defining further the thermal imprint that fracture zones of varying offset lengths may have on the composition, melting conditions, budget and mode of magma emplacement along the mid-ocean ridge system.

(2) Investigating on a larger scale whether such thermal effects tend to integrate and generate broad coldspots in the upper-mantle in the case of closely spaced fracture zones with large offsets, such as in the Equatorial Atlantic.

(3) Studying the degree, nature and length-scales of heterogeneities present in the upper-mantle and its dynamical state; and further test existing models

on the subject, such as the hotspot source - migrating ridge sink model versus stochastic models.

ANCILLARY PROJECTS:

(1) The cruise was part of a long term informal and internationally coordinated and cooperative effort of sampling the Mid-Atlantic Ridge along its entire length. Participating in this project are Dr. H. Bougault, IFREMER, Brest, France and Dr. L. Dmitriev, Vernadsky Institute, Moscow, USSR. IFREMER provided their XRF-laboratory container which was operated by Pierre Cambon during Leg I. Drs. Bougault and Dmitriev were scheduled to participate in the cruise, but had to cancel their participation within a month of departure.

(2) Phytoplankton sinking rates in the Equatorial Atlantic (Leg I). Investigator: Ulf Riebesell, sponsored by Dr. T. Smayda and Dr. J-G Schilling, all at the Graduate School of Oceanography, University of Rhode Island, Kingston, R.I, 02881.

BREAKDOWN OF OPERATIONS:

	Days
Transit*	23.0
Underway Geophysical Surveying**	10.5
Stations (rock dredging)	8.5
Total	44.0

* Includes 14 days of additional transit due to a mechanical/electrical breakdown and a medical emergency.

** Primarily continuous high resolution, mutichannel bathymetric surveying (Seabeam), 12 and 3.5 kHz single channel profiling and underway gravity data collection, and part of the time total magnetic field intensity recording.

PRELIMINARY RESULTS AND NARRATIVE:

Figure 1 provides the ship tracks followed during the cruise. Seabeam bathymetric surveying was continuous along these tracks, except within 200 nm of the coast of Brazil where no recording took place. Figures 2 and 3a to 3c show the location of the 59 dredge stations occupied and their relationships to the tectonics of the region, and our update on where the Mid Atlantic Ridge axis lies in the region based on the sea beam survey conducted during the cruise and the results of the rock dredging operation. Table 1 provides the exact location of the dredge hauls and a brief description of the rock types recovered in each dredge haul. Also listed in Table 1 is the range of Fe/Mg and Nb/Zr ratios obtained by XRF-analyses during Leg I for the first 19 dredge hauls. Forty-four major and trace element analyses were completed from stations 1D to 19D. The results are available upon request. The major elements do not include Na2O, P2O5 and H2O; the trace elements include Nb, Zr, Sr, Rb and Ni. Pierre Cambon, IFREMER, was the analyst. We also conducted reconnaissance seabeam surveys of 5 transform fault - ridge intersections (TFI), identifying the nature and principal structural elements present. These included the Chain FZ - MAR (west intersection); the Romanche FZ - MAR (east intersection); the St. Paul FZ - MAR (east and west intersections); and the 4°N FZ - MAR (east intersection).

MAR segment from the Charcot to the Chain FZ: The first six days were used in transit toward the first station on the Mid-Atlantic Ridge (MAR) around 2° 30'S, 12° 15'W. Cruising was at about 10 knots average, but for 12 hours at half that speed for repairs of one of the two generators. From June 13 to 16 we followed the MAR axis up to the Chain FZ (~1°S) and occupied 6 dredge stations from which fresh glassy volcanics were recovered. The exact location of the ridge axis was unknown and the sea beam system proved to be very effective and invaluable in locating its position, especially since the north-south magnetic anomaly lineaments are essentially nonexistent and cannot be used as a guide in the Equatorial Atlantic. An uncharted left-lateral ridge offset of 20 km length was discovered at the latitude of about 2°S. Both submarine and subaerial types of volcanic rocks were recovered in station 6D, suggesting the possible presence in the past of an island or a very shallow volcanic edifice which has since subsided. The subaerial lava fragments are rounded, highly vesicular, alkalic in composition and have high Nb/Zr ratios, whereas the submarine pillow basalts recovered from the same station are typically tholeiitic; thus the chemical results would seem to support the inference. The variation in Nb/Zr along the 3°-1°S MAR segment is highly variable, irregular and includes unusually high values which are not directly correlated with Fe/Mg variation, suggesting local mantle source variations of either random origin or reflecting the possible influence of a nearby off-ridge hotspot. These results confirm the possible presence of a geochemical anomaly in the region, which was previously suggested on the basis of three dredge hauls occupied in the region (R/V Endeavor, Cruise EN-061, Schilling et al. Nature 313, p187, 1985).

MAR segment from the Chain to the Romanche FZ: From June 16 to 17 we followed the north wall of the Chain FZ, using sea beam and anticipated morphologic grain and tectonics as a guide. On the eve of June 17 we "entered" the MAR segment between the Chain and the Romanche FZ and began to survey this segment until a sea water pipe burst and flooded the main electric motor in direct drive with the ship's propeller. We began to drift for several days - towards Monrovia, Dakar, Canary or Cape Verde Islands, ... no one knew for sure! The motor was washed and the slow process of drying with air guns, blankets and the like and monitoring its electrical resistance began. By then we had begun moving at about one knot with the help of the bow-thruster towards Cape Verde in anticipation of being towed or for repairs, as needed. The weather was good, the mood grim and the ritual Sunday-afternoon barbecue well attended, and a blessing! After one long week of effort and perseverance under the leadership of Captain Roberge and Chief Engineer Niels Berg, we were able to apply full load to the motor, returned to our area of operation and resumed rock dredging on the eve of June 24. By the early morning of June 28 we had occupied 12 dredge hauls along this ridge segment. We found that the axis of the MAR indeed curves into the Romanche FZ, as suggested by the unpublished bathymetric map of Martin Thomas, Univ. College of London (pers. comm.). However this does not take place continuously but in the form of three left lateral, en echelon, displacements of small, volcanically active, extensional basins which characterize the rift valley at its intersection with the Romanche FZ. Very fresh, glassy volcanic rocks as well as peridotites depleted in CaO and Al2O3 were recovered at this intersection. Unusually high Nb/Zr ratios were observed near this intersection (17D), but no particular FeO enrichment was observed, as might have been anticipated for such large ridge offset! At this time it is unknown whether the high Nb/Zr values found at station 17D is mantle-source derived or due to smaller degrees of partial melting in the generation of these lavas.

MAR segment from the Romanche to the St. Paul FZ: On June 28, we then proceeded west along the Romanche FZ towards this next segment. We briefly surveyed the Vema Deep and had a swim call over this unusually deep feature (>7800m). After consultation with LDGO, the end of the cruise was to be extended to July 14 or perhaps 17, in order to compensate for the loss of time due to the ship's breakdown. On the eve of June 29, one of the seaman had symptoms of a cardiac dysfunction, scientific activity stopped and the Conrad had to steam toward the nearest port, Recife or perhaps Fernando de Noronha. We reached Recife in the late afternoon of July 3. The seaman, whose condition had stabilized, was disembarked. Four students also decided to disembark at Recife because they did not like the cruise extension and were unwilling to alter their post-cruise vacation plans! Martine Senglet had to disembark for medical reasons and was flown back to Switzerland. Pierre Cambon also decided to return to France. We left Recife on July 4, 13:30, and resumed dredging and tracking this segment of the MAR on the eve of July 7. We began to manage very effectively the dredging operation with the help of Jim Smith and his LDGO technical staff, two deckmen and the bosun provided by Captain Roberge and with the assistance of the NECOR Seabeam group (Randy Edwards and John Thekkethala). The Global Position System and the Seabeam System were found to be very effective not only in helping find and follow the rift valley but also in targeting for dredging special volcanic and structural features within the valley. From July 7 to 9, eleven dredge stations were occupied on this segment at about 10-15nm intervals and closer near the MAR-Romanche FZ intersection. Fresh glassy volcanic rocks were recovered in all of these stations (19D to 29D, Table 1). The rift valley was found to be obstructed by extensive and very recent constructional volcanism 20nm south of the Equator (25D, Table 1), where the ridge axis shoals from typically 3900-4000m depth to 2800m. The possible influence of a hotspot is suspected. The obstruction is not apparent on Thomas' unpublished bathymetric map which is partly based on a 1983 track made with GLORIA along this rift. Could it be that the constructional volcanism is more recent? Otherwise, this bathymetric map proved fairly accurate at least on a relative sense, but for the MAR-St. Paul FZ intersection which is very complex on a small scale. A nice suite of intrusive rocks typical of fracture zone terrain were recovered at station 29D at the MAR-St. Paul FZ intersection. This intersection is complex and characterized by a chaotic arrangement of small deeps and ridges within the broadening MAR rift valley.

Extensional relay zones within the St. Paul FZ: From July 9 to July 11 we proceeded westward along the St. Paul FZ seeking possible extensional relay zones where recent volcanism may have taken place and the MAR axis may be located. Up to this date the MAR axis between the 25°W segment and the main axis just west of St. Peter and Paul's Rocks remained ill-defined. Using seabeam, anticipated changes in morphologic grain between fracture zone and rift valley terrains and a process of elimination of possibilities based on the length of the MAR axis missing and the hypothesis of a ridge-fracture zone en echelon arrangement without rift overlap, as well as some good luck, we managed during this transit to find 4 short relay zones where recent volcanic activity was confirmed on the basis of recovery of very fresh glassy basalts and the lack of MnO encrustation and intrusive rocks (Fig.2). Our accounting suggests that two relay zones of less than 10nm length were missed and are probably located near 26°W and 27°W (Fig. 2). Time did not allow us to backtrack and test the inference further. The first relay zone (stations 30D and 31D, Fig. 2) was already suggested in Thomas' unpublished bathymetric map. It is highly sedimented but fresh glassy volcanics were also recovered thus suggestive of its youth. The western most relay zone is located 100nm east of St. Peter and Paul's Rocks. As discussed further below, these relay zones may have recently developed by northward rift propagation, as the result of a

possible change in the drift direction of the South American and African plates. This also appears to be the case of the southernmost 55 km of the main MAR axis just west of St. Peter and Paul's Rocks.

MAR segment from 1°N to 5°N: We reached this segment on July 12 and briefly surveyed with seabeam the principal structural elements of the St. Paul FZ-MAR intersection which is located at 0° 40'N and 30° 24'W. As indicated, a new rift seemed to have developed in the past 225,000 years by northward rift propagation from the present intersection to 1° 10'N. This is apparent from the change in direction of the semi-linear morphologic grain of the terrain from typically 340-350° to essentially north or 0-3°, some 225,000 years ago , assuming a full spreading rate of 3.8 cm/yr. Seafloor spreading along this new rift over the past 225,000 years appears to have been strongly asymmetric. We estimate that 80 to 90% of the total accretion took place towards the west. The new ridge axis also progressively shoals northward by about 400-500m. In conclusion, a mechanism similar to that originally proposed for the Vema FZ by Bonatti and Crane (Science 300, p343, 1982), consisting of a fracture zone migration followed behind by rift propagation, may be invoked for the development of this rift and the other relay zones within the broad St. Paul FZ. However in this case, the strike of the fracture zone and the spreading direction would have rotated clockwise rather than counterclockwise. Furthermore, asymmetric spreading could have been a natural consequence of the rotation in a fan-shaped fashion of the various sections of the St. Paul FZ. From July 12 to 18 we occupied 24 dredge stations on the 1°N to 5°N segment of the MAR. The stations were placed at approximately 15-20nm intervals and closer intervals at the intersections with the 2° 30'N FZ and the 4°N FZ, where a series of well developed round seamounts line up within the rift valley. In general, it would seem that as the equatorial fracture zones are approached, there may be a change from fissure type of eruptions (small elongated ridges and vent-like features) to more localized center-type of eruptions (well rounded and defined seamounts, or volcanoes) within the rift valley. This change may possibly reflect the cold-edge effect, increasing viscosity of magmas and decreasing magma budget commonly suggested near ridge-transform fault intersections.

We emphasize that the above general comments are only preliminary and will require further analyses of the ship-board observational data as well as petrologic, geochemical and isotope analyses of the rocks recovered during this cruise.

CONCLUDING REMARKS:

(1) Time did not permit us to sample the MAR between 5°N and 7°N as originally planned. Despite the ten day extension, 4.5 days were not recovered out of the 14.5 days lost due to mechanical breakdown and medical emergency. This probably translates to a loss of a minimum of 10 to 15 stations.

(2) We wish to point out that this cruise was our first direct acquaintance at sea with the Global Positioning System (GPS) and Seabeam capabilities. Both proved to be invaluable new tools in searching for and locating precisely the MAR axis and targeting specific volcanic or tectonic features for dredging. Both systems not only increase the precision in dredging, but also reduce significantly the time necessary to keep the dredge on the seafloor and enhance significantly the chance of rock recovery. Above all, Seabeam in conjunction with the IFREMER XRF-lab container bring a new dimension in relating directly the morphology and structure of the seafloor to the nature of volcanism and rock compositions, essentially in real time during the

cruise. This indeed was very exciting. Seabeam also allowed a far better use of our transit time and permitted reconnaissance mapping of the ridge axis along strike between stations, as well as a rapid reconnaissance and characterization of the principal structural elements of transform fault-ridge intersections (TFI). Our ability of doing just that at 5-6 TFIs and in discovering 4, 10-15nm long, extensional relay zones within the St Paul FZ while in transit, a task which at first seemed comparable to looking for a needle in a hay stack, testify to the future potential of this new capability.

ACKNOWLEDGMENTS:

The professionalism and dedicated assistance and cooperation of Captain Patrick R. Roberge and his ship's company, Jim Smith, Science Officer and his technical staff from LDGO and Randy Edwards and John Thekkethala from the NECOR Seabeam group is greatly appreciated. Particular thanks is extended to Niels Berg, Chief Engineer, and his crew for overcoming difficult mechanical/electrical problems, and to Michael Rawsom, Science Coordinator LDGO, for his continuous assistance in scheduling and organizing the cruise. All these people made the difference in bringing this cruise to successful completion despite several adverse situations. A special thanks goes to Ed Collins, Third Mate for repeatedly providing medical care and also to Brian McCully and Mark O'Rourke for their continuous effort and good spirit during this long and at times enduring cruise. This acknowledgment would not be complete without thanking Frank Paloney and his Galley Crew for their marvelous Sunday-afternoon barbecues. They indeed brought the spirit up! This work was generously supported by NSF under grant OCE 8608626.

Table 1: RC28-06 Dredge Haul Recovery

Station ID#	Latitude Longitude	Depth (m)	Feature dredged	Date	Rock recovery	Glass recovery	Weight (kg)	FeO*/MgO	$(Nb/Zr)_n$
1. MAR Segment between Charcot and Chain FZ.									
RC28-06-1D	2° 32.40' S 12° 14.00' W	3800-3680	Bottom of rift valley floor	6/13	Very fresh glassy pillow basalt and sheet flow fragments w/ striated dark brown crust - aphyric.	abundant	210	0.94-0.97	0.1-0.2
RC28-06-2D	2° 10.70' S 12° 38.10' W	3875-3840	Rift valley floor-central ridge	6/14	A large glassy, plagiophyric pillow basalt and small fragments w/ thin MnO coating on bottom - relatively fresh	limited	150	0.91	0.1
RC28-06-3D	1° 50.59' S 12° 57.32' W	3900-3700	Rift valley floor-small seamount	6/14	(1) Very fresh glassy basalt, plagiophyric tongue - dipped type. (2) Large older pillow basalt w/ minor glass, partly palagonitized and thin MnO coating.	abundant w/nuggets	20	1.15-1.18	0.7
RC28-06-4D	1° 24.54' S 13° 00.39' W	3960-3940	Rift valley floor and foot of east wall	6/15	Large, glassy, partly palagonitized pillow basalts w/ some sediment.	limited	300	1.07-1.18	1.8-2
RC28-06-5D	1° 09.70' S 13° 04.10' W	4070-3880	Rift valley floor- small round seamount-rift curving into Chain F.Z.	6/15	(1) Very fresh small plagiophyric pillow basalt w/ thick glass (1cm) - top of feature. (2) Slightly older pillow basalts and sheet flow fragments w/ Fe2O3 stains, base of feature.	abundant	250	1.16-1.19	0.4-0.6
RC28-06-6D	1° 03.08' S 13° 06.70' W	4350-4000	MAR-Chain FZ intersection, seamount near west wall of rift valley	6/16	(1) Older pillow basalts w/ minor glass. (2) Subaerial looking highly vesicular, rounded basalt fragments w/ vesicles filled w/ ooze. (3) One glass nugget. (4) Serpentinite and greenstone rubbles w/ mud.	limited	300	0.96-1.23 0.19	0.2-2.1 <.2
2. MAR Segment between Chain and Romanche FZ									
RC28-06-7D	0° 08.15' S 16° 25.76' W	4100-3900	MAR - Romanche FZ intersection, small elongated ridge adjacent to deepest part of rift valley floor	6/24	Two very large, fresh, aphyric, glasy pillow basalts w/ dark brown, striated crust w/ possibly an older type - minor MnO stains.	limited	350	0.98-1.02	1.7-1.9
RC28-06-8D	0° 24.30' S 16° 05.36' W	4380-4060	East of rift valley floor	6/25	(1) Fresh, glassy sheet flow basalt fragments w/ thick glass. (2) Slightly older, sheet flow basalt fragments w/ thin glass and dark brown crust w/ minor MnO stains.	abundant thick and massive	15	1.09-1.23	0.6
RC28-06-9D	0° 44.51' S 16° 04.59' W	4330-4280	Rift valley floor, east flank	6/25	(1) Relatively fresh, plagiophyric pillow basalts w/ minor glass retained and 1mm thick MnO coating and thick ooze (Plag. phenocryst rounded 6mm size). (2) Glass fragments.	limited abundant	20 2	1.40-1.43	0.6
RC28-06-10D	1° 03.74' S 15° 58.56' W	4100-3900	Rift valley floor, elongated seamount	6/25	(1) Large, fresh, plagiophyric, glassy pillow basalts w/ crust - glass granular 2-5mm thick most abundant and probably older type. (2) Large, very fresh glassy pillow basalts w/ thick glass (1cm) and shiny crust.	abundant	375	0.91-1.18	0.5
RC28-06-11D	1° 15.63' S 15° 55.21' W	4380-4330	Rift valley floor, small ridge south of rounded seamount	6/26	(1) Very fresh, small, glassy pillow basalts (tongues and toes, dipped type), thick glass. (2) One large pillow basalt w/ glass slightly older type. (3) One small pillow basalt w/ minor glass and MnO encrustation.	abundant	32	0.9	0.5-0.6
RC28-06-12D	1° 32.16' S 15° 53.27' W	4463-4289	Rift valley floor entering Chain FZ, elongated seamount on west side	6/26	Misc. pillow basalts of 2 or 3 age generations, ranging from very fresh and glassy to partly palagonitized and MnO encrusted. One chunk of very fresh glass.	limited	200	0.97-1.13	0.5
RC28-06-13D	1° 21.88' S 15° 55.13' W	4640-4520	Rift valley floor, small seamount on west side	6/26	Small, glassy, aphyric pillow basalts (toe type) and one large one w/ minor glass.	abundant	150	1.08-1.15	0.5

Table 1: Continued.

Station ID#	Latitude Longitude	Depth (m)	Feature dredged	Date	Rock recovery	Glass recovery	Weight (kg)	$\frac{FeO^*}{MgO}$	$\left(\frac{Nb}{Zr}\right)_n$
RC28-06-14D	1° 09.52' S 15° 56.27' W	4040- 3820	Rift valley floor, small hill in middle	6/27	Very fresh to partly altered pillow basalt and sheet flow fragments and rubbles of several age generations.	abundant	380	1.21- 1.44	0.5
RC28-06-15D	0° 14.51' S 16° 14.50' W	4338- 4260	Rift valley floor, curvilinear, deep at intersection w/ Romanche FZ	6/27	Thick mud.	none	1		
RC28-06-16D	0° 16.17' S 16° 14.10' W	4340- 3850	Rift valley floor, curvilinear, deep at intersection w/ Romanche FZ (same as 15D site)	6/27	Pillow basalt fragments and rubble, greenstone, glass breccia and very fresh glass fragments.	abundant, nuggets, popping	250	1.00- 1.37	0.3- 0.7
RC28-06-17D	0° 06.28' S 16° 24.87' W	4540- 4320	MAR - Romanche FZ intersection, north slope of extensional basin	6/27	None.	none	0		
RC28-06-18D	0° 02.66' S 16° 28.02' W	3904- 3769	MAR - Romanche FZ eastern intersection, series of small seamounts forming NW trending ridge	6/28	Pillow basalts, and glass fragments in mud - probably several age generations, hydrothermal stains and some MnO encrustation.	very abundant popping	210	1.02- 1.05	1
3. MAR segment between Romanche and St. Paul FZ.									
RC28-06-19D	1° 00.80' S 24° 36.26' W	3780- 3600	MAR - Romanche FZ western intersection, small seamount on west side of rift valley floor	7/7	Partly altered pillow basalts and rubble w/ minor glass preserved.	limited	75		
RC28-06-20D	0° 58.60' S 24° 33.19' W	4040- 3880	Rift valley floor, east flank, deepest part	7/7	Highly altered rock fragments w/ some remnant plagioclase phenocrysts.	none	3		
RC28-06-21D	0° 53.53' S 24° 34.65' W	4300- 4250	Rift valley floor, west flank, deepest part	7/7	Small fragment of older glass w/ indurated ooze and old fragments of highly plagiophyric and olivine basalts and greenstone fragments?	none	5		
RC28-06-22D	0° 47.43' S 24° 36.67' W	3940- 3850	Rift valley floor, saddle between two deeps near east wall	7/7	Very fresh to fresh pillow basalt fragments of 2 or 3 age generations. Freshest is plagiophyric w/ brown glassy crust, traces of mud. Crane spilled oil!	abundant granular and nuggets	150		
RC28-06-23D	0° 34.30' S 24° 36.70' W	3392- 3333	Rift valley floor, small seamount on east and deepest side	7/7	Three small pillow basalt fragments of different age appearance. Youngest is fresh and glassy w/ traces of ooze. Oldest plagonitized w/ MnO coating.	limited	2		
RC28-06-24D	0° 19.99' S 24° 45.30' W	3075- 2839	Seamount on top of elevated MAR axis - rift completely obstructed by constructional volcanism	7/8	Very fresh, highly glassy aa type of basalt fragment, sheet flow and roapy types - possibly several ages.	abundant large nuggets	120		
RC28-06-25D	0° 09.08' S 24° 48.80' W	3910- 3780	Rift valley floor, center	7/8	(1) Relatively fresh, small pillow basalt fragments, w/ minor glass - highly plagiophyric (~1cm size). (2) Large pillow basalt, glassy, palagonitized w/ MnO coating.	limited	140		
RC28-06-26D	0° 02.20' N 24° 52.29' W	3995- 3905	Rift valley floor, elongated seamount adjacent to deepest part near east wall	7/8	Very fresh, glassy pillow basalts and sheet flows, possibly of 2 or 3 age generations.	extremely abundant nuggets	165		
RC28-06-27D	0° 10.95' N 24° 54.54' W	4000- 3888	Rift valley floor, NW slope of deep near east wall	7/8	(1) Fresh plagiophyric basalt fragments, partly glassy. (2) Fresh glassy sheet flow w/ brown crust. (3) Older, partly glassy pillow basalts.	limited	120		
RC28-06-28D	0° 21.87' N 24° 58.37' W	4024- 3954	Rift valley floor near intersection w/ St. Paul FZ, west side of deep	7/9	Very fresh glassy, plagiophyric pillow basalts and glassy crust fragments.	limited	0.5		

Table 1: Continued.

Station ID#	Latitude Longitude	Depth (m)	Feature dredged	Date	Rock recovery	Glass recovery	Weight (kg)	$\frac{FeO^*}{MgO}$	$\left(\frac{Nb}{Zr}\right)_n$
RC28-06-29D	0° 28.88' N 25° 01.68' W	4050- 3900	MAR - St. Paul FZ intersection, north slope of deep	7/9	(1) Fresh to partly altered pillow basalt fragment w/ minor glass, hydrothermal stains. (2) Peridotites, serpentinites, and anorthosite and chlorotized glass breccia.	limited	450		
4. MAR relay zones within St. Paul FZ.									
RC28-06-30D	0° 40.12' N 25° 27.56' W	4581- 4576	Rift valley floor, deep, west foot wall near saddle point of relay zone	7/9	One chip of brown glassy crust and 3cm long deep sea fish.	none	0.5gm		
RC28-06-31D	0° 39.21' N 25° 27.27' W	4553- 4275	Rift valley floor and east foot wall - adjacent to 30D site	7/10	Very fresh glassy sheet flow basalt fragments w/ crust. Three pillows of varying age and freshness and glass preservation, thick ooze.	limited 1 nugget	?		
RC28-06-32D	0° 49.27' N 26° 21.11' W	4690- 4640	Rift valley floor and east wall - small relay zone	7/10	Fresh glass chips.	limited	<100gm		
RC28-06-33D	0° 59.15' N 27° 41.47' W	4480- 4460	Rift valley floor, flow, relay zone SE of St. Peter and Paul's Rocks - halfway along segment	7/11	Two large glassy, plagiophyric pillow basalts w/ crust and hydrothermal stains,fresh.	good	80		
RC28-06-34D	1° 01.38' N 27° 42.10' W	4570- 4490	Relay zone - St. Paul FZ intersection, rift valley floor near north wall of St. Paul FZ	7/11	(1) One very large glassy pillow basalt w/ thick glass partly palagonitized. (2) Sheet flow w/ glassy granular crust.	limited popping	85		
5. MAR segment between St. Paul' S and 2°30' N FZ.									
RC28-06-35D	0° 47.33' N 30° 24.00' W	3820- 3660	MAR - St. Paul FZ intersection, small seamount	7/12	(1) Fresh glassy, highly plagiophyric pillow basalt fragments w/ olivine and possibly clinopyroxene phenocrysts. (2) Slightly older, aphyric, glassy pillow basalt fragments and one sheet flow. (3) Glass nuggets.	extremely abundant nuggets popping	200		
RC28-06-36D	0° 57.21' N 30° 24.95' W	3320- 3250	Rift valley floor, small elongated seamount	7/12	(1) Fresh, sparsely plagiophyric pillow basalts w/ minor glass. (2) Older, highly plagiophyric pillow basalts w/ minor glass. (3) Older scoriaceous like plagiophyric basalt.	limited	10		
RC28-06-37D	1° 05.75' N 30° 26.20' W	3415- 3275	Rift valley floor, small vent from fissure type ridge near small ridge offset	7/12	Relatively fresh pillow basalt fragments partly palagonitized and abundant glass debris w/ mud.	abundant granular and nuggets	50?		
RC28-06-38D	1° 17.36' N 30° 32.09' W	3780- 3600	Rift valley floor, small seamount in deepest part	7/13	(1) Fresh plagiophyric pillow basalts w/ minor glass. (2) Fresh sparsely plagiophyric pillow basalts w/ minor glass.	limited	15		
RC28-06-39D	1° 30.37' N 30° 40.00' W	3380- 3520	Rift valley floor, ridge adjacent to deepest part	7/13	Relatively fresh, glassy (thick) pillow basalt fragments, tongue type.	good nuggets	10		
RC28-06-40D	1° 42.25' N 30° 38.40' W	3565- 3465	Rift valley floor, small mount part of fissure type eruptive ridge on west deep side	7/14	Very fresh glassy pillow basalt fragments (tongues and toes type) and glass nuggets.	fairly abundant nuggets	100		
RC28-06-41D	1° 55.82' N 30° 38.36' W	3230- 3150	Rift valley floor, lobe into deepest part near east flank	7/14	Very large fresh glassy pillow basalt fragment, possibly of two age generations, and sheet flows.	abundant nuggets	95		
RC28-06-42D	2° 10.54' N 30° 40.54' W	3460- 3420	Rift valley floor, lobe into deep in middle	7/14	Fresh to partly altered pillow basalt fragments w/ some glass.	limited nuggets and	100		
RC28-06-43D	2° 23.10' N 30° 46.10' W	3728- 3620	Rift valley floor projecting into 2°30' N FZ, small seamount in deepest part next to wall	7/14	Four pillow basalt fragments of varying freshness, fragments of glassy crust.	limited	20		

Table 1: Continued.

Station ID#	Latitude Longitude	Depth (m)	Feature dredged	Date	Rock recovery	Glass recovery	Weight (kg)	$\frac{FeO^*}{MgO}$	$\left(\frac{Nb}{Zr}\right)_n$
6. MAR segment between 2°30' N and 4°N FZ.									
RC28-06-44D	2° 52.02' N 31° 16.10' W	3546- 3480	Rift valley floor, small round seamount (1/2nm) east of rift bottom on terrace	7/15	(1) Very fresh glassy pillow and sheet flow basalt (tongues and toes type). (2) One older pillow fragment w/ glass, one deep sea fish (3cm long).	good nuggets	7		
RC28-06-45D	2° 52.20' N 31° 20.70' W	3120- 3020	Large round seamount (1.5nm diam.) 5nm off-axis, west. Same flow line as 44D	7/15	Few small pillow fragments, glass nuggets and one slab w/ minor glass all covered w/ MnO.	limited nuggets	4		
RC28-06-46D	2° 48.66' N 31° 17.14' W	3784- 3580	Rift valley floor, tablemount, east flank of deep	7/15	One very large pillow (metersize) and 2 pillows, glassy w/ crust highly plagiophyric (30-40% phenocrysts), glassy crust fragment.	good crusty	150		
RC28-06-47D	3° 07.90' N 31° 21.83' W	3850- 3780	Rift valley floor, asymetric seamount near deepest part	7/15	(1) Fresh, glassy pillow basalts and two chunks of fresh glass. (2) Older pillow basalt without glass, and mud.	fairly abundant	70		
RC28-06-48D	3° 27.50' N 31° 29.40' W	3980- 3811	Rift valley floor - small hill in western deepest part and adjacent ridge	7/15	(1) Very large pillow basalt (1m diam.) w/ thick glass, hydro-thermally stained and thin MnO film, pillow basalt fragment w/ glass. (2) Very fresh glassy pillow basalts (tongue and toes type).	abundant nuggets of possibly different	90		
RC28-06-49D	3° 42.03' N 31° 30.79' W	3800- 3675	Rift valley floor - lobe into deepest part of central ridge	7/16	Very fresh pillow basalt fragments, (tongue and toes - dipped type) - possibly two age generations both very young - plagiophyric to sparsely plagiophyric, glassy crust fragments, minor ooze.	good	50		
RC28-06-50D	3° 54.50' N 31° 30.96' W	4180- 4080	MAR - 4°N FZ intersection, sea-mount forming end of central ridge	7/16	Fresh glassy pillow basalts and sheet flow fragments w/ recent hydrothermal stains.	limited	30		
RC28-06-51D	3° 55.16' N 31° 32.89' W	4570- 4477	MAR - 4°N FZ intersection, seamount in deep part	7/16	Fresh glassy crust fragment w/ plagioclase phenocrysts.	limited	100gm		
RC28-06-52D	3° 57.40' N 31° 31.20' W	4357- 4210	MAR - 4°N FZ intersection, seamount in line w/ central ridge (see 50D) - near north wall of FZ	7/16	None.	none	0		
RC28-06-53D	3° 58.00' N 31° 33.00' W	3580- 3280	MAR - 4°N FZ intersection, seamount in line w/ 51D station	7/17	(1) Pillow basalt fragments w/ minor glass, one with striated crust. (2) Small glassy sheet flow fragments w/ crust.	good	40		
RC28-06-54D	3° 56.05' N 31° 33.35' W	4642- 4300	MAR - 4°N FZ intersection, small seamount closest to nodal deep - caldera shaped top w/ saucer	7/17	(1) aa - type partly glassy, basalt fragments (from caldera rim?). (2) Pillow and sheet flow basalt fragments of varying freshness. (3) Very fresh glass nuggets of possibly different age generations.	good nuggets	65		
7. MAR - 5°N segment									
RC28-06-55D	4° 54.40' N 32° 41.30' W	3570- 3490	Rift valley floor, elongated seamount east of deepest central part	7/17	(1) Very fresh, thick glassy pillow basalt fragments, aphyric. (2) Sparsely plagiophyric pillow basalt (tongue type). (3) Sheet flow with thin brown glassy crust and sediment coating. (4) Chunks of glass.	good nuggets	200		
RC28-06-56D	4° 36.80' N 32° 39.90' W	3455- 3379	Rift valley floor, central ridge with series of small seamounts (fissure eruption!)	7/17	Spectrum of pillow basalt fragments of 2 to 3 possible age generations, with and without glass, hydrothermal stains and some MnO coating, some very fresh glass nuggets.	good nuggets	130		

Table 1: Continued.

Station ID#	Latitude Longitude	Depth (m)	Feature dredged	Date	Rock recovery	Glass recovery	Weight (kg)	$\frac{FeO^*}{MgO}$	$\left(\frac{Nb}{Zr}\right)_n$
RC28-06-57D	4° 22.30' N 32° 34.70' W	4885	Rift valley floor, west flank of deep in small en echelon segment near 4°N FZ	7/18	Small rock fragments and glass nuggets and fragments.	limited nuggets	1		
RC28-06-58D	4° 17.41' N 32° 34.76' W	4095-3985	Rift valley floor, small rounded seamount at foot of east wall, near 4°N FZ	7/18	Extremely fresh glassy pillow basalts w/ brown and red crust (dipped type), and glass nuggets, flow textures, striations, etc. - sparsely plagiophyric.	good nuggets	200		
RC28-06-59D	4° 11.70' N 32° 34.70' W	4160-4080	Rift valley floor, near 4°N FZ intersection, small rounded seamount on foot of east wall and east wall	7/18	Pillow basalt fragments and rubbles, glass nuggets and debris in sediment, glass breccia, varying freshness of glass and crust.	good nuggets	100		

FeO^* stands for total iron expressed as ferrous oxide.

$\left(\frac{Nb}{Zr}\right)_n$ stands for the $\frac{Nb}{Zr}$ ratio of the rocks normalized to the best estimate of this ratio in chondrites (0.0975)

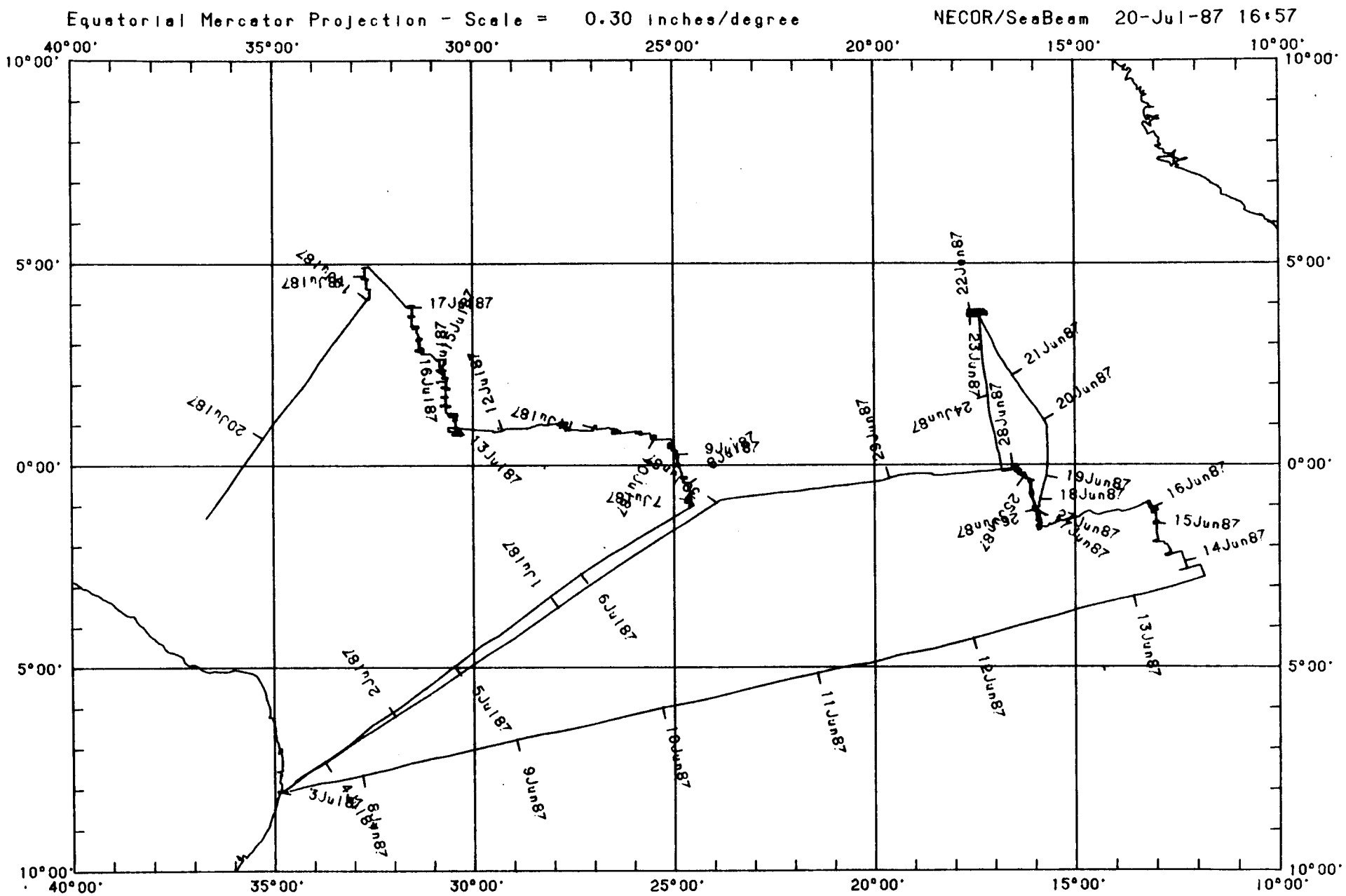

Fig. 1 RC2806 CRUISE TRACK

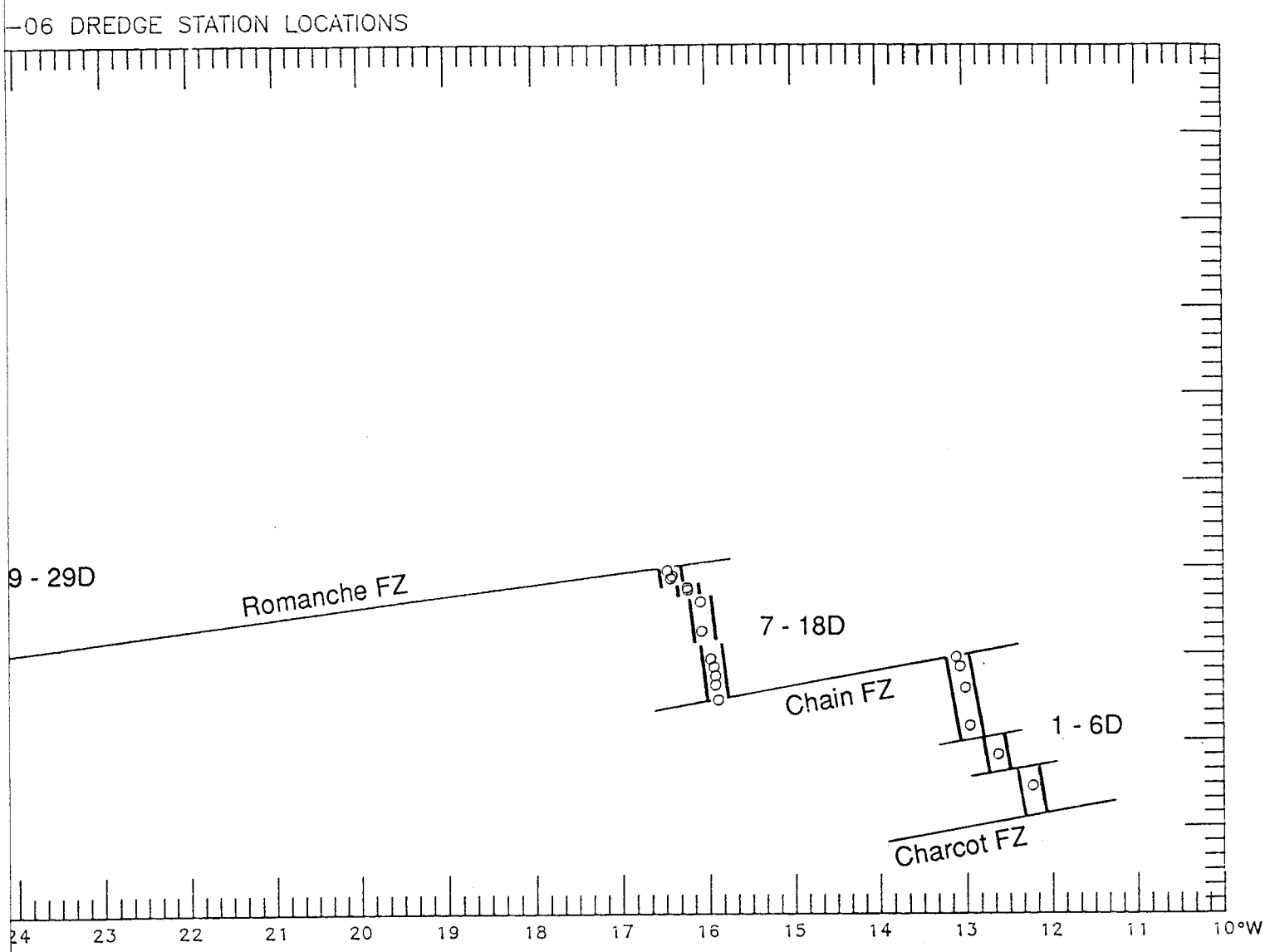
-06 DREDGE STATION LOCATIONS
9 - 29D
Romanche FZ
7 - 18D
Chain FZ
1 - 6D
Charcot FZ
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10°W

Fig. 3a RC28-06 DREDGE STATION LOCATIONS

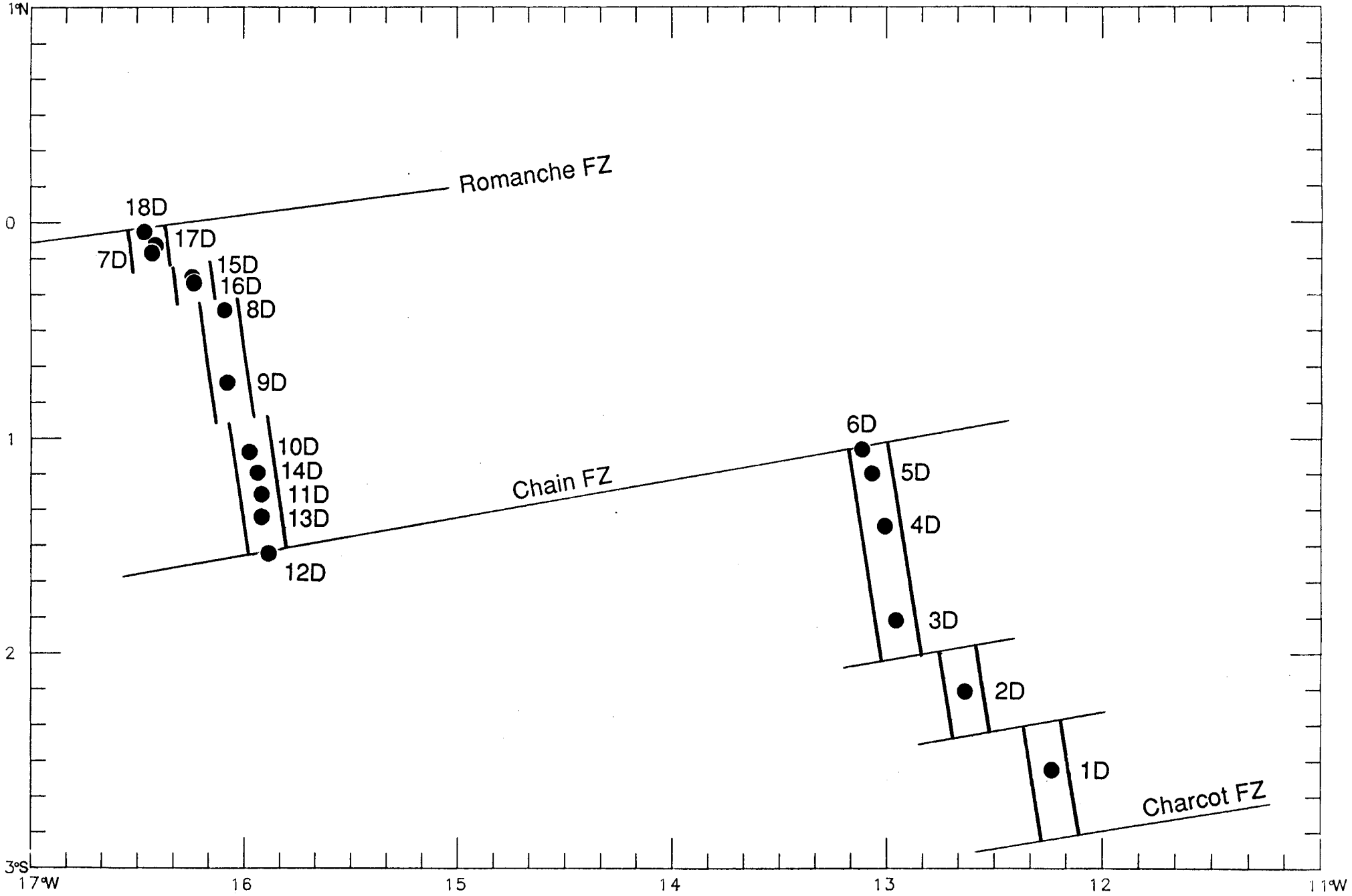

Fig. 3b RC28-06 DREDGE STATION LOCATIONS

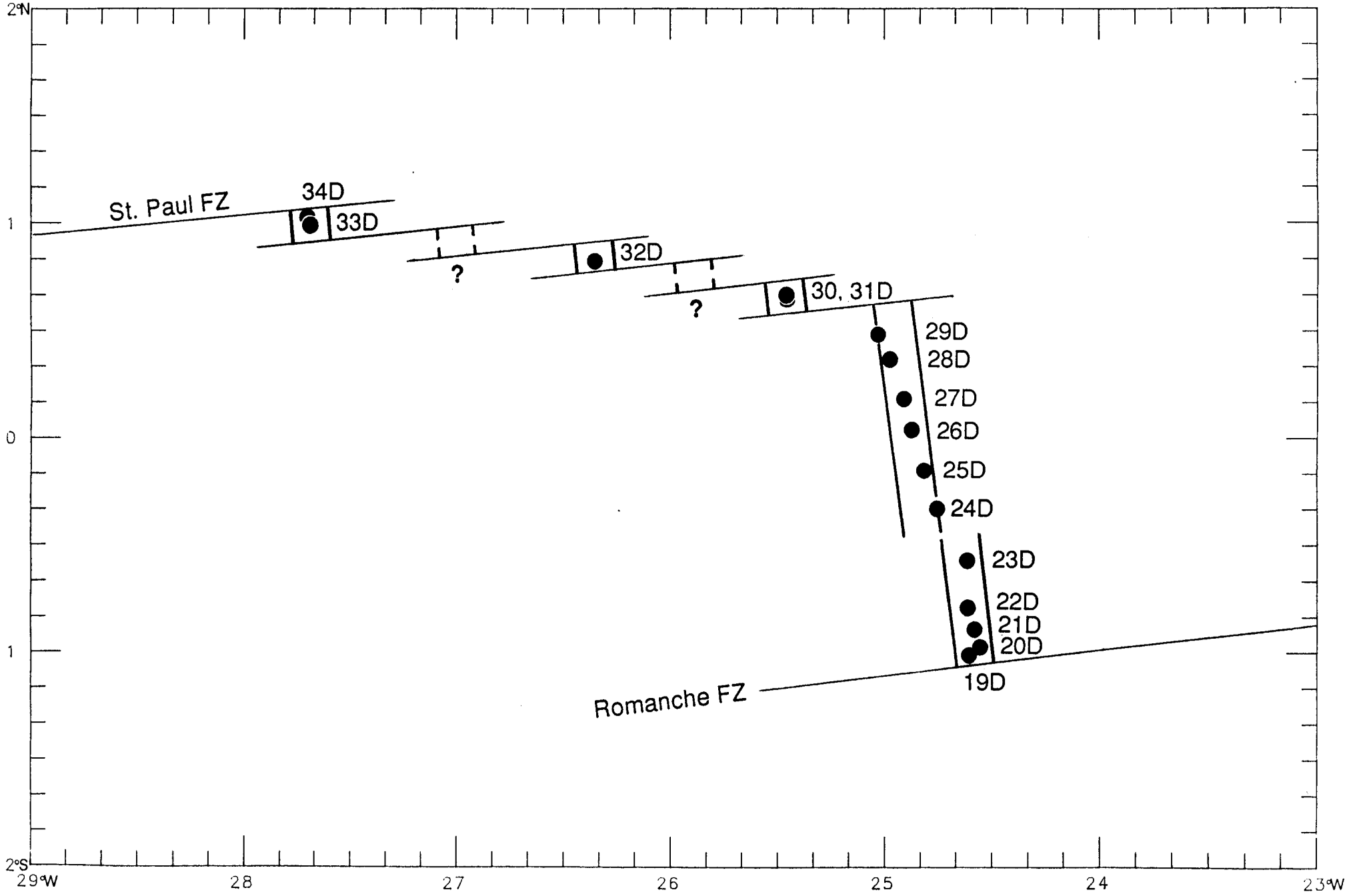

Fig. 3c RC28-06 DREDGE STATION LOCATIONS