

PLEISTOCENE-MODERN DEPOSITS OF THE
LAKE TANGANYIKA RIFT BASIN, EAST AFRICA:
A MODERN ANALOG FOR LACUSTRINE SOURCE ROCKS AND RESERVOIRS

JEAN-JACQUES TIERCELIN,¹ ANDREW S. COHEN,²
MICHAEL J. SOREGHAN,² AND KIRAM-EDDINE LEZZAR¹

¹URA 1278 "Domaines Océaniques," Groupe Riftogène,
Université de Bretagne Occidentale, B.P. 452, 29275 Brest Cedex, France;
and ²Department of Geosciences, The University of Arizona,
Tucson, Arizona 85721, U.S.A.

INTRODUCTION

Bottom sediments of the largest lake of the East African Rift system, Lake Tanganyika (length 650 km; maximum depth 1470 m; volume 18,800 km³) (Fig. 1), were extensively studied between 1983 and 1986 by Project PROBE of Duke University (U.S.A.) and Project GEORIFT (1984-1985) of Elf Aquitaine (France), using a wide range of methods such as reflection seismology, piston coring, and dredging. Interpretation of multifold reflection seismic profiles collected by Project PROBE suggests up to 4 km of sediment has accumulated within local depocenters. In addition, seismic profiles exhibit several seismic discontinuities and associated sequences, interpreted to have resulted from large-scale, temporal changes in local tectonics and/or climate (Burgess and others, 1988; Scholz and Rosendahl, 1988).

Our interpretation of Recent and Modern profundal sediments in Lake Tanganyika is based on high-resolution, 5-kHz seismic surveys, along with multiple Kullenberg cores from the north and south basins of the lake collected during the GEORIFT project, and our interpretation of littoral clastic and biogenic sedimentation is based on grab sampling, observations from SCUBA, and gravity cores collected by the University of Arizona (Cohen, 1990; Soreghan and Cohen, 1991). These previous studies were supplemented by gravity cores collected in the Burundian part of the northern basin during a 1992 joint field operation by the University of Arizona (U.S.A.), the INSU-CNRS (France), and the CASIMIR project (Belgium). In this paper, our goal is to illustrate fundamental differences in facies associations within Lake Tanganyika that are, to a large degree, controlled by the basin structure.

THE LAKE TANGANYIKA RIFT BASIN TECTONIC STRUCTURE AND GEOLOGIC HISTORY

The deep structure of the Tanganyika Basin and the relationship between offshore and onshore structures have been studied by reflection seismic studies, structural field studies, and satellite (Landsat and Spot) imagery studies (Rosendahl and others, 1988; Tiercelin and others, 1988a; Morley, 1988; Ebinger, 1989; Reynes and others, 1993). During its early history, the Tanganyika Rift Basin consisted of three large depositional basins, named, from north to south, the Ruzizi, Kigoma, and Southern basins, which were separated by the Ubwari and Kalemie horst blocks respectively. These three depositional basins consist of one or more half-grabens, with border

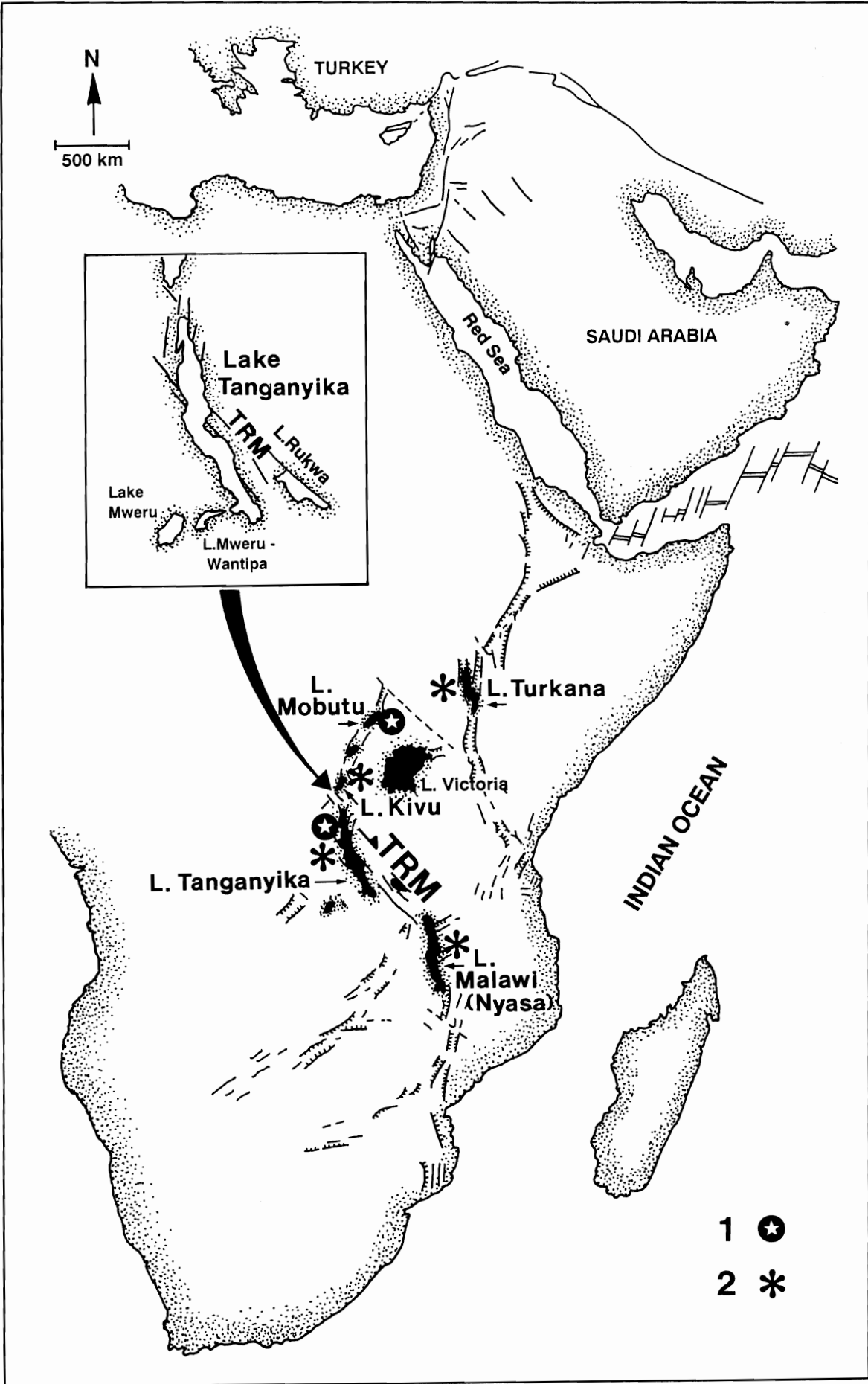


FIG. 1.—The Tanganyika Rift Basin, western branch of the East African Rift System.

faults typically facing the same direction within each depositional basin. The basins are separated by low-relief accommodation zones (Burgess and others, 1988)(Fig. 2A-C). The intervening horsts (high-relief accommodation zones of Rosendahl and others, 1988) formed barriers to deposition during this early phase. Three main seismic sequences, the Lukuga, Mahali, and Zongwe, separated by two seismic discontinuities, have been recognized within the sedimentary pile in the Southern Basin using the PROBE seismic data. In the Kigoma Basin, however, only two sequences, Makara (lower) and Kigoma (upper), have been defined (Fig. 3). The bases of the lowermost sequences (Makara and Lukuga) are defined by a set of three or four high-amplitude reflectors which constitute an acoustic basement that has been traced throughout the Ruzizi, Kigoma, and Southern basins. This acoustic basement, named the "Nyanja Event" (Burgess, 1985), is interpreted as the Precambrian basement-Tertiary sedimentary unit boundary (Burgess and others, 1988; Morley, 1988). Our tentative interpretation of the tectonic and sedimentary evolution of the Makara and Kigoma seismic sequences identified in the Kigoma Basin is shown in Figure 3.

Cohen and others (1993) combined reflection seismic and radiocarbon age data (RSRM) to calculate an age of 9 to 12 Ma B.P. for the onset of lacustrine deposition within Lake Tanganyika (synrift strata). The age estimate provides a maximum age of 12 Ma for the lake, although estimates for the northern and southern basins are significantly younger (7-8 Ma and 2-4 Ma respectively). A late Miocene age for the central basins of Lake Tanganyika agrees with volcanic, border-fault formation and basin subsidence data from the adjacent Lake Kivu and Lake Rukwa basins (Ebinger, 1989; Morley and others, 1992).

LAKE BASIN MORPHOLOGY

The modern geomorphology of the Tanganyika Rift Basin is characterized by two main bathymetric basins, Northern and Southern, separated by a N130°-140° trending ridge called the Kalemie-Mahali Ridge. The later ridge corresponds to a complex, block-faulted structure belonging to the Tanganyika-Rukwa-Malawi transcurrent fault zone (Tiercelin and others, 1988a). In detail, the Northern and Southern basins are characterized by a mosaic of three to four strongly asymmetric half-graben subbasins. These half-grabens are internally faulted and are separated by ridges/antiforms that are, in some cases, buried by sediments. The Ubwari Ridge in the Northern Basin forms a pronounced lakeward extension of the N20°-trending Ubwari horst block. The Kigoma and East-Marungu subbasins correspond to the deepest zones of Lake Tanganyika, with maximum water depths of 1310 and 1470 m respectively (Fig. 4).

Several morphological elements can be defined within these depositional subbasins, based on the structural asymmetry exhibited by the Lake Tanganyika Rift Basin: border-fault margins, littoral platforms, midlake structural highs, and axial-deep basins (Fig. 5A and B). The structural geometry produces a strong control on the modern geomorphology and sedimentary controls. For example, the asymmetry of the trough strongly influences drainage patterns (Cohen, 1990). The Ruzizi River, the second largest tributary, represents an axial margin drainage as it flows from Lake Kivu down the rift axis and enters at the northern end of Lake Tanganyika. The largest tributary is the Malagarasi River, which flows into the lake on the eastern shore and represents a platform margin drainage. Several other permanent and numerous semi-permanent rivers enter

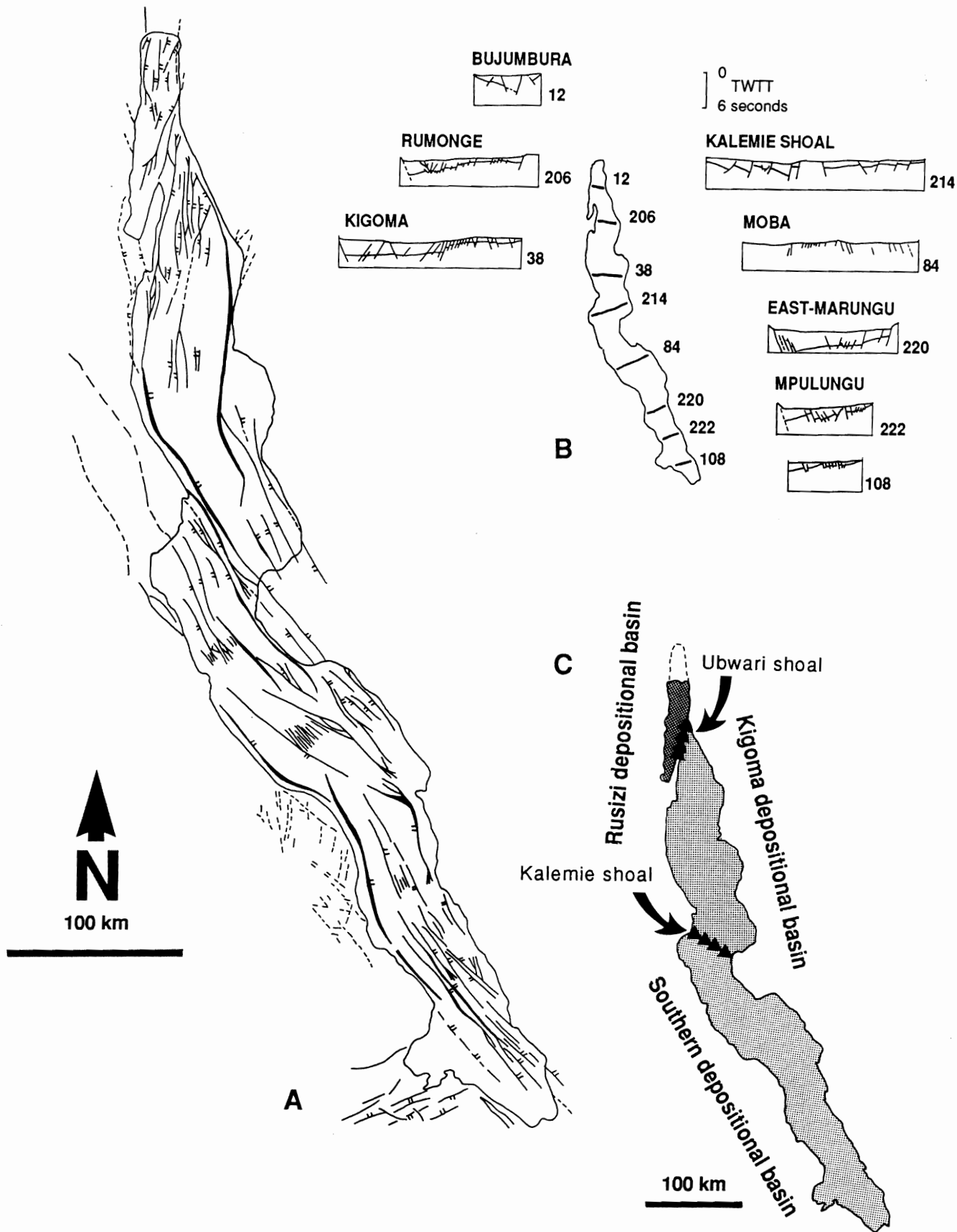


FIG. 2.—Tectonic maps and structural cross sections of the Tanganyika Rift Basin. (A) Simplified fault map from Morley (1988). (B) Schematic cross sections interpreted from multifold seismic coverage of Project PROBE. (C) Early depositional basins (from Burgess, 1985; Burgess and others, 1988). The Ubwari and Kalemie ridges separate the three adjacent Ruzizi, Kigoma, and Southern depositional basins.

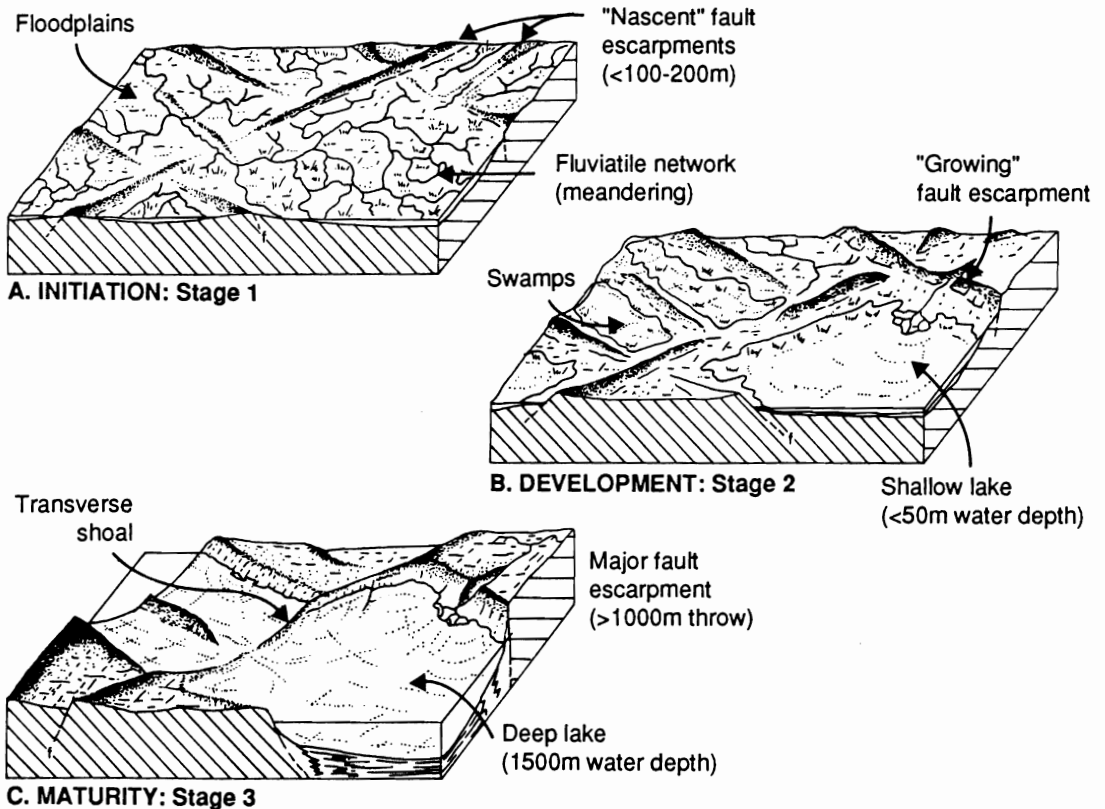
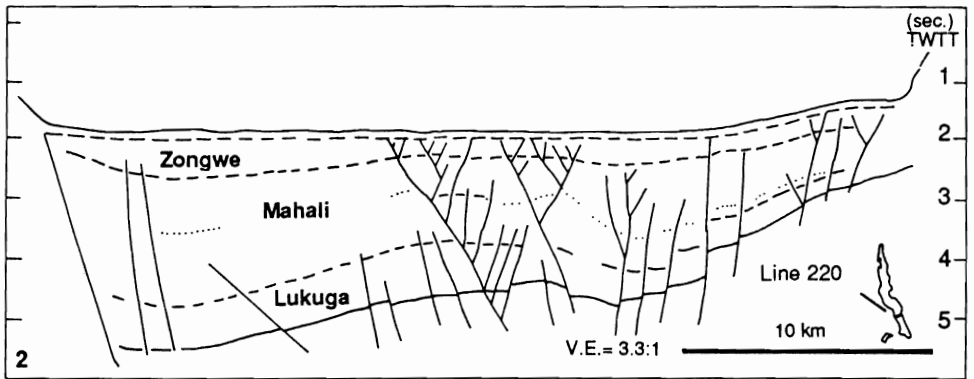
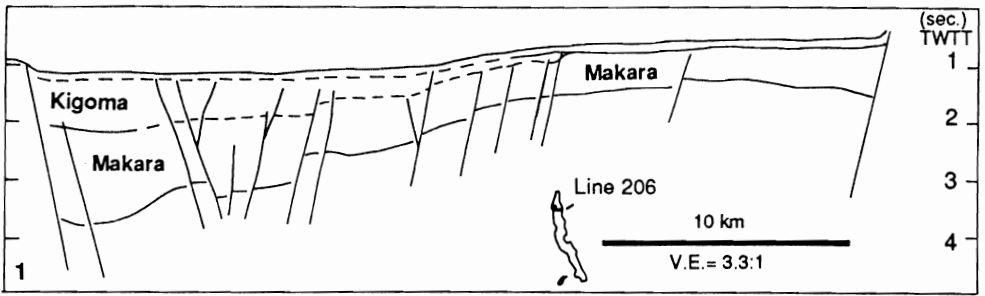


FIG. 3.—Seismic stratigraphic sequences of the Northern (Makara and Kigoma sequences) and Southern (Lukuga, Mahali, and Zongwe sequences) Tanganyika Rift Basin (from Burgess and others, 1988) and proposed successive stages of tectonic and sedimentary evolution as recognized on the Makara and Kigoma seismic sequences (from Tiercelin and Mondeguer, 1991). (A) Stage 1 (The Initiation Stage) is characterized by a broad, subsiding basin occupied by a wide, meandering, fluvial network. (B) Stage 2 (The Development Stage) is illustrated by swamps and shallow lacustrine environments (less than 50 m water depth) occupying elementary half-grabens. (C) Stage 3 (The Maturity Stage) is a progressive stage between shallow lakes of Stage 2 and a single, large, and deep (down to 1500 m water depth) lake resulting from the gradual connection of the Stage 2 half-grabens.

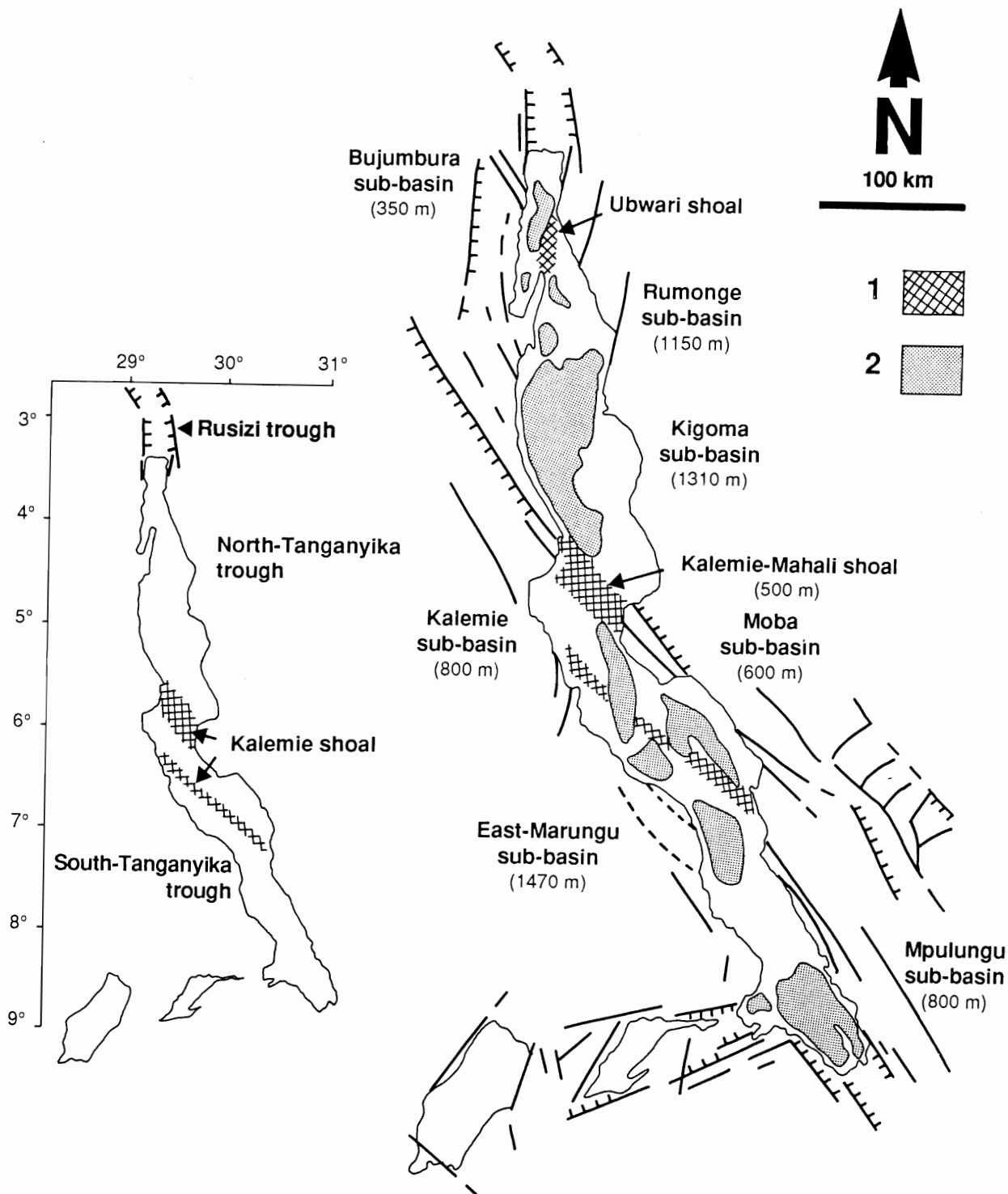


FIG. 4.—Present-day morphology of the Tanganyika Rift Basin. (1) Transverse ridges or midlake structural highs; (2) Axial-deep basins (from Tiercelin and Mondegue, 1991). Shoals are shown by crossed lines (#1), and basins are shown by stippled pattern (#2).

the lake along the platform margin side of the half-graben (Fig. 5A and B). These rivers are typically low gradient and flow across alluvial plains, at least in their lower reaches. The high relief along the border-fault margins comprises numerous closely spaced canyons containing ephemeral streams. Such drainages are characterized by highly variable discharge, mainly during the rainy season.

Lake Tanganyika is meromictic, with an apparently permanent anoxic hypolimnion that varies from below 80 to 100 m in the north to about 240 m in the south. Because of the steep topography of the rift margins, 80 percent of the lake bottom is covered by anoxic waters. The lake waters are mildly alkaline, are characterized by a high Mg^{++}/Ca^{++} ratio, and are relatively fresh. Gases such as carbon dioxide, hydrogen sulfide, and methane are present in the hypolimnion in appreciable quantities. Sublacustrine hydrothermal discharges have been identified on the western flank of the rift with methane-, hydrogen sulfide-, and carbon dioxide-rich fluids (Tiercelin and others, 1993b). High-temperature fluid emission (200°C) is suspected to occur in the deep waters of the lake and may contribute to the increase in the gas content of the hypolimnion (Pflumio and others, 1994).

MIDDLE PLEISTOCENE-MODERN SEDIMENTATION IN THE TANGANYIKA RIFT BASIN

The upper 100 m of the sequence of the Tanganyika Rift Basin was studied using 5 kHz seismic reflection profiling during the GEORIFT project. Three main seismic sequences named the Cameron, lower Mpulungu, and upper Mpulungu sequences, and possibly representing the last 200 Ky, were identified within the southern Mpulungu subbasin (Mondeguer, 1991). More than 50 Kullenberg cores up to 10 to 12 m long, representing upper Pleistocene-Holocene deposition, were recovered from the upper Mpulungu seismic sequence within the Northern and Southern basins. These cores were collected primarily from the deep-water depocenters and littoral platforms. The nature of the seismic discontinuities within the ages has been inferred through correlation with radiometrically dated piston cores.

Sedimentation Related to Littoral Platforms

Littoral platforms are generally associated with the ramped sides of the half-grabens that form the Tanganyika Basin and thus are defined as "lateral littoral platforms" (Fig. 5A and B). Similar littoral platforms also occur along axial rift margins that are generally dominated by wide, longitudinal drainages that create thick, prograding deltas (Fig. 5A and B). The low-relief nature of "lateral littoral platforms" allow large, well-integrated drainages to develop (Cohen, 1990). However, the slow subsidence rates, coupled with the presence of well-developed sublacustrine canyons (see below), promote sediment bypassing of allochthonous clastic sediment into deep water (Cohen, 1990). The result along the platform is the presence of wide zones of coquinas, or "shell graveyards" (Cohen and Thouin, 1987; Cohen, 1989). These lag deposits consist of gastropods, disarticulated bivalves, ostracods, and clastic, quartzo-feldspathic sand, gravel, and silt. Many of the clastic grains and bioclasts are coated.

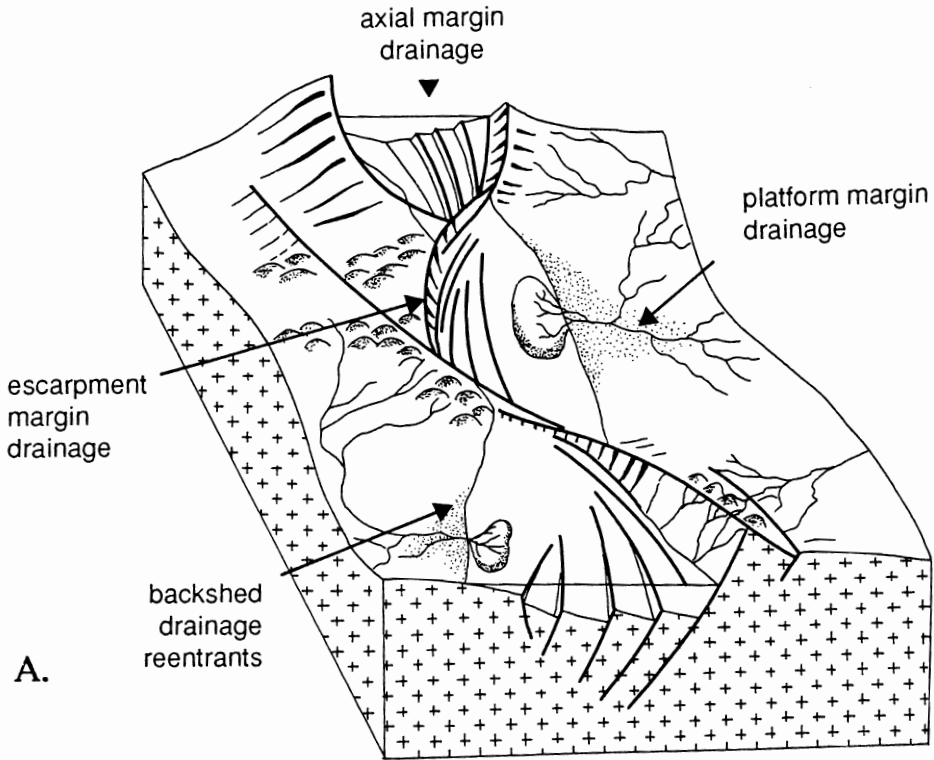
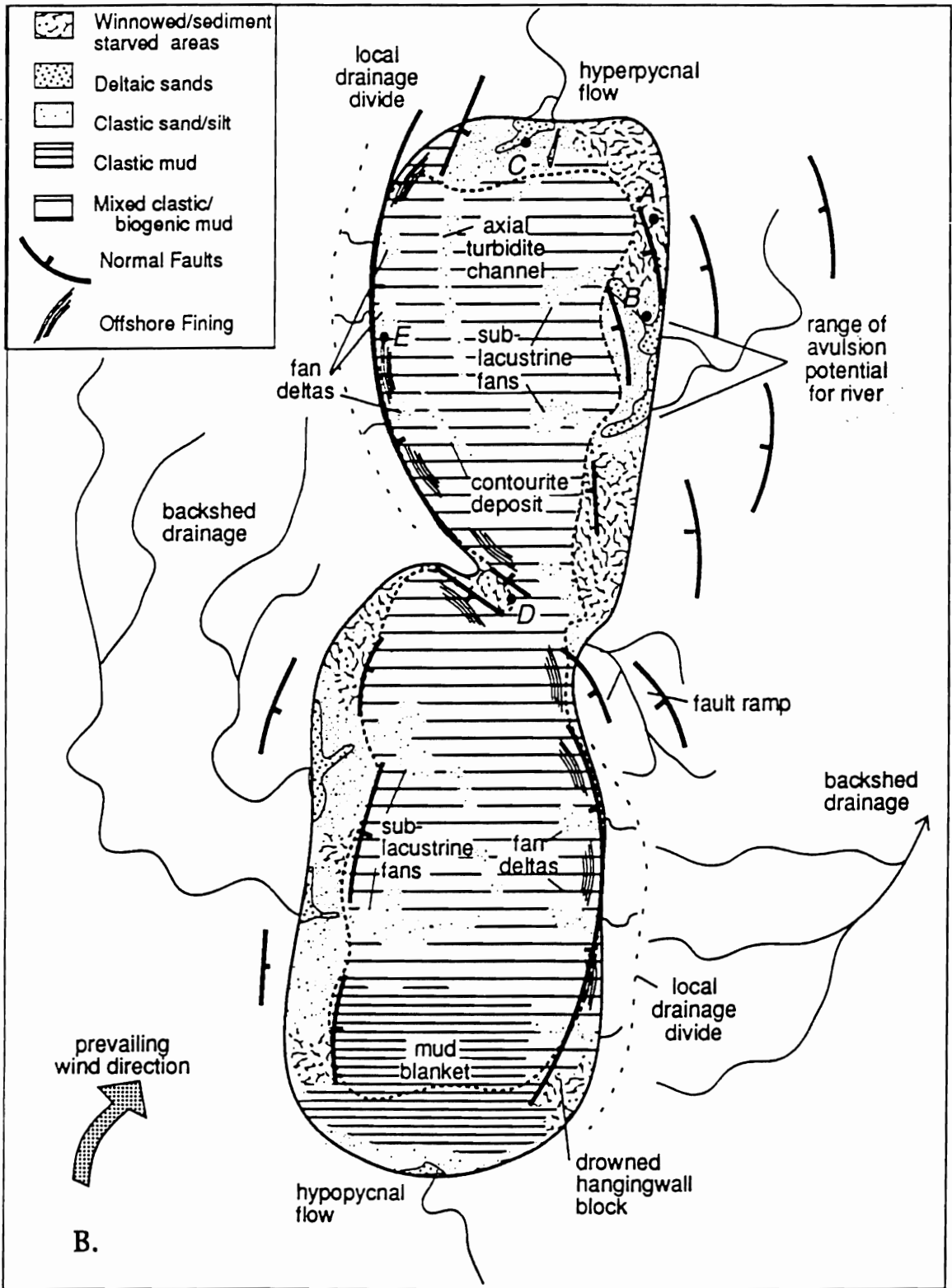


FIG. 5.—(A) Block diagram illustrating alternating half-grabens linked by transverse structural highs and their related rift-basin morphologies and drainages (from Cohen, 1990). (1) Border-Fault Margin; (2) Axial Littoral Platform; (3) Lateral Littoral Platform; (4) Midlake Structural High; and (5) Axial-Deep Basin. (B) This hypothetical rift-lake exhibits the relationships observed in several rift-lake basins between the structurally induced geomorphic controls presented on block diagram A and the resultant facies patterns.



Fluctuating lake level potentially can create a thick lag deposit that extends into relatively deep water. For example, cores SD 43 and 44, collected along the Rumonge lateral littoral platform in 100 m water depth, contain meter-thick beds of heterogeneous quartzo-feldspathic, medium to coarse sand and gravel, with abundant, well-preserved pelecypod and gastropod shells, and shell fragments (Fig. 6). Such sand layers are characterized by a very poor sorting and belong to the "Upper Detrital Formation," as defined in the Northern Basin by Baltzer (1991), which formed between 5000 to 2500 yr. BP. Elsewhere, the lateral littoral platforms are characterized by steep-faced progradational deltas that are typically dominated by silty sand. Such deltas are developed by permanent or temporary rivers. The subaerial environments of these inflows are characterized by transition from a high-energy fluvial system upstream, with sediments composed of poorly sorted gravels, coarse sands, and clays, to a low meandering system downstream, which contribute to the construction of a sandy-silty deltaic plain. Offshore of these deltas, cold, sediment-rich streams generate high-density underflows (hyperpycnal flows) that are characteristic of most Tanganyikan deltas. Extensive silty blankets, ephemeral in nature, cover many of the shell lag deposits. During a future drop in lake level, these silts will probably be winnowed and delivered to the deep-water environments through the sublacustrine canyons. Clastic and carbonate muds give way to diatomaceous, homogeneous or laminated muds below the oxic zone. For example, cores SD 42 and 38, collected in at 100 m water depth on the Rumonge platform and at 300 m on the Kigoma platform respectively, contain black to dark green and white, organic-rich (up to 10-12 percent total organic carbon), sparsely or very finely laminated muds (Fig. 7).

Axial littoral platforms are strongly associated with axial deltas, which are known to play an important role in rift-basin infilling (Cohen, 1990)(Fig. 5A and B). Within the Lake Tanganyika Rift, the largest axial drainage is represented by the Rusizi River, which flows from Lake Kivu to the northern end of Lake Tanganyika. Another example of axial rift drainage and associated deltas is documented by the small Nemba-Kasandjala rivers flowing north from the southern end of the N-S trending Burton's Bay half-graben. The dynamics of the Rusizi Delta are controlled by interaction between the waters of the river, which are heavily loaded with sediments and enriched in dissolved minerals from Lake Kivu waters, and the warmer, less dense waters of the lake, the result being the formation of a strong hyperpycnal flow. Such density flows generate diffuse turbidity currents close to the bottom of the lake or turbid flows floating as "interflows," or as detached nepheloid layers at an intermediate depth in the lake (Pharo and Carmack, 1979; Nelson and Maldonado, 1988). Isochronous deposits from a large flow of this type can be seen in about 30 Kullenberg cores collected throughout the northern Tanganyika Basin and named "Intermediate Detrital Formation" by Baltzer (1991). This formation corresponds to a 0.20 to 3 m-thick layer deposited all over the northern subbasins of Lake Tanganyika (Bujumbura, Rumonge, and Kigoma subbasins). It includes pure clays (smectite-/siderite-rich, organic-poor, less than 1 percent total organic carbon), which often display a characteristic beige color, sands, gravels, and mudballs (Baltzer, 1991; Tiercelin and others, 1992). Ages obtained from pelagic layers above and below the Intermediate Detrital Formation indicate that it was deposited over a very brief interval of geologic time. Baltzer (1991) suggested that deposition occurred over a 500-year period, between approximately 5300 and 4800 yr B.P. (Baltzer, 1991), whereas Bouroullec (1990) suggests that this event occurred more rapidly, between 6850 and 6750 yr B.P.

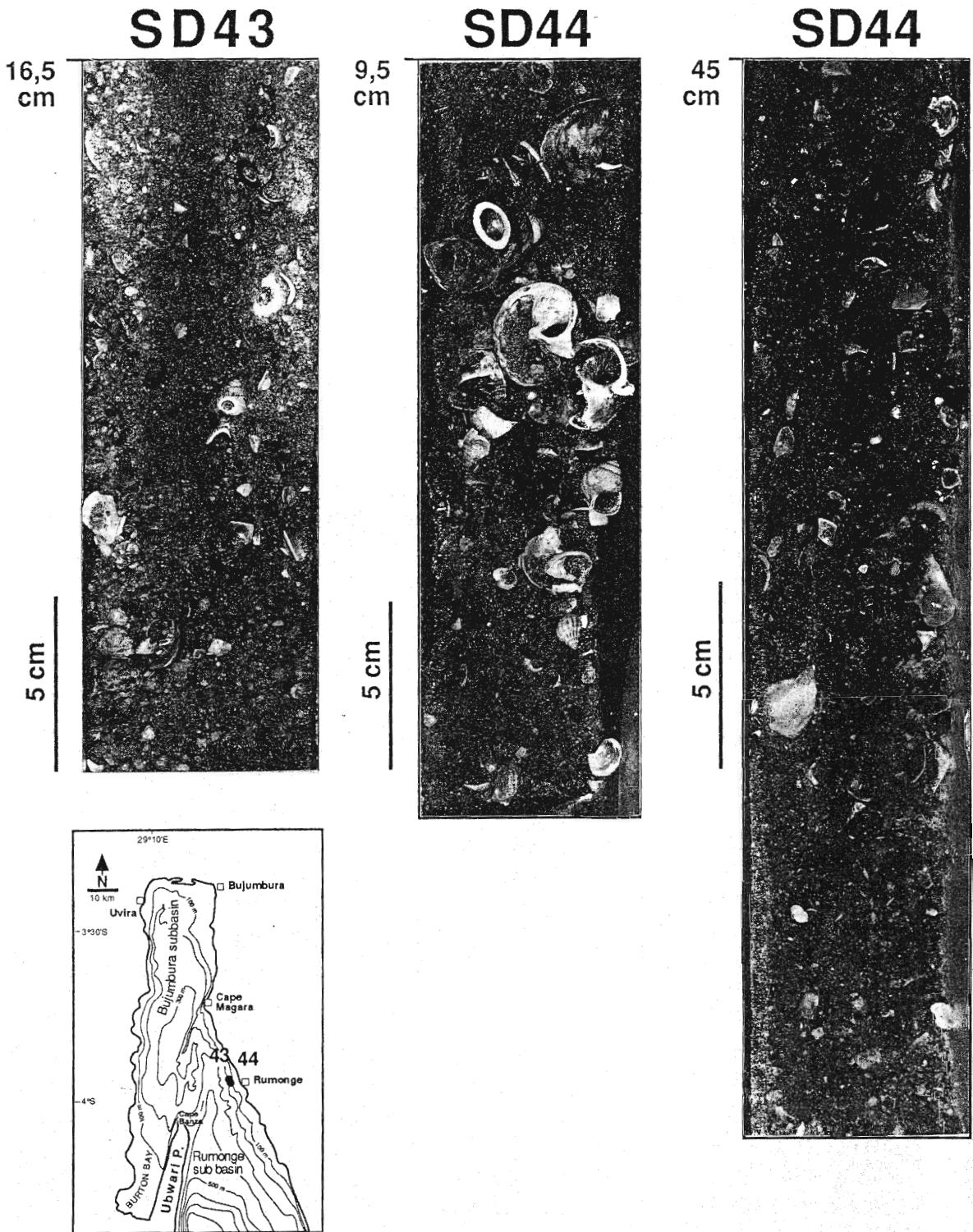


FIG. 6.—Representative littoral platform cores. Cores SD 43 and 44 were collected by Project GEORIFT on the Rumonge littoral platform, eastern flank of the North Tanganyika Basin, in 100 m water depth. Heterogeneous quartzo-feldspathic, medium to coarse sands contain abundant, well-preserved, and fragmented pelecypod and gastropod shells, and form meter-thick beds along the littoral platforms.

Such wide turbiditic events are represented in the sedimentary sequence by stratified seismic facies with medium to strong amplitude and high-frequency reflectors (Tiercelin and others, 1992).

Sedimentation Related to Midlake Structural Highs

The Tanganyika Rift Basin is characterized by two major structural highs, the N130°-140° trending Kalemie-Mahali Ridge, which is part of the Tanganyika-Rukwa-Malawi fault zone and divides the northern and southern bathymetric basins of Lake Tanganyika, and the N20° Ubwari Ridge, which divides the Bujumbura and Rumonge subbasins (Fig. 4). Sedimentation along these structural highs varies between relatively low gradient on top of horst blocks and steeper gradients adjacent to the horst blocks (Tiercelin and others, 1992)(Fig. 5A and B). Coarse-grained lag deposits, similar to those found along the littoral platform, occur along the nearshore reaches of the structural horsts. Because of the limited drainage basin size on the subaerial portion of these narrow horst blocks, these lag deposits consist almost exclusively of bioclasts. Along the submerged part of the Ubwari Peninsula, shell gravels and bioclastic sands occur down to a depth of at least 100 m. In deeper water, below the level of recent low-lake stands, extremely low rates of sediment accumulation occur, dominated by diatom-rich muds. Core SD 12, collected at 200 m of water depth on the Ubwari Ridge, contains alternating layers of dark gray to black homogeneous muds; gray to white, sometimes finely laminated diatomites; and successions of millimeter-thick dark green and white laminae (Fig. 7).

Along the steeper flanks of the horst blocks, gravity induced sedimentation and suspension settling of autochthonous dominate. These sediments are typically black, laminated muds. Interbedded within the fine-grained muds are turbidite deposits dominated by coarse gravel and bioclasts, but also containing clastic silt.

Sedimentation Related to Axial-Deep Basins

Our group and other researchers have dredged and cored sediments from 300 to 1000 m water depth in the Bujumbura, Rumonge, and Mpulungu subbasins, and up to 1270 m in the Kigoma subbasin (Fig. 4). Such sediments are mostly of autochthonous origin and are classified as deep, organic-rich sediments. However, allochthonous clastic, sandy, or silty layers also occur interbedded within these sediments.

Among the deep, organic-rich sediments, the most frequent facies are dark-colored green, black, or beige muds that may be homogeneous, laminated, or flaky. High-resolution seismic records show that they generally form wide "sheet drape" sequences that are characterized by continuous to weakly divergent seismic reflectors. Accumulation rates of 500 to 600 mm per 1,000 years have been estimated for these muds from radiocarbon and magnetostratigraphic data (Tiercelin and Mondeguer, 1991; Williamson and others, 1991). Core MPU 12, collected at 420 m water depth in the central part of the Mpulungu subbasin, illustrates the interbedding of laminated and flaky mud facies. The interval 200 to 250 cm (Fig. 8) consists of dark green or beige laminated muds characterized by two types of laminae: (1) dark green to beige laminae,

(continued on page 53)

FIG. 7.—Sedimentary facies from littoral platforms and midlake structural highs. Core SD 42 was collected by Project GEORIFT on the Rumonge littoral platform at 100 m of water depth. Black to dark green, sparsely laminated muds laterally replace shell graveyards that have been winnowed with muds delivered to the axial-deep basins through canyon systems. Core SD 38 was collected in 300 m of water depth on the Kigoma littoral platform. Very finely laminated, black, dark green and white, organic-rich sediments form wide "sheet drape" sequences on the littoral platform below the oxic zone. Core SD 12 was collected in 200 m water depth on top of the Ubwari Ridge. Small depressions on the top of this ridge are zones of extremely low rates of sediment accumulation (Bouroullec and others, 1992). The SD 12 core section on the left illustrates 10 cm-thick beds of dark gray to black, homogeneous organic muds alternating with either massive or laminated, gray to white diatomites. The SD 12 core section on the right shows a succession of millimeter-thick, dark green and white, diatomitic laminae overlying dark gray, homogeneous, organic muds. Above 100 m water depth these deposits give way to carbonate shelly silts, sands, and gravels in shallow-water areas of the structural highs.

FIG. 8.—Organic-rich facies from deep-water environments of the axial-deep basins. The main axial-deep basins of Lake Tanganyika were cored during the GEORIFT project. Core SD 3, taken in 300 m of water depth in the central part of the Bujumbura subbasin, illustrates meter-thick, dark brown units that are made up of millimeter-thick, beige to light brown, irregular laminations. This facies forms as continuous "sheet drape" sequences that characterize most areas of the Bujumbura subbasin between 200 to 300 m water depth. At greater depths (1000-1300 m), organic sedimentation is represented by very finely laminated facies, or by massive/crumblly, dark gray or black clays (see core SD 29, 1270 m, East Kigoma subbasin). Cores MPU 4, 6, and 12 were collected at 400 to 500 m of water depth in the Mpulungu subbasin, at the southern end of Lake Tanganyika. The MPU 4 core is mainly characterized by flaky muds, which may form decimeter-thick beds or millimeter-/centimeter-thick laminations, interbedded within green or beige homogeneous muds. This flaky facies is made up of millimeter-sized flakes of diatom agglomerates that are probably fecal pellets (Haberyan, 1985). The MPU 6 and 12 cores illustrate the interbedding of laminated and flaky diatomitic mud facies. Millimeter-/centimeter-thick layers of brownish yellow volcanic ash accumulated in the southern Tanganyika Basin during a large, explosive phase of activity of the Rungwe axial volcano located immediately north of Lake Malawi.

FIG. 9.—Clastic facies from deep-water environments of the axial-deep basins. Core SD 17 was collected at 400 m of water depth in the upper part of the Rumonge Channel, which is tectonically controlled by the Ubwari Ridge. This core represents the sharp transition between autochthonous, dark gray, laminated clays and a fining-upward, coarse to very coarse, immature sand. It was probably deposited in the proximal region of a turbidity flow. Core SD 28 was collected at greater water depth (1000 m) at the outlet of the Rumonge Channel in the Kigoma axial-deep basin. At that site, deep-water organic sedimentation, represented by massive or finely laminated, light gray to white diatomites or dark green to white, millimeter-thick, organic oozes (core SD 28, left side), alternates with light gray, massive, silty clays, characterized by floating mica flakes and abundant millimeter-sized plant fragments (core SD 28, right side). This latter unit probably represents a distal turbidite.

approximately 1 cm thick, that are mainly formed by diatom frustules; and (2) dark-colored green or black laminae, approximately 1 mm thick, composed of alternating clayey/organic layers and thin, diatom-rich layers. A flaky mud facies, with millimeter- to centimeter-thick beds, is made up of millimeter-sized flakes of diatom agglomerates and is locally interbedded with the laminated mud facies. This flaky facies was also found forming decimeter- to meter-thick layers in several cores collected at 400 to 500 m of water depth in the Southern Basin (cores MPU 4 and 6)(Fig. 8), as well as in the Northern Basin (Burton's Bay). Such agglomerates have been interpreted as fecal pellets (Haberyan, 1985). High values of total organic carbon (4-12 percent) are characteristic of such facies (Tiercelin and others, 1988b), which correspond to alternating, short-term, high and low periods of biological primary productivity (Hecky, 1991).

Laminated, organic-rich facies have also been cored at 200 to 300 m of water depth in the central part of the Bujumbura subbasin (core SD 3)(Fig. 8), which form large "sheet drape" sequences that are characterized by great seismic homogeneity over the whole basin (parallel to weakly divergent reflectors with good continuity)(Bouroulllec and others, 1992). White-gray "gel" layers, millimeter- to centimeter-thick, have been observed in cores or dredged sediments collected in the Northern Basin (Burton's Bay) and in the south (Mpulungu subbasin)(Mondeguer and others, 1986, 1989). It has been shown that such gels are formed by jumbles of frustules of the planktonic diatom *Nitzschia* spp., which is known to grow abundantly during the periods of deepest mixing of the lake. Several cores collected in the southern Mpulungu subbasin have also exhibited *Nitzschia*-rich layers associated with millimeter- to centimeter-thick, brownish yellow layers of volcanic ash (cores MPU 4, 6, and 12)(Fig. 8) corresponding to a large, explosive eruption, dated at 11,000 yr B.P., of the Rungwe axial volcano at the northern end of Lake Malawi (Fig. 1). Such ashfalls may have favored diatom growth and modified species composition by affecting nutrient concentrations, particularly by injection of Si, which is thought to favor rapid *Nitzschia* growth (Haberyan and Hecky, 1987).

Other organic-rich facies have also been cored at great water depths (1000-1270 m) within the southern part of the Rumonge and Kigoma subbasins. Cores collected in the deepest part of the East-Kigoma subbasin (1270 m water depth) are characterized by crumbly black clays (core SD 29)(Fig. 8) or by successions of homogeneous black clays and very finely interlaminated dark green, olive-gray, and beige, millimeter-thick laminae.

Preservation of such finely laminated sediments and large quantities of organic matter (4-2 percent total organic carbon) in the deep-basin sediments are explained by the anoxic conditions that prevail over most of the bottom of the lake (Coulter and Spigel, 1991). The HI (Hydrogen Index) is as high as 600 (mean value = 387)(Huc and others, 1990), and these sediments could be considered as having a high petroleum potential with 35 kg of hydrocarbons/ton of rock (Huc and others, 1990). Such conditions could explain the oil seep occurrence at Cape Kalamba in the Rumonge subbasin (Tiercelin and others, 1989, 1993a and b). A ^{14}C age of $25,060 \pm 1650$ B.P. and a $\delta^{13}\text{C}$ value of the oil (-21.6 percent) indicate that this oil was generated from essentially contemporary organic matter in the lake sediments (Simoneit, *in* Tiercelin and others, 1993b).

Axial-deep basins are also characterized by the delivery of allochthonous clastic sediments through a dense network of canyon systems. These canyons have formed on many of the platform ramps and structural highs found throughout the Tanganyika Rift Basin. Feeder canyons, generally about 1 km wide and 20 to 50 m deep, have been recognized on echosounding profiles in various parts of Lake Tanganyika (Capart, 1949). Along the Rumonge littoral platform margin, a series of canyons, which extend lakeward from the subaerial courses of rivers, coalesce to form a single canyon that follows the eastern flank of the N-20° trending Ubwari shoal down to the deepest point of the West-Kigoma deep (maximum depth 1310 m). The upper parts of such active canyons are erosion-dominated, controlled by gravity-driven density flows. The bottom of the deeper part of these channels is filled with sands, as observed in cores SD 17-20 (Baltzer, 1991). Core SD 17, collected at 400 m of water depth in the upper part of the Rumonge Channel, shows a sharp-based, fining-upward sequence of black, clayey, coarse to very coarse, immature sand overlying dark gray laminated clays. Reworked chips of dark gray clays and a very immature coarse material with centimeter-sized quartz gravels characterize the basal few centimeters of this bed (Fig. 9). Deep-lake fans have been identified on high-resolution seismic profiles in the deepest parts of the North Tanganyika Basin. In the Bujumbura subbasin, small (5 x 2 km), deep fans have been identified at 300 m of water depth and are related to the activity of canyons perpendicular to the trend of the eastern border fault of the basin. Large, deep fans are associated with the deepest parts of the deep-axial basins (more than 1000 m water depth), such as the Rumonge, Kigoma, Kalemie, or Moba subbasins. Their seismic signature is chaotic and exhibits hyperbolic reflectors in the proximal areas. In the more distal areas, they exhibit well-stratified seismic reflections that are associated with channel terminations. Cores suggest that the sediment consists of distal turbidites, generally formed by alternating gray to black clay and fine silt layers, locally interfingered with thick layers of autochthonous, organic-rich muds or diatom oozes. Core SD 28, collected at 1000 m water depth at the outlet of the Rumonge Channel in the West-Kigoma deep, shows light gray, massive, silty clay, the silt fraction consisting mainly of mica and numerous millimeter-sized plant debris that occur scattered throughout this facies (Fig. 9). Such facies, which alternate with white to light gray, laminated to massive diatomitic clays, probably result from distal turbidite sedimentation.

Turbidity flows can be initiated by catastrophic floods of coastal rivers, or by highly fluid landslides. Both mechanisms are typically initiated during the rainy season along the steep coastlines of the Tanganyika Basin. Other currents may also be responsible for the accumulation of coarse sediments in deep subbasins, particularly at the foot of the border-fault escarpments. There have been few studies of the internal current circulation in Lake Tanganyika, although the existence of bottom currents have been hypothesized based on the presence of scoured bottom surfaces. This scour is indicated by the rarity of soft sediment, as observed by Livingstone (1965) and Coulter (1968), at the southern end of the lake (Mpulungu subbasin). Such currents generally appear on the steeper lake-margins and may be related to turbulence caused by large-amplitude internal waves forcing water movements over the lake bottom (Coulter and Spigel, 1991). Strong contour currents are also suspected to exist and may have reworked old landslide/mass-flow deposits into slope parallel bars at the foot of border faults (Bouroulllec and others, 1992). Contour currents may be also responsible for the construction of series of sediment waves, such as observed in the southern Mpulungu subbasin at the top of the Mpulungu seismic sequence and sampled at about 400 m water depth by the MPU 12 core (Mondeguer and

the deep-axial basins of the lake, forming highly petroliferous sediments. Nevertheless, the distribution of organic facies in bottom sediments shows important and complex lateral variability. Mature source rocks may exist within the sedimentary column. The young geologic age of the Cape Kalamba oil probably indicates a very rapid maturation that resulted from high temperatures, possibly the result of hydrothermal activity.

The Lake Tanganyika Rift Basin also appears favorable to reservoir formation. Large sand bodies are associated with axial or lateral littoral platforms, resulting from redistribution by longshore currents, and fine-grained sediments are transported offshore into the deep-axial basin by turbid flows. Such sand bodies can be considered as potential reservoirs.

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