Morphology, sediments and structure of the Amirante Trench, Western Indian Ocean: implications for trench origin

John E. Damuth*
Lamont-Doherty Geological Observatory of Columbia University Palisades, New York 10964, USA

and David A. Johnson
Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA

Received 9 November 1987; revised 14 March 1989; accepted 21 March 1989

The Amirante Trench is a 600 km long and up to 5200 m deep topographic depression whose origin has remained enigmatic. The trench contains >1 km of undisturbed, ponded turbidites and mass-transport deposits that have been periodically modified by northward flowing contour currents of the Deep Western Boundary Current (DWBC). Morphologically, the trench and adjacent Amirante Ridge resemble an arcuate oceanic arc–trench system and some investigators have suggested that this complex represents some type of subduction zone. However, our analysis of bathymetric and structural data indicate that the trench is not a single, continuous arcuate feature, but is actually a compound feature composed of three discrete, essentially linear segments of differing structural orientations and probable seafloor spreading origins. The northern segment (4°20'–6°20'S) trends NE (−030°) and apparently represents a fracture zone or transform-fault trend related to seafloor spreading in the Mascarene Basin during the Late Cretaceous. The central segment (6°20'–8°40'S) trends NW (−350°) and appears to represent a fracture-zone lineament that is parallel to fracture zones and lineaments created by the opening of the Somali Basin during the Late Jurassic and Early Cretaceous. However, Somali Basin crust apparently does not extend eastward as far as this portion of the trench, so the origin of this segment remains uncertain. The southern segment (8°40'–10°S) trends NW (−310°) and may represent a tensional rift related to seafloor spreading within the Mascarene Basin during the early Tertiary. Further, our data show no convincing evidence that any portion of this feature was a subduction zone at any time during its development. The data also essentially rule out an extraterrestrial impact origin for this region at the end of the Cretaceous.

Keywords: Amirante trench; seafloor spreading; subduction zones; extraterrestrial impact

Introduction

The Amirante Trench (Fisher et al., 1967; 1968) is an arcuate appearing trough-like feature approximately 600 km long, and is one of the most striking bathymetric and structural features of the western Indian Ocean (Figures 1–4). The trench is bounded on the east by the steep, volcanic Amirante Ridge and together these features morphologically resemble an arc–trench subduction complex (e.g. Figure 3, Profile A–B). However, the origin of the trench, as well as its relationship to the plate tectonic evolution of the Western Indian Ocean, remains uncertain. Tectonic reconstructions of the western Indian Ocean (e.g. McKenzie and Selater, 1971; Schlich, 1974; Norton and Selater, 1979; Scrutton et al., 1981; and Masson, 1984; Mart, 1988) have not yet fully explained the origin of the Amirante Trench–Ridge complex, or its relationship to various stages of ocean basin development. One major problem is the absence of identifiable magnetic anomalies in the northern Mascarene and southeastern Somali basins (Schlich, 1974; Scrutton et al., 1981) (Figure 5).

Fisher et al., (1968) speculated that the Amirante Ridge might be an inactive island arc. Miles (1982) suggested, on the basis of free-air gravity models, that density distributions across the Amirante Ridge–Trench complex show evidence of partial or limited subduction within the trench. Subsequently, Masson (1984) suggested that the northern third of the trench and ridge may represent a portion of a major NE–SW trending transform fault that separates the younger (Late Cretaceous) sea floor of the Mascarene Basin from the older (Late Jurassic–Early Cretaceous) crust of the Somali Basin (Figure 5). In contrast, the southern two thirds of the ridge–trench complex are contained solely within Mascarene Basin crust and represent a minor subduction or compressional feature related to the change in seafloor spreading geometry (Figure 5). A more exotic origin for the trench has been proposed by Hartnady (1986), who suggested that the...
entire Amirante Basin may be the impact site of the hypothesized Cretaceous–Tertiary extinction bolide (Alvarez et al., 1980), and that the Amirante Trench and Ridge structures may be the result of that impact.

We conducted shipboard geological and geophysical studies of the Amirante Passage region in 1977 (Johnson and Damuth, 1979; Johnson et al., 1982; 1983) during which time we obtained several geophysical profiles across the southern portion of the Amirante Trench, as well as a piston core and bottom photographs (Figure 2). Initial analysis of these data showed no convincing evidence that the Amirante Trench is a subduction zone feature. On the contrary, the morphology and structure of the trench suggested to us that it is a composite feature comprised of three distinct linear segments, and that each segment may represent a different stage of the region's sea-floor spreading evolution during the late Mesozoic and early Tertiary. In this paper we describe the morphology and sediments of the Amirante Trench and offer some observations bearing on proposed origins for the Amirante Trench–Ridge complex.

Morphology and structure of the trench

The Amirante Trench is flat floored and gradually deepens southward from depths of <4500 m to >5200 m (Figures 2–4). The trench is generally 25–50 km wide and is bounded on the east by the steep Amirante Ridge which rises to within a few hundred metres of sea level. On the west, the trench is bounded by rugged basement ridges and seamounts of less relief (~1000 m; Figures 3 and 4). Close inspection of the regional bathymetry (Figure 2) reveals that the trench is neither arcuate nor a single linear feature of several hundred kilometres in extent. Instead, the trench
Amirante Trench: J. E. Damuth and D. A. Johnson appears to be a composite of three discrete, nearly linear or straight segments that are essentially contiguous, but which have strikingly different orientations (dashed lines in Figure 2): a northern segment between 4°20′S and 6°20′S which trends NE along ~030°; a central segment between 6°20′S and 8°40′S which has a NNW trend of ~350°; and a southern segment between 8°40′S and 10°S which is oriented along a NW trend of ~310°. Near 8°40′S a large seamount nearly fills the trench axis (Figure 4, profile G-H) and marks the boundary between the middle and southern trench segments (see Johnson and Damuth, 1979, their Figure 2 for detailed bathymetry south of 8° S). Roberts et al. (1984) previously noted

Figure 2 Right: Bathymetry of the Amirante Trench, Ridge and adjacent regions (modified from Johnson and Damuth, 1979 and Fisher et al., 1967 and 1968). Location of the map is shown in Figure 1. Contour interval is 0.5 km. Heavy lines show locations of seismic reflection profiles in Figures 3, 4, and 6, as well as bathymetric and gravity profiles shown at left. Dashed line down trench shows the orientations of the three linear structural segments of the trench identified and discussed in the text. Left: Bathymetric profiles (solid lines) and free-air gravity anomaly profiles (dashed lines) from several crossings of the trench axis. Locations at right

234 Marine and Petroleum Geology, 1989, Vol 6, August
that this seamount forms a structural barrier that divides contrasting trench floor sediment facies to the north and south (see below).

**Sedimentation in the trench**

The flat floor of the trench is up to 30 km wide and is underlain by a sequence of acoustically semi-transparent to reflective, flat-lying sediments which are often greater than 1 s TWT (~1 km) thick and appear to be tectonically undisturbed (Figures 3 and 4; see also Roberts *et al.*, 1984; Masson, 1984). Much of this sediment appears to be ponded turbidites, although discontinuous reflectors at some locations (e.g. Figure 4, profile K–L) suggest mass transport deposits (slumps, slides, debris flows), as well as contour-current deposits. Acoustically transparent deposits that occur along the flanks of the trench floor and adjacent lower walls (e.g. Figure 3, profiles C–D–E–F) are probably sediment drifts deposited by contour-current flow of the Deep Western Boundary Current (DWBC) through the trench (see Johnson and Damuth (1979) for complete discussion).

Recently, Roberts *et al.* (1984) conducted long-range side-scan sonar (GLORIA) imaging of the Amirante Trench between 7° and 9°40’S and reported that distinct and contrasting acoustic facies characterize the trench floor to the north and south of the seamount near 8°40’S (this seamount marks the boundary between our middle and southern trench segments; Figure 2). The acoustic facies south of the seamount is characterized by weak acoustic reflectivity and is thought to represent mainly contour-current deposition by DWBC flow from the Amirante Passage into the southern part of the trench (Johnson and Damuth, 1979). In contrast, the acoustic facies to the north of the seamount is highly reflective and is thought to represent mainly episodic deposition by turbidity currents and mass-transport processes with some modification by DWBC flow (Roberts *et al.*, 1984).

Echograms, a piston core (V34-78), and bottom photographs (V34-K29) from the floor of the middle trench segment north of the large seamount (Figure 2) confirm the depositional processes indicated by our seismic profiles and the GLORIA data of Roberts *et al.* (1984). On 3.5 kHz echograms, the western half of the trench floor shows a transparent layer 20 to 30 m thick that is underlain by more stratified sediments (Figure 6). Such acoustically transparent deposits are characteristic of debris-flow deposits (Embley, 1976; Damuth, 1980), and are often observed in narrow fracture-zone valleys of the mid-ocean ridge. The
Amirante Trench: J. E. Damuth and D. A. Johnson
eastern side of the trench floor returns very prolonged
echoes with little or no penetration below the sea floor.
Prolonged echoes such as these are generally returned
from sediments with abundant coarse-bedded silts,
sands, and gravels (Damuth, 1980). The sediments
returning the prolonged echoes appear to overlie and
onlap the transparent deposits toward the west in the
middle of the trench floor (Figure 6).

A piston core was raised from the edge of the
prolonged echo zone near the middle of the trench floor
(Figure 6). The top 330 cm consists of light grey,
homogeneous, structureless calcareous clay; the section
from 330 cm to 380 cm grades from calcareous clay to
silt and shows contorted bedding; and the section from
380 cm to 427 cm is graded calcareous silt to fine sand
with a sharp, irregular base. This entire unit from 0 to
427 cm represents a graded turbidity-current deposit
composed entirely of calcareous debris. The underlying
sequence from 427 cm to the base of the core (563 cm)
is a fine-grained, homogeneous calcareous clay, and
appears to be the top of a similar graded turbidite.

A series of bottom photographs (K29) taken at the
core site show large, angular displaced blocks which
appear to be composed of carbonate material, and
which often exceed 1 m across (Figure 7). These
displaced blocks have obviously been deposited by
slumps or slides originating in relatively shallow water
above the carbonate compensation depth (CCD),
presumably on the upper portion of the steep eastern
wall of the trench (Amirante Ridge). Other bottom
photographs at the camera station show broad, gentle
ripples and subtle scour or smoothing, which indicate

---

**Figure 4** Seismic reflection profiles G to P across the Amirante Trench and Ridge. Locations are shown in Figure 2. Portions of original records along steep slopes (G–H–I–J) are enhanced by dashed lines to show continuity.
flow of the DWBC through the trench either at present or in the recent past (see Johnson and Damuth, 1979; their Figure 20). The 3.5 kHz echograms, piston core, and bottom photographs, thus confirm that mass-transport processes and turbidity currents have deposited the ponded sediments of the trench floor, and that contour-current flow northward along the trench floor probably periodically reworks and redistributes some of these sediments.

Observations bearing on the origin of the trench–ridge complex

Subduction zone or compressional feature
Fisher et al. (1968) speculated, based on morphology, that the Amirante Ridge–Trench complex might be an inactive island arc, although they dredged normal oceanic tholeiites from the ridge. On the basis of gravity models, Miles (1982) suggested that limited subduction occurred within the trench. Masson (1984) suggested that the southern portion of the trench (south of 6°30'S) probably had a compressional origin, although neither he nor Miles observed evidence to suggest a major subduction zone involving several hundred kilometres of crustal consumption. Mart (1988) pointed out that the occurrence of calc-alkaline dolerite dykes and syenite batholiths in the Seychelles Islands supports these interpretations of subduction beneath the Amirante Trench during the Early Tertiary. Despite these studies, the following
Figure 6 High resolution seismic reflection profile (3.5 kHz echogram) across the Amirante Trench floor. Location is along Profile H-H (Figures 2 and 4). Arrow denotes approximate location (projected) of piston core V34-98 and camera station V34-29 (see Figure 7).

Graphic log of core lithology is discussed in text.
observations suggest to us that the Amirante Trench–Ridge complex is probably not the expression of a subduction zone.

Masson (1984) previously defined a discrete northernmost trench segment analogous to ours (trending NE–SW, 030°; Figure 5), and ascribed its origin to transform faulting. However, he did not recognize the separate middle (trend 350°) and southern (trend 310°) linear trench segments that we have identified here (Figure 2). Instead, he envisioned these central and southern segments as a single arcuate feature whose origin he ascribed to compression or limited subduction (Figure 5). Our bathymetric analysis suggests that the trench morphology is neither arcuate, nor a single continuous feature, but rather a composite feature of three separate, but connected, linear topographic/structural segments oriented at 030°, 350°, and 310° (Figure 2). If this three-fold linear segmentation is real, it cannot be easily explained by subduction or compression.

Miles (1982) concluded that free-air gravity profiles observed across the Amirante Trench–Ridge complex cannot be reproduced in a conventional subduction model without the addition of a high-density 2.85 mg/m³ block beneath the ridge, and an increase in sediment thickness (for which there is little evidence) in the trench. He further concluded that, at best, the models indicate only ‘limited’ or ‘partial’ subduction, and do not substantiate the existence of an extensive, diving lithospheric slab. Miles (1982) study indicates that the crustal mass distribution does not resemble a conventional subduction model.

We do not have sufficient gravity data to construct a model for the trench–ridge complex (J. Cochran, personal communication). However, a ‘simple Bouguer’ correction can be applied to our free-air gravity profiles (Figure 2) in order to estimate whether there is a significant mass deficiency associated with the trench. This correction is given by $2 \pi G (\Delta \rho) (\Delta Z)$, where $\Delta \rho$ is the water–rock density contrast, and $\Delta Z$ is the topographic relief of the sea floor along a particular profile. Assuming a water–rock density contrast of $2.67 - 1.03 = 1.64$ g/cm³, the Bouguer correction becomes $0.0686$ mgal/m, or $68.6$ mgal/km. Inspection
Amirante Trench: J. E. Damuth and D. A. Johnson

of our gravity profiles (Figure 2) indicates that the application of a simple Bouguer correction would completely eliminate the negative free-air anomaly (~120 mgal) associated with the trench, and that consequently there appears to be no significant mass deficiency associated with the 'trench'.

In our profiles (Figure 2) the free-air anomaly is of low amplitude and appears to be centred directly over the structural axis of the trench. However, Miles (1982) reported the low to be slight off centre from the trench axis towards the Amirante Ridge (east). In any case, if there was a fully developed arc-trench subduction zone, a significant landward (i.e. eastward) displacement of the gravity minimum, corresponding to a mass deficiency beneath the leading edge of the overriding plate (e.g. Talwani et al., 1961; Grow, 1973) should be observed. Such a landward displacement is not clearly evident. Based on these observations, we believe that the gravity data from the Amirante Trench–Ridge complex (Figure 2 and Miles, 1982) show no strong evidence that the Amirante Trench represents a region of major crustal subduction or compression, although we cannot rule out very limited or partial subduction or compression as proposed by Miles (1982).

Our seismic profiles (Figures 3 and 4), as well as those published by Roberts et al. (1984) and Masson (1984), show a very steep volcanic basement ridge extending from the summit of the Amirante Ridge to the trench floor with no evidence of an accretionary sediment prism. Such an accretionary prism is often characteristic of subduction zones (e.g. Silver, 1969; Shipley et al., 1980; Watkins et al., 1982), and would be expected to occur on the west flank of the Amirante Ridge if the ridge–trench complex was a major subduction zone. Moreover, the landward-dipping surface of a subducting plate can often be observed (on seismic profiles) dipping beneath the inner wall and floor of a trench (e.g. Chase and Buncie, 1969; Watkins et al., 1982). However, this is not observed beneath the Amirante Trench (Figures 3 and 4). Trenches that are remote from volumetrically significant supplies of terrigenous sediment are characteristically free of thick sediment accumulations, presumably because of off-scraping and accretion onto the overriding plate. The Amirante Trench, however, is observed to contain a thick (1–1.5 s TWT), undisturbed accumulation of flat-lying ponded sediments (Figures 3 and 4) with no evidence of an accretionary prism. In fact, we observe no suggestion of sediment deformation within the trench. Despite hypothesizing a compressional origin for the trench, Masson (1984) stated that only one of his seismic profiles across the trench (his Figure 7) showed any hint of deformation. The absence of significant sediment deformation would seem to argue against subduction or extensive compression (assuming a significant volume of sediment was present in the trench at the time of tectonic activity).

Volcanic rocks associated with island-arc volcanism are characteristically andesitic in composition (e.g. Kuno, 1968; Bryan et al., 1972), whereas the rocks dredged from the Amirante Ridge most closely resemble typical oceanic tholeiitic basalts (Fisher et al., 1968). Thus the volcanic rocks associated with the formation of the Amirante Ridge show no evidence of being related to a former subduction zone. However, Mart (1988) noted that the occurrence of a calc-alkaline mineralogical suite of Eocene age syenite on some of the Seychelles Islands suggests that the region was affected by the early stages of subduction. However, the absence of alkaline intrusive rocks argues against mature subduction having taken place.

In summary, these observations and data fail to show any convincing evidence that the Amirante Trench–Ridge complex represents a major zone of compression or mature subduction involving several hundred miles of crustal consumption. We also observed no evidence in the trench morphology or sediments to support the occurrence of 'limited' or 'partial' subduction or compression (Miles, 1982; Masson, 1984); however, we cannot rule it out.

**Complex sea-floor spreading feature**

If the Amirante Trench is comprised of three distinct linear segments with variable orientations (Figure 2) as we propose, then the trench is a compound feature which represents a multiple of tectonic styles. The steep, asymmetrical basement relief of the Amirante and adjacent ridges (Figures 3 and 4), together with the three-fold segmentation (Figure 2), suggest that each of the segments reflects unrelated transient offsets or structural lineaments, perhaps along former fracture zones and/or transform faults.

Individual magnetic anomalies in the eastern Somali Basin and the northwestern Mascarene Basin in the vicinity of the Amirante Trench have not been identified. Consequently, determining the history of the trench requires extrapolating from identified anomaly patterns up to several hundred kilometres away (see Figure 5 and Masson (1984) for detailed discussion and references). The Late Jurassic–Early Cretaceous sequence of magnetic anomalies (M8 through M25) trend E–W in the western Somali Basin, with N–S offsets of the anomalies along fracture zones that parallel the Davie Ridge (Scrutton et al., 1981; Rabinowitz et al., 1983; Coffin and Rabinowitz, 1987; Cochran, 1988) (Figure 5). The southern Mascarene Basin is marked by Late Cretaceous–Early Tertiary anomalies 28 through 34. These anomalies are oriented along an ESE trend and are offset in a right-lateral sense by fracture zones trending in a NNE direction (Schlach, 1974; Norton and Slater, 1979; Masson, 1984) (Figure 5). To the north of the Seychelles Platform, the presence of Tertiary anomalies 23 through 25 (McKenzie and Slater, 1971; Norton and Slater, 1979) indicates that a spreading centre had developed between the Seychelles and the Indian subcontinent by the early Tertiary (c. 50 Ma).

In the Amirante Passage region just south and west of the Amirante Trench, two distinct structural trends, which are oriented nearly orthogonal to one another, are formed by the major basement ridges (Johnson and Damuth, 1979; see their Figure 2). South of the Amirante Passage constricted at 9°S, steep, elongate basement ridges trend in a NE to ENE direction (Figure 2), and are sub-parallel to the linear ridge of volcanic peaks (including Providence Reef) which extends northeastward from Madagascar toward the Amirante Trench. All these ridges probably share a comparable, and perhaps synchronous, history of development. Upper Cretaceous sediments cored on the summits of two of these northeast-trending ridges in the Amirante Passage indicate that this structural trend is of pre-Tertiary age (Johnson et al., 1982; 1983;
Masson et al., 1982). These structures are parallel to the northeast-trending transform fault patterns identified in the Upper Cretaceous crust of the Mascarene Basin (Figure 5).

The northern segment of the Amirante Trench, which we identified as trending northeastly (030°) between 4°20’S and 6°20’S (Figure 3) is also parallel to these ridges, as well as to the trends of Mascarene Basin fracture zones and transform faults (Figure 5). We suggest that this northern segment of the Amirante Trench represents a major transform fault in the Upper Cretaceous crust of the northermost Mascarene Basin. This is in agreement with Masson (1984) who previously recognized this northern trench segment and suggested that it represented a portion of a major transform fault extending from the northeast tip of Madagascar to the northwest margin of the Seychelles Plateau (Figure 5). Masson proposed that this major transform fault marks the boundary between the Upper Cretaceous crust of the Mascarene Basin and the Upper Jurassic-Lower Cretaceous crust of the Somali Basin (Figure 5).

In contrast to this prominent northeast structural trend, basement ridges in the vicinity of the Amirante Passage to the north of 9°S are oriented in a NNW direction (Figure 2; see also Johnson and Damuth, 1979, their Figure 2). The trend of these ridges is sub-parallel to the trend of the Davie Ridge and other major fracture zones in the western Somali Basin (Figure 5) that denote the relative motion of Madagascar southward from the coast of Somalia during the late Jurassic and early Cretaceous (Heirtzler and Burroughs, 1971; Embleton and McElhinney, 1975; McElhinney et al., 1976; Scrutton et al., 1981; Rabinowitz et al., 1983; Coffin and Rabinowitz, 1987).

The trend of the central segment of the Amirante Trench (6°20’S to 8°40’S) that we have identified (Figure 2) is also NNW (~350°), and is parallel to the structural trends of the northeast coast of Madagascar, the Davie Ridge, and the other major fracture zones of the western Somali Basin (Figure 5).

Based on its trend, we originally thought that this central segment of the Amirante Trench might represent some sort of structural lineament or fracture zone related to the opening of the Somali Basin, and as such, might mark the eastern boundary of the Upper Jurassic–Lower Cretaceous crust. However, this interpretation now appears unlikely in light of more recently published data and ideas bearing on the plate tectonic evolution of the western Indian Ocean. Masson (1984) suggested that the Upper Jurassic-Lower Cretaceous crust extends eastward to the major NE-SW fracture zone that includes the northern segment (ours and his) of the Amirante Trench. However, if his reconstruction is correct, our central trench segment is located just eastward of this older crust in younger Upper Cretaceous Mascarene Basin crust (Figure 5). In addition, more recent studies (Coffin and Rabinowitz, 1987; Cochran, 1988) indicate that the boundary between the older Somali Basin crust and the younger Mascarene Basin crust may actually be 300 km west of the Amirante Trench along the Dhow Fracture Zone near 49°-50°E (Figure 5). These observations, if correct, make the interpretation of the central trench segment as a Late Jurassic-Early Cretaceous feature even more untenable. At present, we can only state that the central segment of the Amirante Trench: J. E. Damuth and D. A. Johnson

Amirante Trench–Ridge complex has the appearance of a fracture zone (J. R. Cochran, personal communication), but how and when it formed remains uncertain.

The southern structural segment of the Amirante Trench (8°40’S to 10°S) that we have identified trends northwest (~310°) and is also somewhat difficult to explain or to relate to sea-floor spreading structures. This segment seems to be contained within the Mascarene Basin crust (Figure 5). Possibly early Tertiary spreading in the Mascarene Basin produced tensional rifting and this southern trench segment may be a tensional feature formed during that earlier episode. This segment has an appropriate trend to be a rift (J. R. Cochran, personal communication), but it needs to be examined in more detail to see if its morphology and other geophysical parameters are consistent with this interpretation.

Extraterrestrial impact feature

Recently, Hartnady (1986) suggested that the Amirante Basin may be the impact site of the hypothesized Cretaceous–Tertiary extinction bolide (Alvarez et al., 1980), and that the Amirante Trench and Ridge structures may have resulted from that impact. This argument is largely hypothetical, and actual geological data and observations from the region appear to rule out the possibility of such a catastrophic origin. For example, we have cored in place, undisturbed pelagic oozes from late Eocene–Oligocene (Neogene) age (A. mayaroensis zone) from the crest of a steep volcanic ridge adjacent to the Amirante Trench (Johnson et al., 1982). In addition, Masson et al. (1982) recovered late Campanian pelagic sediments from a neighbouring ridge. It is difficult to explain how a lithospheric-shattering impact so catastrophic that it changed African plate motion and lithospheric stress patterns (Hartnady, 1986) could leave these previously deposited pelagic sediments (or for that matter, the volcanic ridge on which they are deposited) undisturbed. Moreover, Hartnady (1986) hypothesized that the Cretaceous–Tertiary impact created these and adjacent volcanic ridges. If so, then they could not have been in existence in the late Cretaceous when the pelagic sediments were cored from them were deposited.

Conclusions

Our analysis of geophysical data from the Amirante Trench–Ridge complex indicates that the trench is not a single arcuate feature, but rather a compound feature composed of three discrete, linear segments (Figure 2), each of which appears to be the result of different stages in the sea-floor spreading history of the western Indian Ocean. The northern trench segment (4°20’S to 6°20’S) trends northeastly (~030°) and apparently represents a fracture zone or transform fault trend related to sea-floor spreading in the Mascarene Basin during the Late Cretaceous. The central trench segment (6°20’S to 8°40’S) trends NNW (~350°) and is parallel to fracture zones and structural lineaments related to the opening of the Somali Basin and the southerly movement of Madagascar away from Africa during the Late Jurassic to Early Cretaceous. This central trench segment has the appearance of a fracture zone, but its relationship to the plate-tectonic evolution of the region is, as yet, uncertain because the older
Amirante Trench: J. E. Damuth and D. A. Johnson

Somali Basin crust does not appear to extend eastward as far as this trench segment. The southern trench segment (8°40' S to 10° S) trends NW (~310°) and may represent a tensile rift feature related to sea-floor spreading in the Mascarene Basin during the early Tertiary.

Although Masson (1984) previously identified a northern trench segment analogous to ours, he suggested that the southern two-thirds of the trench represents a single arcuate zone of compression or limited subduction within the Mascarene Basin crust. Previous investigators have also proposed that the trench-ridge complex represents some type of subduction zone (Fisher et al., 1968; Miles, 1982). Our analysis of the morphology, structure and sediments of the trench revealed no evidence to suggest that any portion of the trench is the expression of subduction or compression. In addition, our data tend to rule out formation of the trench-ridge complex by the Cretaceous-Tertiary extraterrrestrial impact event (Hartnady, 1986).

Finally, a major objective of our study is to offer some new observations and ideas bearing on the possible origin of this enigmatic region of the sea floor, and thereby to stimulate future studies there. Clearly, the plate-tectonic history of this complex region is not yet well understood, and confirmation of our observations and conclusions, as well as those of previous investigators, will require further testing through future geophysical studies and deep drilling.

Acknowledgements

Collection of the geophysical data, cores, and bottom photographs presented in this paper (Vema Cruise 34, Leg 6), and support for J.E.D. were provided by the Office of Naval Research (Contract N00014-75-C-0210). We thank E.T. Bunce who generously provided ship time to D. A. J. during Leg 7 of Atlantis II cruise 93 to conduct initial geophysical and geological surveys in the Amirante Passage region (supported by National Science Foundation Grant No. OCE76-21522). R. L. Fisher kindly provided unpublished bathymetric data from the northern Amirante Trench. We thank J. Cochran for many helpful ideas and discussions concerning the plate-tectonic evolution of the Amirante region. We thank D. Masson, M. Coffin, and J. Cochran for critical reviews of this manuscript. In addition, J. Sclater, E. Bunce, L. Lawver, P. Rabinowitz, and M. Coffin reviewed various earlier drafts of this manuscript and provided helpful discussion. Contribution number 7113 of the Woods Hole Oceanographic Institution. Lamont-Doherty Geological Observatory contribution number 4481.

References


Damuth, J. E. (1980) Use of high-frequency (3.5-12 kHz) echograms in the study of near-bottom sedimentation processes in the deep sea: A review Marine Geology 38, 51-75


Silver, E. A. (1969) Late Cenozoic underthrusting of the continental margin off northernmost California Science 166, 1269-1266


242 Marine and Petroleum Geology, 1989, Vol 6, August