PRELIMINARY STUDY ON THE PALEOGENE FORMATIONS OF CENTRAL SOMALIA (HIIRAAN, GALGADUUD, MUDUG AND NUGAAL REGIONS)

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In the Faculty of Geology, Somali National University, searches are been carried out since some years on the Somali stratigraphic series, in order to clarify the relationships among the various geological formations (a problem particularly frequent inside the Mesozoic sedimentary sequence are facies etheropies). The field survey is accompanied by the examination of the satellite imagery (LANDSAT), aerial photographs (when existing and accessible) and the records yielded from the drilled wells for hydrocarbons research.

The field excursions are often made difficult by very hot climate, thick bush of thorny type, lack of tracks in wide areas; the observations are limited by the low elevations of the ridges and the scarsity of outcrops over long distances. Large eluvial and "caliche" covers are widespread almost all over the studied areas.

Working groups of the Faculty of Geology, formed by Italian and Somali searchers, have taken into consideration up to now the Jurassic stratigraphic series of the Jubba basin (ANGELUCCI and others, I980)and the Cretaceous of the Webi Shabelle basin (BARBIERI and others, I979); the present work should conclude the preliminary examination of the stratigraphic series of Central and Southern Somalia. The northern part of the country exhibits a different geological situation, due to its tectonic and sedimentary history related to the formation of the Gulf of Aden, along which it extends.

We are grateful to all persons who helped in any way our study and expecially to the Dean of the Faculty in Mogadishu and to the local Authorities of the visited regions.

For the present study unpublished graduation works by SAACDIYA CAARIF QAASIM and by IBRAAHIM MAXAMED FAARAX regarding the area around Garoowe and Eiyl have been considered.

GEOLOGICAL INTRODUCTION

Previous publications

The first geological studies on the Tertiary of Central Somalia are due to G. STEFANINI and were published from I920 to I938, with a rich series of works in "Palaeontographia Italica" (I933 to I938). His studies were accompanied or followed by those of A. SILVESTRI on Foraminifera (I938 - I948), A. AZZAROLI (I948 to I958) on the whole fauna, by G. GIANNINI on the Molluscs (I955), G. CHECCHIA-RISPOLI on the Crustaceans (I946) and on the Echinides (I942 to I950). The microfauna of the Karkar Formation was studied by G. FORTELEONI PIAMONTI and C. PIRINI RADRIZZANI (I975). The stratigraphic sereis was detailed by A. AZZAROLI.

Of a particular usefulness are the reports delivered by the oil companies on the drilled wells for hydrocarbons, deposited at the Ministry for Mineral and Water Resources in Mogadishu.

When not confidential, they have been read through the courtesy of Dr. HILAAL CABDALLA FAARAJ, to whom we are particularly grateful. Among all, the reports by P. LYONS and A. BENNISON of Sinclair Somali Corporation (I960), by ROMPETROL (I975),the publications by the GEOLOGICAL SURVEY TEAM OF THE PEOPLE'S REPUBLIC OF CHINA (I972), by S. U. BARNES (I976), by R. BIGNELL (I977) must be remembered. For comparison with nearby areas the works by W. O. CLIFF (I956), by E. DUCCI and C. PIRINI RADRIZZANI (I969) and by M. BELTRANDI and A. PYRE (I973) must be considered. General informations are contained in the Reports of the Geological Survey of the former British Protectorate of Somaliland; many informations are summarizd by A.P. POPOV, A. L. KIDWAY and S. A. KARRANI (I973) in a report on hydrogeology of Somalia, and earlier by SOMALILAND OIL EXPLORATION CO. (I953) for Northern Somalia.

A reinterpretation of the stratigraphic series of Somalia was proposed by HILAL A. F., G. PAVAN and E. ROBBA (I977);the paleontological record was summarized by G. PICCOLI and HILAL C. F. (I978). The general geological siutation has been illustrated by G. MERLA and others (I979), by M. KAMEN-KAYE and S. U. BARNES (I979), M. KAMEN-KAYE and A. A. MEYERHOFF (I980) , also on the base of the results reached with the wells of the Deep Sea Drilling Project (DSDP) in the Indian Ocean and in the Gulf of Aden; a faunal and floral history of East Africa from Permian to Tertiary was outlined by M. KAMEN-KAYE (I978).

Among the graduation works at the Faculty of Geology in the Somali National University, apart those by SAACDIYA C. Q. and by IBRAAHIM M. F. (I980) already remembered, the following ones have to be listed for our purposes: CABDI SAALAX XUSEEN (I978), MAXAMED XASAN XAAJI AXMED (I978), AXMED YUUSUF ISMACIIL (I980).

Internal reports to the Faculty of Geology regarded also the studied region and its Tertiary sequence; among all that by MAXAMUD CABDI CARUSH (I980), on an excursion to the zone, preceded our inspection on the whole area; his sampling was accompanied by stratigraphic columns of the visited area,as well as by a study of thin sections of the collected samples.

The stratigraphic series

The oldest formation assigned to Paleogene is the Yesomma Sandstone, which contains no fossils, but carbonized fragments of leaves and branches. Its age is deduced from the stratigraphic relationships and is inferred to be Upper Cretaceous and Paleocene or exclusively Paleocene, as in the studied area.

The sandstone is quartzous, locally magnetitic, conglomeratic in the upper levels. The matrix is mostly siltous. Cross bedding is common, of fluvial environment. Its thickness variates from 400 m at Yesomma to 250 northwards, becoming about

I700 m near the coast of the Gulf of Aden. It lies on the Belet Uen Limestone, of a Cretaceous age, in the Hiiran region; the direct contact was never observed in outcrops,but is known from drilled wells. In the Galgaduud region the " Transition layers" were found in the underground inbetween, with a thickness of about 350 m (TAVANI, I949). Towards the interior, in respect to the Indian Ocean, it is to say in the Ogaden region and then in Central Ethiopia, the Yesomma Sandstone covers directly, with a disconformity, older and older rocks of the Mesozoic stratigraphic series; in some parts it rests on limestones of Lower Jurassic age.

The Yesomma Sandstone is covered conformably by the Auradu (or Awradle) Limestone, of a Paleocenic and Lower Eocenic age.

Its age results to be older, Upper Cretaceous, in the Nugal Valley, where it is thicker (to I000 m northwards). The most typical rock of this formation is a limestone in thick banks, with a light brown to whitish colour. The fossils, pretty seldom, are firmly cemented in the rock. Minor lithotypes are dolomias, marls, silty clays, silts and in the upper part sandstones. The total thickness is about 400 m, decreasing to 250, if Northern Somalia is excluded. Paleocarstic phenomena are quite common.

On it the Taleh Formation is lying (Taleex in the Somali spelling). Its name comes from the known fortress of the mullah Mohamed Saiyd Abdulle Hassan (Maxamed Saacid Cabdulle Xasan), the national Somali hero. The Taleh Formation is mainly composed by evaporites, it is to say anhydrite, and gypsum at the surface, with interbeds of dolomia, limestone, marl and clay.

The Taleh Formation represents the third main solphatic body of the Somali stratigraphic sereis, the other being represented by the Main Gyspsum (Lower Cretaceous) and Ferfer Formation (Cenomanian) respectively.

As far as evaporites are concerned, the Main Gypsum Formation is the thickest evaporitic level, up to 500 m (the Mao Member of Garbaharre Foramtion is its partial equivalent in the Jubba Valley); the Ferfer Formation is thin and lentiform; the widest area of evaporites is given in any way by the Taleh

Formation, the outcrops of which extend from Hiraan region to the vicinity of the Somali coast of the Gulf of Aden, forming in particular all Central Somalia beyond the Shabelli River.

The maximum thickness of the Taleh Formation is about 350 meters, decreasing to around 300 southwards in the studied area. It disappears in the vicinity of Kandala, where the Karkar Formation covers directly the Auradu Formation (region of Bari, NE Somalia).

Inside the Taleh complex the El Bur (Ceel Buur) sepiolite level is contained. The formation is almost azoic in many parts; the intercalations of carbonatic or clastic type give an age ranging from Lower to Middle Eocene, on the base of benthonic Foraminifera (among them Nummulites) and Molluscs.

The widespread carstic and paleocarstic phenomena, common in the Taleh as well as in the underlying Auradu Formations , suggested to several geologists to propose the "Mudugh Beds", referred to surface weathering and redeposition phenomena in a very wide area (see, for instance, ROMPETROL, I975 and the Geological Map of Somalia I:I.000.000 by V.N.KOZERENKO et al., I970-I972). The name has been used in mining geology (uranium and thorium mineralizations.

We do not completely agree with this interpretation, which would compel to do like that for many other areas and formations subdue to weathering and alteration phenomena in the equatorial climate of the present and the past of Somalia. Moreover, many carstic phenomena are likely to be very old in age.

The Karkar Formation forms the last part of the stratigraphic series in the studied region. It is the richest in macro and micro-fossils, which can be often easily taken out from the soft marls and even from the limestones, which are the more common types of rocks of this formation. Evaporitic intercalations are seldom. The age of the formation ranges from Middle to Upper Eocene, becoming generally older northwards, as it happens also for the older geological complexes of the area, which result to be time-transgressive. The top of the formation is known out of the studied region and indicates a total maximum thickness of 250 m. The fossils are represented by macroforaminifera (Nummulites, Orbitolites, Alveolina, Somalina,

Discocyclina, a.s.o., illustrated particularly by A.AZZAROLI, I950), planctonic foraminifera, pelecypods, gastropods, echinids, with a strong Tethyan character. Beside the limestones and marls (often very clayey), other lithotypes are dolomias and siltstones. The Karkar Formation is the last one in the stratigraphic succession to have a wide area of extension in Somalia.

The paleontological record

The fossil contents of the studied formations is represented mainly by foraminifera and, as far as the Karkar Formation is concerned, also by molluscs and echinids. The best biostratigraphic correlations were based up to now on macroforaminifera, which are largely known in the stratigraphic sequence of marine environment, studied in the area. Planctonic foraminifera are now under study.

The Yesomma Formation is referred in its lower part to Upper Cretaceous on the base of fossils found in marly intercalations in Northern Somalia as far as Socotra (Suqutra), among which Orbitolina, Inoceramus and Rudistidae; northwards its base is even Lower Cretaceous in age.

In the Auradu Limestone the first Nummulites from Somalia are known, with small individuals, together with Daviesina Danieli SMOUT, Smoutina crusyi DROOGER, Lockhartia tipperi (DAVIES), L.haimei (DAVIES), Kathina major, SMOUT and in the upper part Nummulites atacicus LEYMERIE, Somalina stefaninii SILVESTRI (AZZAROLI, I950, refers it however to Karkar), Alveolina periloculinoides SILVESTRI, A.subpyrenaica LEYMERIE, A. frumentiformis SCHWAGER, Orbitolites complanatus LMK., Sakesaria cotteri DAVIES: a Paleocene and Lower Eocene age results from the faunal associations. Northwards a Maastrichtian age is suggested by Omphalocyclus macroporus (LMK.) and other foraminifera, Globotruncana a.o.

From the carbonatic and clastic intercalations of the Taleh Formation thin beds with many echinids (Sismondia) are known in Northern Somalia, where the formation is thinning to disappearance. Other fossils are Nummulites globulus LEYMERIE, Alveolina timorensis VERBEEK & FENNEMA, A.frumentiformis SCHWAGER, Orbitolites complanatus LMK., Coskinolina liburnica STACHE, Dictyoconus africanus SILVESTRI, with a Lower and Middle Eocene age.

The many Foraminifera from the Karkar Formation are listed by A. AZZAROLI (I950) and by G. FORTELEONI PIAMONTI & C.PIRINI RADRIZZANI (I975); we shall recall here only some of them, which are significant for biostratigraphy. So for Middle Eocene Nummulites gizehensis (FORSKAL), N.millecaput BOUBEE', N. beaumonti D'ARCHIAC, N.perforatus (MONTFORT), N. somaliensis NUTTAL & BRIGHTON, N.discorbinus SCHLOTH, N.lybicus CHECCHIA-RISPOLI, N.aturicus JOLY & LEYMERIE, Dyctioconoides kohaticus (DAVIES), Discocyclina pratti (MICHELIN), D. ephippium (SCHLOTH.); Asterocyclina stellaria (BRUNNER), for Upper Eocene Nummulites fabianii (PREVER), N.chavannesi DE LA HARPE, Pellatispira budensis (HANTKEN) silvestriana (THALMANN), while a longer distribution in time have Orbitolites complanatus LMK., Dictyoconus africanus SILVESTRI, Lockhartia haimei DAVIES, L.tipperi DAVIES, Linderina buranensis NUTTAL &BRIGHTON.

Among the Molluscs E. GIANNINI (I955) has reported the Bivalvia Vulsella falcata MUENSTER, Cardita aegyptiaca (FRAAS), several species of Lucina (L.pharaonis BELLARDI, L. thebaica ZITTEL, L.immanis OPPH., L.mokattamensis OPPH., L. mutabilis LMK., all known also from Egypt), Diplodonta hindu COX, Tellina reticulata (BELLARDI), Meretrix nitidula LMK., Cardium halaense D'ARCH., Corbula exarata DESH., and, exclusive of Upper Eocene, Arca uniformis OPPH., Chlamys subdiscors D'ARCH., Mactra fourtaui COX, and the Gastropoda Velates schmidelianus CHEMNITZ, various Naticidae, Cerithium tchihatcheffi D'ARCH., Terebellum obtusum SOW., Gisortia gigantea MUENSTER, Conus brevis SOW., and for Upper Eocene Rostellaria goniophora BELLARDI, Cassis aegyptiaca OPPH., Heligmotoma niloticum MAYER - EYMAR (the two last species exist also in Middle Eocene). The faunal affinities are strong with India, Egypt and the Mediterranean Paleogene (Italy, Southern France, Spain).

CHECCHIA-RISPOLI reported the Crustacean Decapodes Palaeocarpilius macrocheilus DESM. and P. (Metapodon) lorentheyi CH.-

RISP. and the Echinids Brissoides cranium (LESKE), Echinolampas migiurtinus CH.-RISP., E.fraasi DE LORIOL, E. migliorinii CH.-RISP., Kleinia pulchra CH.-RISP., Linthia mortenseni CH.-RISP., Schizaster delorenzoi CH.-RISP., Lutetiaster maccagnoi CH.-RISP., and others. Among the plants Dasycladaceae are frequent.

The overlying Oligocene deposits contain Nummulites vascus JOLY & LEYMERIE, N.intermedius D'ARCHIAC, N.incrassatus DE LA HARPE, Heterostegina costata D'ORBIGNY and other typical fossils (SILVESTRI, 1937; SOCIN, 1957; AZZAROLI, 1958).

Stratigraphic equivalents outside the studied area.

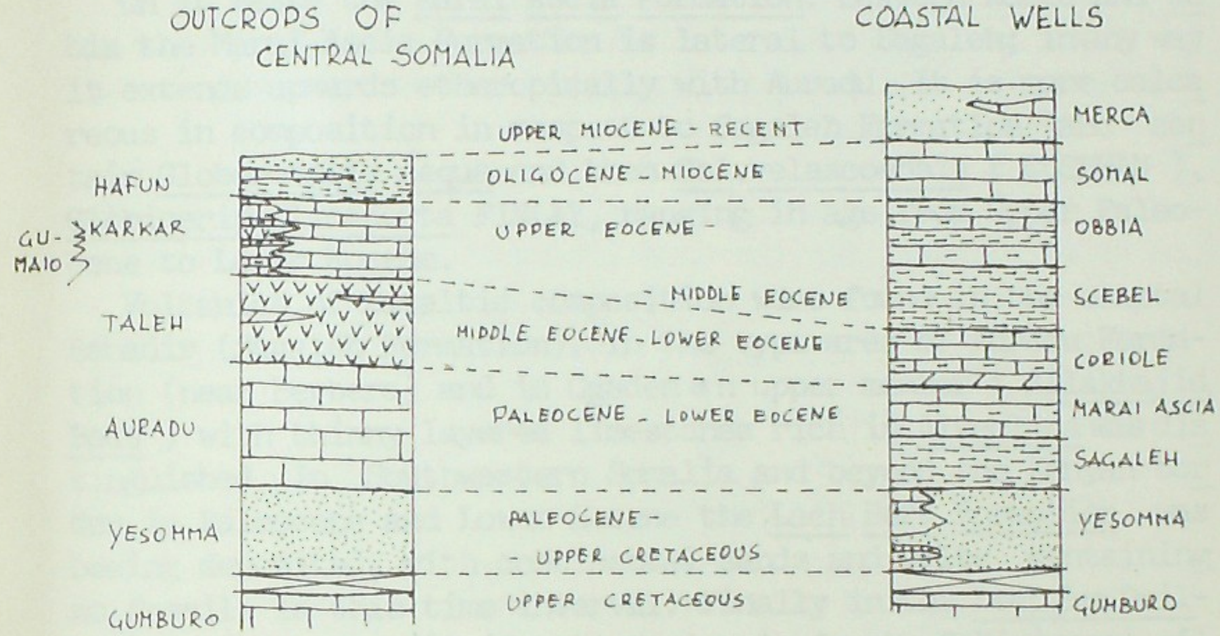
The gradual thickening of the Paleogene formations (except Taleh) northwards towards the coast of the Gulf of Aden and their progressively older age have been already said.

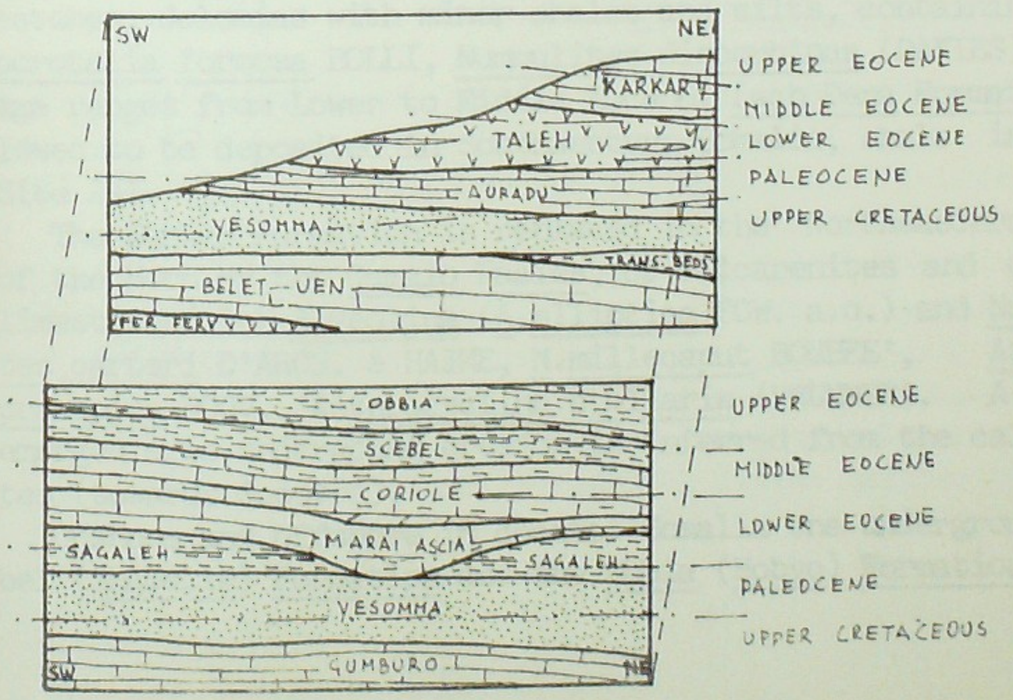
Where the facies differencies become stronger, different formations have been proposed. The same is valid for the underground sedimentary series drilled by deep wells along the Somali coast of the Indian Ocean, where rich microforaminiferal associations of planctonic type have been recovered (see a.o. AGIP MINERARIA, 1957-1977; G.L.SPRAUL, 1959; A.KLAVER, 1964; F.PLUMHOFF, 1967; S.M.ANDREWS, 1968).

The Yesomma Formation has its etheropic equivalent in the Tisgè (Tisjeex) Formation: the age of both ranges from Lower Cretaceous to Paleocene in the region bordering the Gulf of Aden, while becomes younger southwards, as already said, ranging from Upper Cretaceous to Paleocene in the region examined for our research. In the Tisjeex sequence, limestones are prevailing over sandstones; among the fossils Pianella dinarica RADOICIC, Cuneolina cf. laurentii SARTONI & CRESCENTI, Orbitoides media D'ARCH., O.tissoti SCHLUMB., Omphalocyclus macroporus (LMK.), Orbitolina trochus (FRITSCH), Coskinolina sp. , Loftusia sp., Inoceramus, can be listed (CANUTI & MARCUCCI , 1969; DUCCI & PIRINI RADRIZZANI, 1969; MERLA et al., 1979).

The Auradu Formation has its lateral open sea correspondent

FIG.1 - STRATIGRAPHIC CORRESPONDENCE BETWEEN OUTCROPS IN CENTRAL SOMALIA AND COASTAL DEEP WELLS





in the Sagaleh Formation, of a shaly and silty composition, with minor limestones and marls; it contains Globorotalia compressa (PLUMMER), Globigerinoides daubjergensis BRONNIMAN, Globorotalia aequa (CUSHMAN & RENZ) and upwards Globorotalia Pseudomenardii BOLLI. Its age results to be Paleocene.

On it rests the Marai Ascia Formation. Between Adale and Obbia the Marai Ascia Formation is lateral to Sagaleh; in any way it extends upwards etheropically with Auradu. It is more calcareous in composition in respect to Sagaleh Formation and contain Globorotalia aequa and then Gbl.velascoensis (CUSHMAN), Globigerina linaperta FINLAY, ranging in age from Upper Paleocene to Lower Eocene.

Volcanics of basaltic composition were found in the coastal Benadir (Sagaleh Formation). In the type area of Auradu Formation (near Berbera) and in Ogaden an upper member (Allakhajid Beds) with thinny layered limestones rich in Alveolina was distinguished. In Southwestern Somalia and beyond the Kenyan border in Paleocene and Lower Eocene the Lach Dera Formation was beeing deposited, with continental sands and silts containing no fossils in this time interval. Finally in the Deep Sea Drilling Project Site 24I (Somali Basin, in front of Kisimayo) silty shale was met, on which unconformable volcanites are lying.

The Taleh Formation has an etheropic correspondence with the open sea Coriole (Qoryooley) Formation, composed of marls, limestones, dolomias with minor shales and silts, containing Globorotalia formosa BOLLI, Nummulites discorbinus (DAVIES); its age ranges from Lower to Middle Eocene. Lach Dera Formation followed to be deposited in Southwestern Somalia, shale in DSDP Site 24I.

The Karker Formation is replaced in the Northeastern edge of the Horn by the Gumaio Facies, of calcarenites and compact limestones with Alveolina (A.elliptica SOW. a.o.) and Nummulites carteri D'ARCH. & HAIME, N.millecaput BOUBEE', Assilina praespira DOUV., Asterocyclina stellaris (BRUNNER). A nearby emerged area undergoing erosion is inferred from the calcarenites (towards Socotra).

Onshore and offshore in coastal Somalia the underground Scebel (Shabelle) Formation and the Obbia (Hobyo) Formation, the

first made up of marls, shales and silts with Nummulites Discorbinus SCHLOTH., Hantkenina alabamensis CUSHMAN, Globorotalia lehneri CUSHMAN & BERMUDEZ, the other one of shales and silts with some marls upwards, with Globigerina yeguaensis WEINZIERL & APPLIN, Hantkenina dumblei WEINZIERL & APPLIN, Cribrohantkenina sp., are known.

Their geological age is Middle-Upper Eocene and respectively Upper Eocene. Lach Dera Formation follows upwards; in DSDP Site 241 a stratigraphic gap was found.

A particular sequence was met in Garad Mare I well, drilled by A.G.I.P.: a continuous shaly series ranges from Paleocene up to Miocene. For the time interval to which we are referring the biozones from Globorotalia velascoensis (CUSHMAN) to Globorotalia cerroazulensis (COLE) and Cribrohantkenina have been recognized.

NEW GEOLOGICAL OBSERVATIONS

The observations were made by us on field in 1980 and 1981, followed by thin section preliminary examination of the sampled rocks.

We shall expose our results formation by formation.

Yesomma Formation

It was studied in the wide belt of its extension at the East of the Shebeli Valley, where it widens for about 120 km., ranging North to South from the surroundings of Hargeysa to Bulo Burti and Jalalaqsi.

Good outcrops are not common and only separated parts of the sequence are exposed; the maximum continuous observed thickness is about 300 m in the vicinity of the type locality, Yesomma (Yasomman in the local spelling). Other studied sections are Jirta Qamno and Guri Ceel, at the East of Belet Uen (Beled Weyne), capital of the Hiiraan region.

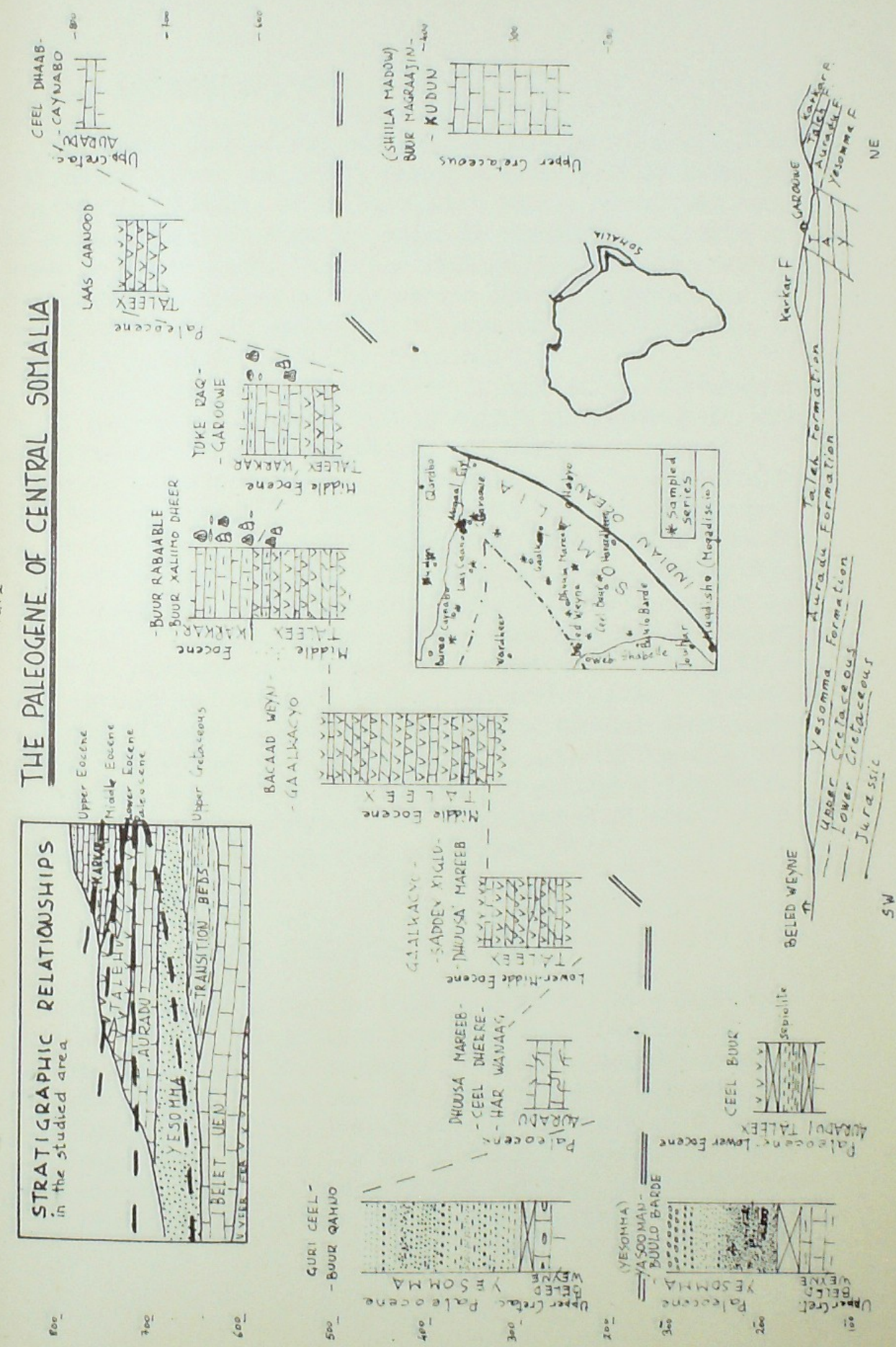
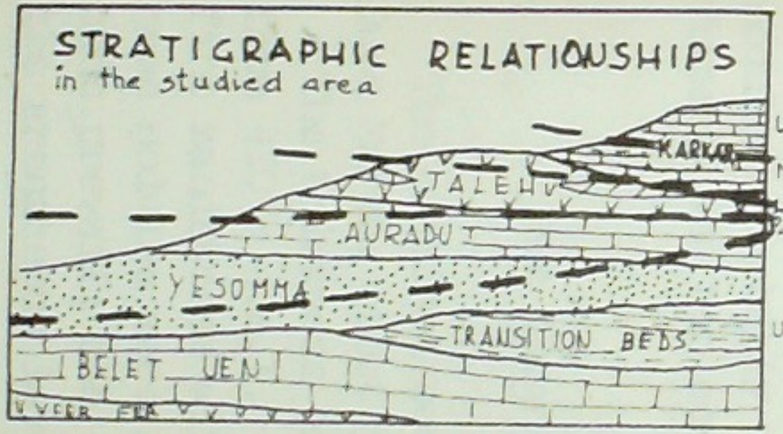
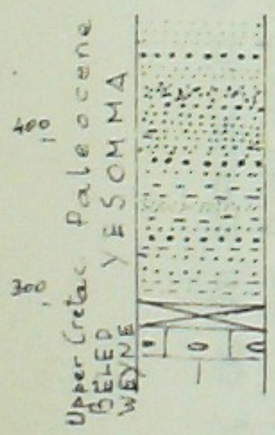
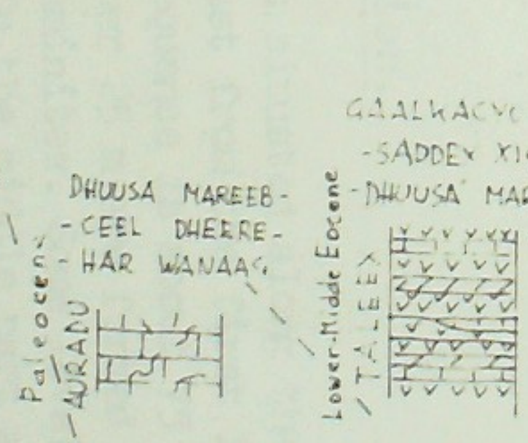


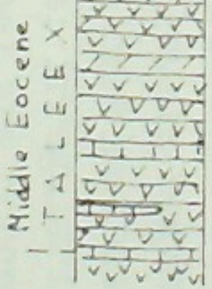
FIG. 2 -

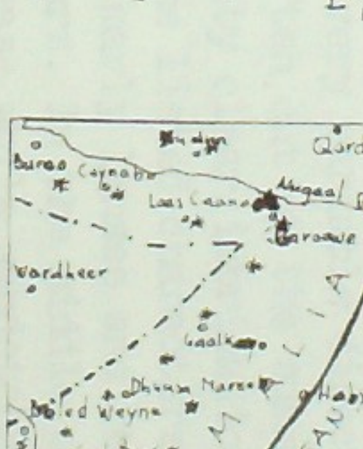
THE PALEOGENE OF CENTRAL SOMALIA

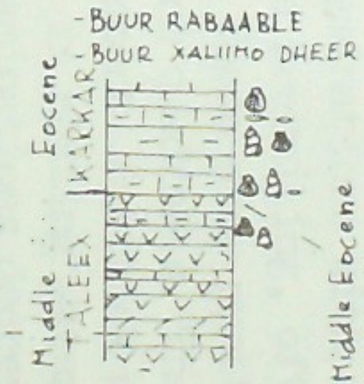


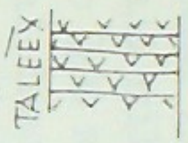


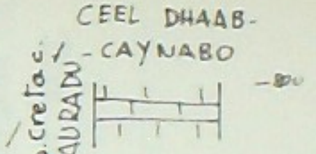


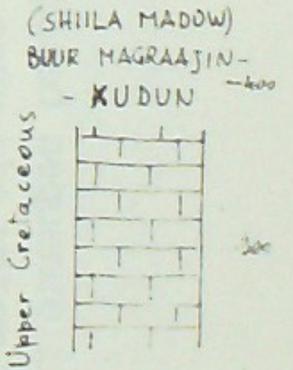


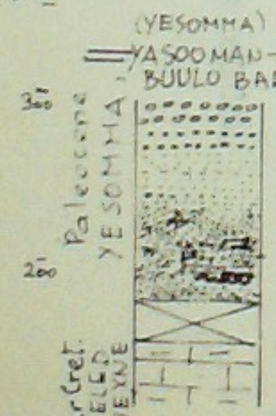


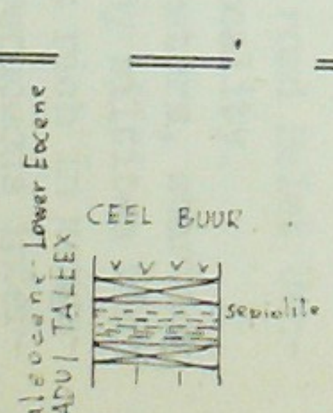


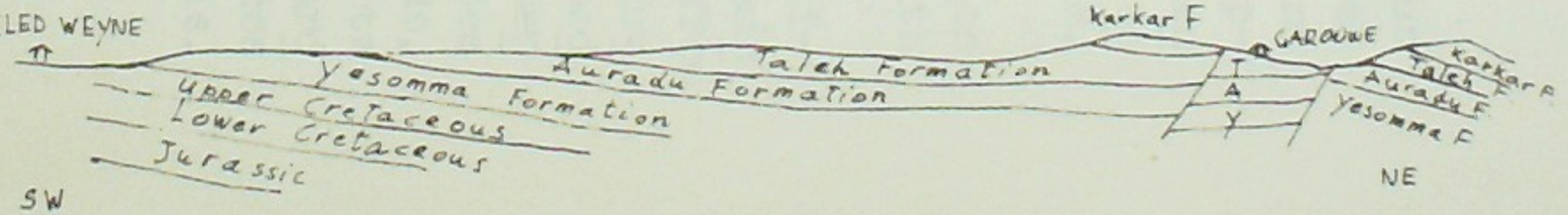












Yesomma section.

The lowest part of the exposed sequence is found at about 220 meters on the sea level, near the water well situated below Yesomma village, NE of Bulo Burti (Buulo Barde). The ruins of a small military fort are still in place. It follows upwards to 300 m o.s.l., near the village. The detailed sedimentological description of this series and the microscopical observations shall be exposed in a later work. (A.ANGELUCCI, M. C.CARUSH, G.MEZZADRI, in preparation).

The basal part of the formation is made of an alternation of siltstones and fine grained to medium size sandtones, with conglomeratic lenses. Sedimentary structures are evident.

Cross laminations with very variable directions and inclinations are prevailing, often cut at the summit by coarse grained levels. These show pretty clear imbrications determined from the northern quadrants. The listed characters indicate a fluvial environment. Cm-thick marly lenses and levels testify sedimentation in resting waters. In the middle part of the sequence cross laminations decrease while sandstones and siltites with burrows and parallel laminations predominate. Upwards, near the village, coarser levels begin to prevail with quartz grains to diameter of some centimetres, alternating with hardly cemented quartzarenites; irregularly scattered dark oxides nodules (probably manganese) are concentrated in some levels. Towards the top conglomerates predominate.

Bur Qamno section.

The examined section is situated along the road Belet Uen-Dusa Mareb, about 50 km east from the first locality.

The thickness of the sequence is about 75 meters, starting from 410 m o.s.l. The lower 25 m are formed by siltites with fine sandstones without laminites. Some levels rich in manganese nodules were found. In the middle part arenaceous interbeds prevail; the siltites show many burrows. Towards the top the arenaceous layers have thickness up to 3 m each.

The sequence is closed by siltitic banks with nodular structures and then by siltites with cross lamination, containing manganese nodules.

Sedimentation environment and age.

The described sequences and other scattered minor outcrops allow to state a continental environment of sedimentation.

Fluvial conditions with various energy situations are inferred. In the type locality channel bar characters are recognized, whilst in other places alluvial plan environment is to be stated.

In the studied area the base of the formation can be assigned to the Coniacian-Campanian, by stratigraphic position; the top is to be regarded as Paleocene, maybe Middle Paleocene.

Auradu Formation.

This formation extends in a 50 km wide belt between Guri Ceel and Dusa Mareb (Dhuusa Mareeb), with a N-S direction, toward Hargeysa. Its outcrops are very poor, in a flat area covered by extended Quaternary cover. It has been not possible to study a continuous sequence and our observations refer therefore to short successions. The research is made more difficult by the many carstic phenomena at various scale, which obliterate the characters of the original rock and give to it a brecciated facies. Extended deposits of "caliche", residual limestone of concretionate type with vadous pisolites in a residual reddish silt, are common.

As it has been said in the forewords, due to the important carstic and weathering phenomena, some authors have erected a new formation, ("Mudugh Beds"); the carstic phenomena were referred to Miocene and Post-Miocene times. We prefer to maintain the original formation name in the area, because the original rock can still be recognized, where it is not deeply carstified, as it happens in many places all over the region,

and because of the likely old age of the carstification, which should have started soon after deposition. In the northern area of the studied region the carstic phenomena are restricted to the basal part of the complex, which is there very thick (up to 1000 m) and has the lower part of a Cretaceous age.

The prevailing rocks of the formation are micritic limestones of a whitish or pale grey colour or detrital limestones with laminae; sometimes are dolomitized and recristallized.

In the detrital limestones quartz rounded clasts are present. No determinable macrofossil has been found.

The Upper Cretaceous age of the formation in the northern part of the area is confirmed by foraminifera recognized in some samples around Hudun (Xudun).

Sedimentation environment and age.

The observed facies indicate a carbonatic platform environment; emersions are proved by paleocarstic phenomena.

The base of the formation has an Upper Cretaceous age in the Nugal Valley; in the southern part it is assigned to the Paleocene, resulting therefore diachronous. The top of the formation reaches everywhere a Lower Eocene age.

Taleh Formation.

The Taleh (Taleex) Formation is the widest complex as extension area of the whole stratigraphic sequence of Somalia.

In the studied region from Dusa Mareb it continuates almost without interruption to the Nugal Valley and crops out again northwards, in less continuous areas. It decreases to disappearence in the northeastern edge of Somalia. The best outcrops are found North of Galcaio (Galkacyo) and in the Nugal Valley, where stratigraphic series have been measured.

In the surroundings of Las Anod (Laas Caanood) thick gypsous levels are cropping out; swelling phenomena of diapiric origin are not seldom. They seem to be due to hydratation of

anhydrite into gypsum.

Bur Halimo Dher section.

The most complete sequence of the formation has been observed at Bur Halimo Dher (Buur Xaliimo Dheer), 10 km South of Rabable, about 30 km Southwest of Garoe (Garoowe). The observed thickness is about 120 m, from 625 m o.s.l.

The lower part is formed by prevailing gypsum, in mm thick laminae, sometimes undulated. They alternate with thin clayey levels. Swelling of the evaporite simulates carstic phenomena (pseudocarstism).

Upwards about 20 m of marls and shales contain gypsarenitic intercalations. In the lower marls many fossils are contained (a.o. Nummulites, Discocyclina, Molluscs, Echinidae). Still upwards 10 meters of layered gypsarenites follow, then shales and gypsum alternate. Vertically isoriented gypsum cristals are formed by recristallization. The summit 10 m of the sequence are given almost only by gypsum sandstones, with some burrows.

Sedimentation environment and age.

The sedimentary sequence suggests an environmental evolution from sebha to a more typical evaporitic situation, with locally marine clastic deposition, sometimes with rich fossil faunas. Toward the end of the sequence in some places a coarser clastic deposition has interrupted temporary the avaporitic sedimentation, which elsewhere continues to the top of the formation.

The age of the formation is known to extend from Lower Eocene to Middle Eocene. The fossils collected at the base of Bur Halimo Dher indicate a Middle Eocene age, as far as preliminary determinations have shown.

Karkar Formation.

The formation extends in a WNW - ESE belt in the southern side of the Nugal Valley and follows eastwards in Northeastern most Somalia, to the edge of the Horn of Africa.

The contact between Taleh and Karkar Formations have been observed in details in two places, 25 km West of Garoowe and near Rabable.

In the first place up to 510 m o.s.l. evaporites of the Taleh Formation are cropping out. On them 20 m of rocks of the Karkar Formation are lying. These are formed by limestones and marls without gypsum. Downwards micritic limestone (10 m about) with chert and detritic limestone with bioclasts are prevailing. The echinid Sismondia is not seldom. Upwards 10 more meters of prevailing biocalcarenites contain chert lenses; micritic limestone, nodular marly limestone and fine grained detrital limestone are also present; parallel laminations have been observed.

Near Rabable the contact is found at about 620 m o.s.l.; where the upper evaporitic levels are covered by marly limestones, micritic limestones, marls, with calcarenitic layers.

Also in other observed sections micritic limestones alternate with marly limestones and marls, sometimes rich in fossils.

Rabable section.

At about 8 km South of Rabable (Rabaable) the Karkar Formation is well exposed for a thickness of 70 meters. The lower 50 m are given by alternating loose and nodular marls, rich in fossils described in the next item, to which 20 m of nodular marly limestones and micritic limestones with some vesicularity follow, closing upwards the exposure.

The fossils of the lower part of Rabable section were determined by L.ALTICHIERI: Vulsella aegyptiaca OPPH., Chlamys hopkinsi (D'ARCH.), Lucina pharaonis BELLARDI, Lucina thebaica ZITTEL, Xenophora cumulans (BRONGN.), Natica bazarkoiensis

D'ARCH., Cerithium tchihatcheffi D'ARCH., Cassidea cf. nilotica BELLARDI, Gisortia (Vicetia) gigantea MUENSTER, Terebellum sp., Cypraea sp., Pinna sp., Ostrea sp., Amusium sp.,and other indeterminable Molluscs, individual Corals and Echinides. All the listed species were already known from Somalia (see: GIANNINI, 1955). The prevailing species distribution is Middle Eocene; some of them extend also to Lower Eocene or respectively Upper Eocene of Europe, Northern Africa, Arabia, Iraq, India. The Middle Eocene age is proved.

Sedimentary environment and age.

The sedimentary environment of the Karkar Formation was infralittoral (epineritic), with carbonatic sedimentation and periodical detrital feeding from nearby emerged areas.

The Middle Eocene age of the basal part of the formation was confirmed by our reasearch. From the literature is well known the extension upwards to Upper Eocene of the formation. Microformainifera and macrofossils collected during our excursion are now under study.

PALAEOGEOGRAPHIC CONSIDERATIONS AND CONCLUSIONS.

The reconstruction of the palaeogeographic evolution of the Somali area has been made possible by the knowledge gathered from the geologic literature and the data gained from the drilled wells for hydrocarbons.

During the Paleocene a wide emerged area extended in the Central and Southern part of the country. Three different portions can be distinguished; the southernmost part was siege of an abundant sedimentation of continental and transitional deposits (Lach Dera Formation, known only from the underground). The prevailing rocks are sandstones and siltstones.

At the northern side of the Baardheere - Jilib line, which is almost normal to the today coast of the Indian Ocean, an

FIG. 3 - EARLY PALEOCENE
Facies Distribution

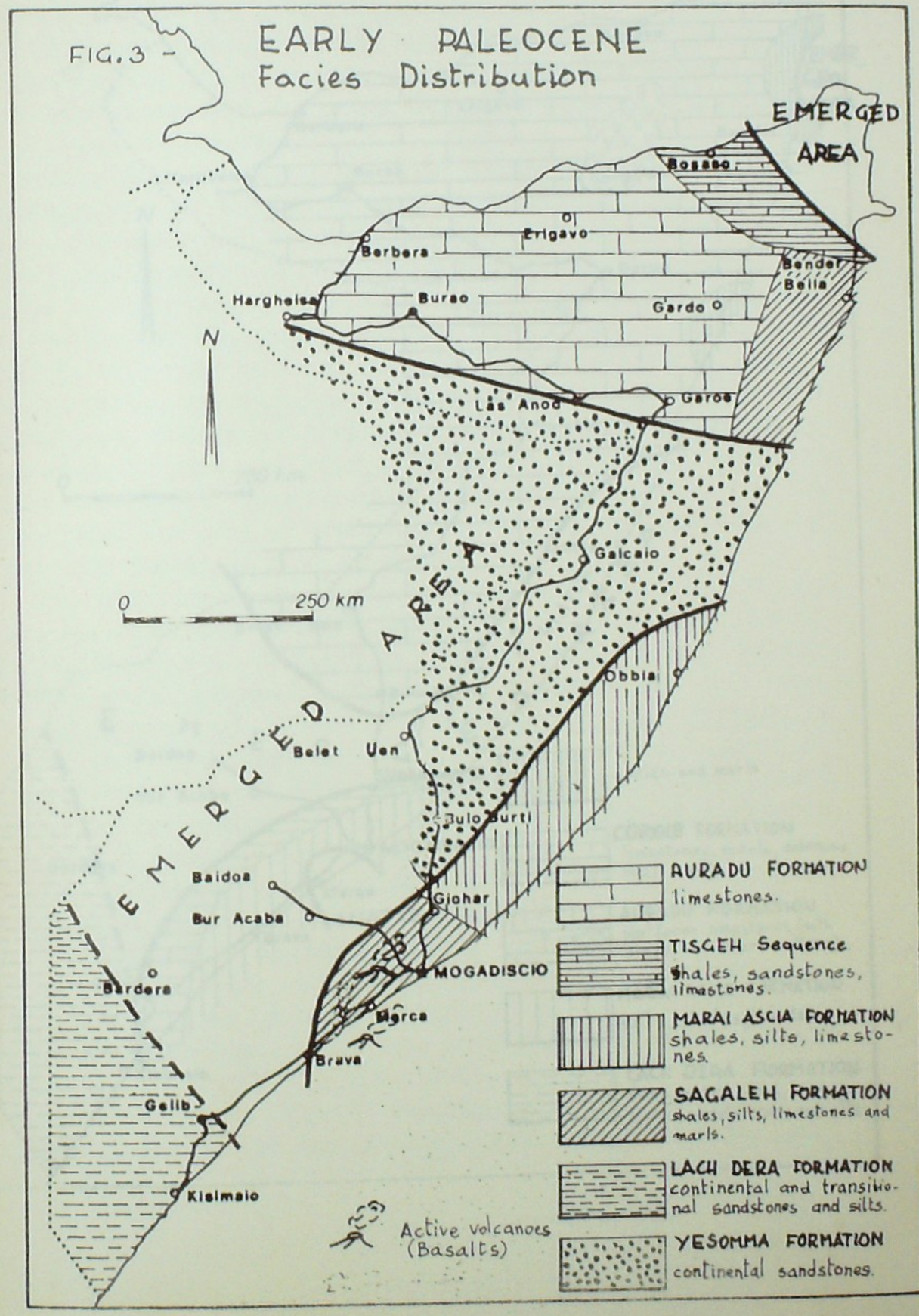
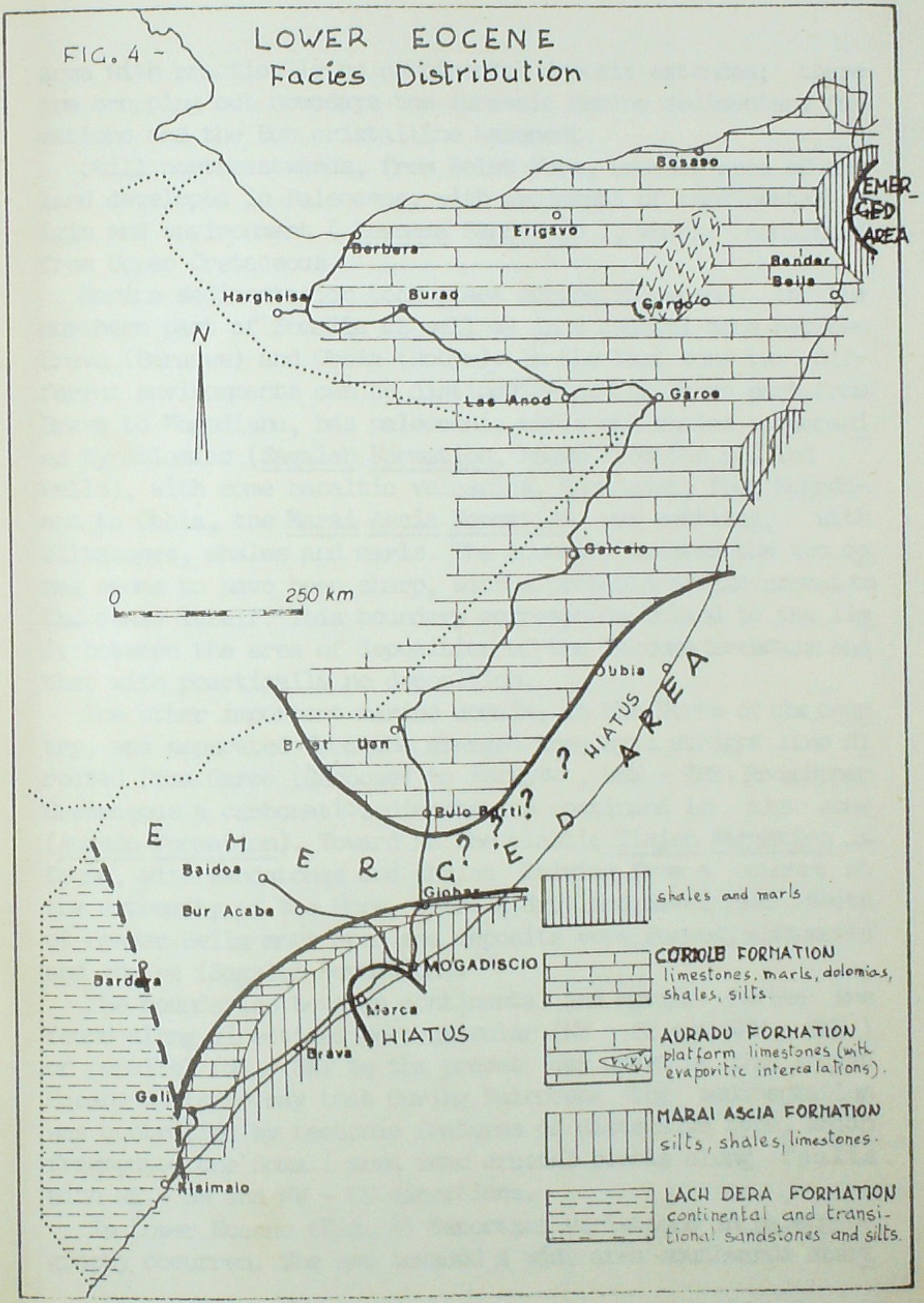


FIG. 4 -

LOWER EOCENE
Facies Distribution



area with practically no continental deposit extended; there are cropping out nowadays the Jurassic marine sedimentary formations and the Bur cristalline basement.

Still northeastwards, from Belet Weyn, another area of dry land developed in Paleocene, with sediments of continental origin and environment (Yesomma Sandstone), which continued from Upper Cretaceous.

Marine sedimentation took place during Paleocene in the northern part of Somalia as well as in a coastal zone between Brava (Baraawe) and Obbia (Hobyo). In the last zone two different environments can be distinguished. A southern part, from Brava to Mogadishu, has paleocenic marls and shales accompanied by dolomias (Sagaleh Formation, known from the drilled wells), with some basaltic volcanics. Northeast, from Mogadisho to Obbia, the Marai Ascia Formation was settling, with siltstones, shales and marls. The boundary between the two zones seems to have been sharp, with a probable strike normal to the coast itself. This boundary corresponds inland to the limit between the area of deposition of the Yesomma Sandstone and that with practically no deposition.

The other important marine domain, in the North of the country, was separated from the emerged area by a stright line directed from Garoe (Garoowe) to Hargysa , WNW - ESE. From Upper Cretaceous a carbonatic sedimentation continued in the zone (Auradu Formation). Toward NE the clastic Tisjeh Formation is found, with sandstones and shales driving from a source at the extremity of the Horn, where a dry land developed. South of Bender Beila more open sea deposits were formed, with marls and shales (Sagaleh Formation).

The boundaries between continental and marine facies are found along directions prependicular (NW - SE and WNW - ESE) or parallel (NE - SW) to the preset day coast of the Indian Ocean. It is to say that during Paleocene the sedimentation was controlled by tectonic features of distensive type, which fragmented the Somali area into crustal blocks along faults with NE - SW and NW - ES directions.

In Lower Eocene (Fig. 4) important variations in paleogeography occurred. The sea invaded a wide area southwards start-

ing from the northern part of Somalia and a wide platform was formed, where carbonatic sedimentation developed in the area formerly covered by the continental sandstones of the Yesomma Formation. The dry land reduced its extension far southwards.

The southern boundary of Auradu limestones is parallel and near to the former (Paleocene) boundary between bare area and Yesomma sedimentation area, as well as to the former boundary between Marai Ascia and Sagaleh Formation (coastal area).

The same limits represent in Lower Eocene the northern boundary between a sedimentary area and a zone with sedimentary hiatus northwards. The sedimentation (between Kisimayo and Jowhar) is of carbonatic type in the near offshore (Coriole Formation) and marine clastic, of deeper sea, seawards (Marai Ascia Formation). The second listed deposits were found in Paleocene more northwards.

The tectonic line we are dealing with separated two crustal blocks with a different behaviour. The northern side has shown a stratigraphic gap in Lower Eocene all along the zone extended between Mogadishu and Obbia, where coastal deposits were meet in Paleocene.

Narrow areas around Garad and Hafun received marly or shaly deposits.

In the southwestern part of Somalia the Lach Dera Formation ontinued to be deposited beyond the line Baardheere - Jilib, with a continental and transitional sedimentation which compensated the subsidence.

Also in Lower Eocene the tectonic directions NW - SE and NE - SW control the sedimentation. Movements parallel to the coast of the Indian Ocean occurred, while the NW - SE faults separated blocks with opposite tilting. An example is the line Jowhar - Belet Weyn; the northern block was being tilted towards NW, the southern block towards SE.

In Middle Eocene (Fig. 5) a general uplifting of the region occurred. The emerged area widens to Galcaio (Galkacyo). North of a line directed NW - SE evaporitic deposition took place (Taleh Formation). These deposits make transition to sea sediments to NE, near Bosaso and to East, where bands of deposits of carbonatic (Coriole Formation), then siltitic and carbona-

FIG.5 - MIDDLE EOCENE
Facies Distribution

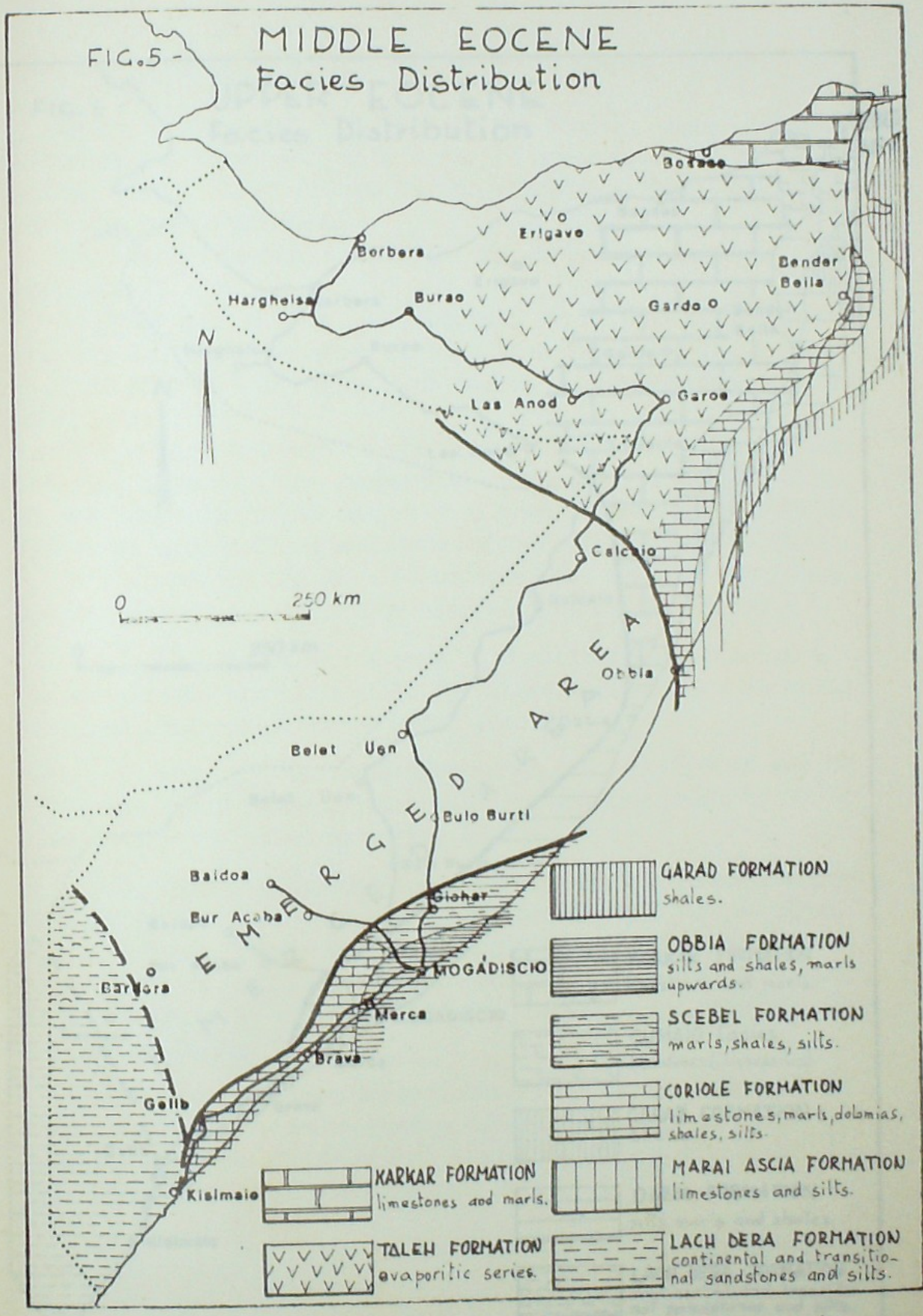
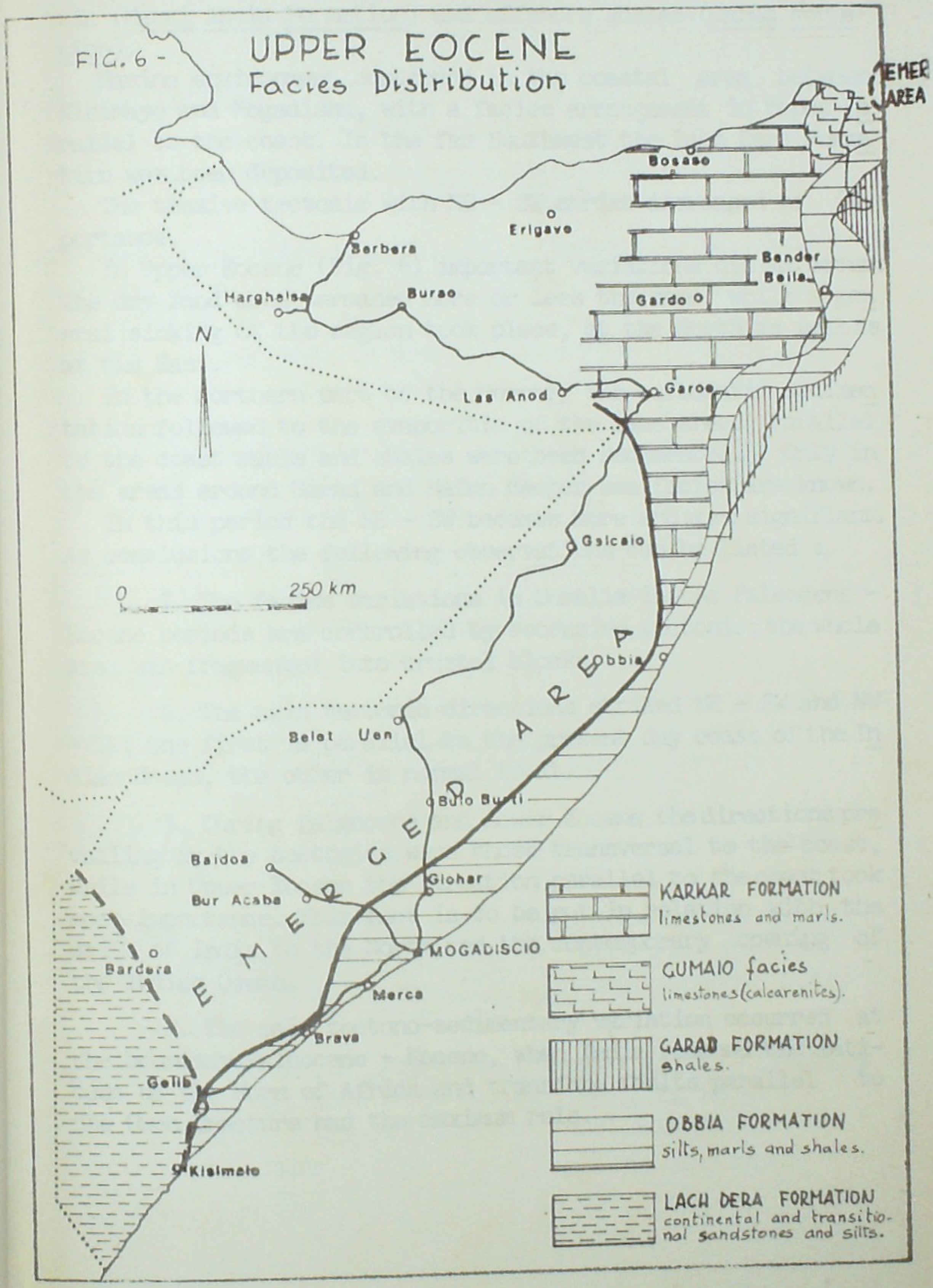


FIG. 6 -

UPPER EOCENE
Facies Distribution



tic (Marai Ascia Formation) and offshore shales (Garad Formation).

Marine environment continued in the coastal area between Kisimayo and Mogadishu, with a facies arrangement in bands parallel to the coast. In the far Southwest the Lach Dera Formation was been deposited.

The tensive tectonic with NE - SW strike increased of importance.

In Upper Eocene (Fig. 6) important variations did not occur. The dry land area permaned more or less the same, while a general sinking of the region took place, at the North as well as at the East.

In the northern part of the country the carbonatic sedimentation followed to the evaporitic of the same area. Parallel to the coast marls and shales were been sedimented. Only in the areas around Garad and Hafun deeper sea facies are known.

In this period the NE - SW becomes more and more signifiant. As conclusions the following observations can be listed :

I. The facies variations in Somalia in the Paleocene - Eocene periods are controlled by estensive tectonic; the whole area was fragmented into crustal blocks.

2. The main tectonic directions striked NE - SW and NW - SE; the first is parallel to the present day coast of the Indian Ocean, the other is normal to it.

3. During Paleocene and Lower Eocene the directions prevailing in the tectonics were those transversal to the coast, while in Upper Eocene the direction parallel to the coast took more importance. This fact is to be put in relation with the drift of India to the North and the contemporary opening of the Indian Ocean.

4. The main tectono-sedimentary variation occurred at the boundary Paleocene - Eocene, when India reached the latitude of the Horn of Africa and transform faults parallel to the Owen fracture had the maximum role.

REFERENCES

AGIP MINERARIA - AGIP SOMALIA, I957 - I977 - Reports. Agip Mineraria, unpublished, Mogadiscio.

ANDREWS S.M., I968 - Final reports. Sinclair Somal Corp., unpublished, Mogadiscio.

ANGELUCCI A., BARBIERI F., CABDULQAADIR MAXAMUUD MAXAMED, MAXAMUUD CABDI CARUSH, PICCOLI G., 1980 - Preliminary report on the Jurassic sequence in the Gedo and Bay Regions (Sout western Somalia). Quaderni Geol. Somalia, vol. 4, pp. 115 - 154, 9 ff., Mogadiscio.

AXMED YUUSUF ISMACIIL, I980 - Studio giacimentologico della formazione uranifera di Dusamareb. Univ. Naz. Somalia, Fac. Geologia, unpublished graduation work, Mogadiscio.

AZZAROLI A., I948 - Alcune Alveoline dell'Eocene inferiore della Migiurtinia. Atti Soc. Toscana Sc. Nat., Vol. 55 pp. 228 - 236, 2 ff., Pisa.

AZZAROLI A., I950 - I macroforaminiferi della serie del Carcar (Eocene medio e superiore) in Somalia e la loro distribuzione stratigrafica. Palaeontogr. Ital., Vol. 47, pp. 99 - I3I, I3 ff., I4 pl., Pisa.

AZZAROLI A., I957 - Missione geologica in Migiurtinia. La Ric. Sc., Vol. 27; pp. 30I - 346, 39 ff., Roma.

AZZAROLI A., I958 - L'Oligocene e il Miocene della Somalia. Stratigrafia, Tettonica, Paleontologia (Macroforaminiferi, Coralli, Molluschi). Palaeontongr. Ital., Vol. 52, pp. I - I43, 34 ff., 26 pl., Pisa.

AZZAROLI A., I97I - Somalia. Geologia. E.N.I., Encicl.Petrol. Gas Nat., Vol. 8, pp. 780 - 784, 3 ff., I pl., Colombo, Milano.

AZZAROLI A. & FOIS V., I964 - Geological outlines of the Northern end of the Horn of Africa. Int. Geol. Congr. - Rep. XXIII Sess., India, Vol. 4, pp. 293 - 3I4, ff. 8, New Dheli.

AZZAROLI A. & MERLA G., I958 - Carta geologica della Somalia e dell'Ogaden. Scale I:500.000. Agip Mineraria & C. N.R., Litogr. Art. Cartogr., Firenze.

AZZAROLI A. & MERLA G., I960 - Carta geologica della penisola somala. Scale I:4.000.000. Agip Mineraria & C.N.R., Litogr. Art. Cartogr., Firenze.

BARBIERI F., CABDULQAADIR M.M., DI GERONIMO I., FAADUMA C.CAYNAB, GIULINI P., MAXAMUUD C.CARUUSH, MICHELINI G., PIÇCOLI G., I979 - Il Cretaceo della regione di Hiiran in Somalia (valle dello Webi Shabelle), con appendice sulla foresta fossile di Sheekh Guure. Mem. Sc. Geol., Vol.32, 23 pp., I6 ff., 3 pl., Padova.

BARNES S.U., I976 - Geology and oil prospects of Somalia, East Africa. Bull. Amer. Ass. Petrol. Geol., Vol. 60, pp. 389 - 4I3, IO ff., Tulsa (Okla.).

BELTRANDI M. & PYRE A., I973 - Geological evolution of Southwest Somalia. In BLANT G., ed., Sedimentary basins of African coast, 2: South and East Africa, pp. I52-I78, IO ff., Ass. Serv. Geol. Afric., Paris.

BIGNELL R., I977 - Petroleum developments in Central & Southern Africa in I976. Bull. Amer. Ass. Petrol. Geol., Vol. 6I, pp. I746 - I794, 30 ff., Tulsa (Okla.).

CABDI SAALAX XUSEEN, I978 - Ricerche e prospettive petrolifere nel bacino di Mogadiscio. Univ. Naz. Somalia - Fac. Geologia, unpublished graduation work, Mogadiscio.

CANUTI P. & MARCUCCI M., I969 - Microfacies aptiens - albiens de l'Ahl Medo et de Candala (Somalie). Proceed. Third African Micropaleont. Coll., pp. 549 - 559, I pl., Cairo.

CHECCHIA-RISPOLI G., I942 - "Migliorinia", nuovo genere di Echinide dell'Eocene della Migiurtinia. Acc. Italia, Rend. Cl. Sc. Fis. Mat. Nat., VII s., Vol. 3, pp. 305 - 309, 3 ff., I pl. Roma.

CHECCHIA-RISPOLI G., I943 - Brissoidi eocenici della Migiurtinia. Atti Acc. Italia, Mem. Cl. Sc. Fis.,Mat.,Nat. Vol. I4, pp. 99 - III, 3 pl., Roma.

CHECCHIA-RISPOLI G., I946 - Su alcuni resti di Crostacei Brachiuri dell'Eocene della Migiurtinia. Boll.Uff.Geol. Italia, Vol. 69 (I944); pp. I09 - II3, 3 ff., Roma.

CHECCHIA-RISPOLI G., I950 - Su alcuni Echinidi eocenici della Migiurtinia. Boll. Uff. Geol. Italia, Vol.70, pp. 2I - 43, 2 pl., Roma.

CLIFT W.O., I956 - Sedimentary history of the Ogaden district Ethiopia. XX Congr. Geol. Intern., Symp. Yacim. Petroleo Gas Nat., Vol. I, pp. 89 - II2, 5 ff., Mexico.

DAINELLI G. & TAVANI G., I956 - Somalia italiana. Lexique Stratigr. Intern., Vol. 4 (5), pp. 37 - 5I, Paris.

DUCCI E. & PIRINI RADRIZZANI C., I969 - Stratigraphy and micropaleontology of some Cretaceous and Lower Eocene formations from the Midjurtinia region (Somalia). Proceed. Third African Micropaleont. Coll., pp. 535 - 547, 2 pl., Nidoc, Cairo.

FORTELEONI PIAMONTI G. & PIRINI RADRIZZANI C., I975 - Microfaunas from the Karkar Formation (Somaliland). Proceed. Fifth African Coll. Micropaleont., Addis Abeba, I972, Rev. Espan. Micropalent., VII s., Vol. 3, pp. 385 - 4I5, I f., 8 pl., Madrid.

GIANNINI E., I955 - Molluschi eocenici della Migiurtinia. Palaeontogr. Ital., Vol. 32, suppl. 7, pp. 23 - 45, 3 pl., Pisa.

HILAL A.F., PVAN G. & ROBBA E., I977 - Geologia stratigrafica della Somalia. Quaderni Geol. Somalia, Vol. I, pp. I9 - 50, I pl., Mogadiscio.

HUNT J.A., I956 - British Somaliland. Lexique Stratigr.Intern. Vol. 4 (5), pp. 3 - 27, Paris.

IBRAAHIM MAXAMED FAARAX, I980 - Caratteristiche geologiche ed idrogeologiche della bassa valle del Nugal da Garoowe ad Eyil. Univ. Naz. Somalia, Fac. Geologia, unpublished graduation work, Mogadiscio.

KAMEN-KAYE M., I978 - Permian to Tertiary faunas and paleogeography; Somalia, Kenya, Tanzania, Mozambique, Madagascar, South Africa. Journ. Petrol. Geol., Vol. I, pp. 79 - IOI, 9 ff., Beaconsfield (Bucks).

KAMEN-KAYE M. & BARNES S.U., I979 - Exploration geology of Northeastern Africa-Seychelles basin. Journ. Petrol. Geol., Vol. 2, pp. 23 - 45, 9 ff., Beaconsfield (Bucks).

KAMEN-KAYE M. & MEYERHOFF A., I980 - Petroleum geology of the Mascarene Ridge, Western Indian Ocean. Journ.Petrol. Geol.. Vol. 3. pp. I23 - I38. 6 ff.. Beaconsfield -

KIER P.M., I957 - Tertiary Echinoidea from British Somaliland. Journ. Paleont., Vol. 3I, pp. 835 - 902, 20 ff., 5 pl., Tulsa (Okla.).

KOZERENKO V.N. et al., I970-72 - Geological map of Somalia. Scale I:I.000.000, U.N.D.P., Min.Ris.Min.Idr., unpublished, Mogadiscio.

LYONS P. & BENNISON A., I960 - Somalia. Geological-gephysical report. Sincalir Somal Corporation, unpublished, Mogadiscio.

MACFADYEN W.A., I935 - The geology and paleontology of British Somaliland. Govt. Brit. Somaliland, 7 pp., 4 pl.London.

MAXAMED XASAN XAAJI AXMED, I978 - Ricerche e prospettive petrolifere del bacino del Darror. Univ.Naz. Somalia, Fac. Geologia, unpublished graduation work, Mogadiscio.

MERLA G., ABBATE E., AZZAROLI A., BRUNI P., CANUTI P., FAZZUOLI M., SAGRI M., TACCONI P., I979 - A geological map of Ethiopia and Somalia (I973) and Comment. C.N.R., 95 pp., 36 ff., 2 geol. maps I:2.000.000, Centro Stampa, Firenze.

NUTTALL W.L.F. & BRIGHTON M.A., I93I - Larger Foraminifera from the Tertiary of Somaliland. Geol. Mag., Vol.68, pp. 49 - 65, 3 ff., 4 pl., London.

PICCOLI G. & HILAL C.F., I978 - Quaderno di paleontologia della Somalia. Quaderni Geol. Somalia, Vol. 2, pp.I-44, Mogadiscio.

PLUMHOFF F., I967 - Reports. Deutsch. Erdoel-Aktienges.(D.E.A. unpublished Mogadiscio.

POPOV A.P., KIDWAI A.L. & KARRANI S.A., I973 - Groundwater in Somali Democratic Republic. U.N.D.P., unpublished, Mogadiscio.

ROMPETROL, I975 - Considerations on the oil prospects of the Democratic Republic of Somalia. Unpublished, Bucarest.

RUGGIERI G., I950 - Foraminiferi del genere Sakesaria nel Paleocene della Migiurtinia. Giorn. Geol., Volume 2I (I949), pp. 94 - 98, 7 ff., Bologna.

SAACDIYA CARIIF QAASIM, I980 - Studio geologico della bassa valle del Nugal sulla base delle immagini Landsat, con rapido controllo sul terreno. Univ. Naz.Somalia Fac. Geologia, unpublished graduation work, Mogadiscio.

SILVESTRI A., I937 - Foraminiferi dell'Oligocene e del Miocene della Somalia. Palaeontogr. Ital., Vol. 32, suppl. 2, pp. 45 - 264, I9 pl., Siena.

SILVESTRI A., I938-I948 - Foraminiferi dell'Eocene della Somalia. Paleontogr. Ital., Vol. 32, suppl. 3 (I938)pp. 49 - 89, IO pl.; suppl. 4 (I939), pp. I - IO2, pl. I2; suppl. 5 (I942), pp. I - 94, 9 pl.; suppl. 6 (I948), pp. I - 56, 5 pl.; Siena - Pisa.

SOCIN C., I957 - Fauna echinologica dell'Oligo-Miocene somalo. Palaeontogr. Ital., Vol. 32, suppl. 7, pp. I - 22, I pl., Pisa.

SOMALILAND OIL EXPLORATION COMPANY, I953 - A geological reconnaissance of the sedimentary deposists of the Protectorate of British Somaliland. Crow, Agents, 42 pp., 5 ff., 3 pl. (geologic map I;I.000.000), London.

SOMMAVILLA E., I977 - Geologia strutturale della Somalia. Quaderni Geol., Somalia, Vol. I, pp. 60 - 93, Mogadiscio.

SPRAUL G.L., I959 - African Horn basin. Amerada Petroleum Corp. unpublished, Tulsa (Okla.).

STEFANINI G., I937 - Cenni sulle località fossilifere oligoceniche e mioceniche della Somalia. Palaentogr. Ital., Vol. 32, suppl. 2, pp. I - 24, 2I ff., Siena.

STEFANINI G., I938 - Cenni sulle località fossilifere eoceniche della Somalia. Palaentogr. Ital., Vol. 32, suppl. 3, pp. I3 - 47, I2 ff., Siena.

TAVANI G., I949 - Fauna malacologica cretacea della Somalia e dell'Ogaden. II. Palaentogr. Ital., Vol. 45, pp. I - 76, ff. 4, II pl., Pisa.

THE GEOLOGICAL SURVEY TEAM OF THE PEOPLE'S REPUBLIC OF CHINA, I972- Report on the petroleum and coal survey in the Somali Democratic Republic, 39 pp., IO ff., I3 pl., Peking.

THE SCIENTIFIC STAFF, 1972 - Deep Sea Drilling Project: Leg 23; Leg 24; Leg 25. Geotimes, Vol. 17 (7), pp. 22-26, 4 ff.; (9); pp. 17 - 21, 2 ff.; (11); pp. 21-24, 3 ff.; Washington (D.C.).

ZUFFARDI COMERCI R., 1937 - Corallari oligocenici e miocenici della Somalia. Palaeontogr. Ital., Vol. 32, sup pl. 2, pp. 265 - 301, 4 pl., Siena.

ZUFFARDI COMERCI R., 1948 - Corallari e Briozoi eocenici della Somalia. Palaeontogr. Ital., Vol. 32, suppl. 6, pp. 57 - 62, I pl., Pisa.