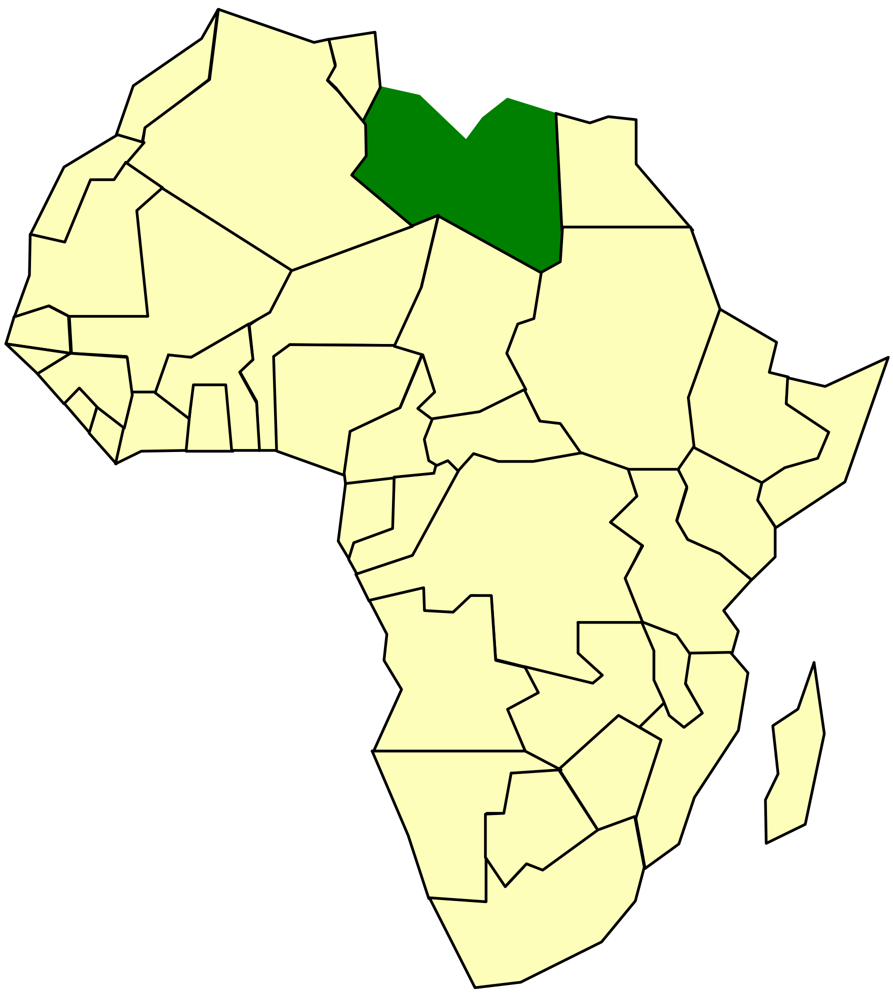
A Guide To

Macrofossil Localities of Libya, Africa

with notes on mineral sites



2000
(with some added material in 2002)

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NOTE FROM THE AUTHOR

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1) FOSSILS AND THE GEOLOGICAL CONTEXT OF LIBYA

In Libya, the Devonian and Carboniferous periods are represented by rocks of marine and continental origin. The Early Devonian Tadrart Sandstone (Fig. 4) contains plant remains and might be expected to yield agnathan and placoderm fishes. The continental Carboniferous sandstone of the Kufra basin (Figs. 1 & 2) is likewise devoid of fish remains. So while there is potential for vertebrate preservation in the Palaeozoic strata none has yet been realized.

The Mesozoic strata are dominated by the “Nubian Sandstone”. This non-marine succession of thick sandstones with interbedded shales is essentially of fluvio-continental origin and is one of the most extensive formations in Africa. Fossilized wood is common in the deposit but vertebrates have yet to be found.

In rocks of cenozoic age fishes, reptiles, birds and mammals are all recorded. Among the fishes, sharks predominate in the marine environment while mostly catfish are found in the fresh-water environment. Fresh-water fishes frequently occur in the mammalian facies of both Eocene to Miocene age. Large crocodiles and turtles abound in the fluviatile facies of Eocene and Miocene age. Some of the crocodiles from Jebel Zelten (see below) were about 8 meters in length, which is equal to the largest Nile crocodiles.

Bird remains are relatively rare compared with those of other major classes of vertebrates: both some wading and large running birds occur in tertiary strata, and ostrich egg shells abound in post-Pleistocene deposits.

All the known fossil mammals of Libya are of Cenozoic age (fig. 5). They occur in marine, fluviatile, lagoonal and continental environments, ranging in age from eocene times onward. Libya is the only country in Africa to have mammalian faunas in strata of all succeeding ages -- Eocene, Oligocene, Miocene, Pliocene and Pleistocene. No Mesozoic mammals are known from Libya despite the widespread non-marine “Nubian” whose partial temporal equivalent south of the equator (the Karroo) is so richly fossiliferous. The discovery of a “Nubian” mammal fauna would be of major importance to the understanding of mammalian evolution on the African continent (Savage, 1971).

2) MACROFOSSIL BEARING FORMATIONS OUTCROPPING WITHIN THE ONSHORE GEOLOGICAL BASINS

In Libya, four onshore geological basins and one offshore basin are present. They are: Al Kufrah, Ghadamis, Murzuq, Sirte and Sabratah (offshore) (fig. 2). The following discusses the outcropping formations of the four onshore Basins containing macrofossils. Note: The figures shown in this document illustrate the most important aspects of the stratigraphy of Liya; however, if you wish to acquire a large scale poster on this subject, please contact Agat Laboratories in Calgary.

AL KUFRAH BASIN

Al Kufrah basin in southeast Libya forms an elongate depression oriented northeast-southwest, with an aerial extent of about 400,000 km2 . The basin fill attains a maximum thickness of 2600 m and comprises a sequence of Paleozoic sediments unconformably overlain by Mesozoic strata and has remained land since the end of Paleozoic times. The center of the basin is sand covered and except for a few small isolated hills of Cretaceous Nubian sandstone outcrops are limited to the north, southeast (fig. 3) and southwest of Al Kufrah oasis. The base of the Paleozoic succession is exposed only in the southeast and southwest where it rests unconformably on Precambrian basement. Thickness estimates suggest that about 1850 m of Paleozoic strata are present in the southwest, compared with 1650 m in the north and 1055 m in the southeast (Turner, 1980).

Binem Formation: Middle-Upper Devonian. The type locality is at Wadi Binem or Wadi Ounga. At Latitude 23 15’ 25” and Longitude 24 23’38” the basal sandstones of the Binem Formation display very common traces and remains of plants, even longer than 1 meter (Bellini et al., 1980). At Latitude 25 47’ 50” and Longitude 23 52’ 30” the Binem displays Nuculoid bivalves of the genus *Kufralaria* (Termier et al. 1980).

Dalma Formation: Carboniferous. The type locality is at Jabal az Zalmah, 160 km NNE of Al Kufrah. At Latitude 23 45’ 07” and Longitude 24 37’ 30” the siltstones and conglomerates of the Dalma Formation display numerous plant remains (Licopodophyta) and roots.

Unknown: Continental Mesozoic. At latitude 22 22’ 55” and Longitude 19 51’ 35” are found in some beds fragments of silicified wood, sometimes small trunks some 20-40 cm long (*Dadoxylon*). These remains are actually observed along the whole belt of the Continental Mesozoic outcrops. (Bellini et al. 1980).

GHADAMIS (Al Hamadah al Hamra) BASIN (including Jifarah Plain & Jabal Nafusah)

The Ghadamis basin received sediments presumably from Late Precambrian to early Paleozoic time. Over two-thirds of this sequence consists of clastic sandstones ranging from conglomerates and arkoses to supermature orthoquartzites and organic shales. They represent different types of depositional environments ranging from continental to transitional and marine facies. The upper third of the sequence is mostly marine carbonates and evaporites ranging in age from Mesozoic to Paleocene and representing mostly very shallow shelf and restricted nearshore marine environments (figs. 4). Most of the Paleozoic sequence is thick in the center of the Ghadamis basin and thins gradually towards the southern edge of the basin which flanks Al Qarqaf arch and gives viable evidence of the existence of this arch as a positive feature throughout Paleozoic time. The main structural features in Paleozoic rocks are oriented in an ENE-WSW direction. These include regional faults and incumbent structures which were affected by the erosional history of the area (Hammuda O.S., 1980). The Jifarah Plain (figs. 1, 2, 6, 7, 8 & 22) can be divided into two major geological areas: **1)** The northern area is defined by the Miocene transgressive series which thickens towards the north. The total thickness of the Mio-Plio-Quaternary formations can reach 600 m along the coast. This sequence consist of thick sandy and calcareous beds with clay intercalations. The Miocene overlies Triassic limestones and Jurassic evaporites in the west and Lower Cretaceous (Upper Triassic) sandstones in the east. **2)** The southern area lies between Al'Aziziyah parallel and Jabal Nafusah. There, thin Quaternary mantle covers Upper Jurassic alternating sandstones, clay and dolomites in the southwestern part, Lower Jurassic evaporites in the middle western part, Triassic dolomitic limestones in the central part and the Lower Cretaceous (Upper Triassic) sandstones in the eastern part (Pallas, 1980). Jabal Nafusah is one of the major geological features in the northwestern corner of Libya (figs. 4, 6, 7, 8 & 22). It is a prominent Mesozoic escarpment rising sharply from the Jifarah Plain about 80 km south of Tripoli. The Mesozoic rocks exposed in the scarp face of Jabal Nafusah range in age from Upper Triassic to Upper Cretaceous (El-Zouki, 1980).

Al Aziziyah Formation (Al Qabil Member): Middle Triassic (Present in Jabal Nafusah). The upper Al Qabil Member of this Formation is a mixed carbonate and fine clastic of variegated color. It is exposed in wadi cuttings of Wadi al Qabil and low hills below AbuShaybah Formation. The other good exposures of this unit are around Ra's Tadut. The upper part of this unit has yielded a fairly rich Carnian molluscan fauna (ammonites and bivalves) (fig. 9). See also the section on "Fossil Localities".

Aouinet Ouenine II Formation (also spelled "Awaynat Wanin"): Middle Devonian. The fauna is abundant: The sandstone and coquina facies association of the Aouinet Ouenine Group is formed of brachiopods, trilobites, bryozoans, corals, arthrodires, etc... (Bellini et al. 1980).

Cabao Formation: Lower Cretaceous. Extends along the escarpment of Jabal Nafusah from eastern Jadu to Tunisia. It consists of a fine to medium cross-bedded sand and sandstone. In a sand quarry at Jannawan, just below the town of Jadu (Locality S27 on fig. 8) the lower part of the Cabao Formation contains abundant vertebrate fossils. Of the fossils collected there are dinosaur vertebra of a *Spinosaurus*, Shark's teeth of the species *Priohybodus arambourgi*, Fish scales and rounded teeth of *Lepidotes*, Crocodile teeth and dermal plates, and Turtle shell fragments (El-Zourki, 1980).

Chameau Mort Formation: Upper Jurassic. Exposed in the scarp face of Jabal Nafusah from the vicinity of Kiklah village in the east to Wazin village in the west at the Tunisia border. The lower part is a sandstone while the upper part consists of a gypsiferous shale and mudstone with ferruginous organic rich laminae, and thin beds of marl containing abundant plant fossils. The following plants were collected from a sand quarry below Yifran town and another locality situated below Ejhaish village: *Piazopteris branerii, Pagiophyllum, Brachyphyllum, Hirmerella, Otozamites, Samaropsis* (El-Zouki, 1980, fig. 7 & 8).

Chicla Formation: Lower Cretaceous sandstone and shale sequence which crops out along the northern escarpment of Jabal Nefusa. Plant fragments and silicified wood (large tree trunks) are fairly common in this formation testifying to its non-marine origin. In addition, several species of freshwater pelecypods have been identified. (Barr et al., 1972).

Dembaba Formation: Upper Carboniferous. A rich fauna of nautiloids is indicative of this formation. The essential species are *Domatoceras* sp., *Paradomatoceras* sp. and *Eohippioceras* sp. NOTE: It is good to emphasize the fact that the lowermost sequences of the Carboniferous cycles are nearly always fossiliferous. The most common facies is fossiliferous, bearing ferruginous oolites, (Syringothyridae, Chonetidae, fish bone beds, etc...) (Bellini et al. 1980).

Kasbah-Leguine and Bir Ben Tartar Formations: Middle Ordovician. Several species of inarticulate brachiopods, trilobites, *Neseuretus* sp. and graptolites (Bellini et al. 1980)

Melez Chograne Formation: Ordovician. Belongs to the Gargaf Group. The marine and transgressive character of this formation is emphasized by the presence of ferruginous oolites. The formation display an abundant fauna consisting of trilobites, cystoides, bryozoans and brachiopods. (Bellini et al. 1980)

Ouan Kasa Formation: Lower Devonian. Present in the Ghadamis basin, but first defined in the Murzuq Basin where its thickness and fossil contents are at a maximum. The fossils present are fish remains, brachiopods and crinoids. (Bellini et al. 1980)

Tarab Formation: Oligocene. (See section on "Fossil Localities")

Wadi Thamat Formation: Middle-Upper Eocene. The lower Al Gata Member contains common oysters and the middle Thmed Al Qusur Member displays frequent casts of large gastropods shells (fig. 10, Megerisi et al. 1980).

MURZUQ BASIN

The Murzuq Basin (figs. 4 & 11) is a large cratonic structure filled with deposits of Cambrian to Quaternary age with a maximum total thickness of more than 3000 m in the central part (Grunert et al. 1980).

Acacus Formation: Silurian. This formation displays different floras which are among the oldest ever discovered. The association is rich and diversified with Psilophytes and Lycophytes (*Taeniocrada, Psilophyton, Dawsonites, Drepanophycus, Protolepidodendron, Archaeosigillaria*, *Precyclostigma*). (Bellini et al., 1980)

Aouinet Ouenine II Formation: Middle Devonian. A rich association of Spiriferidae, Productellidae, Schizophoria, etc... (Bellini et al., 1980)

Murizidie Horst: (Silurian). In the Murizidie area some sediments overlie directly a granite. These Silurian sediments contain an abundant fauna of graptolites (*Climacograptus*), bivalves (Cardiolidae), bryozoans, crinoids, etc... (Bellini et al., 1980).

Ouan Kasa Formation: Lower Devonian. Abundant fauna of different brachiopoda, Mucrospiriferidae, Acrospiriferidae, Crinoidea, Chonetidae, Trilobita, etc... (Bellini et al., 1980)

SIRTE BASIN (Including Cyrenaica Platform)

This basin extends to the south to the Al Kufrah basin and, via a major marine embayment in Eocene times, to the Tibisti massif. Westwards it is bounded by the Al Haruj where major uplift occurred in Oligocene times. To the east, the sedimentary units extend into the Western Desert basin of Egypt. The main source of sediment supply for the Sirte basin was the higher land to the south and west where Mesozoic and Paleozoic rocks have been continuously exposed since Cretaceous times (figs. 12 & 13).

Atrun Limestone: Upper Cretaceous chalky white limestone in the Wadi al Atrun - Marsa al Hilal area of northern Cyrenaica (Fig. 23). The type section of this formation is located near the mouth of the Wadi al Atrun. Coccoliths are common, while only rare ostracodes and radiolaria have been recovered. *Inoceramus*, echinoids and a few brachiopods have been recognized. (Barr et al., 1972).

Cyrene Formation: Oligocene limestone and marls overlying the Slonta Limestone at the ancient Greek ruins of Cyrene. The Cyrene Formation covers a broad area on the upper plateau of Jabal al Akhdar. In the vicinity of Cyrene, this formation is conveniently subdivided into three members: the Shahhat Marl, Algal Limestone and Labrak Calcarenite. *Nummulites intermedius* and *N. vascus* have been recorded (Barr et al., 1972).

Derna Limestone: Middle Eocene prominent limestone unit well exposed along the coastal escarpment near Derna, and present over a large portion of Jabal al Akhdar. This formation is quite fossiliferous, locally containing common algae, echinoids and pelecypods. Abundance of large nummulites including *Nummulites gizehensis, N. curvispira, N. beaumonti,* and *N. subleaumonti* are characteristic of this formation (Barr et al., 1972).

Faidia Formation: Lower to Middle Eocene sequence of shales and limestones overlying the Cyrene Formation on the upper terrace of eastern Jabal al Akhdar. The type section is located along the road below the ruins of the old fortress near the entrance to the village of Al Faidia, about 16 kms south of Shahhat. The Faidia Formation contains common *Pecten*, oysters, echinoids and algae (Barr et al., 1972).

Jardas Formation: Upper Cretaceous limestone. (fig. 14). The type locality is in the vicinity of the village of Jardas al Abid, located 24 kms south of Al Marj in northern Cyrenaica (fig. 23). It is subdivided into the Gasr al Abid Marl, Benia Limestone, Got Sas Marl and Al Feitah Limestone Members. Mollusks and echinoids have been identified from the Gasr al Abid Marl Member. The Benia Limestone Member appears to be rather unfossiliferous; however, some beds are occasionally recorded as being rich in large gastropods and pelecypods including rudists and oysters. The Got Sas Marl Member contains abundant macrofossils (Barr et al., 1972).

Marada Formation: Lower Miocene sequence of rocks exposed along the southern escarpment of Dor Marada in the central Sirte Basin. Plant remains and terrestrial vertebrate (such as mammals) fossils have been recovered in abundance from the sandy beds exposed along the base of Jabal Zelten, while higher in the section and further north, shallow marine fossils are common (e.g.: oysters banks, corals, etc...) (Barr et al., 1972).

Mizda Formation: Upper Cretaceous rocks exposed in the vicinity and south of the oasis of Mizda, located about 175 kms south of Garian. It is subdivided into three Members; Tigrinna marl, Mazuza Limestone and Thala. The type Tigrinna Marl Member contains a rich assemblage of fossil gastropods, brachiopods, pelecypods, and echinoids. Ostracods are also common (Barr et al., 1972).

Regima Formation: Middle Miocene formation originally described in the Benghazi area of northern Cyrenaica (fig. 23). The type locality is located along the face of the escarpment below the village of Regima, about 29 kms east of Benghazi. This formation is very fossiliferous, but often the fossils have been moderately weathered. Mollusks, echinoids, corals and bryozoa are abundant (Barr et al., 1972).

Sahabi Formation: Pliocene. (See section on "Fossil Localities")

Zmam Formation: Upper Cretaceous to Paleocene shale, marl and limestone sequence exposed along the southwestern border of the Hon graben (=Djofra graben) on the western margin of the Sirte Basin. The type section of the Zmam Formation is located on an isolated hill near the entrance of Wadi Tar, about 48 kms northwest of the oasis of Socna. It is subdivided into the Had Limestone, Upper Tar Marl, Socna Mollusk Bed and Lower Tar Marl Members. The Lower Tar Marl is richly fossiliferous. Pelecypods, gastropods, echinoids and a small button coral are common. The Socna Mollusks Beds are highly fossiliferous containing abundance of mollusks including *Venericardia desori* and *Nerinea* sp. The upper Tar Marl contains some undocumented macrofossils (Barr et al., 1972).

3) FOSSIL LOCALITIES

QUATERNARY
Middle Pleistocene

Wadi ash Shati (Ostracods and Mollusks [gastropods & Bivalves])

Note: See also Wadi ash Shati in the Middle Devonian-Lower Carboniferous section.

(Petit-Maire et al. 1980) This wadi runs along the southern slope of the east trending anticlinal Al Qarqaf arch and forms the northern boundary of Murzuq basin. Quaternary gravel, sand and alluvium deposits fill the depression, the bottom of which is covered by saline sabkhas with a typical "ploughed soil" aspect. The altitude of the sabkhas is 260 m a.s.l. and they are sometimes separated by outcrops of carboniferous beds.

The surface of the sabkhas is marked by typical large (+/- 1 m) polygonal desiccation patterns, with salt crystals in a clayey sand matrix. The upper crust, 10-20 cm thick, is underlain by a very hard gypsum bed, about 25 cm thick, under which sandy clays are found. Between these sabkhas and the white limestone formation, fossiliferous localities are found. In some places (fig. 15, localities VII, XIV) lacustrine shells have been found alternating with sand and gravel layers over 10 m thick.

Gypsum is present in every case, most commonly as microcrystals (sometimes agglomerated) but sometimes as thin transparent plates (western localities). The coarser grains or shell fragments are sometimes cemented by gypsum. This gypsum may originate either from lake evaporation processes or capillary rise during later (possibly recent) periods.

In the northwestern localities, shells are often interbedded with gravel and are mostly angular ferruginous concretions which appear to have been transported by water only over short distances. The fossiliferous beds are disturbed, eroded, gullied or destroyed by runoff in the areas of the fluvial fans. In eastern localities gravel is also present and though smaller in size is still not rounded.

The facies of the fossiliferous layers vary considerably, sometimes within a few meters and at the same level. One finds either hard coquina, more or less rich in sandy sediment, or loose deposits. The shells also are fragmented to varying degrees (1mm long fragments to whole valves or even complete specimens). In a few cases whole mollusk colonies are cemented by calcite.

The coquina-type deposits are found only in the western localities. They clearly correspond to a "beach-rock" with frequent ebb and flow arrangement of mollusks valves and, despite the discontinuity of outcrops, one can follow the shoreline of the ancient lake for some 100 kms. In the eastern localities, no coquina deposits were observed. In the Brak project area (fig. 15, locality IV) a large *Cardium* colony escaped erosion but shows no sign of cohesion.

At all levels the invertebrate fauna is dominated by *Cerastoderma glaucum,* the Mediterranean *Cardium, Melania tuberculata* and *Hydrobia* sp.

PLIOCENE

Sahabi area (Mammals [whales, horses, rhinoceros, hippopotamus, elephants], Fish, reptiles, mollusks, gypsum, archeology)

(Heinzelin et al. 1980). The Qasr as Sahabi is an old Roman, Byzantine and Turkish fort, now ruined, situated 100 km south of Ajdabiya on the road to Jalu (figs. 16a & 16b). Its surroundings became famous in the early thirties through the discovery of fossil vertebrates.

Three formations are present in the area:

Formation M (Middle Miocene similar to Upper Al Rajmah Formation) is a semi-consolidated bioclastite exposed in the floor of the sabkhat, totally or partially decalcified and gypsified; erosional relief or shallow reefs MR with coralla of Madreporaria; large echinoids *Echinolampas* and *Clypeaster* , large gastropods *Strombus* and other mollusk shells, as a rule gypsified (except echinoids). Only a few meters are exposed in the area. The type exposure is at P53 and "Cluster of fossil reefs" west of it. (fig. 17).

Formation P (Upper Miocene) contains lattices of gypsum crystals in a rather sparce mineral matrix, dark sand or clay; large and deep (over 5 m) desiccation cracks at places, filled with gypsum; very few fossils except at P120 where large gypsified tree trunks were recorded (fig. 17).

The Sahabi Formation (Lower to Middle Pliocene) lies on Formation P. The lower part of the Sahabi Formation is marine transgressive, and the middle and upper parts are more littoral, estuarine and lagoonal. Its total thickness varies from 50 to 70 meters. It is divided into seven (7) members. The four (4) members with obvious fossils are described below:

<u>Member T</u> has a thickness varying from 4 to 22 m and is composed of sand with abundant marine fauna (*Gryphaea*, fish teeth and sirenian skeletons) at places, and scattered and dislocated land mammal bones. The type exposure is at lower P10, P116 and upper P51 (fig. 17). Over localities P66 and P115, a whole group of sirenians (*Metaxytherium serresii*) were stranded and died. Occasional teeth of *Carcaradon* , the great white shark, are found interspersed with the sirenians. Numerous longitudinal cuts are observed on the ribs of the sirenians and they confirm that the sharks fed on the dead and dying sirenians. Similar, deeply incised bit marks, again, presumably from sharks, have been observed on the ribs of dolphins (Locality P4).

<u>Member U-1</u> is composed of sands with clay lenses and clay balls incorporating well preserved bones of land mammals as well as shark teeth. Very large petrified stems at places in the lower part, internal sandstone casts, epigenesis from former gypsified tree trunks. In the southern sectors, the upper contact with U-2 is underlain by a characteristic fish bed, resulting from high

mortality of fishes in saline water. Its thickness in the area varies from 0 to 20 m and is best exposed in P16 (fig. 17).

Member U-2 displays an interbedding of sand, clay and dolomitic crusts, generally comprised between two main dolomitic beds, the lower one is usually strongly bioturbated and contains fish scales and decalcified shell beds of mollusks and ostracods. Marine facies interbedded in the middle part, with decalcified shell beds, *Gryphaea*, bioturbations and whale bones. Its thickness in the area varies from 2 to 8 m and is best exposed in P71 (fig. 17).

Member V displays variable white to green sands and sandy clays with lenses of gray dolomite, gypsum crystals, frequent clay balls. In the lower part, fossil mammal bones are not unfrequent, generally included in channels of coarse to gravely sand (a skull of *Stegotetrabelodon* was discovered in area P19 and is now displayed in Tripoli). In the upper part, bones are scarce and rolled. There are two main occurrences of silicified wood: a lower one slightly above U-2 (P128) and an upper one 15 m to 20 m higher, both in the same state of preservation. The thickness of this member in the area varies from 35 to 39 m and is best exposed in P13 and P134 (fig. 17).

Notes on the paleontology

The table below shows the complete list of vertebrate fossils found at As Sahabi (Boaz, 1993).

Mammalian fauna from As Sahabi			
Cercopithecoidea	*Macaca cf. lybica*	Cetacea	*Lagenorhynchus*
	Libypithecus cf. markgrafi		*Plantanistidae*
Hominoidea	*Indet.*	Equidae	*Hipparion sitifense*
Insectivora	*Crocidurinae gen. sp. ind.*		*Hipparion africanum*
Sciuridae	*Atlantoxerus getulus*	Rhinocerotidae	*Diceros neumayri*
Ctenodactylidae	*Sayimys sp.*	Suidae	*Nyanzachoerus kanamensis*
Cricetidae	*Myocricetodon cherifiensis*		*Nyanzachoerus devauxi*
	Protatera yardangi		*Nyanzachoerus jaegeri*
Muridae	*Progonomys sp.*	Anthracotheriidae	*Merycopotamus petrocchii*
Ursidae	*Agriotherium africanum*	Hippopotamidae	*Hexaprotodon sahabiensis*
	Indarctos atticus	Giraffidae	*Samotherium africanum*
Viverridae	*Viverra*	Bovidae	*Miotragocerus cyrenaicus*
	Viverridae		*Leptobos syrticus*
Hyaenidae	*Percrocuta eximia*		*Redunca darti*
	Percrocuta senyureki		*Hippotragus cordieri*
	Hyaenictitherium		*Damalacra*
	Euryboas		*Raphicerus*
Felidae	*Machairodus*		*Gazella*
Phocidae	*Monachus*		*Prostrepsiceros lybicus*
Proboscidea	*Amebelodon cyrenaicus*	Sirenia	*Metaxytherium serresii*
	Stegotetrabelodon lybicus		
Aves		**Pisces**	
Phalacrocoracidae	*Phalacrocorax*	Chondrichthyes	*Carcarodon megalodon*
Anhingidae	*Anhinga*	Polypteridae	*Polypterus*
Pelicanidae	*Pelicanus*	Clariidae	*Clarias*
Ciconiidae	*Leptoptilos*	Bagridae	*Clarotes*
	Anastomus	Mochokidae	*Synodontis*
Accipitridae	*(an indet. vulture)*	Ariidae	*Arius*
Anatidae	*(a swan)*	Centropomidae	*Lates*
	(a goose)	Sparidae	*Indet.*
	Netta rufina	Percoidea	*Indet. A*
	Aythya nyroca		*Indet. B*
Reptilia			
Boidae	*Indet.*		
Crocodilia	*Euthecodon*		
	Crocodylus		
Trionychidae	*Trionyx triunguis*		
Testudinidae	*Geochelone*		

<u>Vertebrates</u>: All exposed formations and members contain bones. They are extremely dissimilar in relative content of bones and in kind of assemblages. In Formation M are encountered sirenians skeletons and scattered remnants of fishes. Member T contains abundant shark teeth including *Carcharodon megalodon* and some other fish remains, more or less partial sirenians skeletons or scattered remains of them, isolated remains of turtles, crocodiles, birds and land-mammals. Member U-1 is specially rich in well-preserved bones, in sand channels; the presence of bird and land mammal bones is optimal, shark teeth and remains of water reptiles are still currently associated. Member U-2 is less rich; crocodile and turtle remains are still present.

Lower Member V contains locally land-mammal remains in sand channels; upper Member V is poorer, there are still rolled crocodile bones.

Echinoderms: Large echinoids *Clypeaster* sp. and *Echinolampas* sp. are abundant in the northern outcrops of Formation M between P116 and P40.

Fossil wood: Three ways of preservation of fossil wood is observed: in gypsum (Formation P at P120 displays large gypsified tree trunks with preserved structure of palm tree), in sandstone (near P120 and the "Petrified Forest"), and in chalcedony (in U-1 at P16, and in V at P125 & P128).

Description of main profiles (as seen on fig. 17)

The following describes the fossil content of the Members which contains the most obvious and interesting specimens in the profiles concerned. For information on the full stratigraphic geological column of each localities, we recommend you refer to Heinzelin et al, 1983.

P1: Member U-1... 0.4 m sand with traces of rootlets and mottling; 0.2 m fish bed in stratified green clay.

P2: Member U-2.... decalcified shell beds and shell molds; some *Gryphaea* and scattered sirenian bones or rib cages.

P3: Member U-2.... some gypsum, thin dolomitic crusts, decalcified shell beds, scattered coprolites and fish bones; 0.50 m green sandy clay with brackish water mollusks.

P4 and P4A: Member U-2... fossil bones, sometimes associated in the lower part; lower contact eroded and perforated by bivalves, about 1 m bioturbated sand containing fossil bones and teeth, coprolites, mollusks shell molds.

P5: Member U-1, at the base, contains white greenish sand and concentration of unassociated bones and teeth in an obliquely stratified bed.

P6: Member U-1... about 1 m impure dolomitic crusts and gypsic sandy clay capped with fish bed in stratified green clay.

P7: Member U-2... a few *Gryphaea* , scattered fossil bones and decalcified mollusks shells.

P8: Member U-2...mollusk shell molds; about 2 m bioturbated and fossiliferous sand, changing laterally from large curved burrows to thin vertical burrows, to incipient dessication cracks and to *Gryphaea* concentrations, scattered bones observed, as well as the scar left by C. Petrocchi excavation MM 12 = CP 12 (fossil whale displayed in Tripoli Museum).

P9: Member U-1... 1 m gypsic green clay capped with fish bed in stratified green clay.

P10: Member T... rolled concretions and bones, shark teeth and *Gryphaea* in sand matrix as well as a gypsified shell bed and gypsified coquina. Member U-1... scattered fossil bones at several levels, including a large whale rib near the base. Member V ... a medium to coarse sand with silicified wood, silcrete layer and sparse fossil bones.

P11, P34 & P65: A partial rostrum of Pristidae near the upper contact of Formation T. The 12 m of Member U-1 contains gypsum crystals; 0.7 mixed sand and clay balls which represents the main fossil bone horizon including also a silicified stem of palm-tree (collected Fac. Benghazi); 9.7 m yellowish to white sand with a mottled horizon P11B; 0.3 m stratified green clay with fish bed.

P12: Large gypsum crystals in both Formations M & P. Formation M also contains one sirenian skeleton. Member U-1... green clay with fish scales and coprolites at the upper contact.

P13: Member V (38.75 m) contains rather abundant silicified wood at two intervals.

P14: Member U-1 displays a fossil bone concentration.

P15 & P17: Member T... 1.5 m thick fossiliferous sand concentrated by deflation: bones, teeth and coprolites, sirenian ribs, corroded *Gryphaea*, mollusk shell molds. Mammal bones are encountered in Member U-1.

P16: In the lower contact of the 16 m thick Member U-1, rather large pieces of silicified wood with preserved structures can be found flat lying and coated with gypsum. Higher up can be seen the mold in brown sandstone of a big standing tree trunk. Fossil bones and much silicified wood with well preserved structures (some rooted in-situ and coated in cellular gypsum) can be observed in the top 9.5 m of Member U-1. The outer surface of the standing tree trunk in U-1 bears several well marked teardrops likely due to the dissolution of a gypsic outer cast. No wood structure is preserved in the brown sandstone; the stems of the "petrified forest" at P131, near P28, are completely similar in facies and situation, except that the latter are lying horizontally, without obvious preferential orientation.

P18 & P19: Member V... observed scar left by C. Petrocchi excavation MM8 = CP 8 = GS 1 (skull of *Stego tetrabelodon* displayed at Tripoli).

P32A: The 13.5 m of Member U-1 contains three levels of bone concentrations, scarce silicified wood. A 0.4 m thick interval of stratified green clay contains a fish bed.

P41: Member M displays numerous large echinoids. Member T displays sirenians ribs.

P50: Formation M... bioclastite with large bioturbations Ophiomorpha, various gypsified mollusk shells and several sirenian skeletons.

P51: Formation P displays some sirenian ribs. The decalcified coquina of Member T are associated with fish teeth and large blocks of stromatolites.

P66 & P66W: Member T... an 8.8 m white to greenish sand intervals, Ophiomorpha and sirenian rib cage in upper part; about 1 m yellow sand containing a large number of sirenian skeletons together with other bones and scattered *Gryphaea*.

P70: The lower part of Member T is concealed by residues of gypsum mining. The upper part is 5.4 m thick of fine yellow sand; 0.8 m *Gryphaea* bed associated to decalcified coquina of smaller mollusk shells, to bioturbations including Ophiomorpha and to siltstone slabs; 0.4 m undulating decalcified coquina of small shells, algal concretions, whale and sirenian bones; 0.3 m dark grey clay with plant impressions similar to reeds. Member U-2 displays 0.3 m white bioturbated dolomite with molds of *Melanoides tuberculata*; one horizon with large shell molds and another one with fossil bones in brecciated sand.

P88: Member V... scattered silicified wood.

P99: Fossil bones occur at various level within Member U-1.

P116: The upper 50 cm of Formation M shows large Ophiomorpha, internal molds of mollusk shells in green siltstone, few gypsified fossils.

P128 & P129: Within the 11 m of Member V, silicified wood occur at several levels.

Note on the archeology and gypsum mining in the Sahabi area: There are many archeological occurrences related to the natural outcrops of MR reefs. Some of them have been dated from Late Roman to early Byzantine times on the presence of characteristic potsherds. Occupations were all directed to gypsum mining in the natural occurrences provided by the top of the reefs; the latter were indeed pitted and upturned on their entire surface. Judging from the debris left, the purpose of the mining was the production, on the spot, of rectangular flakes of translucent gypsum, to be framed as glass in wooden doors and windows.

MIOCENE

Regima Formation near Benghazi (Mollusks)

Exposure of the Regima Formation can be seen (fig. 18) in a large limestone quarry near the Benghazi to Benina highway. A varied molluscan fauna along with *Borelis melo* occur in this twenty-five foot face in which the carbonate grades laterally between soft chalky limestone and well indurated limestone.

Ar Rajmah Formation (Wadi al Qattarah Member) (Gypsum)

The coarsely crystalline facies are exposed in an area between the villages of Ar Rajmah and Al Abyar (fig. 19). Gypsum occurs in flat lenses about 200 m long, 150 m wide and up to 13 m thick. In Ar Rajmah area, gypsum beds consist of rows of vertically oriented selenite crystals that are few centimeters up to 2 meters long. Further north in Hawa al Barraq quarry near the village of Qabr Jirah, an entire lens consists of a single row of giant crystals that are 10-13 m long and are locally interrupted by a detrital bed of reworked crystal fragments.

Cyrene (Oysters)

The lowest mappable unit in the Miocene is the Cyrene marl composed of marl and soft, yellow, grey, and greenish marly limestone, in part glauconitic, of Aquitanian age (Christie, 1955). The Cyrene marl and limestone vary greatly in thickness from about 25 meters near Cyrene to zero a few kilometers southeast of El Faidia. This formation is rich in fossils including Operculina complanata, Pecten vezzanensis, and Chlamys zitteli.

MIDDLE MIOCENE

BP & Oasis meteorite impact structures and Libyan desert glass

In southeast Libya (figs. 20a & 20b) two circular structures 80 km apart have been identified as meteorite impact structures (astroblemes) because of: (1) structural geometry, (2) style of deformation, and (3) microscopic evidence of high-pressure shock metamorphism of quartz grains. The structures are designated, informally, the BP structure (2.8 km in diameter; lat. 25 19’ N and long. 24 20’E) and the Oasis structure (11.5 km in diameter; lat 24 35’ N and long. 24 24’ E). The BP structure is also known in reports under the name of “Jebel Dalma”.

These structures were detected originally on orbital images. They lie 125-165 km northeast of Al Kufrah oasis where surface rock is quartz conglomerate, sandstone, and siltstone of the continental Nubian Sandstone (Lower Cretaceous) containing silicified wood. Although the color of the Nubian is, characteristically, varied shades of white, yellow, brown, and orange; in many places it is black, even on a fresh surface. This derives from iron-oxide mineralization so intense that blocks of the Nubian, only a few feet distant, resemble blocks of basalt.

Although no meteorite fragments, shatter cones, impact glass, Ni-Fe spherules, or megascopic breccias were found at either site, samples of sandstone from both structures show widespread shock metamorphic effects in quartz. The structures are dated only as post-Nubian; their close spacing and their similar weathered and eroded states suggest that they were formed simultaneously, or nearly so, by double impact.

The occurrence of the unique and distinctive Libyan Desert glass (Fig. 20b), discovered in 1932, lies only 150 km east of the libyan structures, in Egypt. The proximity of the structures to the glass site and the lack of disturbed strata of Nubian Sandstone in the area of the glass occurrence, suggest that the glass may have been produced by the impact events that produced the structures, however it has not yet been proven. The fission-track method has been used to date the Libyan Desert glass at 28 million years. **Note:** When the author was working in his quartz mine in Colombia, he read a report (source unknown) on the purity of the Libyan Desert Glass. This report mentioned that this "glass" was the purest quartz found in nature and that it could be used (does it already?) to fabricate electronic devices.

Jabal Zaltan (Mammals, turtles, crocodiles, birds, fish, plants)

Jabal Zaltan (fig. 21) contains a rich fauna. Mammals are found in the fluviatile and estuarine facies of this complex. but not in the lagoonal and reef facies. Root casts are common in the fluviatile facies, but other plant remains are rare. There is abundant silicified wood on the surface. The great majority of the invertebrates are trace fossils, but occasional bands of echinoids mark minor periods of marine invasion across the estuaries: invertebrates are relatively rare in the mammal-bearing facies. Fishes are much rarer than one might expect in a basically aquatic environment, and are usually sharks rather than non-marine fishes. Turtles and crocodiles of several species abound; some of the crocodiles are very large, probably up to 8 metres in length; birds are very rare, and only a few bones have been recognised. The mammal fauna comprises the following:

Mammals of Jabal Zaltan	
Sirenia	
Proboscidea	*Mastodon angustidens, M. pygmaeus*
	Deinotherium cf. hobleyi
Hyracoidea	
Rhinocerotidae	*Aceratherium*
	Brachypotherium
Anthracotheriidae	*Brachyodus*
	Hyoboops cf. africanus
Giraffidae	*Prolibytherium magnieri*
	Palaeotragus
Suidae	*Bunolistriodon massai*
	Diamantohyus
Ruminant	*Dorcatherium*
	Walangania
Carnivora	*Afrocyon buroletti*
Creodonta	*Hyainailouros*

There are aquatic elements -- sirenian with crocodile and turtle; hydrophytic browsers -- possibly deinotheres, anthracotheres and pigs; and truly bush browsers -- mastodons, rhinoceroses and giraffes. There are no grazers, arboreal or fossorial taxa, nor any micromammals. The carnivores are rare as always in a fauna, but are remarkable for their size; the most outstanding is a nearly complete skull of *Hyainailouros* which is 68 cm long.

Articulated skeletons are very rare, partially associated remains not uncommon, but the majority of the mammals occur as isolated skull, mandible and post-cranial fragments. (Savage, 1971).

OLIGOCENE

Garet al Luban (Amber, Fish teeth, Mollusks, Nummulites)

At Garet al Luban, some twenty kilometers west of Marada (figs. 24 & 25) a fossiliferous formation of Oligocene age yields Nummulites, mollusks, fish teeth, fossil wood and amber nodules. **Note:** For more information, refer to the Amato (1928) document given in "Recommended literature". The author was not able to find this article.

Jabal al Hasawinah (Frogs, mammals, fish and gastropods)

In 1977 many specimens (at least seven) of fossil frogs (fig. 26) were found in Jabal al Hasawinah (documentation point 2081-H-D-20/4 on the 1:250 000 geological map [see Jurak, 1978... in the "Recommended Literature" section]) in central Libya in what is known as the Lower Oligocene Tarab Formation. Mammals (*Titanohyrax* sp.), fishes and gastropods were also found in association with these frogs (*Xenopus*). The Formation is characterized by a 6 m thick sequence of thinly bedded claystone, marlstone and calcilutite of lacustrine origin preserved in six isolated tectonically wedge-in relics.

Oasis of Zella (Mammals, carnivore, turtle, crocodile)

The south and west fringes of the Sirte basin have nearshore facies and those at Zella (an oasis on the northeastern fringes of the Harouj) have yielded a few bones (fig. 5). They occur in a conglomerate that is probably estuarine. The fauna recorded comprises *Palaeomastodon, Phiomia wintoni, Megalohyrax palaeotherioides, Brachyodus* cf. *gorringei*, carnivore, turtle and crocodile.

Cyrene (Nummulites, Echinoids)

At Cyrene, the archeological site in Cyrenaica (fig. 23), the Oligocene rocks, totaling 40 meters thick, are well exposed. At the base is an 8 meter band of soft marly banded limestone or calcareous marl. Above this is a band of sandy marl 2 meters thick, containing peculiar branch-like concretions, which was termed the "spring-forming marl". Above the "spring-forming marl" are 30 meters of limestones rich in nummulites and echinoids (Christie, 1955).

UPPER EOCENE TO LOWER OLIGOCENE

Area unknown (complete remain of fish)

While shopping in the main city core of Benghazi, the author came across a postcard displaying the fossilized fish named “Mene Rhombea” (Fig. 43). The postcard states that the fish comes from Libya but does not mention where from within the country. It is here assumed that it is of Eocene Age because of the occurrence of this same species in the deposit of Monte Bolca in Northern Italy. As of today, the author has not been able to find out more information about this fish.

Dur at Talhah (Mammals [whales, etc...], Reptiles [turtles, crocodiles, etc...], Fish [sharks, rays, sawfish, lungfish, catfish, etc...], Plants [Tree trunks, fruits, etc...]).

“Dur at Talhah” means “The long escarpment”. Vertebrate fossils were first found in 1952 on this escarpment (fig. 27) lying at Lat. 25 45’ N and oriented east-west, extending from Long. 17 45’ E to 19 05’ E, a distance of 150 kms.. The sediments reach a maximum thickness of 100 m, and have been subdivided into three distinct lithological units (fig. 28 and fig. 29) which are, from base to top, respectively, the Evaporite Unit (45 m, Upper Eocene), Idam Unit (35 m, Lower Oligocene) and Sarir Unit (unfossiliferous 20 m, Oligocene). Marine pelecypods and gastropods, which indicate an Upper Eocene age, have been found in the basal Evaporite Unit. The rest of the sequence above is devoid of invertebrates but vertebrates are abundant in several horizons in both the Evaporite and Idam Units.

The vertebrate fauna consists of nine mammal, five reptile, and seven fish genera (see Table below). Their lateral distribution is the 150 km length of the escarpment, while vertically, they appear to be most common in three horizons, one in the Evaporite Unit and two in the sandy Idam Unit above. In size and variety this fauna is second only in the African continent to that of the Fayum in Egypt. As the faunal chart shows (fig. 30) the proboscideans are the most important group at Dur at Talhah, with all but six of the 34 sites yielding *Moeritherium* and/or *Barytherium*.

Table 2: Dur at Talhah vertebrate fauna

CLASS	EVAPORITE UNIT	IDAM UNIT
Mammalia	*Barytherium*	*Barytherium*
	Moeritherium lyonsi	*Moeritherium trigodon*
	Phiomia	*Phiomia wintoni*
		P. minor
		Creodonta
		Hyracoidea
		Arsinoitherium
	Sirenia	*Sirenia*
	Cetacea	*Rodentia*
Reptilia	*Chelonia*	*Chelonia*
		(Pelomedusidae)
	Dyrosaurus	
	Crocodilus	
	Crocodilia	*Crocodilia*
		Gigantophis
		Tomistoma
Chondrichthyes	*Pristis*	*Pristis*
Osteichthyes	*Fajumia*	*Fajumia*
	Aetobatus	
	Myliobatis	
		Protopterus
		Lates

Evaporite Unit: The fauna of the Evaporite Unit consists of both vertebrate and invertebrates. Of the latter, by far the most common is *Ostrea clot-beyi*. Other invertebrates present, although much rarer and more poorly preserved due to limonization, are pelecypods from the families Lucinidae and Glycymeridae (*Diplodonta*), the helicoid gastropod *Calyptraea* and Turritellidae.

The vertebrate fauna is plentiful and is composed primarily of marine species, notably whales, turtles and sirenians. Several fish and reptile species are present, including *Crocodilus*, *Tomistoma*, the chondrichthyid fish *Pristis* and the osteichthyids *Fajumia*, *Aetobatus* and *Myliobatis*. Rarer finds of proboscideans were made.

Idam Unit: The fauna consists of invertebrate trace fossils (but no invertebrates as yet) and abundant vertebrates. The two principal vertebrate-bearing sandstone horizons are separated vertically by 5-15 m and appear to lie higher in the succession towards the west. A thin micromammal bed has been found at one locality, and has yielded poorly preserved remains of a rodent and hyracoid. The most abundant vertebrates are the proboscideans with two species of *Barytherium*, *Moeritherium trigodon*, *Phiomia wintoni* and *P. minor*. Of the other terrestrial vertebrates found, the large subungulate *Arsinoitherium* is present at one locality, and the sole carnivore is a creodont. Crocodiles (*Tomistoma*), chelonians (Pelomedusidae), fishes (*Pristis*, *Lates* and *Protopterus*) are common, with one occurrence of a boid snake, *Gigantophis*.

A notable feature of the upper fossiliferous horizon is the abundance of limonitic casts of the water-lily fruits *Nymphaeopsis* sp. and *Teichosperma bachmanni*. silicified remains of trees, sometimes with the branches intact, are also common, lying on the weathered level sandstone outcrops.

<u>The vertebrate fauna of the Idam and Evaporite Units</u>: The vertebrates present are summarized in the Table above and their distribution is summarized in fig. 31 which also records the vertebrate localities (see fig. 30 for fauna at each site).

As mentioned earlier, the most common fossils are the proboscideans which occur at most localities. The remains discovered include skulls, mandibles, numerous teeth and much post-cranial skeletal material. preservation of the teeth is very good, but some of the skeletal material is highly encrusted with gypsum or limonite.

Another abundant group of vertebrates in the fauna is that of various fish, including sharks, rays, sawfish and lungfish. The latter, *protopterus*, occurs exclusively in the Idam Unit, as do *Lates* and members of the family Siluridae (catfish). Of the other genera, two are found only in the Evaporite Unit (*Aetobatus*, *Myliobatis*), while *Fajumia* and *Pristis* appear in both units. The remains consist of skulls (particularly the silurids), abundant vertebrae, the distinctive, serrated, elongate sawfish rostri, ray dentitions and shark's teeth.

Other aquatic genera present include one specimen of a whale vertebra, five ribs of sirenians from the Evaporite Unit, and three genera of crocodiles including *Crocodilus* and *Tomistoma*. The latter is found in the Idam Unit, and the former is from the Evaporite Unit. The material comprises several portions of skulls (one complete), teeth and vertebrae. Other reptiles found include *Giganthophis*, a large aquatic snake (Idam Unit) and chelonians. The turtles occur in both units, but those of the Idam Unit have been identified as Pelomedusidae, or marsh turtles.

<u>Area unknown</u> (Sirenia)

In the vicinity of Lat. 28 15'N and Long. 18 30'E, about 140 km west of Jabal zaltan (fig. 5), are found Sirenia. Some 40 skeletons or partial skeletons were seen in a relatively small area of about 15 sq. km. The skeletons are characterized by their very dense ribs which fossilize well. Only two of the skeletons contain cranial remains; one skull and mandible had a few broken teeth (Savage, 1971)

CRETACEOUS

Ghadamis (Inoceramids/bivalves)

Thirteen inoceramid species (fig. 32) and/or subspecies belonging to the genus *Inoceramus sensu lato* and to the subgenera *I. (Endocostea), I. (Selenoceramus), I. (platyceramus), I. (Cordiceramus?)* and *I. (Trochoceramus)*, have been obtained from the area.

In terms of lithostratigraphy, the inoceramid bearing rocks, in the area studied (figs. 33 & 34), belong to two units of Al Hamadah (Ghadamis) basin: the Mazuzah Member of the Mizdah Formation and the Lower Tar Member of the Zimam Formation (fig. 35).

<u>Mazuzah Member</u>: Owing to the high resistance of the rock, the Mazuzah Member often caps mesas or builds hamada plateaus with steep to vertical sides. Inoceramid remains occur in almost every outcrop at various levels, often repeatedly in a single section. The preservation of inoceramid remains is rather variable as articulated or disarticulated shells, debris or disintegrated prisms of the prismatic layer. Very typical of the Mazuzah member is the occurrence of large shells more than 15 cm long, in some localities up to 40 cm. Large shells sometimes form clusters; multiple encasing of almost closed valve pairs is also observed. Species diversity of the inoceramid assemblages is usually low. A remarkable exception is the locality SW of Sinawan (fig. 34) where four inoceramid species have been determined. Besides inoceramids, the Mazuzah Member yields only scarce macrofossils in the area.

<u>Thala Member</u>: Macrofossils found in the Thala Member are usually rich in specimens but poor in number of species. Some beds contain a dwarfed assemblage of bivalves, sometimes together with gastropods. No inoceramids were found in the area.

<u>Lower Tar Member</u>: The sequence of the Lower Tar Member may be divided into three parts of unequal thicknesses: The <u>lower part</u> terminates by a prominent bed of fossiliferous limestone or dolomitic limestone, forming a morphologically conspicuous ledge. This key bed and/or the underlying strata represent the first layer with inoceramids. The <u>middle part</u> consists mainly of marls and/or claystone. In the eastern part of the area, this marl horizon contains innumerable shells of oysters (*Agerostrea ungulata, Amphidonta overwegi*). A thin (10-20 cm) interbed of biocalcarenite in the upper part of the marl layer is crowded with poorly preserved inoceramid shells and their fragments. The <u>upper part</u> contains locally frequent inoceramid shells and represent the uppermost inoceramid bearing layer in this member. It contains casts of *Omphalocyclus macroporus*. The mode of occurrence and preservation of inoceramid remains in the Lower Tar Member is similar to that in the Mazuzah Member, i.e., articulated or disarticulated shells, shell debris, etc. On the other hand, large shells (15 cm or longer) have not been found. The diversity of inoceramid assemblages is extremely low.

TRIASSIC

L4-51 (Complete fish)

The only occurrence of complete Triassic fish in Libya is located (unfortunately) at a depth of 10,840' below sea level in oil well L4-51 (well L4, in concession 51) in the Southeast Sirt basin. *Cleithrolepis major* (fig. 36) was discovered in the Amal Formation (Triassic: Anisian) by AGOCO geologists in 1982, in a core sample in the Nafoora Field.

Prior to the discovery of the fossil fish, the Amal Formation was considered to be of Cambro-Ordovician age (470 million years). The reassignment of the formation to the Triassic (231 million years) resulted in a major revision on the geological evolution of the Sirt Basin. Species closely comparable to Cleithrolepis are known to be present in the Triassic rocks of Germany, South Africa, South and North America, and Australia (Gardiner, 1988)

It is also interesting to know that 9 feet below the occurrence of the fish, the Amal Formation displays a 2" thick layer full of trilobites (pers. comm.).

Gharyan area (Coprolite, fish remains, gastropods, pelecypods)

Triassic phosphorites are located in Gharyan area, northwestern Libya (fig. 22). They include a phosphatized fauna of pelecypods and gastropods with fish teeth and bone fragments. They form the lower part of Abu Shaybah Formation, and are composed of phosphate elements, such as pellets (10-15%), micronodules (10-15%), intraclasts (4-15%), coprolites (<10%) and bone fragments (4-10%). The bone fragments are elongated, and filled with microsparite.

MIDDLE TO UPPER CARBONIFEROUS

Oasis of Kufra (Plant impressions)

Plant fragments are found in different localities near the Oasis of Kufra (Wagner, 1960. Map not provided). They are stem fragments and remnants of foliage, all of which have been preserved in a rather coarse-grained sandstone. The grain of the rock is too coarse to permit the preservation of details. The plants belong to *Pinakodendron* species, and *Sigillaria (Rhytidolepis) mamillaris-trigona*, and *Pecopteris* species.

It is supposed that *Sigillaria* and *Pinakodendron* came from strata of Namuro-Westphalian age (Middle carboniferous), almost certainly not older than the upper Visean and not younger than the lower Stephanian. The *Pecopteris* should be younger than Westphalian (Upper Carboniferous). Although these plant remains are rather badly preserved, their occurrence is sufficiently rare to merit a mention in this research. Indeed, before the discovery of these sites, no mention of Upper Carboniferous floras had been made either from Libya or neighbouring areas. In fact, the nearest occurrence of Upper Carboniferous plant fossils is in northwestern Algeria, in the southern Oranais, where coal-bearing Westphalian strata are developed.

MIDDLE DEVONIAN TO LOWER CARBONIFEROUS

Wadi ash Shati (Plants impressions & trunks, Bone fragments)

Note: See also Wadi ash Shati in the Quaternary (Pleistocene) section.

Abundant Lycophyte macrofossils have been collected from the Paleozoic strata of the Wadi ash Shati valley (figs. 37 & 38). They come from the Middle Devonian-Lower carboniferous deposits of the Murzuq basin and belong to at least three subsequent, continually developing floral assemblages (fig. 39).

Bi'r al Qasr-Idri Flora: This Middle Devonian plant assemblage is represented mostly by less favorably preserved impressions (phytodetritus) coming from quartzitic, fine grained, sandstones. Among the remains some delicate axes of *Protolepidodendron helleri* and *scharyanum* were identified. The majority of the thanatocoenosis is composed of unidentifiable small-sized detritus of defoliated, penultimate to ultimate lycopodiopsid twigs. The state of the fossils indicates that a long-distance removal of the detritus must be presupposed.

On the contrary, in the Idri Formation, relative by large specimens of polystelic trunks have been found appearing in layers of ferruginous, mostly oolitic, fine-grained sandstones and ferruginous siltstones, often with claystone pebbles, brachiopods and bone fragments. The trunks do not reveal determinable anatomical structures.

Tarut-Ashkidah Flora: Although Frasnian deposits of the Wadi ash Shati area (Quttah and Dabdad Formations) are poor in plant fossils, the younger Devonian formations (Tarut and Ashkidak Formations) have yielded a relatively abundant collection. The fossils come from deposits of cyclic, iron ore bearing sedimentation of a neritic sea. Numerous casts, impressions and compressions of lycopsid axes are preserved in ferruginous oolites, sandstones with ooids, and ferruginous sandstones. Among the more satisfactorily preserved specimens defoliated axes of *Pseudolepidodendropsis scobiniformis* predominate. Inside some casts, mostly in the *Knorria*-stage of decortication, there are remnants of vascular tissues completely mineralized. Many of the plant fragments are mixed with pebbles and invertebrate fossils (brachiopods). The casts of lycopsid axes occur in numerous natural exposures along the Wanzarik-Brak-Ashkidah road.

One of the most surprising discoveries is made at the so-called "Paul's Garden" locality, south of Tarut (fig. 40). Due to favorable, selected weathering, numerous trunks, stocks, root organs and dropped stems of arborescent Lycophytes were preserved *in situ* there. They were preserved in primary, original positions, forming a unique example of a plant overgrowth fossilized *in situ* (fig. 41). Observations suggest that stems, originally up to 3 m long, could be related to the species *Leptophloeum rhombicum*. The "Paul's Garden" locality could be explained as remnant of dense, nearly forest-like overgrowth of flat tidal plains on the SE margins of Al Qarqaf uplift dry-land.

Marar Flora: In the lower part of the Marar Formation, a thick sequence of marine, quartzone sandstones developed containing ferruginous concretions including fragments of lycopsid tissues. The fossils are collected in the area NE of the Brak-Tamanhant-Sabha road (figs. 37 & 38). They represent impressions of cortical tissue fragments washed out into the sea. A determination of individual taxa is often difficult, largely due to pre-fossilization damage of the cortex pieces. The majority of the concretion fossils belong to lepidodendropsid and archaeosigillarian plants, mainly to the species *Lepidodendropsis africanum*. The sandstones also contain unidentifiable casts of shoots, fossilized in a similar way to those from the ferruginous sandstones of the Ashkidah Formation. The number of shoot casts indicates that the lycopsid vegetation must have been very dense.

LOWER DEVONIAN

Tassili N'Ajjer area (Brachiopods)

(Dubois P. et al., 1969) In the Murzuk Basin, immediately on top of the Upper Hard Bed and in the first few meters of the Orsine Formation (shales and sandstones), especially in Fadnoun and Oued Tadjeradjeri, an abundant fauna very rich with brachiopods can be picked up all over the basin (Fig. 42). Occasionally, *Acrospirifer primaerus* and *Spirifer rousseavi*, of Siegenian time, can be found together with *Acrospirifer paradoxus* of Emsian time. (**Note**: the formation names mentioned here may have changed since Dubois et al. wrote their article. They may now be referring to the Aouinet Ouenine II Formation or the Ouan Kasa Formation ???).

4) GLOSSARY

Astrobleme:	Deeply eroded meteorite impact structure.
Dur:	Hills. Mountainous or hilly area surrounding a plain
fesh-fesh	soft, fine, very loose soil material consisting of gypsum, clay and very fine detritus
hamadah	rocky desert plateau
irq:	dunes, sand sea
Jabal:	Mountain
kaf	cliff, peak, ridge
Sarir:	Desert Plain.
shati:	beach, shore
Wadi:	runoff

5) REFERENCES

Assereto R., Benelli F. (1971). Sedimentology of the Pre-Cenomanian Formations of the Jebel Gharian, Libya. In: Symposium on the geology of Libya. Editor Carlyle Gray. Faculty of Science, University of Libya. Pages 37-86.

Barr F.T., Weegar A.A. (1972). Stratigraphic nomenclature of the Sirte Basin, Libya. The Petroleum Exploration Society of Libya.

Bellini E., Massa D. (1980). The Palaeozoic of the southern Basins of Libya. In: The Geology of Libya, Vol. I, Page 1-50.

Boaz , Noel T. (1996). Vertebrate Palaeontology and Terrestrial Palaecology of As Sahabi and the Sirt Basin. In: The geology of Sirt Basin, Vol. I. Editors M.J. Salem, A.J. Mouzughi, O.S. Hammuda. Pages 531-539.

Christie A.M. (1955). Geological report on Cyrenaica, Libya. American Overseas Petroleum Ltd. Pages 1-20.

Desio Ardito (1968). History of geologic exploration in Cyrenaica. In: Geology and Archaeology of Northern Cyrenaica, Libya. Editor: F.T. Barr; Petroleum Exploration Society of Libya, 10th Annual Field Conference. Pages 79-113.

Diemer Edmond (Geophysicist) : Kindly provided the pictures of LDG samples shown in figures 20b. He can be reached at 149 rue du Murger Papillon, F-77350 Le Mée sur Seine. Phone/Fax: 33-1-64-37-32-31.

Dubois P., Beuf S., Biju Duval B. (1969). Lithostratigraphy of Lower Devonian Sandstones of the Tassili N'Ajjer. In: Geology, Archeology and Prehistory of Southwestern Fezzan, Libya. Ed. William H. Kanes, Pages 125-130.

El-Arnauti A., Shelmani M. (1988). A contribution to the northeast Libyan subsurface stratigraphy with emphasis on Pre-Mesozoic. In: Subsurface palynostratigraphy of Northeast Libya. Eds. A. El-Arnauti, B. Owens, B. Thusu. Garyounis University Publications. Benghazi. Pages 1-15.

El Hawat Ahmed S. (1980). Intertidal and storm sedimentation from Wadi al Qattarah Member, Ar Rajmah Formation (Middle Miocene), Al Jabal al Akhdar. In: Geology of Libya, Vol. II, P. 449-461.

El Hawat Ahmed S., Shelmani Mohamed A. (1993). Short notes and guidebook on the geology of Al Jabal al Akhdar, Cyrenaica, N.E. Libya. In: Sedimentary basins of Libya. 64 pages.

El-Zouki Ashour Y. (1980). Stratigraphy and lithofacies of the Continental Clastics (Upper Jurassic and Lower Cretaceous) of Jabal Nafusah, NW Libya. In: The geology of Libya. Vol. II. Academic press. Pages 393-418.

Fatmi A.N., Bahlul A., Eliagoubi, Hammuda Omar S. (1980). Stratigraphic Nomenclature of the pre-Upper Cretaceous Mesozoic Rocks of Jabal Nafusah, NW Libya. In: The geology of Libya. Vol. I. Academic press. Pages 57-65

Futyan A., Jawzi A.H. (1996) The Hydrocarbon Habitat of the Oil and Gas Fields of North Africa with emphasis on the Sirt Basin. In: The Geology of Sirt Basin. Vol. II., Editors M.J. Salem, A.S. El-Hawat, A.M. Sbeta. Pages 287-308.

Gardiner B. (1988). A new *Cleithrolepis* from the Triassic of central Cyrenaica, northeast Libya. In: Subsurface Palynostratigraphy of Northeast Libya. Eds. A. El-Arnauti, B. Owens, B. Thusu. Garyounis University Publications, Benghazi-Libya, P. 259-265.

Goudarzi Gus H. (1980). Structure -- Libya. In: The geology of Libya. Vol. III. Academic Press, Pages 879-892.

Grunert Jorg, Busche Detlef (1980). Large-scale fossil landslides at the Msak Mallat and Hamadat Manghini escarpment. In: The geology of Libya. Vol. III. Academic press. Pages 849-860.

Hallett D., El Ghoul A. (1996). Oil and Gas Potential of the deep trough areas in the Sirt Basin, Libya. In: The Geology of Sirt Basin. Vol. II., Editors M.J. Salem, A.S. El-Hawat, A.M. Sbeta. Pages 455-483.

Hammuda Omar S. (1980). Geologic factors controlling fluid trapping and anomalous freshwater occurrence in the Tadrat Sandstone, Al Hamadah al Hamra' area, Ghadamis basin. . In: The geology of Libya. Vol. II. Academic press. Pages 501-507

Heinzelin, Jean de; El-Arnauti, Ali (1983): Geology of the Sahabi area: with a geological map at scale 1:25,000. The research Center, Garyounis University, P.O. Box 9521, Benghazi, Libya. Pages 1-87.

Heinzelin, Jean de; El-Arnauti, Ali; Gaziry, Wahid (1980): A preliminary revision of the Sahabi Formation. In: The geology of Libya. Vol. I. Academic press. Pages 127-133.

Hlustik Antonin (1991). Late Palaeozoic Floras of the Wadi ash Shati area, Libya. In: The geology of Libya, Vol. IV. Editors: M.J. Salem, O.S. Hammuda, B.A. Eliagoubi. Elsevier. Pages 1275-1284.

Kleinsmiede W.F.J., Van Den Berg N.J. (1968). Surface geology of the Jabal al Akhdar, Northern Cyrenaica, Libya. In: Geology and Archaeology of Northern Cyrenaica, Libya. Editor: F.T. Barr; Petroleum Exploration Society of Libya, 10th Annual Field Conference. Pages 115-123.

Lagha Salem (1997). Petrography of the Triassic Phosphorites in Gharyan Area, NW Libya. In: Petroleum Research Journal (Libya), Vol 9. Page 45-50.

Megerisi Mohamed, Mamgain V.D. (1980). The Upper Cretaceous-Tertiary Formations of Northern Libya. In: The Geology of Libya, Volume I, Academic Press. Pages 67-72.

Pallas P. (1980). Water resources of the Socialist People's Libyan Arab Jamahiriya. In: The Geology of Libya, Volume II, Academic press. Pages 539-594

Petit-Maire, N.; Casta, L.; Delibrias, G.; Gaven, Ch.; Testud, A.-M. (1980); Preliminary data on Quaternary Palaeolacustrine Deposits in the Wadi ash Shati area, Libya. In: The Geology of Libya, Volume III, Editors M.J. Salem and M.T. Busrewil, Academic press. Pages 797-807.

Pickford Martin (1991). Biostratigraphy Correlation of the Middle Miocene Mammal Locality of Jabal Zaltan, Libya. In: The geology of Libya. Vol. IV. Eds M.J. Salem, O.S. Hammuda, B.A. Eliagoubi. Elsevier. Pages 1483-1490.

Savage R.J.G. (1971). Review of the fossil mammals of Libya. In: Symposium on the geology of Libya. Editor Carlyle Gray. Faculty of Science, University of Libya. Page 215-225.

Sola M., Ozcicek (1990). On the hydrocarbon prospectivity of North Cyrenaica. In: Petroleum Research Journal, Libya. Vol. 2, Page 25-41.

Spinar Zdenek V. (1980). The discovery of a New Species of Pipid Frog (Anura, Pipidae) in the Oligocene of Central Libya. In: The geology of Libya, Vol. I, Page 327-348.

Termier Henri, Termier Genevieve (1980). A New Large Nuculoid Bivalve in the Devonian Binem Formation of Al Kufrah (SE Libya). In: The geology of Libya, Vol. I, Page 305-307

Thusu Bindra, (1996). Implication of the Discovery of Reworked and *in situ* Late Palaeozoic and Triassic Palynomorphs on the Evolution of Sirt Basin, Libya. In: The geology of Sirt Basin, Vol. I. Editors M.J. Salem, A.J. Mouzughi, O.S. Hammuda. Pages 455-474.

Tmalla Ahmed F.A. (1996). Latest Maastrichtian and Palaeocene Planktonic Foraminiferal Biostratigraphy of Well A1a-NC29A, Northern Sirt Basin, Libya. In: The Geology of Sirt Basin. Vol. I., Editors M.J. Salem, A.J. Mouzughi, O.S. Hammuda. Pages 195-232.

Troger Karl-Armin, Rohlich Pavel (1991). Campanian-Maastrichtian Inoceramid (Bivalvia) Assemblages from NW Libya. In: The geology of Libya. Vol. IV. Editors M.J. Salem, O.S. Hammuda, B.A. Eliagoubi. Elsevier. Pages 1357-1381.

Turner Brian R. (1980). Palaeozoic sedimentology of the southeastern part of Al Kufrah Basin, Libya: A Model for oil exploration. In: Geology of Libya, Vol. II, P. 351-374.

Underwood Jr. James R., Fisk Edward P. (1980). Meteorite impact structures, Southeast Libya. In: The geology of Libya, Vol. III. Editors M.J. Salem, M.T. Busrewil. Academic Press. Pages 893-900.

Wennekers J.H.N., Wallace F.K., Abugares Y.I (1996). The Geology and Hydrocarbons of the Sirt Basin: A Synopsis. In: The Geology of Sirt Basin. Vol. I., Editors M.J. Salem, A.J. Mouzughi, O.S. Hammuda. Pages 3-56.

Wight A.W.R. (1980). Palaeogene Vertebrate Fauna and Regressive Sediments of Dur at Talhah, Southern Sirt Basin, Libya. In: The geology of Libya, Vol. I., Pages 308-325.

Wright E.P., W. M. Edmunds (1971). Hydrogeological studies in Central Cyrenaica, Libya. In: Symposium on the geology of Libya. Editor Carlyle Gray. Faculty of Science, University of Libya. Pages 459-482.

6) RECOMMENDED LITERATURE

Amato, A. (1928): Resine fossili in Cirenaica. Notiz. Econ. della Cirenaica, v. 1, no. 3, p. 9-11, Bengasi.

Barnes V.E., Underwood J.R. Jr. (1976): New investigations of the strewn field of Libya Desert glass and its petrography. Earth and Planet. Sci. Lett., 30, 117-122

Boaz N.T., El-Arnauti A., Gaziry A.W., De Heinzelin J., Boaz D.D. (eds) (1987): Neogene Paleontology and Geology of Sahabi. Liss, New York.

Burckle L.H. (1982): Diatoms in coprolites from the upper Neogene of Sahabi, Libya. Garyounis Sci. Bull. Spec. Issue 4, 13-14.

Burollet P.F. (1963). Field trip guide book of the excursion to Jebel Nafusa. 1st. Saharan Symposium *Petroleum Exploration Society*, Libya, 19 pages.

Checchia Rispoli B. (1933). Di un nuovo genere di <Pristidae> del Cretaceo superiore della Tripolitania. Reale Accademia d'Italia. - Memorie della classe di Scienze Fisiche, Matematiche et Naturali, Roma, Vol. IV, p. 1-16, Pl. I, fig 1 a 5.

D'Erasmo, G. (1952): Paleontologia di Sahabi (Cirenaica); II. I pesci di Sahabi. (Rendiconti Accademia Nazionale dei Quaranta, Rome, Ser. 4, 3: 33-69.

Deunff J., Massa D. (1975). Palynologie et stratigraphie du Cambro-Ordovicien (Libye nord-occidentale). C.R. Acad. Sci., Paris, 281, Ser. D, 21-24.

Domning D.P. (1982). Fossil Sirenia from the Sahabi Formation. Garyounis Sci. Bull., Spec. Issue 4, 29-32.

Fatmi A.N. (1977). The Upper Triassic (Carnian) ammonite genus *Mojsisovicsites* from Jabal Gharyan, (Jaba Nafusa) Libya. Libyan J. Sci. 7A, 35-48.

Goudarzi, G.H. (1970). Geology and mineral resources of Libya: A reconnaissance. (U.S. Geological Survey Professional Paper 660).

Hammuda O.S, Sbeta A.M., Mouzughi A.J., Eliagoubi B.A. (1985). Stratigraphic nomenclature of the Northwestern Offshore of Libya. The Earth Sciences Society of Libya

Havlicek V., Massa D. (1973). Brachiopodes de l'Ordovicien superieur de Libye Occidentale; implications stratigraphiques regionales. Geobios., 6, 267-290

Jurak L. (1978). Geological map of Libya; 1:250 000. Sheet: Jabal al Hasawinah NH 33-14. Industrial Research Centre. Tripoli, 87 pages.

Kanes W.H., eds. (1969). Geology, Archaeology and prehistory of southwestern Fezzan, Libya. Petrol. Explor. Soc. Libya, 11th Annu. Field. Conf.

Klitzsch E., Lejal-Nicol A., Massa D. (1973). Le Siluro-Devonien a Psilophytes et Lycophytes du bassin de Mourzouk (Libye). C.R. Acad. Sci., Paris, 277, Ser. D., 2465-2467.

Kohman T.P., Lowman P.D. Jr., Abdel khalek M.L. (1967). Space and aerial photography of the Libyan Desert silica glass area (abs.) Paper presented 30th Annu. Meteorit. Soc. Meet. (Moffett Field, California, Oct. 1967).

Lefranc J.P. (1954). Decouverte d'une formation a vertebres et vegetaux d'age tertiaire au bord occidental du desert libyque (Sahara oriental). C.R.Acad.Sci., Fr., 239, p. 1822-1824.

Lejal-Nicol A. (1972). Contribution a l'etude de la flore paleozoique a Lycophites de Libye et des bassins du Djado et de Fort-Polignac. Publ. Lab. Paleobot. Univ. Paris, 6, 464p.

Lejal-Nicol A. (1975a). Sur une nouvelle flore a Lycophytes du Devonien inferieur de la Libye. Paleontographica, 151, 52-96.

Lejal-Nicol A. (1975b). Sur la paleoflore du Devonien Moyen a Superieur de la Libye. Bull. Soc. Hist. Nat. Afr. Nord, 66, 61-96.

Massa D., Havlicek V., Bonnefous J. (1977). Stratigraphic and faunal data on the ordovician of the Rhadames basin (Libya and Tunisia). Bull. Cent. Rech. Explor. Prod. Elf-Aquit., 1, 3-27.

Massa D., Jaeger H. (1971). Donnees stratigraphiques sur le Silurien de l'Ouest de la Libye. In: Colloque Ordovicien-Silurien (Brest, 1971) Bur. Rech. Geol. Min. Bull. 73, 313-321.

Massa D., Moreau-Benoit A. (1976). Essai de synthese stratigraphique et palynologique du Systeme Devonien en Libye occidentale. Rev. Inst. Fr. Petrole, 31, 287-333.

Massa D., Nicol-Lejal A. (1971). Le Devonien a Lycophytes de la Libye sud-occidentale: Consequences paleophytogeographiques. C.R. Acad. Sci., Paris, 273, 1182-1185.

Petrocchi, C. (1940): Una stazione paleolitica nella zona di Sahabi (Sirtica). (Annali del Museo Libico di Storia Naturale, II, 295-302, tav. XXI-XXIV.

Rohlich, P. (1978): Geological development of Jabal al Akhdar, Libya. (Geol. Rundschau, 67, 2, 401-412).

Saad S.I., Ghazali G. (1976). Palynological studies in Nubia Sandstone from Kharga Oasis. Pollen Spores, 18, 407-470.

Simons Elwyn L., Rasmussen D. Tab (1990). Vertebrate paleontology of Fayum: History of research, faunal review and future prospects. In: The geology of Egypt. Edited by Rushdi Said. Pages 627-638.

Van Der Eem J.G.L.A. (1983). Palynological investigation of well L4-51. Arabian Gulf Oil Co. (AGOCO). Internal Report, 8 pages.

7) FIGURES

Fig. 1: Geologic map of Libya (Goudarzi, 1980)

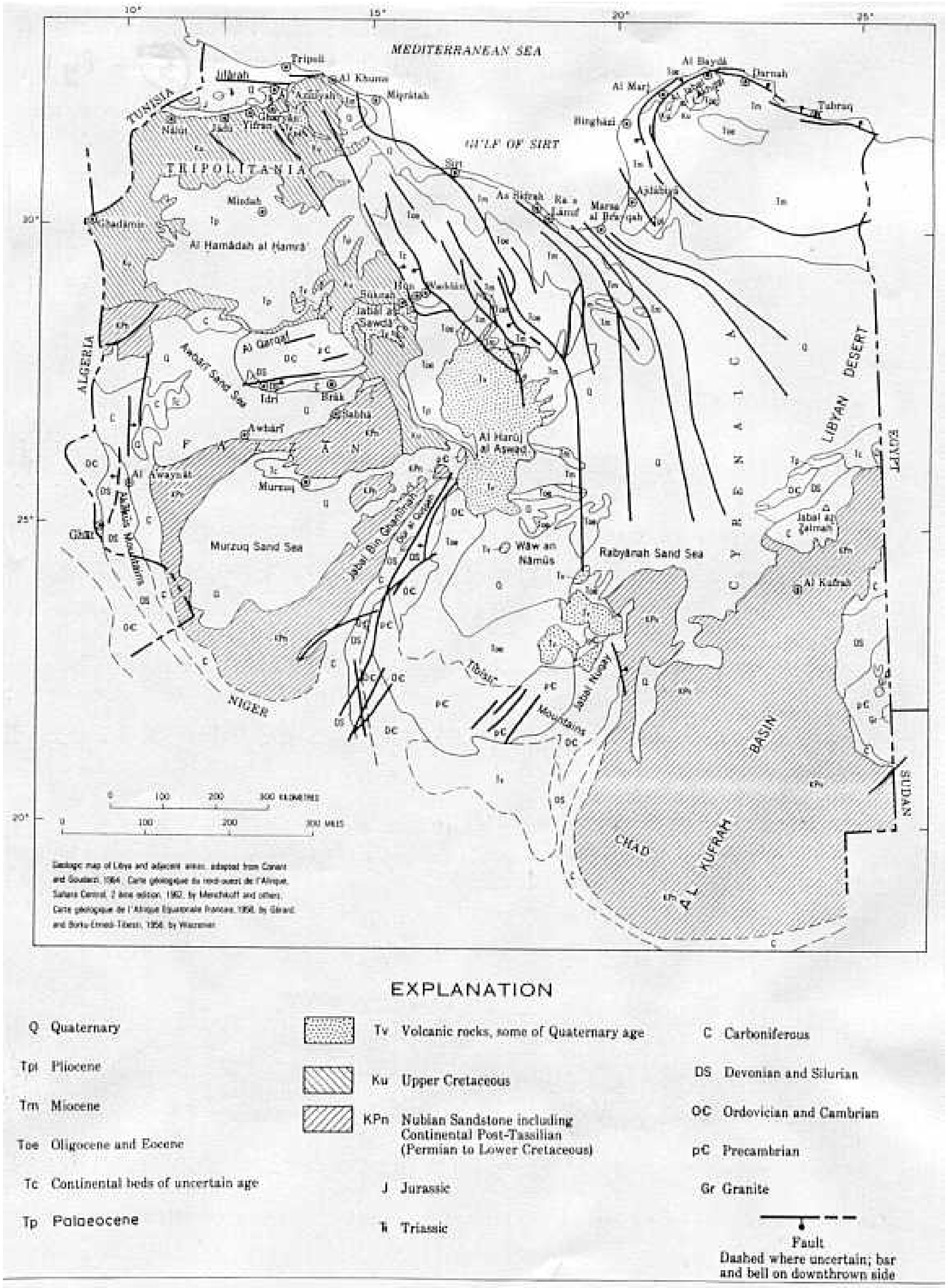


Fig. 2: Geological basins of Libya (Tmalla, 1996)

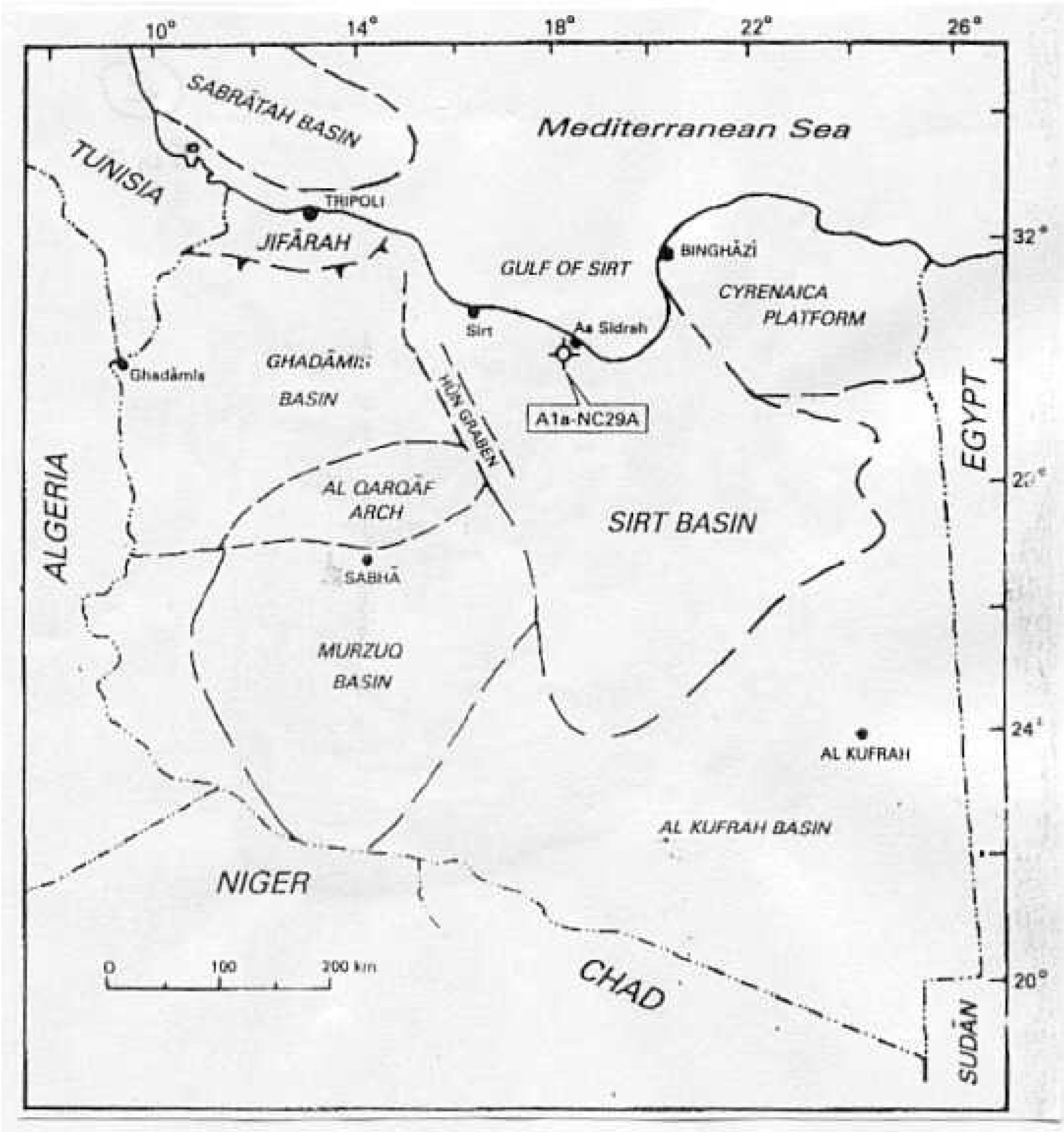


Fig. 3: Geological map of the southeast Al Kufrah Basin (Turner, 1980)

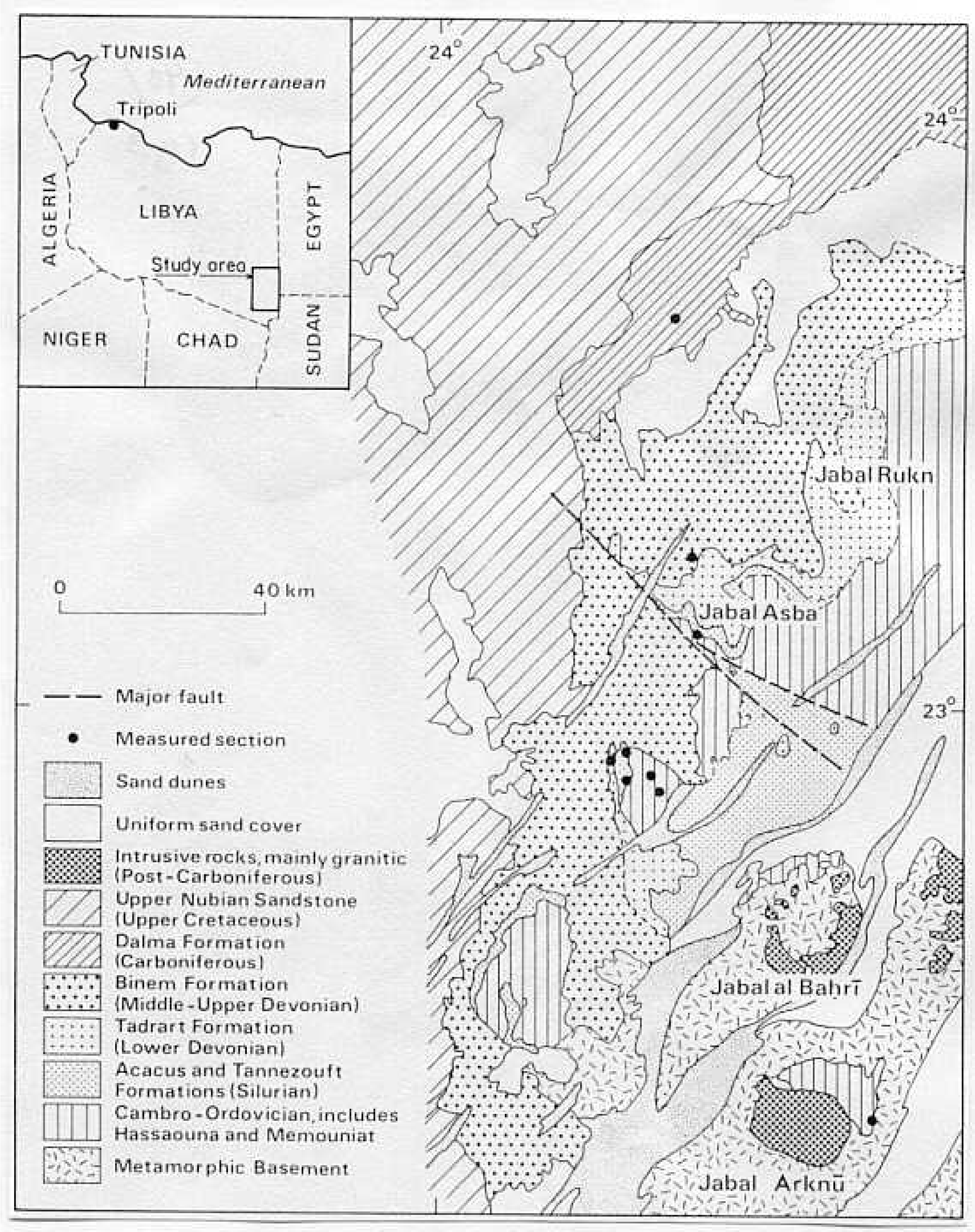


Fig. 4: Correlation of the proposed Paleozoic lithostratigraphic units with formations of Hammadah (Ghadamis), Murzuq and Kufra Basins (El-Arnauti et al., 1988).

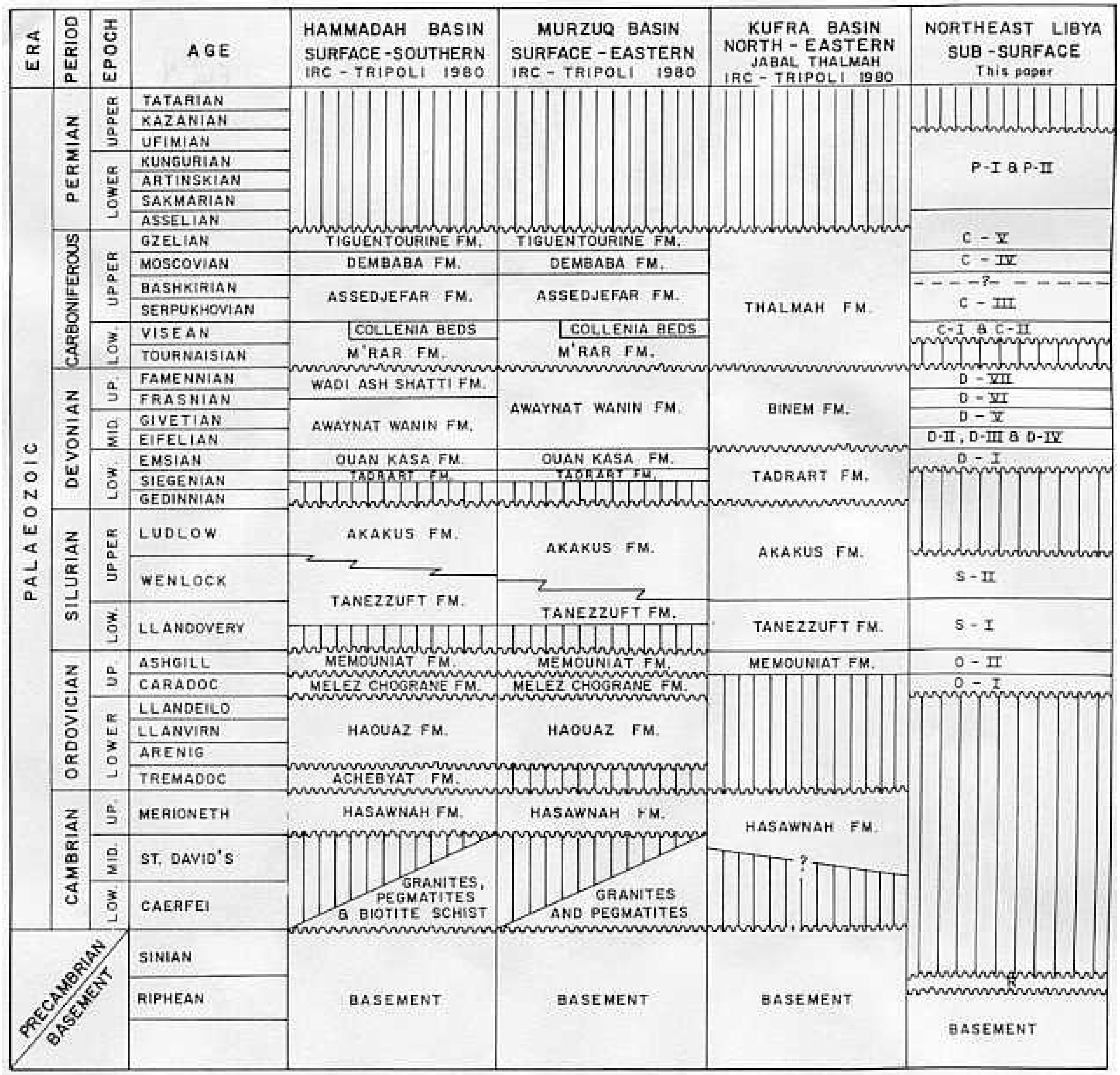


Fig. 5: Libya mammal sites (Savage, 1971)

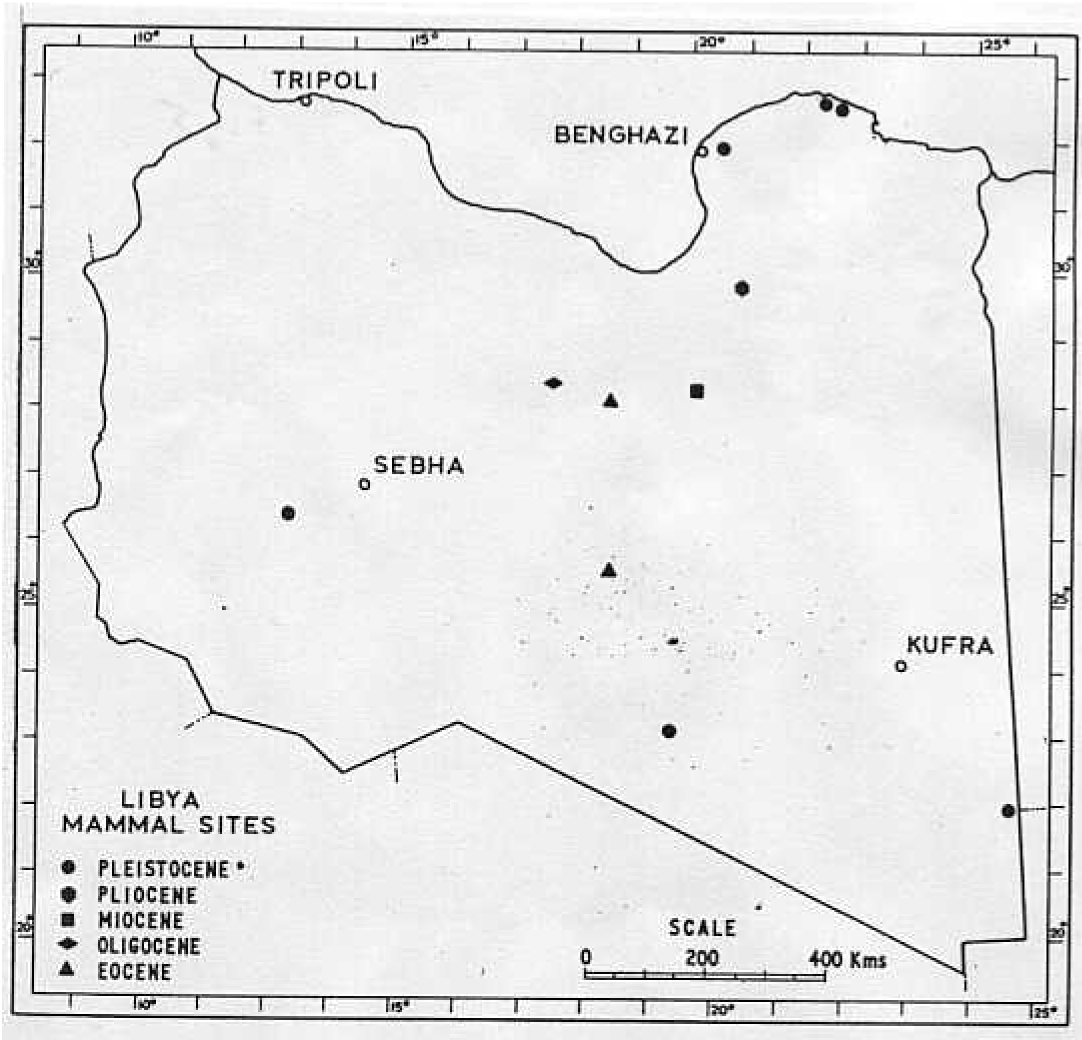


Fig. 6: Geological sketch map of Jabal Gharian [eastern Jabal Nafusah area] (Assereto et al. 1971)

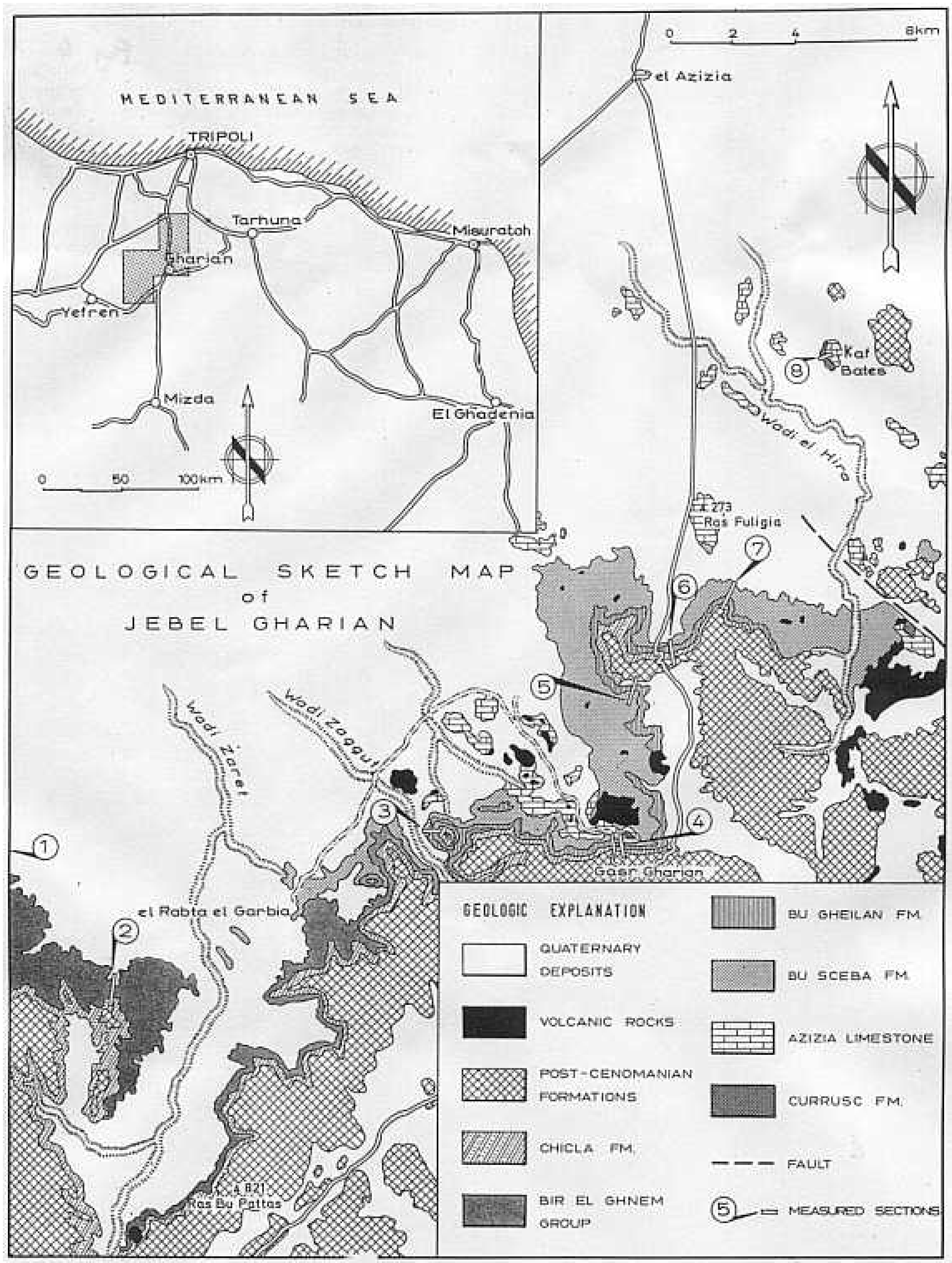


Fig. 7: Geological map of Jabal Nafusah (El-Zouki, 1980)

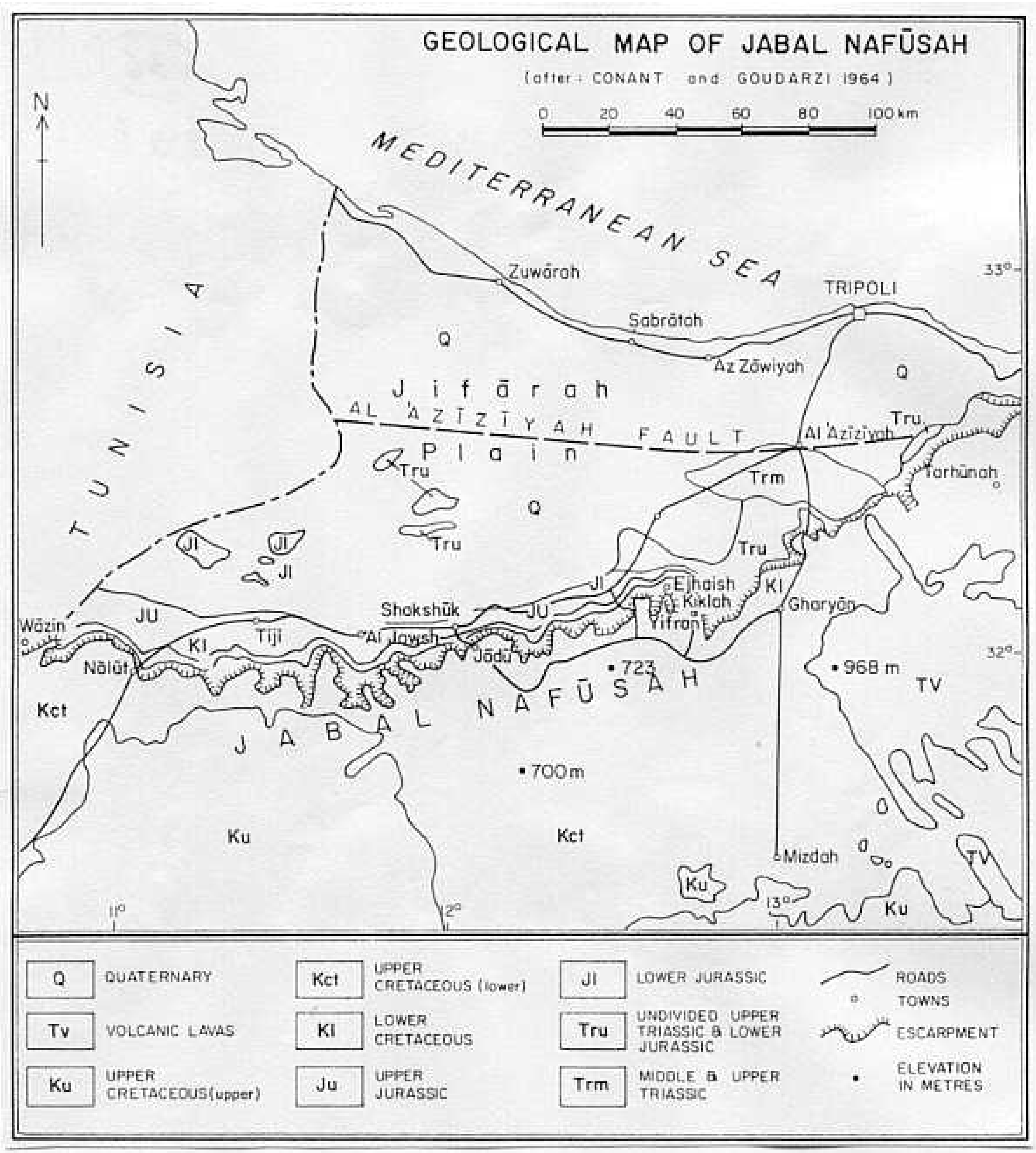


Fig. 8: Locality map showing some sections measured in Jabal Nafusah (El-Zouki, 1980)

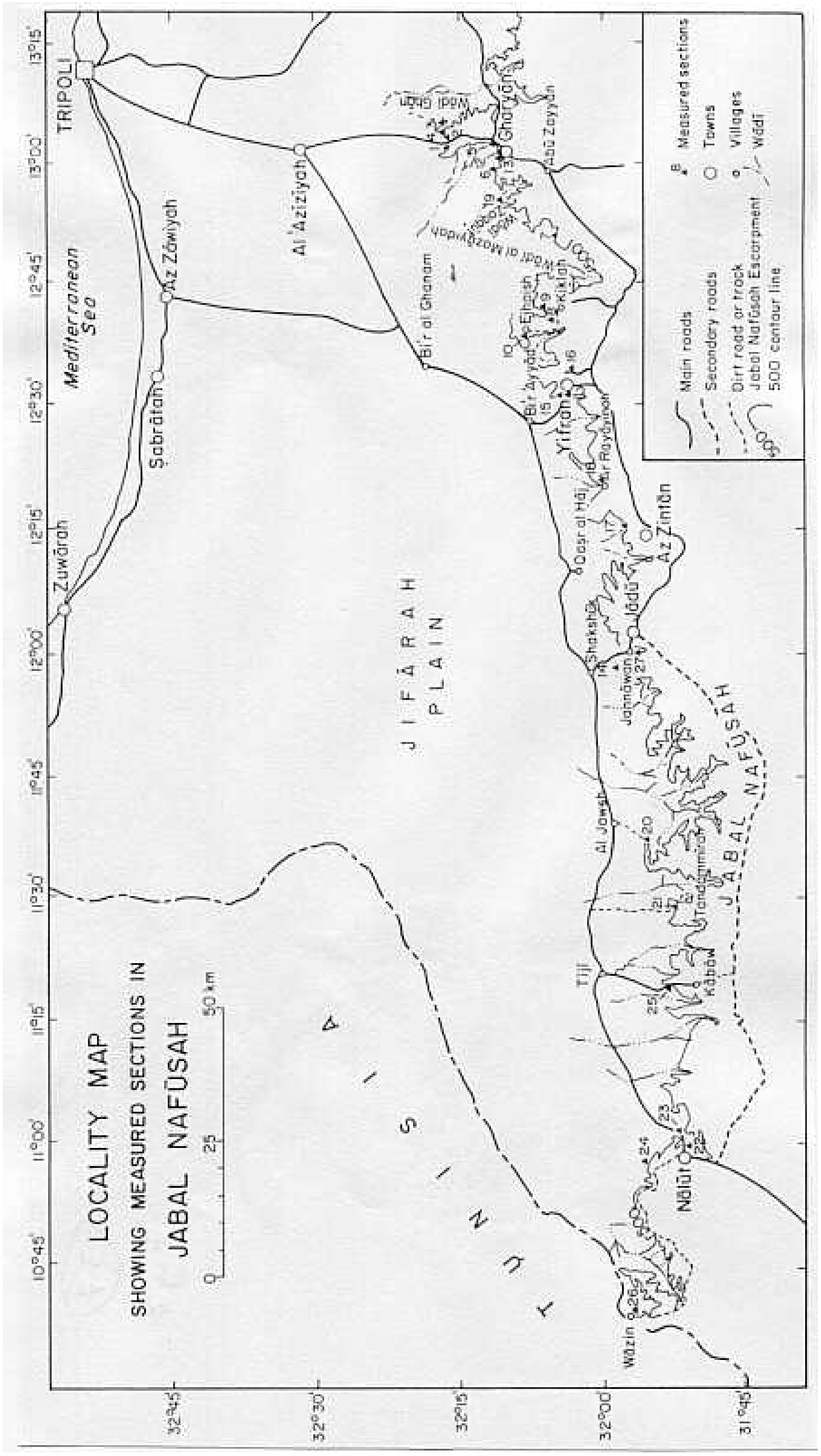


Fig. 9: Proposed stratigraphic nomenclature of Pre-Upper Cretaceous rocks of Jabal Nafusah (Fatmi et al., 1980)

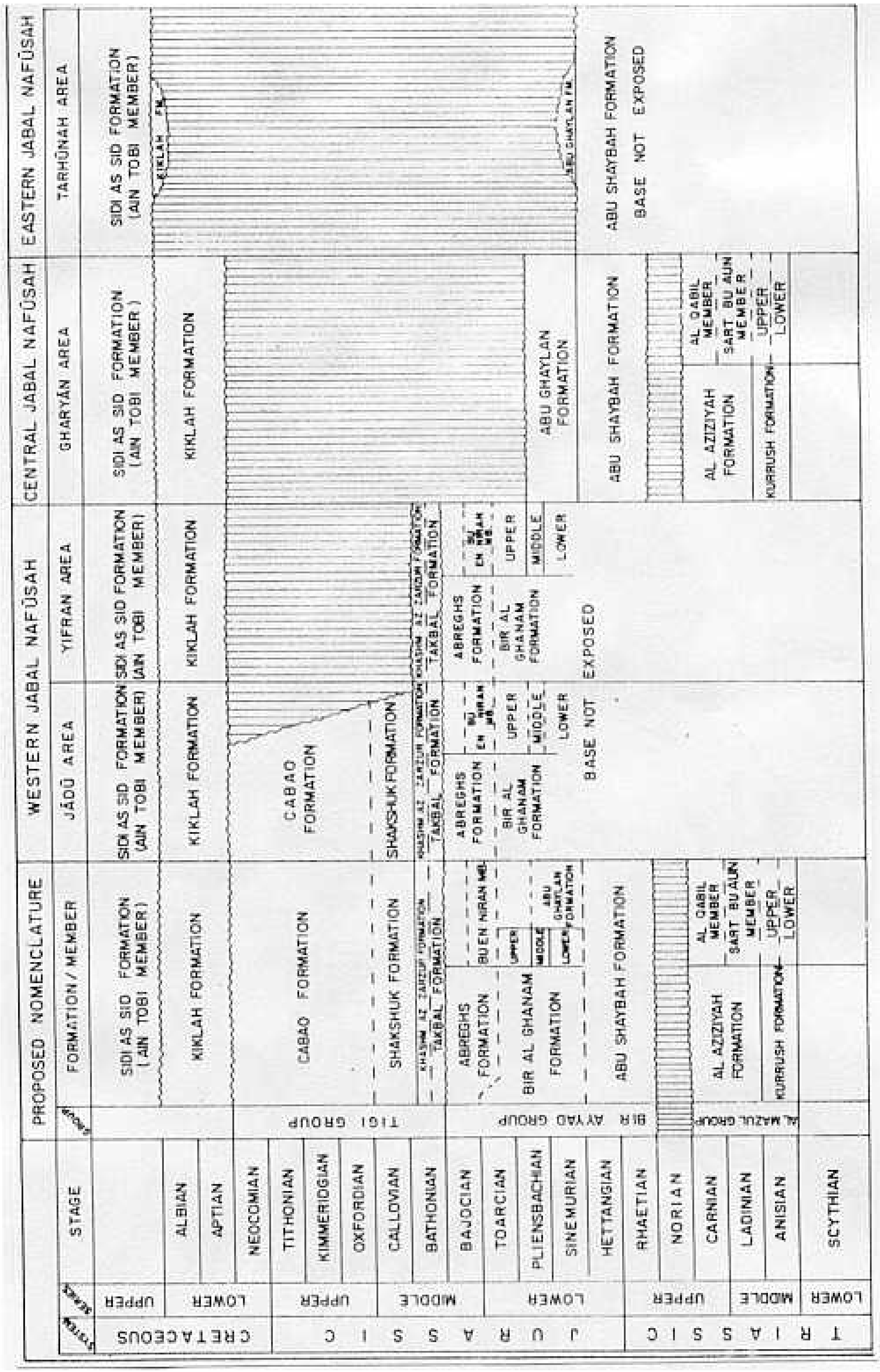


Fig. 10a : Upper Cretaceous-Tertiary formations of northern Libya (Megerisi et al. 1980)

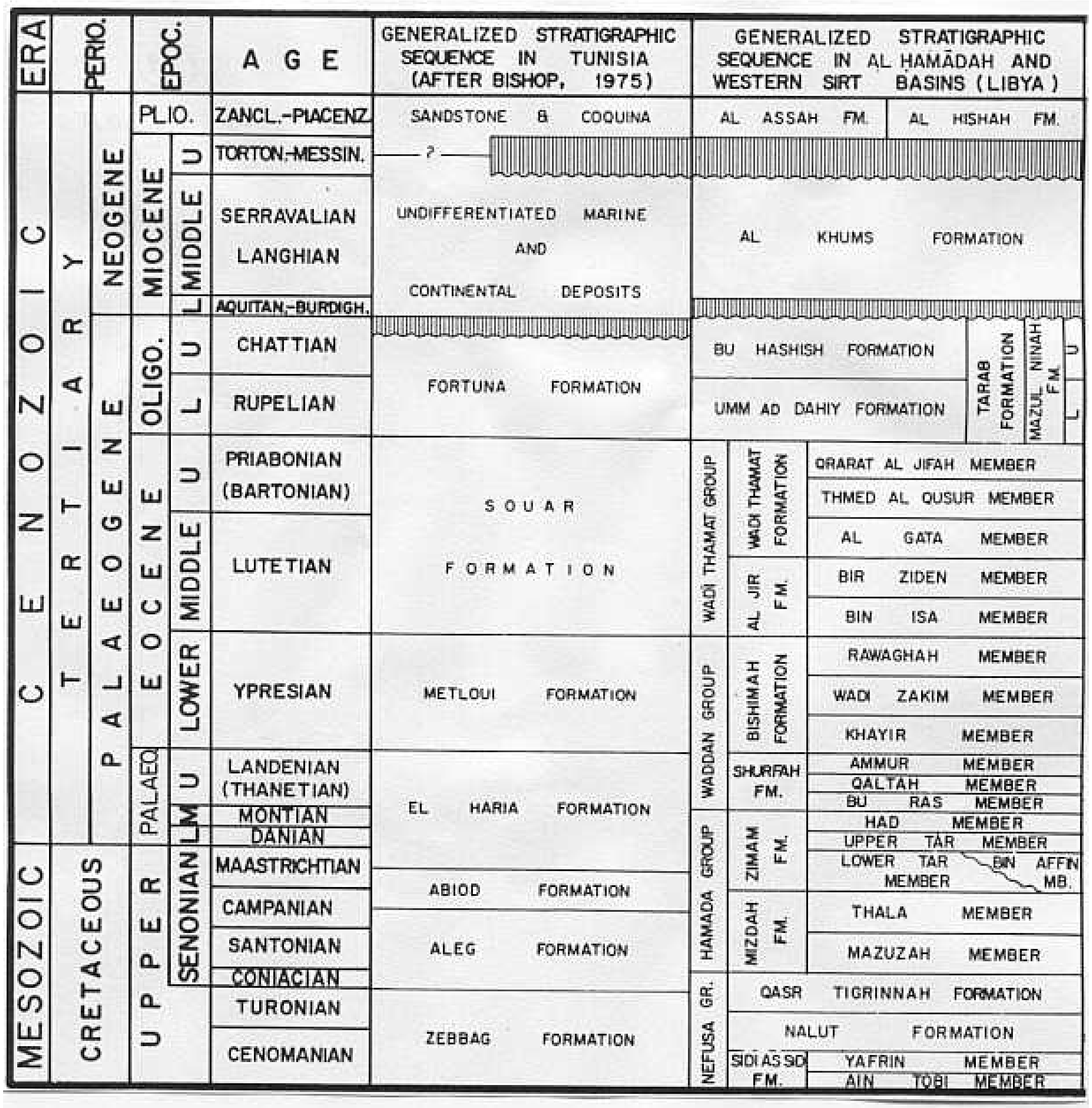


Fig. 10b : Upper Cretaceous-Tertiary formations of northern Libya (continue)(Megerisi et al. 1980)

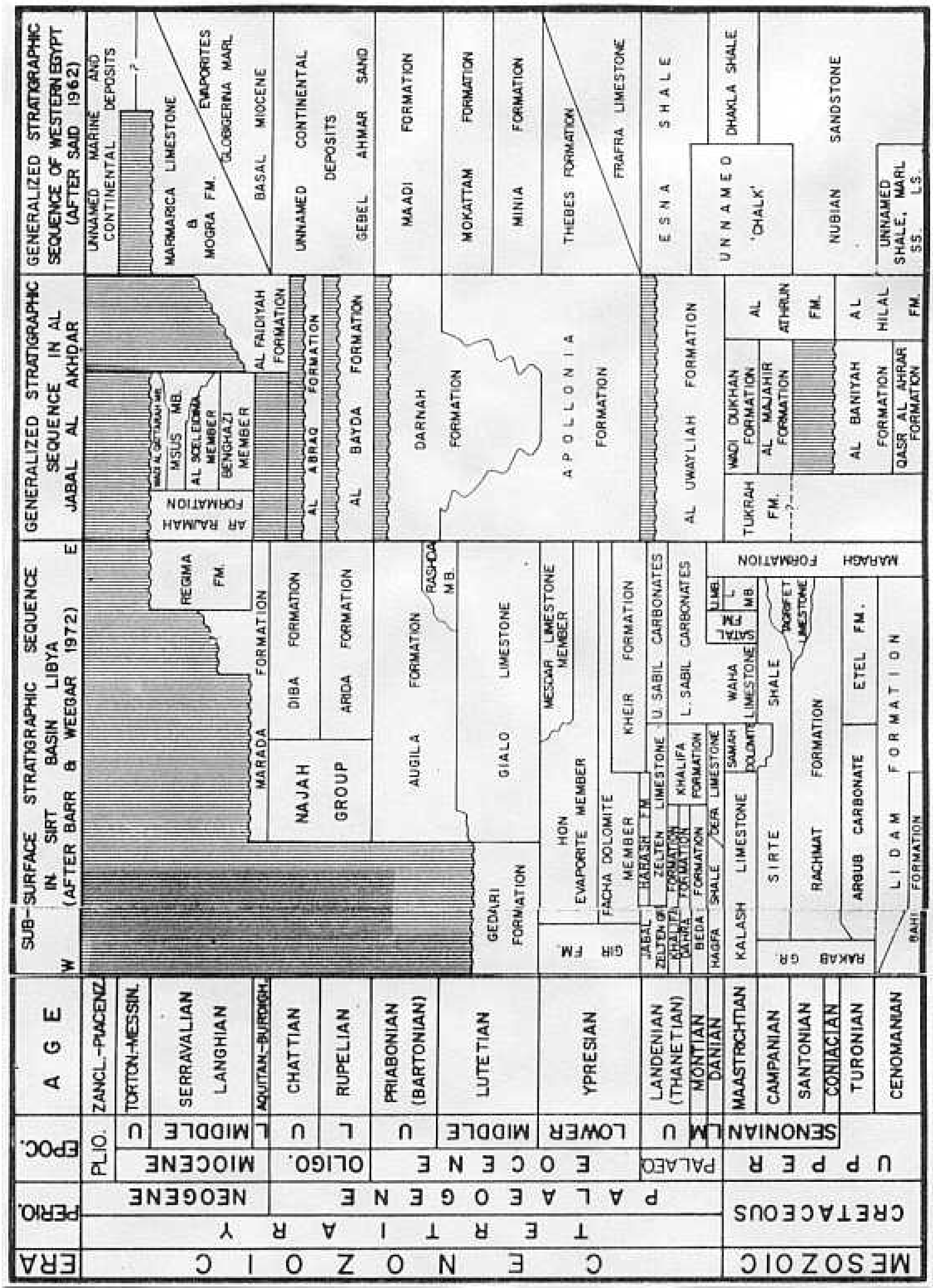


Fig. 11: Generalized geological map of the Murzuq basin (Grunert et al. 1980).

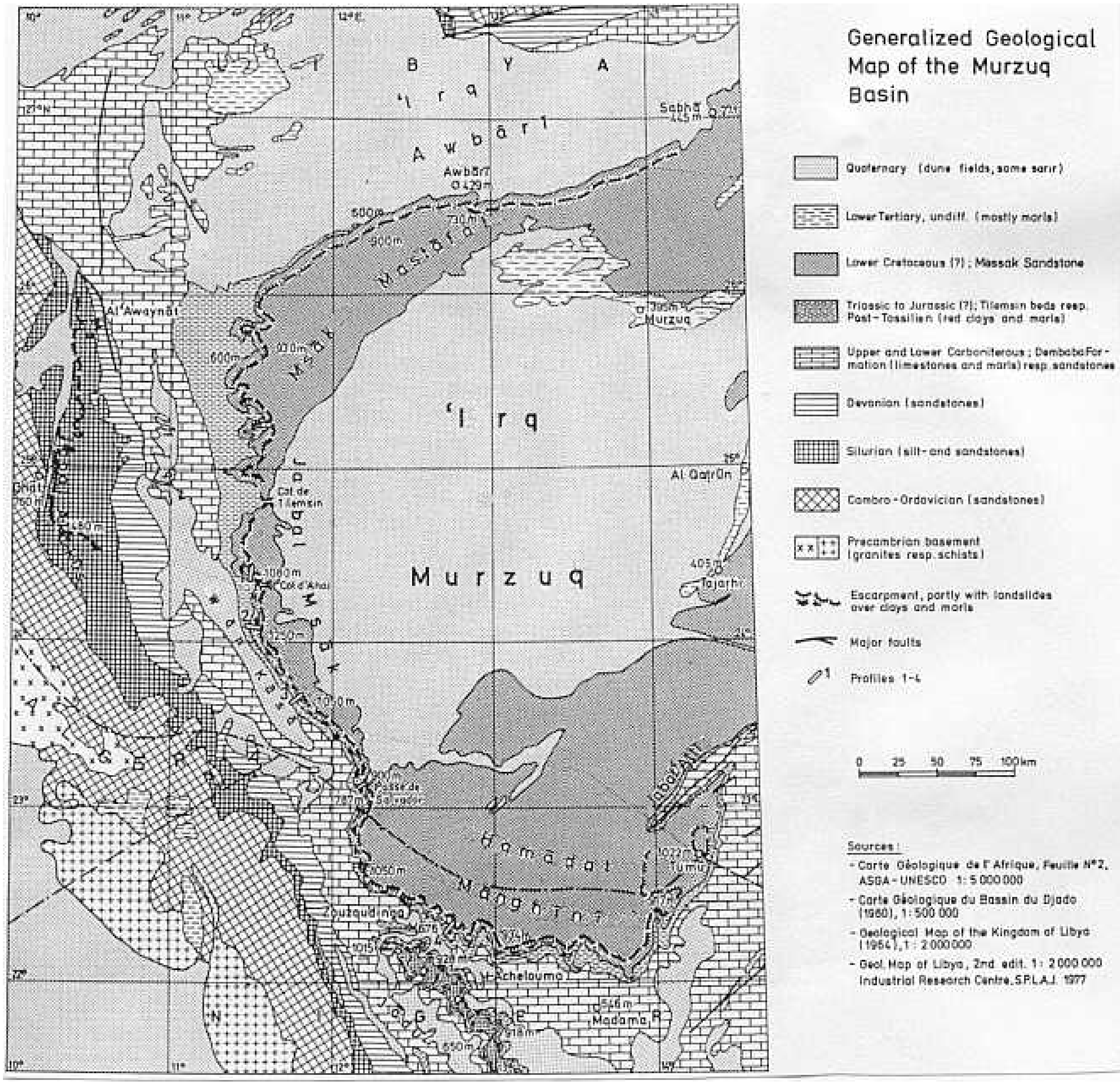


Fig. 12: Generalized stratigraphic succession in the Sirt Basin (Hallet et al. 1996).

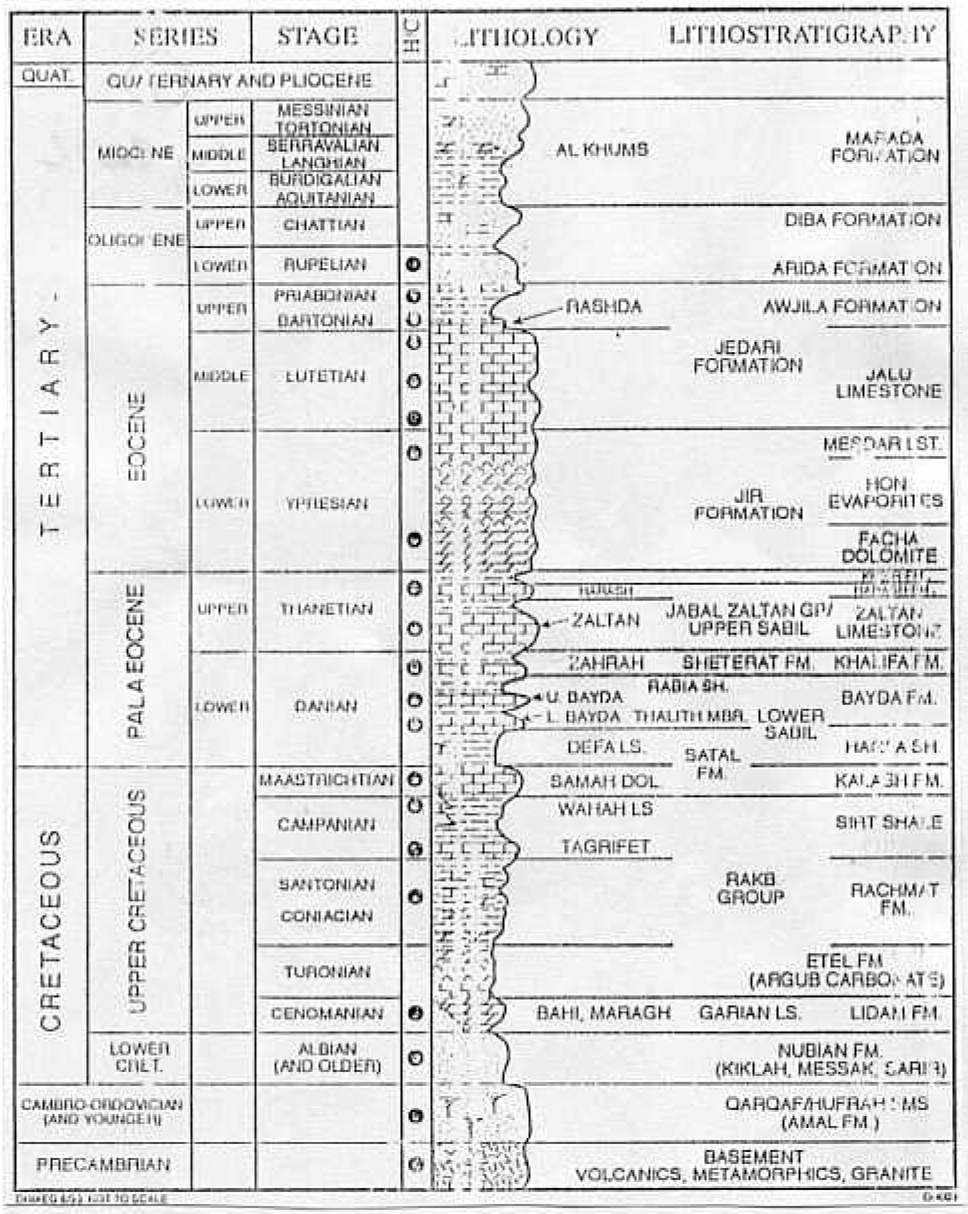


Fig. 13: Tertiary Correlation and nomenclature of the Sirte Basin (Wennekers et al., 1996)

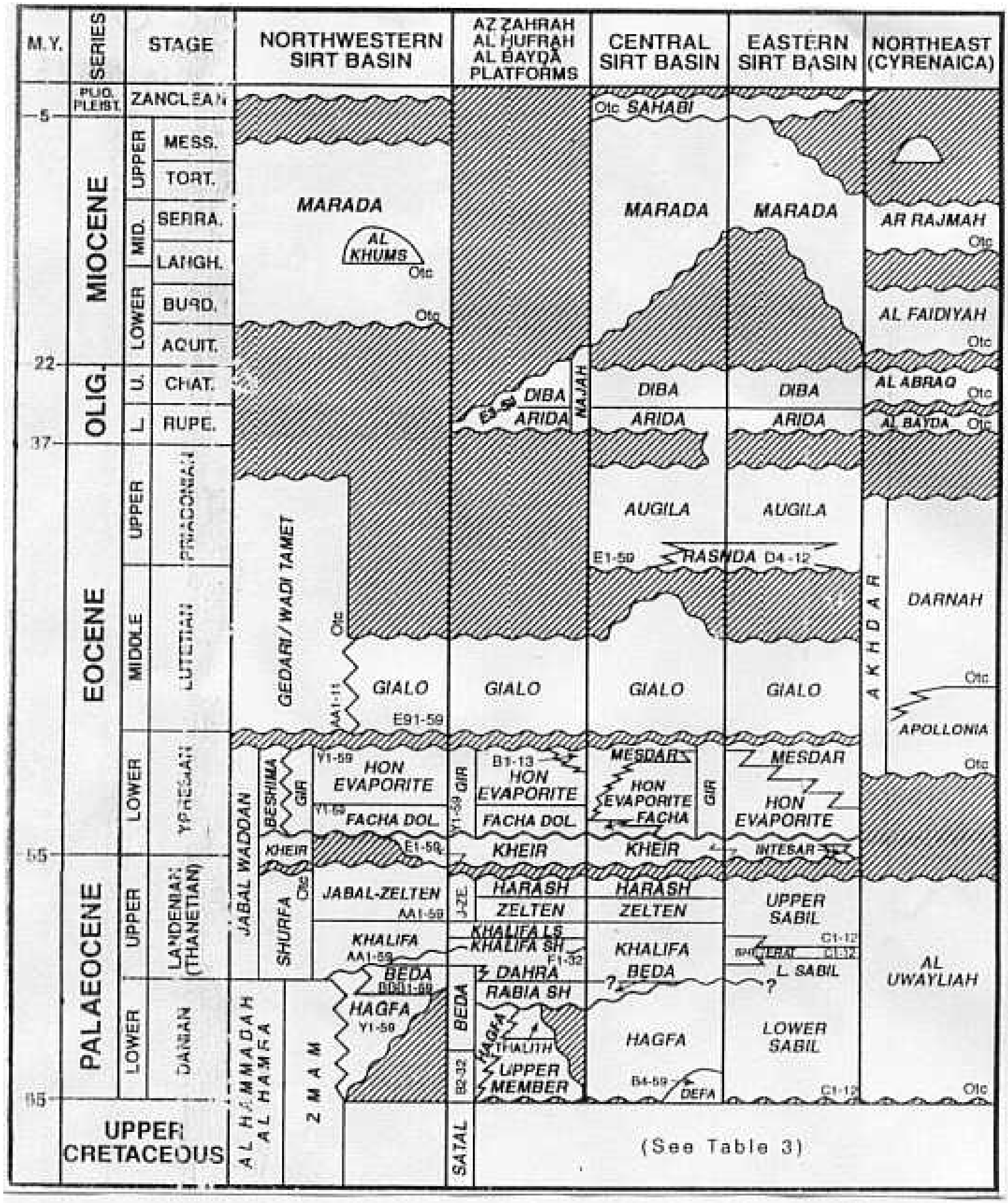


Fig. 14: Stratigraphic subdivision of the Cyrenaica Platform (Kleinsmiede et al., 1968)

GP	FORMATION	MEMBER	AGE
SIRTE	REGIMA		Miocene
	AL KUF	Al Faidia Clay	Oligocene
		Labrak Calcarenite	
		Algal Limestone	
		Shahhat Marl	
TAMET	AKHDAR	Slonta Limestone	Upper to Middle Eocene
		Derna Limestone	
		Apollonia Limestone	
HAMADA	WADI DUCCHAN		Paleocene (?) to Maestrichtian (?)
	JARDAS	Al Feitah Limestone	Campanian to Coniacian
		Got Sas Marl	
		Benia Limestone	Coniacian to U. Cenomanian
		Gasr al Abid Marl	Cenomanian

Fig. 15: Location of fossiliferous deposits observed in the Wadi ash Shati area (Petit-Maire et al., 1980).

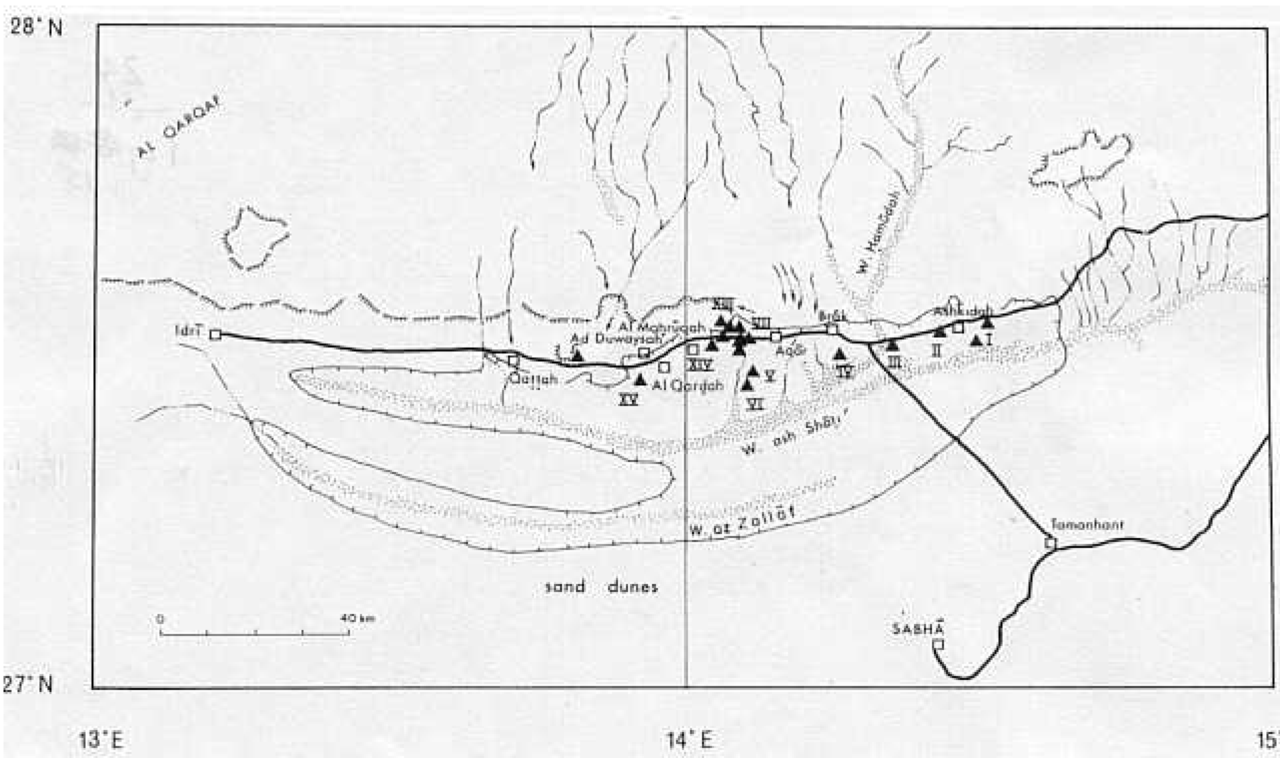


Fig. 16a: Qasr as Sahabi (Heinzelin et al., 1980)

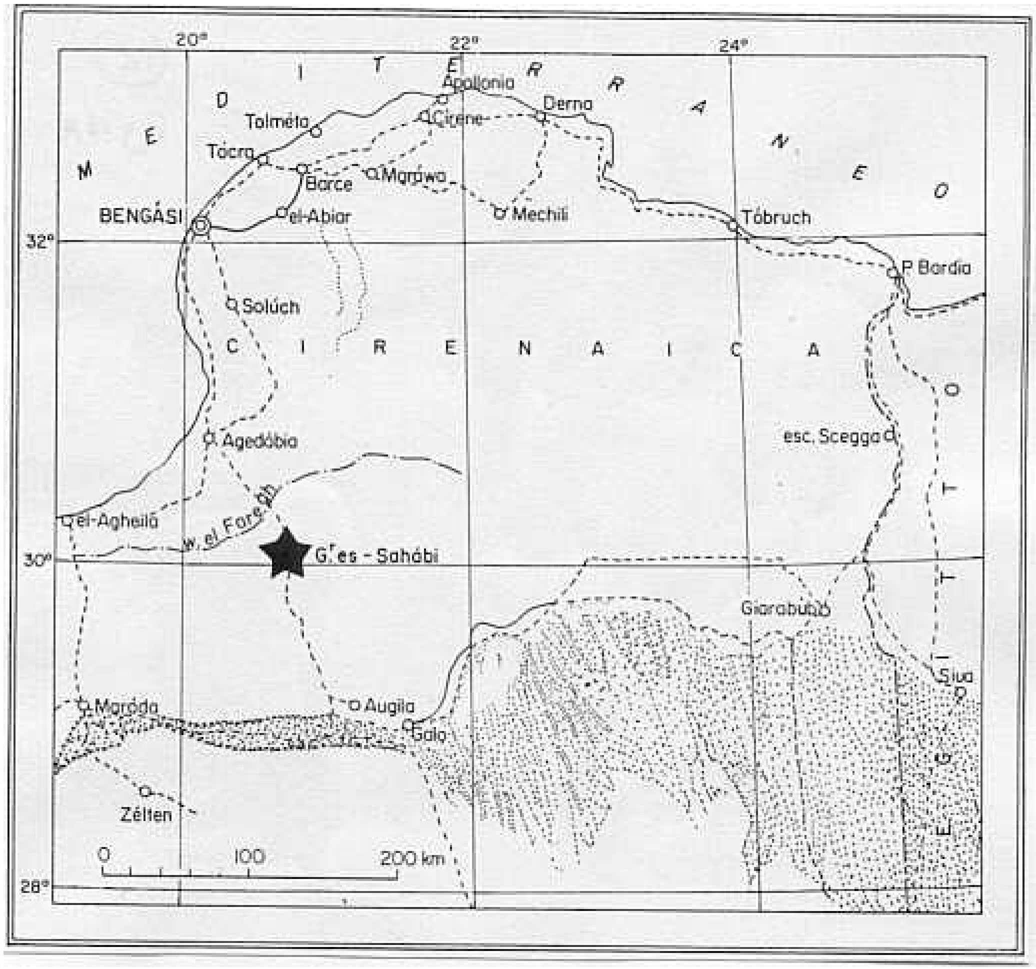


Fig. 16b: Geological map of central Cyrenaica. The Sahabi Pliocene deposit is shown with a star southeast of the town of Agedabia (Wright et al. 1971)

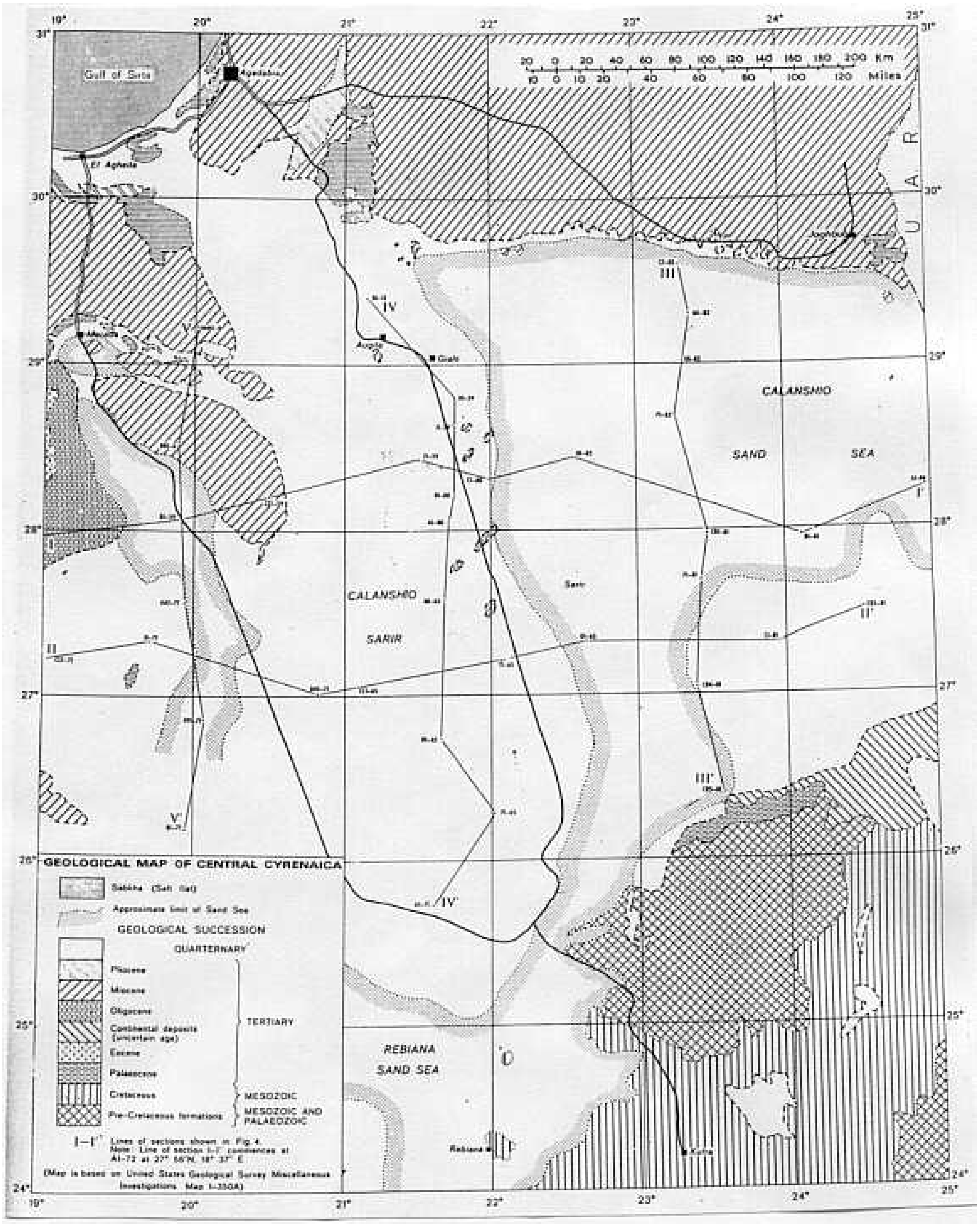


Fig. 17: Location of the Sahabi profiles. Accessible outcrops are stippled (Heinzelin et al. 1980)

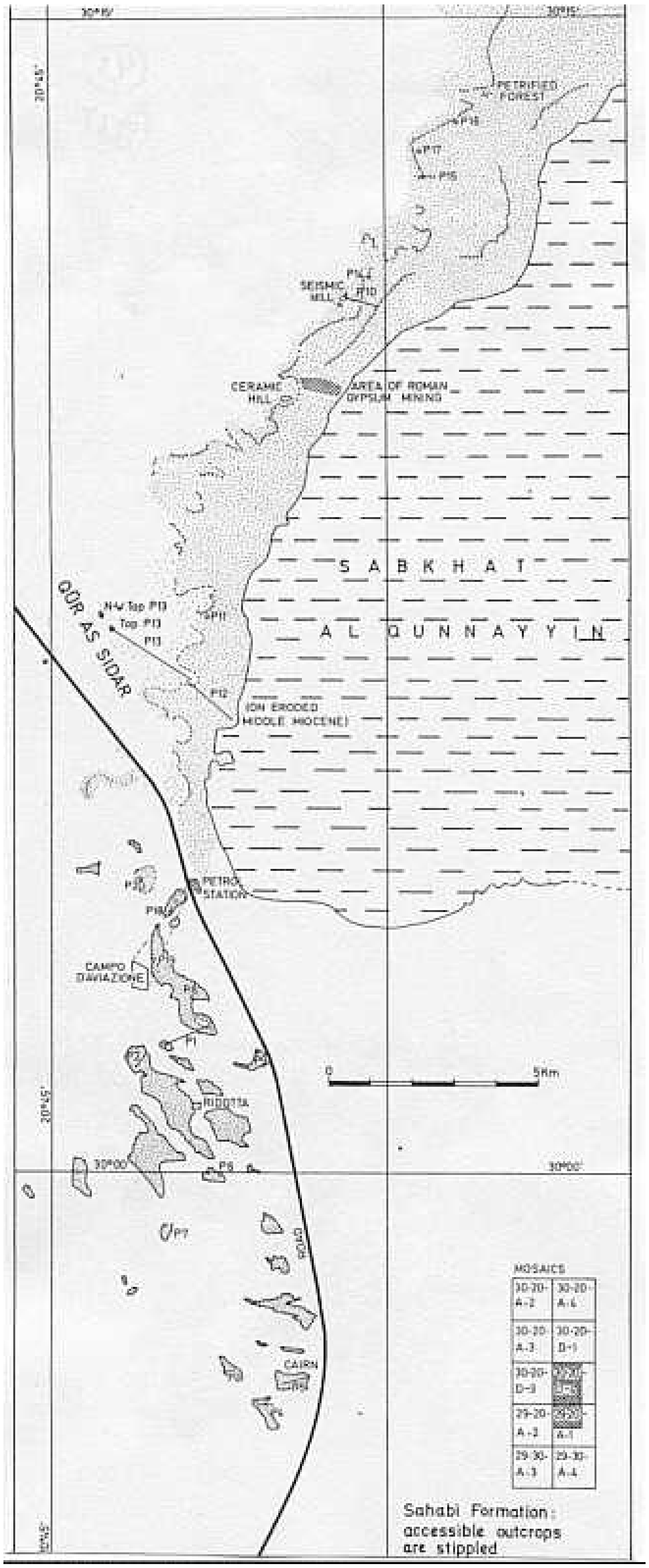


Fig. 18: Exposure of the Regima Formation (Miocene) in a large limestone quarry on the Benghazi to Benina highway. (Kleinsmiede et al., 1968).

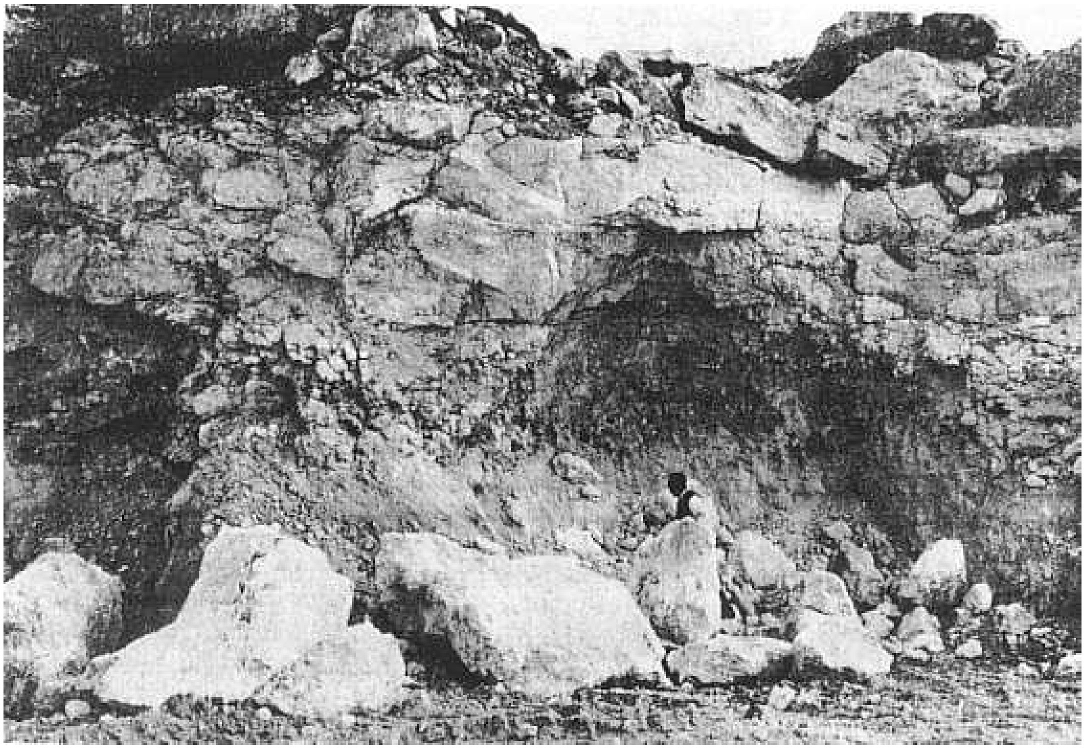


Fig. 19: Location map showing the extent of Wadi al Qattarah Member, the approximate limit of gypsum facies, and the location of sections A (quarry at Hawa al Barraq) and B (quarry at Ar Rajmah). (El-Hawat, 1980)

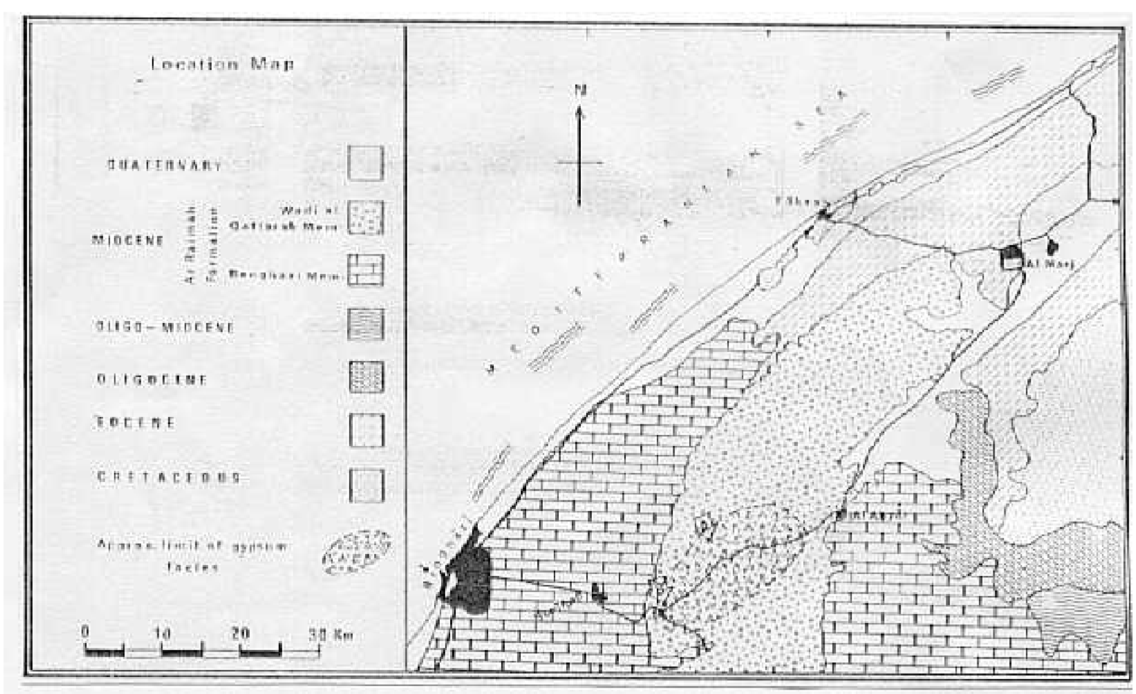


Fig. 20a: Generalized geologic map of Al Kufrah region, showing localities of two impact structures northeast of Al Kufrah oasis. (Underwood et al., 1980).

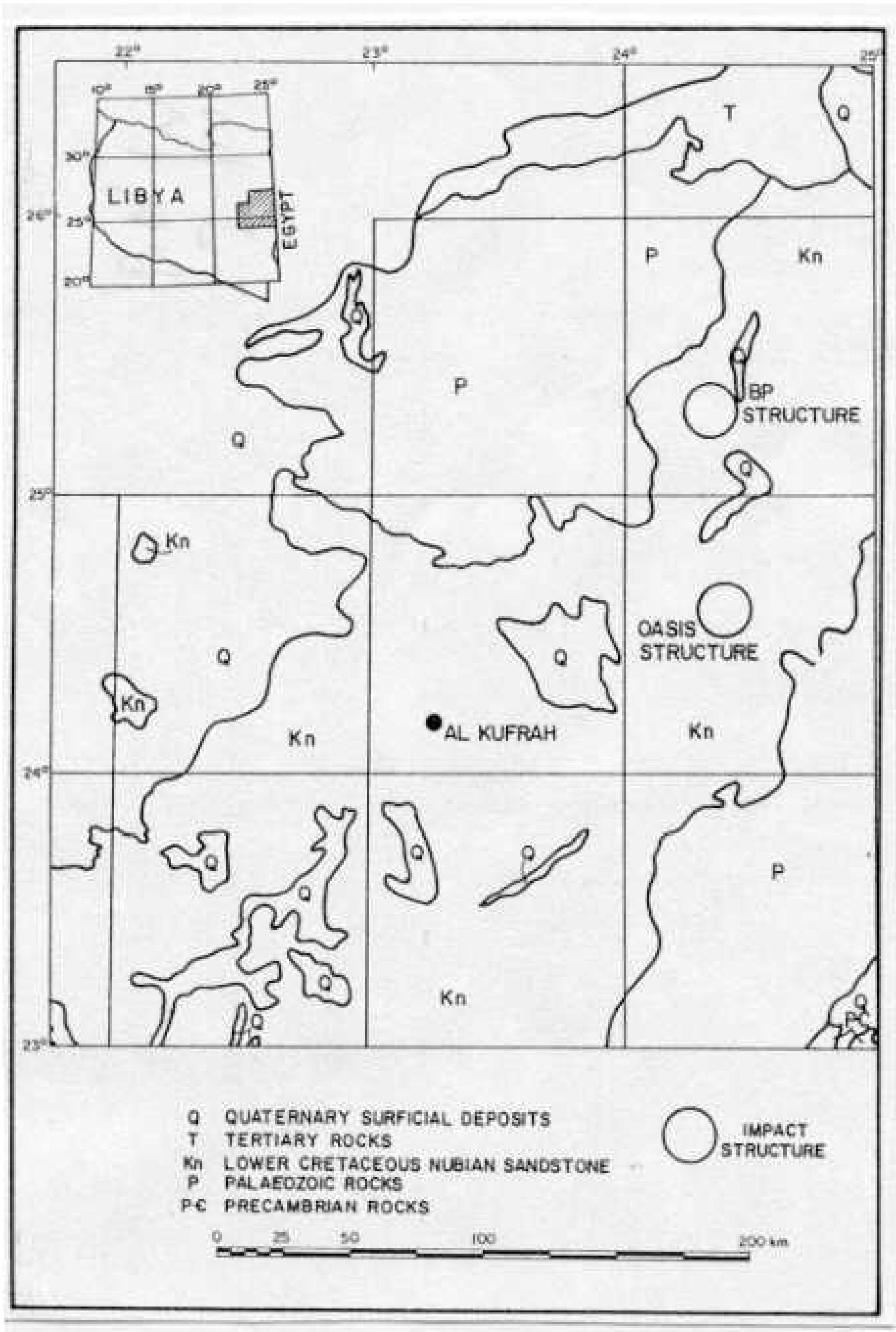


Fig. 20b: The "Libyan Desert glass" (LDG) has apparently no connection with the Oasis or BP structures, according to the author below, even though an impact origin is most likely. The samples below have been found in the inter-dune corridors of the Great Sand Sea (Libyan Desert in Egypt). These are from the personal collection of Mr. Edmond Diemer, geophysicist, who has been working since at least 1995 on LDG. He was involved in the Bologna Congress "Silica 96" and is regularly updating the bibliography concerning this glass (about 200 papers).

Fig. 21: Faunal list of mammals from Jabal Zaltan arranged according to their chronological ranges with comparisons to similar species from other parts of Africa. (Pickford, 1991).

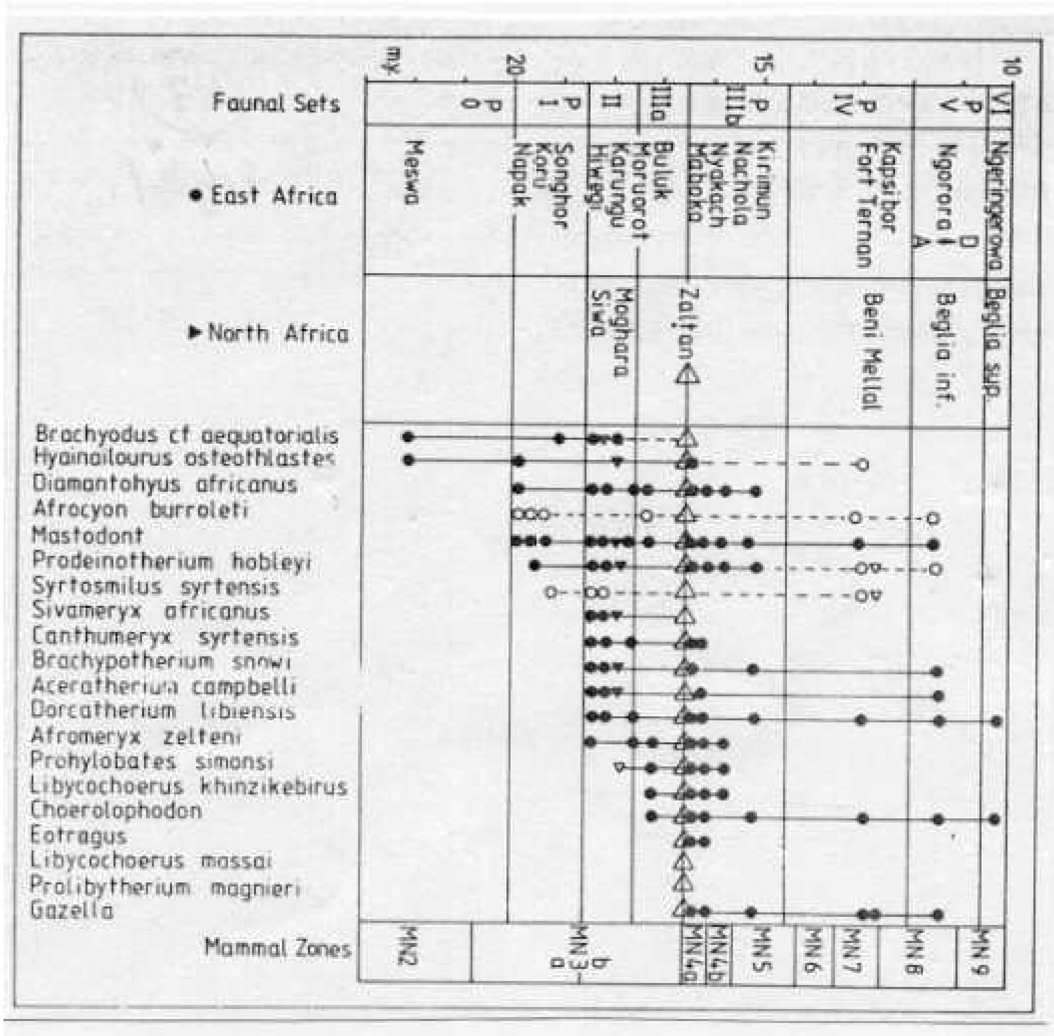


Fig. 22: Geologic map showing location of the Gharyan phosphorite (Lagha Salem, 1997)

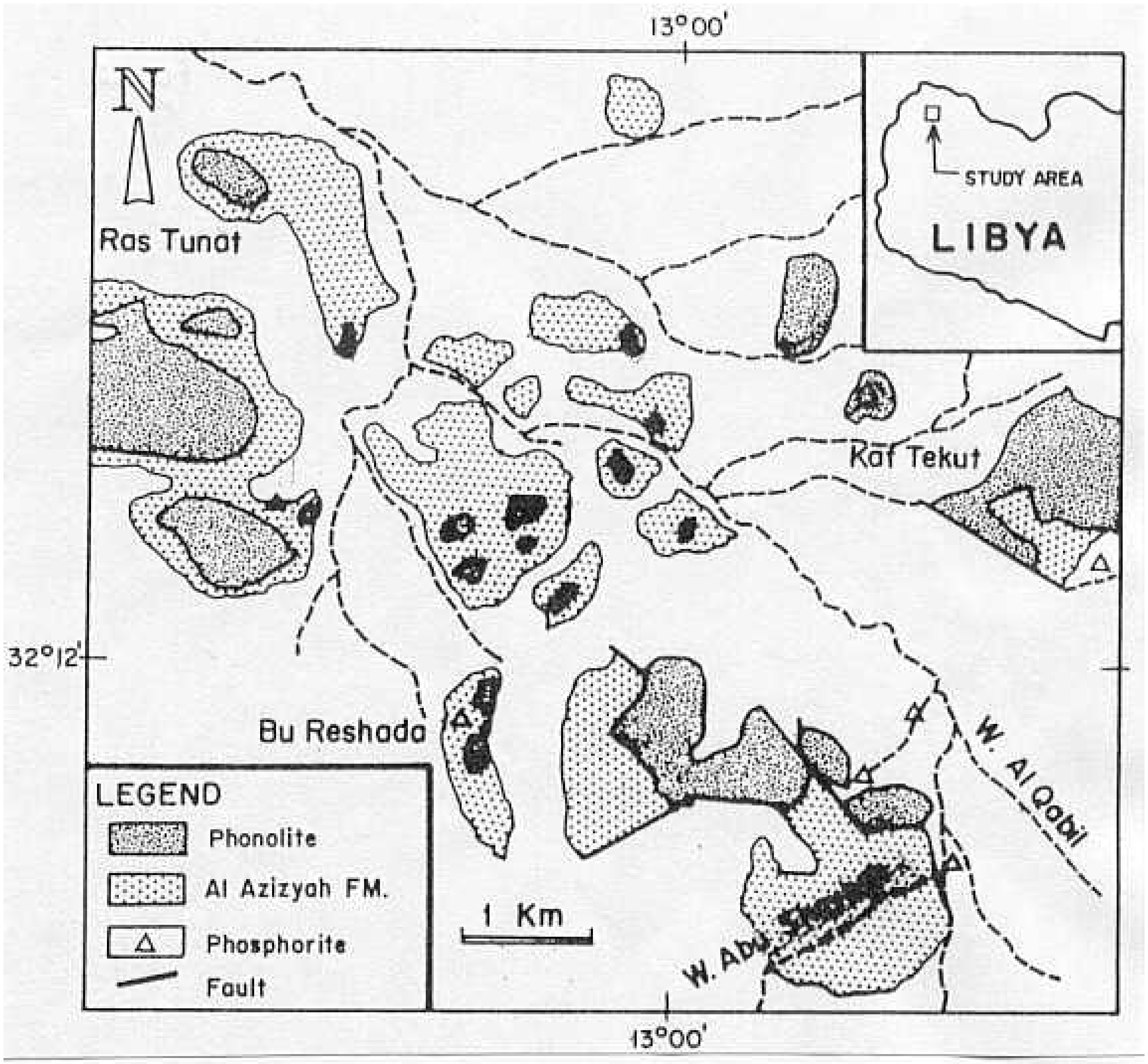


Fig. 23: Geological map of North Cyrenaica (Sola M. et al.. 1990)

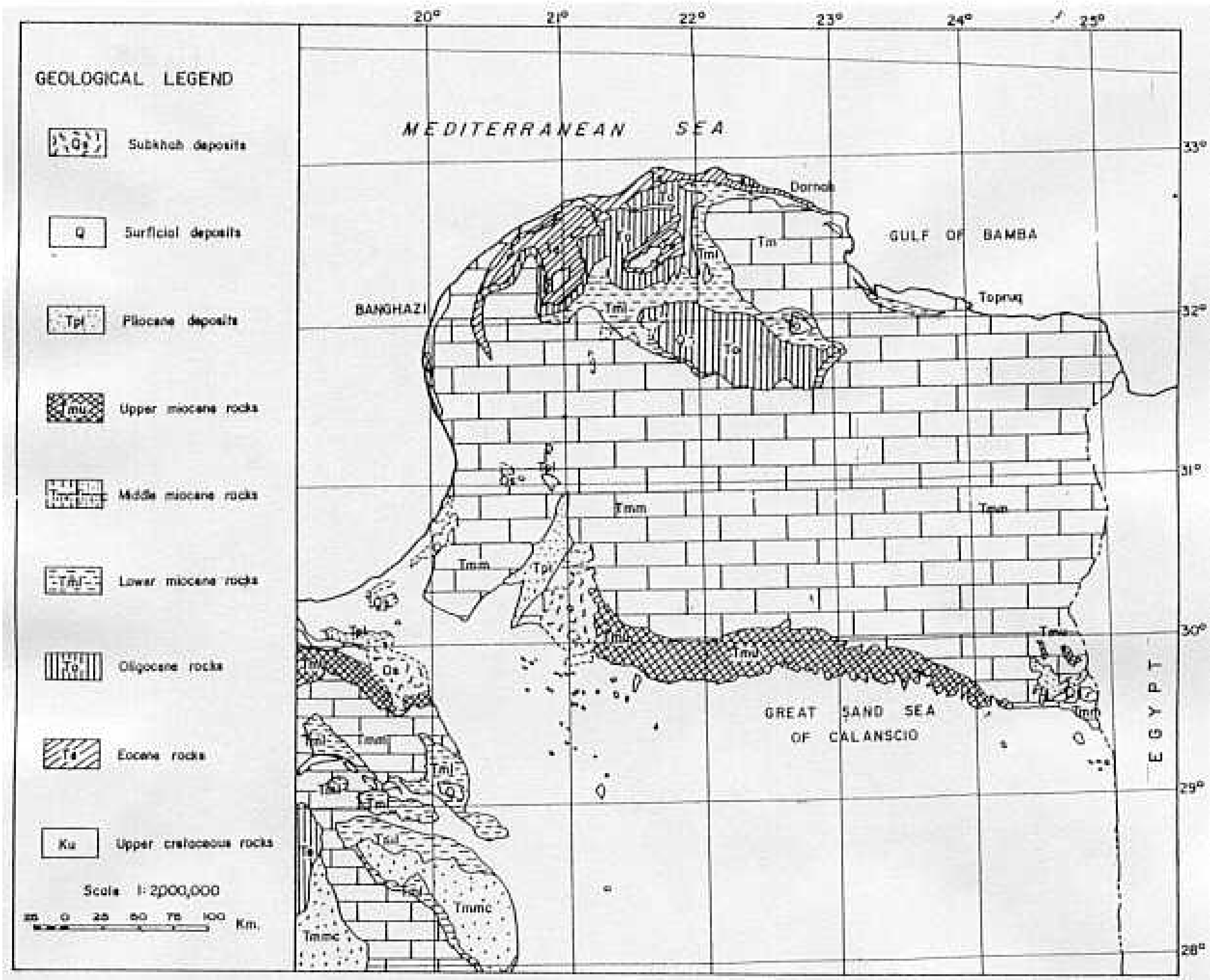


Fig. 24: Extension of 1) marine Miocene sediments; 2) marine Miocene missing; 3) marine quaternary, in north and northeast Libya. (Desio, 1968).

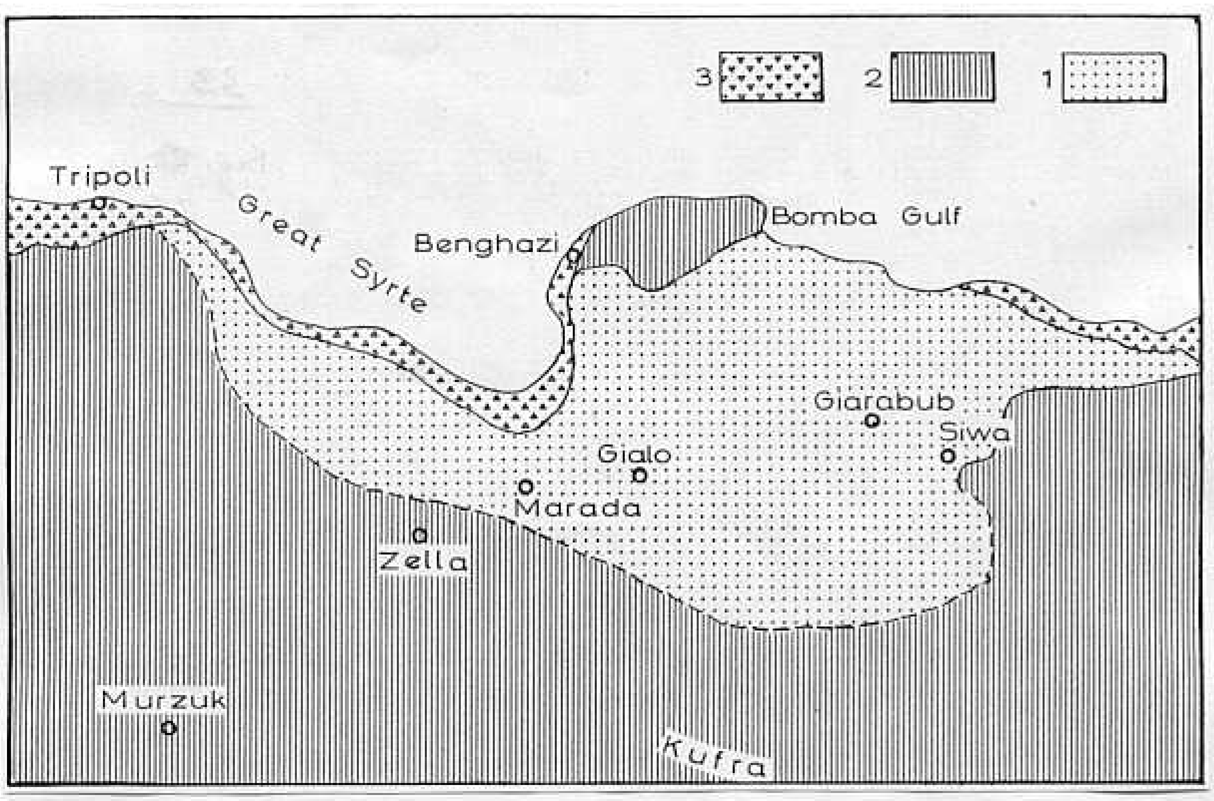


Fig. 25: Geological sketch-map of the region of Marada. 1) Upper Eocene; 2) Oligocene; 3) Lower Miocene (marine); 4) Lower Miocene (continental); 5) Middle Miocene; 6) Salty red soil of sabkha; 7) Sand dunes; 8) Sand blanket; 9) Amber nodules; 10) Fossil wood. (Desio, 1968).

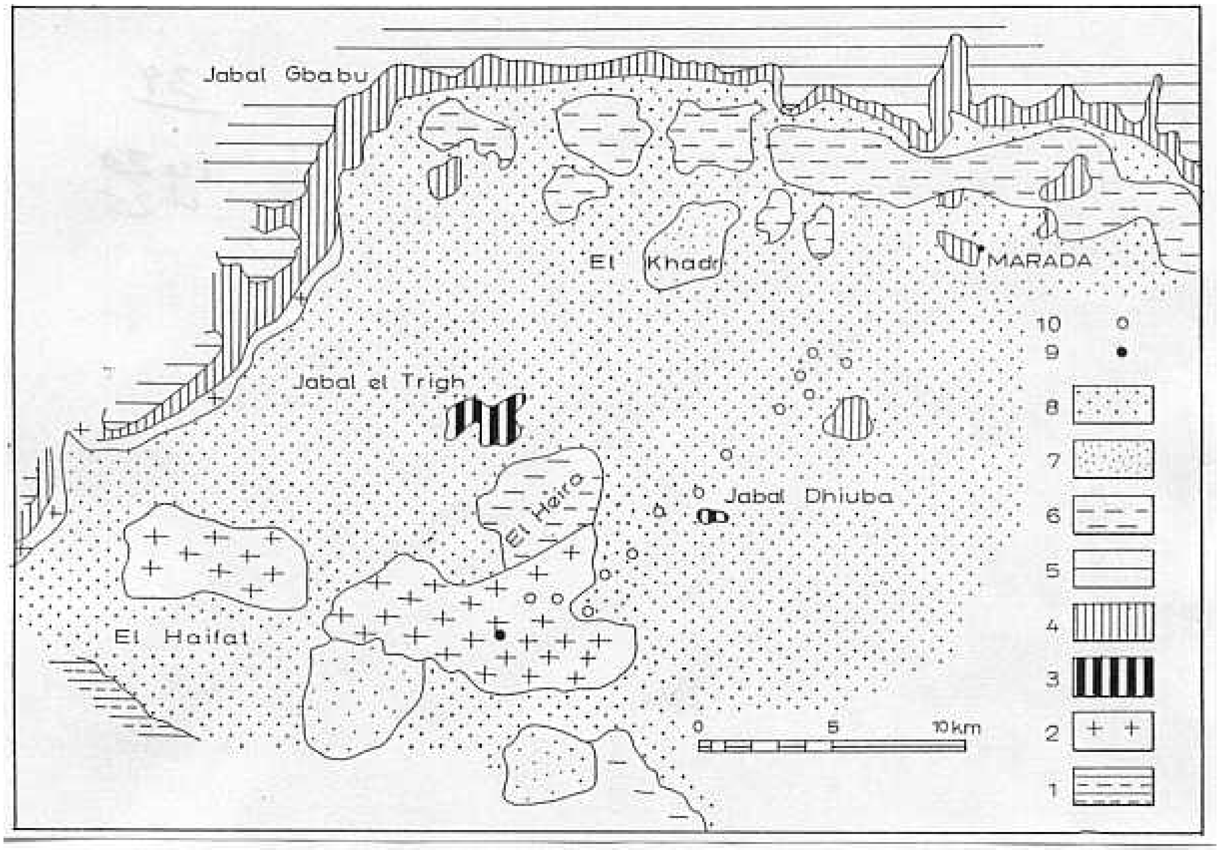


Fig. 26: *Xenopus (Libycus) hasaunus* (frog) from the Tarab formation (Spinar, 1980).

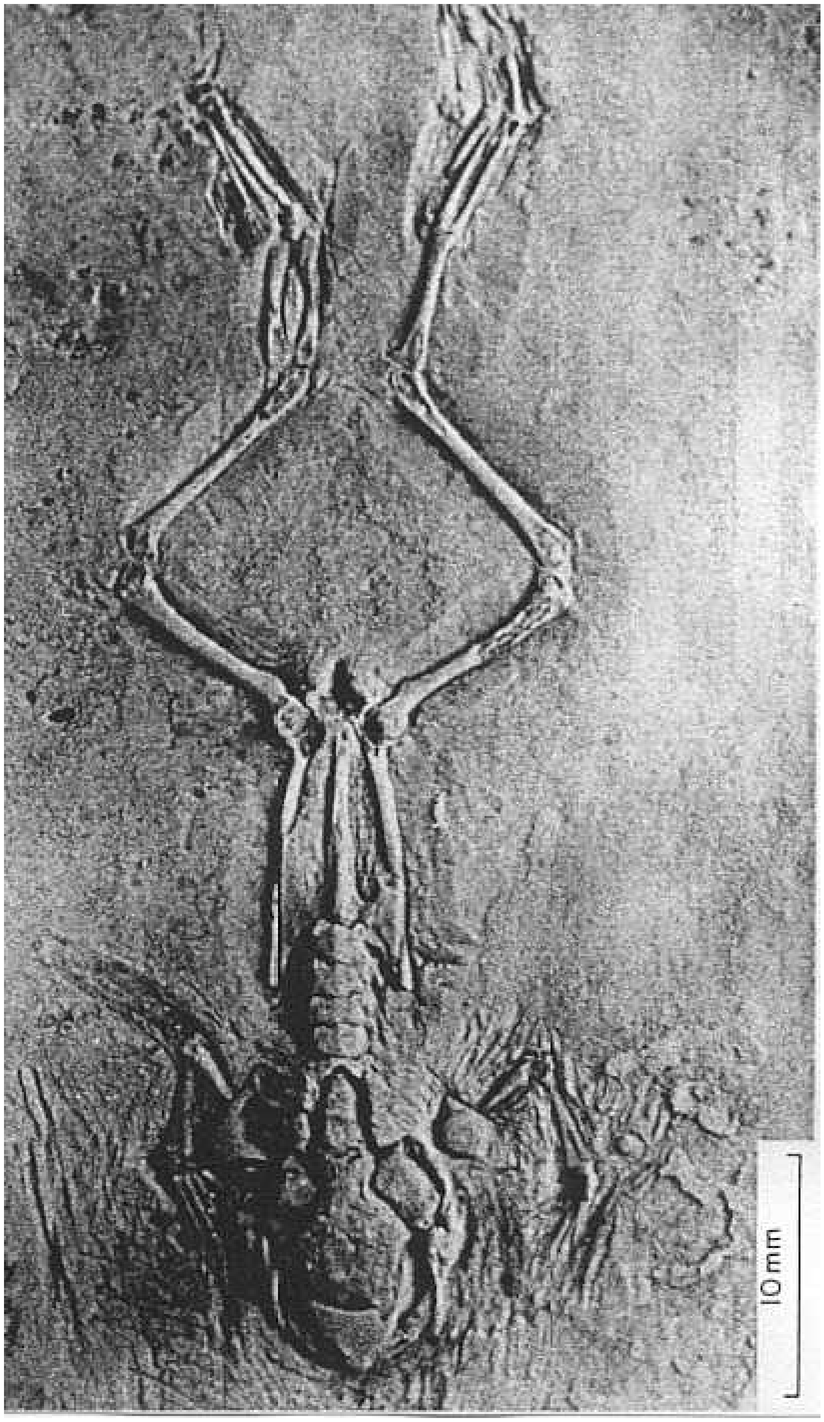


Fig. 27: Tertiary geology map of Sarir Tibisti area (Wight, 1980).

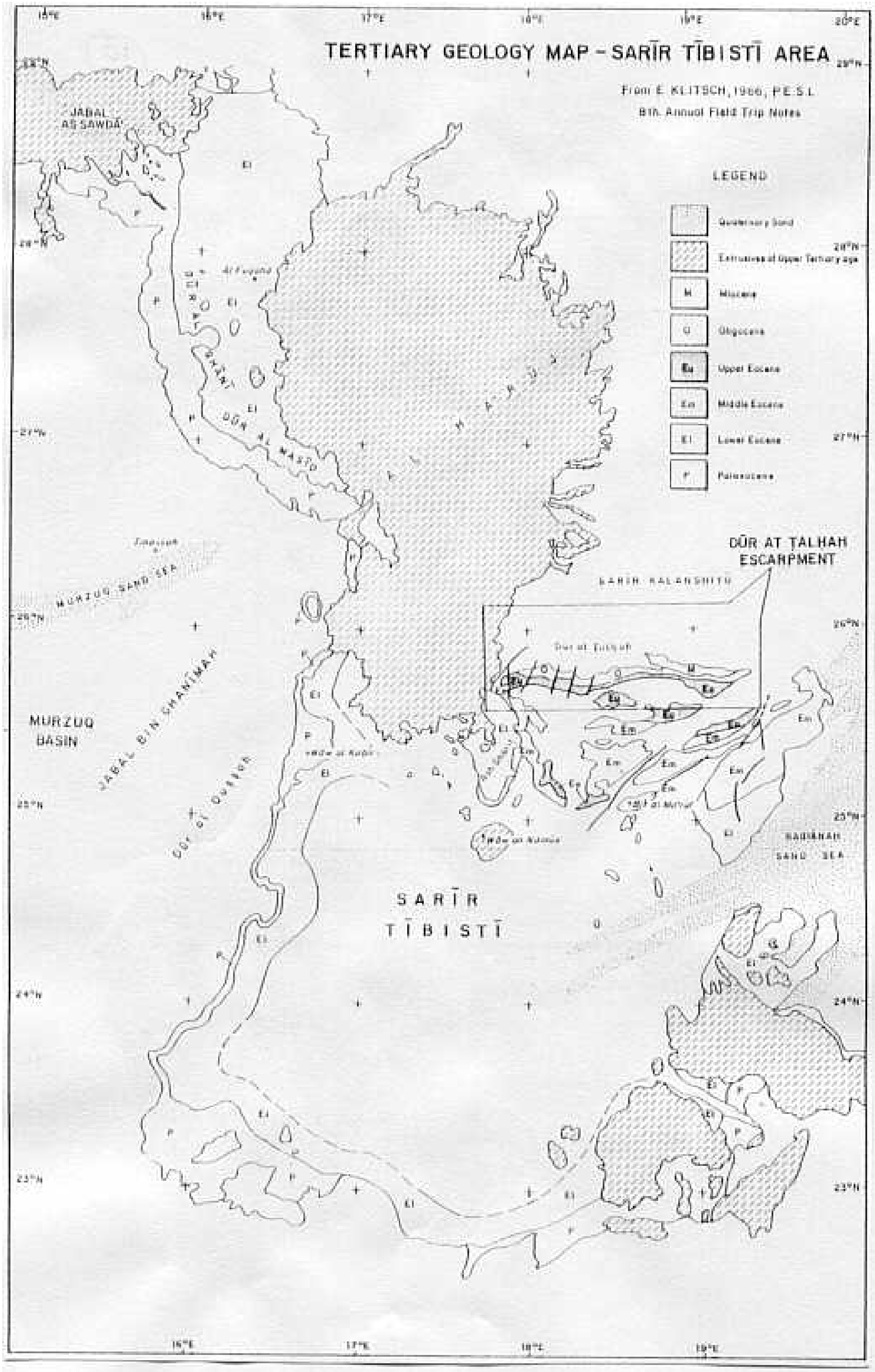
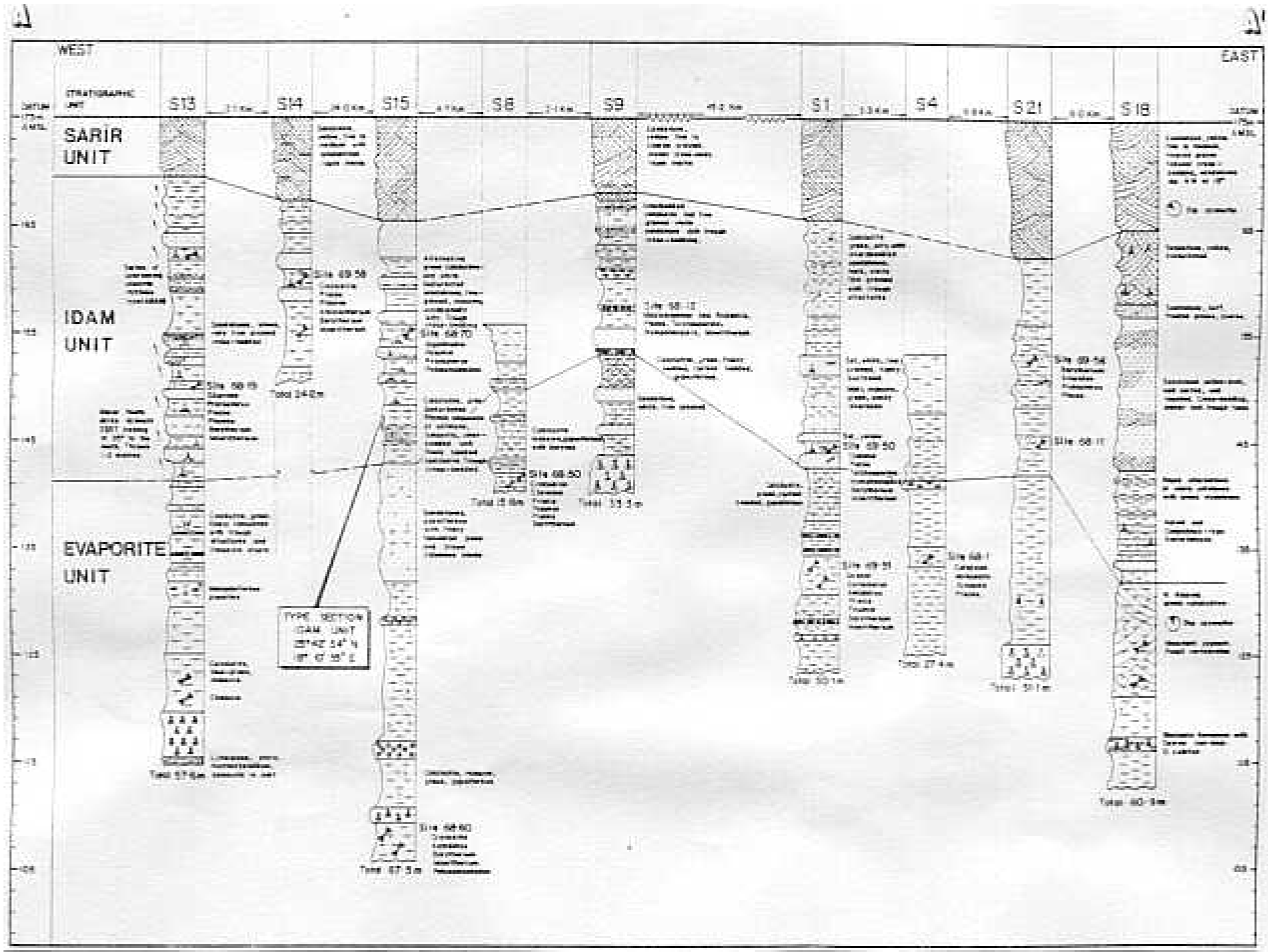
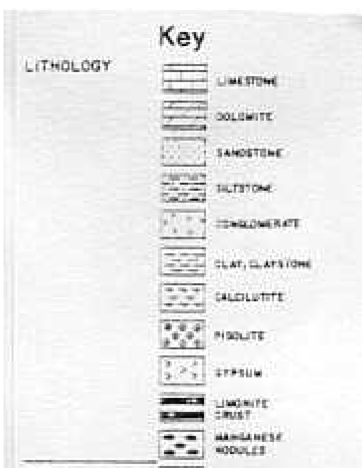


Fig. 28: Lithostratigraphic correlation along the Dur at Talhah escarpment in Southern Sirte basin (Wight, 1980).





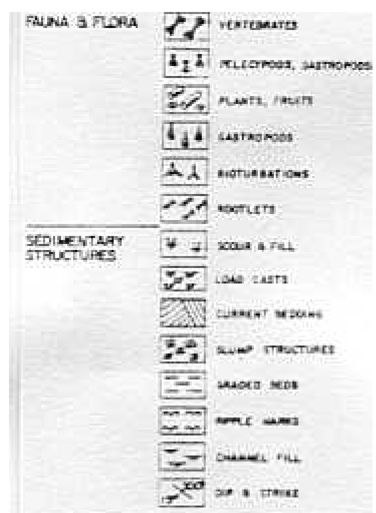


Fig. 29: Schematic N-S cross section across Dur at Talhah escarpment (Wight, 1980).

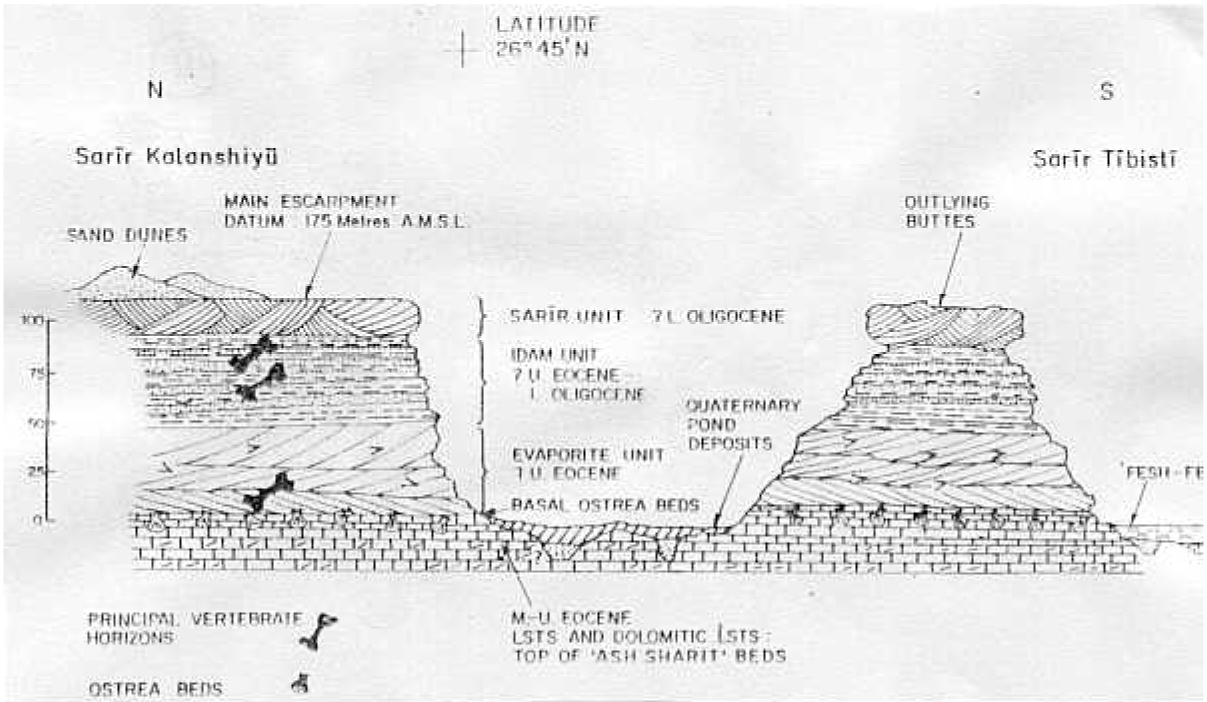


Fig. 30: Dur at Talhah vertebrate and plant faunal chart (Wight, 1980).

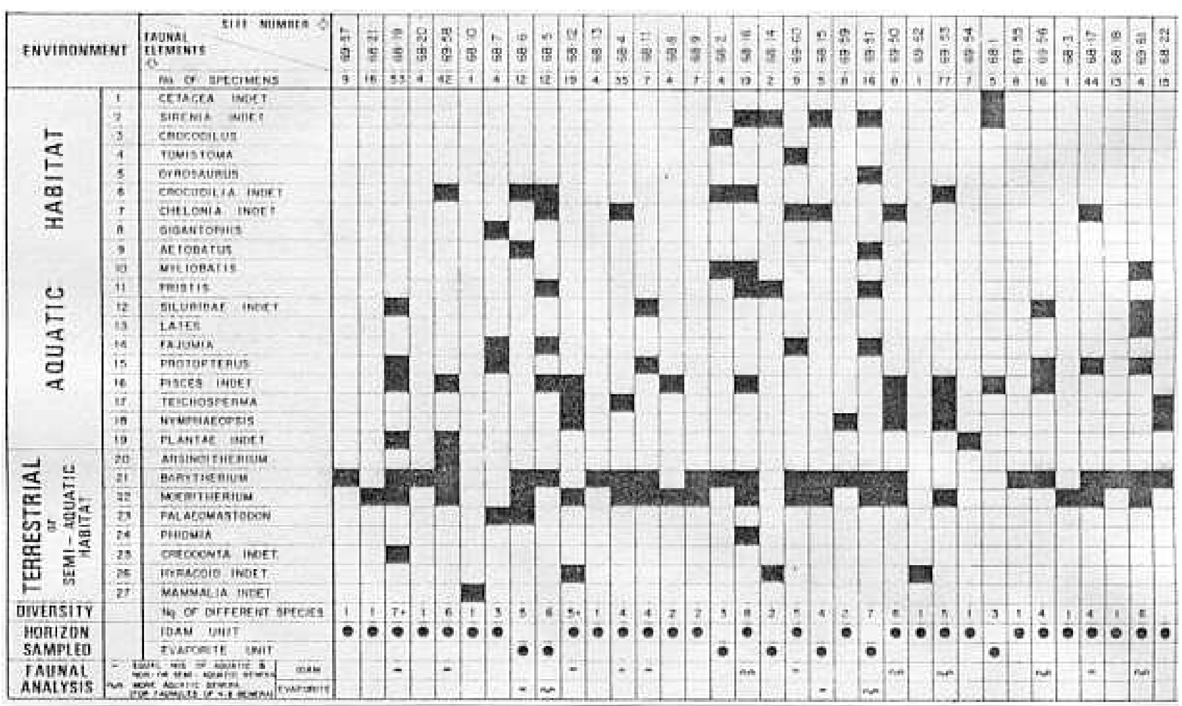


Fig. 31: Location of vertebrate sites in Dur at Talhah (Wight, 1980).

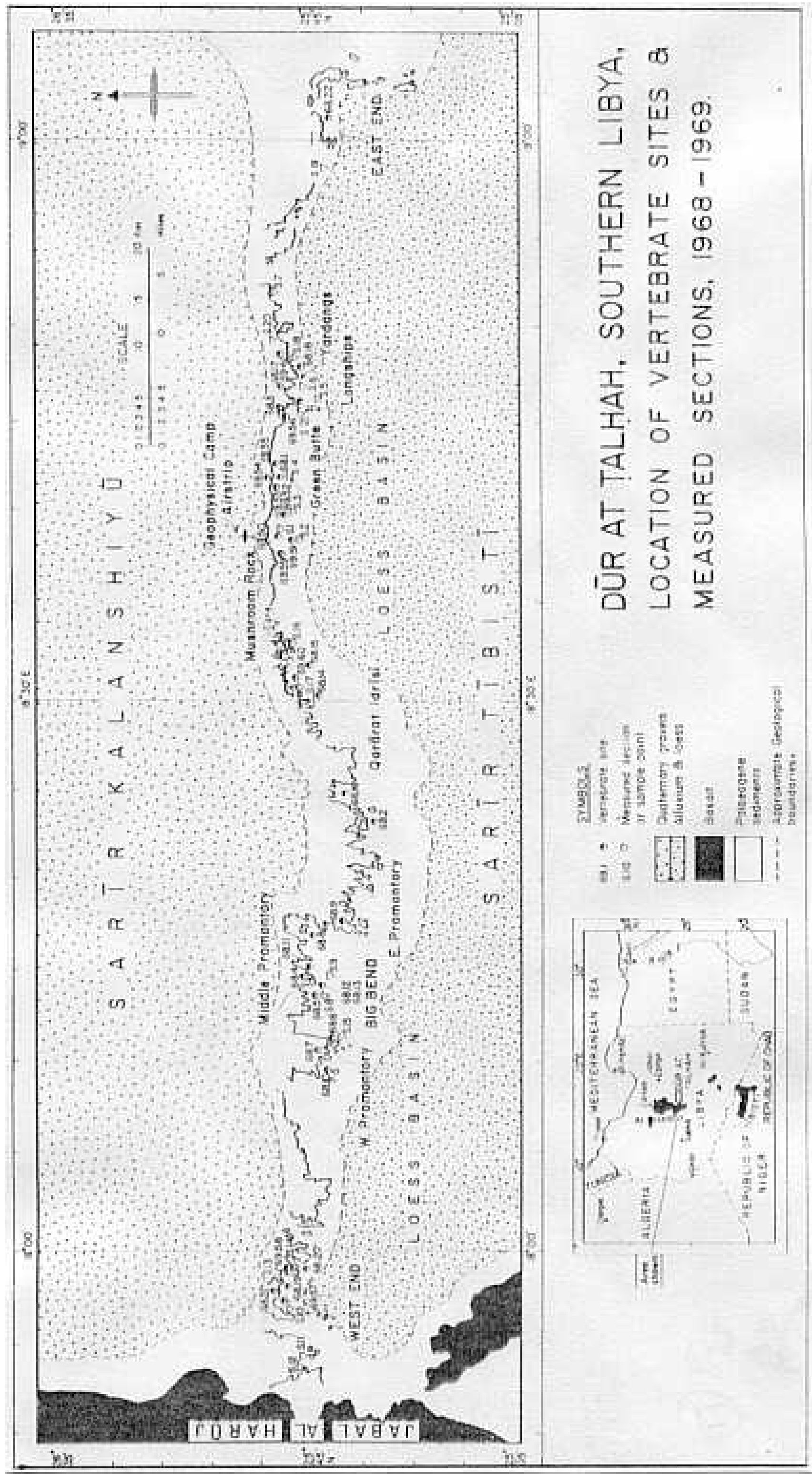
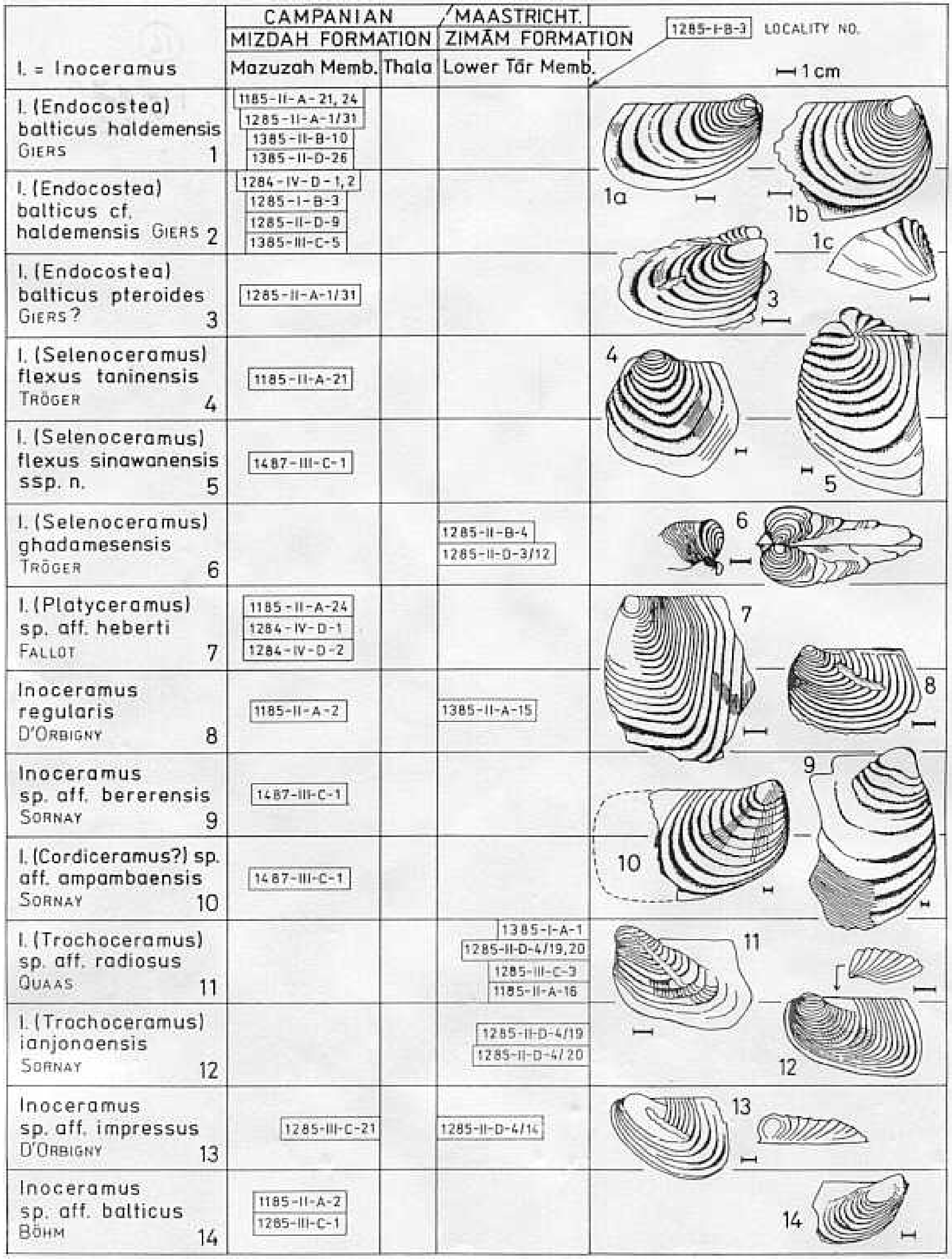


Fig. 32: Distribution of inoceramid species and subspecies in Campanian and Maastrichtian



I. = Inoceramus	CAMPANIAN MIZDAH FORMATION Mazuzah Memb.	Thala	MAASTRICHT. ZIMĀM FORMATION Lower Tār Memb.
I. (Endocostea) balticus haldemensis GIERS 1	1185-II-A-21, 24 1285-II-A-1/31 1385-II-B-10 1385-II-D-26		
I. (Endocostea) balticus cf. haldemensis GIERS 2	1284-IV-D-1, 2 1285-I-B-3 1285-II-D-9 1385-III-C-5		
I. (Endocostea) balticus pteroides GIERS? 3	1285-II-A-1/31		
I. (Selenoceramus) flexus taninensis TRÖGER 4	1185-II-A-21		
I. (Selenoceramus) flexus sinawanensis ssp. n. 5	1487-III-C-1		
I. (Selenoceramus) ghadamesensis TRÖGER 6			1285-II-B-4 1285-II-D-3/12
I. (Platyceramus) sp. aff. heberti FALLOT 7	1185-II-A-24 1284-IV-D-1 1284-IV-D-2		
Inoceramus regularis D'ORBIGNY 8	1185-II-A-2		1385-II-A-15
Inoceramus sp. aff. bererensis SORNAY 9	1487-III-C-1		
I. (Cordiceramus?) sp. aff. ampambaensis SORNAY 10	1487-III-C-1		
I. (Trochoceramus) sp. aff. radiosus QUAAS 11			1385-I-A-1 1285-II-D-4/19, 20 1285-III-C-3 1185-II-A-16
I. (Trochoceramus) ianjonaensis SORNAY 12			1285-II-D-4/19 1285-II-D-4/20
Inoceramus sp. aff. impressus D'ORBIGNY 13	1285-III-C-21		1285-II-D-4/14
Inoceramus sp. aff. balticus BÖHM 14	1185-II-A-2 1285-III-C-1		

deposits of Libya (Troger et al., 1991)

Fig. 33: Location map of the inoceramid localities in the Ghadamis-Darj area (Troger et al, 1991).

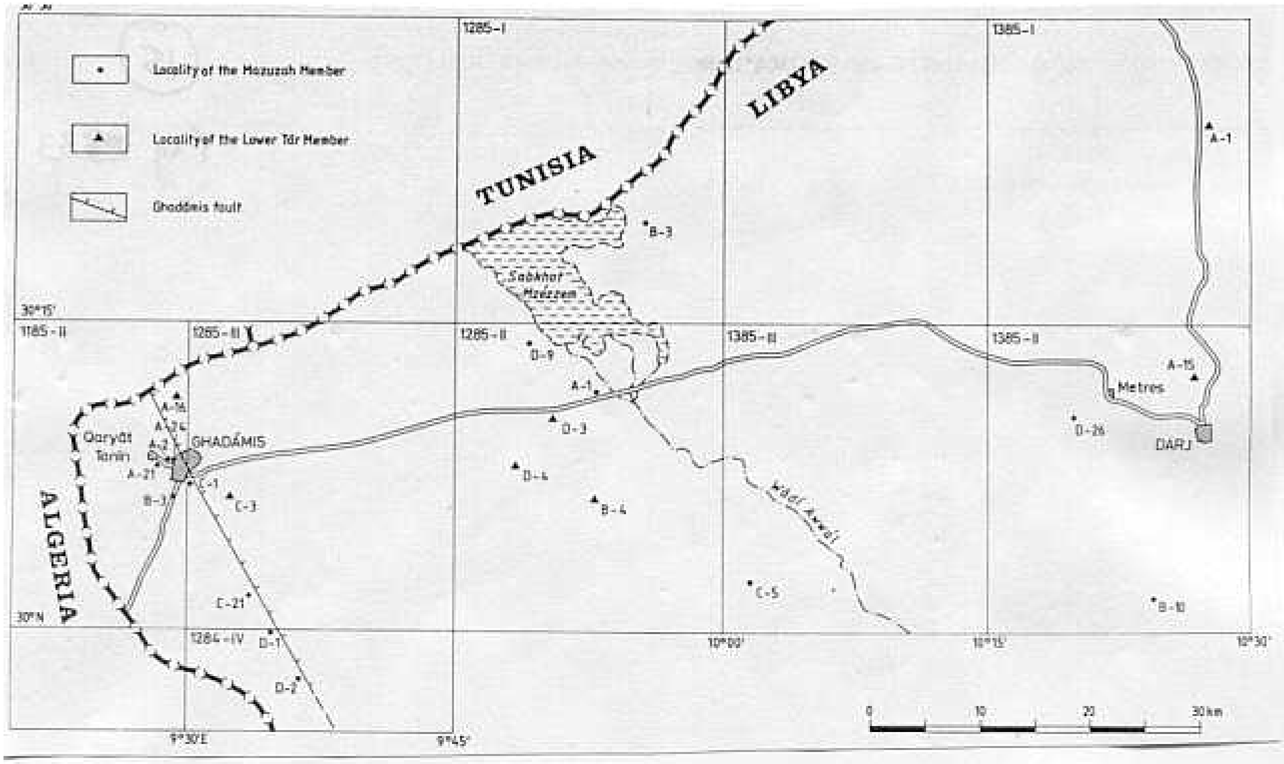


Fig. 34: Delimitation of the inoceramid study area and location map of the inoceramid locality in the Mazuzah Member at Sinawan (Troger et al, 1991).

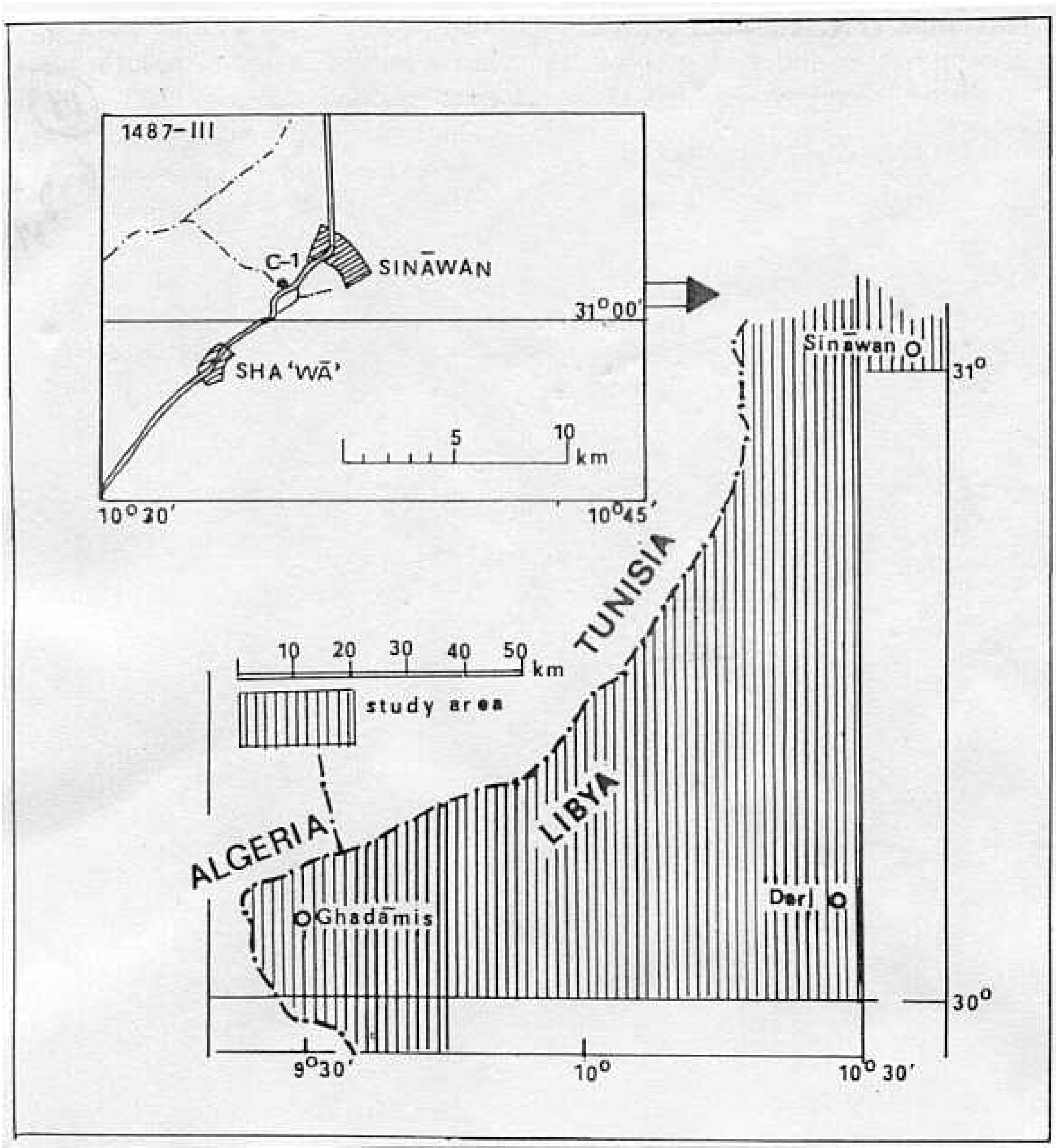


Fig. 35: Generalized lithostratigraphic scheme of the Campanian and Maastrichtian layers in the Ghadamis-Darj-Sinawan area (Troger et al, 1991).

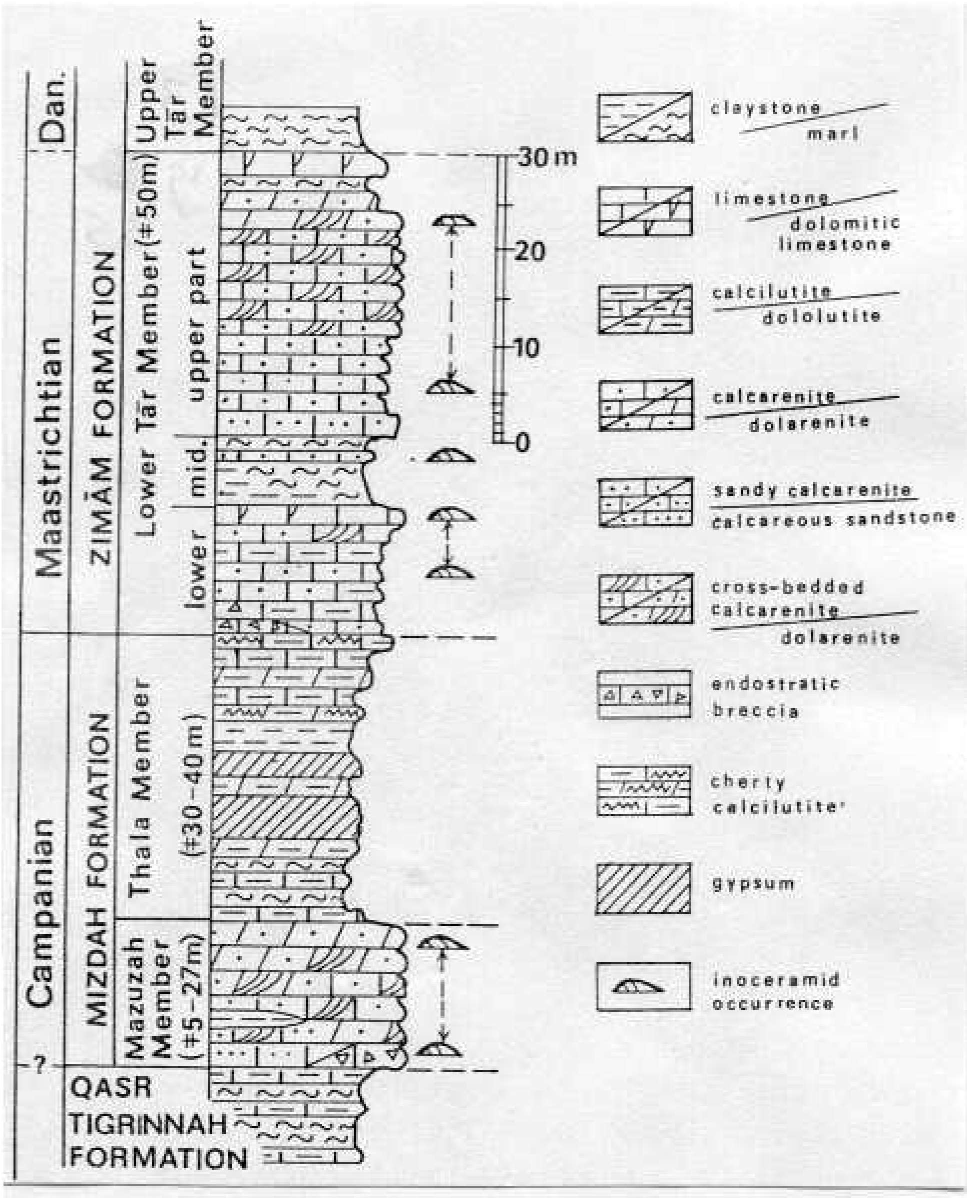


Fig. 36: Triassic fish (Cleithrolepis Major) found in a core of well L4-51 at a depth of 10,840' in the Alma Formation (Thusu, 1996).

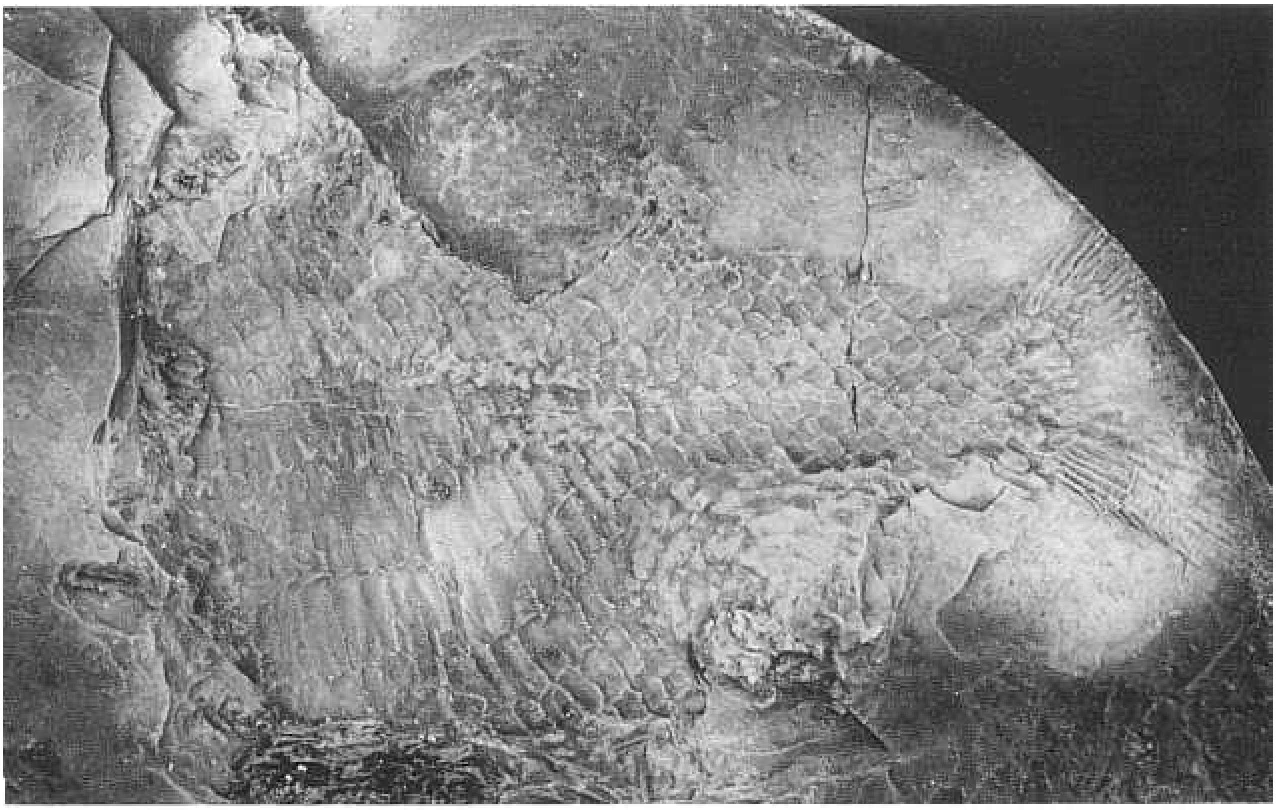


Fig. 37: Location map of Jabal Nafusah (Hlustik, 1991).

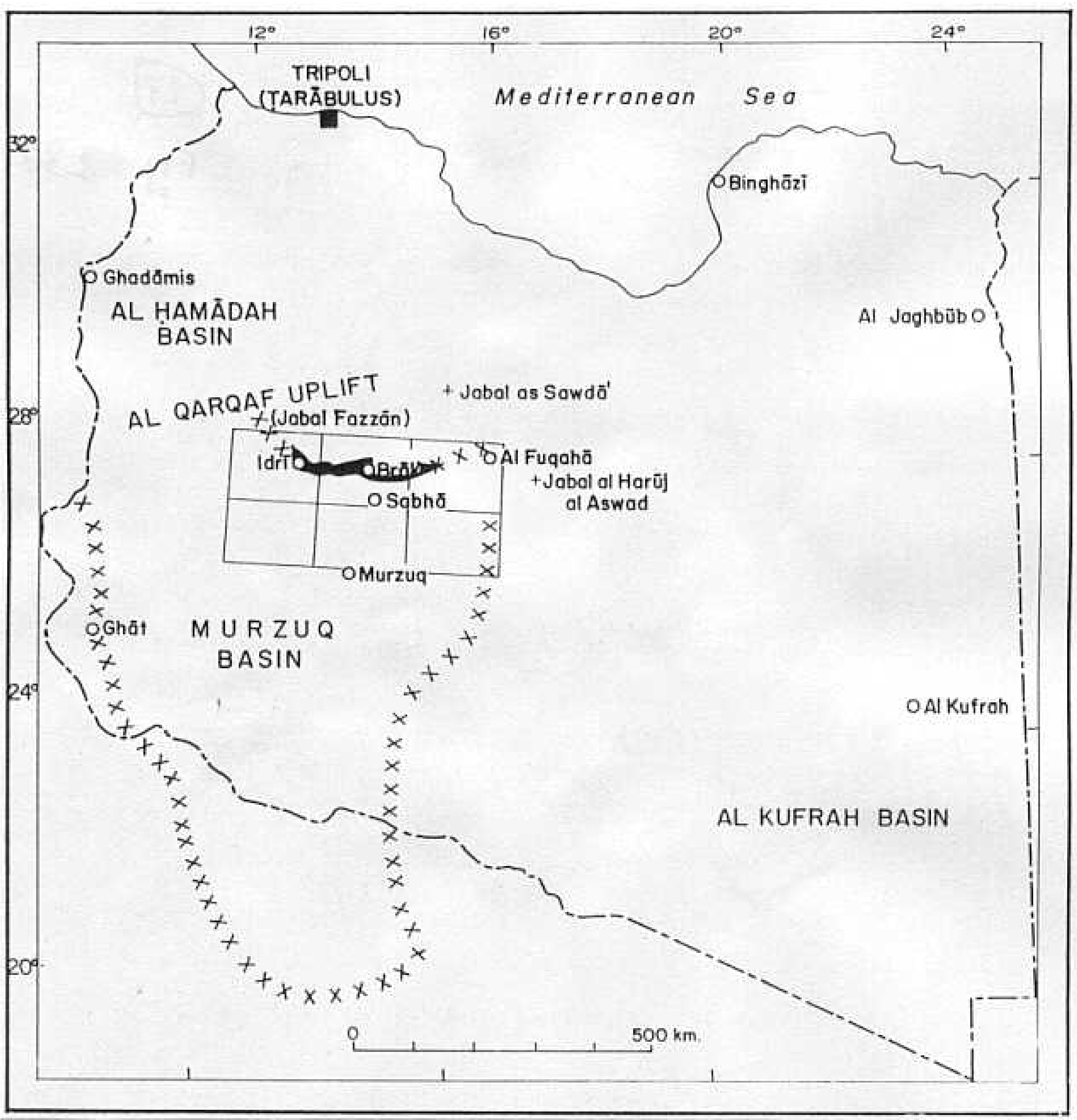


Fig. 38: The most important localities of the described floras in the Wadi ash Shati area: 1) Idri, 2) Wanzarik, 3) Barqan, 4) Quttah, 5) Tarut, 6) Al Mahruqah, 7) Aqar, 8) Brak, 9) Ashkidah, 10) Sabha, 11) Samnu, 12) Az Zighan (Hlustik, 1991).

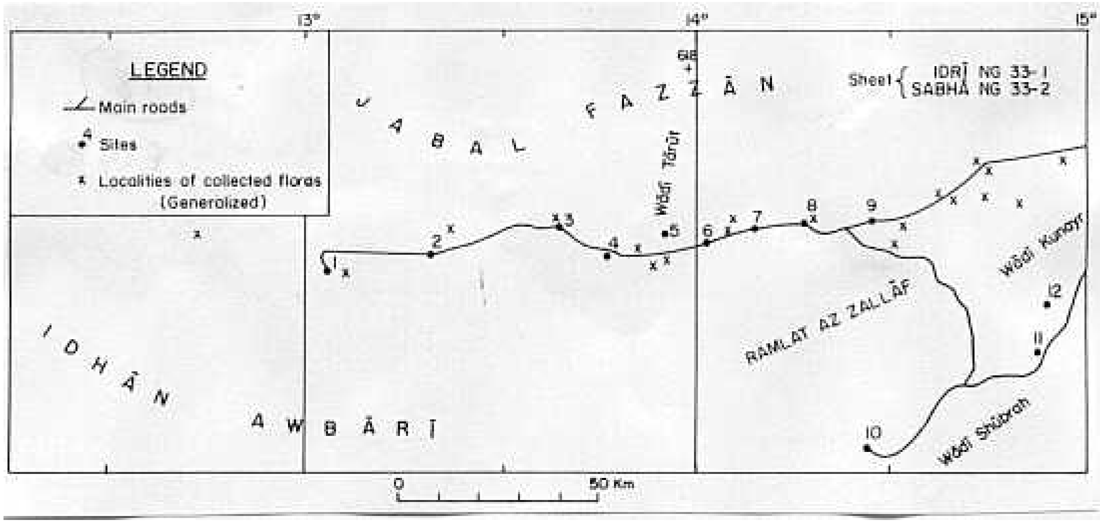


Fig. 39: Late Paleozoic Formations in the Wadi ash Shati area: *L*, *A*, *B* = main iron ore horizons; *Biv* = Bivalvian key-bed; *Bif* = Bifungites key-beds (Hlustik, 1991).

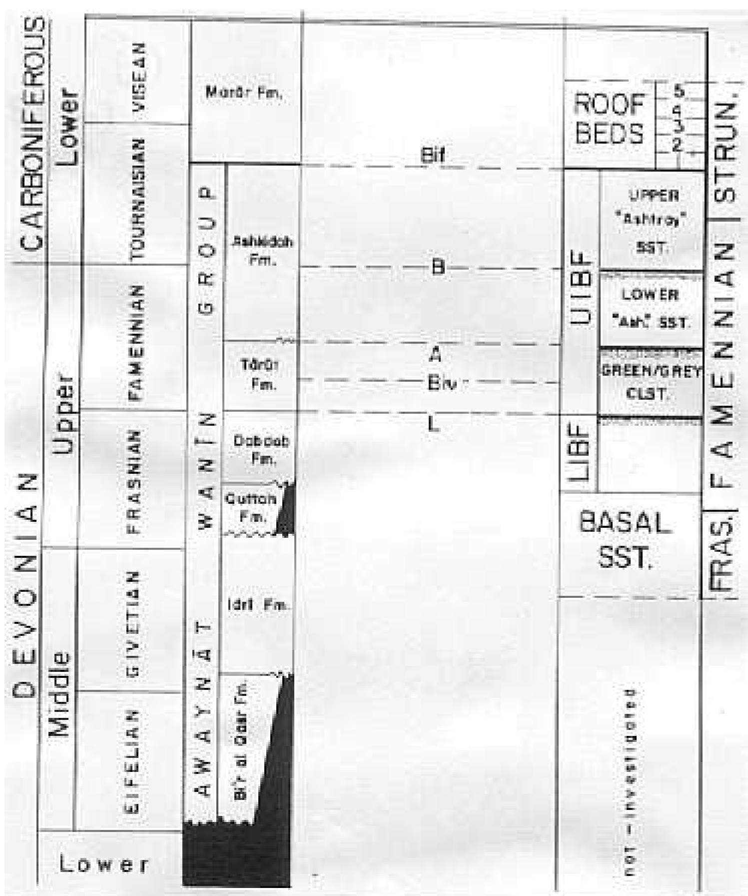


Fig. 40: Location map of the "Paul's Garden" locality with *Leptophloeum*-like trunks *in-situ*. The number of fossils is approximately expressed by the size of the characters (Hlustik, 1991).

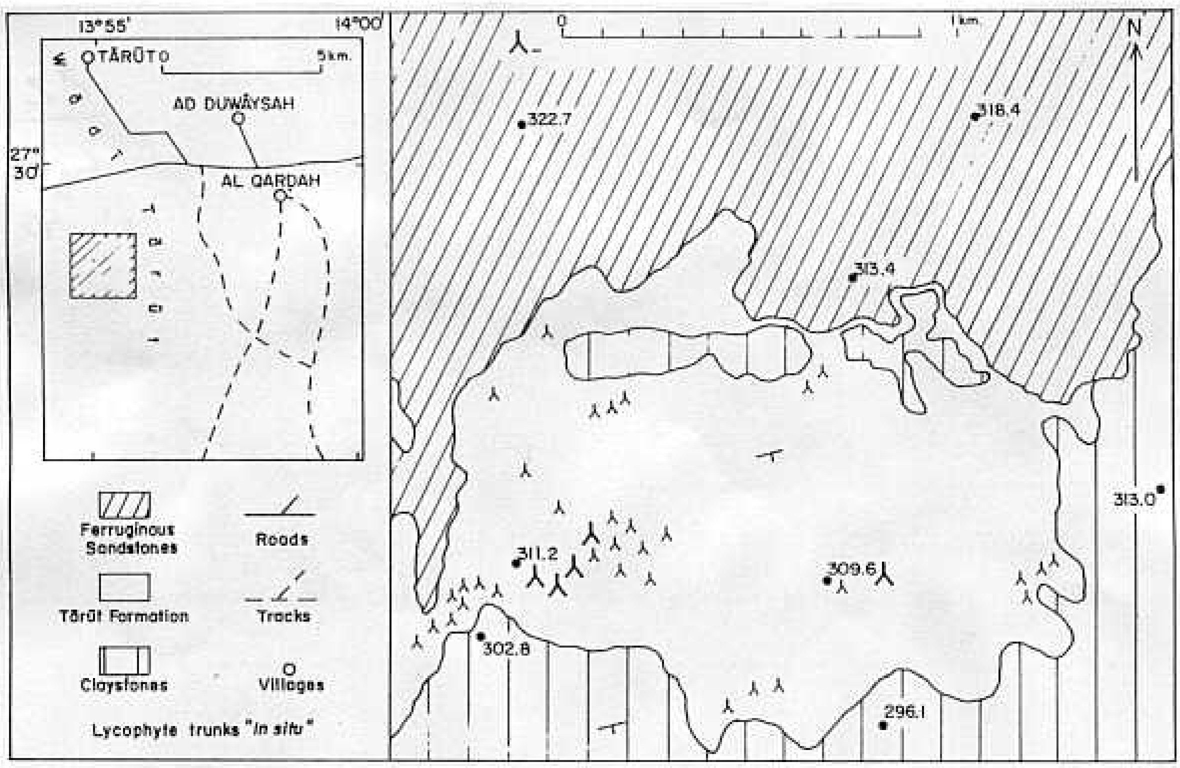


Fig. 41: Schematic restoration of the *Leptophloeum*-like trunk fossils at the "Paul's Garden" locality, south of Tarut. Stems and stumps preserved *in-situ* within the uppermost iron ore lens of the Tarut Formation; they probably represent a tree-Lycophyte overgrowth upon a tidal oolitic substratum (Hlustik, 1991).

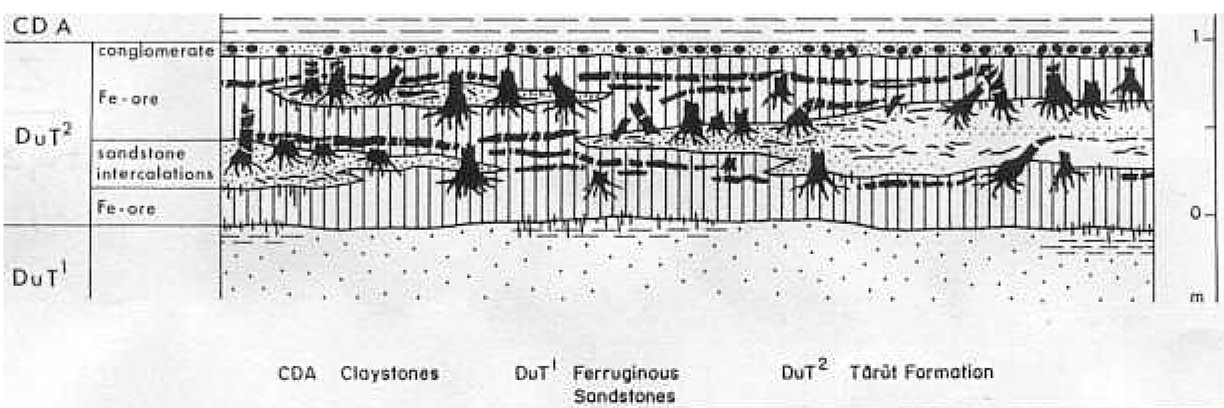


Fig. 42: Lower Devonian of the Tassili N'Ajjer area (Dubois P. et al., 1969)

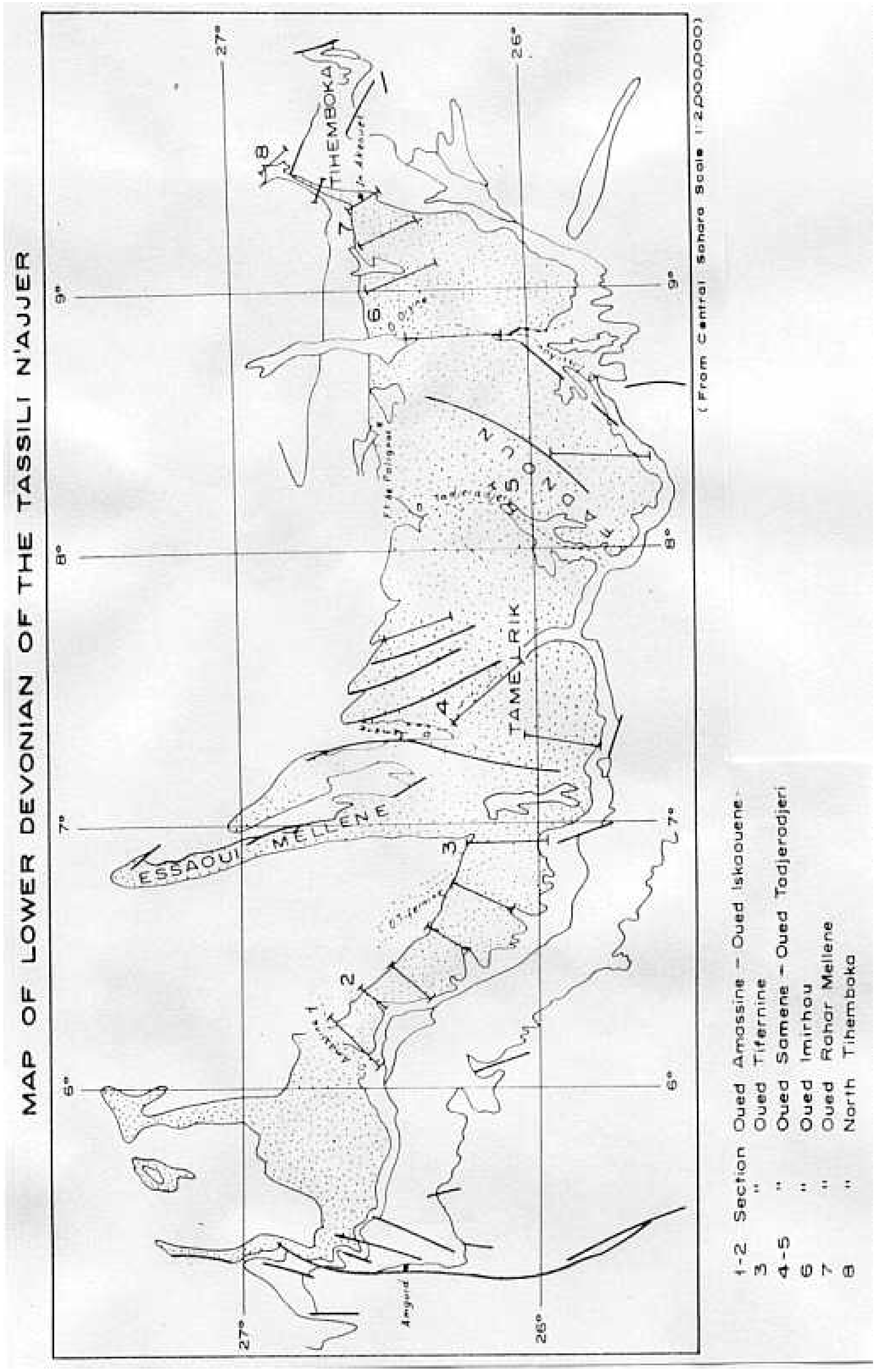


Fig. 43: "Mene Rhombea" fossil fish of possible Eocene Age, with inscription at the back of postal card.

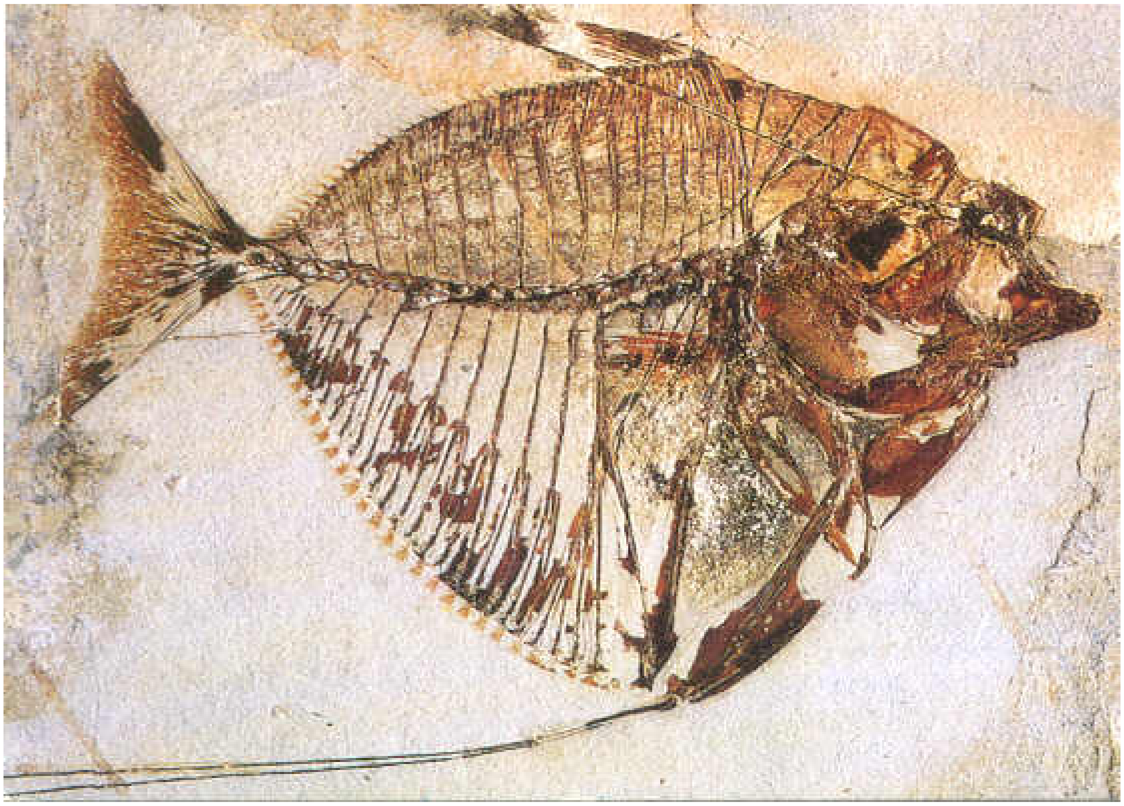


Fig. 44: Table showing one possible way of cataloguing your fossils (Taken from the author's computer application "*A Pictorial Encyclopedia of Fossilized Fishes with Cataloguing of all Known Genera* ".