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**IMPERIAL ETHIOPIAN GOVERNMENT**

**NATIONAL WATER RESOURCES COMMISSION**



**ETHIOPIA - FRANCE COOPERATIVE PROGRAM**  
**WABI SHEBELLE SURVEY**

IN COLLABORATION WITH

FRENCH MINISTRY  
OF FOREIGN AFFAIRS

NATIONAL WATER RESOURCES  
COMMISSION

BCEOM\_ORSTOM\_EDF  
IGN\_BDPA

**IV**

**GEOLOGICAL SURVEY**  
**OF THE WABI SHEBELLE BASIN**

**A. Maps at 1/1000 000 and 1/250 000**  
**with explicative notes**



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- I. Explicative note of the geological map of the WABI SHEBELLE basin at a scale of 1/1000 000
- II. Explicative note of the geological map of OGADEN at a scale of 1/250 000 (7 sheets)
- III. Geological map of the WABI SHEBELLE basin at a scale of 1/1000 000 (1 sheet - colours)
- IV. Geological map of OGADEN at a scale of 1/250 000
  - 7 sheets :
    - 1 - DEGAHBOUR
    - 2 - DUHUN
    - 3 - KEBRI-DAHAR
    - 4 - IMI
    - 5 - GODE
    - 6 - GODERE
    - 7 - MUSTAHIL

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# IMPERIAL ETHIOPIAN GOVERNMENT

## NATIONAL WATER RESOURCES COMMISSION



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EXPLICATIVE NOTE  
OF THE  
GEOLOGICAL MAP OF THE WABI SHEBELLE BASIN  
AT A SCALE OF 1/1 000 000

SEPTEMBER 1972

Hydrological Service  
ORSTOM

## INTRODUCTION

The geological map of the WABI SHEBELLE Basin at a 1/1.000.000 scale results of the synthesis of the photo-interpretation studies and of the prospections carried out by the hydrogeological and soil-science divisions of the Mission for the WABI SHEBELLE Study.

It was entirely set up by geological photo-interpretation.

As regards the part of OGADEN South of a line passing through DEGAHBOUR, DEGAH-MEDO, SEGEG, IMI, photo-interpretation as well as prospections along itineraries were undertaken by the hydrogeological division. Complementary elements or details were brought by the soil science studies in the region unexplored by the geologist. A geological map comprising seven sheets at a scale of 1/250 000 for this zone is being published separately.

For the Northern part of the Basin, the mapping out of the geological contours was determined, using the main soil science units related to the bed-rock and the geological observations made by the soil-scientist during his prospections.

The base of the map is the planimetric map at 1/1000 000 set up by the topographic division of the WABI SHEBELLE Project.

The origins of the different formations have been determined according to the classification set up by MOHR (1963).

Under the supervision of G. CASTANY, from B.R.G.M., Consultant Scientist, this map was drawn up by D. BAUDUIN, ORSTOM hydrogeologist and his assistant J.C. JULLIEN, using the studies by G. RICHE, ORSTOM soil scientist.

D. BAUDUIN wrote the explicative note.



## I. GENERAL FEATURES AND GEOMORPHOLOGICAL OUTLINE OF THE BASIN

The WABI SHEBELLE Basin situated in the South-Eastern part of ETHIOPIA, spreads on a 190.000 Km<sup>2</sup> area between the Northern parallels 5° and 9°30' and the Eastern meridians 38°30' and 45°. It includes part of the BALE, ARUSSI and HARAR provinces.

The WABI SHEBELLE is a permanent river. It is 1.300 km long from its source to the Somalian frontier and is supplied mainly by the left bank tributaries originating from the High Plateaus of ARUSSI and CHERCHER. The tributaries of its downstream part and the FAFEN present intermittent flows.

The climate varies with the relief which declines from the North-West to the South-East. Three climatic regions exist :

- High plateaus zone (altitude : over 2.000 meters) including the basaltic and cristalline regions, with important rainfall (1.800 to 800 mm) and not very high temperatures (maximum 23°)
- Intermediate zone (altitude between 2.000 and 1.000 m) limestone "causses", moderate rainfall (800 to 400 mm) and moderate temperatures (maximum 32°).
- Semi-arid zone of OGADEN (altitude below 1.000 m) with little rainfall (400 to 150 mm) and high temperatures (maximum : 40°).

The vegetation of these climatic zones varies from forest to semi desertic savanna with thorny bushes.

The geomorphology of the basin is closely linked to the nature of geological formations. The following large morphological regions can be pointed out :

- North-West and at the Northern limit of the Basin : high basaltic lands.

They appear a large tabular basaltic plateaus or gently undulating hills consisting of volcanic ash. The mean altitude of these plateaus is 2.500 m. The rivers are suddenly deeply embanked (some dozens of meters). These plateaus are commanded by a line of ancient much eroded volcanos which form the relief limiting the basin. The highest is Mount CACCA culminating at 4.200 meters.

- In the North- North-East : A granitic precambrian mass

The mountain mass is more or less dislocated and constists in chaotic and often altered cristalline rocks.

The erosion of these cristalline formations resulted in the formation of important glacis (Alemaya region).

- In the Centre : Limestone causses.

This large limestone region spreads from the North-East of the Basin (JIJIGA region) to a line roughly passing through HAMERO - HADAD, DANAN and KEBRI-DAHAR. It consists in large limestone plateaus deeply cut through by the WABI-SHEBELLE in the West and the FAFAN in the East.

- In the South : Gypseous series cut through by the MUSTAHIL limestone bed.

The gypseous series practically occupy all the Southern and South-Eastern part of the Basin. They can be seen outcropping in rounded hills. On these soft formations, intense erosion results into the formation of thick alteration deposits (alluvial deposits and colluvions) forming more or less important sediment depressions.

The WABI SHEBELLI and FAFAN valleys show largely spread alluvial deposits.

These gypseous series are cut through by the hard MUSTAHIL limestone bed which forms a bluff over the FAFAN and WABI SHEBELLE valleys and is well represented especially West of the WABI SHEBELLE where it is the skeleton of a large plateau.

- On the Eastern limit : The JESSOMA sandstone bluff.

It dominates the FERFER gypseous series and the KEBRI-DAHAR limestone .

## II. DESCRIPTION OF THE VARIOUS FORMATIONS

They must be classed in four categories :

- 1°) - Quaternary formations (alluvial deposits and local deposits)
- 2°) - Secondary age sedimentary formations
- 3°) - Volcanic formations of miocene age
- 4°) - Granite and metamorphic rocks of the precambrian age.

### 2.1. Quaternary formations

The quaternary formations which can be seen on the map belong to two types :

- alluvial deposits from the important rivers and consisting of allochtoneous material transported along long distances.
- local deposits, formed on the spot or transported along very short distances, the composition of which is directly linked to the bed-rock.

### 2.1.1. Alluvial deposits from important rivers

They can be seen in all the valleys of rivers originating from the high plateaus but spread especially in the WABI SHEBELIE Lower Valley, in the DAKETA, FAFEN and JERER valleys.

The valleys of the Higher WABI SHEBELIE and its main tributaries (SIYANAN, UNGWATA, RAMIS, ERRER) are deeply embanked in the limestone plateau and only show a very narrow strip of alluvial deposits which generally do not exceed a 100 m width.

#### The alluvial deposits of the Lower WABI SHEBELIE Valley

On emerging from the limestone gorges (about 40 m. North of IMI), the alluvial deposits stretch out on either side of the river along a 400 km distance down to the frontier. Their surface varies much and may attain a 15 km width.

Over 30 m thick, they consist of weathered material from the high volcanic plateau (silt, sand, gravel) and entirely cover up the substratum of the main gypseous formation.

The alluvial deposits are flooded downstream of IMI and on a larger scale, in the depression between KELAFO and MUSTAHIL where the WABI SHEBELIE divides into several arms. In this depression, a permanent swamp can even be observed.

#### The alluvial deposits of the DAKETA, FAFEN and JERER

They distinctly contain more limestone than those of the WABI-SHEBELIE and are also composed of clay and limestone deposits.

After KEBRI-DAHAR, the FAFAN divides and finally spreads out into several water spreading depressions where more or less saline deposits can be observed.

### 2.1.2. Recent local deposits

The composition of recent local deposits is linked to the nature of the substratum from which they derive directly.

These deposits are mainly represented by the alluvial and dejection cones of intermittent rivers by the colluvial and slope deposits and by weathered rock layers. The thickness of these deposits varies very much. They are more or less important on the soft gypseous series where they form spreading zones often extending to the outlet of the intermittent rivers of OGADEN. On the limestone and crystalline rocks, they mainly consist of weathered rock layers of these formations.

The most important alluvial depressions have been represented on the map. They are localized in the Southern part of the basin between the WABI SHEBELIE and the FAFEN.

## 2.2. Sedimentary formations

### 2.2.1. ADIGRAT sandstones (Lias)

This formation indicates the beginning of the Jurassic transgression on the cristalline base which reached the Western frontier of ETHIOPIA. It is composed of soft coarse-grained and sometimes clayed red sandstone. Its thickness varies between 30 m and 50 m. This sandstone can be seen near the bottom of high valleys in the CHERCHER and HARAR provinces North - North-East of the Basin. But owing to its thinness, its extension is very limited. The most important sandstone outcrops have been observed in the higher valley of the RAMIS and its tributaries. This formation is sometimes absent : in the region South of HARAR, can often be seen the KEBRI-DAHAR limestone directly in contact with granite.

### 2.2.2. The KEBRI-DAHAR limestone (Kimmeridgian - Portlandian)

This very thick formation (though its thickness is not determined) probably exceeding 400 m, outcrops on over half of the basin. Limited in the North - North-West by basaltic plateaus, in the North-East by granite, in the South by the main gypseous formation and in the East by the Jessoma sandstone, it forms semi-desertic causses consisting in large plateaus cut through by the deep valleys of the main courses of important rivers such as the WABI SHEBELLE and its tributaries.

At a short distance after the MALKA-WACANA falls, the WABI SHEBELLE and its tributaries cut deeply through this formation. The WABI SHEBELLE gorges are often more than 500 m deep in the SHEK-HUSSIEN region.

The formation essentially consists of sublithographic limestone in thick and distinctly stratified beds with intercalated and often thick marly layers (DAKETA Lower Valley) gypseous or sandstone layers. Some intercalations of recifal limestone can also be found.

### 2.2.3. The main gypseous formation (Neocomian)

At the end of the Portlandian age, occurred a phase of sea regression and a period of sedimentation in shallow water of lagoon type. The main gypseous formation results from this sedimentation.

This gypseous series, concordant on KEBRI-DAHAR limestone, appears in the Southern part of the Basin between the Northern parallel : 7°20' and the frontier. It is covered in the South-West and the South-East by the MUSTAHIL limestone which forms a more or less broken up plateau.

It consists of alternating marl, clay, massive gypsum in thick beds, dolomites and saline layers. Its thickness increases Southwards and exceeds 300 m. This soft formation has the aspect of small rounded hills. The drainage pattern is particularly dense in this area. Intermittent rivers flow down to the alluvial plain of the WABI SHEBELLE forming large debris cones. Many rivers form closed catchment areas where overland flow concentrates in large water spreading basins (DANAN, DALAD Basins...).



#### 2.2.4. MUSTAHIL limestone (Barremian - Albian)

The calcareous-dolimitic layer of the MUSTAHIL formation crowns the main gypseous formation and forms the skeleton of the Lower OGADEN plateaus.

On the right bank of the WABI SHEBELLE, it is a strip stretching from the Western limit of the basin (EL KERE region) to KELAFO. It also constitutes the top of the plateaus near MUSTAHIL and BURKUR.

On the left bank, the MUSTAHIL limestone is more important and forms a bluff over the WABI SHEBELLE from GODE to the frontier. It is frequently broken up between the WABI SHEBELLE and the FAFEN but forms a continuous plateau on the right bank of the FAFEN under the FERFER gypsum and the JESSOMA and BELET UEN formations.

This formation is moderately thick (30 m about) and consists in marly and clayed beds surmounted with a very hard reddish dolomitic bed.

#### 2.2.5. FERFER gypsum (Cenomanian)

The FERFER formation is not very thick (15 to 30 m) and is composed of massive gypsum, of gypseous marlstone and dolomites. It has been deeply weathered and dissolved and can only be found at the farthest South-Eastern part of the basin between the MUSTAHIL limestone and the BELET UEN and JESSOMA formations. It is often covered with colluvial deposits derived from the weathering of the BELET UEN and JESSOMA formations.

On the plateau between LAZOLALE, SHILAVO and FERFER, local dissolutions have made possible the formation of basins such as the IGLOLE and SHILAVO basins.

#### 2.2.6. BELET UEN zoogenous limestone and sandstone (Turonian)

The BELET UEN formation is composed of sandstone and of very hard zoogenous limestone. This limestone forms a steep slope East of the FERFER - BARMEGO road, in the farthest South-western part of the basin below the JESSOMA sandstone formation.

#### 2.2.7. JESSOMA sandstone (Senonian)

The JESSOMA sandstone formation ends the secondary sedimentary series of the WABI SHEBELLE basin. It shows a major transgression as sandstone outcrops can be seen up to the North of the Basin, in direct contact with the KEBRI-DAHAR limestone and under the basaltic layers of the TRAPP series.

This soft sandstone formation has been much weathered and can only be seen at the limits of the basin or on the top of isolated hillocks.

However, once again can be seen more or less weathered, large, sandstone spreading zones, disseminated in all the basin.

The most important outcrops exist :

- On the Eastern side of the basin :

East of a track from FERFER to KEBRI-DAHAR on the BELET UEN formation.

East of the DEGAHBOUR-JIJIGA track on the KEBRI-DAHAR limestone.

- West of the Basin :

In the EL KERE region on the MUSTAHIL limestone.

- North-West of the Basin :

Between GELEMSO and the South of GOLOLCHA, on the KEBRI-DAHAR limestone.

This formation mainly consists of sandstone and quartzite of a mainly red purplish colour, which must have been very thick. In fact it is 100 m thick at ELE KERE and about 50 m thick near DEGAHBOUR on the track leading to AWARE.

### 2.3. Volcanic formations

#### 2.3.1. The TRAPP series (Miocene)

The TRAPP series consists of volcanic formations which covered during the Miocene age, the KEBRI DAHAR limestone and the JESSOMA sandstone. This series results from the volcanic eruptions combined with important tectonic movements to which the formation of the Rift Valley is due. Mainly composed of basaltic layers, of ash deposits and volcanic tuffs, it forms reliefs limiting the basin and the large plateaus which dominate the secondary formations.

It stretches in ARUSSI over all the Western part of the horn and occupies a more or less narrow strip on the Northern border of the Basin from GOLOLCHA to GIRAWA. It also crowns the limestone plateaus on either side of the WABI SHEBELLE in the LEGE HIDA region and forms a stretch of N.W. - S.E. reliefs included between the FAFEN and the JERER, South of JIJIGA.

The horizontal basaltic layers form the skeleton of these high plateaus.

The farthest Western part of the Basin is covered up with important deposits of volcanic ash. In the GUEDEB plain which is a large depression between the volcanic deposits and the MALKA-WAKANA falls, the layers of volcanic tuffs alternate with basalt layers.

### 2.3.2. Intrusive basalts (Miocene)

Jutting through the sedimentary cover, basaltic peaks can be seen all over the Basin.

These peaks result from tectonic movements subsequent to the formation of the Rift Valley during the Miocene age.

They are different from those of the TRAPP series and consist of basalt with olivine of doleritic type. They can be seen forming two lines between DEGAH-MEDO and DANAN and along the WABI SHEBELLE left bank between IMI and GODE and in isolated hillocks around FIK and near KEBRI-DAHAR. The basaltic hills present in general a very characteristic arc-shaped aspect.

### 2.4. Granite and metamorphic rocks (Precambrian)

The precambrian substratum appears North of the Basin where it forms the reliefs of HARAR culminating at a 3.000 m. height.

Its composition varies much and consists of more or less metamorphosed granite of migmatite type, rich in black mica and amphiboles with beds of ribboned feldspar. Pegmatitic gneiss and granite with two sorts of micas and amphiboles can also be found.

Overlying this granite, limestone of the KEBRI DAHAR formation can be seen in some places.

## III - STRUCTURE

The secondary formations regularly slope gently down to the South West ( $5^{\circ}$  to  $10^{\circ}$ ) without any distortion.

Only the settling of granite caused a few local accidents in the KEBRI DAHAR limestone.

These formations are broken up by a network of faults with moderate throw whose directions are mainly N.W.- S.E. and N.E.- S.W.

Various arguments allow to believe that the lower Valley of the WABRI SHEBELLE took the place of a tectonic basin. These arguments are as follows :

1°) - The WABI SHEBELLE flows N.W - S.E, a practically straight direction from IMI to the frontier, and following the preferential direction of the fracturation.

2°) - Presence of an important structure with faults in the KELAFO region and of a longitudinal fault parallel with the Valley between KELAFO and BURKUR.

3°) - Basaltic peaks appear along the left bank of the WABI SHEBELLE from IMI to GODE.

In the North, the basalts have covered the KEBRI DAHAR limestone and the JESSOMA sandstone in large sub horizontal layers.

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A N N E X

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LEGEND FOR GEOLOGICAL MAP  
OF WABI SHEBELLE BASIN

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# LEGEND FOR GEOLOGICAL MAP OF WABI SHEBELLE BASIN

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## SEDIMENTARY FORMATIONS

### Quaternary

:

Recent deposits  
Alluvial deposits of great rivers

### Secondary

:

JESSOMA sandstone.....	Senonian	} Upper cretaceous
BELET UEN nodular limestone.....	Turonian	
FERFER gypsum.....	Cenomanian	
MUSTAHIL limestone.....	Barremian	} Lower cretaceous
	Albian	
Main gypsum formation....	Neocomian	
KEBRI-DAHAR limestone.....	Kimmeridgian	} Upper Jurassic
	Portlandian	
ADIGRAT sandstone.....	Lias	

### Eruptive rocks

:

Basalts	
Volcanic ash }	Trapp series - Miocene
Volcanic tuff }	
Intrusive basalt	Miocene
Metamorphic granite	Pre-Cambian

### Conventional signs

:

Faults

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EXPLICATIVE NOTE  
OF THE GEOLOGICAL MAP OF OGADEN  
AT A SCALE OF 1/250 000  
(7 Sheets)

SEPTEMBER 1972

Hydrological Service  
ORSTOM

## INTRODUCTION

The geological map at 1/250 000 of OGADEN was undertaken at the time when the study of underground water took place in this region. It especially aims at localizing the limits of the main geological formations.

This map is not the result of a regular geological survey . It is a photogeological interpretation.

In order to prepare this map, the following work was carried out in different stages :

1°) - Geological observations on the important road axes :

GODE - FERFER

FERFER - SHILAVO - KEBRI-DAHAR

KEBRI-DAHAR - GODE

KEBRI-DAHAR - DEGAHBOUR

DEGAHBOUR - SEGEG - DUHUN - DANAN

2°) Simultaneous interpretation of aerial photographs at 1/50 000 from the U.S. Mapping Mission (coverage in 1964) and transfer on base maps at 1/100 000 which were drawn using the mosaics resulting from these aerial photographs.

3°) Examination of available drilling logs.

4°) Local detailed studies : KELAFO, BARMEGO, KEBRI-DAHAR, DANAN regions.

5°) Transfer of the limits determined at the scale of 1/100 000 on the final planimetric base map at 1/250 000.

All the recent weathering deposits visible on aerial photographs have been transferred on this map, even if in several cases, they cannot constitute, owing to their thinness, a distinct geological formation.

Under the supervision of G. CASTANY from BRGM, scientific Consultant, this map was drawn up by D. BAUDUIN, ORSTOM geologist and his assistant J.C. JULLIEN using the studies by G. RICHE, ORSTOM soil scientist.

D. BAUDUIN wrote the explicative note.



## I. THE MAPPED AREA

### 1.1. Limits

The mapped area forms the Southern part of the WABI SHEBELLE and FAFEN catchment basins in ETHIOPIA. It is situated between the Northern parallels : 5° and 8°15' and the Eastern meridians : 41°30' and 45°30'. Its Northern limit is slightly above the following localities : DEGAHBOUR, DEGAH-MEDO, SEGEG and IMI. Its Southern limit is formed by the border separating ETHIOPIA from SOMALIA. East and West, the mapped area ends at the limits of the WABI SHEBELLE and FAFEN river basins.

### 1.2. Sheet layout

The base of the geological map is the planimetric base map at 1/250 000 drawn up by the Cartographical Division of the Mission for the WABI SHEBELLE Study.

The geological map consists of 7 sheets following the planimetric map (see the index of sheets on the adjoining map). These sheets are represented by the following names : DEGAHBOUR, DUHUN, KEBRI-DAHAR, IMI, GODE, GODERE, MUSTAHIL.

## II. STATIGRAPHY

### 2.1. Quaternary formations

The quaternary sediments are grouped in two categories according to their origin :

- Alluvial deposits of large rivers composed of elements transported along long distances,
- Recent local deposits either formed on the spot or composed of elements transported along very short distances.

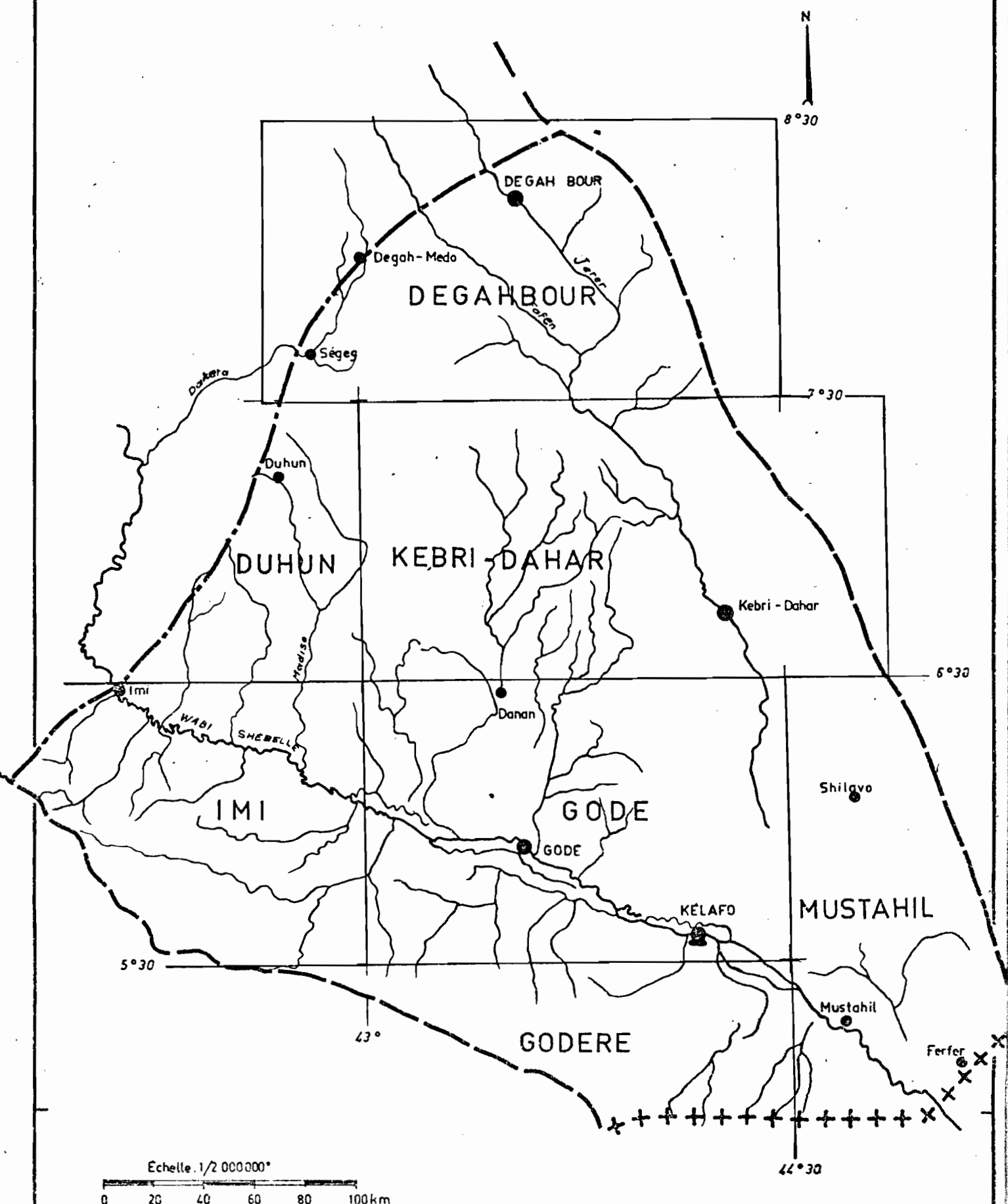
#### 2.1.1. Alluvial deposits of large rivers

They mainly consist in the WABI SHEBELLE, FAFEN and JERER alluvial deposits.

- The alluvial deposits of the WABI SHEBELLE are mainly composed of elements resulting from the weathering of volcanic rocks on the high plateaus. These deposits consist in more or less sandy silts and gravels rich in ferromagnesian minerals and in mica which confirms their volcanic origin. Though their substratum is gypseous, these deposits are not very salty.

Tableau d'assemblage  
des feuilles de la carte géologique  
au 1/250 000\*

Index of adjoining sheets  
geological map scale 1/250 000



These alluvial deposits are quite thick and spread continuously from IMI to the frontier on either side of the WABI SHEBELLE (IMI, GODE, MUSTAHIL sheets). But their extent varies largely and between GODE and MUSTAHIL, three large alluvial plains can be observed :

- The GODE plain spreading largely on the right bank of the WABI SHEBELLE.
- The KELAFO plain on the left bank of the WABI SHEBELLE
- The flooding plain spreading between KELAFO and MUSTAHIL on either river bank.

North of the GODE plain up to IMI, the alluvial deposits are not so important and are limited to a moderately large strip about 5 km wide.

- The alluvial deposits of the FABEN and JERER distinctly contain more limestone than those of the WABI SHEBELLE. Composed of clay and limestone deposits, they have been transported along shorter distances.

They do not spread much up to FANHAD (15 km Northwards of KEBRI-DAHAR) but then spread in several water spreading hollows on the main gypseous series :

- The hollow upstream of KEBRI-DAHAR
- The hollow downstream of KEBRI-DAHAR
- The DOBOWEIN hollow
- The IGLOLE plain.

Southwards, the alluvial deposits become more and more gypseous.

These deposits can be seen on the DEGAHBOUR, KEBRI-DAHAR sheets and in the farthest North-Eastern part of the GODE sheet.

#### 2.1.2. Recent local deposits

All the sediments formed on the spot or transported along short distances have been grouped together in this formation.

They consist of :

- alluvial deposits and debris cones from intermittent rivers
- colluvial, slope and piemont deposits
- weathering layers
- wind erosion deposits

Their thickness varies and their petrographical nature is directly linked to the nature of the substratum :

- scarcely saline red sandy silt deposits with limestone crusts on the KEBRI-DAHAR and MUSTAHIL limestones.

- red gypseous silts with limestone pebbles of local origin, on the gypseous series (main gypsum and Ferfer Gypsum).

These local deposits are represented on all the map sheets. On the soft gypsum formations, they spread very largely.

## 2.2. Sedimentary formations

The sedimentary series of OGADEN stretching from the Upper Jurassic to the Upper Cretaceous, ~~includes~~ the 6 following main formations.

### 2.2.1. The KEBRI-DAHAR limestone (Kimmeridgian-Portlandian)

This formation is especially composed of sublithographic limestone in distinctly stratified layers with marl and gypsum intercalations and corallian beds.

At the top of the formation, the limestone very gradually shows an increasing lagoon-like facies composed of marly limestone intercalations, of marls and of gypsum.

MOHR (1963) indicates a fauna comprising : Cephalopodes (*Belennopsis tanganensis*, *Anavirgatites*) of Gastropodes, Echinoderms (*Burgundia Semichathrata*, *Cidaris glandularies*, *Nerinea Desvodijsi*) and of Coelenterates (corals) which allows to consider the KEBRI-DAHAR limestone as dating back from the Upper Jurassic (Kimmeridgian - Portlandian).

This formation occupies a large area represented on the DEGAHBOUR sheet, the most Northern part of the DUHUN sheet and the 2/3 Eastwards of the KEBRI-DAHAR sheet. It is very important being over 400 m thick.

### 2.2.2. The main gypseous formation (Neocomian)

At the end of the Portlandian age a regression of the sea takes place followed by a sedimentation phase in shallow water or water of the lagoon type.

The deposited sediments compose the main gypseous formation which occupies a large part of OGADEN. It is made up of alternating marls, more or less gypseous clays, of thick beds of massive gypsum, of dolomites and thick saline layers.

The gypseous formation over 300 meters thick in the North, becomes visibly thicker South of OGADEN.

The outcropping surface of this formation is very large. It can be seen on all the sheets except on those of DEGAHBOUR. On the DUHUN and KEBRI-DAHAR sheets, gypseous formation gradually substituted for KEBRI-DAHAR limestone can be observed.



### 2.2.3. The MUSTAHIL limestone (Barremian-Albian)

The upper part of the main selenituous formation is crowned by a dolomitic-calcareous layer about 30 m thick.

This layer comprises more or less marly and white chalky beds surmounted with a reddish-coloured dolomitic layer. It forms a very distinct bluff over the main gypsum, which represents a major geomorphological feature of Lower OGADEN.

This level is very fossiliferous. MOHR notes there the following fauna : *Vergilia Vogeli*, *Mytilus equatorialis*, *Toxaster collegnoi*, *Pygaulus Kelleri*, *Arca Gabrieli* for the Barremian, sp *cheloniaceras*, sp *Parahophites*, sp *Ancyloceras* for the Albian. These origins were confirmed by the fossiles collected in the region. The MUSTAHIL limestone would therefore belong to the Barremian-Albian age.

The MUSTAHIL limestone forms the skeleton of the plateaus in Lower OGADEN. It overhangs, forming a bluff, the billowing reliefs of the main selenituous formation between the WABI SHEBELLE and the FAFEN, South of the line : KEBRI-DAHAR, GODE (GODE and MUSTAHIL sheets). South of the WABI SHEBELLE, it can be seen as a structural surface in the KELAFO and MUSTAHIL region and forms the South-Western border of the basin stretching to EL KERE (IMI, GODE, GODE, MUSTAHIL sheets). East of the FAFEN, this continuous layer is often covered with FERFER gypsum or with the BELET-UEN and JESSOMA formations (GODE, MUSTAHIL sheets).

### 2.2.4. The FERFER gypsum (Cenomanian)

Over the main selenituous formation, appears another gypsous series : the FERFER gypsum belonging to the Cenomanian age.

This series is not very thick (15 to 20 m) and consists in gypseous marl, limestone and dolomite. It only outcrops in the South-Eastern part of OGADEN where it covers more or less unbrokenly the SHILAVO plateau (SHILAVO, MUSTAHIL sheets).

### 2.2.5. The zoogenous limestone and the sandstone of BELET-UEN (Turonian)

They consist in alternating sandstones and very hard zoogenous limestone. They are only represented in the most Southern part of the basin where limestone form a cliff ; East of the track between LAMMABAR and FERFER (MUSTAHIL sheet).

The limestone formation of BELET VEN is fossiliferous (*Belenopsis ultimus*, *Terebratulina gracilis*, sp *Requienia*, sp *Monopleura*, *Orbitolines*) : this formation could be considered as belonging to the Turonian age.

### 2.2.6. The JESSOMA sandstone (Senonian)

The JESSOMA sandstone formation end the sedimentary series of OGADEN. IT is especially composed of sandstone and purplish red quartzite.

Largely transgressing on the previous series they even appear directly in contact with the KEBRI-DAHAR limestone .

In OGADEN, they have been weathered and are localized at the edge of the basin or on top of isolated reference hillocks. They form all the Eastern side (DEGAHBOUR, KEBRI-DAHAR, MUSTAHIL sheets) and at the top of several hillocks on the main gypsum (DUHUN sheet).

### 2.3. Eruptive rocks

Some basaltic outcrops can be seen in OGADEN where they form not very high round hills often presenting the aspect of an arc. These are basalt with olivine belonging to the doleritic type.

They jut through the KEBRI-DAHAR limestone between DEGAH-MEDO and SEGEG (DEGAHBOUR sheet) and East of KEBRI-DAHAR in the EL-HAR region (KEBRI-DAHAR sheet).

From IMI to GODE, they mark out the left bank of the WABI SHEBELLE cutting through the main selenitous formation (IMI and GODE sheets).

These volcanic eruptions are linked to the important tectonic movements of the miocene age which resulted in the formation of the Rift Valley.

## III. TECTONIC

The secondary formations of OGADEN present a monoclinial structure. They gently slope to the South-West with a very low dip of 5° to 10°. They are broken up by a fault system with a moderate throw.

These faults have two main directions NW-SE and NE-SW which are distinctly seen in the KELAFO and MUSTAHIL region. As in the case of volcanic eruptions, this system of faults is linked to the formation of the Rift Valley and consequently would belong to the miocene age.





**ETHIOPIA - FRANCE COOPERATIVE PROGRAM**  
**WABI SHEBELLE SURVEY**

IN COLLABORATION WITH  
FRENCH MINISTRY OF FOREIGN AFFAIRS  
NATIONAL WATER RESOURCES COMMISSION  
BCEOM, ORSTOM, EDF  
IGN, BDPA

**IV**  
**GEOLOGICAL MAP**  
**OF WABI SHEBELLE BASIN**

DECEMBER 1973



QUATERNARY  
QUATÉNAIRE

TERTIARY  
TERTIAIRE

SECONDARY MESOZOIC  
MÉSOZOÏQUE SECONDAIRE

Miocene  
Miocène

Cretaceous  
Crétacé

Jurassic  
Jurassique

Precambrian  
Précambrien

Recent local deposits  
Dépôts locaux récents

Alluvial deposits of great rivers  
Dépôts alluviaux des grands cours d'eau

Basalts  
Basaltes

Volcanic ashes  
Craques volcaniques

Volcanic tuffs  
Tufs volcaniques

Intrusive basalts  
Basaltes intrusifs

Senonian  
Sénonien

Turonian  
Turonien

Cenomanian  
Cénomannien

Barremian  
Barémien

Albian  
Albien

Neocomian  
Néocomien

Kimmeridgian  
Kimmeridgien

Portlandian  
Portlandien

Lias  
Lias

Metamorphic granites  
Granites métamorphiques

Faults  
Failles

GESOMA sandstones  
Gites de GESOMA

Nodular limestones of BELET-SEN  
Calcaires nodulaires de BELET-SEN

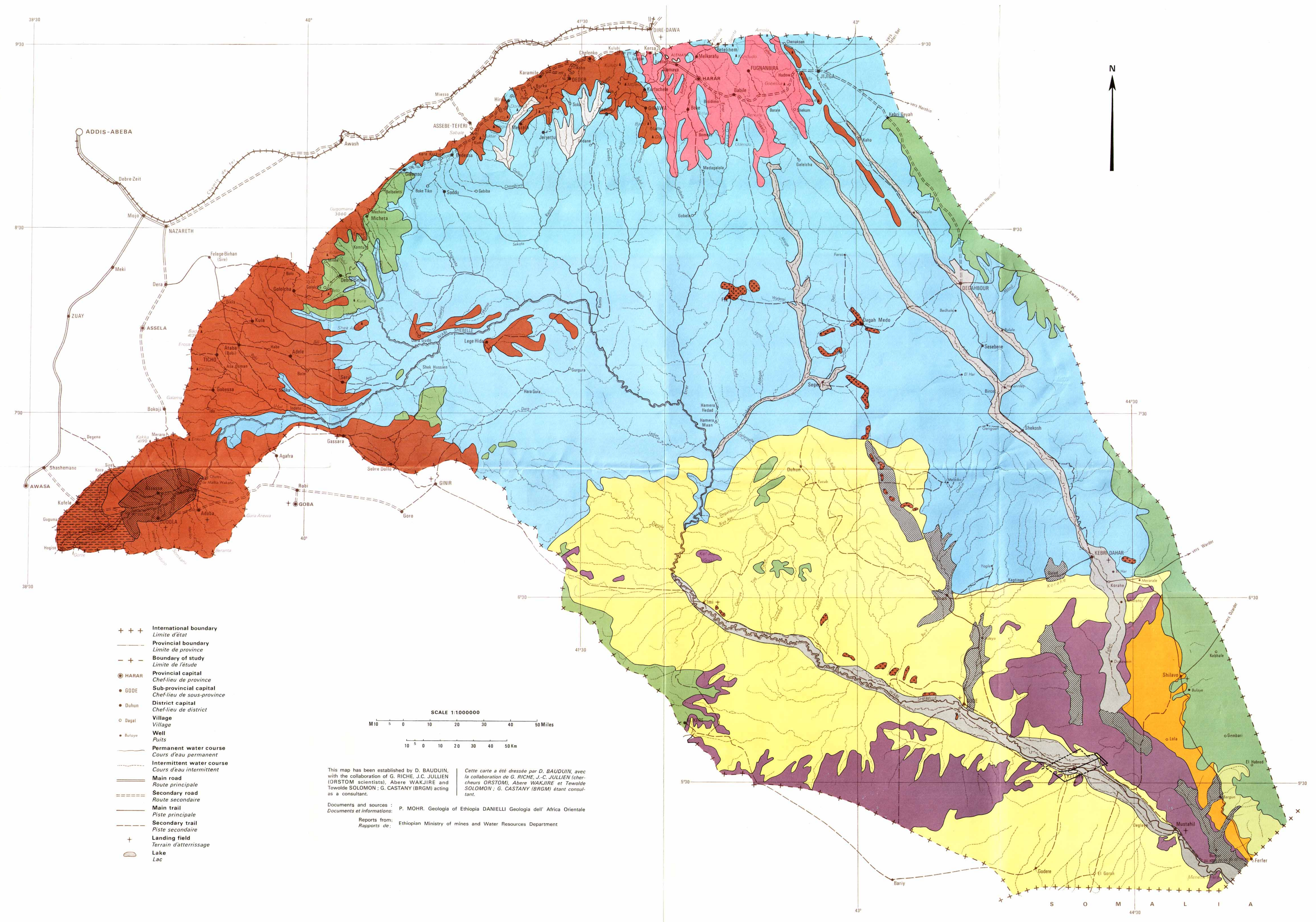
FERFER gypsum  
Gypses de Ferfer

MUSTAHIL limestones  
Calcaires de MUSTAHIL

Main gypsum formation  
Formation gypseuse principale

KEBRI DAHAR limestones  
Calcaires de KEBRI DAHAR

ADIGBAT sandstones  
Gites d'ADIGBAT







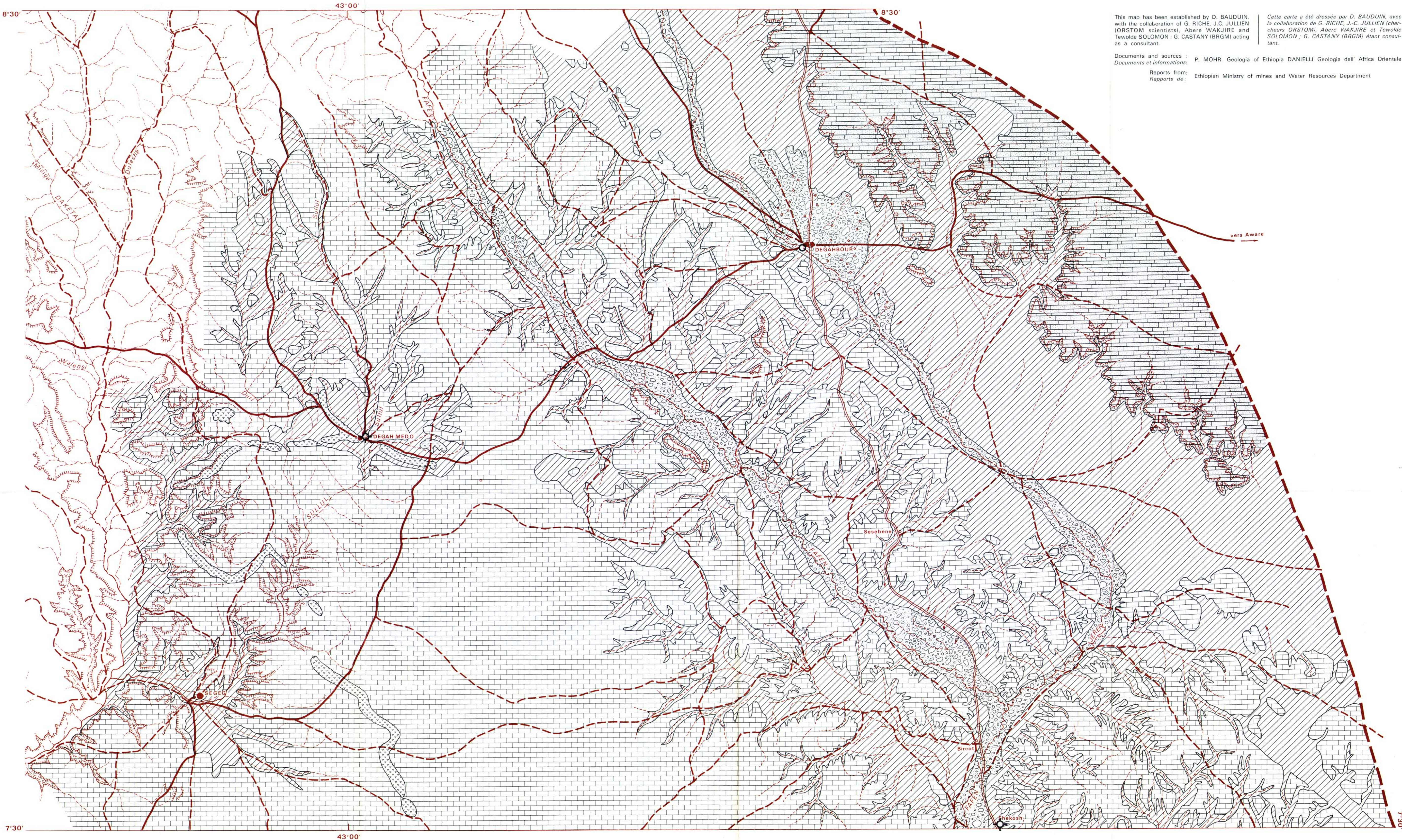
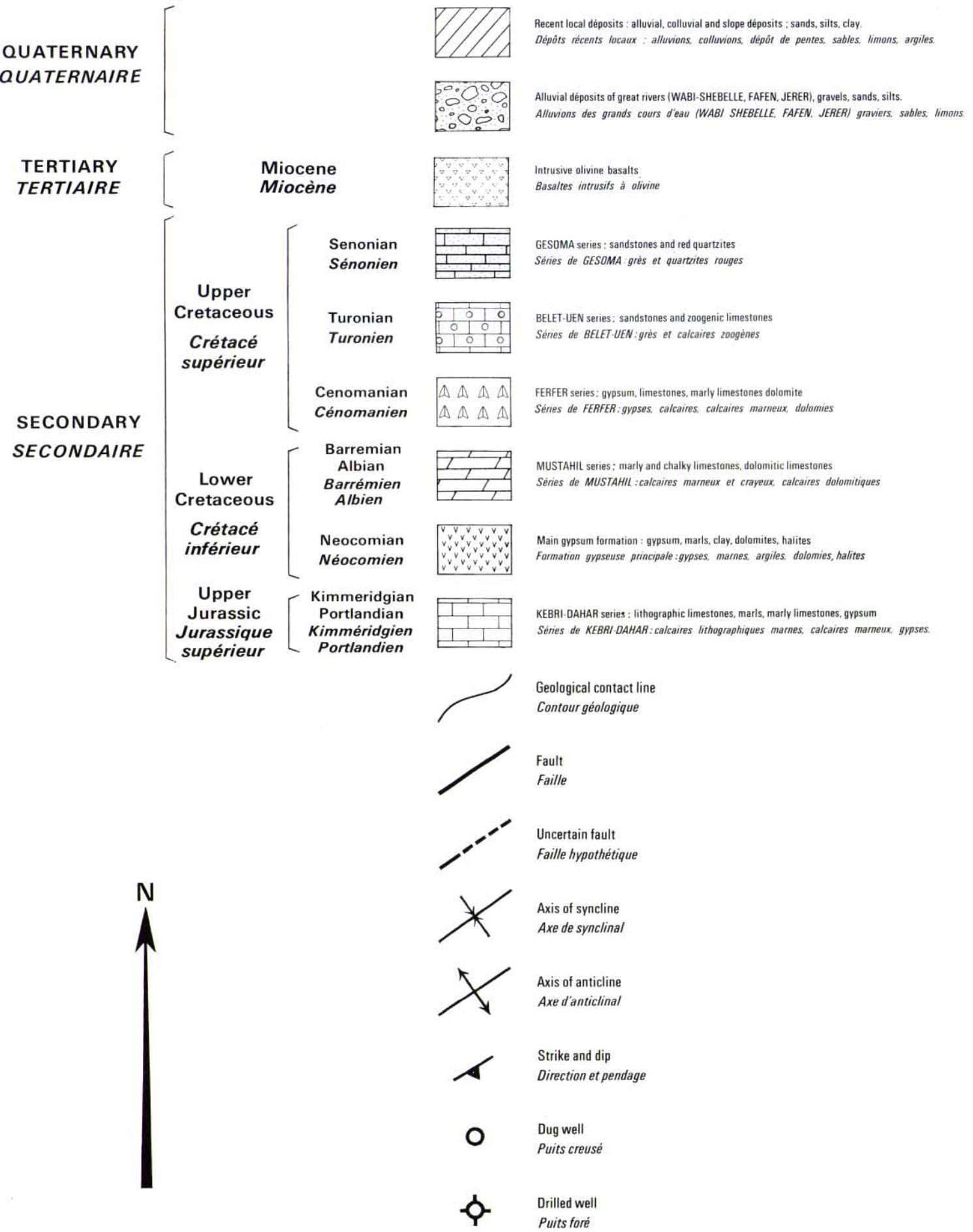
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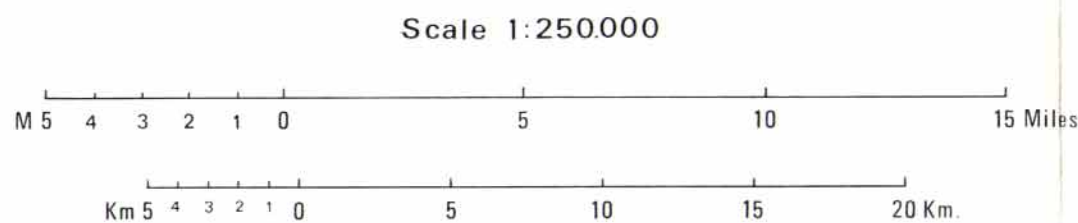
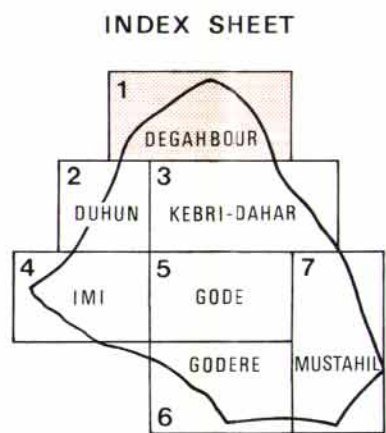
IV  
GEOLOGICAL MAP OF OGADEN

DEGAHBOUR

APRIL 1974  
MAP N°1



Planimetric map based on the provisional sketches at approximately 1:100000 and using the map at 1:500000 established by the WAR OFFICE (EAST AFRICA, 1946)  
Drafted in 1969 by the NATIONAL WATER RESOURCES COMMISSION WABI SHEBELLE SURVEY.  
Fond planimétrique établi d'après les esquisses provisoires au 1:100000 environ appuyées sur la carte au 1:500000 du WAR OFFICE EAST AFRICA (1946).  
Exécuté en 1969 au NATIONAL WATER RESOURCES COMMISSION - ETUDE DU WABI SHEBELLE.



Town, important village, administrative center  
Ville, village important, centre administratif

Small village  
Petit village

Main road or trail  
Route ou piste principale

Secondary trail  
Piste secondaire

Foot trail, trail  
Piste à pied, sentier

Limit of study zone  
Limite de l'étude

Permanent river  
Rivière permanente

Temporary river, thalweg, flow trace  
Rivière temporaire, thalweg, trace d'écoulement

Lake, water plane  
Lac plan d'eau

Important hill summit  
Sommet important

Small isolated hill summit  
Petit sommet isolé

Cliff, rocky escarpment, plateau boundary  
Falaise, escarpement rocheux, limite de plateau

This map has been established by D. BAUDUIN, with the collaboration of G. RICHE, J.C. JULLIEN (ORSTOM scientists), Abere WAKJIRE and Tewelde SOLOMON; G. CASTANY (BRGM) acting as a consultant.

Documents and sources : P. MOHR, Geologia of Ethiopia DANIELLI Geologia dell' Africa Orientale

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Rapports from: Ethiopian Ministry of mines and Water Resources Department

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IGN\_BDPA

# DUHUN

APRIL 1974  
MAP N°2



**Miocene**  
*Miocène*

Upper  
Cretaceous  
*Crétacé  
supérieur*

Lower  
Cretaceous  
*Crétacé  
inférieur*

Upper  
Jurassic  
*Jurassique  
supérieur*


*Crétacé  
supérieur*


Lower  
Cretaceous  
*Crétacé  
inférieur*


Upper  
Jurassic  
*Jurassique  
supérieur*


r  
is


Upper  
Jurassic  
*Jurassique*  
*supérieur*


 Recent local deposits: alluvial, colluvial and slope deposits ; sands, silts, clay  
*Dépôts récents locaux : alluvions, colluvions, dépôt de pentes, sables, limons, argiles*


 Alluvial deposits of great rivers (WADI SHEBELLE, FAFEN, JERER), gravels, sands, silts.  
*Alluvions des grands cours d'eau (WADI SHEBELLE, FAFEN, JERER) graviers, sables, limons*


 Intrusive olivine basalt  
*Basaltes intrusifs à oléine*


 GESOMA series : sandstones and red quartzites  
*Séries de GESOMA grès et quartzites rouges*

 BELET UEN series : sandstones and zoogenic limestones  
*Séries de BELET UEN grès et calcaires zoogènes*

 FERFER series : gypsum, limestones, marly limestones, dolomite  
*Séries de FERFER gypses, calcaires, calcaires marneux, dolomites*

 MUSTAHL series : marly and chalky limestones, dolomitic limestones  
*Séries de MUSTAHL calcaires marneux et craieux, calcaires dolomitiques*

 Main gypsum formation : gypsum, marls, clay, dolomites, halites  
*Formation gypseuse principale : gypses, marnes, argiles, dolomites, halites*

 KERBI-DAHAR series : lithographic limestones, marls, marly limestones, gypsum  
*Séries de KERBI DAHAR calcaires lithographiques marnes, calcaires marneux, gypses*

	Geological contact line <i>Contour géologique</i>
	Fault <i>Faïlle</i>
	Uncertain fault <i>Faïlle hypothétique</i>
	Axis of syncline <i>Axe de synclinal</i>
	Axis of anticline <i>Axe d'anticlinal</i>
	Strike and dip <i>Direction et pendage</i>
	Dug well <i>Puits creusé</i>
	Drilled well <i>Puits foré</i>



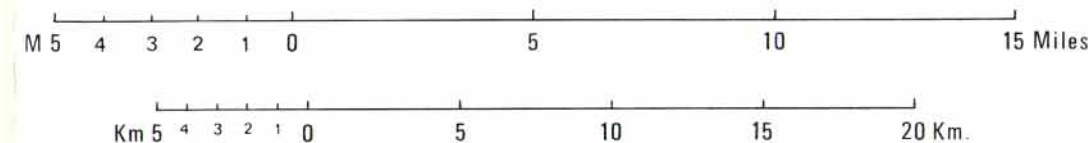
Planimetric map based on the provisional sketches at approximately 1:100000 and using the map at 1:500000 established by the WAR OFFICE (EAST AFRICA. 1946)

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*Fond planimétrique établi d'après les esquisses provisoires au 1:100000 environ appuyées sur la carte au 1:500000 du WAR OFFICE EAST AFRICA (1946).*

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Scale 1:250.000

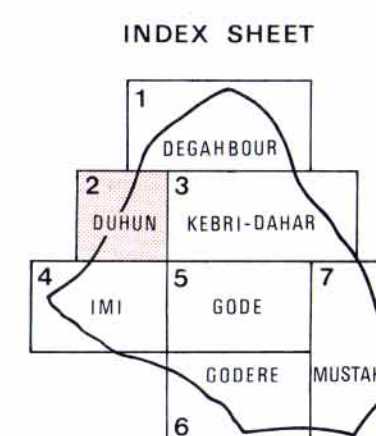


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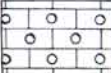



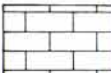
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NATIONAL WATER RESOURCES COMMISSION  
BCEOM, ORSTOM, EDF  
IGN, B D P A

IV  
GEOLOGICAL MAP OF OGADEN

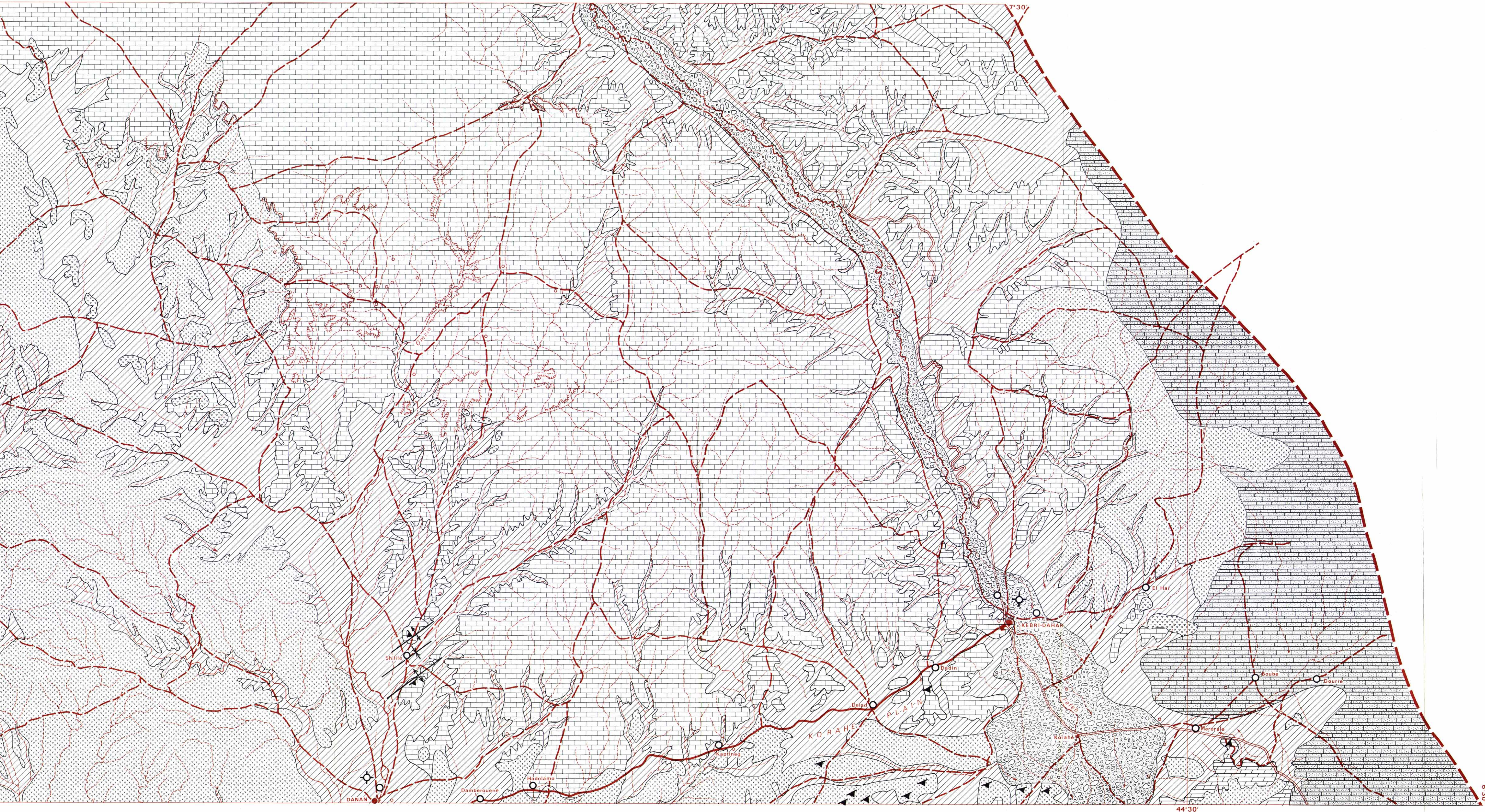
KEBRI-DAHAR

APRIL 1974  
MAP N°3

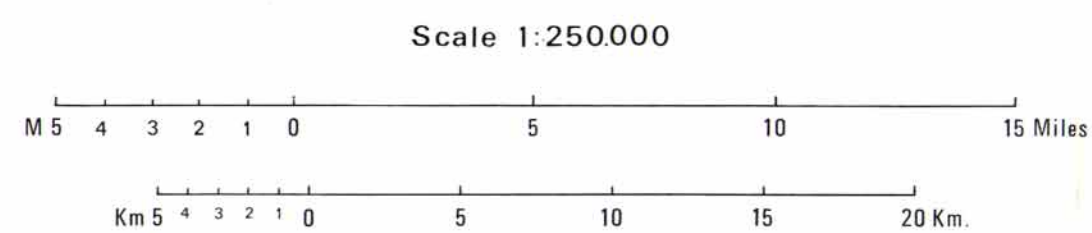
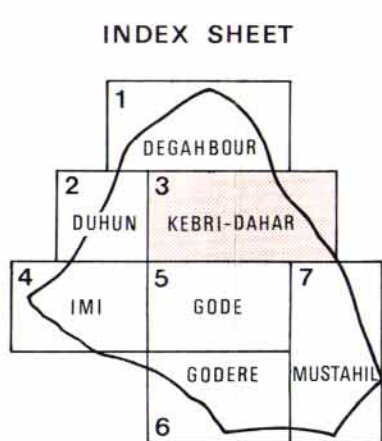


QUATERNARY QUATÉNAIRE			Recent local deposits: alluvial, colluvial and slope deposits: sands, silts, clay. Dépôts récents locaux: alluviaux, colluviaux, dépôt de pentes: sables, limons, argiles.
			Alluvial deposits of great rivers (WABI-SHEBELLE, FAYEN, JERER), gravels, sands, silts. Alluvions des grands cours d'eau (WABI-SHEBELLE, FAYEN, JERER): graviers, sables, limons.
TERTIARY TERTIAIRE	Miocene Miocène		Intrusive olivine basalts Basaltes intrusifs à oléine
			GOSOMA series: sandstones and red quartzites Séries de GOSOMA: grès et quartzites rouges
SECONDARY SECONDAIRE	Upper Cretaceous Crétacé supérieur		Senonian Sénonien
			Turonian Turonien
			Cenomanian Cénomanien
	Lower Cretaceous Crétacé inférieur		Barremian Albian Barémien Albien
			Neocomian Néocomien
			Kimmeridgian Portlandian Kimmeridgien Portlandien

 Geological contact line Contour géologique	 Fault Faille
 Uncertain fault Faille hypothétique	 Axis of syncline Axe de synclinal
 Axis of anticline Axe d'anticlinal	 Strike and dip Direction et pendage
 Day well Puits creusé	 Drilled well Puits foré



Planimetric map based on the provisional sketches  
at approximately 1:100000 and using the map at  
1:500000 established by the WAR OFFICE (EAST  
AFRICA, 1946)  
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COMMISSION WABI SHEBELLE SURVEY  
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 Town, important village, administrative center Ville, village important, centre administratif	 Small village Petit village
 Main road or trail Route ou piste principale	 Secondary trail Piste secondaire
 Foot trail, trail Piste à pied, sentier	 Limit of study zone Limite de l'étude

 Permanent river Rivière permanente	 Temporary river, thalweg, flow trace Rivière temporaire, thalweg, trace d'écoulement
 Lake, water plane Lac plan d'eau	 Important hill summit Sommet important
 Small isolated hill summit Petit sommet isolé	 Cliff, rocky escarpment, plateau boundary Falaise, escarpement rocheux, limite de plateau

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IV  
GEOLOGICAL MAP OF OGADEN

IMI

APRIL 1974  
MAP N°4



QUATERNARY  
QUATÉNAIRE

TERTIARY  
TERTIAIRE

SECONDARY  
SECONDAIRE

Upper Cretaceous Crétacé supérieur	Senonian Sénonien		Recent local deposits : alluvial, colluvial and slope deposits : sands, silts, clay. Dépôts récents locaux : alluvions, colluvions, dépôt de pentes, sables, limons, argiles.
			Alluvial deposits of great rivers (WABI-SHEBELLE, FAFEN, JERERI), gravels, sands, silts. Alluvions des grands cours d'eau (WABI-SHEBELLE, FAFEN, JERERI) graviers, sables, limons.
Lower Cretaceous Crétacé inférieur	Turonian Turonien		Intrusive olivine basalts. Basaltes intrusifs à oléine.
			GESOMA series : sandstones and red quartzites. Séries de GESOMA grès et quartzites rouges.
	Cenomanian Cénomanien		BELET-JEN series : sandstones and zoogenic limestones. Séries de BELET-JEN grès et calcaires zoogènes.
			FERFER series : gypsum, limestones, marly limestones, dolomites. Séries de FERFER, gypse, calcaires, calcaires marneux, dolomies.
Upper Jurassic Jurassique supérieur	Barremian Albian Barémien Albien		MUSTAHIL series : marly and chalky limestones, dolomitic limestones. Séries de MUSTAHIL, calcaires marneux et coquilles, calcaires dolomitiques.
			Main gypsum formation : gypsum, marls, clay, dolomites, halites. Formation gypseuse principale : gypses, marnes, argiles, dolomies, halites.
	Neocomian Néocomien		KEBRI-DAHAR series : lithographic limestones, marls, marly limestones, gypsum. Séries de KEBRI-DAHAR, calcaires lithographiques marneux, calcaires marneux, gypses.

Geological contact line  
Contour géologique

Fault  
Faille

Uncertain fault  
Faille hypothétique

Axis of syncline  
Axe de synclinal

Axis of anticline  
Axe d'anticlinal

Strike and dip  
Direction et pendage

Dug well  
Puits creusé

Drilled well  
Puits foré

Town, important village, administrative center  
Ville, village important, centre administratif

Small village  
Petit village

Main road or trail  
Route ou piste principale

Secondary trail  
Piste secondaire

Foot trail, trail  
Piste à pied, sentier

Limit of study zone  
Limite de l'étude

Permanent river  
Rivière permanente

Temporary river, thalweg, flow trace  
Rivière temporaire, thalweg, trace d'écoulement

Lake, water plane  
Lac plan d'eau

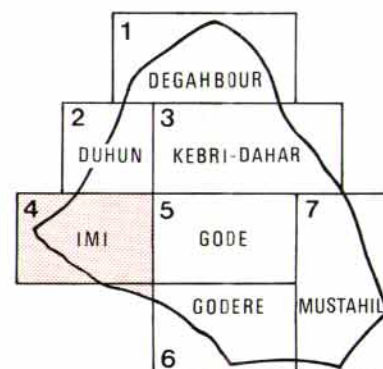
Important hill summit  
Sommet important

Small isolated hill summit  
Petit sommet isolé

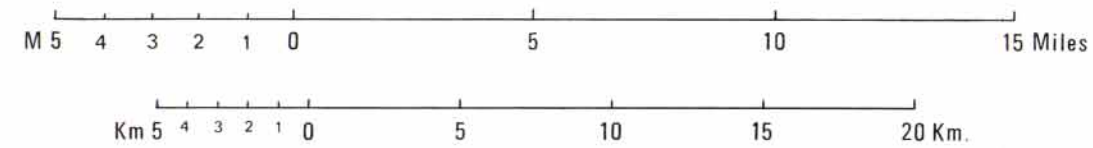
Cliff, rocky escarpment, plateau boundary  
Falaise, escarpement rocheux, limite de plateau

Planimetric map based on the provisional sketches  
at approximately 1:100000 and using the map at  
1:500000 established by the WAR OFFICE (EAST  
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INDEX SHEET



Scale 1:250000



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IV  
GEOLOGICAL MAP OF OGADEN

GODE

APRIL 1974  
MAP N°5



QUATERNARY  
QUATÉNAIRE

TERTIARY  
TERTIAIRE

SECONDARY  
SECONDAIRE

Upper Cretaceous Crétacé supérieur	Miocene Miocène	Senonian Sénonien		Recent local deposits : alluvial, colluvial and slope deposits : sands, silts, clay. <i>Dépôts locaux récents : alluviaux, colluviaux, dépôt de pentes, sables, limons, argiles.</i>
				Alluvial deposits of great rivers (WABI-SHEBELLE, FAFEN, JERER), gravels, sands, silts. <i>Alluvions des grands cours d'eau (WABI-SHEBELLE, FAFEN, JERER) graviers, sables, limons.</i>
Lower Cretaceous Crétacé inférieur	Cenomanian Cénomannien	Intrusive olivine basalts		Intrusive olivine basalts <i>Basaltes intrusifs à olivine</i>
				GESOMA series : sandstones and red quartzites <i>Séries de GESOMA : grès et quartzites rouges</i>
		BELET-UDEN series : sandstones and zirconiferous limestones		BELET-UDEN series : sandstones and zirconiferous limestones <i>Séries de BELET-UDEN : grès et calcaires zirconifères</i>
				FERFER series : gypsum, limestones, marly limestones dolomitic <i>Séries de FERFER : gypse, calcaires, calcaires marneux, dolomites</i>
Upper Jurassic Jurassique supérieur	Barremian Albian Barémien Albien	MUSTAHIL series : marly and chalky limestones, dolomitic limestones		MUSTAHIL series : marly and chalky limestones, dolomitic limestones <i>Séries de MUSTAHIL : calcaires marneux et craieux, calcaires dolomitiques</i>
				Main gypsum formation : gypsum, marl, clay, dolomites, halite <i>Formation gypseuse principale : gypse, marne, argiles, dolomites, halite</i>
		NEOCOMIAN Néocomien		KEBRI-DAHAR series : lithographic limestones, marls, marly limestones, gypsum <i>Séries de KEBRI-DAHAR : calcaires lithographiques, marne, calcaires marneux, gypse</i>

Geological contact line  
Contour géologique

Fault  
Faille

Uncertain fault  
Faille hypothétique

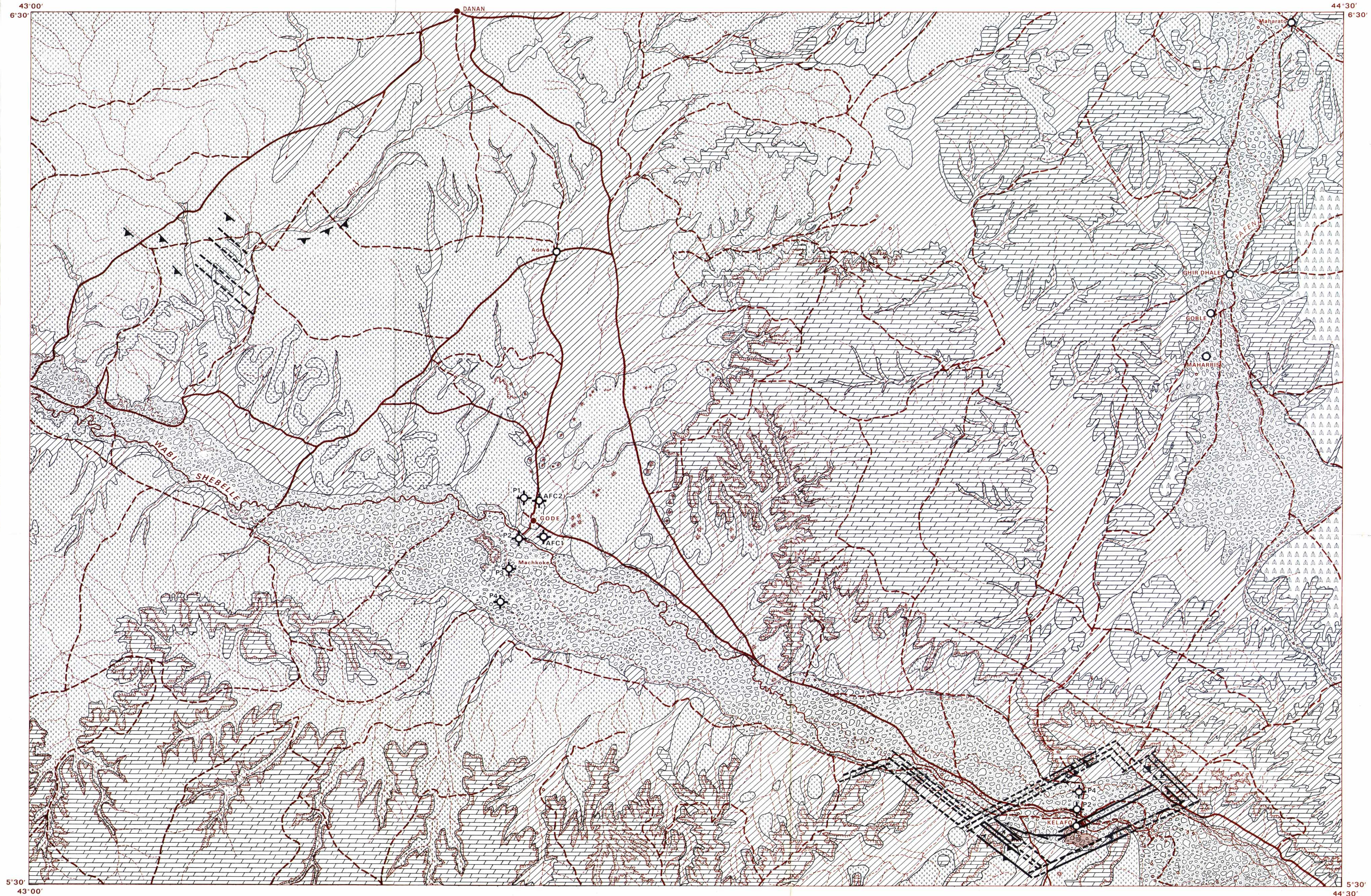
Axis of syncline  
Axe de synclinal

Axis of anticline  
Axe d'anticlinal

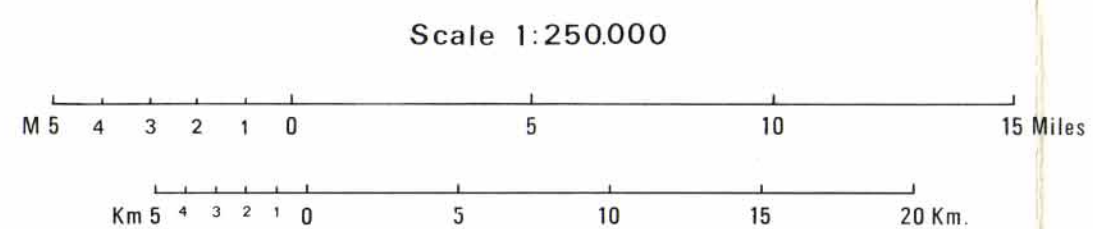
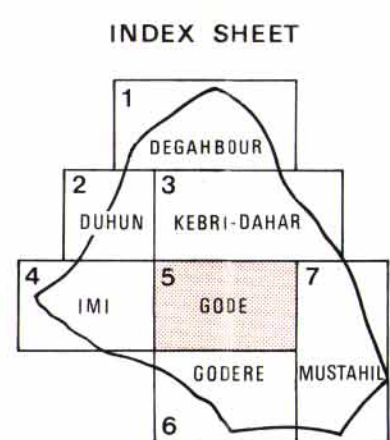
Strike and dip  
Direction et pendage

Dug well  
Puits creusé

Drilled well  
Puits foré



Planimetric map based on the provisional sketches at approximately 1:100000 and using the map at 1:500000 established by the WAR OFFICE (EAST AFRICA, 1946).  
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Ville, village important, centre administratif  
Small village  
Petit village  
Main road or trail  
Route ou piste principale  
Secondary trail  
Piste secondaire  
Foot trail, trail  
Piste à pied, sentier  
Limit of study zone  
Limite de l'étude

Permanent river  
Rivière permanente  
Temporary river, thalweg, flow trace  
Rivière temporaire, thalweg, trace d'écoulement  
Lake, water plane  
Lac plan d'eau  
Important hill summit  
Sommet important  
Small isolated hill summit  
Petit sommet isolé  
Cliff, rocky escarpment, plateau boundary  
Falaise, escarpement rocheux, limite de plateau





ETHIOPIA - FRANCE COOPERATIVE PROGRAM  
WABI SHEBELLE SURVEY

IN COLLABORATION WITH  
FRENCH MINISTRY OF FOREIGN AFFAIRS  
NATIONAL WATER RESOURCES COMMISSION  
BCEOM\_ORSTOM.EDF  
IGN\_B DPA

IV  
GEOLOGICAL MAP OF OGADEN

GODERE












APRIL 1974  
MAP N°6



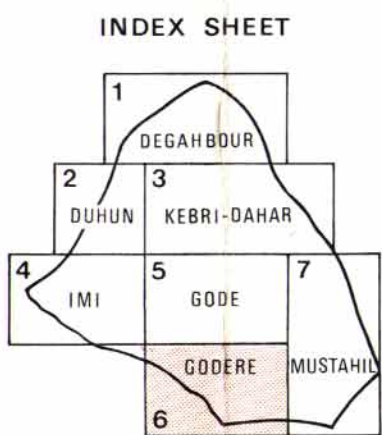
QUATERNARY  
QUATÉNAIRE

TERTIARY  
TERTIAIRE

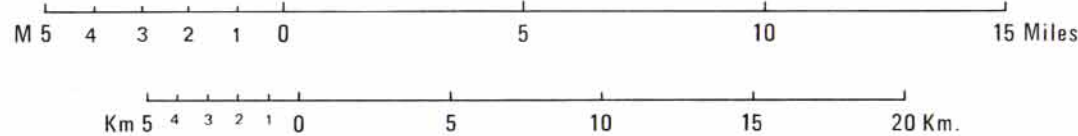
SECONDARY  
SECONDAIRE

QUATERNARY QUATÉNAIRE			Recent local deposits : alluvial, colluvial and slope deposits : sands, silts, clay. Dépôts récents locaux : alluvions, colluvions, dépôt de pentes, sables, limons, argiles.
			Alluvial deposits of great rivers (WABI-SHEBELLE, FAFEN, JERER): gravels, sands, silts. Alluvions des grands cours d'eau (WABI-SHEBELLE, FAFEN, JERER): graviers, sables, limons.
TERTIARY TERTIAIRE	Miocene Miocène		Intrusive olivine basalts Basaltes intrusifs à oléine
	Upper Cretaceous Crétacé supérieur	<div><div>Senonian Sénonien</div><div>Turonian Turonien</div></div>	<div><div>GESOMA series : sandstones and red quartzites Séries de GESOMA : grès et quartzites rouges</div><div>BELET-UEN series : sandstones and zoogenic limestones Séries de BELET-UEN : grès et calcaires zoogènes</div></div>
SECONDARY SECONDAIRE	Lower Cretaceous Crétacé inférieur	Cenomanian Cénomanien	FERFER series : gypsum, limestones, marly limestones, dolomites Séries de FERFER : gypse, calcaires, calcaires marneux, dolomites
		Barremian Albian Barrémien Albien	MUSTAHIL series : marly and chalky limestones, dolomitic limestones Séries de MUSTAHIL : calcaires marneux et crayeux, calcaires dolomitiques
	Upper Jurassic Jurassique supérieur	Neocomian Néocomien	Main gypsum formation : gypsum, marls, clay, dolomites, halites Formation gypseuse principale : gypse, marnes, argiles, dolomites, halites
		Kimmeridgian Portlandian Kimmeridgien Portlandien	KEBRI-DAHAR series : lithographic limestones, marls, marly limestones, gypsum Séries de KEBRI-DAHAR : calcaires lithographiques, marnes, calcaires marneux, gypse
		Geological contact line Contour géologique	
		Fault Faille	
		Uncertain fault Faille hypothétique	
		Axis of syncline Axe de synclinal	
		Axis of anticline Axe d'anticlinal	
		Strike and dip Direction et pendage	
		Dug well Puits creusé	
		Drilled well Puits foré	

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Scale 1:250000



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Piste à pied, sentier  
Limit of study zone  
Limite de l'étude

Permanent river  
Rivière permanente  
Temporary river, thalweg, flow trace  
Rivière temporaire, thalweg, trace d'écoulement  
Lake, water plane  
Lac plan d'eau  
Important hill summit  
Sommet important  
Small isolated hill summit  
Petit sommet isolé  
Cliff, rocky escarpment, plateau boundary  
Falaise, escarpement rocheux, limite de plateau



የኢትዮጵያ ንጉሠ ነገሥት መንግሥት  
ጠቅላይ የውሃ ሀብት ልማት ኮሚሽን ጠላረፎ ቤት  
IMPERIAL ETHIOPIAN GOVERNMENT  
NATIONAL WATER RESOURCES COMMISSION



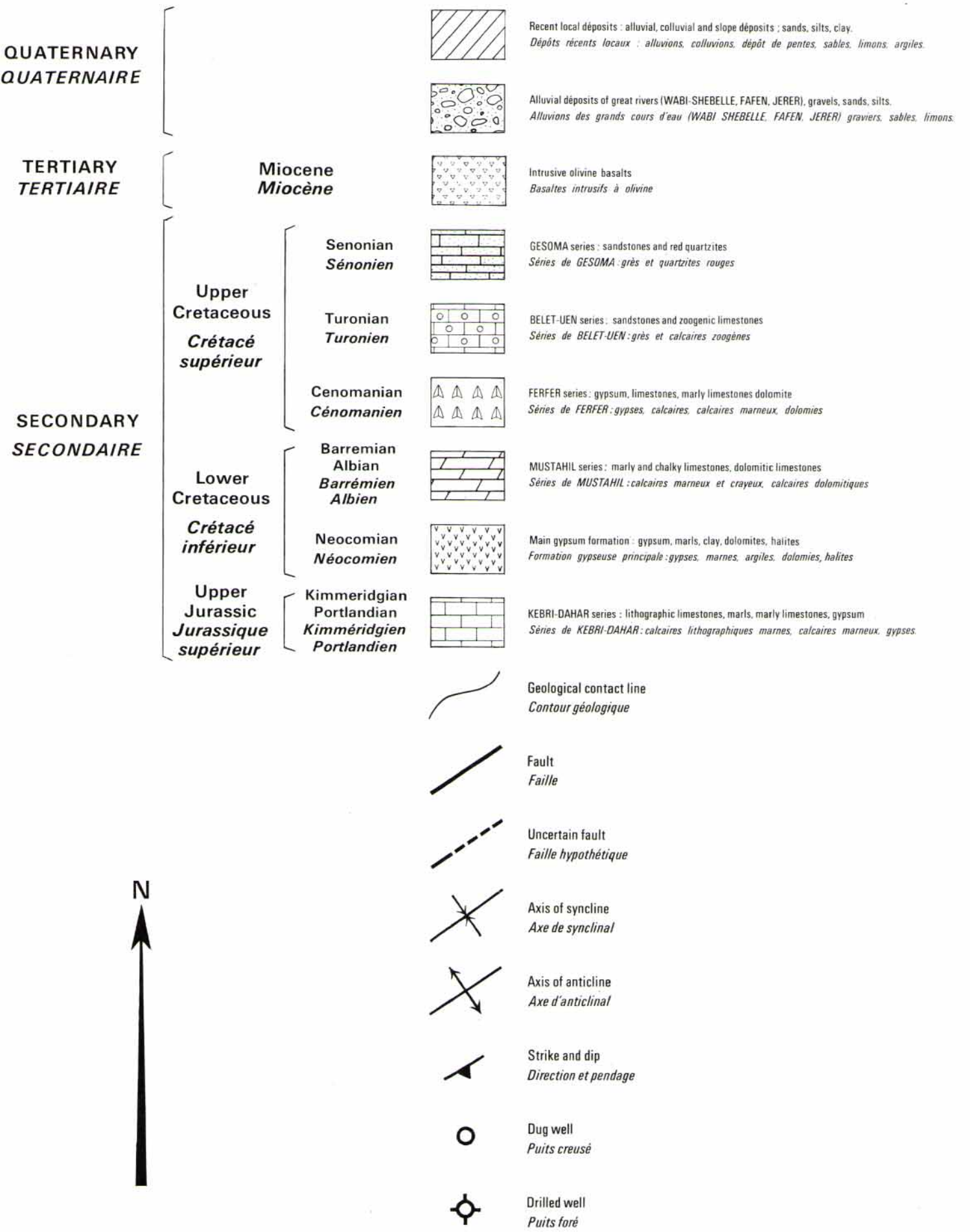
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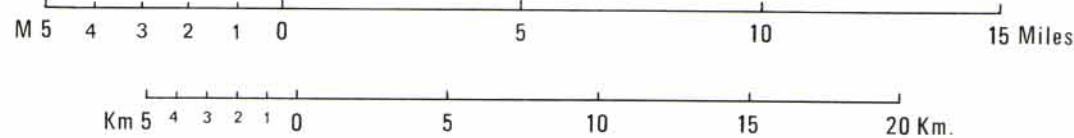
IV  
GEOLOGICAL MAP OF OGADEN

MUSTAHIL

APRIL 1974  
MAP N°7



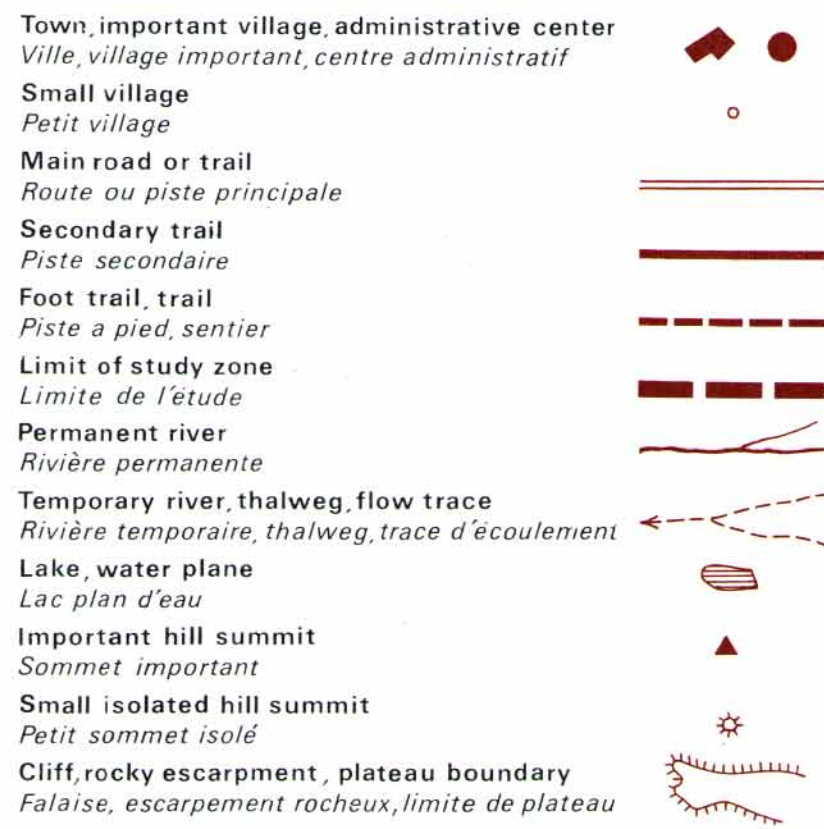
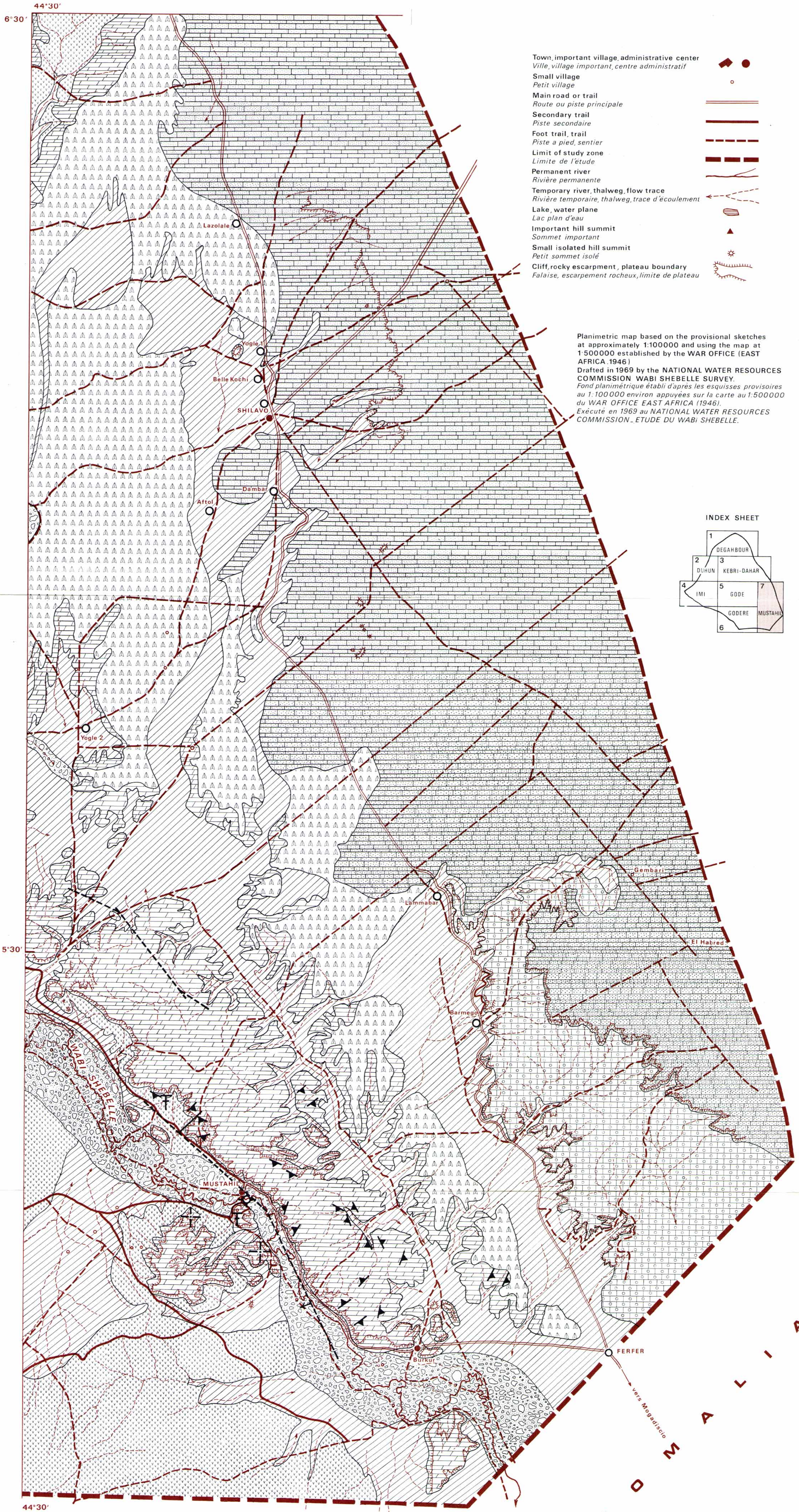
Scale 1:250000



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INDEX SHEET

