7. GEOLOGIC FRAMEWORK OF THE FALKLAND PLATEAU[1]

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ABSTRACT

This chapter is a synopsis of the knowledge of the geologic framework of the Falkland Plateau region derived from the results of geophysical measurements and DSDP deep-sea drilling through 1980. The main geophysical and geological properties are assembled to provide a factual basis for establishing the interrelationships of the Falkland Plateau, Falkland Trough, and North Scotia Ridge and their relation to Gondwanaland and to the early opening of the South Atlantic.

INTRODUCTION

During several cruises of the research vessels *Vema* and *Conrad* of the Lamont-Doherty Geological Observatory, a considerable amount of geophysical and geological data has been gathered in the Falkland[3] Plateau region. Emerging from interpretations of these data and core samples from deep-sea drilling by *Glomar Challenger* (Legs 36 and 71) is a partially decipherable geologic history from Mesozoic to Recent times—a history that includes the breakup of Gondwanaland and formation of the Falkland (escarpment) Ridge, sedimentary filling of the Falkland Plateau Basin, subsidence and depositional environment of Maurice Ewing Bank, the development of a collision complex along the north slope of the North Scotia Ridge, and erosion of sediments by bottom currents.

GEOMORPHIC AND GEOPHYSICAL SETTING

Falkland Plateau

The Falkland (marginal) Plateau is a submarine projection from the South American continental margin that extends for about 1800 km east of the Falkland Islands (Figs. 1 and 2). The plateau is bordered on the north by an escarpment and on the south by the North Scotia Ridge. Between the plateau and the ridge is the Falkland Trough, which starts as a slight depression in the continental shelf north of Isla de los Estados (Staten Island) and ends at about 42°W where it opens out into the Georgia Basin with a depth of 3700 meters. Integrated maps (with explanatory texts) of the bathymetry are given by Rabinowitz et al. (1978) and LaBrecque and Rabinowitz (1981); magnetic anomalies by LaBrecque and Rabinowitz (1977); free-air gravity anomalies by Rabinowitz (1977); and sediment thickness by Ludwig, Carpenter, et al. (1978a).

The seafloor slopes gently eastward from the Falkland Islands to about 52°30′W, whereupon the Falkland Plateau acquires a fairly level floor at an average depth of 2600 meters. Farther eastward is an elevated morphostructural unit, called Maurice Ewing Bank by Barker, Dalziel, et al. (1977), with a slightly rounded top at less than 1500 meters.

On the north, the nearly east-west-trending Falkland Escarpment marks the northern edge of the Falkland Plateau. It extends from the continental slope to about 40°W, dropping at places from 2200 meters to 5100 meters over a distance of 15 km, with a slope as high as 45° (Le Pichon et al., 1971; Lonardi and Ewing, 1971). East of 40°W there is a low basement ridge which extends 800 km along the trend of the escarpment to about 28°W, where it merges with the Islas Orcadas Rise. The southern flank of the Plateau deepens gently to the south into the Falkland Trough.

The base of the Falkland Escarpment is characterized by a linear negative magnetic anomaly. Other anomalies that parallel this anomaly are also present farther north. On the westernmost part of the escarpment, the anomaly is either subdued or not present. In addition, the base of the escarpment is characterized by a linear free-air gravity anomaly with values less than −75 mgals. Steep gradients in the isostatic gravity anomalies are coincident with the linear magnetic anomaly. Rabinowitz and LaBrecque (1979) modeled the Falkland Escarpment magnetic anomaly, called Anomaly G, as an edge-effect anomaly separating continental and oceanic crust; they viewed the isostatic gravity gradient as resulting from elevated oceanic basement adjacent to continental crust.

South of the escarpment, on the Falkland Plateau, the magnetic anomalies are subdued and form a magnetic quiet zone, except over Maurice Ewing Bank, where fairly high amplitude anomalies may be associated with block faulting or intrusive volcanics. The Falkland Plateau has generally positive free-air gravity anomalies, with values greater than 75 mgals over Maurice Ewing Bank. Just south of the escarpment, between 42° and 52°W, there is a narrow −25 to zero mgal zone that is associated with a shallow sub-basin which trends north of Maurice Ewing Bank.

[1] Ludwig, W. J., Krashenninikov, V. A., et al., *Init. Repts. DSDP*, 71: Washington (U.S. Govt. Printing Office).

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[3] Followed here is the English usage of Falkland Plateau, Falkland Islands, and Falkland Trough. In Argentine literature, the name Malvinas is used.

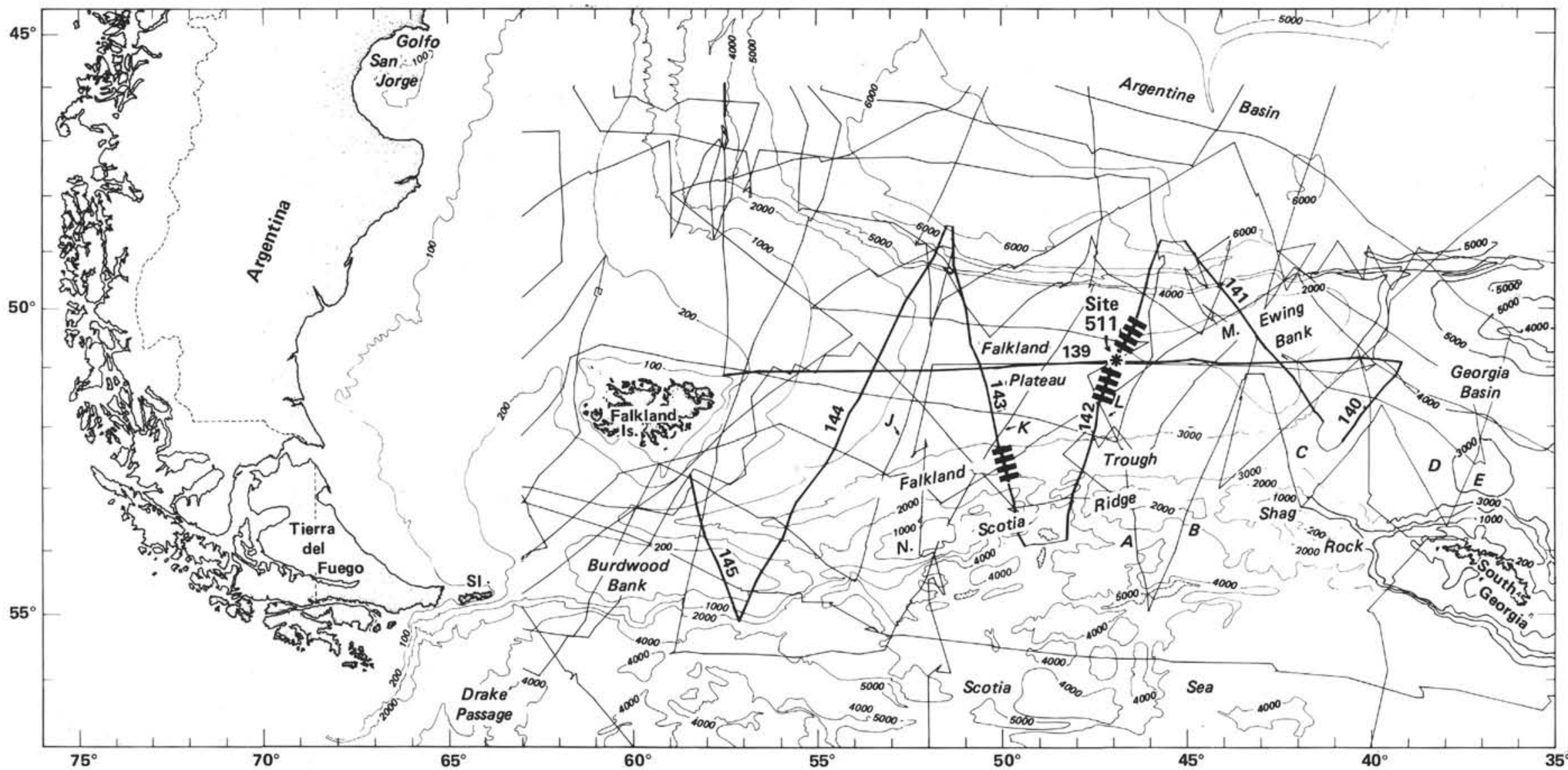

Figure 1. Bathymetric setting of the Falkland Plateau, Falkland Trough, and North Scotia Ridge. Contours in meters, from Rabinowitz et al. (1978). (Heavy lines represent locations of multichannel seismic reflection profiles; light lines are single-channel seismic reflection profiles. Tracks denote locations of reflection record sections reproduced in this chapter. S.I. = Staten Island.)

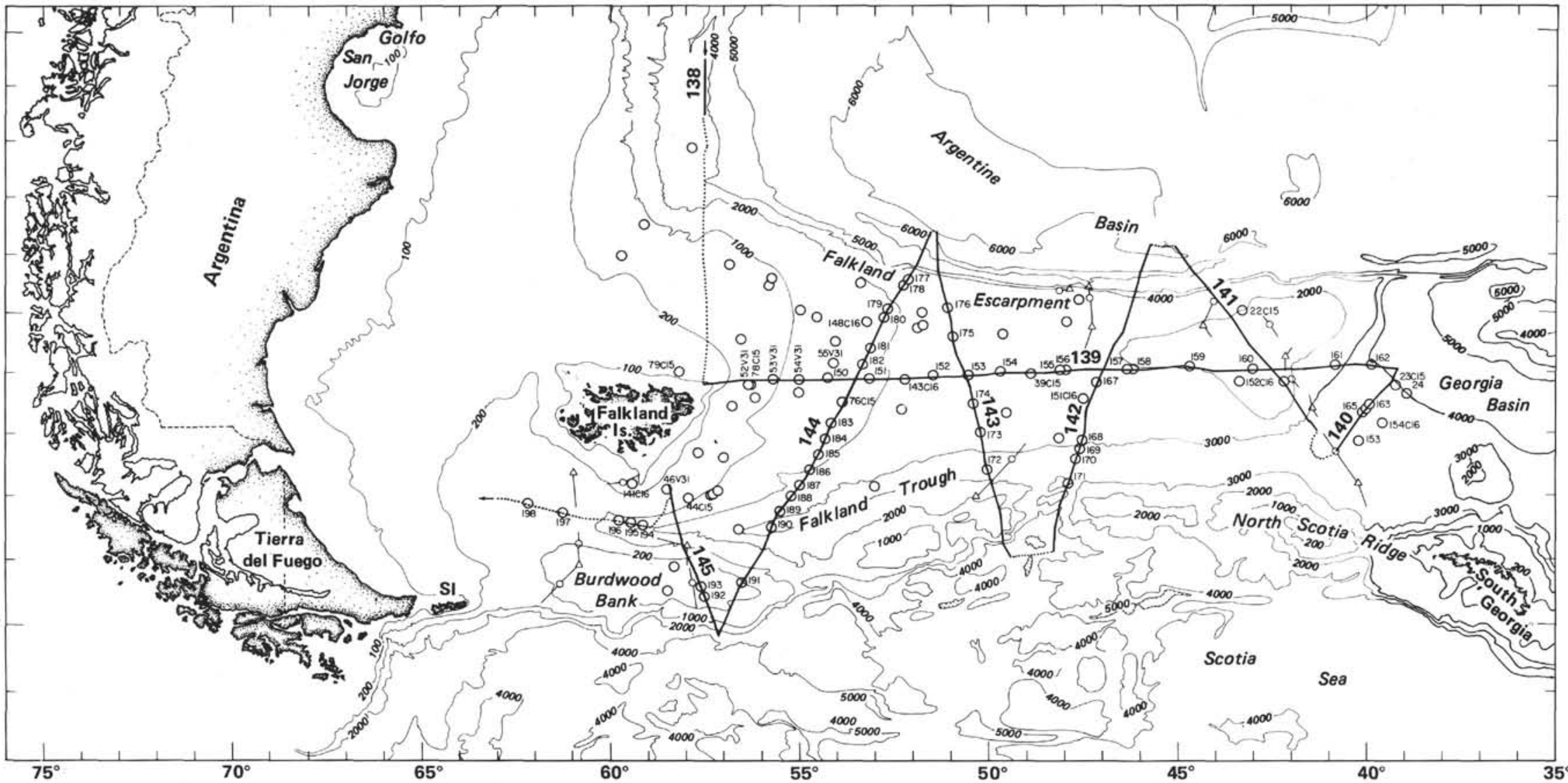

Figure 2. Locations of sonobuoy wide-angle reflection and refraction profiles (designated by open circles) and multichannel seismic reflection profiles (cf. Fig. 1). Dotted line indicates ship's track along which no reflection measurements were obtained.

North Scotia Ridge

The North Scotia Ridge is a complex of shallow banks and submarine ridges that extends 2000 km from Tierra del Fuego to South Georgia (Figs. 1 and 2). The ridge is generally viewed as the northern east–west-trending limb of the loop-shaped Scotia Arc, which provides physiographic continuity between the southern tip of South America and the Antarctic Peninsula. Between 49°W and 48°W there is a narrow gap in the ridge with a sill depth of about 3000 meters. This gap is an important passageway for water masses from the Scotia Sea into the western South Atlantic.

Because of the similarity between Paleozoic and Mesozoic rocks of the Andes mountains of southernmost South America and the present Antarctic Peninsula, there seems to be general agreement among geologists that the North and South Scotia ridges represent fragments of a once-continuous Antarctandes cordilleran system that were displaced eastward by the westward drift of South America (Dalziel and Elliot, 1973; Dott, 1976; deWit, 1977). According to Dalziel (1974) and Dalziel et al. (1974, 1975) the western margin of southernmost South America was the site of an andesitic volcanic arc initiated in Late Jurassic time. During Early Cretaceous time the arc broke away from the continent to form a marginal sea basin between the arc and the continental interior. During early Late Cretaceous time, the arc moved back toward the continent, resulting in deformation and uplift of the marginal basin floor and the adjacent arc to produce parts of the southern Andes.

DeWit (1977) maintains that the opening of the marginal basin was preceded by southward movement of the east–west part of the arc away from the continent (the Falkland Plateau) in the latest Jurassic to form a small ensialic marginal basin (the Falkland Trough), leaving a remnant arc (the North Scotia Ridge). According to deWit, further rotation of the active arc (the Antarctic Peninsula) with seafloor spreading behind the arc led to the opening of the marginal sea basin, now represented by the ophiolites in the southern Andes, the central Scotia Sea, and the Weddell Sea.

From all indications, South Georgia was attached to South America along the present southern margin of Burdwood Bank in late Mesozoic time and represents part of the postulated marginal basin (Dalziel et al., 1975). Because lithologically similar rocks of the southernmost Andes and South Georgia are deformed and intruded in like manner, it is inferred by Dott (1976) that the fragmentation of South Georgia from South America and its eastward displacement 2000 km to its present position must have occurred after the Late Cretaceous–Eocene Andean orogeny. Largely on the basis of spreading rates calculated from dated magnetic anomalies, Winn (1978) estimates that the displacement occurred during early Oligocene to middle Miocene time.

Seismic refraction measurements of the Burdwood Bank portion of the North Scotia Ridge by Ludwig et al. (1968) show the northern part of the Bank and Falkland Trough to be underlain by upward of 8 km of sediment in a large embayment in the shelf, named by them the Malvinas Basin. Andean cordilleran rocks are believed to approach the surface to form the southern margin of the Bank. From single- and multichannel seismic reflection profiles of the Falkland Plateau, Falkland Trough, and central portion of the North Scotia Ridge, Ludwig Windisch, Houtz, et al. (1978) and Ludwig and Rabinowitz (1982) show that the north wall of the Ridge is the front of an accretionary prism of sediments or collision complex, created by oblique convergence of the ridge toward the Plateau. The convergence results in upbuilding of the Ridge by folding and thrusting of near-surface layers of sediment in the Falkland Trough, while deeper layers advance smoothly beneath.

The map of free-air gravity anomalies (Rabinowitz, 1977) shows belts of positive anomalies greater than 150 mgals over the North Scotia Ridge and negative anomalies less than −150 mgals over the north wall of the Ridge and Falkland Trough, with steep gradients between the gravity high and low. The gravity minimum implies anomalously low crustal and mantle density or a great thickness of low-density sediment beneath the north wall. Davey (1972) reconciled the gravity minimum over Burdwood Bank with the thick sediments discovered there by Ludwig et al. (1968).

The free-air gravity minimum intersects the continental margin of Tierra del Fuego immediately north of the Andean foothills at about 54°30W, indicating on-shore continuity of the collision complex of the North Scotia Ridge. Field mapping in the Andean cordillera has delineated major east–west-trending shear zones active since the mid-Cretaceous (Bruhn and Dalziel, 1977). These include the western end of the Strait of Magellan and parts of the Beagle Channel. They were associated with the closure of the marginal basin and may be related to the first eastward movement of South Georgia away from South America (Dalziel et al., 1975).

LaBrecque and Rabinowitz (1977) show that Burdwood Bank and the North Scotia Ridge to South Georgia have essentially no magnetic expression and probably are not similar in composition to the oceanic basin crust south of the Ridge. The boundary between the smooth magnetic anomaly pattern of the Falkland Plateau–North Scotia Ridge province and the rough pattern of the Scotia Sea follows approximately the 2000-meter isobath of the south side of the Ridge.

PLATE TECTONICS SETTING

The plate tectonic scheme in the South Atlantic, as revealed by the distribution of earthquakes, is shown in Figure 3. From studies of magnetic anomaly lineations, Griffiths and Barker (1971) and Barker (1970, 1972a,b) estimate the western part of the Scotia Sea to be a minimum of 20 m.y. old (early Miocene) and a maximum of 40 m.y. old (late Eocene). They and Ewing et al. (1971) conclude that the seafloor in the western Scotia Sea was generated along a northest-trending, spreading ridge (the West Scotia Ridge) which terminates near a gap in the middle of the North Scotia Ridge near 50°W longitude. South Georgia may have been moved eastward along a transform fault by spreading from this ridge.

The oldest identifiable magnetic anomalies in the eastern Scotia Sea, behind the South Sandwich Island Arc, are associated with crust 8 m.y. old and trend

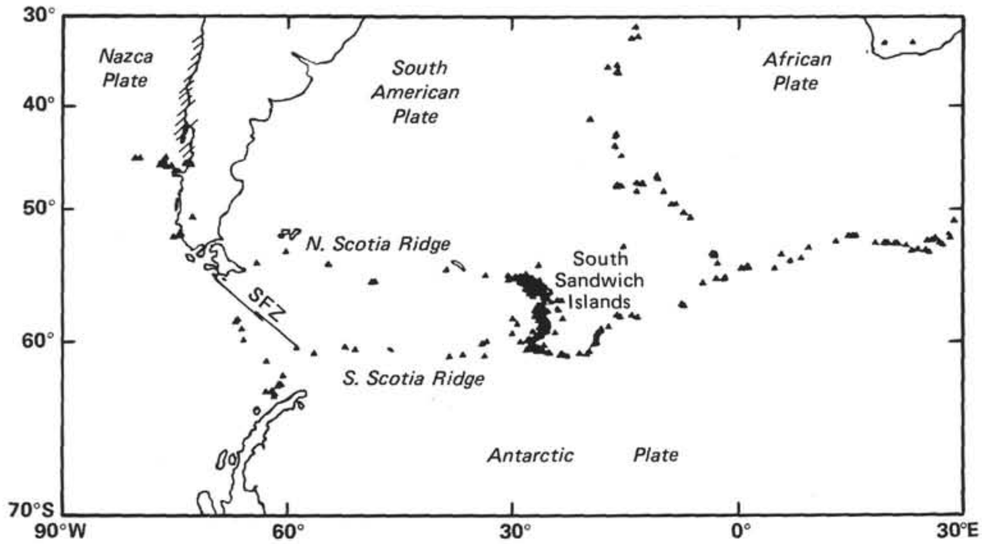

Figure 3. Seismicity of the South Atlantic and Scotia Sea, 1963–1973, reproduced from Forsyth (1975) (courtesy of *Journal of Geophysical Research*). The Scotia Sea plate is bounded by the North Scotia Ridge, South Sandwich Ridge, South Scotia Ridge, and Shackleton Fracture Zone (SFZ).

north–south. Thus it would appear that the Scotia Sea has undergone a three-phase history of development; one phase of opening in the Mesozoic accounting for the central section of the sea, another in late Oligocene to late Miocene time (27–9 Ma) involving northwest-southeast opening of the Drake Passage in the western Scotia Sea, and the third involving east–west opening of the seafloor in the eastern Scotia Sea from the late Miocene to the present (deWit, 1977; Barker and Burrell, 1977; LaBrecque and Rabinowitz, 1977; LaBrecque and Hayes, 1979).

The present low level of seismicity in the Scotia Sea would seem to indicate that seafloor spreading has ceased. Thus the boundaries between the South American, Scotia Sea, and Antarctic plates are not clearly defined at this time. From analysis of fault plane solutions of recent earthquakes, Forsyth (1975) concludes that the Scotia Sea plate is a complex series of microplates which are *presently* under southwest–northeast regional compression owing to the rotation of the Antarctic Plate relative to South America; earthquakes occur at zones of weakness, such as the former plate boundaries in the Drake Passage and the North and South Scotia ridges. This component of relative motion of the Scotia Sea plate(s) and South American Plate is manifested by the scissorlike closing of the Falkland Trough since the North Scotia Ridge became an active collision zone (Ludwig and Rabinowitz, 1982).

CRUSTAL STRUCTURE

From interpretation of a line of two-ship seismic refraction profiles, Ewing et al. (1971) showed that the velocity structure of the eastern portion of the Falkland Plateau (Maurice Ewing Bank) and Falkland Trough were indicative of continental crust and oceanic crust, respectively. Several seismic profiles recorded near the edge of the Falkland Escarpment also indicated continental basement rock. Therefore, Ewing et al. concluded that the entire plateau is a submerged continental block and that the Falkland Trough is a sliver of oceanic crust between it and the North Scotia Ridge. Sonobuoy wide-angle reflection and refraction profiles later revealed the presence of a basin between the Falkland Platform and Maurice Ewing Bank containing 4–5 km of south-dipping sediments (Ludwig, Carpenter, et al., 1978; Ludwig, Windisch, Houtz, et al., 1978) but added no information on deep crustal structure.

Ludwig and Rabinowitz (1980) acquired long lines of multichannel seismic reflection measurements and sonobuoy reflection and refraction measurements on the Falkland Plateau (Fig. 2). The velocity–depth sections from modified $X^2 - T^2$ solutions of buoys recorded longitudinally and transversely to the plateau are shown in Figures 4 and 5, respectively. The western part of the Falkland Plateau is a sediment-filled basin bordered on the west by the Falkland Platform, on the north by a ridge associated with the Falkland Escarpment, on the east by Maurice Ewing Bank, and on the south by the North Scotia Ridge. The basin floor thus formed is underlain by either *oceanic* crust or greatly attenuated continental crust.

A significant increase in sediment thickness occurs over a short distance about 150 km east of the Falkland Islands (Fig. 4). Here the basement dips steeply toward the basin floor, in the same way as has been observed for the change from continental crust to oceanic crust farther north across the rifted part of the margin (see Ludwig, Windisch, Ewing, et al., 1978). A similar declination of the basement toward the (ocean) basin floor occurs south of the Falkland Islands (between sonobuoy station 194 and MCS line 145) (Fig. 2); that is, there is a basement high that extends south of the Falkland Islands (the Cape Meredith High) which marks the shelf edge and separates the Malvinas Basin from the Falkland Plateau Basin.

The interpretation that the Falkland Plateau basin is floored by oceanic crust is based only on a few sonobuoy profiles, which recorded high-speed refracted arrivals from layers having velocities and thicknesses in-

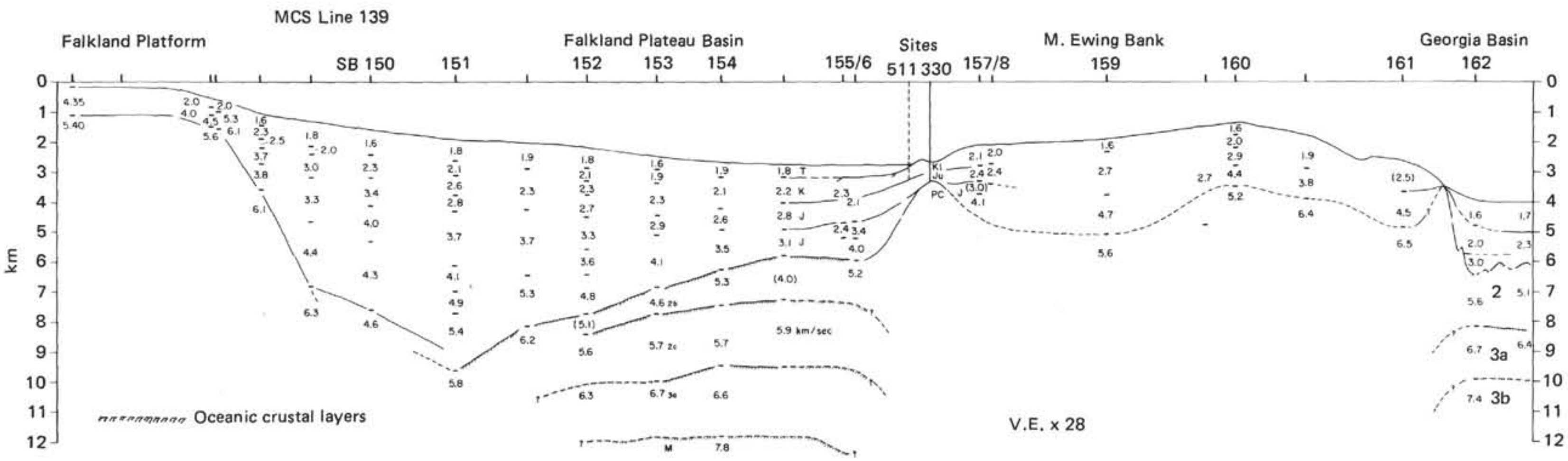

Figure 4. Velocity structure section of the Falkland Plateau, from solutions of air gun–sonobuoy seismic reflection and refraction profiles. See Figure 2 for location. Velocities less than 4.8 km/s are interval velocities from wide-angle reflection data; higher values are unreversed, refraction velocities. Included on the section are the locations of Site 330 (Barker, Dalziel, et al., 1977) and Site 511 (this volume) projected northwestward onto the line of section. The velocities and thicknesses of high-velocity layers beneath the Falkland Plateau Basin are interpreted to represent oceanic crust, or highly attenuated continental crust. KL = Lower Cretaceous; JU = Upper Jurassic; PC = Precambrian; M = mantle. Parentheses indicate that the velocity is assumed.

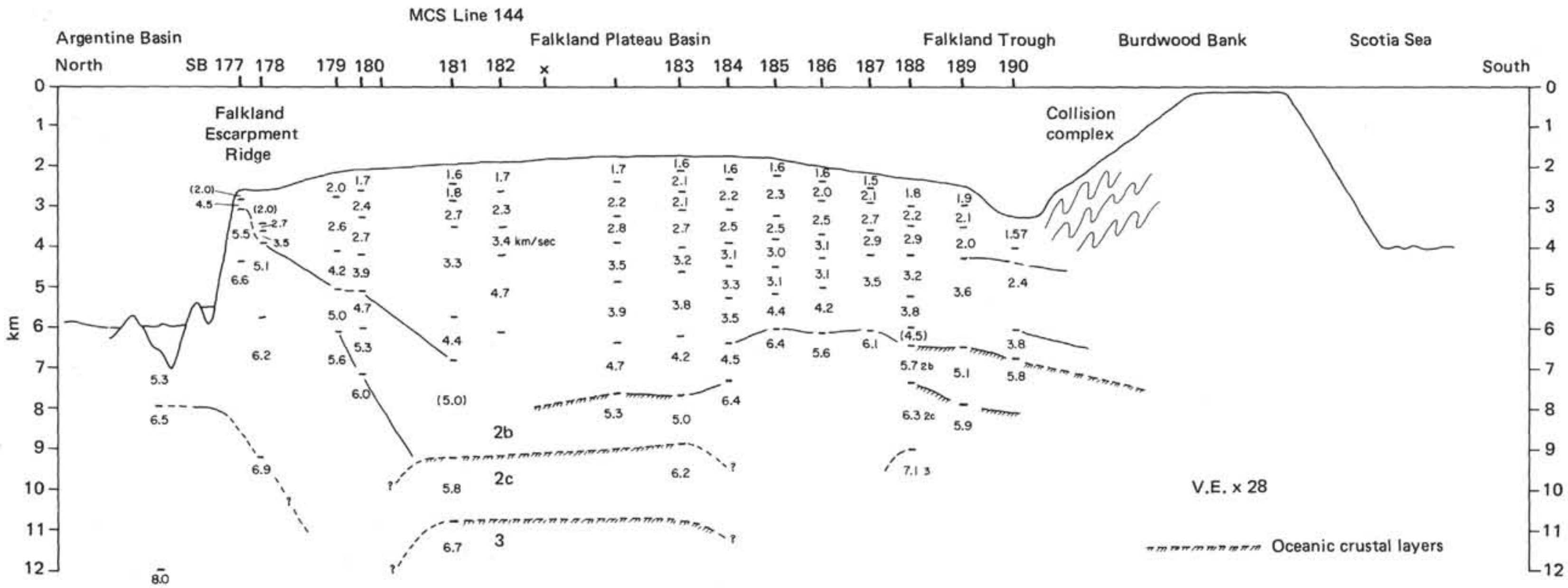

Figure 5. Velocity structure section of the Falkland Plateau, from solutions of airgun-sonobuoy reflection and refraction profiles. (Explanation same as for Figure 4.)

dicative of oceanic crustal layers and from reflections assumed to be critical reflections from the mantle (Ludwig and Rabinowitz, 1980). By measuring the range and reflection time to the onset of the critical reflections, and assuming an appropriate mantle velocity, the thickness of Layer 3 can be computed.

It has been suggested that Magnetic Anomaly G observed along the conjugate rifted and sheared portions of Argentina and South Africa may mark the boundary between continental and oceanic crust (Rabinowitz and LaBrecque, 1979). A marginal magnetic anomaly is observed at the base of the Falkland Escarpment but not elsewhere on the Plateau. LaBrecque and Rabinowitz (1977) and LaBrecque and Hayes (1979) have identified the Mesozoic sequence of Anomalies M0 to M4 in the western Georgia Basin, just off Maurice Ewing Bank. A measurement using the same angular distance from Anomaly M4 to Anomaly G observed on the conjugate margin of South Africa places Anomaly G near the center of Maurice Ewing Bank. This indicates that the Bank may have occupied a position closer to the Falkland Islands Platform; i.e., the floor of the Falkland Plateau Basin may represent a zone of seafloor spreading or stretching and subsidence of continental crust during early rifting of the continents. Royden et al. (1980) calculated the subsidence history of the basin sediments at a site just south of the Falkland Escarpment Ridge and concluded that the basement there consisted of either oceanic crust or transitional crust which is primarily oceanic in character.

SEISMIC STRATIGRAPHY AND DEEP-SEA DRILLING

Single-channel and multichannel seismic reflection profiles and sonobuoy refraction measurements (Ludwig, Windisch, Houtz, et al., 1978; Ludwig and Rabinowitz, 1980) reveal the presence of a basement ridge which forms the northern edge (escarpment) of the plateau. In the vicinity of 46°W longitude the escarpment is a structure formed by the collapse along faults of an outer shelf platform of sediments. In the Falkland Plateau Basin, widespread sheets of sediment dip southward from the ridge and are truncated updip by an erosional unconformity (Fig. 6). The sediments lap out against the Falkland Islands Platform and Maurice Ewing Bank. The lower boundary of the depositional sequence has been disrupted through oblique convergence of the North Scotia Ridge toward the Plateau, resulting in deformation and uplift of the near-surface sediment layers of the Falkland Trough onto the north side of the North Scotia Ridge, whereas the thick lower layers advance smoothly beneath (Ludwig and Rabinowitz, 1982) (Fig. 7). The plane of decollement between the offscraped and subducted sediments apparently is a well-lubricated surface along which the sediments become mechanically decoupled and gravity sliding results.

During 1974, DSDP drilling at three sites (Sites 327, 329, and 330) on the Maurice Ewing Bank recovered a stratigraphic sequence of Jurassic to Holocene sediments which provided significant knowledge of the sedimentary paleoenvironmental history of the South Atlantic since the breakup of Gondwanaland (Barker, Dalziel, et al., 1977). From 1975 to 1978 a considerable number of piston cores were obtained on the Maurice Ewing Bank by the ARA *Islas Orcadas*. Studies of the piston cores, the seismic reflection profiles, and the DSDP corehole data by Ciesielski and Wise (1977), Ciesielski (1978), Ciesielski et al. (in press), and Wise et al. (1982) provide the bases for reconstructing the geologic history of the bank and for establishing paleoceanographic and paleoclimatic trends represented in the sedimentary record.

Knowledge of the gross geologic history of the Falkland Plateau has been expanded by DSDP drilling at Site 511 in the basin province of the Plateau, about 10 km south of Site 330 (this volume). With some exceptions, lithostratigraphic units essentially were continuous across the bank and basin province; interruption of units is largely due to erosion.

An interpreted reflection time section passing through Site 511 and near Sites 330 and 327 is shown in Figure 8 (cf. Barker, 1977). The structural-stratigraphic framework here is that of shallow marine coastal downlap of sediments against a basement continental slope to the south, followed by slope front fill and draping by pelagic sequences. In the basin province of the Plateau, the pelagic sequences are quite thick and presumably constitute the fill of the Falkland Plateau basin. As mentioned earlier, the configuration of reflectors in the central part of the basin is that of widespread sheets of sediment dipping to the south. In the parallel sheet-drape facies generally described by Sangree and Widmer (1977, p. 176), "parallel reflections... drape over contemporaneous topography with only gradual changes in thickness or reflection character and suggest uniform deposition independent of the bottom relief. The pattern is strongly indicative of deep-marine hemipelagic clays and oozes." The sonobuoy refraction measurements suggest that the basin is floored by ocean crust.

At Site 511 the erosional surface that truncates the southward-dipping sheets of sediment on the Plateau was formed during Late Cretaceous–early Tertiary time. It probably was eroded by a northward-flowing, eastward-intensified bottom current, possibly a precursor to the circumpolar current. This surface of unconformity may not have chronostratigraphic significance, as the current system, and thus the boundary between the erosional zone and adjacent depositional zone, may have migrated with time.

At Site 511, a thick section of black shales encountered at about 500 meters below seafloor contains upward of 4% organic carbon, which has high potential for generating petroleum. The black shales, also encountered at Sites 327 and 330, were deposited just prior to the breakup of Gondwanaland, sometimes under euxinic conditions in relatively shallow water. Their present position at 3100 meters depth below sea level indicates subsidence of the margin of Maurice Ewing Bank by about that amount. Geochemical analyses indicate that the type of organic matter in the shales is kerogen Type II, which is in an early stage of oil generation (Deroo et al., von der Dick et al., both this volume).

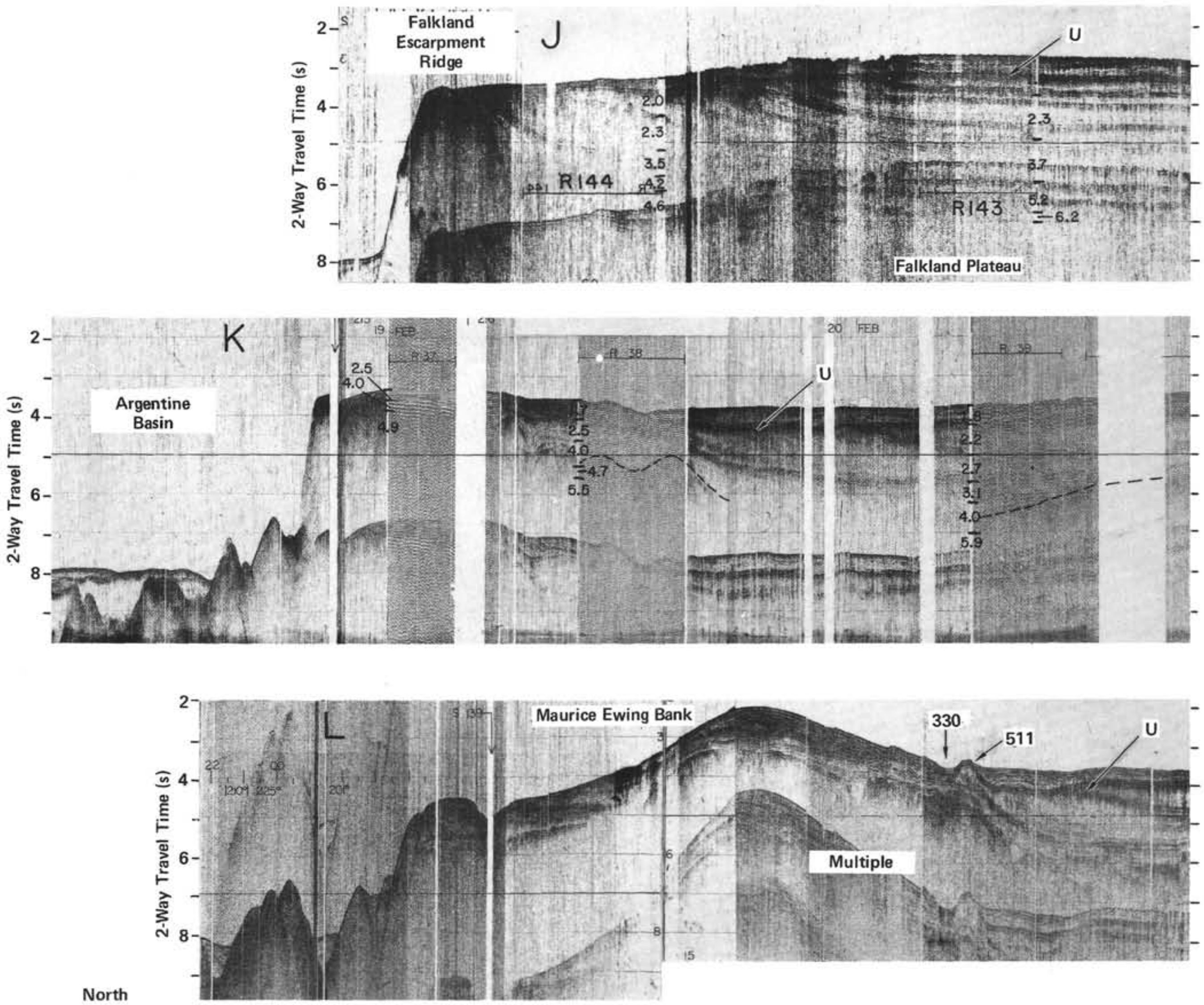

Figure 6. Single-channel seismic reflection record sections of the Falkland Plateau, Falkland Trough, and North Scotia Ridge (from Ludwig, Windisch, Houtz, et al., 1978). See Figure 1 for locations. The velocities and thicknesses from sonobuoy stations are plotted on the sections. Interpretation of record section L in the vicinity of Site 330 is given by Barker (1977). See Figure 8 for the correlation of reflectors and lithology cored at Site 511. The general configuration of seismic reflectors in the Falkland Plateau basin is that of widespread sheets of southward-dipping sediments truncated updip by an erosional unconformity. Drilling at Site 511 indicated that the surface of unconformity (U) was formed near the Tertiary/Cretaceous boundary. Note that a high velocity basement ridge forms the Falkland Escarpment Ridge in the basin province of the Plateau (cf. Fig. 5), whereas the escarpment is associated with a topographic buildup or collapsed outer shelf platform north of Maurice Ewing Bank, along record section L (cf. Ludwig, this volume).

Euxinic Late Jurassic beds and euxinic Early Cretaceous beds at Sites 511 and 330 are separated by a biostratigraphic hiatus of about 20 m.y., indicating that the basin floor may have been uplifted to near or slightly above sea level for that period of time (Jeletzky, this volume). The surface of nondeposition appears as a prominent reflector within the shale unit that can be traced for an appreciable distance updip from the drill sites; the shale unit appears to lap out downdip against the basement continental slope of Maurice Ewing Bank.

HISTORY OF THE FALKLAND PLATEAU

During Late Jurassic time, the continents of South America, Africa, Antarctica, Australia, and India were joined in a single continent called Gondwanaland (Fig. 9). The Falkland Plateau was attached to Africa along the present southern margin of Agulhas Bank. A Middle(?) to Late Jurassic inland sea transgressed the southwestern part of Gondwanaland and became increasingly restricted, until by about Oxfordian time claystones rich in organic matter were being deposited in a shallow, quiet-water environment.

At about 135 m.y. ago, Gondwanaland broke apart, basaltic lavas filled the gaps, and new ocean floor gradually formed as the continents separated. It is likely that the newly formed north margin of the western part of the Falkland Plateau was uplifted along a transform fault to form a continental rim, which, in turn, formed a rim basin to the south between the continent (Falkland Platform) and the emerged Maurice Ewing Bank. Vee-

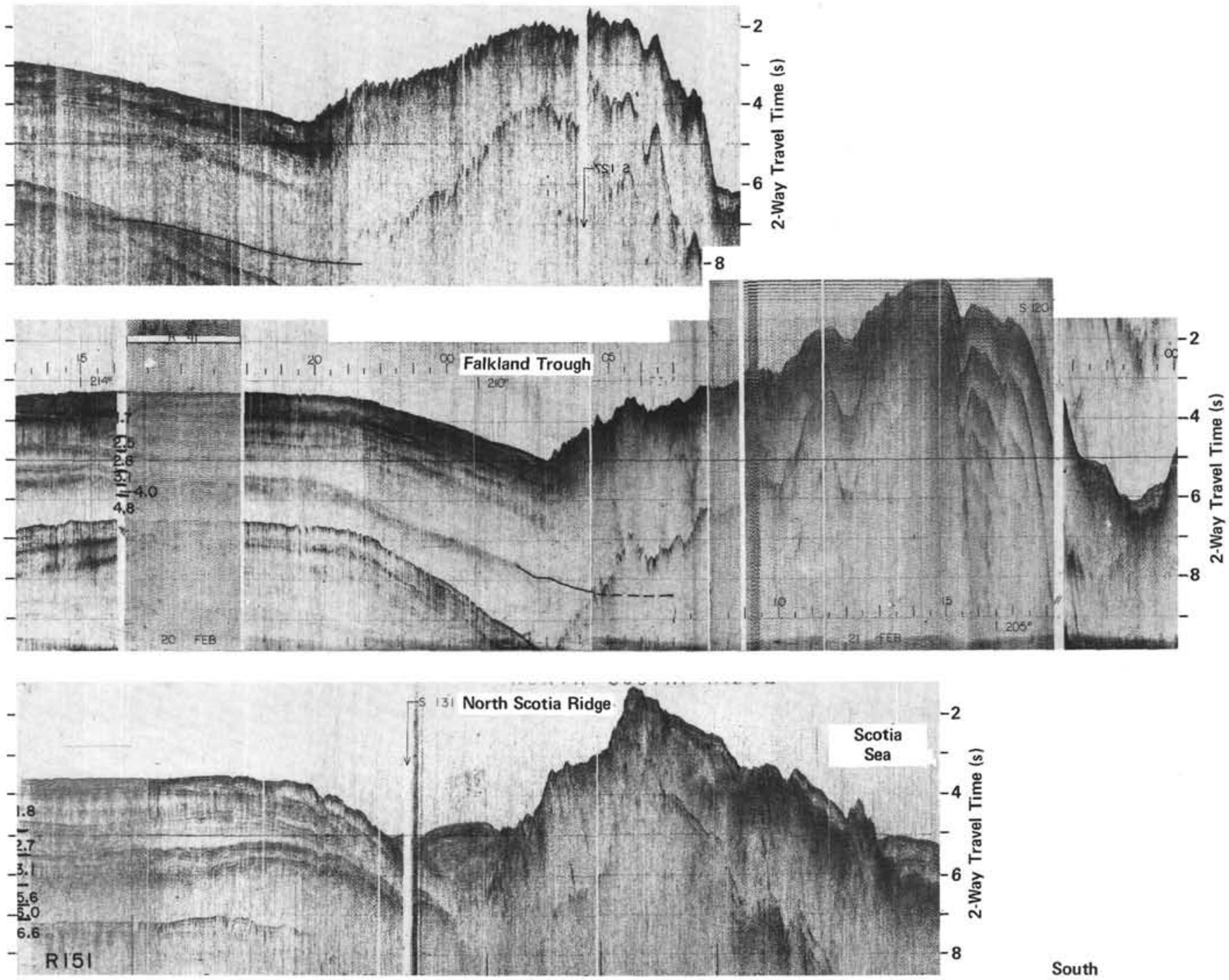

Figure 6. (Continued).

vers and Powell (1979) interpret the configuration of seismic reflectors on the southwestern Exmouth Plateau in terms of a transform-fault–derived ridge, the erosion and subsidence of which produced a northward-prograded wedge of clastic sediments.

After the inception of seafloor spreading, the western Falkland Plateau was a broad basin well below sea level. It is probable that sediment eroded from the rim and the continental interior accumulated on the basin slope in a wedge of foresets or onlaps. Stagnant conditions continued on Maurice Ewing Bank through the Aptian, producing a thick section of black shales, rich in organic matter.

During Albian time, about 25 m.y. after the breakup of Gondwanaland, the depositional environment of the Falkland Plateau changed dramatically. The black shales of Maurice Ewing Bank were succeeded by well-oxygenated nannofossil claystones, presumably because the eastern tip of Maurice Ewing Bank drifted past the tip of Africa and deep, oxygenated water entered the South Atlantic from the Indo-Pacific. By late Albian time, Maurice Ewing Bank had begun to subside and continued to subside as it spread laterally away from the spreading ridge. During this time, the continental rim probably subsided to below sea level by normal fault collapse. Through continued collapse along faults, the rim became the escarpment of the ridge that forms the northern edge of the Falkland Plateau (Fig. 6) (see Veevers and Powell, 1979, fig. 6).

Draping of contemporaneous topography by pelagic sediments in the Late Cretaceous filled the Falkland Plateau Basin and probably covered the escarpment ridge. Major scouring of the plateau and exposure of older sediments by bottom currents occurred at or near the Tertiary/Cretaceous boundary, producing the seismic reflection pattern of southward-dipping sheets terminated updip by erosional truncation.

Tertiary sediments in the basin province of the Plateau are believed to be quite thin. In contrast, Maurice Ewing Bank, because of its higher elevation, received thick carbonate and siliceous biogenic sediment throughout the Tertiary, recording major changes in paleoceanographic and paleoclimatic conditions. The Tertiary sequence there is characterized by sharp fluctuations in

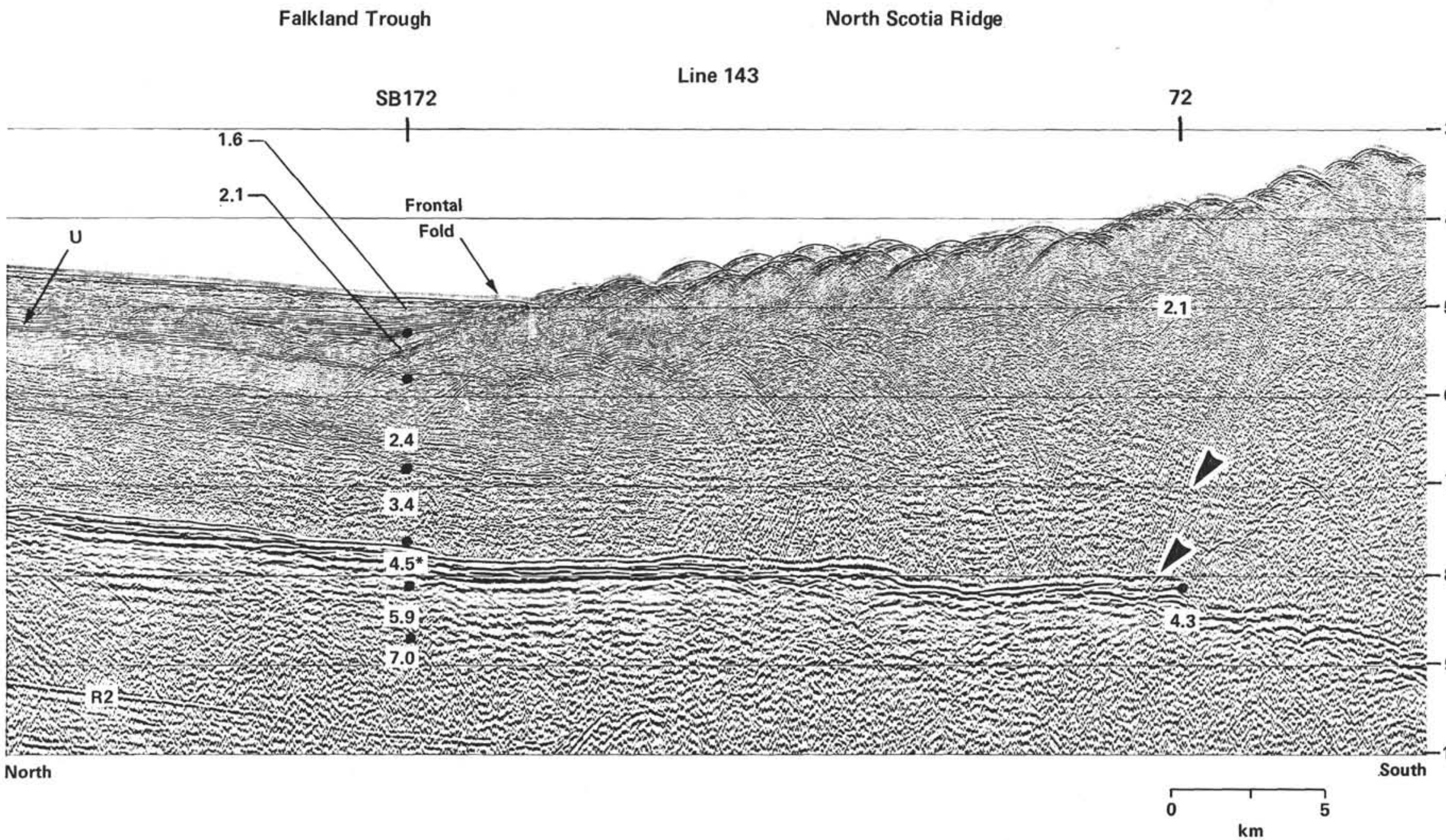

Figure 7. Multichannel seismic reflection record section of the Falkland Trough and lower slope of the North Scotia Ridge along Line 143 (from Ludwig and Rabinowitz, 1981). See Figure 1 for location. The velocities and layer thicknesses from sonobuoy 172 and two-ship refraction profile 72 of Ewing et al. (1971) are plotted on the section. Convergence of the ridge toward the plateau results in deformation of sediments of velocity less than 3.4 km/s into ridges at the frontal fold and subsequent obduction onto the north side of the ridge while the higher velocity layers advance below. Arrowheads designate the undeformed sediments beneath the collision complex. (U = surface of unconformity; asterisk denotes assumed velocity.)

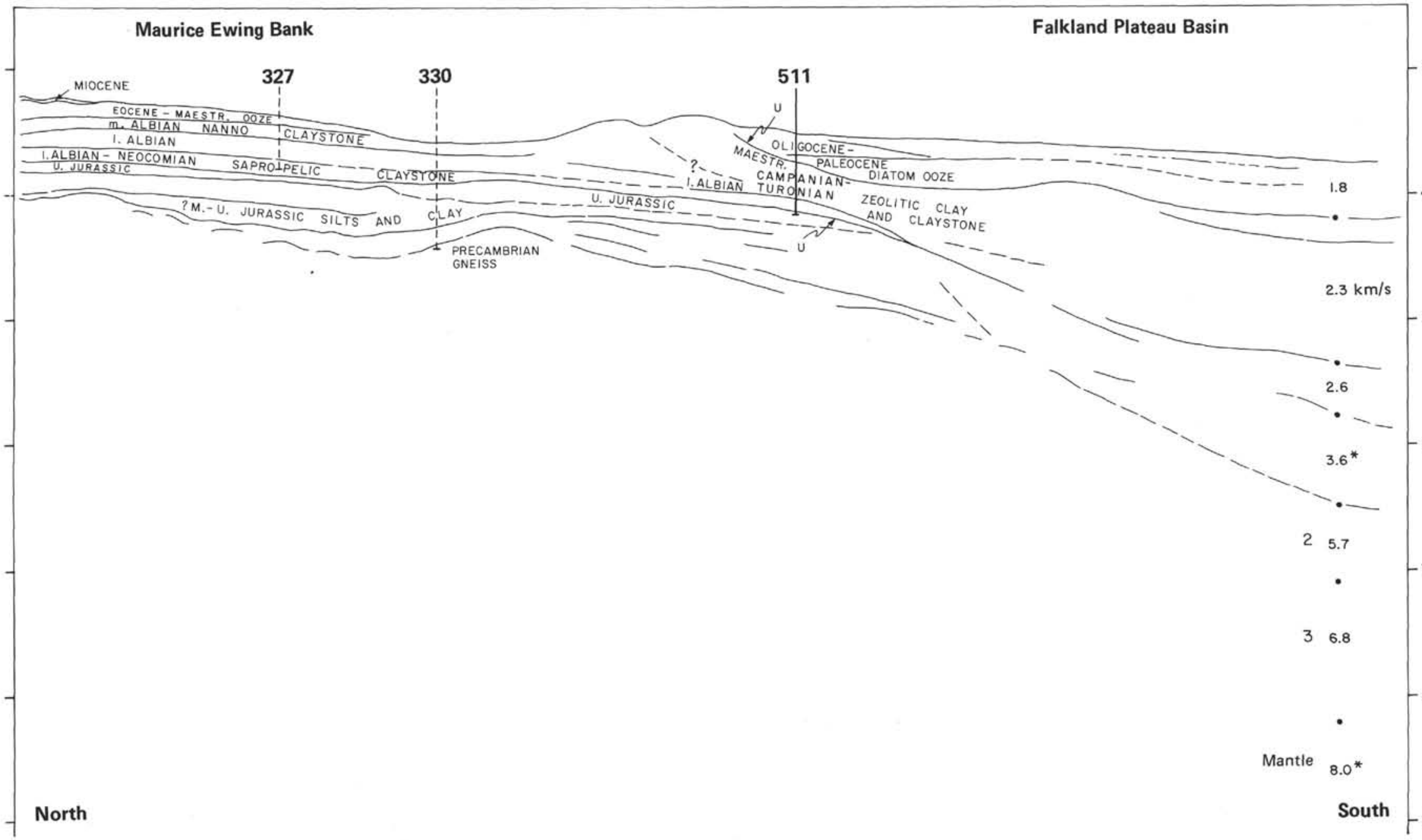

Figure 8. Line drawing of multichannel seismic reflection profile and correlation with lithology cored at Sites 327 and 330 (Barker, Dalziel, et al., 1977) and Site 511 (this volume). See Figure 2 for location. Site 511 was located on the southern, paleoshelf margin of Maurice Ewing Bank in the basin province of the Falkland Plateau. (U = surface of unconformity.)

Figure 9. Reconstruction of Gondwanaland before breakup, after Norton and Sclater (1979). As in most reconstructions, there is a large overlap of the Antarctic Peninsula onto the Falkland Plateau. It is tempting to speculate that the overlap may be accommodated by the rim basin of the Falkland Plateau.

the carbonate compensation depth, severe deterioration of climate in Antarctica, and complex erosional events (Wise et al., in press).

PETROLEUM POTENTIAL OF THE FALKLAND PLATEAU

The configuration of seismic reflectors and borehole data indicate that the sediments of the Falkland Plateau are largely pelagic sediments of Cretaceous and Tertiary age. However, the seismic data suggest that clastic depositional facies may underlie the more continuous draped pelagics at the Jurassic and Lower Cretaceous shelf margins of the basin and that they are also contained in fault block structures in the central part of Maurice Ewing Bank and, possibly, occur as carbonate buildups at the northern edge of the Bank (Ludwig, this volume).

The black shales cored on the southern, paleoshelf margin of Maurice Ewing Bank are rich in organic matter and have high potential for generating petroleum. The increasing maturation of organic matter with depth of burial indicates that the zone of petroleum generation should be reached in the black shales at regions of burial deeper than at the margin on Maurice Ewing Bank. Seismic profiles suggest that although the black shales terminate at the southern margin of the Bank and thus are not present in the basin province of the Plateau, they continue to the northern margin of the Bank where traps against faults and carbonate buildups occur.

There are probably fewer chances for petroleum accumulation at the southern flank of the Falkland Plateau, within the collision complex. The sediments there are so highly structured that the terrain is acoustically irresolvable. Gravity sliding in the lower part of the complex owing to the release of interlayer water during compaction further reduces the possibility of petroleum entrapment. Moreover, source beds are unlikely components of a collision complex believed to consist largely of obducted Falkland Trough turbidite and hemipelagic sediments.

Additional drilling and seismic surveying are needed to determine the hydrocarbon prospects of the Falkland Plateau. The region offers some formidable well-completion problems. Water depths in the potential locations mentioned range between 1500 and 2600 meters. The environment is hostile, with strong surface and bottom currents, high winds, and the ever-present danger of encountering icebergs.

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REFERENCES

Barker, P. F., 1970. Plate tectonics of the Scotia Sea region. *Nature*, 228 (No. 5278):1293-1296.

_______, 1972a. Magnetic lineations in the Scotia Sea. *In* R. J. Adie (Ed.), *Antarctic Geology and Geophysics:* Oslo (Universitetsforlaget), pp. 17-26.

_______, 1972b. A spreading center in the East Scotia Sea. *Earth Planet. Sci. Lett.*, 15:123-132.

_______, 1977. Correlations between sites on the eastern Falkland Plateau by means of seismic reflection profiles, Leg 36, DSDP. *In* Barker, P. F., Dalziel, I. W. D., et al., *Init. Repts. DSDP*, 36: Washington (U.S. Govt. Printing Office), 971-990.

Barker, P. F., and Burrell, J., 1977. The opening of the Drake Passage. *Mar. Geol.*, 25:15-34.

Barker, P. F., Dalziel, I. W. D., et al., 1977. *Init. Repts. DSDP*, 36: Washington (U.S. Govt. Printing Office).

Bruhn, R. L., and Dalziel, I. W. D., 1977. Destruction of the Early Cretaceous marginal basin in the Andes of Tierra del Fuego. *In* Talwani, M., and Pitman, W., III (Eds.), *Island Arcs, Deep-Sea Trenches and Back-Arc Basins*. Am. Geophys. Union, Maurice Ewing Ser. 1:395-405.

Ciesielski, P. F., 1978. The Maurice Ewing Bank of the Malvinas (Falkland) Plateau: Depositional and erosional history and its paleoenvironmental implications [Ph.D. dissert.]. Florida State University, Tallahassee.

Ciesielski, P. F., Ledbetter, M. T., and Ellwood, B. B., in press. The sedimentary and paleoceanographic record of southern ocean rises: Part I. The Maurice Ewing Bank. *Mar. Geol.*

Ciesielski, P. F., and Wise, S. W., 1977. Geologic history of the Maurice Ewing Bank of the Falkland Plateau (Southwest Atlantic sector of the Southern Ocean) based on piston and drill cores. *Mar. Geol.*, 25:175-207.

Dalziel, I. W. D., 1974. Evolution of the margins of the Scotia Sea. *In* Burk, C. A., and Drake, C. L. (Eds.), *The Geology of Continental Margins:* New York (Springer-Verlag), pp. 567-579.

Dalziel, I. W. D., deWit, M. J., and Palmer, K. F., 1974. A fossil marginal basin in the southern Andes. *Nature*, 250(No. 5464): 291-294.

Dalziel, I. W. D., Dott, R. H., Winn, R. D., and Bruhn, R. L., 1975. Tectonic relations of South Georgia Island to the southernmost Andes. *Geol. Soc. Am. Bull.*, 86:1034-1040.

Dalziel, I. W. D., and Elliot, D. H., 1973. The Scotia arc and Antarctic margin. *In* Nairn, A. E. M., and Stehli, F. G. (Eds.), *The Ocean Basins and Margins, 1: The South Atlantic:* New York (Plenum Press), 171-245.

Davey, F. J., 1972. Gravity measurements over Burdwood Bank. *Mar. Geophys. Res.*, 1:428-435.

deWit, M. J., 1977. The evolution of the Scotia arc as a key to the reconstruction of southwestern Gondwanaland. *Tectonophysics*, 37: 53-81.

Dott, R. H., 1976. Contrasts in tectonic history along the eastern Pacific rise. *In* Sutton, G. H., Manghnani, M. H., and Moberly, R. (Eds.), *The Geophysics of the Pacific Ocean Basin and its*

Margin: Washington, D.C., Am. Geophys. Union, Geophysical Monograph, 19:299–308.

Ewing, J. I., Ludwig, W. J., Ewing, M., and Eittreim, S. L., 1971. Structure of the Scotia Sea and Falkland Plateau. *J. Geophys. Res.*, 76(No. 29):7118–7137.

Forsyth, D. W., 1975. Fault plane solutions and tectonics of the South Atlantic and Scotia Sea. *J. Geophys. Res.*, 80(No. 11):1429–1443.

Griffiths, D. H., and Barker, P. F., 1971. Review of marine geophysical investigations in the Scotia Sea. *In* R. J. Adie (Ed.), *Antarctic Geology and Geophysics:* Oslo (Universitetsforlaget), pp. 3–11.

LaBrecque, J. L., and Hayes, D. E., 1979. Seafloor spreading history of the Agulhas basin. *Earth Planet. Sci. Lett.*, 45:411–428.

LaBrecque, J. L., and Rabinowitz, P. D., 1977. *Magnetic Anomalies Bordering the Continental Margin of Argentina.* AAPG Argentine Map Series.

———, 1981. *General Bathymetric Chart of the Oceans (GEBCO)* 5th Ed., Sheet 5-16: Ottawa (Canadian Hydrographic Service for 1HO and 10C [UNESCO])

Le Pichon, X., Eittreim, S. L., and Ludwig, W. J., 1971. Sediment transport and distribution in the Argentine Basin. 1. Antarctic bottom current passage through the Falkland Fracture Zone. *In* Ahrens, L. H., Press, F., Runcorn, S. K., and Urey, H. C. (Eds.), *Physics and Chemistry of the Earth:* Oxford (Pergamon Press), 8:1–28.

Lonardi, A. G., and Ewing, M., 1971. Sediment transport and distribution in the Argentine Basin. 4. Bathymetry of the continental margin. Argentine Basin and other related provinces. Canyons and sources of sediment. *In* Ahrens, L. H., Press, F., Runcorn, S. K., and Urey, H. C. (Eds.), *Physics and Chemistry of the Earth:* Oxford (Pergamon Press), 8:79–21.

Ludwig, W. J., Carpenter, G., Houtz, R. E., Lonardi, A. G., and Rios, F. F., 1978. *Sediment Isopach Map of the Argentine Continental Margin.* AAPG Argentine Map Series.

Ludwig, W. J., Ewing, J., and Ewing, M., 1968. Structure of the Argentine continental margin. *Bull. Am. Assoc. Petrol. Geol.*, 52: 2337–2368.

Ludwig, W. J., and Rabinowitz, P. D., 1980. Seismic stratigraphy and structure of the Falkland Plateau. *Bull. Am. Assoc. Petrol. Geol.*, 64:742. (Abstract)

———, 1982. The collision complex of the North Scotia ridge, *J. Geophys. Res.*, 87(B-5):3731–3740.

Ludwig, W. J., Windisch, C. C., Ewing, J. I., Lonardi, A. G., and Rios, F. F., 1978. Structure of Colorado basin and continent-oceanic crust transition off Bahia Blanca, Argentina. *In* Watkins, J. S., Montadert, L., and Dickerson, P. W. (Eds.), *Geological and Geophysical Investigations of Continental Margins:* Tulsa (AAPG), Am. Assoc. Petrol. Geol., Memoir, 29:113–114.

Ludwig, W. J., Windisch, C. C., Houtz, R. E., and Ewing, J. I., 1978. Structure of the Falkland Plateau and offshore Tierra del Fuego. *In* Watkins, J. S., Montadert, L., and Dickerson, P. W. (Eds.), *Geological and Geophysical Investigations of Continental Margins:* Tulsa (AAPG), Am. Assoc. Petrol. Geol., Memoir, 29:125–137.

Norton, I. O., and Sclater, J. G., 1979. A model for the evolution of the Indian Ocean and the breakup of Gondwanaland. *J. Geophys. Res.*, 84:6803–6830.

Rabinowitz, P. D., 1977. *Free-air Gravity Anomalies Bordering the Continental Margin of Argentina.* AAPG Argentine Map Series.

Rabinowitz, P. D., Delach, M., Truchan, M., and Lonardi, A., 1978. *Bathymetry Chart Argentine Continental Margin.* AAPG Argentine Map Series.

Rabinowitz, P. D., and LaBrecque, J. L., 1979. The Mesozoic South Atlantic and evolution of its continental margins. *J. Geophys. Res.*, 84(No. B11):5973–6002.

Royden, L., Sclater, J. G., and Von Herzen, R. P., 1980. Continental margin subsidence and heat flow: Important parameters in formation of petroleum hydrocarbons. *Bull. Am. Assoc. Petrol. Geol.*, 64(No. 2):173–187.

Sangree, J. B., and Widmier, J. M., 1977. Seismic stratigraphy and global changes of sea level, Part 9: Seismic interpretation of clastic depositional facies. *In* Payton, C. E. (Ed.), *Seismic Stratigraphy: Applications to Hydrocarbon Exploration:* Tulsa (AAPG), Am. Assoc. Petrol. Geol., Memoir, 26:165–184.

Veevers, J. J., and Powell, C. McA., 1979. Sedimentary wedge progradation from transform-faulted continental rim: Southern Exmouth Plateau, Western Australia. *Bull. Am. Assoc. Petrol. Geol.*, 63(no. 11):2088–2096.

Winn, R. D., 1978. Upper Mesozoic flysch of Tierra del Fuego and South Georgia Island: A sedimentologic approach to lithosphere plate restoration. *Geol. Soc. Am. Bull.*, 89:533–547.

Wise, S. W., Ciesielski, P. F., MacKenzie, D. T., Wind, F. H., Busen, K. E., Gombos, A. M., Haq, B. U., Lohmann, G. P., Tjalsma, R. C., Harris, W. K., Hedlund, R. W., Beju, D. N., Jones, D. L., Plafker, G., and Sliter, W. V., 1982. Paleontologic and paleoenvironmental synthesis for the Southwest Atlantic Ocean Basin based on Jurassic to Recent faunas and floras from the Falkland Plateau. *In* Craddock, C. C. (Ed.), *Antarctic Geoscience:* Madison (University of Wisconsin Press), pp. 155–163.