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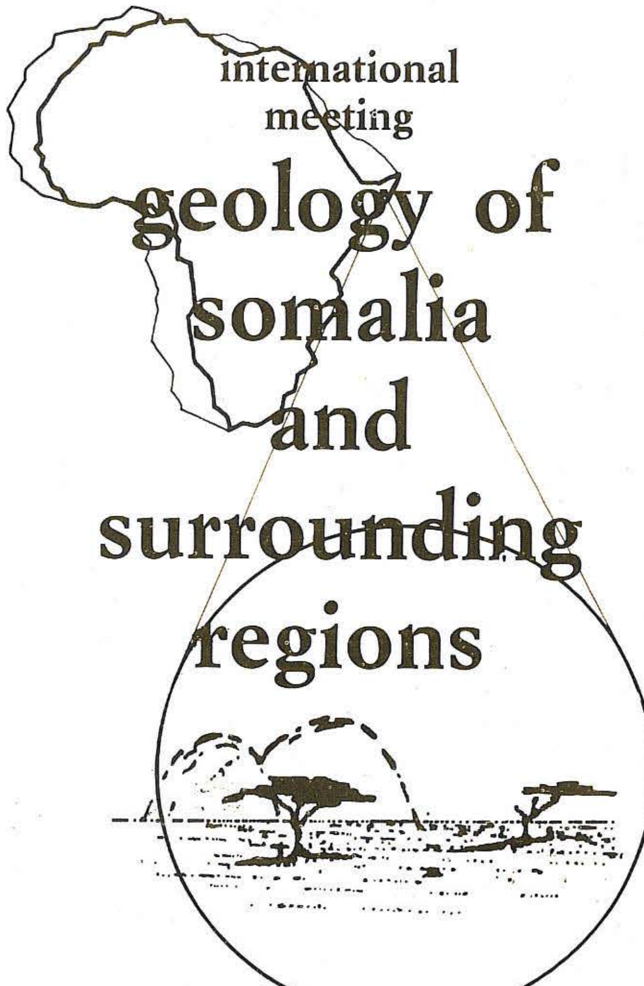

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E X C U R S I O N   A

GEOLOGY OF THE LUUQ-MANDERA BASIN

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CONTENT

1. INTRODUCTION

The purpose of this excursion is to point out the main stratigraphic and structural features of the Luuq-Mandera Basin. An introduction to the stratigraphy and tectonics , as well as an outline of the setting of its basement, is made before the description of stops.

Two main sedimentary basins may be recognized in southerns Somalia (Fig.1): the NE-SW trending Mesozoic-Tertiary Somali Coastal Basin, and the NNE-SSW Mesozoic Luuq-Mandera Basin. These two basins, whose basements are as deep as 5000 m or even more below sea level, are separated by the so-called "Bur Region", a wide elliptical area where the basement rises to the surface.

The Coastal Basin consists of a thick (more than 7000 m) sedimentary prism of Jurassic to Recent calcareous, marly and terrigenous units with some Cretaceous and Lower Tertiary volcanic episodes. The succession is known exclusively by means of geophysical prospections and drillings for oil exploration which, however, have not reached the basement. The environmental and structural development of this basin is strictly related to the birth of the Indian Ocean and the relative motions of India, Madagascar and East Africa.

A belt of NE-SW-trending, steeply-dipping normal faults, parallel to the present Indian Ocean Coast, separates the Somali Basin from the Bur Region.

In this region, the basement outcrops discontinuously near inselbergs and monadnocks standing out of a cover of recent sediments. Because of this patchy distribution and the actual limited width of the outcrops, it is difficult to recognize the structure of the Bur Region, although a NW-SE trend seems to prevail in some areas. During the Mesozoic and Tertiary, the Bur Region was a high separating the Somali Basin from the Luuq-Mandera Basin. It is still uncertain whether the region had also emerged in the meanwile.

The Luuq-Mandera Basin is a wide NE-SW-trending synclinorium. The basin is limited to the SE by the structural high of the Bur Region and, to the west, by the crystalline basement of NE Kenya. Along the axial belt of the basin, drillings for oil exploration have met 4400 m of sedimentary units (from Cretaceous to Triassic) without reaching the basement. Since the sedimentary sequence in its eastern side (i.e. along the margin

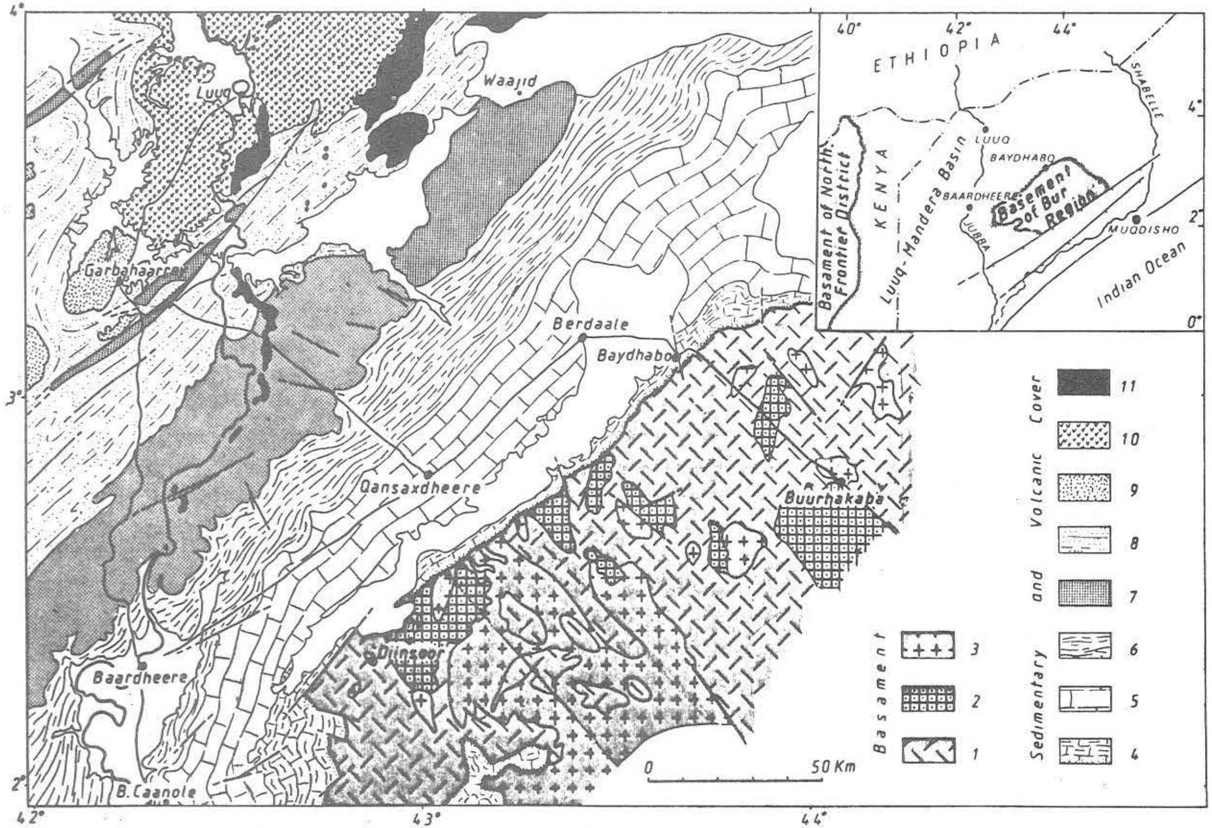

Fig.1: Geological sketch of SW Somalia: 1) Dinsor sequence; 2) Olontole sequence; 3) Granite; 4) Deleb, Uanei, Baidoa Formations; 5) Goloda Formation; 6) Anole Formation; 7) Uegit Formation; 8) Garbaharre Formation, Busul Member; 9) Ambar Sandstones; 10) Garbaharre Formation, Mao Member; 11) Tertiary Basalts.

of the Bur Region) is less thick (2500-3000 m) and probably starts later (i.e. Early/Middle Jurassic), the Luuq-Mandera Basin must be considered a subsiding elongated area which, at least at the beginning of the Mesozoic, was invaded by the sea during the dismembering of Gondwana.

2.CRYSTALLINE BASEMENT OF THE BUR AREA
(F.P.Sassi)

This basement covers an area of about 30.000 sq.km, but outcrops only locally in isolated and relatively small hills (called "Bur"), sometimes very near them or along "wadi". Elsewhere (i.e. about 99% of the whole area), it is covered by a thin (1-30 m) veneer of recent residual sediments. Therefore available field and laboratory data are based on few outcrops and on study of the cores of some drills.

The Bur basement is made up of two rock complexes: the Olontole Complex and the Dinsor Complex.

The Olontole Complex consists of migmatites, gneisses, and local granulites amphibolites and quartzites, all cross-cut by injected granitoid bodies.

The Dinsor Complex partly consists of metapelitic and metapsammitic high-grade sequences and migmatites, and partly of quartzites, iron-rich quartzites and marbles. The latter (i.e. quartzites and marbles) are typical in the Dinsor Complex. Injected granitoid bodies also cross-cut this series.

The general structural situation and relationships between the Olontole Complex, the Dinsor Complex, and the younger granitoid bodies are shown in Fig.2. It consists of a sequence pf pre-to synmetamorphic synforms and antiforms, cross-cut by younger NE-SW faults and fractures.

Rb-Sr whole rock isochrons indicate the lower Paleozoic age of the younger granites (Bur Akaba: 516 $\pm$ 42 Ma; Bur Kuulow: 520 $\pm$ 59 Ma). The youngest rock-producing process in the Bur area therefore belongs to the Panafrican Event.

3. SEDIMENTARY SEQUENCE OF THE LUUQ-MANDERA BASIN

3.1 JURASSIC-CRETACEOUS SEDIMENTARY CYCLES
(P.Bruni & M.Fazzuoli)

The Luuq-Mandera Basin is a long-lived deep linear trough extending northwards from the coast of southern Somalia. It may

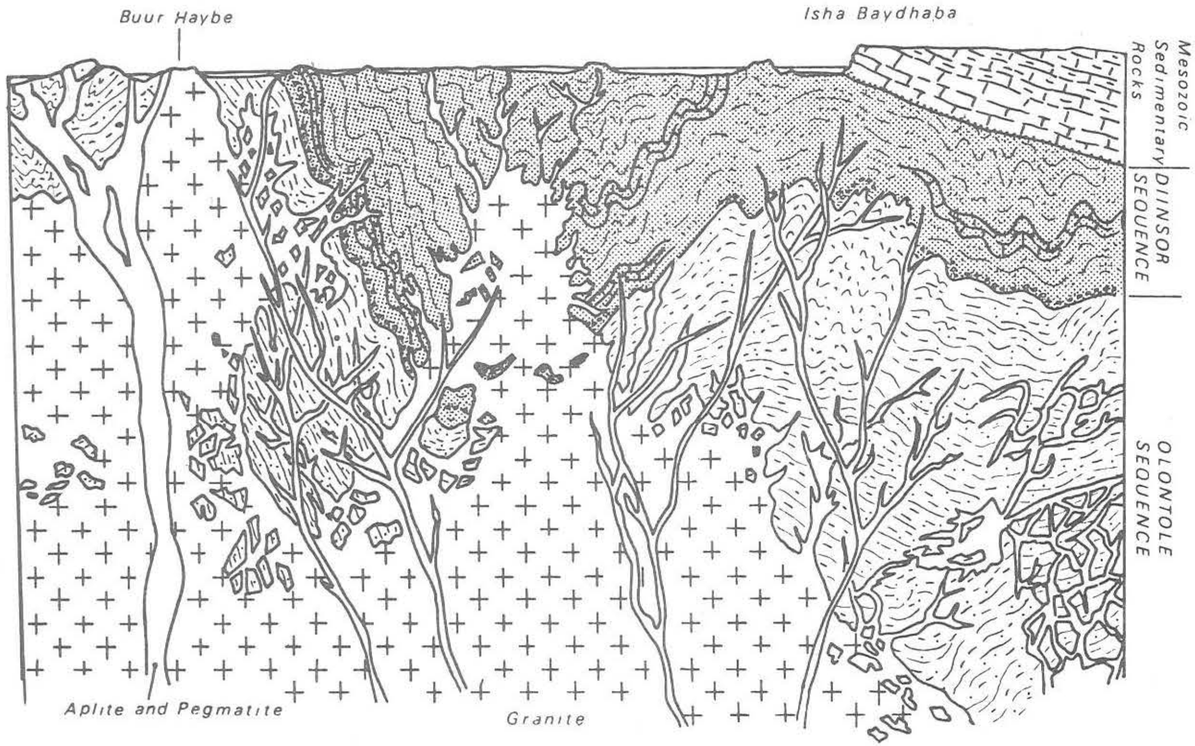

Fig.2: The crystalline basement of the Bur Region

be considered as a subsiding elongated area tectonically linked to another wide subsiding area, the Somali Basin (Fig.1) which subsequently became the western Indian Ocean.

Two main transgressive-regressive cycles have been recognized in the Jurassic-Early Cretaceous succession. They were preceded by a further sedimentary cycle whose deposits, found by geophysical prospections, have only been reached in the Hol1 well in the axial part of the basin.

The sedimentary evolution of this area may be summarized as follows (BELTRANDI & PYRE, 1975; CANUTI et al.,1983; ANGELUCCI et al.,1983, MONTANARI, 1984; PICCOLI et al.,1986; BUSCAGLIONE et al.,1987):

a) Late Triassic to Early Jurassic cycle, linked to a phase of continental rifting. Deposition began with of continental conglomerates and sandstones comparable with the Karroo of the eastern belt of Kenya. It was followed by "azoic" limestones (lacustrine?) and by a thick sequence of evaporites.

b) Early to Middle Jurassic cycle, linked to the transgression which occurred during the Lias in the "Arabian-Malagasy" portion of Tethys. This transgression probably started in the Luuq-Mandera Basin during the Early Jurassic and reached its apex during the Early Toarcian with ammonite marls. Then a regression with minor oscillations ensued and lasted up to the Early Bathonian.

The cycle development appears to be quite in agreement with the eustatic curve proposed by Haq et al., 1987. Although "tectonic subsidence" caused by the early detachment of Madagascar moving away from east Africa may have played an important role, in our opinion, this cycle is mainly ruled by eustatic elements.

c) Middle to Late Jurassic, possibly extending(up to the Early Cretaceous) cycle. A new sedimentary cycle started during the Bathonian, producing marine sedimentation both to the south (south-eastern Kenya and south Madagascar) and to the north--western (central-northern Ethiopia) (faunas with "Eligmus": ARKELL, 1952; KAMEN-KAYE,1978; MERLA et al., 1979). In the Luuq Mandera Basin a restricted platform became more open, and during the Oxfordian it developed into an open although quite shallow sea, with marly deposits and pelagic faunas (ammonites and belemnites). Shallow-sea conditions prevailed again starting from the Kimmeridgian up to the end of the Jurassic and to Early Cretaceous. During the ?Early Cretaceous the sea definitely retreated from the south-western Somali area. In this

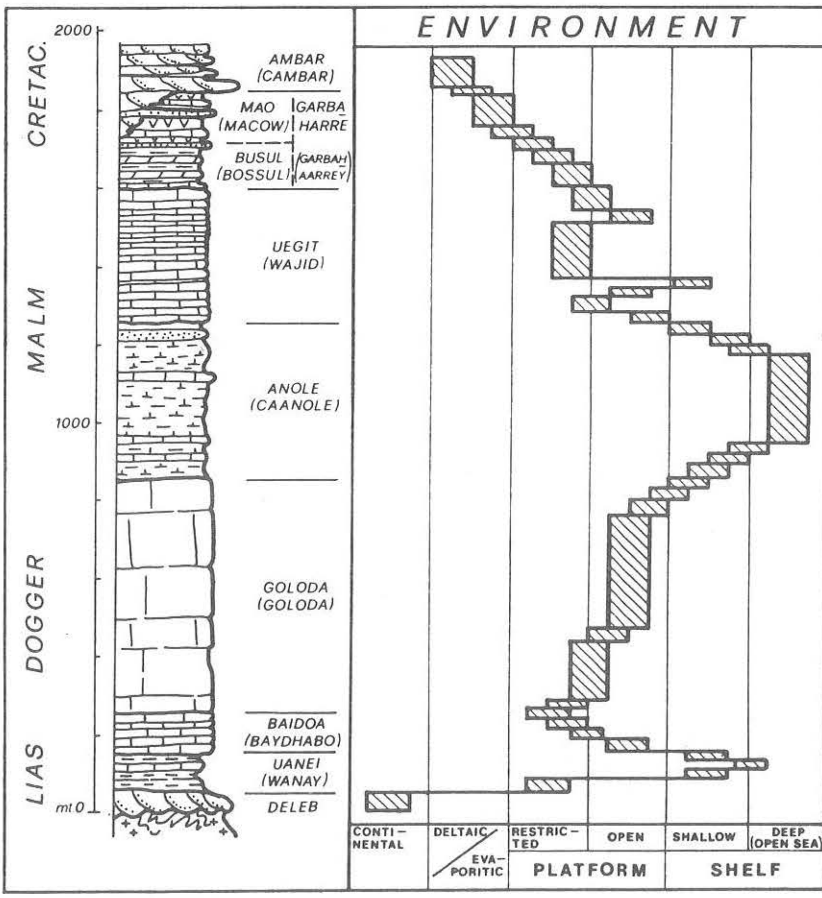

Fig.3: Stratigraphic column of the Luuq-Mandera Basin

cycle the deeper environment (Middle-Late Oxfordian) was established later in relation to the highest marine level. As regards this case, we believe that eustatism played a secondary role compared to "tectonic subsidence", linked to the detachment of Madagascar during " a little prior Late Oxfordian" (RABINOVITZ et al.,1982, 1983; BOSELLINI, 1986).

As for the presence of emerged areas surrounding the Luuq-Mandera Basin, these were probably located in Kenya and Ethiopia. However, only the area of Kenya played a significant role in the clastic sedimentation of the Luuq-Mandera Basin. Paleocurrents suggest that the source area of terrigenous supply of the Ambar Sandstones may be located in Kenya (Fig.6). There is no evidence that the Bur region was emergent while sedimentation was going on in the Luuq-Mandera Basin.

The following succession may be recognized in the field, from bottom to top (Fig.4, 5): Deleb Formation; Uanei Formation; Baidoa Formation; Goloda Formation; Anole Formation; Uegit Formation; Garbaharre Formation (subdivided into two members: Mao and Busul); Ambar Sandstones.

Deleb Formation

This is the older sedimentary unit above the basement and is referrable to the Adigrat Sandstone (HILAL et al.,1977). It ourcrops very clearly NE of Isha Baydhabo and consists of quartzose conglomerates and coarse to very fine sandstones. Thickness varies from 0 to 30 m, probably owing to the underlying uneven peneplained surface. The sedimentary environment was continental (fluvial) to transitional (deltaic).

The age, not definable because of the lack of fossils, has been tentatively ascribed to the Early Liassic.

Uanei Formation (see Stop I-2)

Several lithotypes occur in this formation, from the bottom: dark grey marly limestones and marls; grey fossiliferous calcilutites; grey and reddish marls with ammonites; red nodular calcilutites; yellowish marls with ammonites; reddish (ferruginous) calcarenites. The thickness of the formation ranges from 80 to 120 m. Fossils include pelecypods, gastropods, brachiopods, ammonites, foraminifers, coproliths. Vidalina martana Farinacci, Parahildaites and Protogrammoceras occur in the upper part of the unit and a ?Domerian-Toarcian age may be inferred. The sedimentary environment varies from a more or less restricted lagoon to a relatively deep shelf with fine

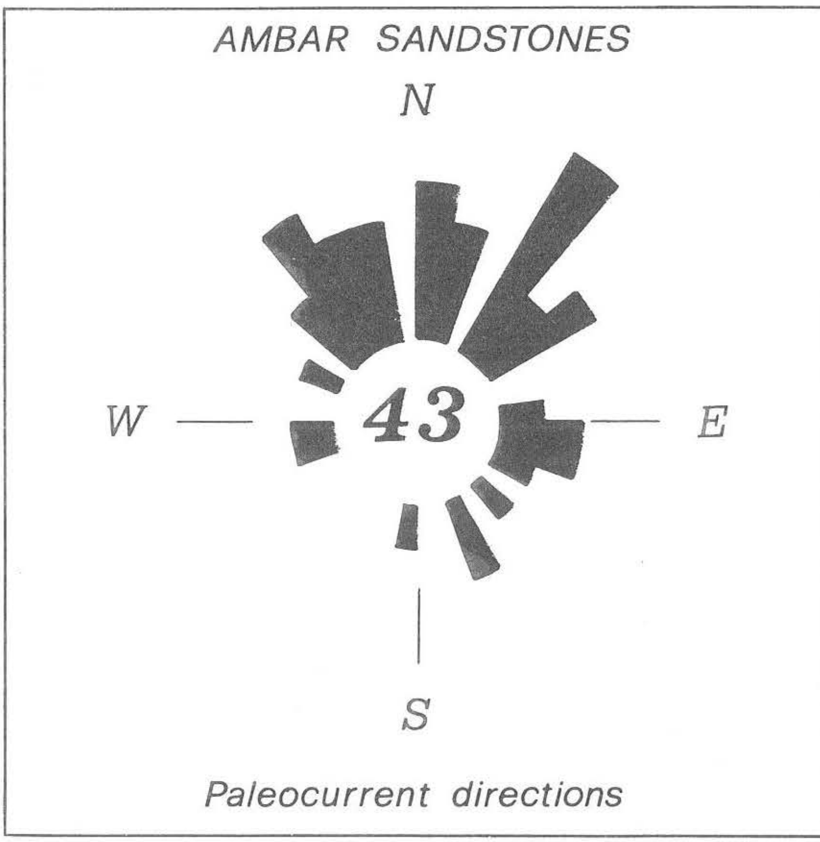

Fig.4: Paleocurrent directions in the Ambar Sandstones.

clastic supply. Marls with ammonites represent the climax of the transgressive phase of the Early to Middle Jurassic sedimentary cycle.

<u>Baidoa Formation</u> (see Stop I-2)

From the bottom this consists of : grey-brown bioturbated calcarenites; grey oncoidal calcilutites, bioturbates, grey brown calcilutites, grey calcarenites. Thickness is about 100 m. Fossils occurring in this are pelecypods, echinoderms, ostracods and foraminifers. The age is Early Dogger: Aalenian--Bajocian. The environment in the lower part of the formation is referable to an open carbonate platform with medium to high energy conditions making a transition to a restricted platform below the wave base. The upper part (as well as the lower part of the overlying unit) was sedimented during the regressive phase of the Early to Middle Jurassic sedimentary cycle.

<u>Goloda Formation</u> (see Stop I-3)

This is the thickest calcareous unit in Somalia (about 600 m). Many lithotypes occur: in the lower part grey calcilutites, yellow-pink recrystallized limestones and dolomites; in the middle-upper part yellowish-brown calcarenites prevail over coquinas and bioturbated calcilutites. Fossils are abundant everywhere except in the lower part. Pelecypods, gastropods, echinoderms, calcareous algae, foraminifers and coproliths may be found. In the upper part foraminifers become more frequent. The age is Bathonian-Early Callovian. The environment was restricted platform in the lower part and open platform in the upper part, showing features of a marginal zone with high energy and open circulation. In thus marks the beginning of the transgressive phase of the Middle to Late Jurassic (up to Early Cretaceous) sedimentary cycle.

<u>Anole Formation</u> (see Stop II-1a)

The lithology mainly consists of marls and marly limestones (about 60%) and fossiliferous calcilutites, lumachella beds and calcareous sandstones. Thickness, as well as marly content, increases from NW (300 m) to SW (400 m). Pelecypods, gastropods, brachiopods, ammonites, belemnites and foraminifers indicate a Late Callovian to Late Oxfordian age (Early Kimmeridgian north of Baidoa). The sedimentary environment of the lowest and highest parts of the formation are referable to a shallow shelf, whereas in the middle part deep shelf conditions (open sea phase of the sedimentary cycle) prevailed.

<u>Uegit Formation</u> (see Stop II-2, 3)

In this unit several lithotypes are cyclically repeated. From the bottom they are: oolitic calcarenites, oncoidal calcilutites and bioclastic calcilutites; marls and ferruginous sandstone are scarce. Thickness varies from 300 to 350 m. Fossils are pelecypods, gastropods, brachiopods, echinoderms, individual and colonial corals, calcareous algae and foraminifers. The age ranges from Late Oxfordian-Kimmeridgian to ?Early Portlandian. Some small sedimentary phases may be identified (FAZZUOLI, 1985). At the base a regressive phase is marked by the transition from shallow shelf (at the top of the Anole Fm.) to open and then to restricted platform. During the second phase, the sea level rose and a shallow shelf environment established. During the third phase, the sea-level dropped and environments of open platform and subsequently of restricted platform were again established.

<u>Garbaharre Formation</u> (see Stop IV-1)

This unit has been subdivided by Barbieri (1968) into two members: Busul (lower) and Mao (upper). The sedimentary features are closely connected with the regressive phase of the Middle to Late Jurassic sedimentary cycle.

Busul Member

Yellow finely laminated calcarenites; grey bioclastic calcilutites; lumachellas, quartzose sandstones with parallel or cross-laminations in the lower part. Yellow, finely laminated calcarenites, yellowish dolomitic limestones and dolomites with rare marly levels prevail in the upper part. Thickness is about 300 m. Only pelecypods have been recognized.

The age is tentatively referred to the Late Portlandian. The sedimentary environment changes from shallow marine to transitional.

Mao Member (see Stop III-2)

The lower part of this unit shows marked heteropies. West of the Jubba River, the lithology consists of an alternation of thick gypsum and anhydrite levels (up to 70% of the sequence) and beds of shales, calcarenites, marly limestones and dolomites. East of the Jubba, the sequence becomes less rich in evaporites and consists of well-bedded, yellowish dolomites, calcarenites and autoclastic breccias. Sandstones and marls also occur.

In the upper part of the unit, the lithology consists of red and green shales (in levels up to 10 m thick) alternating with gypsum levels (4-5 m thick). Marly limestones, dolomitic limestones and dolomites are subordinate; cross-bedded sandstones are also present. Thickness is about 300 m. Fossils are very rare; only pelecypods have been found. The age is tentatively referred to the Early Cretaceous. The sedimentary environment of the lower part is referable to a restricted shallow basin, highly evaporitic in the south western area and marine--restricted, whereas it is less evaporitic in the north-eastern area. The upper part was deposited during or immediately after the Early Cretaceous retreat of the sea, in ephemeral basins (barred lagoons ? - playas ?), with increasing continental clastic supply.

Ambar Sandstones (see Stop III,1,2; Stop IV,1)

The Ambar Sandstones outcrop in northeastern Kenya and western Somalia; while in Kenya the unit is thick (several hundreds of meters) and almost exclusively arenaceous, in Somalia it is thinner (only a few hundreds or tens of meters) and presents calcareous, marly and shaly interbeds. Moreover, in the Garbaharre area the formation fringes out into three arenaceous bodies (up to a few tens of meters) separated by limestone levels. It makes a lateral transition to the Mao Member of the Garbaharre Formation.

In the Garbaharre area the age of the Ambar Sandstones is tentatively referred to the Early Cretaceous.

Paleocurrents (Fig.4), the sedimentological characters of the sandstones, and the shallow marine and low energy facies of the Busul Member suggest for the Ambar Sandstones a continental environment in Kenya, where the area of clastic supply was located, and a littoral and deltaic environment in western Somalia.

3.2 TERTIARY FORMATIONS AND MORPHOLOGICAL EVOLUTION OF THE JUBBA VALLEY

(Ali Kassim Mohamed, L.Carmignani & P.Fantozzi)

After the Cretaceous regression the region was no longer submerged by sea. Available data on Tertiary evolution regard only a few continental or volcanic formations and some morphological elements. Reconstruction of the post-Cretaceous evolution is therefore incomplete.

The Cretaceous regression was followed by a long phase of peneplanation, later followed by general uplifting movements as well as morphological evolution, which gave rise to the actual Jubba valley.

During the first phase of this evolution a NE-SW elongated lacustrine basin was formed between the fold belt SW of Garbahaarrey and the NE-SW elongated relief corresponding to the monocline of calcareous rocks belonging to the Uegit Formation (Fig.5A) This depression was filled by the Faanweyn Formation represented by up to 10 m of whitish lacustrine sandy clays. Only few erosional remains actually occur in an area of at least 600 sq.km. This unit makes up the oldest discordant formation on the Jurassic-Cretaceous succession in the Jubba valley. Two important rivers were probably the main tributaries of the lake. The former probably corresponds to the present Jubba stream, upstream from Luuq, and the latter to the paleo-Dawa, which flowed in a different course from its actual one. The present course of the Dawa river is the result of a recent capture made by the Jubba.

As shown in Fig.5, in the area of Mandera the old Dawa went SE, and flowed in the outskirts of the actual town of Garbahaarrey and then into the above-mentioned lake. Evidence in support of the old course of the Dawa is furnished by morphology and especially by the Garbahaarrey and Sengif belts (Fig. 6) where the river cut deep gorges (Fig.5).

As shown in Fig.5B, the lake depression was orthogonally cut by the paleo-Jubba. The old drainage was located 100 m higher than the actual Jubba course and is still easy to reconstruct between Luuq and Bardheere. It is now filled by alluvial deposits (Kuurekta Formation) and sealed by a basaltic flow (Fig. 5C). The Kuurekta Formation waries in thickness from more than 50 m (in the paleothalweg, upstream from Luuq) to 10-20 m (SE of Luuq). It consists of fluvial conglomerates and quartzose sands; pebbles are composed of vulcanites and quartzites; intercalations of volcanic ashes (rhyolites?) are almost always present.

These fluvial deposits are covered by thick basaltic flows (almost 30 m thick); these volcanites also occur extensively east of the paleothalweg of Jubba, where they lie directly on the Jurassic and Cretaceous formations. According to some preliminary radiometric investigations (TRAVERSA, pers.comm.), the

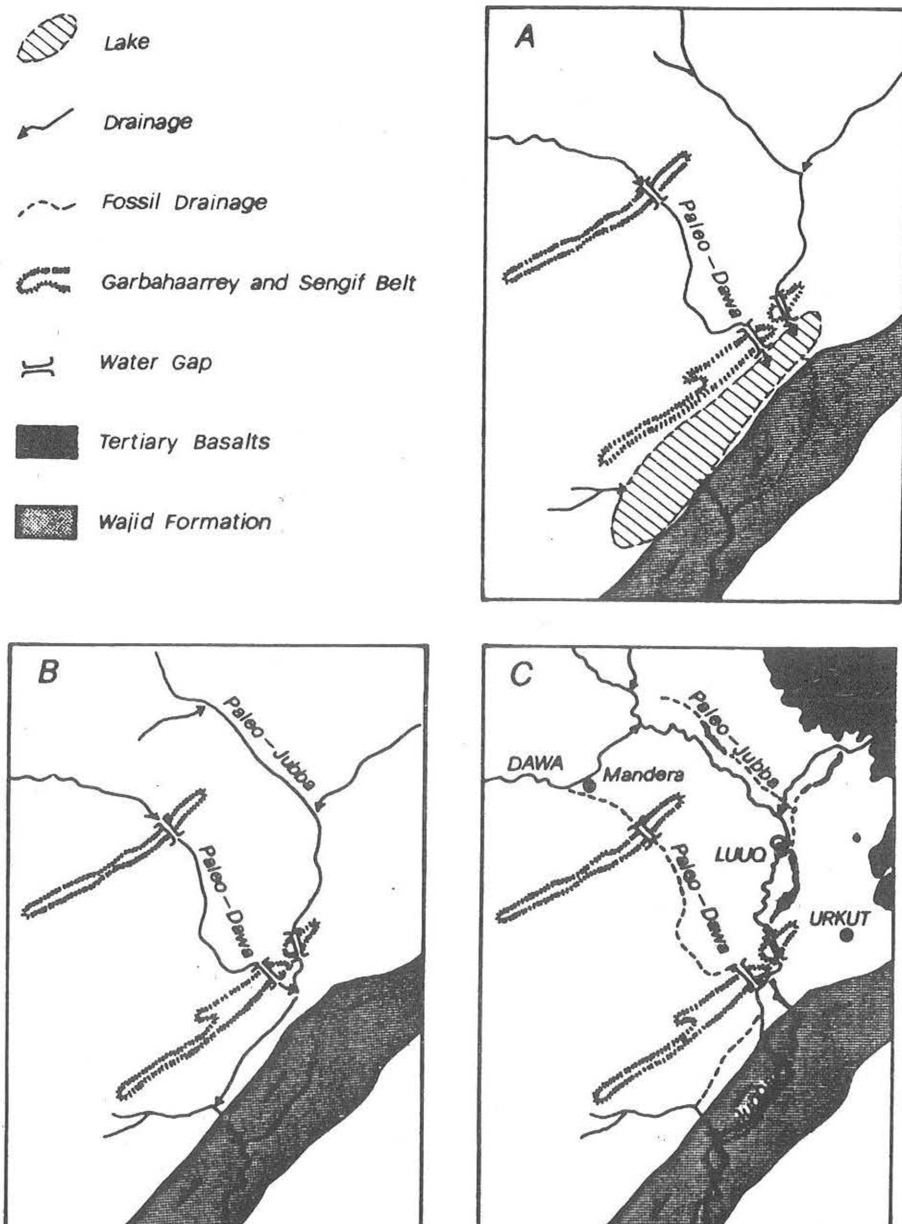

Fig.5: Tertiary morphological evolution of the Gedo Region

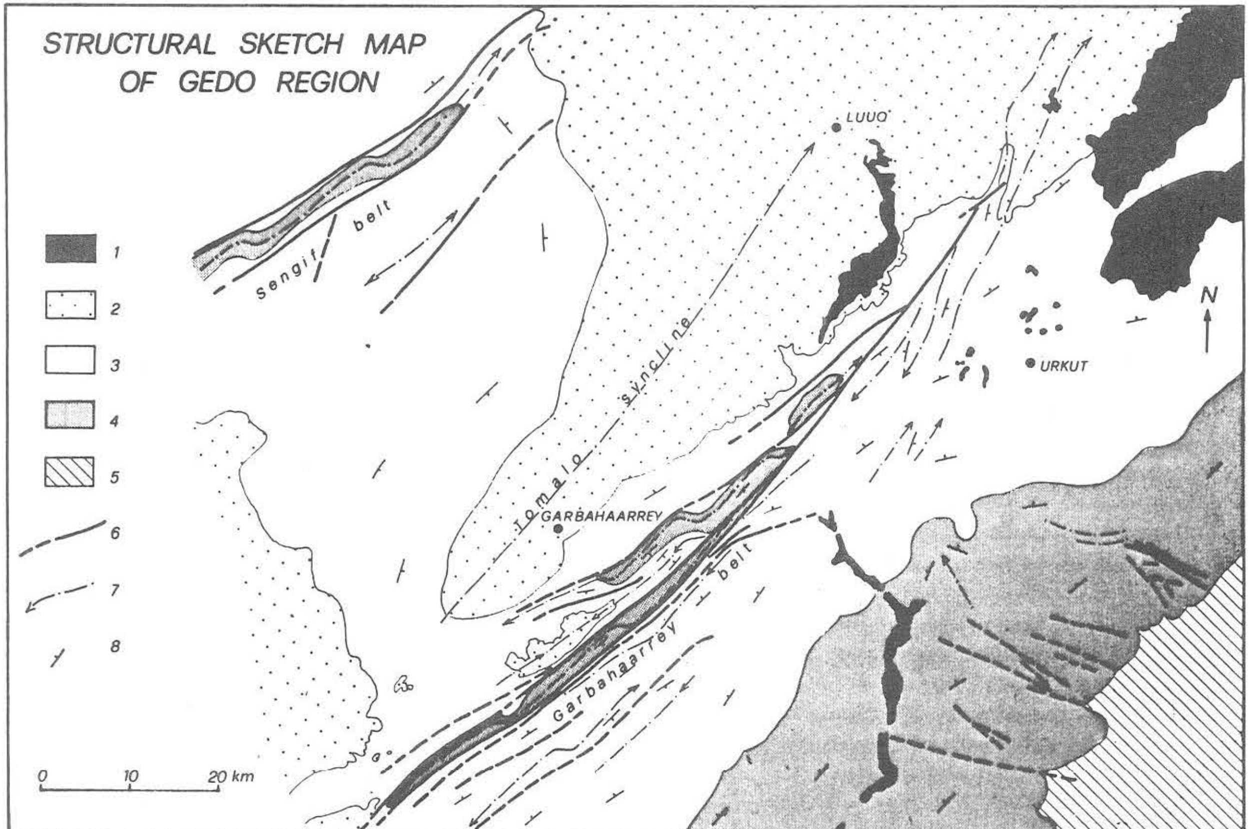

Fig.6: Structural sketch map of the Gedo Region: 1) Tertiary Basalts; 2) Garbaharre Formation, Mao Member and Ambar Formation (Upper Jurassic-Lower Cretaceous); 3) Garbaharre Formation, Busul Member (Upper Jurassic); 4) Uegit Formation (Kimmeridgian); 5) Anole Formation (Late Callovian-Late Oxfordian); 6) Fault; 7) Fold axis; 8) Bedding.

age of the basalts is Oligocene.

These data represent the only chronological evidence of the Tertiary evolution of the Jubba valley, but many authors express doubts on this point because the morphology of the paleo thalweg is too well-preserved to be so old.

Data from the Institute of Geochronology of the Italian National Council of Research, Pisa, have recently demonstrated the presence of excess Ar40 in several basaltic samples. The apparent age values must therefore be considered older than the real ones.

After the basaltic flows, the Jubba valley underwent a deepening process resulting in the actual thalweg. This phase also involved the capture of the Dawa, upstream from Dolow, which produced a fossil drainage of more than 100 km from the Garbahaarrey area to Kenya, beyond Mandera (Plate 5C). This fossil drainage is still shown by long patches of forest which followed the course of the paleo-Dawa in the past.

4. TECTONICS OF THE LUUQ-MANDERA BASIN

(Ali Kassim Mohamed, L.Carmignani & P.Fantozzi)

North-west of the Bur Region the sedimentary cover dips about 1°-2° towards NW for more than 100 km, up to the Luuq and Garbahaarrey areas. Further westwards the average dip trends SE and E, then the Precambrian basement outcrops again beyond the frontier with Kenya. The main structure of the Jubba valley upstream from Bardhere is therefore a wide syncline between two crystalline outcrops.

A system of SW-NE-trending faults and gentle plicative structures complete the picture. Some faults affect the SE limb of the synclinorium, i.e. the Barbaadan and Buuraha Haacad Faults, but most are concentrated in the axial zone of the basin. The major structures of this area are shown in Fig.6 and in the photogeologic map attached to this guide. The Cretaceous formations outcropping in the central zone of the basin are deformed in an extensive syncline with limbs dipping less than 5° and axes trending SW-NE and gently dipping NE (Tomalo Syncline). Two strongly deformed belts trending SW-NE and 10 km wide, develop both NW and SE of the syncline and extend for more than 100 km. They comprise folds with strongly dipping limbs and faults visible in air photos and satellite images. (Plate 4).

The NE belt (Sengif Belt) is composed of a long anticline limited at both sides by two faults; it extends from the Dolow area for about 110 km as far as Kenya.

The SW belt (Garbahaarrey Belt) develops for about 130 km and includes a main fault (Garbahaarrey Fault) trending N40 E, following the deformed zone along almost its entire length, and a system of secondary faults which are slightly oblique in relation to the main fault. The belt section SE of Garbahaarrey is affected by major deformations; both SW and NE the deformations gradually decrease and at last completely disappear. The greatly deformed part is characterized by many developing secondary faults and strongly marked by plicative structures (Buraha Wakab, Garbahaarrey and Bussul Anticlines; Bussul Syncline) with limbs dipping 30°-40°, rarely 50°. The profile of the folds is symmetrical or slightly asymmetrical with NW vergence (Plate 5).

Systematic variations of axial fold orientation represent a particular feature of these folds.

Torsion involves the major folds, quite regularly every 10-15 km, always being clockwise. A similar geometry also occurs along Sengif Belt (Plate 4).

According to Beltrandi & Pyre (1973), the fold belts are due to a complicated system of normal faults. All anticlines correspond to small horsts. Horst uplifting was caused by the flow of pre-Jurassic evaporites and shales belonging to the Anole Formation from the axial zone of the Tomalo syncline to the limbs.

Carmignani et al.(1983), have hypothesized that the two belts may be due to right-wrenching tectonics probably associated to a transpressional component. The shear direction is inferred by a series of "en échelon" folds (in the NE part of the Garbahaarrey belt) and by the angular relations between the secondary faults and the main one. Within this deformative framework, regular axial torsion may also be explained: its rotational direction is in agreement with right shear deformation. The geometry of the Garbahaarrey belt suggests that a shear belt spread from the area SE of Garbahaarrey, where it produced major general displacement.

Geophysical investigations and the Hol 1 well (BURMAH OIL Co.,1973) demonstrated the existence of a NE-SW-trending pre--Jurassic graben, having its axis nearly coinciding with the Tomalo Syncline (BELTRANDI & PYRE, 1973). The two deformative belts of Sengif and Garbahaarrey run parallel to the Tomalo Syncline for more than 100 km at a steady distance (60 km) from

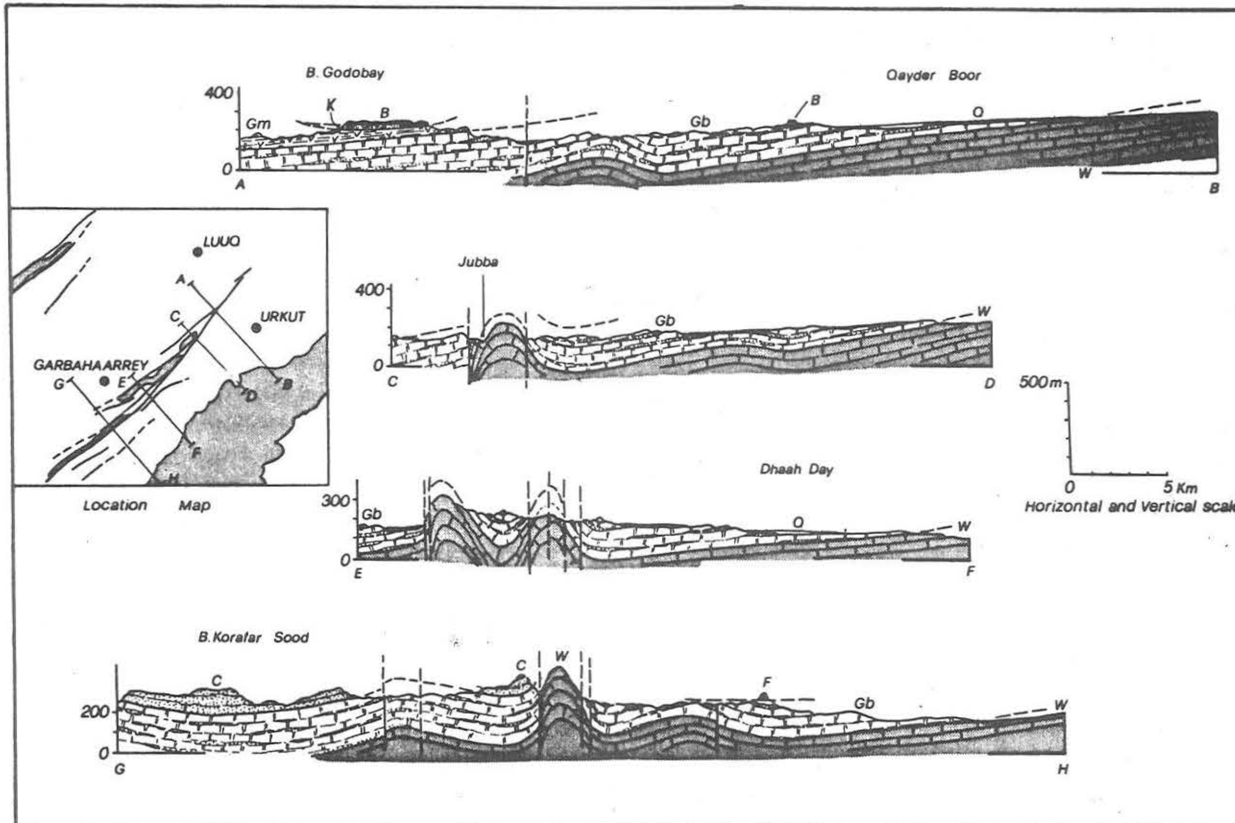

Fig.7: Geological section across the Garbaharrey Belt: Q) Quaternary cover; B) Basalts (Tertiary); K) Kuurekta Formation (Tertiary); F) Faanweyn Formation (Tertiary); c) Ambar Formation (Upper Jurassic-Lower Cretaceous); Gm) Garbaharre Formation, Mao Member (Lower Cretaceous); Gb) Garbaharre Formation, Busul Member (Upper Jurassic); W) Uegit Formation (Kimmeridgian).

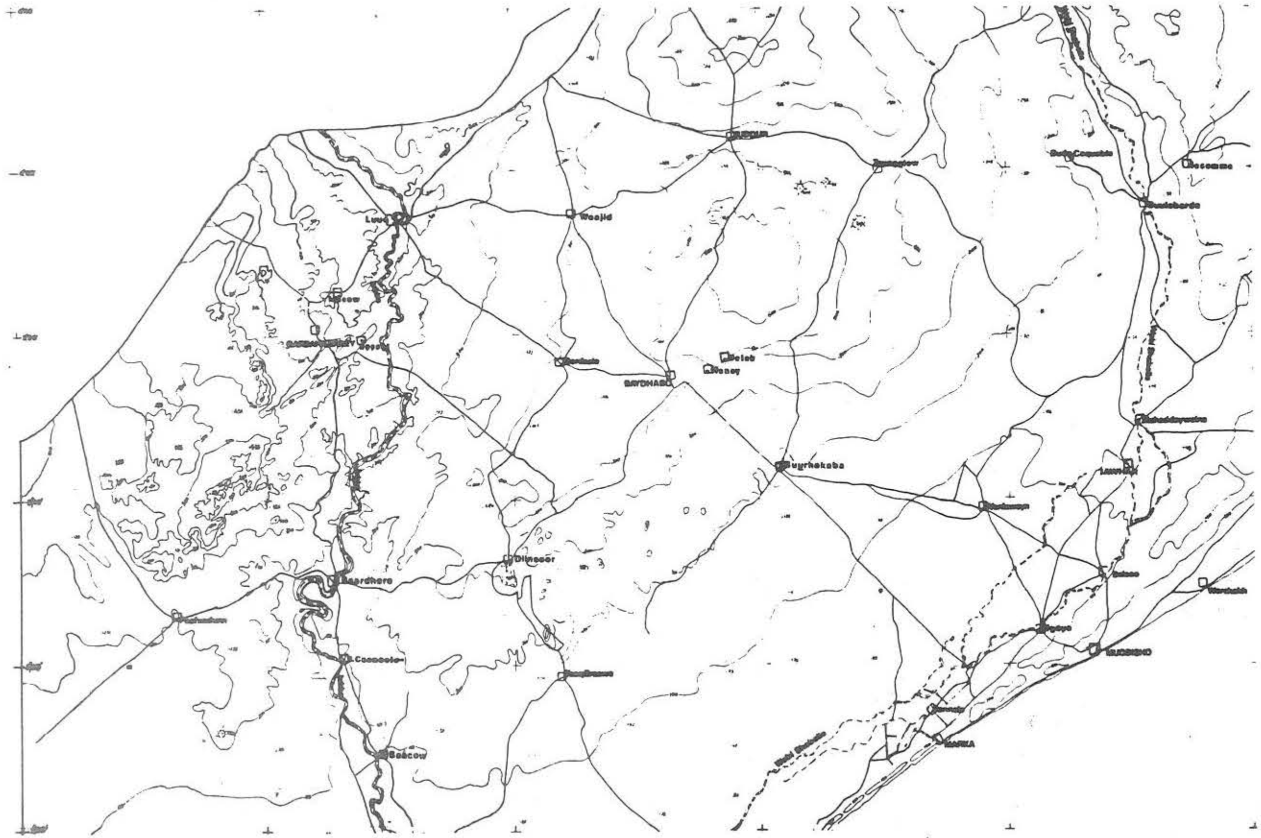

Fig.8: Sketch road map of the excursion

each other. These belts are probably located near marginal faults of the pre-Jurassic basin. These old faults of the basement may have been reactivated as wrenching faults after the Early Cretaceous, causing two narrow fold belts in the overlying sedimentary cover.

5. EXCURSION IN THE GEDO AND BAY REGIONS

(Field Leaders: Ali Kassim Mohamed, L.Carmignani & M.Fazzuoli)

First day: Bur Crystalline Basement and Lower Jurassic formations in the Bay Region.

The first day of the excursion is devoted to an examination of the granites of the crystalline basement of the Bur Region and of the older unit of the sedimentary sequence in the Isha Baydhabo area. In particular, some levels of the Uanei and Baidoa formations, representative of the Lower Jurassic sedimentary cycle, will be examined, and their sedimentological and paleogeographical significance will be discussed.

Along the road from Mogadishu to Afgoi we cross first red sands of the coastal dunes and then dark argillaceous alluvional sediments, which outcrop beyond the Shebeli as far as the village of Wanla-Wein.

140 km from Mogadishu, on the right side of the road, there is a small bur (Bur Leego), whereas northwards the broad granite outcrop of Bur Heybo -one of the largest Bur in the region- begins to appear on the horizon.

186 km from Mogadishu, on the outskirts of the village of Buurhakaba, the typical granitic bur outcrops.

STOP I-1. Bur Kuulow. Field Leader: Hawa Hersi Hussein.

Bur Kuulow consists of a pinkish granite in which numerous melanocratic xenoliths have been found. It belongs to the "younger granites" of the Panafrican Event: its Rb-Sr whole-rock isochron age is 520 $\pm$ 59 Ma.

The Bur Kuulow granite consists of quartz, microclinperthite, albite (<10% An), biotite and sometimes horneblende. Apatite and sphene are common in small amounts. The distribution of the mineral components is not homogeneous. The grain size is medium to large. Planar and linear anisotropies can sometimes be detected.

The xenoliths commonly show sharp boundaries and angular shapes. Most of them consist of banded amphibolites, in which the leucocratic bands have a gneissic composition and the melanocratic bands are rich in horneblende and sphene. The amphibole is clearly crystallized at the expense of an older clinopyroxene, of which some relics can still be observed.

Some Ca-rich xenoliths also occur. They consist of calcite, diopside, olivine (alterned to talc), horneblende and actinolite. The crystallization of the horneblende is complex; the older crystals include diopside, the youngest ones fill fractures. These Ca-rich xenoliths are considered to be fragments of the marbles from the Dinsor Complex.

STOP I-1bis. A small outcrop of rhyolites has been found at Bur Durdur, near Bur Kuulow. These acidic volcanics outcrop poorly over an area of about 100 sq.m, covered by dense vegetation. They lie directly over the crystalline basement rocks, i.e., over the same granitoids which outcrop in the surroundings. They fill an old, small morphological depression.

The occurrence of these acidic volcanics, and that of some basaltic dykes found in the crystalline basement of the Bur Region, suggest that this region was affected, to some extent, by the rift-related volcanism of East Africa.

At a distance of 186 km from Mogadishu, on the outskirts of the village Buurhakaba, a typical granite Bur outcrops. Its Rb-Sr whole-rock isochron age is 516 $\pm$ 42 Ma. Towards the north-east the sharp shape of Bur Heybo is still well in sight.

We continue towards Baydhabo. About half an hour later the "Baydhabo Scarp" begins to appear on the horizon, marking the contact between the crystalline basement of th Bur area and the Jurassic sedimentary cover. This contact is not placed at the lower break of the slope, but some hundred meters down. The hard limestones belonging to the Baidoa Formation protected the underlying soft marls of the Uanei Formation, and gave rise to this slope.

STOP I-2. Upper part of the Uanei Formation at Isha Baydhabo (Fig.9).

The stop consists of two separate parts: the lower portion of the section may be observed along the course of the Togga Shiikh Hasharow, and the upper portion across the scarp of Baydhabo, near the camel market (BUSCAGLIONE et al.,1987).

We follow the course of the Togga Shiikh Hasharow, its source ("Isha") being in the town center. In the Togga Shiikh Hasharow, from the bottom, the following lithological levels (Fig.9) outcrop:

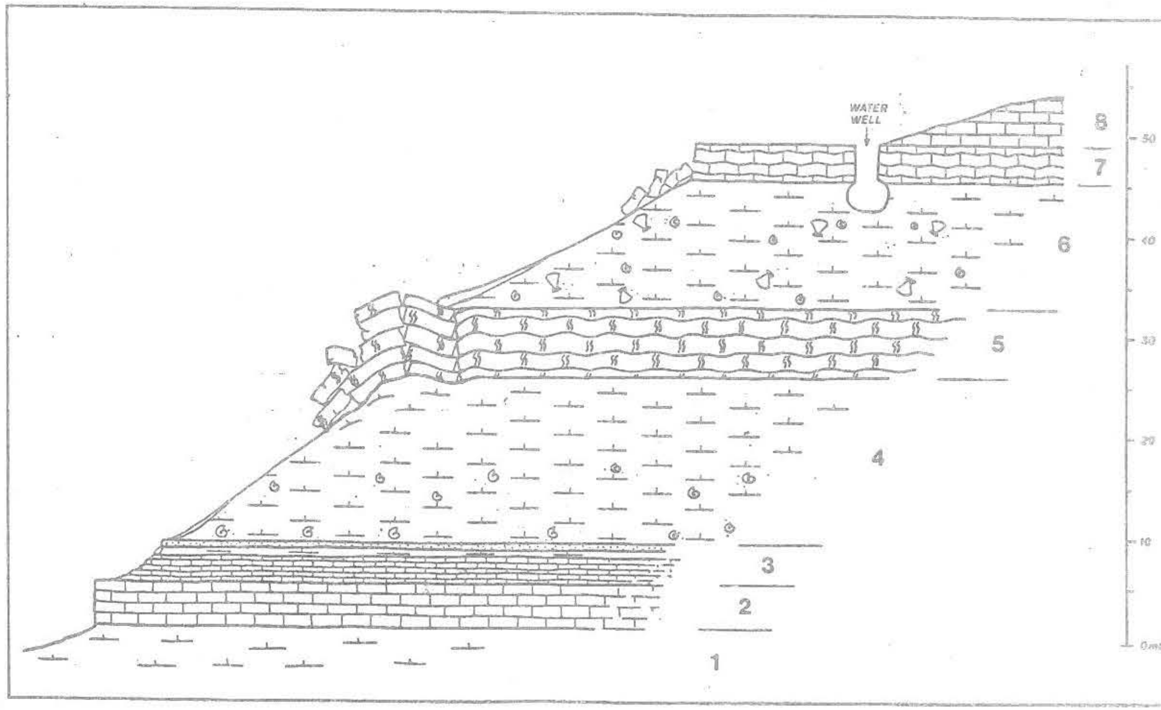

Fig.9: Geological section across the Baydhabo scarp (STOP I-2) Numbers refer to lithological levels cited in the text.

1- (0,50 m): grey-green marls.

2- (4,50 m): dark grey calcilutites, 20 - 60 m thick. The limestones beds are weakly folded and consist of bioturbated bioclastic wackestones and some lumachella layers.

3- (3,50 m): thin beds (5 - 10 cm) of grey marly limestones alternating with marls. The beds show nodular structures, probably due to strong burrowing. At the top of this level is a bed (10-15 cm thick) showing fine but clearly horizontal or weakly wavy lamination. The laminae are composed of bioclastic/ /peloidal wackestones alternating with peloidal/bioclastic grainstones.

Fossils present in levels 2) and 3) are: pelecypods, gastropods, brachiopods, echinoderms, benthic foraminifers (among others, Vidalina? martana Farinacci and Pseudocyclammina liasica Hottinger) (BUSCAGLIONE et al., 1987). The age is Lowermost Toarcian.

The sedimentary environment was partially restricted, subtidal, under the wave base. Only the lumachellas and laminated fine calcarenites are probably storm deposits: the lumachellas may be interpreted as proximal tempestites, the laminated calcarenites as distal tempestites (ALLEN, 1984 ; AIGNER, 1985). The laminated calcarenites mainly make up the flat area at the base of the Baydhabo scarp.

After a short walk parallel to the base of the slope, we climb as far as the camel market at Isha Baydhabo.

The upper part of the section is composed, from the bottom, of the following levels:

4- (16/18 m): reddish shaly marls (more marly and yellowish near the base, covered by talus). In the lower part of this level ammonites occur (Parahildaites madagascariensis and Protogrammoceras sp.) (BUSCAGLIONE et al. 1987)

5- (6/8 m): grey-brown or pink nodular calcilutites, well stratified (5-30 cm), with rare thin shaly interbeds. Texture consists of recrystallized mudstones, with abundant iron oxides in scattered crystals or concentrated along stylolites. The beds are strongly bioturbated by horizontal worm tracks. This level appears to be tectonically deformed: as the general structure is weakly inclined (2'-5') the beds are deformed and some are very steep (50'-70'): we believe that this deformation may either be a superficial feature, or could be due to deformations of the underlying marls. No fossils have been observed in this level.

6- (16 m): grey and yellow-green massive marls, mostly covered by talus. Fossils in this level are: pelecypods (Opis aff.parvicarinata Thévenin), gastropods and ammonites (Parahildaites madagascariensis; Hildaites sp. (BUSCAGLIONE et al., 1987).

7- (4/6 m): well-stratified (10-40 cm) brown-yellowosh calcilutites and calcarenites. Textures consist of recrystallized mudstones and intraclast-pellet (coproliths) grainstones. The calcarenite levels show sedimentary structures, such as graded bedding, cross-bedding and "hummocky" structures; the calcilutite levels have a "wavy" structure. Some levels, 10-15 cm thick, show a "crumpled" structure (BOGACZ et al., 1968), i.e., the bed is completely brecciated, with cm-sized, rounded to subangular, strongly packed clasts or fragments of laminae. Calcarenites are interpreted in our opinion as storm deposits (proximal tempestites) whereas the "crumpled" beds are tentatively referred to an upward reflux of material, where a reverse density bedding exists (BOGACZ et al.,1968; DZULYNSKI, 1968). Shocks caused by earthquakes may trigger this proces (HAMPTON & DEWEY, 1983).

Levels 4), 5) and 6) were deposited on a relatively deep shelf with abundant clastic supply. They mark the apex of the transgressive phase of the Lower-Middle Jurassic sedimentary cycle. Level 7) marks a return to a shallower shelf, where the effect of storm-induced waves was active. The age is Lower Toarcian.

8- (10 m): the top of the scarp is composed of grey-brown bioturbated calcarenites and grey calcilutites in beds 15-40 cm thick. Textures consist of bioclastic, oncoidal and peloidal packstones/grainstones and bioclastic/oncoidal wackestones. Sedimentary structures are represented by cross-laminations, bioturbations and some coquinas. Fossils are: pelecypods, gastropods, echinoderms, foraminifers (Mesoendothira croatica Gusic, typical form; Nubecularia reicheli Rat; Globochaeta alpina Lombard; Favreina cf. eiggensis Bronniman; Favreina fendiensis Bronniman & Zaninetti) (BUSCAGLIONE et al., 1987). The age is Lower Dogger: Aalenian-Bajocian. The sedimentary environment is referable to an open platform, with high energy conditions.

The calcarenites of the Baidoa Formation, outcropping at the top of the slope, are quarried as building stone.

We continue towards Awdiinle. Just beyond Baydhabo the rock is covered by superficial argillaceous deposits, entirely cultivated with sorghum, probably derived from the alluvial reworking of marls and shales of the Anole Formation outcropping extensively to the NW.

From Awdiinle we continue towards Qansaxdheere along the new road to Baardheere. Here the Goloda Formation outcrops rarely because of a thick cover of terra rossa and caliche. Better exposure of the calcarenites of the Goloda Formation is found after this covered area.

STOP I-3.

After Qansaxdheere, for several kilometers , the calcarenites of the Goloda Formation still outcrop. Farther along the road runs downhill and is almost completely covered by soils and caliche. This is the outcropping area of argillaceous lithotypes belonging to the Anole Formation.

We reach Bardheere.

Second day: Middle-Late Jurassic formations of the Luuq--Mandera Basin.

The second day of the excursion will permit to examine the Middle-Upper Jurassic formations of the eastern flank of the Luuq-Mandera Basin: the Anole and Uegit Formations, respectively representing the open-sea phase and the carbonate-platform regressive phase of the Middle-Late Jurassic sedimentary cicle. Another important problem that will be examined and discussed regards the peculiar structural features of the Garbahaarrey area (narrow elongated anticlines).

If the road is good enough- during the rainy season the entire region is not very practicable- the group may divide, each one choosing one of two itineraries: the site of the Buraha Markaabley Bardheere dam or the Anole Formation at the Bur Canoole.

Bur Canoole Group: from Bardheere we go south to Kisimayo for about 30 km as far as the village on the outskirts of Bur Canoole and the Jubba Valley.

STOP II-1a. Anole Formation at Bur Canoole

The Bur Canoole hills, about 40 km south of Bardheere, look like big terraces, about 90 m above the bed of the Jubba river. The lower part of the Anole Formation outcrops here. Going from the thalweg of the river as far as the hill terrace, the following sequence may be observed (Fig.10):

a- (20/25 m): grey or yellow-grey marls with marly limestone beds, 10-20 cm thick. On the bed of the river, the latter consist of bioclastic, peloidal, quartzose packstones. Fossils

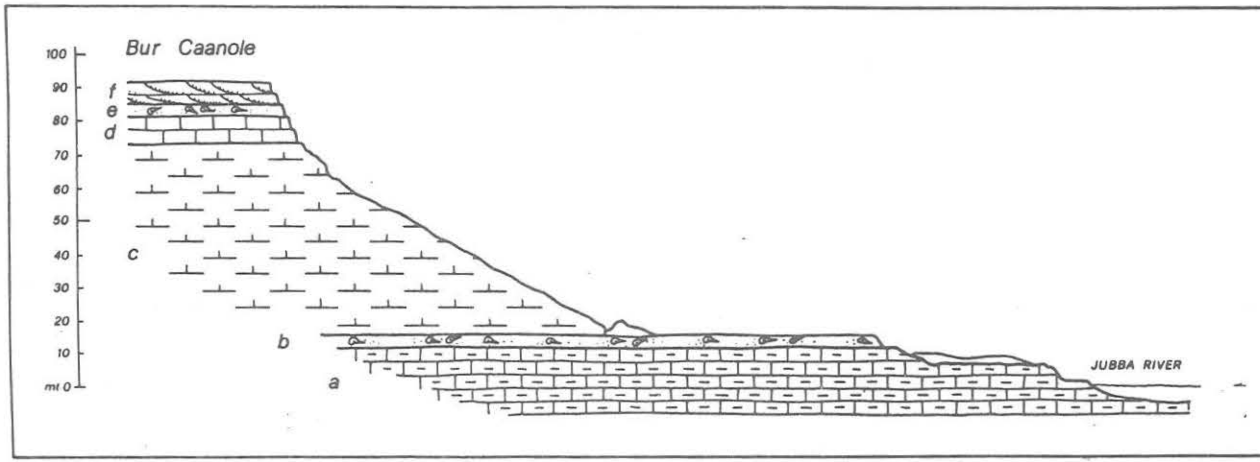

Fig.10: Geological section across the Bur Caanole (STOP II - 1a) . Letters refer to lithological levels cited in the text.

identified by Stefanini (1931) and Buscaglione (1984) (enclosed in square brackets) are:
pelecypods = Ceromyopsis kiliani, Exogyra vinassai Diaz, Prospondylus aubryi (Douvillé), Pholadomia carinata, (Paleonucula cuneiformis (Sowerby), Homomya sp.);
gastropods = (Ampullina coxi Stefanini);
brachiopods = Rynchonella subtilis Szain, Rynchonella gregoryi Weir, Alcothyris kitchini sp.nov.;
ammonites = Macrocephalites (Kamptokephalites) somalensis sp. nov., Hecticoceras issa sp. nov., Perisphinctes (Groussouvria) steinmanni Parona & Bonarelli.

b- (some meters): dark grey lumachella level consisting of bioclastic and quartzose floatstones and packstones/grainstones. This level makes up the flat terrace at the foot of the hill. Fossils are abundant:
pelecypods = Plicatula sp., Lima sp., Exogyra sp., Alectryonia sp., (Lopha solitaria Sowerby, Exogyra fortuai Stefanini, Paleoncula cuneiformis Sowerby, Homomya sp., Modiolus imbricatus Sowerby, Eligmus rollandi Douvillé);
brachiopods = Terebratula ruspolii sp.nov., Terebratula haualites, Aulacothyris jubaensis Weir, (Somalirynchia africana Weir, Somalirynchia bihendulensis Weir em.Muir-Wood; Lophrotyris cf. subsella (Leymerie));
belemnites = Belemnites sp., (Belemnopsis sp.).

c- (60 m): grey marls with rare fossils.
pelecypods = Lima sp.;
ammonites = Perisphinctes sp. ;
belemnites = Belemnites sp.;
aptychus.

d- (10 m): dark grey calcilutites made up of bioclastic wackestones. Fossils are:
pelecypods = Acrosalenia gananensis sp.nov., (Modiolus imbricatus);
brachiopods = Rynchonella africana Weir, Terebratula bicanaliculata Schlotheim, Terebratula glenday Weir, (Lophrotyris subsella (Leymerie)).

e- (0,50 m): lumachella bed with Belemnites tanganensis.

f- (5 m): yellow-brown calcareous sandstone beds (10-50 cm thich), composing the flat top of the hill. The sandstone beds show cross-laminations, hummocky structures and ripples and may be interpreted as possible storm deposits.

The age of the Bur Canoole sequence may be inferred as Late Callowian/Early Oxfordian (BUSCAGLIONE, 1984).

The environment was subtidal, generally under the wave base, and is referable to a shelf with open sea conditions.

Then we leave and reach Baardheere.
Together with the other group we continue to Garbahaarrey.

Dam of Buraka Markaabley Group: we go along the track going to Baydhabo and after 2 km turn left towards Buuraha Markaableey.
32 km later we reach the site planned for the building of the dam.

STOP II-1b. Buraka Markaabley - Dam Site
The dam will rest on marls of the Anole Formation, although the upper part will reach the overlying Uegit Formation. It will be built in massive concrete and will be 42.00 m high; the reservoir area will extend to Luuq (further data are available from the Jubba-Bardheere Dam Project in Mogadishu).

We leave for Bardheere, where we meet the other group and then continue towards Garbahaarrey.
Beyond the Jubba bridge the valley floor is composed first of alluvia and, when the road begins to climb, of marls of the Anole Formation. The upper part of the latter includes layers of calcareous sandstones with cross-laminations. The contact with the overlying Uegit Formation, made up of less weathered lithotypes, is marked by a sharp slope visible many kilometers away. The Uegit Formation, composed of well-bedded micritic limestones and calcarenites, is clearly visible from the road.
18 km away from Bardheere the bottom of the Uegit Formation constituted by a level of oolitic calcarenites crops out.

STOP II-2. Basal oolitic level of the Uegit Formation
The contact between the Anole and Uegit Formations is sharp and marked by a break in the slope of the hill. The highest level of the Anole Formation is composed of quartzose--calcareous sandstones with horizontal or weakly wavy laminations, probably referable to distal storm deposits. The lowest level of the Uegit Formation is a 10-12 m thick bed of oolitic calcarenites (COCCHI, 1982). The calcarenites consist of oolitic grainstones in the lower part, and of oolitic grainstones//packstones with concentric-radial ooids.
The oolitic grainstones are composed of small (0,1-0,4 mm) ooids with thin oolitic envelopes; the nuclei are made up of bioclasts and peloids. Fossils are pelecypods, echinoderms, foraminifers and gastropods. Sedimentary structures are repre-

sented by horizontal or weakly wavy laminations, with some iso--orientation of bioclasts.

In the oolitic grainstones/packstones the ooids are large (0,5-1 mm) and have thick envelopes, with evident concentric as well as radial structure. Some ooids are broken and re-oolitized and also show micritic peloids, lumps and large intraclasts. In some samples a micritic matrix is present, but in others it is recrystallized. Bioclasts, represented by pelecypods, echinoderms and foraminifers, are generally scarce.

Sedimentary structures consist of bioturbation, horizontal or weakly wavy laminations; a bimodal distribution of grains also occurs.

As regards the environment, a shoal in a high turbolence environment may be inferred in the lower level. The radial oolites of the upper level, according to Simone (1974), may have formed in lower turbulence and high salinity coastal pools, placed behind the marginal complex.

The entire Uegit Formation is crossed by the road and if we have enough time we can stop again, especially near a layer with large Nerinea.

Then we enter the peneplained area, composed of slightly NW-dipping limestones of the Uegit Formation.

The chain of the hills characterized by steep limbs and smooth tops visible from the NE, is made up of sandstones, marly limestones and dolomites of the overlying Busul Member belonging to the Garbahaarre Formation. The road runs slightly downhill, following the dip-slope as far as Togga Dhuurta and the nearby village of Faan Weyn.

On the exposed bed of the Togga Dhuurta, the top of the Uegit Formation outcrops, whereas along the Togga the upper part of this formation is well exposed.

STOP II-3. Oncolitic level on top of the Uegit Formation (Algolite Marker) (Fig.12)

The upper part of the Uegit Formation is composed, going upwards, of some lumachella beds, subordinate beds of sandstones and siltstones and, on top, beds of oncoidal calcirudites. The thickness of the calcirudite beds varies from 10 to 140 cm. The calcirudites consist of oncoidal packstone/rudstone; the micritic matrix ranges from 30 to 50%. The average size of the oncoids is 0,6-0,8 cm, but may reach more than 2 cm; the shape is generally elliptical, but rounded as well as lobate oncoids also occur. Many oncoids are in stylolitic contact. Frequent peloids occur together with the oncoids; bioclasts are scarce,

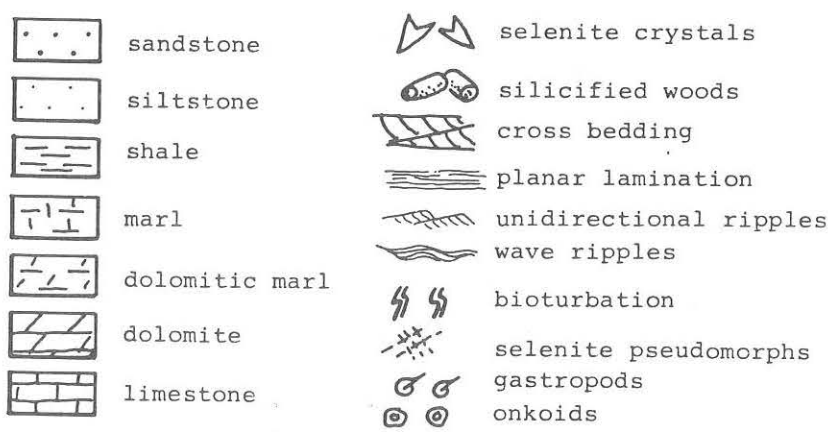

Fig.11: Table of simbols used in Figg.12 to 16.

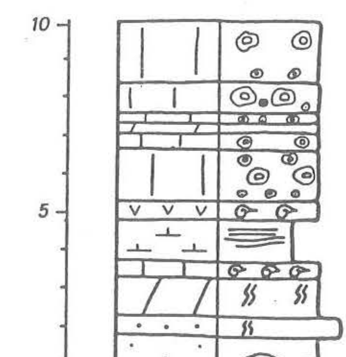

Fig.12: Section of Togga Dhurta at Faanwein (STOP II-3).

sometimes composing the nuclei of the oncoids: they are represented by pelecypods, echinoderms, gastropods, benthic foraminifers. Quartz grains are less than 10%.

Sedimentary structures are represented, in some beds, by inverse grading, i.e., the base of the beds is composed of calcarenites and the upper part of a calcirudite (Fig.11). Some horizontal or inclined coarse laminae, made up of grains of different size occur, as well as bioturbated areas filled with micritic matrix. In some samples the grains also show a bimodal size distribution (large oncoids and peloids or small oncoids). Iron oxides are widespread in the matrix and on some weathered surfaces of rocks, where they constitute a thin black film in the intra-oncoidal area.

The large size and regular shape suggest a subtidal depositional environment with encrusting organism, where the oncoids frequently rolled and became larger. The high packing, bimodal distribution of the grain, and micritic matrix indicate an extended channelized area, probably with tidal control, connecting the open sea with a more restricted lagoon. Tidal currents may have transportated the oncoids inside the lagoon, where they accumulated together with the lagoonal calcareous mud.

This level is present in the entire region and since it is clearly visible in air photos ("Algolite Marker"), it is usually considered as a boundary marking the Garbaharre and Uegit Formations. The higher hills north of Togga Dhuurta consist of the Bosul Member at the bottom and probably Pliocene deposits at the top. The latter is composed of white sandy shales, about 20 m thick and covered by several metres of silcrete called the Faanweyn Formation, from the name of the large hill south of Togga Dhuurta.

We continue through a sub-horizontal sequence of sandy limestones and reddish sandstones, with frequent levels of lumachella with pelecypods.

The hills to the north are the "Garbahaarrey Belt" consisting of two anticlines separated by a syncline: the Bossul Anticline, the Bossul Syncline and the Garbahaarrey Anticline. The Uegit Formation outcrops at the core of the anticline and the Ambar Formation at the core of the syncline.

We cross the sandy dolomitic limestones interbedded with friable quartz sandstones and shales belonging to the Bosul Member (Garbahaarre Formation). It is characterized by a sharper morphology with hills and frequent slopes.

Lumachella with pelecypods of the Busul Member outcrop representing the bottom of the member, just before Garbahaarrey along the track to Baardheere. The contact with the overlying Ambar Sandstones is located at the base of the hills running W to E of the track.

We reach Garbahaarrey.

Third day: Cretaceous Formations of Luuq-Mandera Basin and discordant Tertiary of Luuq.

The third day of the excursion is devoted to the younger (Upper Portlandian - Lower Cretaceous) formations of the Luuq-Mandera Basin in the Garbahaarrey-Luuq area: the Garbahaarrey Formation is subdivided into the carbonate Busul Member and evaporitic Mao Member, and the Ambar Sandstones. The lateral relationships between the Mao Member and the Ambar Sandstones will be discussed. East of Luuq, Tertiary basalts and pre-and post-basalt sediments will be examined and the Tertiary morphological evolution will also be discussed.

After leaving Garbahaarrey we proceed along the Garbahaarrey-Luuq road. At first the road goes through isolated hills composed of sandstones bolonging to the Ambar Formation, and then follows the slope southeast of the core of the Tomalo Syncline. It follows the contact with the Busul Member, which is partly covered by terra rossa and composes the slope on the left of the road.

The Ambar Sandstones outcrop 9 km from Garbahaarrey along the road. At the following two stops we can observe the most peculiar features and sedimentary structures typical of this formation, e.g. cross-laminations.

STOP III-1. Ambar Sandstones

Garbahaarrey-Luuq road 3 km after Garbahaarrey. Looking SSW towards the hills i.e., towards Garbahaarrey, a natural continuous cross-section shows the depositional geometry of the Ambar Sandstones (Fig.13). These form a flat sub-horizontal body a few tens of metres thick, prograding above the Busul Member of the Garbahaarrey Formation by the accumulation of foreset beds down a steep frontal slope. The Ambar Sandstones indicate a delta environment, and the Busul Member a prodelta; in our opinion, the Ambar Sandstones may represent an example of a shallow-water fluvial-dominated delta as suggested by i) the relatively reduced thickness in the arenaceous body; ii) the high sandstone shale ratio; iii) the shallow-water facies

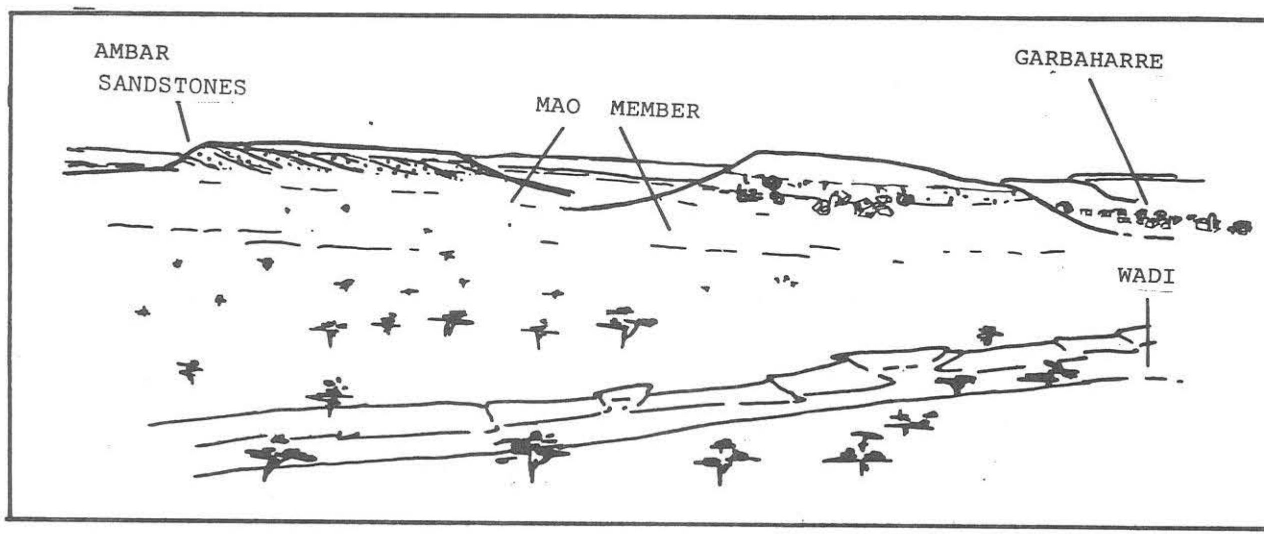

Fig.13: Landscape of the hills of Garbaharrey (Ambar Sandstones) looking southwards. (STOP III-1)

of the Mao Member, making a lateral transition to the Ambar.

STOP III-2. Ambar Sandstones

Garbaharrey-Luuq road, 4 km after Garbahaarrey. A widely covered sequence of the Ambar Sandstones outcrops (Fig.14); however, it may be stated that: i) the unit is built up of three arenaceous levels; ii) the second level gradually disappears downcurrent. The latter is well exposed and is characterized by two cross-stratified beds thinning NE (with silicified woods and fish tooth remains), over- and underlying thin- to medium-bedded bioturbated or wave-ripple cross-laminated sands and marls. The sequence is considered indicative of a delta--front, inter-deltaic and prodelta environment.

STOP III- 3. Ambar Sandstones

Garbahaarrey-Luuq road, 7 km after Garbahaarrey. The Ambar Sandstones here reach a thickness of a few tens of metres (Fig.15); the lowermost level is still present but the others are thinned out. The sequence thickens upwards and shows in the lower portion (at the foot of the hill) bioturbated current- or wave-ripple laminated sands and marls (at the top of the Macow Member) suggesting a prodelta environment, followed by planar and trough cross-stratified sandstones, interpreted as mouth bars, and thick cross-bedded beds interpreted as channel deposits. Upwards the arenaceous sequence ends with medium--bedded planar and cross- stratified sands, probably reflecting the gradual vanishing of the distributary channel.

The chain of the hills visible from here is the structure of Garbahaarrey.

After the village of Maykaareebay we find the Macow well and the village of Macow, representing the type-locality of the Mao Member which makes up the evaporitic upper part of the Garbahaarrey Formation.

STOP III-4. Garbahaarrey Formation - Mao Member

Leaving the Garbahaarrey-Luuq road, at the top of the slope of Macow, we turn left on the road to Burwago. After some kilometers, descending towards the large paleo-thalweg, the lower portion of the Mao Member outcrops, 25 m thick.

Several intervals may be identified, from the bottom (Fig.16):

a) 4m-cyclic alternance of thin beds of dolomites, silty shales and gypsum beds; thick dolomite beds, with abundant gypsum crystals, from the top of this interval.

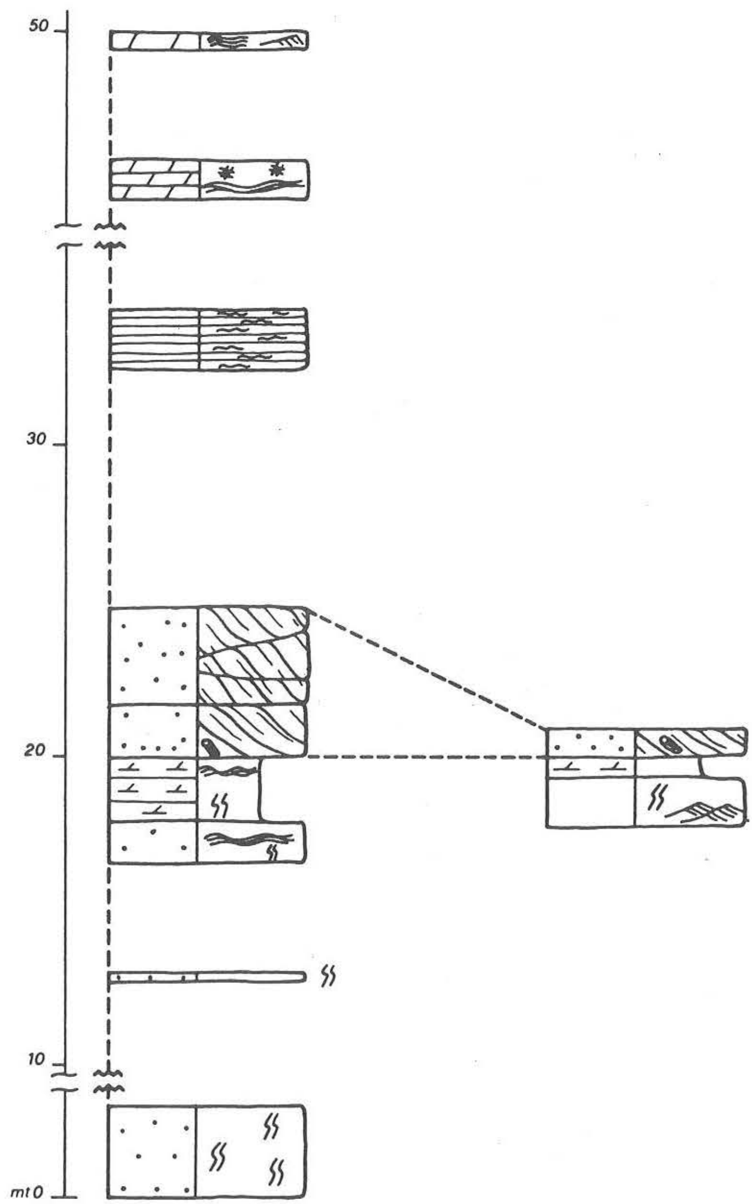

Fig. 14: Section of the Ambar Sandstone (STOP III-2)

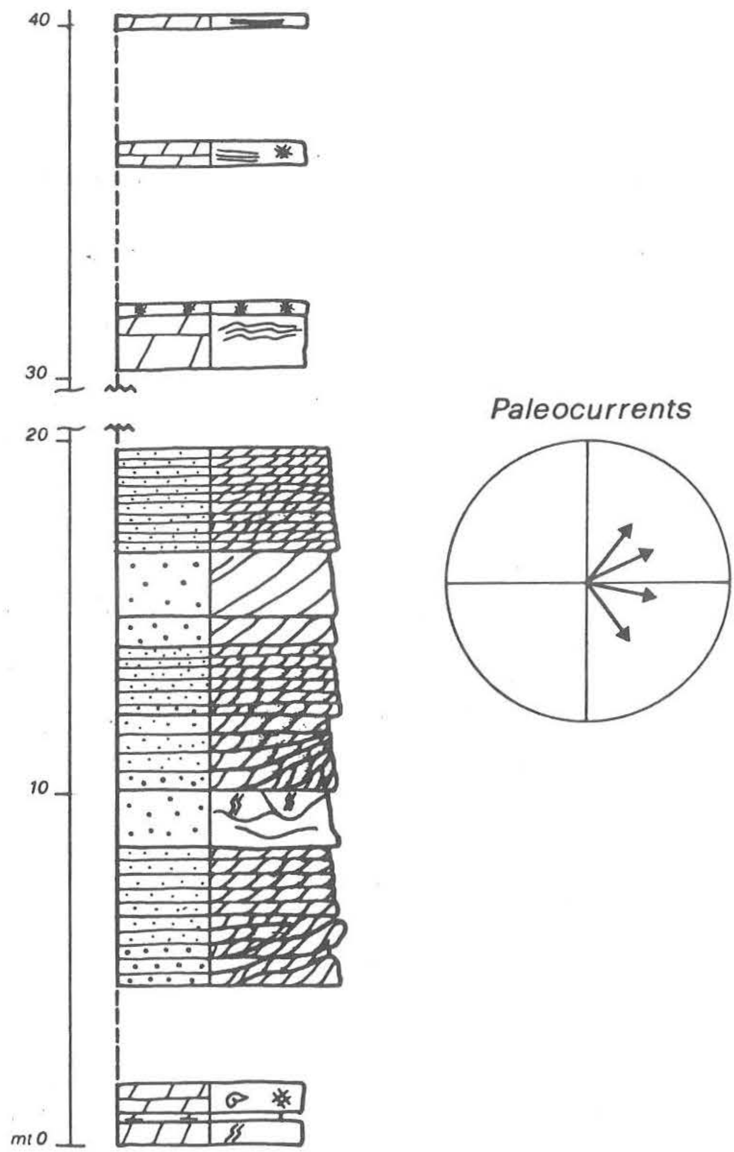

Fig.15: Section of the Ambar Sandstones (STOP III-3)

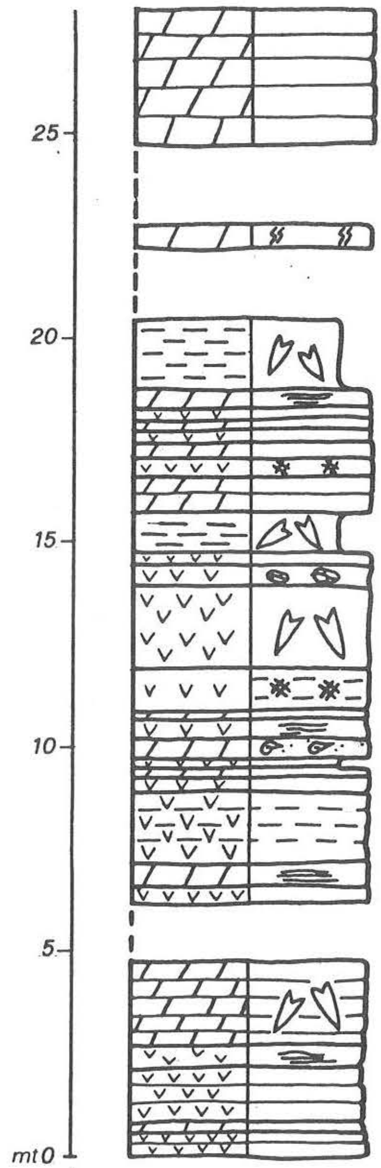

Fig.16: Section of the Mao Member (STOP III-4)

b) 4m-dense alternance of thin levels of gypsum and shales; a few dolomite beds, massive or with lumachella levels.

c) 4m-above a bed of vuggy dolomite with gypsum seams, a 3-m thick bank of roughly laminated gypsum which contains small rounded crystalline "eyes". Upwards the gypsum become brecciated and nodular.

d) 3,50m-green and red shales with abundant rosette-shaped gypsum crystals, laminated and vuggy dolomites, nodular gypsum with small levels of dolomite.

e) 4,50m-green shales with rosette-shaped gypsum, included between two levels of laminated or massive dolomite.

f) 3m-dark-grey dolomites in beds 20-30 cm thick, coarsely crystalline; upwards horizontal or weakly wavy laminations.

Some points are noteworthy in this sequence, i.e.:

- the presence of thick shaly or silty-shaly levels, alternating with dolomites and gypsum;

- the lack of gypsum levels with well-formed "enterolithic" structure;

- the abundance and relatively high thickness of the dolomitic levels;

- the transitional shale-dolomite-gypsum or shale-gypsum passages;

- on a large scale, the lateral transition between the Mao Member and the Ambar Sandstones.

In our opinion all these elements indicate a shallow basin in (possibly intermittent) connection with the sea, probably and extended lagoon partly fed by fine- or even coarse-grained terrigenous clasts (Ambar Sandstones), in which evaporitic episodes frequently occurred. Current directions in the Ambar Sandstones indicate a southern provenance (i.e. from Kenya and the Bur Region) of the clastic material; only the finest materials (clay or silt) reached the Macow area, where they intercalated with the transitional sediments of a weakly hyperhaline (dolomites) or higly hyperaline (evaporites) environment.

To the south is a general view of the relict hydrography we crossed before. At the top of the hill along the Macow slope, the road still runs in the same unit and follows the axial plane of the Tomalo Syncline (see Fig.14).

About 15 km before Luuq the alternation of dolomites and evaporites observed at the previous stop is still well exposed. From Luuq we continue along the left bank of the Jubba. Friable quartzose sandstones, evaporites and shales, representing the upper part of the member, are also well exposed. Walking along a short path, we cross the entire upper part of the Mao Member.

We stop for lunch on the river-bank. After lunch, we continue to the hills of Kuurecta, just where the Luuq discordant Tertiary outcrops.

STOP III-4. Tertiary volcanites and sediments

These consist of a fluvial succession about 40 m thick and composed of conglomerates with elements of alkaline volcanites (trachytes, phonolites) and quartzites with some layers of ash tuffs. The fluvial succession is overlain by about 10 m of olivine basalts with columnar structures. As shown in the attached map, this complex outcrops just in correspondence to the hills marking the old course of the Jubba. Basalts protected the underlying loose fluvial deposits from erosion, so that they are morphologically located higher than the present field plane. Fig.16 illustrates the old course of the Jubba as far as Garbahaarrey. The only fossils found in the fluvial conglomerates are silicified tree trunks referred to the Pliocene (Piccoli, pers.comm.). Some of these are visible at this stop.

We return to Luuq and, if we have enough time, we can visit the fort; then we return to Garbahaarrey.

Fourth day: Relationships between Busul Member and Ambar Sandstones.

In the fourth day of the excursion, the vertical relationships between the Busul Member and the Ambar Sandstones will be shown and the significance of silicified trees will be discussed. The structural and geomorphological features of the region between Garbahaarrey and the Jubba River will also be examinated.

We follow the Garbahaarrey-Quansaxdheere road.

12 km from Garbahaarrey, beyond the first relief (which corresponds to the Garbahaarrey Anticline) we stop at the central syncline.

After a short walk in the bush, we reach a hill composed of Ambar Sandstones and outcropping in the central part of the Bosul Syncline.

STOP IV-1. Garbahaarrey Formation - Busul Member and Ambar Sandstones (Fig.17).

At the foot of the hill thin- to medium-bedded marls, dolomitic limestones and fine sandstones (Busul Member) outcrop; bioturbations and planar or wave laminations are common. Many

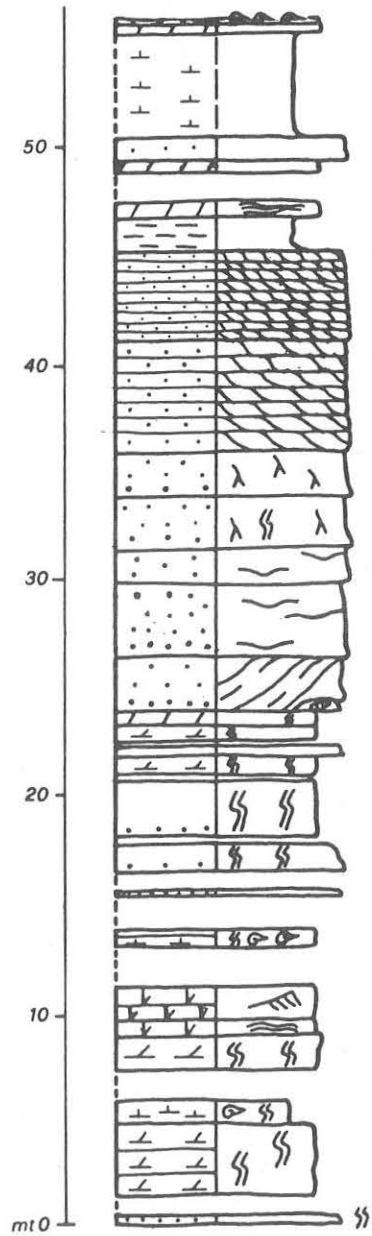

Fig.17: Section of the Busul Member and Ambar Sandstones (STOP IV-1)

silicified tree trunks of questionable stratigraphic position are scattered on the ground. It is also possible to observe the inserting cavity of a tree trunk in the Ambar Sandstones. Above a slightly erosive surface, the Ambar Sandstones follow, forming a 25-30 m fining-upwards sequence. In the lower part, thick-bedded cross-laminated or massive sandstones (with silicified tree trunks up to 3 m and probable dish-structures) are present, whereas in the upper part contains medium- and fine--bedded, planar and ripple cross-stratified sandstones. The sequence ends with limestones, sandy limestones and marls. After the junction to Bardheere the road transversally curs the narrow Bossul Anticline, then crosses the arenaceous or dolomitic limestones alternating with friable quartzose sandstones and argillites of the Busul Member (Garbahaarey Formation). The morphology appears quite rough and is characterized by hills and frequent slopes.

We reach the Burdhubbo refugee camp and take the ferry to Burdhubbo.

A few kilometres farther on, we find a thin basalt outcrop placed along the Kuuretka basalt ridge. Subsequently, along the road the Uegit Formation, composed of micritic limestones and well-bedded calcarenites, is clearly exposed. A sharp slope marks the transition to the Anole Formation, whose outcropping zone is represented by a depression completely covered by soils and caliche.

After Quansaxdheere and Berdale we arrive at Baydhabo, where we have lunch. Carrying on, we arrive in Mogadishu at about 5 p.m.

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7. LIST OF THE SOMALI AND ENGLISH NAMES OF THE LOCALITIES MENTIONED IN THE GUIDEBOOK

Awdiinle = Andinle
Baydabo = Baidoa
Bardheera = Bardera
Bossul = Busul
(Bur) Caanole = (Bur) Anole
Burdhubbo = Bur Dubo
Buurhakaba = Bur Akaba
Cambar = Ambar
Diinsor = Dinsor
Faan Weyn = Fanwen
Garbaharrey = Garbaharre
Isha Baydhabo = Iscia Baidoa
Jubba = Giuba
Luuq = Lugh
Kuurecta = Kurecta
Macow = Mao
Wanay = Uanei
Waajid = Uegit