Development of a lacustrine terminal fan and a coarse grained delta in the tertiary Daban Basin (Northern Somalia)

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ABSTRACT

The Daban Basin developed in a rapidly subsiding half graben of the Gulf of Aden rift system. It is filled with 2700 m of transitional to continental clastic deposits of Middle Eocene to Oligocene age. Toward the top of the succession, perennial lake sediments interfinger with a thick delta sequence. The basal portion of this delta system consists of conglomeratic mouth-bars deposited in shallow water at the lacustrine margin. The middle and upper portions include stacked and horizontally laminated sandstone units, deposited at the lake margin as a terminal fan which was fed by ephemeral streams during a period of aridity. The mouth bar delta was a very efficient depositional system which conveyed sands to the centre of the lake. In contrast, the terminal fan was dominated by sheet flows and built up mainly in the marginal area of the lake, but run-off from rare large storms transported sandy material to the centre of the perennial lake. Sediment supply and facies distribution in the delta complex were controlled by climatic changes and by the asymmetric geometry of the basin that guided the stream drainage.

Key words: Northern Somalia, terminal fan, coarse grained delta, half graben.

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RESUMEN

La cuenca de Daban se desarrolló en un semigraben muy subsidente del sistema de rift del Golfo de Adén. Se rellenó con 2700 m de depósitos clásticos de transición a continentales de edad Eoceno Medio a Oligoceno. Hacia el techo de la sucesión los sedimentos de lago perenne se interdigitan con una potente secuencia deltaica. La parte basal de este sistema deltaico consiste en barras de desembocadura conglomeráticas depositadas en aguas someras del margen lacustre. Las porciones media y superior incluyen apilamientos de unidades arenosas con laminación horizontal, depositadas en el margen lacustre en forma de un abanico terminal alimentado por corrientes efímeras durante un periodo de aridez. El delta de barras de desembocadura era un sistema muy eficaz que transportaba arenas hasta el centro del lago. Por el contrario, el abanico terminal estaba dominado por flujo laminares y se construía sobre todo en el área marginal del lago, pero la escorrentía de grandes, aunque raras, tormentas transportaba material al centro del lago perenne. El suministro de sedimento y la distribución de facies en el complejo deltaico estaban controladas por cambios climáticos y por la morfología asimétrica de la cuenca que guiaba las corrientes de drenaje.

Palabras clave: Somalía Norte, abanico terminal, delta de grano grueso, semigraben

INTRODUCTION

Extensive research on marine and lacustrine coarse grained deltas and fan deltas has demonstrated that deposition is controlled by many factors such as tectonic setting, basin margin gradient, eustatic sea-level changes, wave and tide currents, and fluvial clastic supply (Ethridge & Wescott, 1984; Dunne & Hempton, 1984; McPherson *et al.*, 1987; Nemec & Steel, 1988; Massari & Colella, 1988; Wood & Ethridge, 1988; Ito, 1989; Nemec, 1990; Postma, 1990; Billi *et al.*, 1991).

Deltas and fan deltas prograding into small and shallow lakes are not significantly reworked by waves and tides, rather they are mostly influenced by lake level changes related to climatic fluctuations and tectonic movements.

Lacustrine deltas and fan deltas are frequently found in rift basin settings and the influence of boundary faults on fluvial drainage pattern, sediment supply and lake morphology is reflected in their architecture and facies distribution (Link & Osborne, 1978; Dunne & Hempton, 1984; Frostick & Reid, 1987; Kazanci, 1988; Leeder *et al.*, 1988; Anadón *et al.*, 1989; Cavazza, 1989; Gawthorpe & Colella, 1990). Rift basin shoulders usually are not the major source of sediments because the crests of tilted faulted blocks act as barriers to fluvial drainage; the fault scarp fans are therefore generally small (Dunne & Hempton, 1984; Frostick & Reid, 1987; Anadón *et al.*, 1989; Gawthorpe & Colella, 1990). Major supply of sediments to rift basins is carried by the axial drainage (i. e. parallel to the master faults) and by rivers coming from hanging-wall dip-slopes facing the boundary faults (Dunne & Hempton, 1984; Frostick & Reid, 1987; Leeder *et al.*, 1988; Flint *et al.*, 1989).

Lake water levels are sensitive to climatic fluctuations and changes in basin geometry caused by tectonic movements. These fluctuations complicate the facies relationship of lacustrine deltas and fan deltas.

Ríver regímes react to climatic conditions. Lacustrine delta systems may receive huge quantities of sediments transported either by perennial rivers or by ephemeral streams.

The aim of this paper is to analyze the development of a lacustrine delta system in the Daban rift basin, located on the northern Somalia continental margin. The lower portion of the delta contains coarse grained mouth bar sequences, while the middle and upper sections are composed of thick, stacked sandstone units with sedimentary features typical of terminal fans. Terminal fans are lobate topographic forms built up by ephemeral streams in which the water discharge is progressively reduced down fan by evaporation and infiltration. Rivers that build terminal fans do not erode in their lower reaches, but rather deposit sands, dominated by parallel lamination during sheet floods (Mukerji, 1976; Friend, 1979; Parkash *et al.*, 1983).

The toe of the terminal fan of the Daban Basin prograded into a perennial lake and, for this reason, differs from other terminal fan (cf. Mukerji, 1976; Friend, 1978; Parkash *et al.*, 1983; Tunbridge, 1984) which end in alluvial plains or playas.

REGIONAL SETTING

The Daban Basin was rapidly subsiding and active during the opening of the Gulf of Aden. The latter links (Fig. 1) the East African rift and the Red Sea with the Carlsberg ridge in the NW Indian Ocean (Laughton *et al.*, 1970). The Gulf of Aden is a young oceanic basin formed from the breakup of the Afro-Arabian continental block and the north-eastward drift of the Arabia plate. It was formed in the eastern termination of the «Central Africa Lineament», a belt of crustal weakness which runs from the Guinea Gulf to the Indian Ocean (Cornacchia & Dars, 1983; Abbate *et al.*, 1986).

During the initial stage of the Gulf of Aden rifting «en échelon» WNW fractures and rapidly subsiding basins were formed and active clastic sedimentation commenced. These basins were located on the Somalian and Arabian continental margins (Fig. 1) (Beydoun, 1970; Abbate *et al.*, 1986) and received clastic supply from the adjacent uplifting blocks.

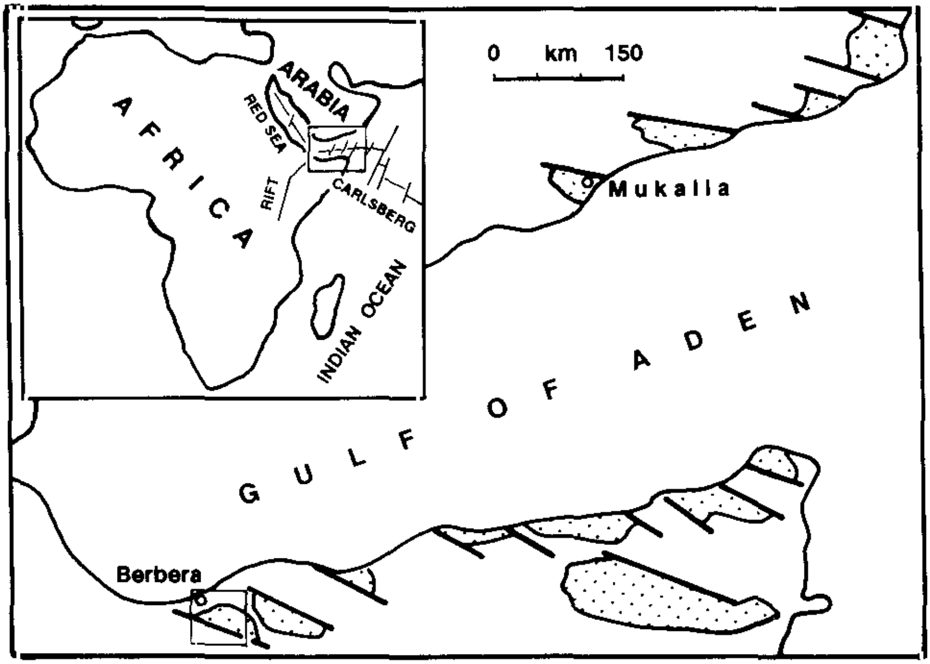

Fig. 1—Map showing location of Oligo-Miocene basins (stippled) in the Somalia and Arabia continental margins that were formed during the Gulf of Aden rifting. Insert: outline of the Red Sea, East Africa Rift, Gulf of Aden and Indian Ocean Carlsberg Ridge system.

Fig. 1.- Mapa de situación de las cuencas Oligo-Miocénicas (punteado) en los márgenes continentales de Somalía y Arabia formadas durante el rifting del Golfo de Adén. En el recuadro, trazado del Mar Rojo, Rift de Africa Oriental, Golfo de Adén y sistema de cresta de Carlsberg del Océano Indico.

THE DABAN BASIN

The Daban Basin belongs to the Gulf of Aden rift system and is located on the Northern Somalia continental margin 25 km SE of Berbera (Fig.1). It is a half-graben structure filled with 2700 m of Middle Eocene to Oligocene predominantly clastic deposits. The master fault is located along the southern margin of the basin and dips northward (Fig. 2). The basin is bounded by Mesozoic to Early Tertiary shallow marine limestones and continental sandstones that rest unconformably on Precambrian to Early Paleozoic basement.

The Daban Basin is elongated in an E-W direction (Fig.2) and is 20 to 40 km wide (Hunt, 1960; Bruni *et al.*, 1987). Basin fill deposits form a broad syncline and rest conformably on the Middle Eocene Taleh Evaporites. The northern limb has a gentle southern dip, while the beds of the southern margin have a steeper dip and are truncated by the Dagah Shabele (leopard

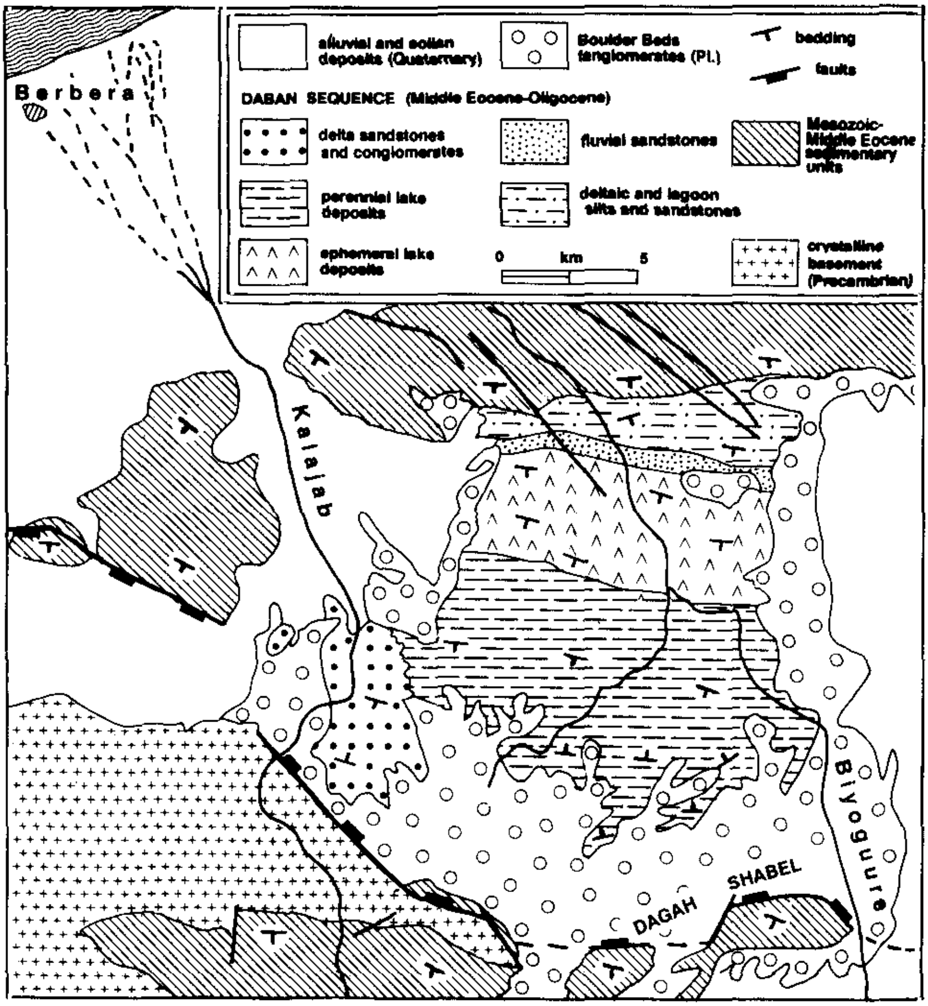

Fig. 2—Simplified geology of the Daban Basin (modified from Hunt, 1960 and Bruni et al., 1987).

Fig. 2—Geología simplificada de la cuenca de Daban (modificado de Hunt, 1960 y Bruni et al., 1987).

stone) fault zone which places them against the Mesozoic and the basement rocks (Fig. 2). This fracture is the surface expression of the master border fault.

The basin fill grades upward from transitional to continental sediments (Macfadyen, 1933; Abbate *et al.*, 1983; Sagri *et al.*, 1989). From the bottom of the sequence upward six sedimentary environments are distinguished (Fig. 3): restricted lagoon, marine delta, lagoon, alluvial plain, ephemeral, and

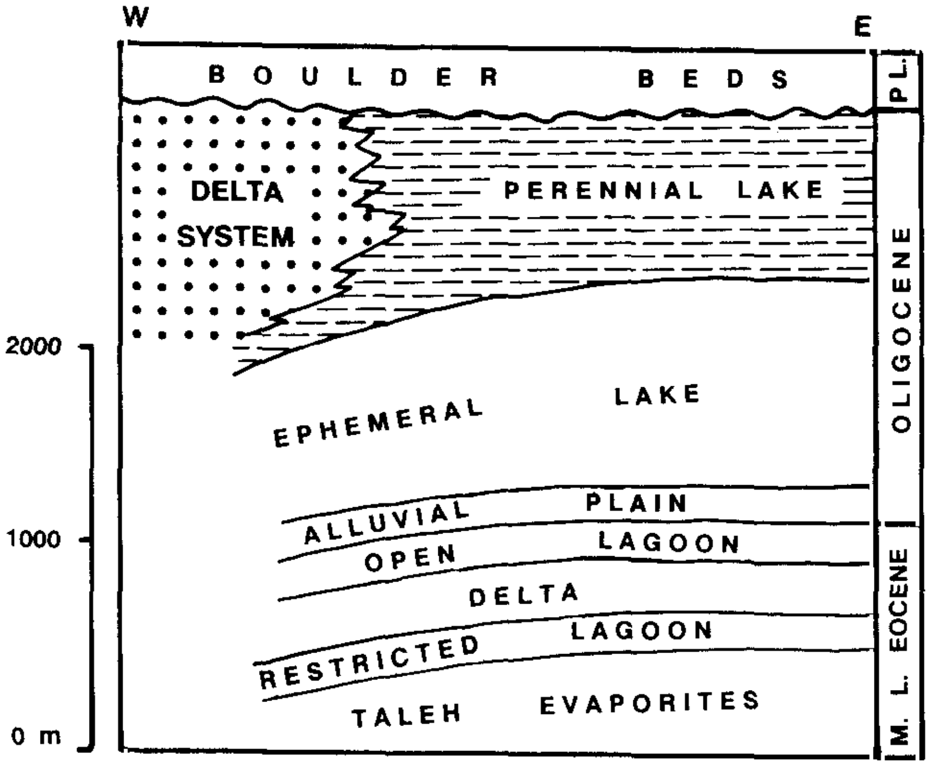

Fig. 3—Schematic stratigraphy of the Daban Basin fill.
Fig. 3—Estratigrafía esquemática del relleno de la cuenca de Daban.

perennial lake facies. The latter shows a lateral transition into a thick lacustrine delta sequence (Fig. 4).

After the deposition of the Middle-Late Eocene sediments, during the regression that affected the whole Somali-Arabian continental block, the Daban area was cut off from the sea and Oligocene fluvial and lacustrine deposits then filled the basin (Abbate *et al.*, 1983; Sagri *et al.*, 1989). During this continental episode teh Daban Basin was a well developed half graben fed by streams with clastics derived from faulted blocks of the Somali escarpment. At the end of the Oligocene the sediments were deformed and unconformably overlain by Pliocene Boulder Beds fanglomerates derived from the Somali Plateau which was rising to the south.

FACIES ASSOCIATION IN THE LACUSTRINE DELTA SYSTEM

The sediments of the perennial lake (900 m thick) are green siltstones and sandstones with chalky limestone and marlstone interbeds, that contain fresh

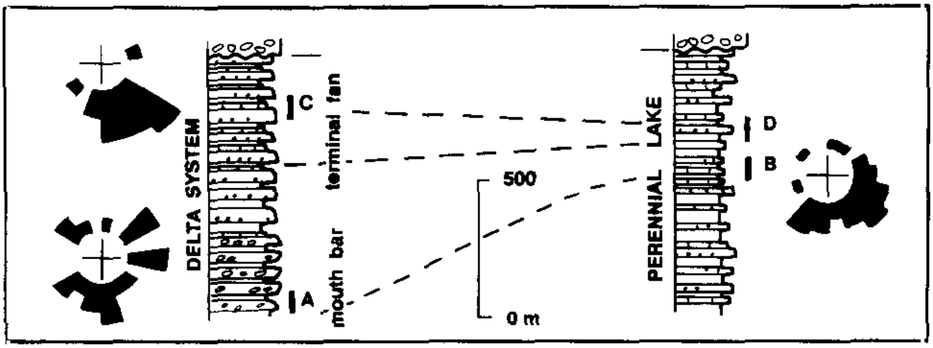

Fig. 4—Rose diagrams of paleocurrent directions and generalized stratigraphic sections through the perennial lake and delta system sequences in the Daban Basin. Dashed lines indicate some key beds correlations. Capital letters indicate the position of the sedimentological logs reported in Figs. 5 and 8.

Fig. 4—Diagramas en rosa de las direcciones de paleocorrientes y cortes estratigráficos generalizados de las secuencias de lago perenne y del sistema deltaico de la cuenca de Daban. Las líneas discontínuas indican las correlaciones de algunas capas clave. Letras mayúsculas: posición de los perfiles de las Figs 5 y 8.

water fishes of Oligocene age (Van Couvering, 1982), gastropods, ostracods and silicified trees (Macfadyen, 1933). The perennial lake deposits grade westward into a thick delta sequence (Fig. 4) composed of conglomerates, sandstones, siltstones and nodular fresh-water limestones.

The lowermost part of delta system is covered by Pliocene Boulder Beds fanglomerates and Quaternary deposits (Fig. 2). The middle and upper portions are particularly well exposed.

In many cases thick beds of chalky limestone, sandstone and tuff can be visually traced from the lacustrine to the delta sequences (Fig. 4) (Hunt, 1960; Bruni *et al.*, 1987).

The exposed delta succession can be divided in two parts: (a) a coarse grained mouth-bar delta, overlain by (b) a thick sandstone units of a terminal fan (Fig. 4).

Coarse grained mouth-bar delta. The mouth-bar delta succession, 250 m thick, consists of upward thickening and coarsening sequences, ranging from 5 to 10 m thick. Each sequence is composed of three main facies, which are, from bottom to top (Fig. 5, log A):

1. Green siltstone and marlstone wave rippled, cross or horizontally laminated, which are locally intensely bioturbated, were deposited in mouth bar-front, interdistributary and interlobe ponds. Nodular, massive or finely horizontal laminated fresh water limestones are locally interbedded with these fine grained sediments and represent marginal lake deposits in areas sheltered from a continuous influx of terrigenous detritus.

2. Coarse sandstone beds, varying in thickness from 50 to 100 cm. This

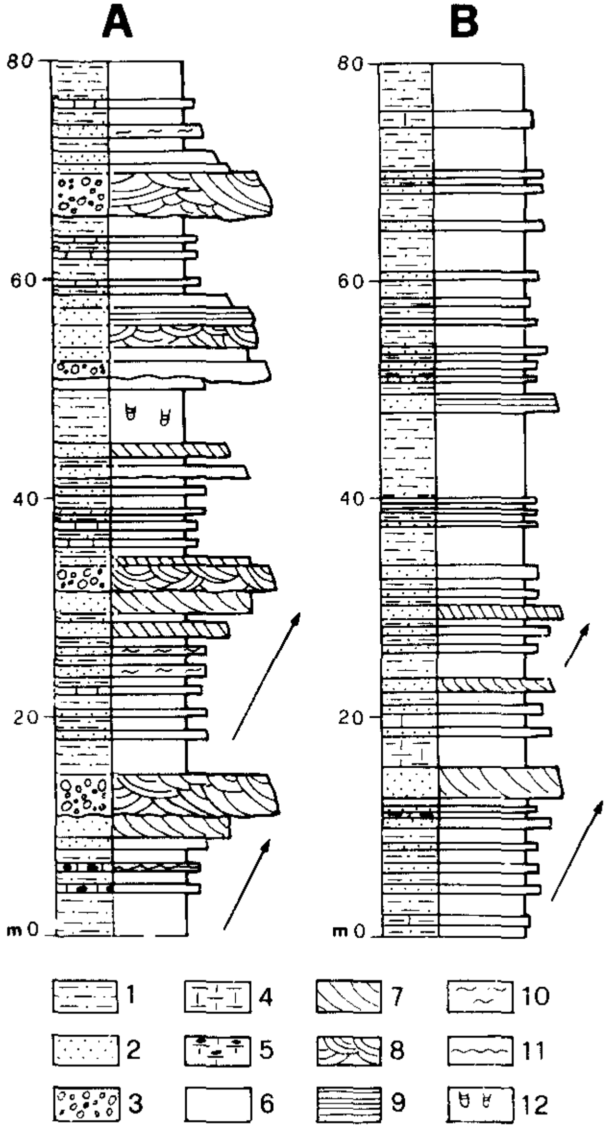

Fig. 5—Sedimentological logs of the coarse grained mouth bar delta in the proximal (A) and distal (B) areas. For stratigraphic position of the logs see Fig.4. 1: siltstones; 2: sandstones; 3: conglomerates; 4: marls; 5: limestones and cherty limestones; 6: massive; 7: cross-bedding; 8: trough cross-bedding; 9: horizontal lamination; 10: wave ripples; 11: nodular beds; 12: burrows.

Fig. 5—Perfil sedimentológico del delta de barras de desembocadura conglomeráticas en las *áreas proximales* (A) *y distales* (B). *Ver la Fig. 4 para la situación estratigráfica. 1: limolitas;* 2: areniscas; 3: conglomerados; 4: margas; 5: calizas y calizas con sílex; 6: masivo; 7: estratificación cruzada; 8: estratificación cruzada en surco; 9: laminación horizontal; 10: ripples de oscilación; 11: capas nodulares; 12: bioturbación.

facies is characterized by trough and planar cross stratification and locally by horizontal laminations. Small wave ripples are present at the top of some beds. This facies is interpreted as proximal mouth-bar deposits.

3. Coarse grained, clast supported conglomerates in beds 1-5 m thick (Fig. 6). They are poorly to moderately sorted with a sandy matrix. Clasts are well rounded, imbricated and their maximum size reaches 50 cm. They are derived from the Mesozoic to Eocene limestones and from the basement. Clast imbrications, where present, give scattered paleocurrent directions with main flows directed towards the E and S (Fig. 4). Beds have a lenticular shape and generally erosional bases. They are massive, normal and reverse graded, or trough cross stratified. The foresets meet the basal erosional surface tangentially. Taken together, the sedimentary structures of this facies are indicative of tractional deposition by strong currents. The scoured bases and the lenticular broad geometry of the beds suggest deposition in shallow distributary channels at the top of mouth bar sequences.

Towards the centre of the lake the mouth bar succession grades into fine to coarse green sandstones with horizontal or cross laminations and containing clay clasts, or into fine sandstones with current ripples (Fig. 5, Log B). The sandstones are interbedded with lacustrine sediments consisting of green siltstones, fresh water limestones and marls. The sandstones occur as isolated beds or are arranged in thickening and coarsening upward sequences (Fig. 7) representing distal mouth bar deposits. High concentration of bedload sediment may have permitted traction currents to extend down the delta front for a greater distance into the centre of the lake.

Terminal fan. The upper 600 m of the delta system is characterized by thick stacked sandstone units separated by interbeds of siltstones and limestones (Fig. 8, Log C). The following three facies are distinguished.

1. The sandstone facies consists of very thick units (up to 30 m, Fig. 9) which are laterally continuous and have basal surfaces that are nearly planar or locally slightly erosive. Imbricated conglomerates are locally present in pockets at the base of the slightly erosive beds.

The sandstone is red or brown and is medium to coarse grained. Angular intraformational clasts, composed of nodular cherty limestones and green siltstones, are common. Lenses of conglomerates are rarely found inside the units. Where present they are imbricated or show clustering.

Horizontal planar laminations are the dominant sedimentary structure (Fig. 8, Log C). Plane-laminated units are locally capped by cross laminated fine sandstones. Dish and fluid escape structures and soft sediment convolutions have been found. The top of the unit show intense red pedogenic alterations and rootlet horizons.

The diffuse horizontal lamination suggests that the thick sandstone beds were deposited by heavily laden sheet floods (Hogg, 1982; Parkash *et al.*, 1983; Harvey, 1984; Tunbridge, 1984).

Fig. 6—Upper portion of a coarse grained mouth bar sequence, composed of cross-laminated sandstones and conglomerates.

Fig. 6—Parte superior de una secuencia de barra de desembocadura de grano grueso constituida por areniscas con laminación cruzada y conglomerados.

Paleocurrent data indicate N and NW sources for the sediments (Fig. 4).

2. Beds, 1-3 m thick, of siltstones and mudstones are interbedded within the thick sandstone units. They are generally massive and intensely bioturbated, although horizontal and ripple cross laminations are present in some siltstone layers.

These sediments were deposited under low water energy conditions, by episodic currents into interlobe ponds or during periods of little coarse clastic supply.

3. Limestone beds are locally associated with siltstones and mudstones horizons. They consist of nodular, massive or finely horizontal laminated chalky beds containing brown cherty lenses, ostracods, fresh water fishes, algal remains and silicified tree trunks. Locally, mud cracks, wave ripples and roots of aquatic plants have been found. These calcareous sediments represent lake margin deposits laid down in ponds protected from detrital supply.

Towards the lake centre the horizontally laminated, thick sandstone pass into mudstone, limestone and marl (Fig. 8, Log D) or grade laterally into a few thin, isolated beds of parallel laminated fine sandstone and graded sandstone layers with well developed Bouma subdivision (Fig. 10), up to 1 m thick.

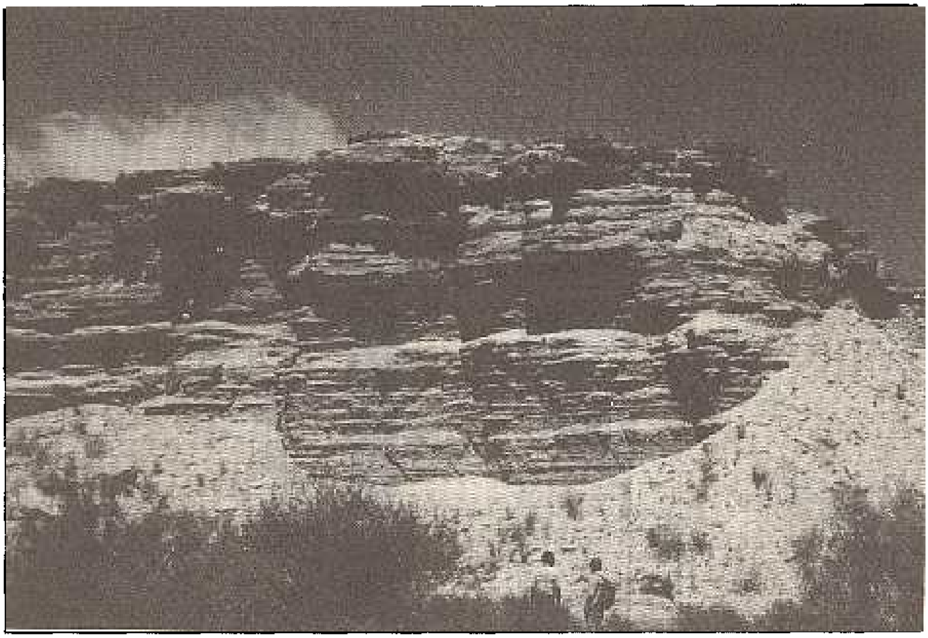

Fig. 7—Sandstone beds arranged in thickening upward sequences interbedded with marls and siltstones deposited in the distal portion of the mouth bar.

Fig. 7—Capas de arenisca dispuestas en secuencias estratocrecientes intercaladas con margas y limolitas, depositadas en la parte distal de la barra de desembocadura.

These sandstone units represent the distal deposits of the terminal fan that episodically reached the central portion of the lake.

A well exposed sandstone bed can be followed for about 10 km from the terminal fan into the central part of the lake (Fig. 11). Near the shore this bed is 10 m thick and consists of horizontally laminated, medium to coarse sandstones. It thins abruptly 4 km downcurrent and grades into a 2 m thick horizontally laminated, fine sandstone bed, which in turn thins to one meter of graded sandstone. This graded turbidite bed can be followed for 6 km to the central part of the lake and it maintains constant thickness and sedimentary features.

DEPOSITIONAL MODEL AND PALAEOGEOGRAPHY

The Daban half graben, located in a arid zone, provides a good example of the tectonic and climatic controls that influence the deposition of a delta system prograding into a perennial lake.

The asymmetry of the half graben, bounded to the south by the Dagah

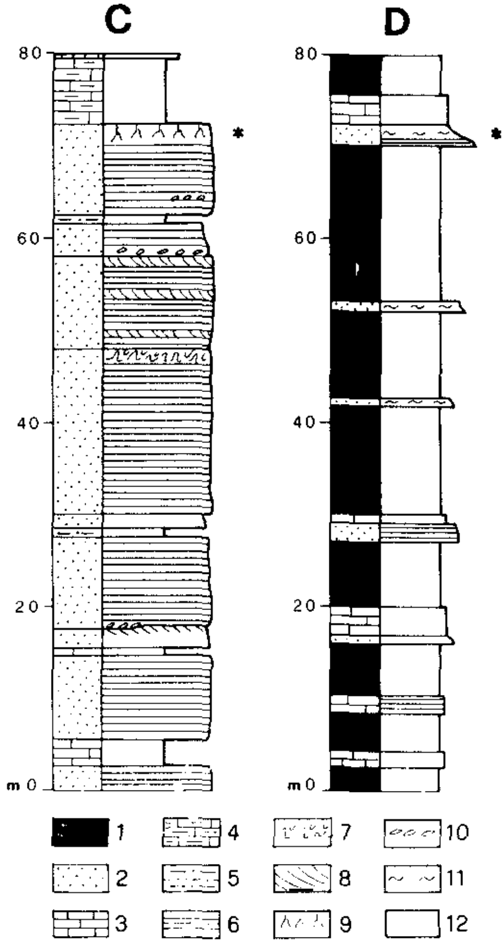

Fig. 8—Sedimentological logs of the stacked thick sandstone units of the terminal fan (C) and fine sediments of the central lake with isolated sandstone beds (D). The latter are the downcurrent equivalent of some thick sandstone units of the terminal fan. The beds with asterisk are correlated through the basin (see Fig.11). For stratigraphic position of the logs see Fig.4. 1: mudstones; 2: sandstones; 3: limestones; 4: marls; 5: siltstones; 6: horizontal lamination; 7: convolute lamination; 8: cross-bedding; 9: roots and paleosols; 10: imbricated pebbles; 11: sandstones with Bouma sequences; 12: massive bed.

Fig. 8—Perfil sedimentológico de las unidades apiladas de arenisca del abanico terminal (C) y los sedimentos finos de centro del lago con capas aisladas de arenisca (D). Las últimas son el equivalente corriente abajo de algunas de las potentes unidades de areniscas del abanico terminal. Las capas con asteriscos se correlacionan en toda la cuenca (ver Fig. 11). Para la situación estratigráfica de los perfiles, véase la Fig. 4. 1: lutitas; 2: areniscas; 3: calizas; 4: margas; 5: limolitas; 6: laminación horizontal; 7: laminación contorsionada (convolute); 8: estratificación cruzada; 9: raíces y paleosuelos; 10: cantos imbricados; 11: areniscas con secuencias de Bouma; 12: capa masiva.

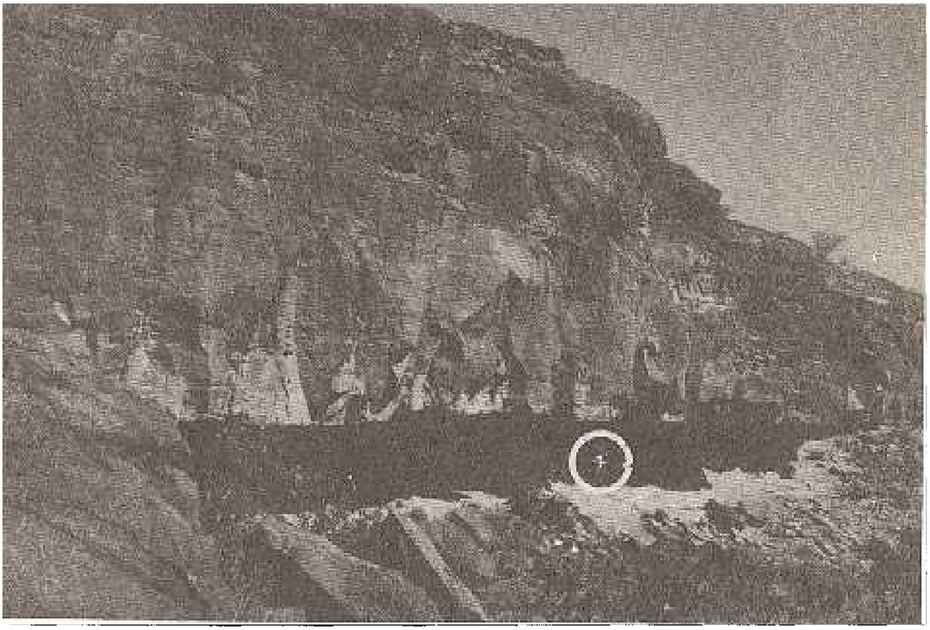

Fig. 9—Horizontally laminated thick sandstone unit with planar basal surface of the terminal fan resting on top of lacustrine siltstones.

Fig. 9—Unidad potente de areniscas con laminación horizontal y base plana del abanico terminal decansando sobre limolitas lacustres.

Shabele master fault (Fig. 13), controlled the clastic supply into the perennial lake. In the Daban Basin sparse clastic supply (only few calcareous slide blocks) came from the master fault escarpment. This agrees with previous reports from similar rift basins.(e.g. Cohen *et al.*, 1986; Frostik & Reid, 1987; Leeder *et al*, 1988; Anadón *et al.*, 1989; Cavazza, 1989). On the contrary, as indicated by paleocurrent data (Fig. 4), the main supply of coarse material came from the hanging-wall dip slope facing the major boundary fault and from the western axial rivers.

The development of the delta complex occurred during the final stages of filling of the Daban Basin and was preceded by important vertical movements (Abbate *et al.*, 1986). The deposition started with the conglomeratic mouth bar sequences and the coarse material was transported by relatively steep streams flowing down the hanging wall ramp of the episodically active half graben and from axial streams flowing along the base of active fault scarps (Fig. 13 A).

The high sediment supply and the low gradient of the lake margins favoured the formation of mouth-bars instead of Gilbertian foreset beds (Dunne & Hempton, 1984).

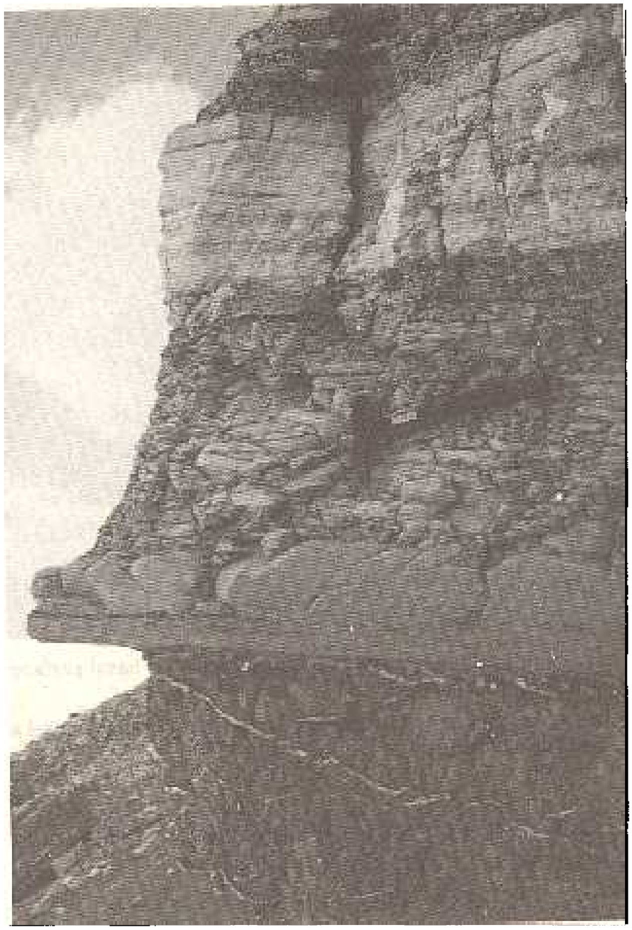

Fig. 10— Graded sandstone bed interlayered in the central lake deposits. This bed can be visually followed for about 10 km and grades upcurrent into a 10 m thick horizontally laminated sandstone units of the terminal fan sequence (see Fig. 11).

Fig. 10—Capa de areniscas granoclasificadas interestratificada en los depósitos de centro de lago. Esta capa se puede seguir visualmente alrededor de 10 km y pasa, corriente arriba, a una unidad de 10 m de espesor de areniscas laminadas horizontalmente de la secuencia de abanico terminal (ver Fig. 11).

The mouth-bar delta was a very efficient depositional system, and it was even capable of transporting sand to the central area of the perennial lake. The result is a series of isolated beds and coarsening and thickening upward distal mouth bar sequences.

With time, the topography was smoothed, the river gradients decreased and the drainage basins widened. The resulting streams carried finer grain sizes, and only sands and no gravels were transported to the lake margin. At

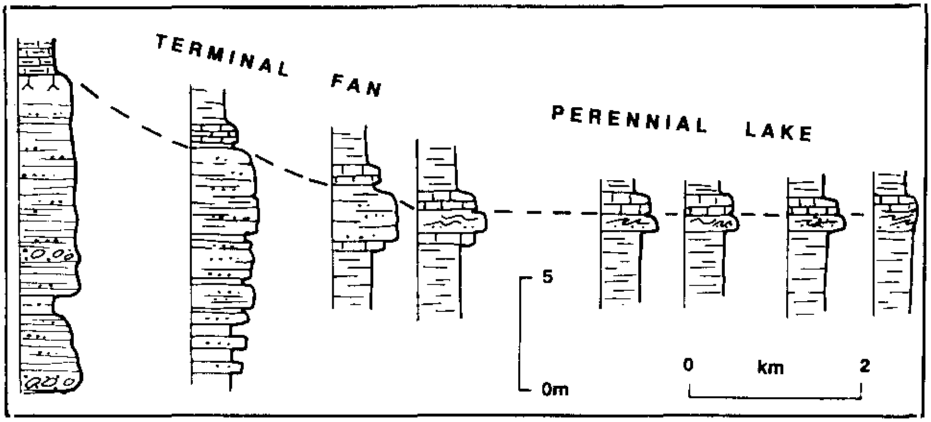

Fig. 11—Correlation through the basin of a thick sandstone unit of the terminal fan, passing downcurrent into a graded sandstone bed in the centre of the lake. The same bed is reproduced in the sedimentological log of Fig. 8.

Fig. 11—Correlación a través de la cuenca de una unidad gruesa de areniscas del abanico terminal, que pasa corriente abajo a una capa de areniscas granoclasificadas en el centro del lago. La misma capa se reproduce en el perfil sedimentológico de la Fig. 8.

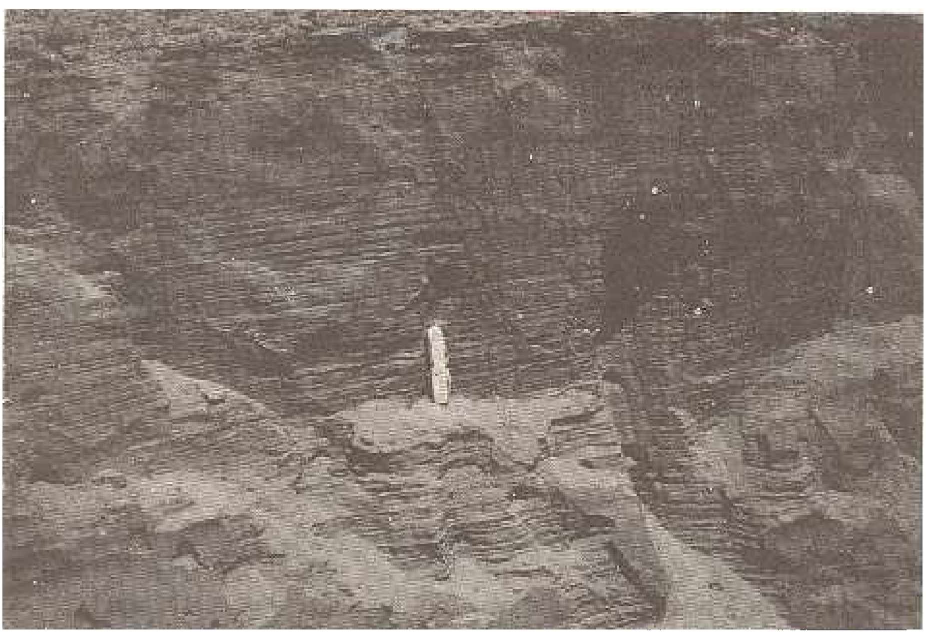

Fig. 12—Modern horizontally laminated sands of the Kalajab terminal fan, near Berbera.

Fig. 12—Arenas laminadas modernas del abanico terminal de Kalajab, cerca de Berbera.

the same time, a period of aridity affected the Daban area and the fluvial regime was reduced drastically. The delta system was then fed by ephemeral streams which, during floods, lost their water downstream by evaporation and infiltration. Towards the lower part of the streams the increasingly laden sediment currents were not able to cut channels. Rather, streams spread out as sheets over wide areas and deposited terminal fans (Mukerji, 1976; Friend, 1978; Parkash *et al.*, 1983; Ori, 1986; Olsen, 1987). In this fashion, smooth, wide lobes of horizontal laminated sands were deposited by sheet flows at the end of the poorly incised distributary channels of the ephemeral fluvial system in the flat coastal area of the Daban lake (Fig. 13B).

The terminal fan of the Daban Basin was a low efficiency sediment transport system. The majority of the clasts were dumped as thick horizontally laminated sandstone units at the lake margin causing the central lacustrine zone to be starved of coarse sediment (Fig. 8, Log. D). Only very few flood events could by-pass the terminal fan lobes and continue to reach the lake centre as hypopycnal flows. These concentrated flows were diluted and became turbulent currents, capable of carrying coarse sediments to the lake centre where rare turbidite sandstones interbed with lacustrine marls and shales.

Near Berbera, a modern analog of a terminal fan is represented by the Kalajab fluvial system that crosses the NW margin of the Daban Basin (Fig. 2). The Kalajab ephemeral stream originates at the edge of Somali plateau and, emerging from the foothills of the northern Somali escarpment, spreads on the Berbera coastal plain.

On the Somali plateau the average annual rain fall is 430 mm/year (Sheikh area) whereas the Berbera coastal plain is an arid region with only a tenth of the rain fall (45 mm/year, Hunt, 1960). The Kalajab stream loses most of its discharge in the dry coastal plain and divides into flat distributary channels to give rise to a terminal fan (Fig. 2). Downstream, the individual distributary channels gradually disappear by merging at the toe of the fan. The resulting sandy deposits of the Kalajab terminal fan show horizontal lamination (Fig. 12) (Billi & Tacconi, 1983), which resemble the thick sandstone units (facies 1) of the ancient lacustrine terminal fan.

SUMMARY

The Daban half graben gave rise to a rapidly subsiding basin that developed during the rifting of the Gulf of Aden which culminated in continental frag-mentation and formation of a narrow oceanic basin.

In the Late Oligocene, during the last phase of the filling of the basin, huge clastic supply built up thick delta sequence at the NW margin of a perennial lake.

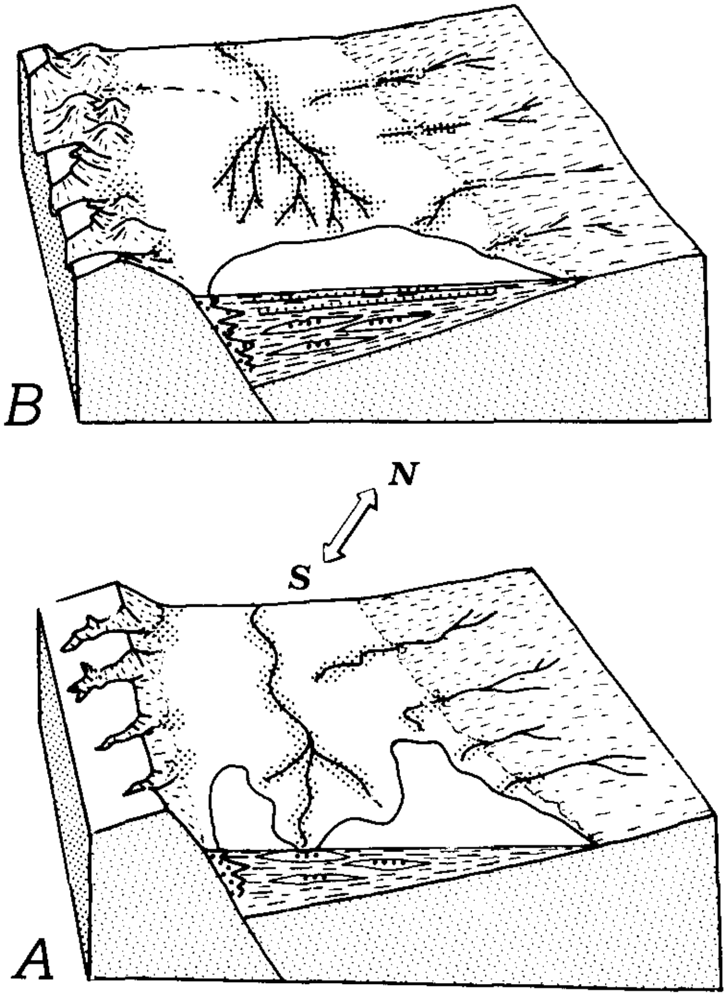

Fig. 13—Palaeogeographic reconstructions of the Daban Basin during the deposition of the lacustrine delta system. (A) Development of the coarse grained delta with deposition of conglomeratic mouth bars at the lake margin and arenaceous distal mouth bars at the lake centre. The delta was mainly fed by streams flowing parallel to the master fault. (B) Development of the terminal fan fed by ephemeral streams during a period of aridity. Deposition of horizontally laminated sand lobes in the flat coastal area of the lake and rare turbidite sandstone beds in the lake centre.

Fig. 13.—Reconstrucciones paleogeográficas de la cuenca de Daban durante el depósito del sistema deltaico lacustre. (A) Desarrollo de un delta de grano grueso con depósito de barras de desembocadura conglomeráticas en el margen del lago y barras arenosas distales en el centro del lago. El delta se alimentaba principalmentepor corrientes que fluían paralelamente a la falla principal. (B) Desarrollo del abanico terminal alimentado por corrientes efímeras durante un período de aridez. Deposito de lóbulos de areniscas con laminación horizontal en el área costera plana del lago y de raras capas de areniscas turbidíticas en el centro del lago.

The abundant clastic supply, the shallow water and weak lake currents caused the formation of conglomeratic mouth bars at the base of the delta system (Fig. 13 A).

A period of aridity that affected the Daban area during the later stages of the basin filling drastically changed the fluvial regime. Ephemeral streams produced a terminal fan system at the lake margin (Fig. 13 B).

The asymmetric geometry of the Daban half graben (Fig. 13) controlled the clastic inflow and the delta system was fed by an axial drainage and by streams flowing down the northern hanging-wall ramp of the Daban basin.

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