New data on the geology of the Romanche FZ, equatorial Atlantic: PRIMAR-96 cruise report

Article *in* Giornale di Geologia · January 1997

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Giornale di Geologia, ser. 3ª, vol. 59/1-2, 1997, pp. 3-18, Bologna

New data on the geology of the Romanche FZ., equatorial Atlantic: PRIMAR-96 cruise report

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Abstract

An oceanographic expedition was carried out in May and June 1996 with the R/V Gelendzhik to the Romanche Fracture Zone (F.Z.), in the frame of an Italian-Russian joint program for the geological study of the equatorial Atlantic (PRIMAR). We present here a cruise report, with some preliminary data and scientific results. The choice of the ship was determined mostly by the availability of a new, state of the art oceanic multibeam system (SIMRAD EM-120-S).

The ’96 expedition focused on the Romanche F.Z. western ridge/transform intersection (RTI) and complemented a 1994 expedition that covered the eastern RTI. Multichannel seismic reflection, gravimetric and magnetometric profiles were collected, as well as bottom rock samples. Moreover, we acquired over 10,000 nautical miles of high resolution multibeam bathymetry. With these new data the entire active part of the Romanche transform (>900 km) has been covered by multibeam morphobathymetry.

Introduction and background

The peculiar geological setting of the equatorial Atlantic has been described in several previous works (Bonatti et al., 1979, 1991, 1994, 1996a, 1996b; Bonatti and Ligi, 1994). The Mid Atlantic Ridge (MAR) is offset in the equatorial region by a set of close-spaced, long offset transform. They include the St. Paul, Romanche and Chain transforms, that together offset the MAR axis by almost 2000 km, forming a broad equatorial megashear zone. Satellite derived altimetry imagery shows clearly that these structures can be traced across the entire Atlantic from the South American to the African continental shelves (Fig. 1).

The Romanche FZ. is the largest among equatorial transforms (~ 900 km offset) and is located very close to the equator. The St. Paul transform (offset ~ 400 km) is located between 1°N and 2°N i.e., roughly 180 km north of the Romanche. The Chain transform (offset ~ 300 km) is located about 180 km south of the Romanche. Each of these transforms has a strong topographic signature, generally a deep transform valley paralleled by prominent transverse ridges. These transverse ridges constitute major topographic anomalies relative to the thermal subsidence curve for the oceanic lithosphere.

The Romanche is characterized by a deep, roughly E-W seismic valley flanked on both sides by two transverse ridges and by a system of secondary parallel troughs and ridges. The shallowest depths (< 1 km) are reached in the narrow transverse ridge flanking the northern side of the transform, east of about 17° W. This constitutes a major topographic anomaly that rises up to 4 km above the level predicted by the thermal contraction depth/age law (Bonatti et al., 1994; Bonatti and Ligi, 1994). The Romanche transform can be traced into continental margins both in the

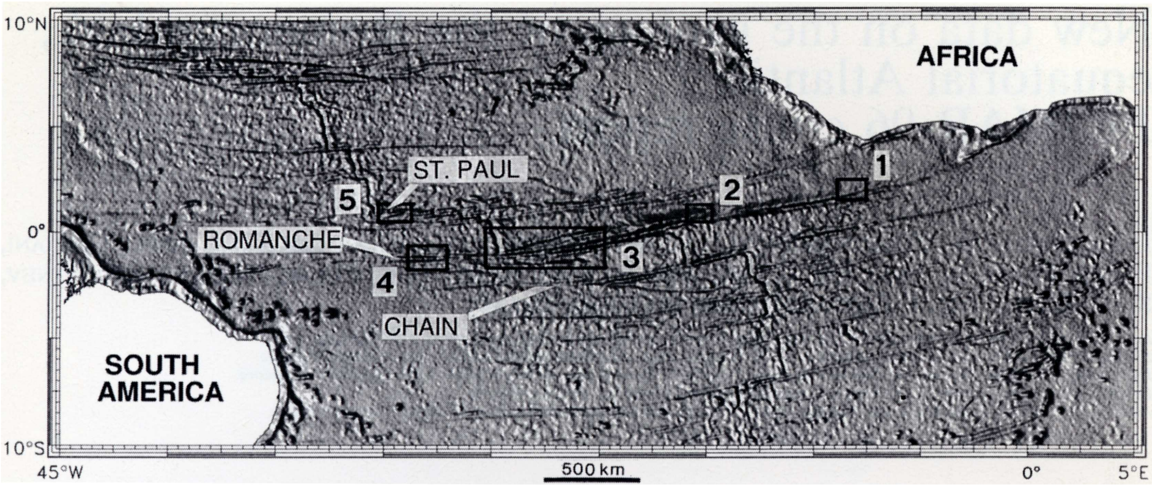

Fig. 1 - SeaSat, GeoSat and Ers—1 satellite gravity map of the equatorial Atlantic, version 7.2 (Sandwell and Smith, 1992), with indicated PRIMAR-96 working areas. An illumination from W, 60° over the horizon is assumed for the shading. Mercator projection at 0°.

African and the S American side; it probably originated as a continent/continent transform at the time of initial rifting of the proto Atlantic.

Among the results of our previous expeditions we cite the following: (a) evidence of strong vertical tectonics in the transverse ridge close to the eastern RTI (Bonatti et al., 1994; Bonatti et al., 1996b; Efimov et al., 1996; Mazarovich et al., 1997; Gasperini et al., 1997); (b) discovery of lower Cretaceous (~ 140 my old) deposits near the eastern RTI (Bonatti et al., 1996a); (c) evidence that the transform boundary migrated to its present position from a «paleo-Romanche» transform corresponding to a presently aseismic valley located on the northern side of the present boundary (Bonatti et al., 1994; Bonatti and Ligi, 1994).

Methods

Swath bathymetry

The bottom topography was obtained with a SIMRAD EM12-120S multibeam echosounder that, by mean of its 120 degrees aperture (81 beams) covers a width of sea floor about 3.5 times the depth. The data were processed using the Simrad Software package NEPTUNE. Contour levels and shaded relief maps of the entire surveyed area were compiled aboard using IRAP (Geomatic) and PLOTMAP (Bortoluzzi and Ligi, 1987; 1988; Ligi and Bortoluzzi, 1989) software packages. Together with the depth sounding, backscatter data from each reflection have been collected, allowing the creation of backscatter maps of the surveyed areas. This type of information is similar to that acquired by the Side-Scan-Sonar systems and is used to estimate the reflectivity of the sea floor, that depends on its roughness and on the presence of a sedimentary cover. The depth data have been corrected by periodically carrying out sound velocity profiles in the water column and normal calibration procedures for pitch, roll and heave compensation.

Multichannel seismic reflection

A number of high resolution seismic reflection profiles were acquired, for a total length of over 2000 km with equipment of IGM, Bologna. An array of 2 SODERA G.I. guns has been employed as a sound source, operating in harmonic mode configuration, with a capacity of 210 cubic inches for the generators and the same for the injectors, at a working pressure of 2000 psi. Gun synchronization for each shot station was activated by the IGM G.I. controller system (Masini and Ligi, 1995). The receiving streamer employed 32 channels (each with 20 hydrophones) spaced 25 m apart.

Shot interval was 50 m, yielding a coverage of 800% Seismic source and nearest channel were spaced 150 m apart. Digital acquisition was performed with a sampling rate of 1 msec and record length of 11 sec. The quality check of seismic data was obtained onboard by two different methods: a) an on-line neartrace section acquired on a graphic recorder driven by a PC-based seismic acquisition software (SEISACQ), that showed continuously on a video monitor the incoming signal and the section; b) a post-plotting of each neartrace seismic line after reading of the acquired magnetic tapes. The preliminary standard processing (Deconvolution, NMO, Stacking) of some of the acquired lines has been performed on board using the processing software DISCO (CogniSeis).

Magnetometry

Two magnetometers were at sea during almost the entire cruise (multibeam data acquisition, seismic reflection survey and transit). An «Overhauser» Mod. GSM-19MD by GEM, Ontario, was used by the Italian group; offset from GPS antenna was 320 m. The Russian team used a proton precession Mod. MPM-7 build by NIPI Okeangeofisika; its offset from GPS antenna was 265 m. Both magnetometers had a resolution of 0.1 nT. The data were collected with a sampling rate of 10 sec by the same computer controlling the navigation.

Due to the relative vicinity of the magnetic equator, magnetic data in this region are only partially useful to the recognition of the geological setting, because the only parameter detectable by a ship-towed magnetometer is the total magnetic field. After a standard processing of the field data, the very low value of the signal to noise ratio does not allow a clear recognition of the magnetic stripes running perpendicularly to the spreading direction. Further processing of the data will be attempted to filter the noise and obtain a reliable estimate of the magnetic anomalies.

Gravimetry

At least two of a set of 4 quartz thermally stabilized Mod. GMN-K gravimeters assembled in Russia by Vniigeofisika were running during multibeam and seismic reflection acquisition. The sensors were mounted on gyroscopic platforms, very close to the ship's center of gravity. Their height above sea level was 0.7 m. The instruments had a resolution of 0.04 mGal and were equipped with circuitry to compensate ship's accelerations. The instruments were calibrated on known reference points with a portable gravimeter Lacoste and Romberg Mod. G-327, in the ports of Abidjan and Napoli.

Scientific objectives

Based on the results of our previous expeditions to the same region, we set the following objectives for the PRIMAR-96 cruise (Fig. 1):

AREA 1 - Outcrop of the «fossil» Romanche transverse ridge, off the African continental margin — The topographic signature of the Romanche transverse ridge is recognizable from the African to the south American shelves, and segments of the transverse ridge locally outcrop on the ocean bottom as topographic highs, even close to the margins. Previous geophysical data, as well as rock samples, suggest an anomalous crustal structure of the transverse ridge just outside the Romanche eastern RTI, where it consists of a thick sequence of old (early Cretaceous and Paleocene/Eocene) sediment (Romanche Sedimentary Sequence, RSS; Bonatti et al., 1996a). Honnorez et al. (1994) described the recovery of old metasedimentary rocks from a portion of the «fossil» Romanche transverse ridge located off the African continental margin, around 2°N and 6°30'W. One of the scientific objectives of our '96 expedition was the acquisition of seismic data and rock samples from this structure, in order to determine its character (seismic facies, geometry, lithology and age) in comparison with the RSS outcropping near the eastern RTI. The aim was to estimate the lithological continuity of the transverse ridge and the lateral extent of the anomalous deposits recovered near the RTI. Fig. 2a shows the location of seismic and depth sounding lines.

AREA 2 - African plate, Romanche EZ. eastern RTL — Two multichannel seismic reflection lines have been acquired in this area, to

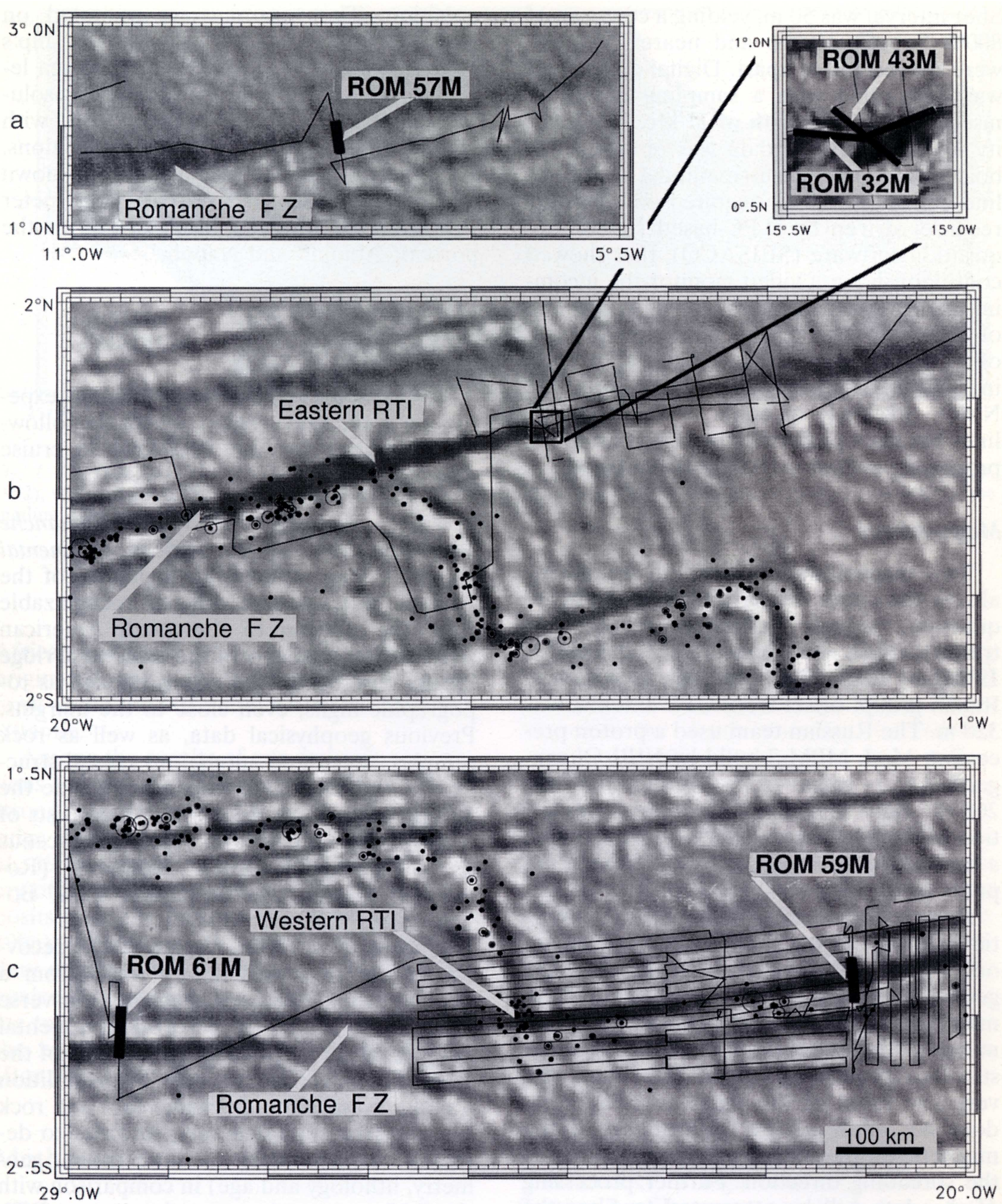

Fig. 2 - Tracks of the multibeam/magnetics/gravity/seismic reflection survey carried out during cruises PRIMAR-94 and 96. **a**, *AREA-1*; **b**, *AREA-2*; **c**, *AREA-3* and *AREA-4*. Thick lines indicate seismic sections presented in this report (ROM-32M, ROM-43M, ROM-57M, ROM-59M and ROM-61M). Earthquake epicenters (Magnitude >5) mark plate boundaries (black circles).

complete the RSS mapping in the vicinity of the Romanche eastern RTI. Here, the RSS appears to be affected by folding, faulting and overthrusting, suggesting strong transform-related compressional tectonics. The aim of the survey was to define the lateral extent of the sequence and the 3-D geometries of the tectonic structures (folds and overthrusts) in

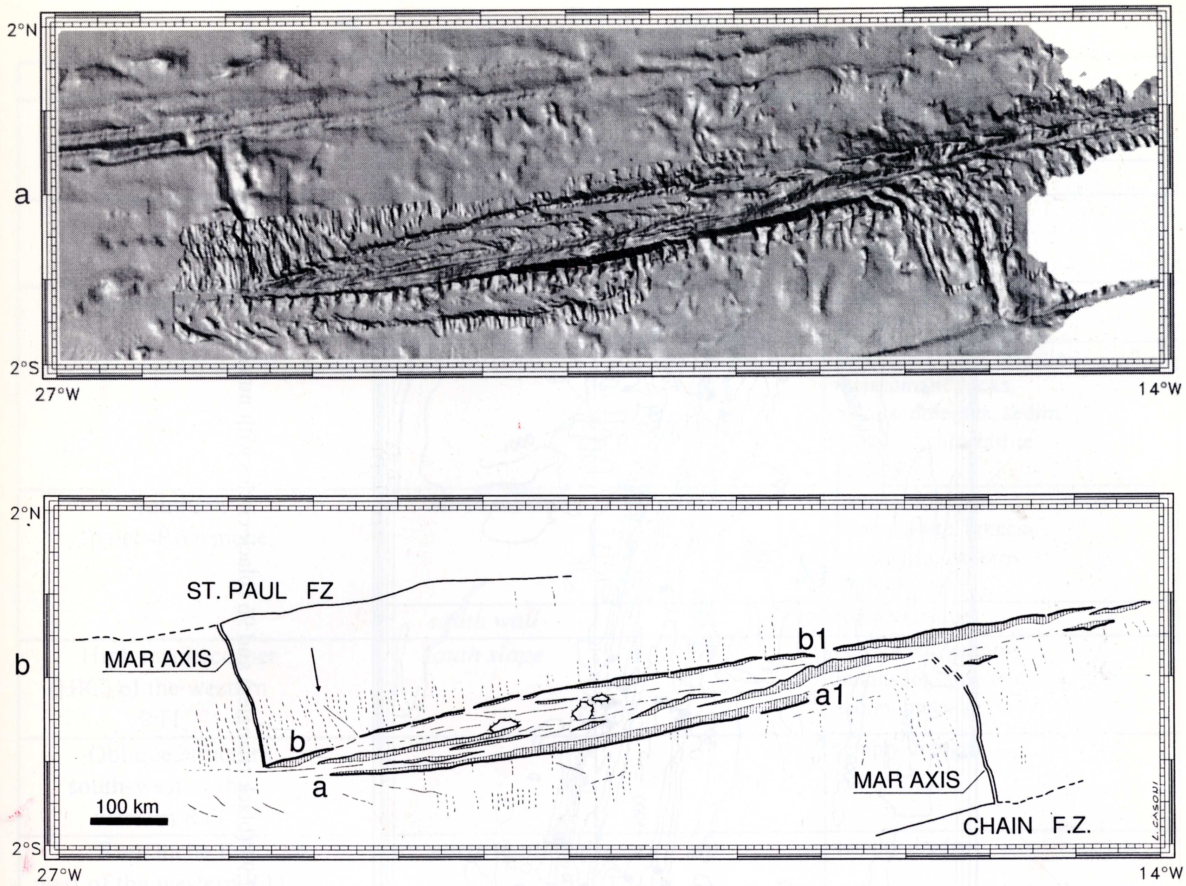

Fig. 3 - **a**, shaded relief map of the Romanche region derived from the'96 bathymetric survey and previous data (see text). The shading was obtained assuming illumination from W, 60° over the horizon. Mercator projection at 0°; **b**, line drawing of the main structural features. The arrow indicate a sharp change in the ocean floor fabric orientation. Lines a-a_l, and b-b_l separate oceanic sectors showing different fabrics. Hatched areas are transform-related normal-faults scarps.

order to infer the stress field responsible for the observed deformation. Fig. 2b shows the location of seismic and depth sounding lines.

AREA 3 - Romanche F.Z. western RTI active part — This was the main part of the PRIMAR-96 program. Fig. 2c shows the navigation lines of the multibeam survey. The objective was to complete the morphobathymetric mapping of the entire Romanche F.Z. started in 1992. The western intersection area was poorly known because only sparse single beam bathymetry existed. A bathymetric map including all available data from the Romanche F.Z. area was produced after the first PRIMAR expedition, merging data from Montì and Mercier (1991), Searle et al. (1993) and our own cruises (Bonatti et al., 1991). Contour lines of Montì and Mercier (1991) and Searle et al. (1993) were digitized by using DIGMAP software (Bortoluzzi and Ligi, 1986). This map was useful to recognize the main structural features but poor in the western RTI area. The new map, that includes our PRIMAR-96 data (Figs. 3 and 4a), reveals the great complexity of the Romanche system, with the presence of secondary transverse ridges and valleys that may represent former transform boundaries. Measurements of the backscatter energy from the bottom (Fig. 4b) has been particularly useful in determining the location of neo-volcanic zones on the ridge axis and in accurately locating dredging stations.

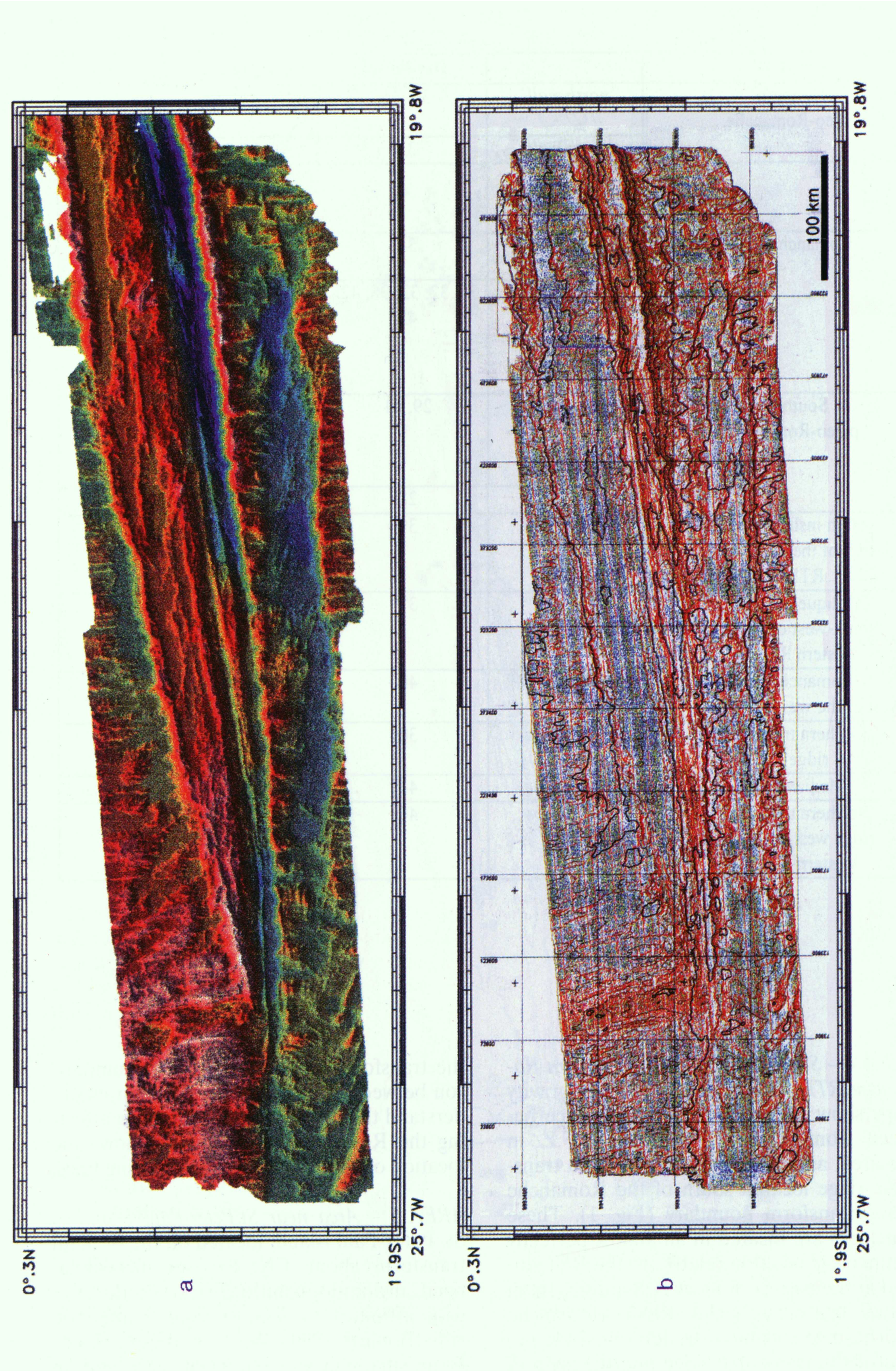

Fig. 4 - **a**, shaded relief map of the Romanche western intersection, derived by the AREA-3 multibeam survey; **b**, bottom reflectivity map of the same area. Red levels indicate «high-backscatter» while blue levels «low-backscatter» of the ocean bottom. Red levels dominate near the MAR axis (neo-volcanic zone) and around the transform valley (transverse ridges and normal faults scarps).

Tab. 1

Location		Dredges #	Lithology
Northern paleo-Romanche	*north wall*	36, 45	ophicalcite breccia.
	south wall	35	basalts.
			basalts, hyaloclastite breccia, sedimentary breccia
Romanche F.Z.	*north wall*	34	basalts, hyaloclastite breccia, sedimentary breccia
	south wall	31, 32, 33, 38, 42, 43	peridotites, serp. breccia, metasomatic rocks, basalts, dolerites, sedim. breccia, hyaloclastite breccia
Southern paleo-Romanche	*north wall*	29, 41	basalts, dolerites, hyaloclastite, breccia, peridotites, gabbros, limestones
	south wall	28	(empty dredge)
High inside corner (HIC) of the western RTI	*south slope*	39	peridotites, gabbros, basalts, basaltic breccias, sedim. breccias
Oblique structure south-west of the western RTI		37	(empty dredge)
Romanche F.Z. west of the western RTI	*north wall*	40	(empty dredge)
Southern transverse ridge	*south slope*	30	gabbros, sedim. breccia
Median ridge	*south slope*	44	(empty dredge)
Northern transverse ridge west of the western RTI	*north slope*	46	peridotites, serp. breccia, sedim. breccia; evidence of faulting

AREA 4 - South American Plate, western Romanche RTI «fossil» trace — Satellite gravity maps show a minimum in the distance between Romanche FZ. and Chain F.Z. in this area, as well as the presence of a transverse ridge located south of the Romanche active transform boundary (Fig. 1). These structures are located in an almost perfectly symmetrical position relative to the RSS studied at the eastern RTI. A N-S multichannel seismic line crossing the «fossil» Romanche F.Z. has been acquired to determine the nature of the transverse ridge and the style of the transform-related tectonics. A comparison between the two RTI could help us understand the large scale deformations affecting the Romanche area. Fig. 2c shows the location of seismic and depth sounding lines.

AREA 5 - Area near St.Peter-Paul Island — St. Peter-Paul island, located on the St. Paul transform about 1“’N, exposes metasomatized mylonitic mantle-derived peridotites with affinities to mantle from continental rifts (Bonatti, 1990). We carried out a multibeam survey in the vicinity of the island, in order to

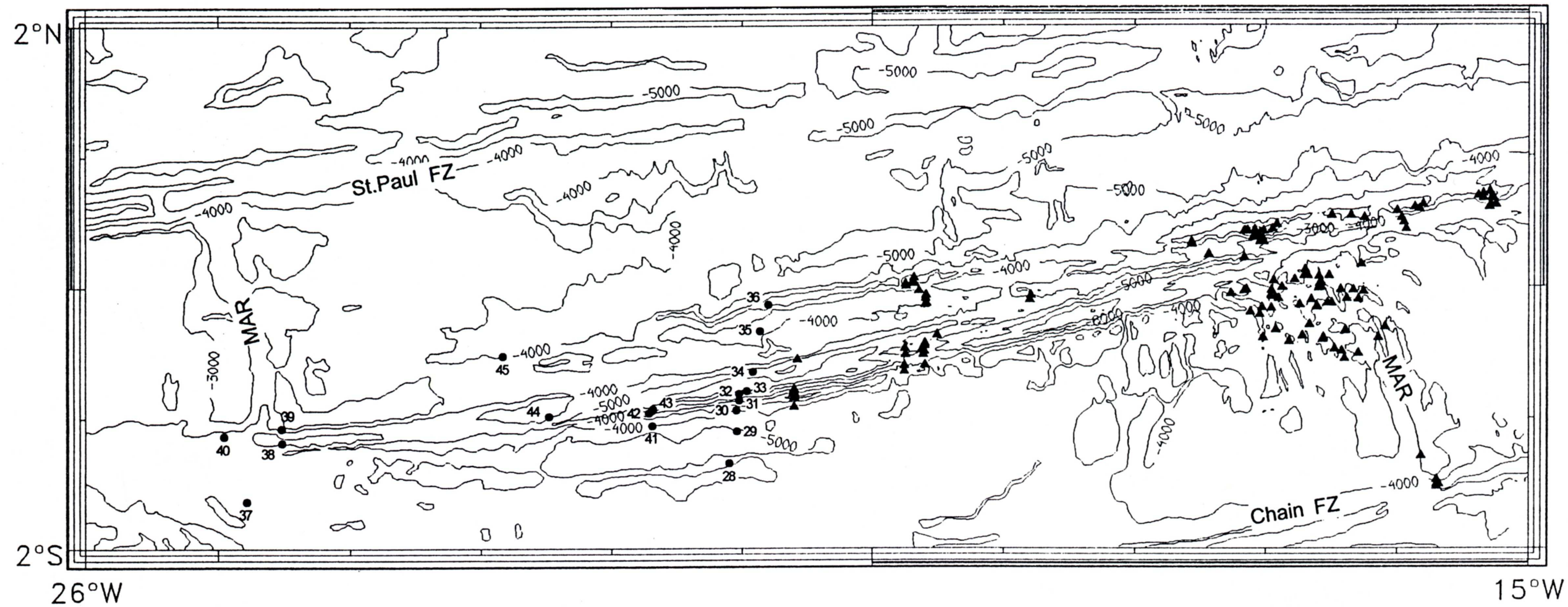

Fig. 5 - Location map of the dredging stations carried out during PRIMAR-92,93 (black triangles) and 96 (black circles with number) expeditions, over a simplyfied bathymetric map of the Romanche region (isolines each 1000 m).

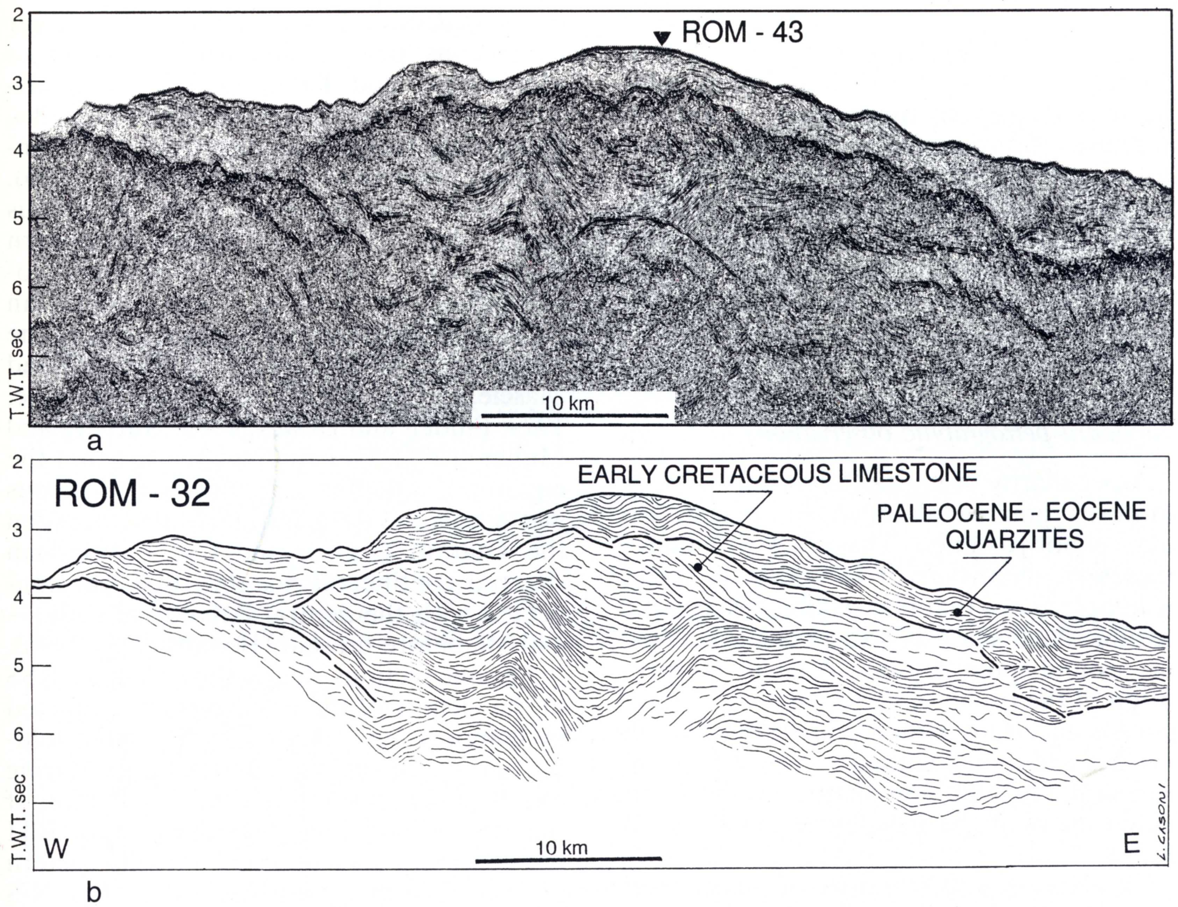

Fig. 6 - **a**, portion of an E-W seismic reflection profile (ROM-32M, see Fig. 2 for location) collected along the crest of the Romanche transverse ridge. Vertical scale is in two-way time (seconds); **b**, the interpreted section. Seismic units are identified on the basis of dredged samples.

investigate the structural framework of this peculiar feature.

Rock sampling

Twenty dredge stations were carried out during the PRIMAR-96 cruise to the Romanche F.Z. Dredging operations took place from 23rd May 1996 to 18th June 1996 and from latitude 0°49'.60 N to latitude 1°38'.60 S, and from longitude 14°18'.10 W to longitude 28°32'.30 W. Fourteen dredges were successful and brought on deck about 800 kg of rocks. The remaining six dredges were empty or contained only sediments.

The rocks include the following lithotypes: serpentinized peridotite, gabbro, basalt, dolerite, metasomatic rocks, limestone, serpentinite breccia, gabbro breccia, basaltic breccia, hyaloclastite breccia, sedimentary breccia, ophicalcite breccia. The most widespread lithological types are peridotite and basalt.

Dredging location

Dredges station were located in the central and western parts of the Romanche transform, except for dredge #27 which was carried out to the east of the eastern RTI. The most relevant morphostructures related to the transform domain have been sampled, i.e. the active transform zone and its western intersection with the MAR; the inactive western sector; the north and south paleotransform zones, and transverse ridges.

Dredges #29 through #36 were located along a narrow, north- south trending profile near 21°W between 0° and 1° S, in order to investigate the three main transform structures, i.e. the north and south paleo-Romanche, and the active Romanche FZ. The location of the dredge stations and the distribution of the rock types in relation with the morphostructures are reported in Tab. 1. Fig. 5 shows the location of dredging station carried out in the Romanche area during PRIMAR-92, 93 and 96 cruises.

Shipboard petrographic observations

A peculiarity of most of the sampled peridotites is the great abundance of plagioclase and clinopyroxene. These two mineral phases frequently occur in mm-scale layers or in aggregates that may exhibit a magmatic texture. Plagioclase is also present as coronas around spinel crystals. A clear interpretation of the origin of these plag+cpx aggregates is uncertain. However, textural characteristics and modal contents suggest that impregnation by melt percolation may have affected many of the Romanche mantle peridotites.

The basalts consist mostly of pillow fragments with variolitic-spherulitic textures. Basalts from dredges #34, #35 and #42 (north wall of the Romanche FZ., south wall of the north paleo-Romanche, and south wall of the Romanche F.Z., respectively) show the presence of Ti-Augite+olivine, suggesting an alkaline character of the basaltic melt.

Preliminary results

Data processing is still in progress and the following considerations are only based on preliminary evaluations.

1. The Romanche transverse ridge in the vicinity of the eastern RTI consists of a thick (> 4 sec TWT) pile of sediments, that were sampled during this and previous expeditions. If we assume normal spreading from the MAR axis at a rate of 17.5 mm/y (Cande et. al., 1988), the age of the oceanic crust in this area ranges between 55 and 60 Ma. According to dredged samples and seismic profiles (Figs. 6 and 7), this sedimentary sequence (RSS) is formed by two units: lower Cretaceous pelagic limestones (similar to «Maiolica») and Paleocene/Eocene quartzites; thus it constitutes an «age anomaly», being older than the predicted age of the underlying basement (Bonatti et al., 1996). Moreover, the presence early-Cretaceous pelagic deposits near the Romanche eastern RTI is not in agreement with palaeoceanographic reconstructions, which assume an Aptian-Albian age for the initial stage of the equatorial Atlantic opening (Sibuet and Mascle, 1978; Rabinovitz and Labreque, 1979; Pindell and Dewey, 1982; Nurberg and Muller, 1991). Our findings suggest that the equatorial Atlantic in the lower Cretaceous was a narrow, deep basin, located between the Gulf of Guinea and the S American sheared continental margins, that was connected with the central Atlantic already ~ 140 Ma before present (Bonatti et al., 1996a).

Seismic sections clearly show that the RSS in the vicinity of the eastern RTI is affected by compressional tectonics, displaying folding and overthrusting. Data obtained during our ’96 cruise suggest that the distribution of the RSS is not limited to the eastern RTI but continues also along the «fossil» eastern extension of the transverse ridge. The N-S lateral extent of these deposits is limited to a narrow belt parallel to the inactive transform valley. These observations, and the «age anomaly» of the RSS, suggest two different hypothesis for the evolution of the Romanche FZ. area:

— a narrow (max. 50 km wide) belt or fragments of continental/transitional crust between Africa and S America never underwent «normal» spreading processes, being trapped by the simultaneous action of two or more transform/transcurrent faults that prevented those blocks form «drifting» during the separation of African and S American continental plates. In this case, we could find old blocks that did not move significantly from their original locations since the earliest stage of the equatorial Atlantic opening and could have been deformed by subsequent transform-related vertical tectonic;

— alternatively, or in conjunction with the previous hypothesis, an «oscillatory spreading» model (Bonatti and Crane, 1982) could be applied to this area in order to explain the age anomalies and other related features, like ridge-jump scars and aborted

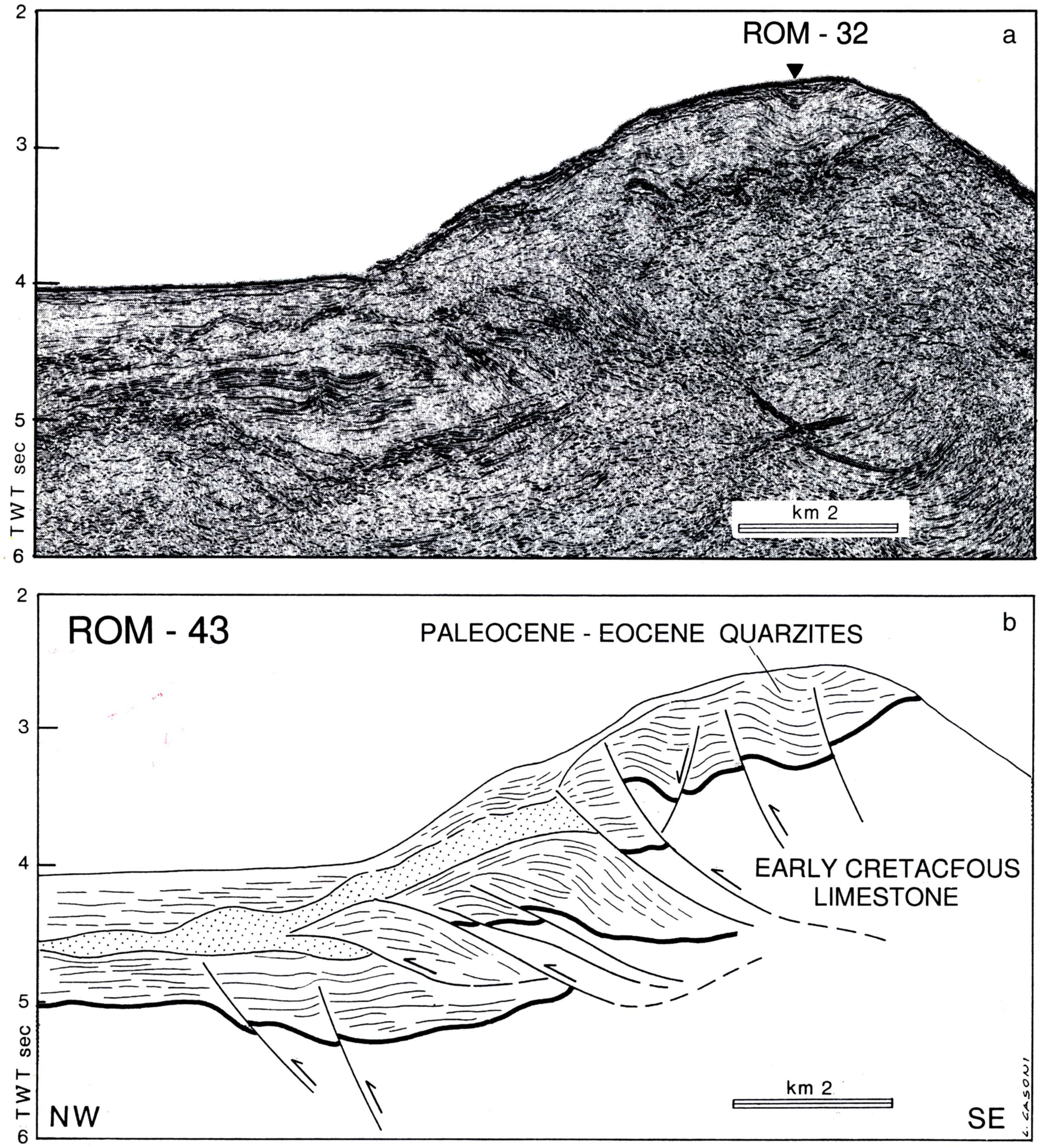

Fig. 7 - **a**, NW-SE seismic reflection profile (ROM-43M, see Fig. 2 for location) running across the Romanche transverse ridge. **b**, the interpreted section.

transform traces observed in the Romanche region. Following this model, ridge/transform geometry changes (i.e., ridge jumps and/or transform migrations) provide mechanisms by which blocks of oceanic lithosphere could be transferred from the African to the S American plate or vice versa, reversing their sense of motion.

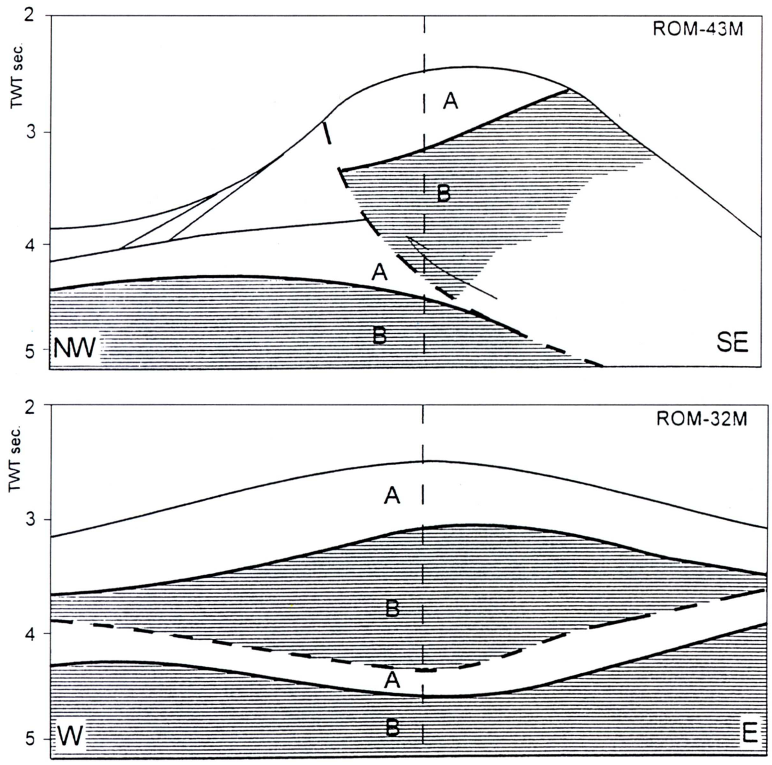

Fig. 8 - Simplified geological section of the Romanche transverse ridge near the eastern RTI, obtained by ROM-43M (top) and ROM-32M (bottom) interpretation. Vertical dashed line indicates the intersection point. Seismic units were subdivided according to dredged samples. **A**, Palaeocene/Eocene quarzites; **B**, lower Cretaceous, «Maiolica» type limestones.

2. We attempted, during PRIMAR-96, to unravel the deformation history of the RSS in the vicinity of the Romanche eastern RTI. Processing of N-S sections is complicated by the strong topographic gradients that limit the seismic energy propagation in depth, and by the presence of «backscatter» and «peg-leg» noise, only in part filtered by «stacking», due to the relatively short offset of our receiving streamer. Fig. 8 shows two orthogonal, simplified geological sections across the Romanche transverse ridge near the eastern RTI, derived from an interpretation of profiles ROM-32M (Fig. 6) and ROM-43M (Fig. 7). In this model, a single inverse—master-fault displace the RSS, forming a stratigraphic repetition, mostly evident in the E-W section: A-B-A-B, where A indicate Paleocene/Eocene quarzites and B lower Cretaceous limestones. Lateral pinching-out of the seismic units, as well as evidence of different seismic facies (well layered and weakly layered) alternating within the section, support this interpretation. Thus, the RSS could represent the remnant of narrow E-W aligned basins that were inverted by a post-Eocene compressional phase and possibly an earlier phase marked by the unconformity that divide the two seismic units. The newly acquired seismic lines give better constraints on the lateral extent of the RSS. Based on these lines, we will prepare a tectonic map of the eastern Romanche RTI, in order to reconstruct the 3-D geometry of the tectonic structure and the associated stress field.

Kinematic reconstructions are hampered by the absence of magnetic stripes due to the vicinity of the magnetic equator. We are trying to overcome this problem through seismostratigraphic analysis and modelling of the transverse ridge's vertical movements (Gasperini etal., 1997). An important target will be the analysis of the clear unconformity detected in seismic profile ROM-57M (Fig. 9); it separates deformed packages and undeformed onlapping layers, thus marking the end of the last compressional event.

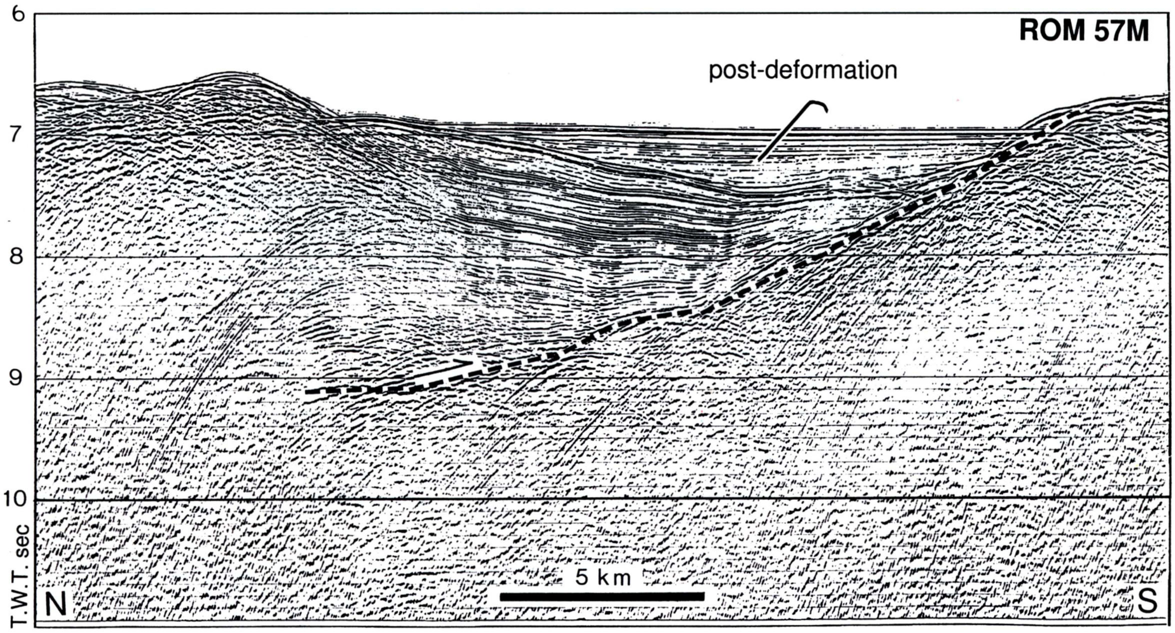

Fig. 9 - N-S seismic reflection profile (ROM-57M) crossing the «fossil» Romanche transverse ridge near the Romanche F.Z. eastern RTI (AREA-2; see Fig. 2 for location). We note a major unconformity separating deformed and undisturbed packages, marking the last compressional phase affecting the Romanche transverse ridge in this area.

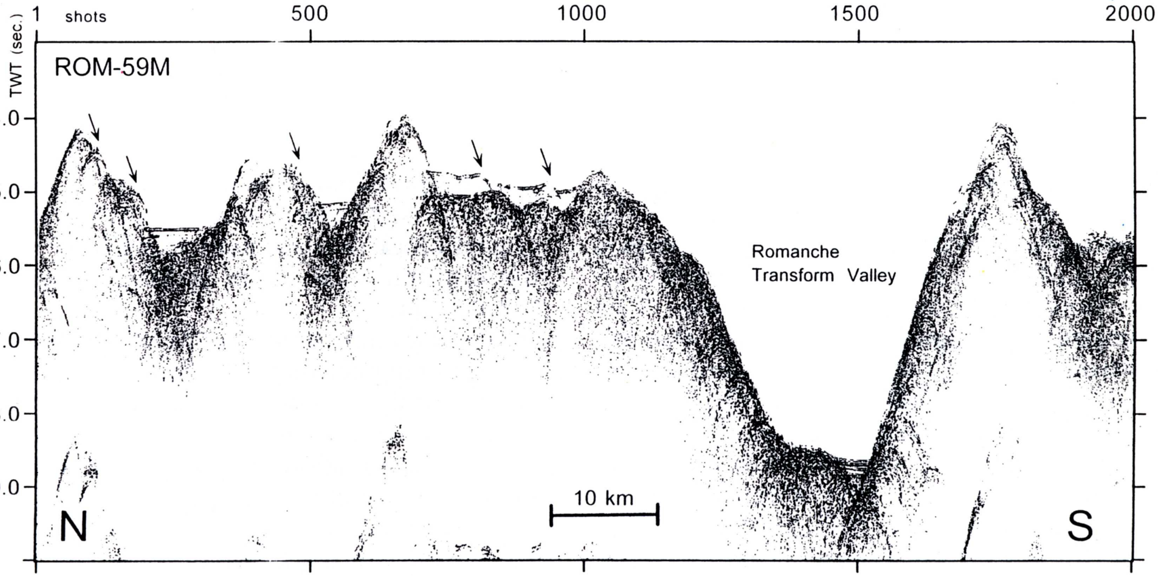

Fig. 10 - Neartrace display of a N-S multichannel seismic reflection profile crossing the Romanche transform valley (ROM-59M, Fig. 2 for location). This profiles shows extensional transform-related tectonics, i.e., normal faults (indicated by arrows) dipping toward the main transform valley. These faults affect the oceanic basement and locally displace the sedimentary infill of E-W oriented secondary troughs.

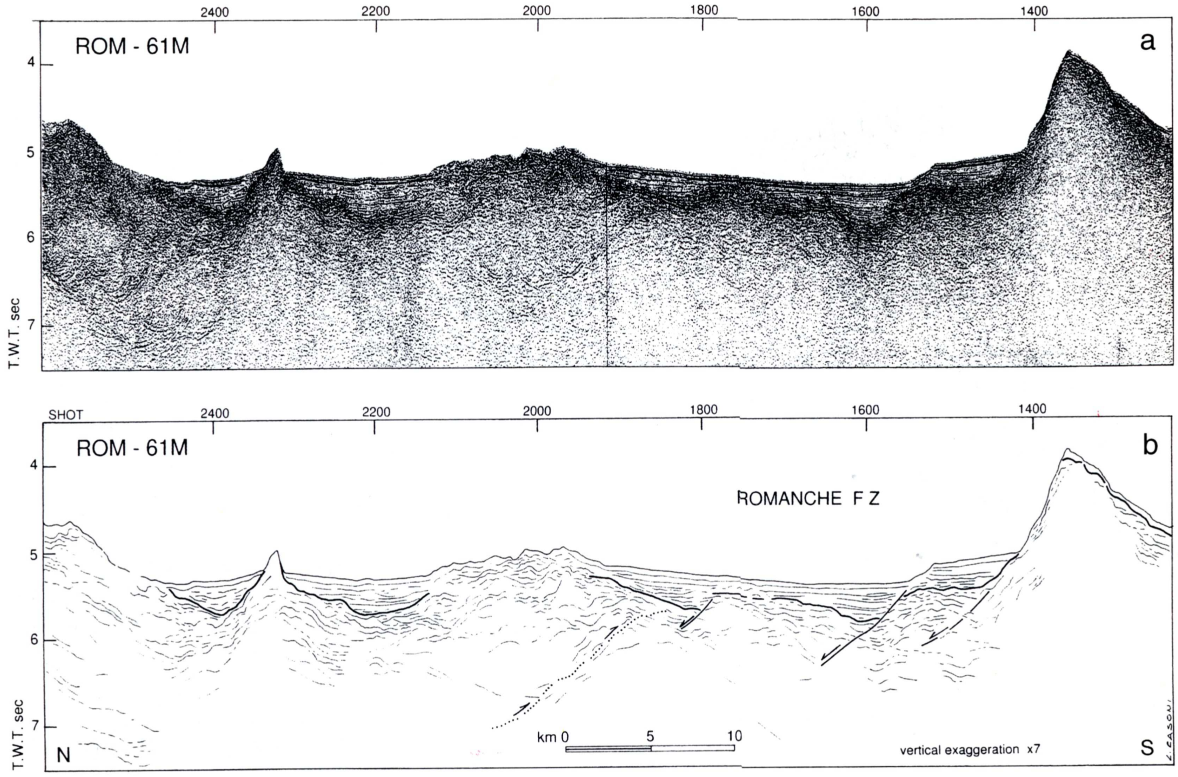

Fig. 11 - **a**, N-S multichannel seismic reflection profile (ROM—6IM, constant-velocity—migrated section) crossing the inactive trace of the Romanche FZ. outside the western RTI (Fig. 2 for location); **b**, interpreted profile. Compressive deformation affecting the layered block constituting the northern boundary of the western Romanche «fossil» trace are visible. This structural setting recall the deformation pattern observed near the eastern RTI.

3. The morphobathymetric maps of Figs. 3a and 4a gives a new detailed image of the Romanche region. It consists of a complex system of ridges and troughs, sub-parallel to the presently active transform valley. This composite configuration supports the hypothesis of ridge and/or transform migrations during the evolution of the Romanche region. Two major features, indicated in Fig. 3b, are lines a-a_1 and b-b_1, marked by E-W oriented, discontinuous ridges, located south and north of the present-day Romanche F.Z., respectively. They separate two distinct morphological fabrics:

a) a «normal» oceanic crust outside the sector bounded by a-a_1, and b-b1, characterised by crustal patterns sub-parallel to the spreading axis, not affected by important deformation;

b) a tectonized pattern between a-a_1, and b-b_1 that includes the present-day Romanche principal displacement zone and is characterised by large scale deformation and crustal block displacement along E-W striking transtensional faults, terminating across the two lines.

A preliminary analysis of the N-S seismic lines running across this deformed sector indicates only extensional features (ROM-59M, Fig. 10), while evidence of compressional deformation is restricted to the previously described transverse ridge segments located close to the eastern RTI, in the Romanche inactive part.

The western intersection lacks some of the typical features observed at RTI's of other fracture zones (i.e. high inside corner, nodal deep); the same was observed at the eastern RTI, as described by Bonatti et al. (1996).

Tranpressional and transtensional regimes at transform boundaries can be related to changes in the spreading geometry (Menard and Atwater, 1968; Bonatti, 1978; Bonatti et al., 1994; Pockalny ez al., 1996). Evidence of change in the spreading direction was observed near the Romanche western RTI, at about 23°50'W longitude. In the vicinity of the ridge axis the fabric pattern of the oceanic crust is roughly parallel to the axial valley trace. Moving toward the east, about 110 km off the ridge axis, we note a sharp change in the fabric orientation, indicated by an arrow in Fig. 3b. This is a consequence of a major change in the S American/African relative motion vector that can be dated, assuming an average spreading rate of 1.75 m/y for the MAR in this region (Cande et al., 1988), at about 56 My ago.

4. The transverse ridge at the western «fossil» trace of the Romanche FZ. Differs from its symmetrical equivalent located outside the eastern RTI. The topographic anomaly near the western RTI is mostly related to the presence of a less pronounced transverse ridge that bounds to the south the fossil trace of the Romanche FZ. The northern boundary is constituted by a ridge that shows structural similarities with the transverse ridge at the eastern RTI. We note evidence of minor compressional features marked by a folded layered block displaced by a low-angle inverse fault in a N-S multichannel seismic section crossing the Romanche western «fossil» trace (Fig. ll). This block is onlapped by recent deposits that constitute the infilling of the «fossil» valley and are locally affected by transform-related normal faulting, as also observed in the active part of the Romanche FZ.. Thus, transtension along E-W striking normal faults constitutes the most recent tectonic pattern, not only along the active part of the Romanche transform, but also along its «fossil» trace.

Acknowledgments

We are very grateful to officers and crew of the R/V Gelendzhik for the skill and cooperation in the field work. Thanks are due also to G. Bortoluzzi, L. Casoni and G. Gallerani who in various capacities helped make the field work possible, to A. Argnani and A. Polonia for helpful discussions.

This research was sponsored by the Italian C.N.R. (progetto strategico Mar Russo/Dorsali).

Contribution N. 1097 of Istituto di Geologia Marina del C.N.R.

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