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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

B. Hydrogeological survey of Ogaden

December 1972

ORSTOM

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N O T E

IN THE TABLES, FRENCH DECIMAL NOTATION IS USED :

THE FIRST DECIMAL FIGURE IS PRECEDED BY A COMMA

INSTEAD OF A POINT.

The present report is a synthesis of the studies carried out from 1967 to 1971 by the Hydrogeological Division of the WABI SHEBELLE Project

The following scientists, engineers and technicians participated in the hydrogeological studies :

- Daniel BAUDUIN, "Maitre de Recherches" (ORSTOM) and chief of the Hydrogeological Division of the French Mission.

- Jean-Louis JULLIEN, ORSTOM Hydrogeologist.

- ABERA WAKJIRA, Ethiopian Geologist.

- TEWOLDE SOLOMON, Ethiopian Technician.

During the preliminary phase of studies, the hydrogeological teamwork was conducted by Professor J. AUROUZE, Hydrogeological Consultant (3).

From 1969 until the achievement of this report, scientific studies were conducted by M. Gilbert CASTANY, Assistant Manager at BRGM and assigned by ORSTOM as Consultant in ETHIOPIA (4).

1. HYDROGEOLOGICAL STUDIES

1.1. Limits and objectives

The Hydrogeological survey included in the general study for the development of the WABI SHEBELLE Basin is limited to the Southern zone. This region will be referred to as "OGADEN" though this regional name is also used for a much larger territory stretching beyond the limits of the catchment area of the WABI SHEBELLE, particularly to the East.

This region is the most arid zone of the Basin and is only regularly supplied by the two main rivers : the WABI SHEBELLE with a permanent flow and the FAFEN with an intermittent flow.

It is therefore essential to know the ground water resources of this region in view of its agricultural as well as its pastoral development.

The purposes of the hydrogeological study were :

- The delimiting of geological units which may constitute utilizable reservoirs.

- The study of ground waters, their potential and eventual utilization.

The present report gives the results and conclusions achieved as regards a first evaluation of water resources and also indicates the possibilities of utilizing the ground water.

Needless to say that the few drillings carried out and the complete lack of any geophysical survey do not allow a detail study of the various aquifers.

The hydrogeological survey described in this report is to be considered mainly as a reconnaissance study of water-bearing formations and their potentialities, but it may nevertheless be used as a base when beginning future research-work and also bring indications as to how this work must be conducted.

1.2. Previous studies and geological documentation

Before the creation of the WABI-SHEBELLE Project Survey in ETHIOPIA, very few geological studies and no hydrogeological study had been undertaken in OGADEN.

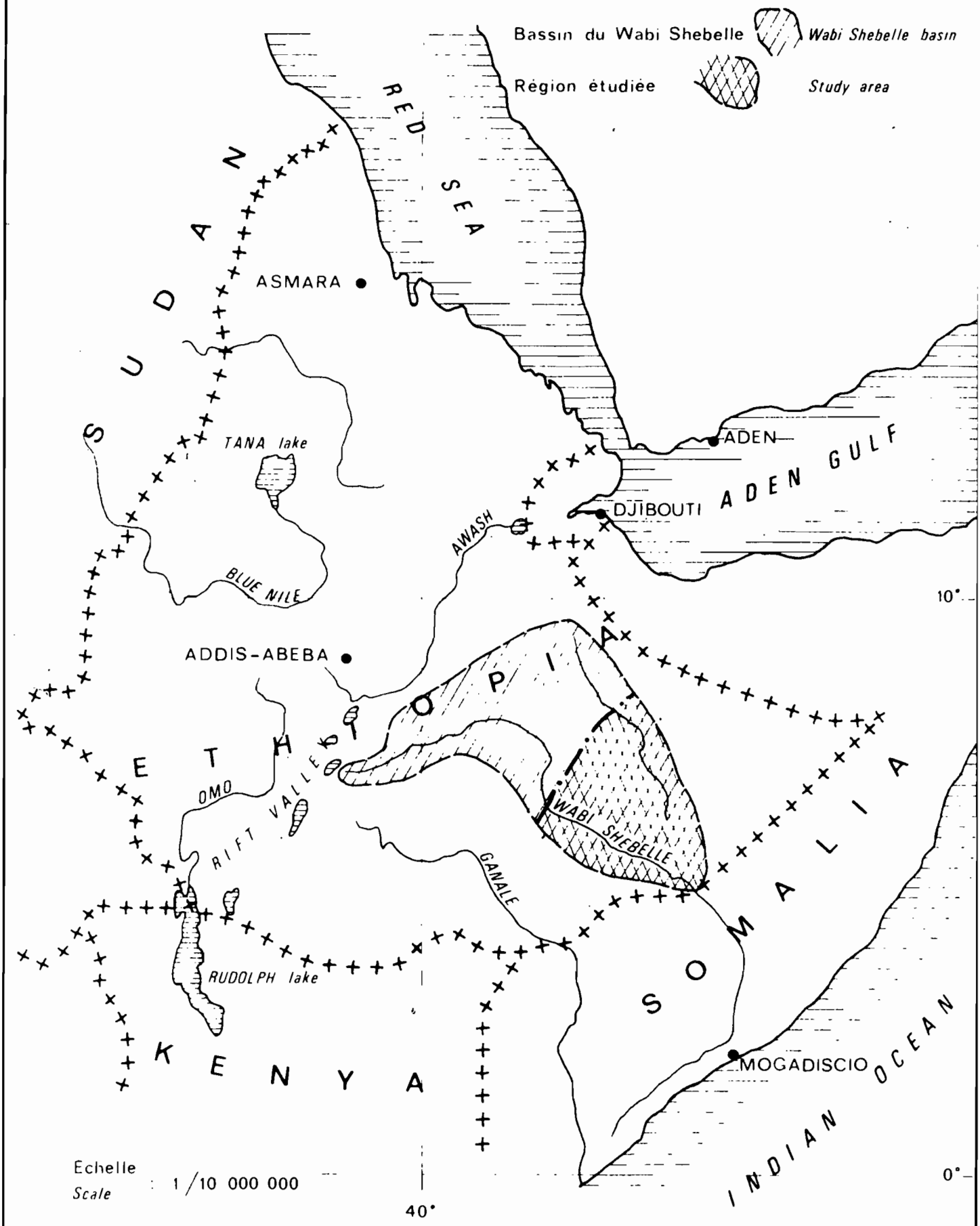
- The geological documentation was limited to several small-scale maps and a few general documents on the geology of ETHIOPIA.

- The cartographical documents, in the following publication order, consisted of :

1°) The geologic map at 1/8000.000 by DANIELLI (1941)

2°) The geologic sketch of the Somalian Peninsula at 1/600.000 by STEFANINI

CARTE DE SITUATION ___ *LOCATION MAP*



O.R.S.T.O.M. Service Hydrologique | date | des. | ETR-291591

3°) - The KEBRI-DAHAR sheet from the "Carta Geologica della Somalia e d'ell OGADEN" drafted in 1967 by the AGIP Mineraria for oil research.

4°) - The geological map of AFRICA Horn at 1/2000.000 by MOHR (1963)

Two general works deal with geology in ETHIOPIA :

"Geologia d'ell Africa Orientale by DANIELLI (1943)

"Geology of ETHIOPIA" by MOHR (1963).

As regards hydrogeology, several logs of wells and drillings for water intake carried out by the services of the Water Resources Department as well as some logs of drillings undertaken by the Ethiopian Mine Services, constitute the only available knowledge.

1.3. Topographic and planimetric documentation

The topographic maps used are all at a small scale and consist of a map at 1/1.000.000 and its enlargement at 1/500.000 drafted by the "War Office" (1946) and the quality of which is insufficient as regards planimetry as well as topography.

The WABI SHEBELLE Project drafted a series of planimetric base maps at different scales from the aerial photographs at 1/50.000 of the Basin.

The scales of these planimetric base maps at different scales from the aerial photographs at 1/50.000 of the Basin.

The scales of these planimetric base maps are respectively : 1/100.000, 1/250.000, 1/100.000 for all the basin, 1/50.000 for the WABI SHEBELLE Lower Valley. Their quality is very good and they have been used as bases for the geologic maps and hydrogeologic sketches.

1.4. Studies and methods

Before undertaking the study of ground-water resources, it was proved necessary to determine with relative accuracy the geological frame of OGADEN, As previously said, the existent geological data being very insufficient, a geological map of OGADEN at a scale of 1/250.000 in seven sheets was drawn through photogeological interpretation and checking on the field.

A second geological map at 1/1000.000 of the whole basin was also drafted. For the Southern part, the map at 1/250.000 was used and the Northern part is based on the photogeological interpretation and geological observations made by the Soil Science Division during the prospection. These two series of maps and the corresponding notices are published separately (1,2).

The dynamics and geochemistry of shallow water-tables were studied on existent water points visited several times in the course of an hydrologic cycle, and the corresponding data are noted on well-card indexes

As these water-tables present utilization possibilities, the most interesting were explored by bore-holes. Consequently:

- the fluctuations of the alluvial water-table of the WABI SHEBELLE were surveyed using three lines of piezometers.

(1-2) See bibliography at the end of the report.

- The KEBRI-DAHAR limestone under the gypsum layer was reconnoitred by two deep bore holes.

Finally, several zones,presenting because of their structure specific hydrogeological features, were studied more in detail. (KELAFO REGION)

2. GENERAL CHARACTERISTICS OF THE REGIONAL GEOGRAPHY

After situating the WABI SHEBELL Basin in its general physical complex, the various physical and climatic factors of OGADEN conditioning the ground water regime will be mentioned in this chapter

2.1. General summary characteristics of the WABI SHEBELLE Basin

2.1.1. Limits, relief and hydrography (graph n° 1)

The WABI SHEBELLE Basin is located in the South-East of ETHIOPIA between 5° and 9°30' North parallels and 38°30' and 45° East meridians. It is limited to the North by the Awash Basin and the depression of the Rift Valley, to the East by the GANALE Basin and to the West by a desert region stretching to the bay of ADEN. Its total surface to the frontier of SOMALIA, including the FAFEN basin, is about 190.000 km2 (like the Blue Nile Basin) and it is in fact the largest drainage basin of ETHIOPIA.

The WABI SHEBELLE Basin rests to the North against the large tertiary basaltic mass which occupies all central ETHIOPIA and culminates at 4.000 meters' altitude. The altitude soon declines and is approximately 150 m. at the frontier of SOMALIA.

The WABI SHEBELLE is a permanent river mainly supplied by the tributaries flowing down from the High Plateaus, but the tributaries of the downstream part, as well as the FAFEN which forms an independent basin, are temporary rivers.

The WABI SHEBELLE flows across the frontier into SOMALIA and disappears by evaporation in a vast water spreading zone.

2.1.2. Climate

The climatic regime of the Basin depends on the relief which slopes from the North West down to the South East.

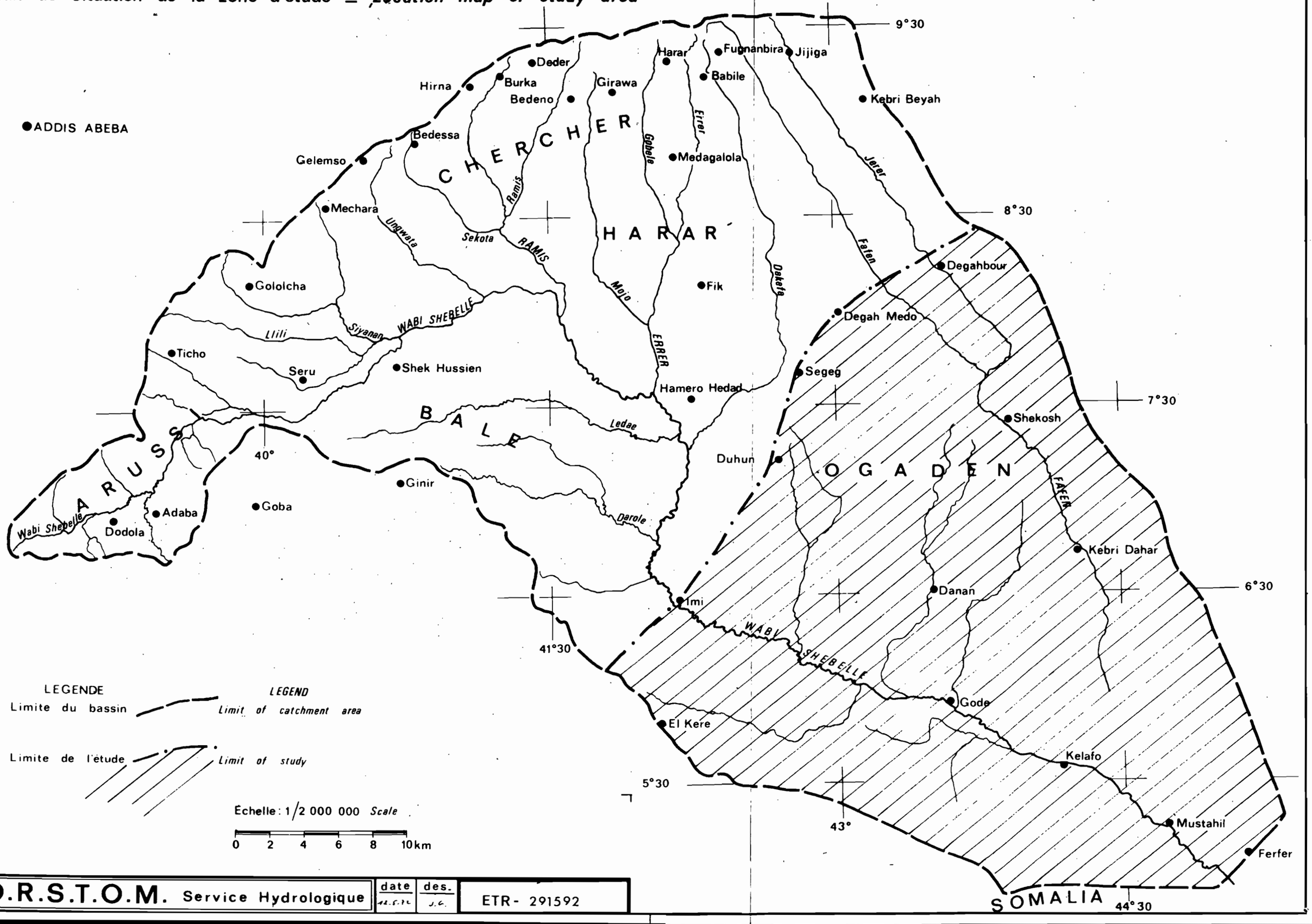
Three climatic zones corresponding to the relief may be distinguished:

a) A zone of up-lands over 2.000 m. high, characterized by :

- 1.800 mm to 800 mm mean annual rainfall with a dry winter season from November to February and a rainy season from March to October and scarcely no rainfall in June.

Gr_2

Plan de situation de la zone d'étude _ *Location map of study area*



LEGENDE — *LEGEND*

Limite du bassin — *Limit of catchment area*

Limite de l'étude — *Limit of study*

Echelle : 1/2 000 000 *Scale*

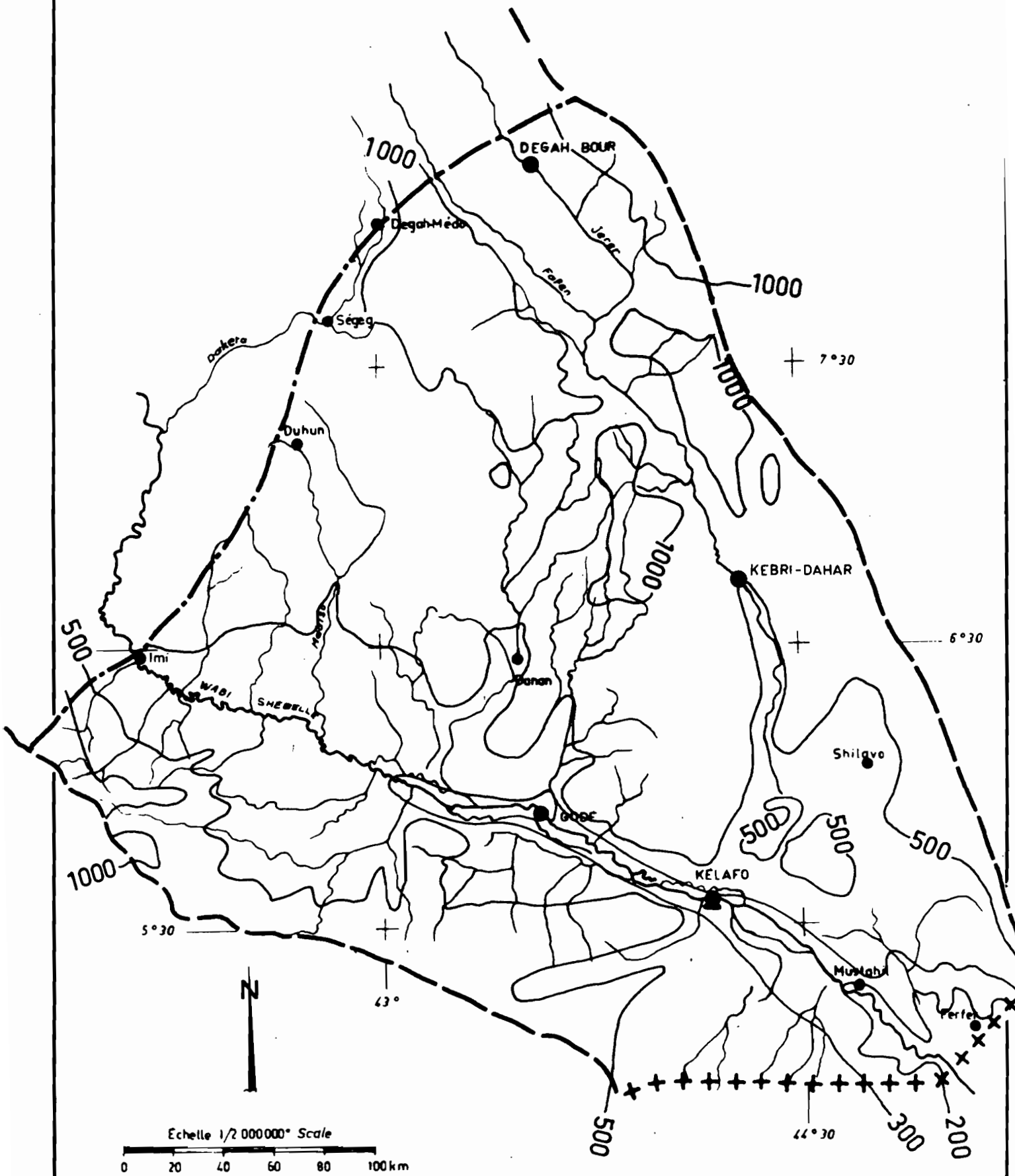
0 2 4 6 8 10km

O.R.S.T.O.M. Service Hydrologique	date 22.5.72	des. J.C.	ETR- 291592

OGADEN Gr_3

COURBES HYPSOMETRIQUES_*HYPSOMETRIC CONTOURS*

(en mètres) *(in meters)*



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	12.5.72	J.C.	

- moderate temperatures, sometimes below 0° during winter months.

- a vegetation of forest and tree savannahs.

b) - The intermediate zone with an altitude comprised between 2.000 meters and 1.000 m, characterized by :

- warmer temperatures

- a vegetation belonging to the tree savannah type.

- a mean rainfall from 800 to 400 mm in two very distinct seasons : from March to May and from July to October.

c) - The semi-arid zone of OGADEN, below 1.000 meters'altitude, characterized by :

- rainfall under 400 mm distributed in two rainy seasons of equal importance (April-May and October-November).

- high temperatures : the maximum being approximately 40°C.

- a vegetation of thorny bushes belonging to the semi-desert type.

2.1.3. Main geological features (geological map at 1/1.000.000)

For more details concerning the geology of the basin, see map of the basin at 1/1.000.000 and its explicative notice (2).

The basin comprises two great geological units, i.e. :

- a volcanic region, formed during the tertiary age to the North of the Basin, called TRAPP series and mainly consisting of basalt, ash and volcanif tuff, with a cristalline substratum which outcrops in the HARAR region.

- a large sedimentary basin (secondary age) to the South, consisting of limestone, gypsum, marl and sandstone. This sedimentary series stretches from the Upper Jurassic to the Cretaceous period. The formations present a monoclinal aspect with a general South-Eastern dip of several degrees and are broken by a fault system mainly directed NW-SE and NE-SW and corresponding to the formation of the Rift Valley.

2.2. General characteristics of the area under study : OGADEN

2.2.1. Area and limits (graph n° 2)

The area under study is described in paragraph 2.1.2. as the semi-arid zone of OGADEN. It stretches over the South-Eastern part of the Basin and is limited to the North by a line passing approximately through IMI, DUHUN, SEGEG, DEGAH MEDO, DEGAHBOUR. This region is located between 8°15' and 5° North parallels and 41°35' and 45°25' East meridians and its total surface area is approximately 70.000 km2. It corresponds to the Lower Basins of the WABI SHEBELIE and FAFEN.

A more detailed map of this region can be found as annex to this report and comprises all the names of places mentioned herein (graph n° 31).

2.2.2. Relief (graph n° 3)

OGADEN forms a large sedimentary plateau declining to the South-East and scoured by two important rivers : the WABI SHEBELLE and the FAFEN and by their tributaries.

Altitude is about 1.000 meters in the Northern part between SEGEG and DEGAHBOUR and gradually declines to 150 m at the outlet of the WABI SHEBELLE.

The morphology depends on the lithology of the strata and on the influence of weathering on the latter.

The hypsometric contours of map 3 are drawn from the topographic map at 1/500.000 and though they are schematic, they show well enough the general display of slopes.

2.2.3. General climatic data

The climatic factors of OGADEN are studied in detail in the report on "General hydrology of the WABI-SHEBELLE basin" published at the same time as this report. Here is only given an outline of the main climatic parameters affecting ground water recharge.

The OGADEN climate belongs to the equatorial semi-arid type. It is characterized by mean annual rainfall under 400 mm distributed in two rainy seasons, high temperatures and consequently, intensive evaporation.

2.2.3.1. Precipitations (graphs n° 4 and n° 5)

No rainfall observations are available for long periods. Only three stations : DEGAHBOUR, KEBRI DAHAR and KELAFO operated in a very discontinuous way before the first observations were carried out by the Project in 1968. It is therefore difficult to estimate the mean annual rainfall in OGADEN.

All the annual rainfall datas collected at the OGADEN stations are grouped in recapitulative table n° 1 Data for 1969 and 1971 correspond to the Survey Project's stations.

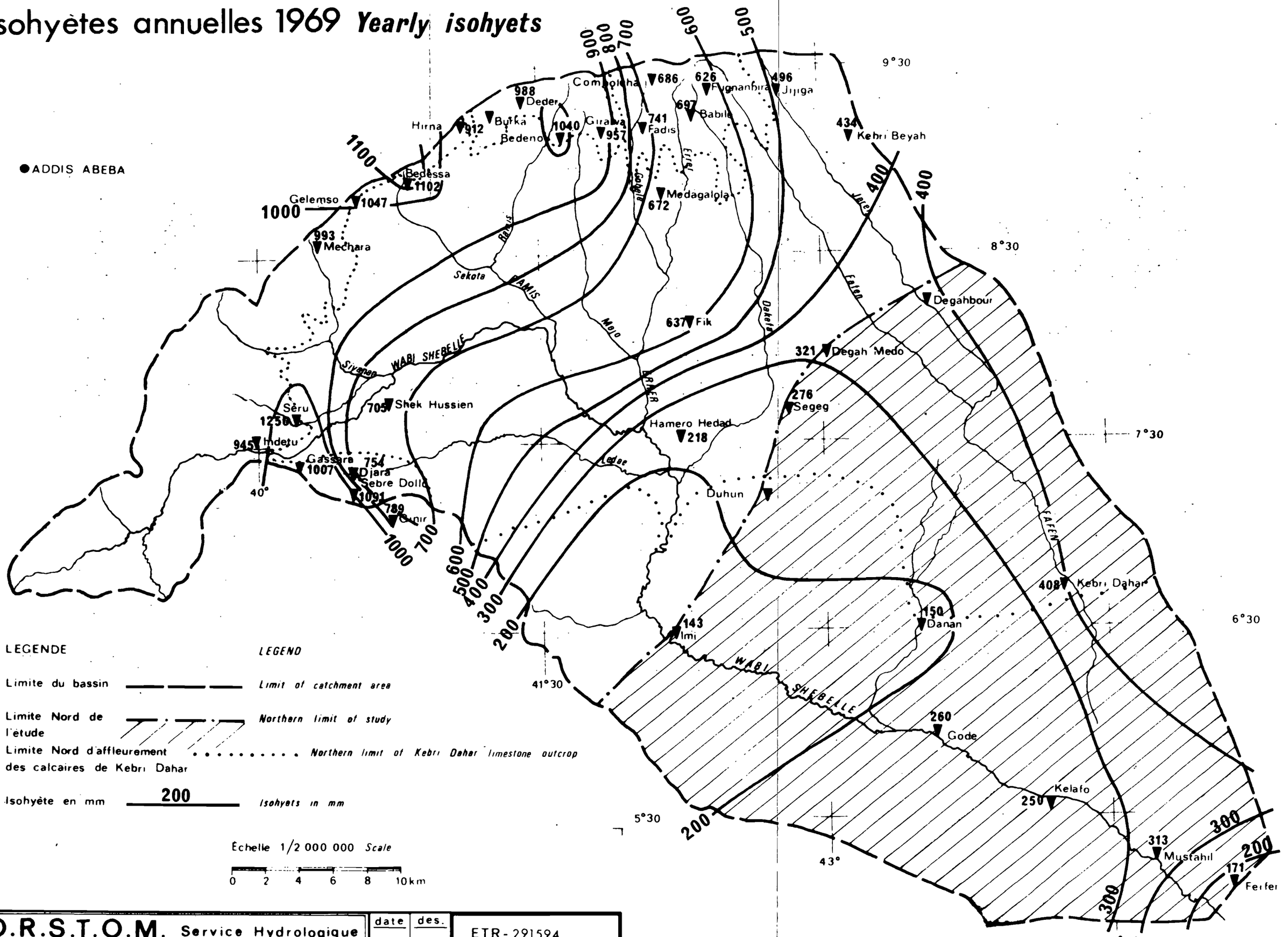
Moreover, yearly isohyets for 1969 and 1970 were drawn on maps n° 4 and n° 5. They correspond to all the OGADEN region and to the recharge area of KEBRI DAHAR limestone, except for the summits of high regions to the North and West of the Basin.

Table n° 1 and the isohyetal map reveal that :

Interannual irregularity of rainfall is considerable. At KEBRI DAHAR station where data were collected for nine years, the maximum rainfall observed is 469 mm and the minimum : 155 mm or three times less. This irregularity

Gr_4

Isohyètes annuelles 1969 *Yearly isohyets*



LEGENDE — *LEGEND*

Limite du bassin — *Limit of catchment area*

Limite Nord de l'étude — *Northern limit of study*

Limite Nord d'affleurement des calcaires de Kebri Dahar — *Northern limit of Kebri Dahar limestone outcrop*

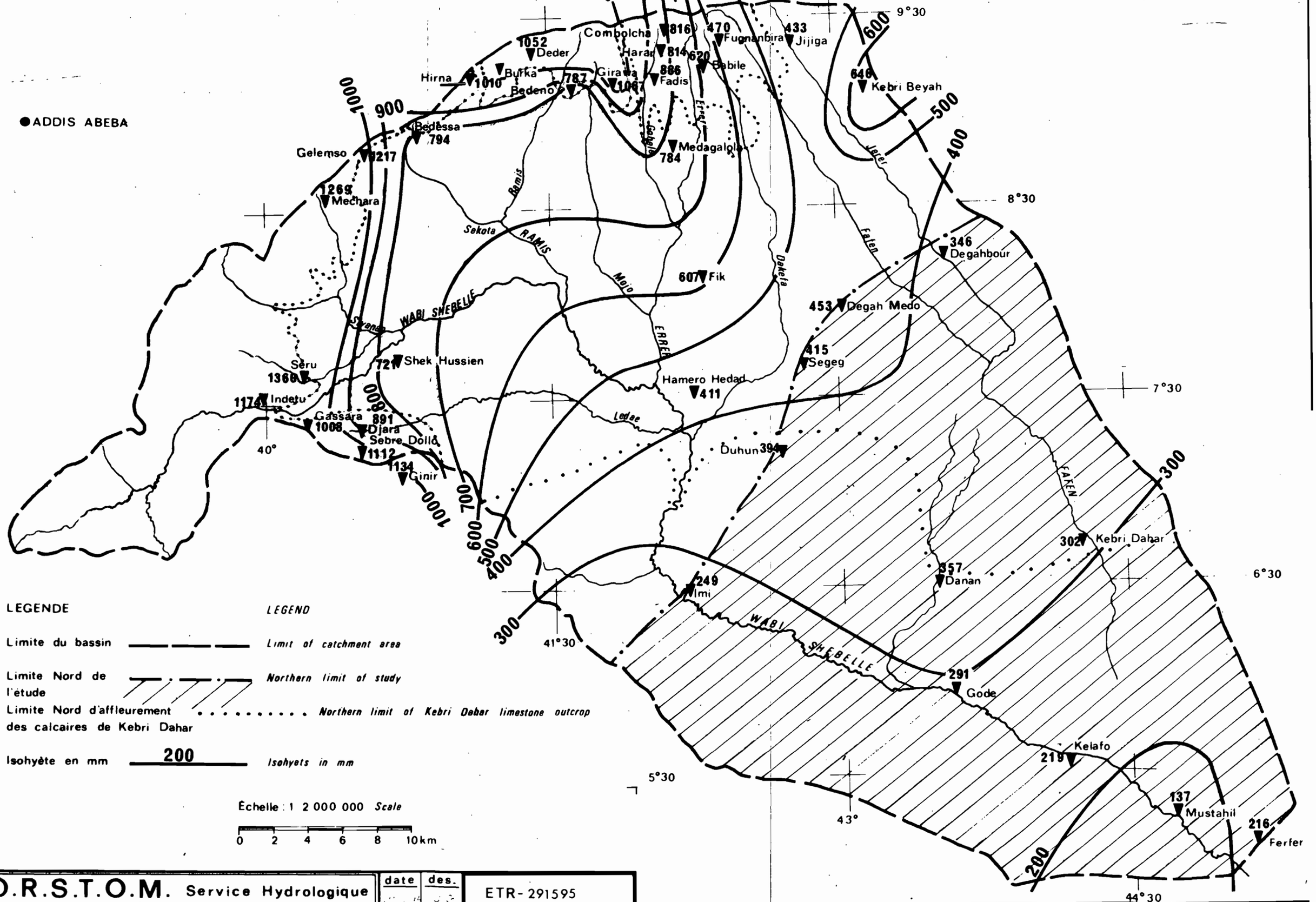
Isohyète en mm — 200 — *Isohyets in mm*

Échelle 1/2 000 000 *Scale*

0 2 4 6 8 10 km

O.R.S.T.O.M. Service Hydrologique	date	des.	ETR-291594

Isohyètes annuelles 1970 *Yearly isohyets*



LEGENDE — *LEGEND*

Limite du bassin — *Limit of catchment area*

Limite Nord de l'étude — *Northern limit of study*

Limite Nord d'affleurement des calcaires de Kebri Dahar — *Northern limit of Kebri Dahar limestone outcrop*

Isohyète en mm 200 — *Isohyets in mm*

Échelle : 1 2 000 000 *Scale*

0 2 4 6 8 10 km

O.R.S.T.O.M. Service Hydrologique	date	des.	ETR-291595

TABLE N° 1

RECAPITULATIVE TABLE OF ANNUAL RAINFALL IN OGADEN (in mm)

Stations	Coordinates	1955	1957	1958	1959	1960	1961	1962	1964	1965	1966	1969	1970	1971
DEGAHBOUR	8°13' N 43°33' E	225,5		(344,5)		393,1	337,0						346,1	363,4
DEGAH-MEDO	7°58' N 43°01' E											320,9	452,6	340,6
SEGEG	7°38' N 42°43' E											276,2	415,5	324,6
DUHUN	7°12' N 42°37' E												394,1	479,5
IMI	6°26' N 42°06' E											143,1	249,3	127,3
DANAN	6°30' N 43°30' E											149,6	357,4	134,1
KEBRI-DAHAR	6°45' N 44°11' E			192,3	187,7	469,4		236,1	155,5	381,6	268,2	407,6	302,0	261,9
GODE	5°58' N 43°30' E											259,8	291,5	291,5
KELAFO	5°36' N 44°08' E		255,1	142,7	(66,0)		291,6					250,0	219,2	
MUSTAHIL	5°15' N 44°39' E											313,5	137,0	427,1
FERFER	5°05' N 45°05' E											170,9	215,7	165,7

In parentheses : incomplete data.

affects the recharge of shallow alluvial water-tables or of water-spreading basins.

The annual rainfall progressively decreases from the North-West to the South-East. Though datas for long periods are not available, mean annual rainfall corresponds to approximately 400 m at DEGAHBOUR and progressively decreases to about 150 mm at FERFER.

In the outcrop zone of KEBRI DAHAR limestone which stretches far to the North of the Basin, mean annual rainfall is higher : approximately 500 mm and in some areas, from 700 mm to 1.000 mm. The KEBRI-DAHAR limestone water table is therefore well recharged.

Table N° 2 gives the total monthly rainfall for 1969 and 1970 for all the OGADEN stations. This rainfall is distributed in two rainy seasons : the first from March to May and the second from September to November.

These two rainy seasons are equal in length and are separated by two dry seasons from December to February and from June to August.

Northwards, the dry summer season (June to August) is less pronounced and some rain-storms may occur during this period.

These tropical rain-storms are localized and characterized by their intensity to which is due important runoff.

2.2.3.2. Evaporation and its conditioning factors

The only available data on evaporation and parameters conditioning evaporation in OGADEN are those of the GODE climatic station installed in July 1968. Two types of evaporation measurements exist : on evaporation pan and on PICHE evaporometer, and may be considered as correct for all OGADEN as the climatic features scarcely vary throughout the region. These results are given in table n° 3.

The maximum evaporation corresponds to the dry summer season in July, August and September and the minimum evaporation to the two rainy seasons.

The total annual evaporation resulting from two years' observations on evaporation pan is approximately 3.800 mm, and consequently, the mean annual evaporation of free water surface is about 3.000 to 3.200 mm. This very high value affects the water-loss of floods in water-spreading depressions.

Wind and temperatures are the two main factors affecting evaporation.

Wind is always high and its mean annual velocity always exceeds 2m/s and even 6m/s during the dry summer months.

A E-N.E wind blows during the winter months from November to April and a S-W wind from May to October.

The mean monthly temperatures are always very high, from 27° to 30°C in GODE and higher still in KEBRI DAHAR : from 29°C to 35°C.

The maximum mean monthly temperatures are comprised between 32° and 38°C, the minimum varying between 21° and 25°C. The warmest months are March and April at the end of the dry season.

2.2.4. Vegetation

The natural vegetation of OGADEN belongs to the semi-desert type and consists of a more or less dense thorny thicket of various species corresponding to the base rock.

The alluvial plains of the WABI SHEBELLE and the water spreading depressions of the FAFEN are covered with various types of gramineae.

Along the banks of the WABI SHEBELLE, a fringing forest mainly consisting of Tamaris and palm-trees grows more or less in relation to the depth of the alluvial water-table.

Cultivated zones are few. Seasonal cultivation only exist during the flood periods or when floods subside, in the WABI SHEBELLE alluvial plains (KELAFO and MUSTAHIL zone) or in the water-spreading depressions of the FAFEN and of tributaries (Region of DANAN, KORAHE....).

2.2.5. Hydrography - Hydrology

The regime of the WABI SHEBELLE, FAFEN and tributaries is studied in the general detailed hydrological report already mentioned in 2.2.3. Herein are only described the main features of the hydrological regime and in particular, the hydromorphologic features of alluvial depressions.

OGADEN comprises two types of drainage systems :

a) two distinct drainage basins :

- The WABI SHEBELLE basin with a permanent flow.
- The FAFEN basin with a temporary flow regime during the rainy season.

b) Basins and depressions collecting overland flow of local endhoreic type.

These water-spreading basins exist at the outlets of most of the temporary rivers of OGADEN.

One may note the presence of an endhoreism at the level of some OGADEN rivers as well as at the level of FAFEN (which does not join the WABI), and even at another stage, at the WABI level, this river disappearing before reaching the sea.

TABLE N° 2

MONTHLY DISTRIBUTION OF RAINFALL IN OGADEN FOR 1969 and 1970 (in mm)

Stations	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL
DEGAHBOUR	0	67,9	41,0	12,4	46,1	0	0	0	31,8	5,0	-	-	
DEGAH-MEDO	0	69,4	10,2	28,1	80,8	4,0	0	3,8	28,0	39,9	56,7	0	320,9
SEGEG	10,4	24,9	37,4	19,4	83,2	0	0	0	14,0	0	86,9	0	276,2
DUHUN	-	-	-	-	-	0,4	0	0	22,8	44,5	44,9	0	
IMI	2,8	3,4	29,9	3,4	34,7	0	0	0	0	30,4	38,5	0	143,1
DANAN	0	8,6	37,7	14,0	35,8	6,9	0	0	0,2	1/,7	28,7	0	149,6
KEBRI-DAHAR	0	21,0	21,6	0	166,6	0	0	0	0	64,0	134,4	0	407,6
GODE	0	4,2	26,8	23,8	57,4	2,7	0	0	0	112,1	32,8	0	259,8
KELAFO	0	0	17,0	0	74,1	5,2	0	0	0	89,5	64,2	0	250,0
MUSTAHIL	0	5,6	20,2	26,4	109,5	0,3	0	0	17,2	81,3	53,0	0	313,5
FERFER	0	0	3,7	18,0	22,6	0,8	0	0	2,4	101,8	21,6	0	170,9

YEAR 1970

Stations	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL
DEGAHBOUR	0	0,2	46,0	100,7	45,9	28,7	0	7,7	21,7	95,2	0	0	346,1
DEGAH-MEDO	21,5	0	96,5	75,3	25,5	17,7	2,1	2,9	94,4	116,7	0	0	452,6
SEGEG	28,0	8,7	145,9	96,5	23,1	10,1	0	1,3	51,5	50,4	0	0	415,5
DUHUN	15,5	0	62,3	166,8	69,5	0	0	0	20,6	59,4	0	0	394,1
IMI	6,2	0	20,2	56,0	71,4	0	0	0	5,2	90,3	0	0	249,3
DANAN	0,3	0	52,3	162,4	5,5	0	0	0	0	136,9	0	0	357,4
KEBRI-DAHAR	14,5	0	3,0	172,2	6,7	0	0	0	28,4	77,2	0	0	302,0
GODE	0	0	50,7	150,7	34,6	0	0	0	0,8	54,7	0	0	291,5
KELAFO	0	0	0	150,8	11,3	0	0	0	0	51,4	5,7	0	219,2
MUSTAHIL	0	0	8,5	83,4	25,4	0	0	0	2,2	15,8	1,7	0	137,0
FERFER	0	0	4,0	122,7	34,3	0	0,1	0,5	0	51,7	2,4	0	215,7

- : Unavailable data

TABLE N° 3

MEAN DAILY EVAPORATION IN MM

GODE CLIMATIC STATION

I - Evaporation pan (Colorado type ; surface 1 m2)

Year	J	F	M	A	M	J	Jt	A	S	O	N	D	Annual evaporation in mm
1968								10,6	11,4	7,5	7,8	9,0	
1969	9,9	11,8	11,0	10,8	8,3	10,9	11,3	12,1	11,4	7,4	7,9	9,8	3724
1970	10,7	12,0	11,4	7,2	8,8	10,6	11,2	12,2	12,0	8,2	9,4	10,7	3973
1971	11,9	11,1	10,8	9,1									

II - PICHE evaporometer

Year	J	F	M	A	M	J	Jt	A	S	O	N	D	Annual evaporation in mm
1968								9,1	12,6	5,4	5,8	7,2	
1969	8,7	10,1	9,3	8,5	7,1	10,8	11,0	13,5	11,9	4,4	5,0	6,6	3247
1970	8,3	10,8	7,0	4,4	6,2	6,2	9,1	4,5	8,7	5,4	7,7	6,8	2559
1971	8,3	8,2	6,9	4,9									

2.2.5.1 - The WABI SHEBELLE Basin

1) Flow regime

The Lower WABI SHEBELLE has a perennial flow regime characterized by two flood periods corresponding to the two rainy seasons of the High Plateaus. The first flood period stretches from March to May, the second from mid-July to November. In June the flow is relatively low and the minimum flow period is December to February.

The WABI SHEBELLE flows into the vast alluvial plain stretching from IMI to the frontier and its mean annual discharge corresponds here to 80 to 100 m3/s and scarcely varies until KELAFO as losses in very localized flood basins are compensated for by the tributaries of OGADEN.

The mean annual discharge then decreases in the flood spreading zones between KELAFO and MUSTAHIL and is approximately 70 m3/s at the frontier.

Depending on their origin, two types of floods can be observed :

- distant floods originating from the High Plateaus and flowing slowly with a very considerable volume.

- local and short OGADEN floods with a much smaller overland flow. These can give rise to a very high peak discharge especially if a flood from the High Plateaus occurs at the same time.

The discharge of peak floods decreases from the upstream part to the downstream part owing to the sweeping off of peak loads in the alluvial plains between KELAFO and MUSTAHIL. The maximum discharges recorded during the 1968-1970 period are 650 m3/s at GODE and IMI. 330 m3/s at KELAFO and 250 m3/s at BURKUR.

Minimum flow is very pronounced. The minimum low water discharge decrease progressively from IMI to the frontier. The minimum discharges observed in March 1971 at the end of a particularly dry season are 4,2 m3/s at GODE, 3,6 m3/s at KELAFO and 2,5 m3/s at BURKUR.

These general hydrological data reveal mainly the existence of a regime of constant losses, from the upstream to the downstream part, which is particularly pronounced between KELAFO and BURKUR during the flood periods as well as during minimum flow periods. Some of these losses evaporate in the water-spreading depressions, the other losses recharging the alluvial water-table.

2) Hydromorphologic characteristics

From IMI to the frontier, the WABI flows along a 500 kilometers' distance in a general NNW-SSE direction following a small slope. The longitudinal profile of the Lower Valley carried out by the Topographic Division of the Project indicates a total mean water level slope corresponding to 0,33 m/km and only 0,20 m/km in the reach of KELAFO-MUSTAHIL.

The WABI SHEBELLE flows out of the limestone gorges 35 km to the North of IMI and continues to the frontier through its alluvia which overly the uniform substratum of the main gypsum formation.

It is supplied, especially on the right bank, by important temporary tributaries such as the MADISO.

The WABI SHEBELLE cuts more or less deeply through its alluvial deposits. The height of the banks varies from 8 m to less than 3 m, depending on reaches.

Alluvial depressions can be seen either on the left bank or on the right bank of the river. According to the hydromorphologic features of the Valley, three sections may be distinguished.

a) The IMI-KELAFO section

In this section, the WABI flows in a well marked-out channel. Flood areas are relatively small and floods only occur in very high flow periods.

From the upstream part to the downstream part, three alluvial depressions can be seen :

- The alluvial depression to the South of IMI which is only about 5 km wide and where short inundations only occur during peak floods.

- The large GODE alluvial basin stretching along 70 km on the right bank of the river and approximately 12 km wide and which ends with the GUERREI narrowing formed by the MUSTAHIL limestone plateaus. In this depression, the WABI SHEBELLE deeply cuts its alluvial deposits and there is no flooding.

- The Northern KELAFO basin or ILO UEN Basin on the left bank of the river is 35 km long by approximately 10 km wide and ends on the same level as KELAFO by the narrowing of the GALUEN limestone hills. In this section, the banks are lower but flooding only occurs during the peak flood periods. A secondary channel exists but it is only used during the flood period.

b) KELAFO-MUSTAHIL region

After the KELAFO narrowing, the banks of the WABI SHEBELLE are not pronounced.

The WABI SHEBELLE divides into numerous channels. Overflowing is considerable and permanent marshes exist in the depressions. This plain is 70 km long and 15 km in its greater width. It ends up by a narrowing marked by limestone hills at MUSTAHIL.

c) The Southern MUSTAHIL section

Downstream from MUSTAHIL, the WABI SHEBELLE sinks again in its alluvium. The alluvial plain is very narrow down to BURKUR and limited by rocky scarps, crowned with MUSTAHIL limestone.

Downstream from BURKUR, another alluvial flood basin can be seen.

2.2.5.2. The FAFEN Basin

- Flow regime

The FAFEN has a temporary regime of flow. The flows can be observed during the two OGADEN rainy seasons and are characterized by succeeding sudden floods, the river bed usually drying up between two floods. The number of flood days varies from one year to the other in relation to the very irregular rainfall of OGADEN. In KEBRI DAHAR, 40 flood days were observed in 1969 and 112 days in 1970. These floods generally occur in April and May for the first season and in october and November for the second one.

Therefore, the mean annual volume of water varies in a large proportion and the recharging of the alluvial water table is consequently very fortuitous.

The discharge of the maximum peak flood recorded in KEBRI DAHAR in the 1968-1971 period is 60 m3/s, but considering the great irregularity of rainfall, certain floods may exceed 100 m3/s.

- Hydrodynamic characteristics

The FAFEN drainage basin is completely independant from the WABI SHEBELLE Basin.

The FAFEN flows in a general N.N.W-S.S.E. direction, first on the KEBRI DAHAR limestone substratum down to KORAHE (20 km to the South of KEBRI-DAHAR), then on the main gypsum formation down to the last water spreading basin and finally, on the FERFER gypsum in the South.

The FAFEN is joined by an important left bank tributary : the JERER at approximately 80 km to the South of DEGAHBOUR. The other tributaries do not meet the FAFEN directly but end up in the alluvial plain and form alluvial fans where floods spread in large water spreading zones.

North of FANHAD, on the sublitographic limestone substratum of KEBRI DAHAR, scarcely developed alluvial deposits form a strip ; 3 km long, on either side of the FAFEN. The FAFEN bed is well marked out and ther is no considerable overflowing.

Conversely, the water spreading zones of tributaries are very large.

To the south of FANHAD, the following water spreading plains and hollows can be observed.

a) The water-spreading plain upstream from KEBRI DAHAR

This plain spreads out from FANHAD to KEBRI DAHAR and there, it is approximately 7 km wide.

The FAFEN bed is embanked and floods are non-existent. The alluvial deposits consist of red silt with limestone crusts.

b) Water spreading plain downstream from KEBRI DAHAR

From KEBRI DAHAR to KORAHE, this plain progressively spreads out to a 20 km width. The FAFEN bed is still well cut and floods are only due to water from temporary rivers.

c) Southern KORAHE Basin

After KORAHE, the FAFEN bed varies and is lost in a large depression. Floods spread out in sheets and form big temporary marshes which evaporate during the dry season.

This large plain is 45 km long and its mean width is 10 km.

The surface of flood zones consisting of hydromorphic soils or brown clay soils is about 350 km2. South of the Basin the FAFEN finds several well-scoured channels.

d) DOBAWEIN Basin

The FAFEN bed is once more scarcely distinct in the DOBAWEIN basin which spreads over 750 km2. Flood zones (200 km2) occupy the Eastern part of the hollow.

The volume and duration of floods are weaker than in the basin south of KORAHE.

The hollow is closed to the South by a gully bordered by the MUSTAHIL limestone plateaus where the FAFEN flows in a single but not very distinct bed.

e) The last FAFEN Basin or IGLOLE plain

After leaving the gully, the FAFEN definitively loses itself in a last NW-SE depression entirely composed of gypsum formations. The FAFEN reaches this basin very episodically and only when important floods occur.

This plain also receives water from local temporary rivers and the flood area is approximately 70 km2.

f) the FAF Basin

This depression which can be related to the FAFEN drainage system is never directly flooded by the FAFEN. If forms a vast, 30 km long, NW-SE Basin stretching in a parallel direction to the WABI SHEBELLE and collecting runoff water from local temporary rivers.

2.2.5.3. Spreading basins and depressions

Many closed spreading basins and depressions exist on the various geological formations. Covered with recent transportation or weathering sediments, they collect overland flow from small streams during the rainy season and usually contain a temporary phreatic water-table.

3. GEOLOGY AND GEOMORPHOLOGY OF OGADEN

A geological map of OGADEN at a scale of 1/250.000 in seven sheets can be found with its notice as a complementary document in this report (1). This map was drawn through geological photo-interpretation and the areas shown on the aerial photographs were identified during the geological prospections, using the data provided by soil-science studies. An accurate determination of stratigraphic series as well as of the limits of each of these formations was thus obtained.

The lithology of formations was determined through observations on outcrops or on drilling logs.

3.1. Geological formations : lithology and location

Apart from several basaltic outcrops, the general stratigraphy of OGADEN exclusively consists of sedimentary series distributed from the base to the top in seven main formations which are presented in their consecutive order :

3.1.1. KEBRI-DAHAR limestone

This very thick limestone formation of Upper Jurassic age probably belongs to the Kimmeridian-Portlandian stage.

a) Lithology

The lithological characteristics of this formation essentially composed of limestone have been observed on rock scarps forming the WABI SHEBELLE gorges upstream from IMI, on the OGADEN plateaus to the North of KEBRI DAHAR as well as in two deep drillings installed at SHEKOSH and at KEBRI DAHAR in the FAFEN Valley.

Two distinct facies are observed :

- At the base, sublitographic compact limestone of a yellowish white, forming stratified beds a few centimeters to 1 meter thick, and intercaled with beds of more abundant marl and very few gypsum beds. The SHEKOSH drilling for water intake cuts through this formation down the first 140 meters; the log shows yellowish-white sublithographic limestone down to 110 m, the last 30 cm consisting of a more detritic bluish-grey limestone. The fault system is usually weakly developed.

- At the top, the lithographic limestone changes into a facies of more pronounced lagoon type indicating a transition to the upper main gypsum formation. Then, limestone beds alternating with marly limestone, more or less gypseous clay and massive gypsum can be observed.

This facies can again be found through the first 150 meters of the KEBRI DAHAR drilling which was carried out by continuous core-drilling.

The log of this drilling is represented on graph n° 6 (book plate).

Below, from 150 meters down to a 212 meters'depth, which is the lower limit of the drilling, once again can be seen more compact and lightly coloured limestone corresponding to the facies of the main strata of the KEBRI DAHAR formation above described.

Apart from stratification joints and from several cavernous dolomitic layers observed in the upper part of the drilling, the general fault system is weakly developed.

b) Location and thickness

This formation outcrops on a large area (approximately 95.000 km2) in the WABI SHEBELLE Basin. It occupies all the centre and North-Eastern part an forms a large plateau in which the WABI SHEBELLE and its tributaries are deeply embanked.

This limestone occupies the North-Eastern region of OGADEN on either bank of the FAFEN and forms a belt approximately 100 km wide. The Southern limit of its outcrops corresponds to a line : KEBRI-DAHAR - DANAN. To the West of DANAN and South of the KEBRI - DAHAR line, the limestone is surmounted with the gypsum formation.

As no bore hole has yet entirely cut through this limestone, it is difficult to determine its thickness accurately. The KEBRI DAHAR and SHEKOSH drillings reveal that the upper layers presenting a more pronounced lagoon-type facies are approximately 150 m. thick and the lower and intermediate layers are at least 200 m thick. Consequently, the minimum thickness is 350 m.

3.1.2. Main gypsum formation

Above the KEBRI DAHAR limestone, the series consists of gypseous marl formations and of gypsum corresponding to a phase of lagoon sedimentation of neocomian age (Lower Cretaceous).

This gypsum formation is surmounted at the top with a MUSTAHIL limestone bed approximately 30 meters thick.

Owing to its morphological and hydrogeological importance, this limestone has been purposely studied apart in the survey of the main gypsum formation, though from the stratigraphic point of view, it is related to the latter. The series continues above the MUSTAHIL limestone with gypseous marl, limestone and dolomites.

COUPE GEOLOGIQUE DU FORAGE — GEOLOGICAL LOG OF KEBRI-DAHAR

DE KEBRI-DAHAR N°3 BORE-HOLE N°3

Coordonnées *Coordinates* | Latitude 6°44'N | Longitude 44°17'E

Début d'exécution 26-11-70 *Date of starting*

Fin d'exécution 11-2-71 *Date of finishing*

Echelle verticale 1 / 400 *Vertical scale*

Profondeur en mètres *Depth in meters*	Diamètre du forage (en mm) *Diameter (in mm)*	Figuré *Symbol*	Lithologie *Lithological description*	Porosité Fissuration *Porosity Fissuration*
0	168mm		Colluvions argileuses *Clayey colluvium deposits*	
	145mm		Calcaire blanc avec intercalations de marnes et argiles *White limestone-marly and clayey intercalations*	Mediocre *Very low*
10			Calcaire marneux bariole *Marly limestone - various colours*	Faible *Low*
20			Calcaire marneux blanc-gris *White-grey marly limestone*	Bonne *Good*
			Calcaire cargneulise jaune / *Yellow cavernous limestone*	Très bonne *Very good*
30			Alternance de calcaires jaunes et de marnes vertes *Yellow limestone and green marl alternated*	Faible *Low*
40			Calcaire marneux bleu-gris *Grey-blue marly limestone*	Mediocre *Very low*
			Gypse massif / *Massive gypsum*	
50			Alternance marnes et calcaires bleu-gris *Marl and blue-grey limestone alternated*	Faible *Low*
60	116mm		Calcaire blanc-gris *White-grey limestone*	Faible *Low*
			Gypse massif / *Massive gypsum*	
70			Calcaire marneux avec quelques fins lits d'argile marnes sableuses à la base *Marly limestone with foliated clay sandy marl at the base*	Faible *Low*
80				
			Gypse massif / *Massive gypsum*	
90			Gypses avec intercalations d'argiles et marnes gris-vert gypseuses *Gypsum with intercalations of clay and grey-green gypsous marl*	Faible *Low*
100				
110			Alternances de calcaires marnes et argiles gypseuses en lits fins *Limestone marl gypsous clay alternated*	Faible *Low*
120				
130				
			Niveau calcaire fossilifere *Fossiliferous limestone*	Bonne *Good*
140	100mm		Argiles et marnes *Clay and marl*	Nulle *Zero*
			Gypse massif *Massive gypsum*	
150			Alternances de calcaires marneux et marnes gris-bleu *Grey blue marly limestone and marl alternated*	Faible *Low*
160				
170			Calcaire blanc-gris compact 1_Quelques fins lits argileux 2_Un niveau de gypse 3_Un niveau calcaire detritique — — *White-grey compact limestone with 1_ Thin layers of clay 2_ One gypsous layer 3_ One detritic limestone layer*	Faible *Low*
180				
190				
200			Calcaire compact gris intercalations de calcaires marneux et d'argiles bleu-vert *Grey compact limestone intercalations of marly limestone and blue-green clay*	Faible *Low*
212				

a) Lithology

Two deep bore holes cut through this formation. One is located in DANAN and is 140 m. deep, the other in GODE continues the previously existing broad drilling, from 80 m, down to a 250 meters'depth. This was achieved by constant core-drilling and enabled to obtain a continuous and accurate log of the formation. The logs of these bore-holes are represented on graphs 7 and 8.

The main gypsum formation consists of alternated and more or less thick layers of marl, clay, massive gypsum and pure Cl Na.

Marl and clay are usually green or brown and very gypseous.

The thickness of massive or finely crystallized gypsum beds is variable and a 6 m. thick bed in the GODE bore hole, is the thickest bed observed.

Thick saline beds (one of them 10 m thick) were observed at the base of the YODE bore-hole.

b) Location and thickness

This formation is well represented in OGADEN where it occupies all the central zone from Duhun to YODE. It is limited to the North-East by the KEBRI-DAHAR limestone outcrops and to the West and South by the relief of MUSTAHIL limestone.

The substratum of the WABI SHEBELLE Valley from IMI to the frontier is entirely constitued by this formation this being also true for the FAFEN Valley from FANHAD to the South of KORAHE.

It was impossible to determine the thickness of the main gypsum formation as the GODE bore-hole (250 m deep) does not reach the Upper wall of the KEBRI DAHAR limestone furthermore, the Danan bore-hole located to the North of GODE, though not far from where this formation meets the KEBRI DAHAR limestone, does not reach it at 140 m depth.

Consequently, this formation is very thick and certainly exceeds 300 m. Its thickness may even slightly increase to the South.

3.1.3. Mustahil dolomitic limestone (Barremian - Albian)

a) Lithology

Marly limestone and white fossiliferous clayey limestone surmounted with a hard 8 to 10 m. thick dolomitic bed forming a scarp which constitutes the structure of the Lower OGADEN plateaus

COUPE GEOLOGIQUE DU FORAGE — GEOLOGICAL LOG OF DANAN BORE-HOLE

DE DANAN

Coordonnées / *Coordinates*	Latitude 6°30'N	D'après le Water Resources Département / *From Water Resources Department*
	Longitude 43°29'E	

Echelle verticale 1/400 *Vertical scale*

Profondeur en mètres / *Depth in meters*	Figuré / *Symbol*	Lithologie / *Lithological description*
10		Calcaire gypseux blanc-jaune et brun / *White-yellow and brown gypsous limestone*
15,2		
20		Marnes gypseuses / *Gypsous marl*
27,4		
30		Gypse massif blanc / *White massive gypsum*
30,4		
40		Marnes grises et blanc-grises / *Grey and white-grey marl*
50		
57,9		
60		Gypse massif blanc / *White massive gypsum*
67,9		
70		Marnes gypseuses avec quelques bancs de gypse et de dolomie / *Gypsous marl with layers of gypsum and dolomite*
80		
82,3		Marnes gypseuses avec quelques bancs de dolomie / *Gypsous marl with layers of dolomite*
90		
91,4		Marnes argileuses grises gypseuses au sommet / *Grey clayey marl gypsous at the top*
100		
106,2		Gypse massif blanc / *White massive gypsum*
110		
111,5		
112,8		Marnes grises / *Grey marl*

Gr_8

COUPE GEOLOGIQUE DU FORAGE — GEOLOGICAL LOG OF GODE BORE-HOLE

DE GODE

Coordonnées / *Coordinates*: Latitude 5°55' N; Longitude 43°55' E

La coupe des 140 premiers mètres a été dressée par le Water Resources Département

The log of the 140 first meters has been drawn by Water Resources Departement

Echelle verticale 1/400 *Vertical scale*

Profondeur en mètres — *Depth in meters*	Figuré — *Symbol*	Lithologie — *Lithological description*
0		Calcaires gris — *Grey limestone*
6,0		Calcaire gréseux — *Sandy limestone*
16,8		Calcaire argileux et gypseux — *Gypsous and clayey limestone*
35,2		Alternance d'argile bleue et de gypses — *Blue clay and gypsum alternated*
42,8		Gypse massif – quelques lits d'argile — *Massive gypsum – some layers of clay*
56,0		Dolomie gypseuse — *Gysous dolomite*
62,0		Gypse massif — *Massive gypsum*
72,4		Marnes et argiles gypseuses rouges — *Marl and gypsous red clay*
85,6		Argiles gypseuses bleu-grises — *Blue - grey gypsous clay*
96,4		Dolomies gypseuses — *Gypsous dolomite*
110,8		Dolomies bleu-grises avec lits d'argile et de gypse — *Grey-blue dolomite with clay and gypsum*
130		Dolomies gypseuses — *Gypsous dolomite*
140		Calcaire marnes-sableux brun-jaune — *Brown-yellow marly and sandy limestone*
142,2		Alternance fines de marnes bleues et de gypse — *Blue marl and gypsum alternated*
149,0		Gypse finement cristallisé / *Finely cristallized gypsum*
151,6		Calcaire marneux et marnes bleu-grises — *Marly limestone and blue-grey marl*
154,9		Gypse finement cristallisé — *Finely cristallized gypsum*
160,1		Alternance de marnes bleu-grises et de gypse — *Blue-grey marl and gypsum alternated*
164,6		Gypse massif blanc — *White massive gypsum*
168,7		Marnes bleu-grises gypseuses — *Blue-grey gypsous marl*
171,9		Gypse massif - Lits d'argiles à la base — *Massive gypsum – Layers of clay at the base*
178,3		Marnes bleu-vertes argileuses — *Blue-green clayey marl*
183,5		Marnes gypseuses — *Gypsous marl*
188,0		Marnes bleu-vertes gypseuses avec Cl Na — *Blue-green gypsous marl with Cl Na*
193,8		Argiles brunes avec lits de Cl Na — *Brown clay with Cl Na*
200,0		Marnes bleu-grises et blanches avec cristaux Cl Na — *Blue-grey white marl with crystallin Cl Na*
216,7		Cl Na pur — *Pure Cl Na*
228,6		Marnes bleu-grises argileuses salées — *Blue-grey saline and clayey marl*
236,3		Cl Na pur — *Pure Cl Na*
241,3		Marnes bleues et brunes argileuses et salées — *Blue-grey saline and clayey marl*
250,3		

MUSTAHIL limestone constitutes the structural surface of broken up plateaus located between the WABI SHEBELLE and the FAFEN. South of a line passing through GODE-KEBRI DAHAR. To the East of the FAFEN, it forms a continuous tabular area surmounted with FERFER gypsum which is often decomposed and dissolved on the spot. On the Southern bank of the WABI SHEBELLE,it covers the plateaus situated at a variable distance from the river.

The thickness of this limestone is variable and corresponds to approximately 30 meters.

3.1.4. FERFER gypsum (Cenomanian)

Another not very thick gypsum series of Cenomanian origin overlies the main gypsum series.

a) Lithology

This series consists of massive gypsum layers alternated with gypseous marl.

b) Location and thickness

This gypsum exists in the South-Eastern part of OGADEN and can be seen on top of the MUSTAHIL limestone plateaus between the WABI SHEBELLE and the sandstone cliff of JESSOMA to the East.

It is particularly well represented on the LAZOLALE - SHILAVO - FERFER plateau where it is locally weathered and dissolved, forming small depression.

This gypsum is only approximately 15 to 20 meters thick.

3.1.5. Zoogenous limestone and BELET UEN sandstone (Turonian).

The series continues above the FERFER gypsum with alternated sandstone and not very thick (about 10 m) zoogenous limestone.

In OGADEN, very hard zoogenous limestone can only be seen in the farthest South-Eastern part, in a triangle situated between Lammabar and the frontier. It forms a cliff to the East of the SHILAVO - FERFER road.

3.1.6. JESSOMA sandstone (Senonian)

JESSOMA sandstone ends the cretaceous sedimentary series of OGADEN. It mainly consists of more or less coarse sandstone and of red quartzite .

It largely transgresses on the previous series and even appears directly in contact with the KEBRI DAHAR limestone in the Northern part of the WABI SHEBELLE basin (CHERCHER region and to the North of GHINIR).

In OGADEN it only occupies a marginal position and forms a cliff at the Eastern limit of the Basin from DEGAHBOUR to FERFER and in the EL KERE region it surmounts the MUSTAHIL limestone plateaus.

Some isolated hillocks can also be observed between DUHUN and IMI.

3.1.7. Quaternary formations

The term "quaternary formations" groups all the weathered and decomposed deposits of previously existing sedimentary (limestone, marl, gypsum) or cristalline (granite and basalt) strata of the Higher Basin, transported in the valleys or formed locally in depressions or basins. These sometimes thick formations generally contain shallow water tables which can be easily utilized.

Three types of quaternary formations may be observed :

- The WABI SHEBELLE alluvial deposits consisting of mixed weathered material from the high cristalline and volcanic plateaus, and limestone and gypsum sediments derived from sedimentary formations.

- Local deposits transported on short distances only.

- Weathering layers directly linked to the particular character of the subjacent base-rock.

3.1.7.1. WABI SHEBELLE alluvial deposits

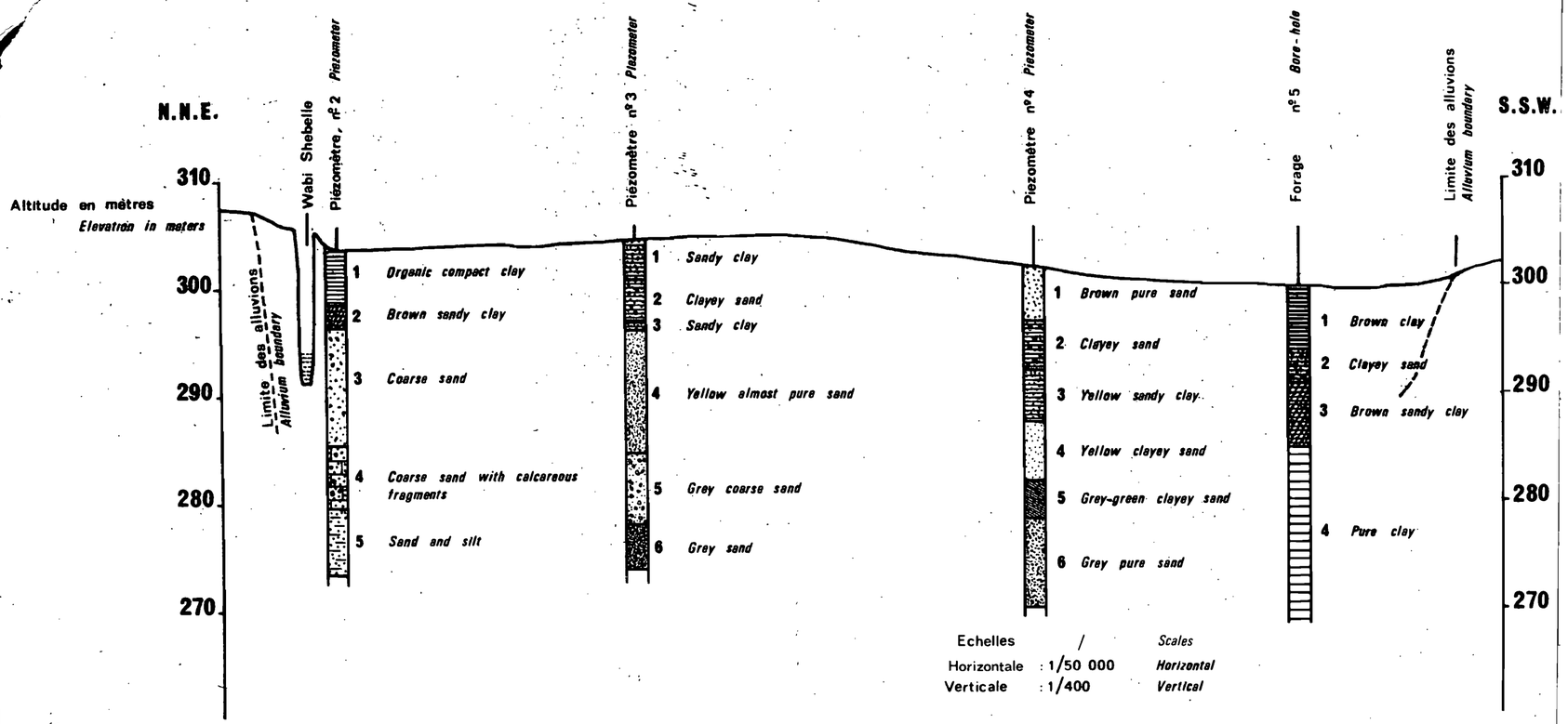
These are certainly the most important quaternary deposits in OGADEN. The alluvial plain begins 30 km to the North of IMI and uniformly continues down to the frontier.

Coupe de la plaine alluviale à GODE

(rive droite du Wabi)

Cross-section of the alluvial plain of GODE

(right bank of Wabi)



Les altitudes sont rattachées au profil en long du Wabi Shebelle

The elevations are relative to the Wabi Shebelle longitudinal profile

_ LÉGENDE _

Piézomètre nº 2

1 Argile compacte organique
2 Argile sableuse brune
3 Sable grossier
4 Sable grossier à débris calcaire
5 Sable limon

Piezomètre nº 3

1 Argile sableuse
2 Sable argileux
3 Argile sableuse
4 Sable jaune presque pur
5 Sable gris grossier
6 Sable gris

Piezomètre nº 4

1 Sable brun pur
2 Sable argileux
3 Argile sableuse jaune
4 Sable argileux jaune
5 Sable argileux gris vert
6 Sable pur gris

Forage nº 5

1 Argile brune
2 Sable argileux
3 Argile brune sableuse
4 Argile pure

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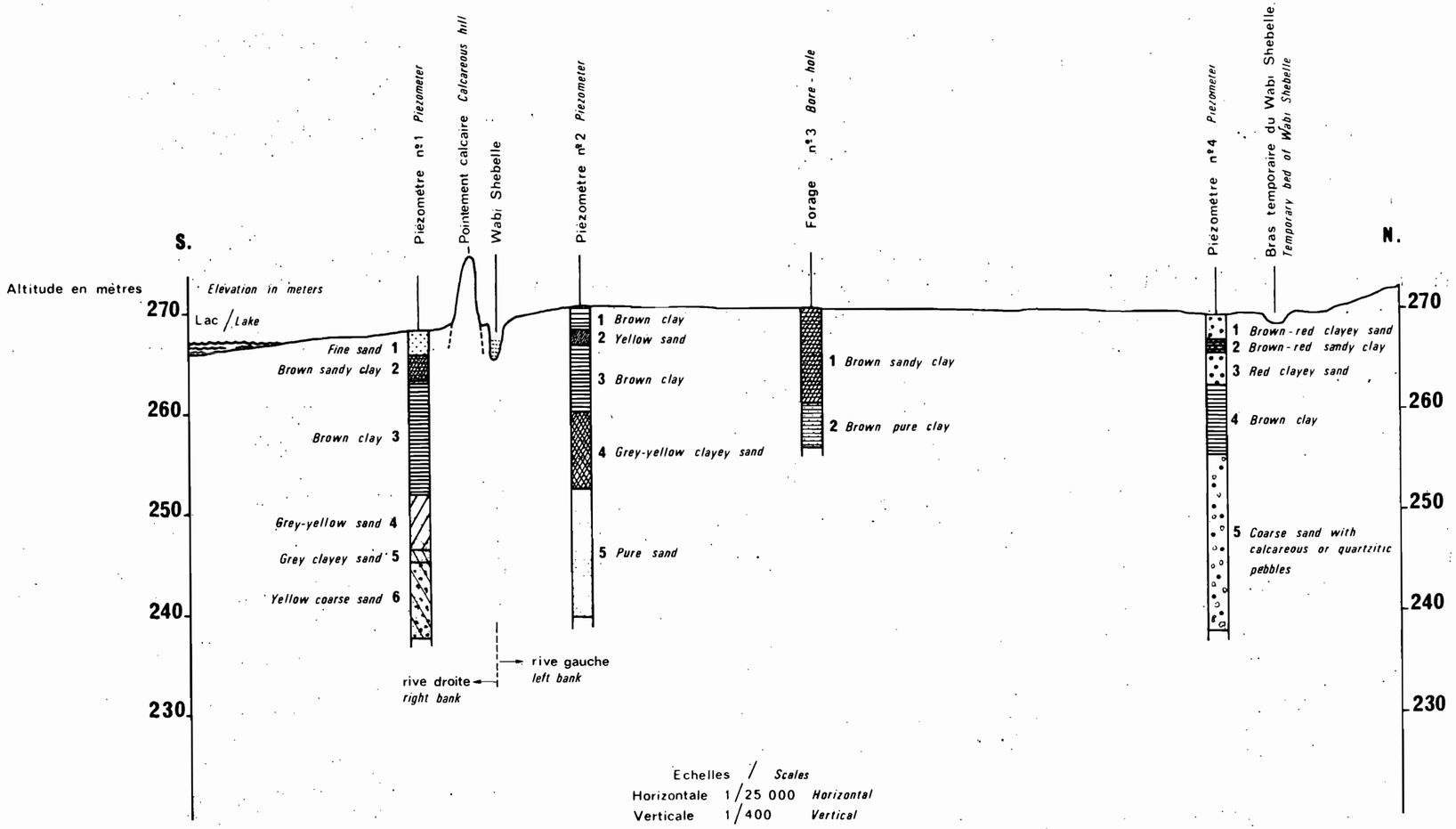
Gr_10

Coupe de la plaine alluviale à KELAFO

Cross-section of the alluvial plain of KELAFO



Echelles / *Scales*

Horizontale 1/25 000 *Horizontal*

Verticale 1/400 *Vertical*

Les altitudes sont rattachees au profil en long du Wabi Shebelle

The elevations are relative to the Wabi Shebelle longitudinal profile

- LEGENDE -

Piezomètre n° 1

1 Sable fin
2 Argile sableuse brune
3 Argile brune
4 Sable gris-jaune
5 Sable argileux gris
6 Sable grossier jaune

Piezomètre n° 2

1 Argile brune
2 Sable jaune
3 Argile brune
4 Sable argileux gris-jaune
5 Sable pur

Forage n° 3

1 Argile sableuse brune
2 Argile pure brune

Piezomètre n° 4

1 Sable argileux brun-rouge
2 Argile sableuse brun-rouge
3 Sable argileux rouge
4 Argile brune
5 Sable grossier a graviers calcaires ou quartzitiques

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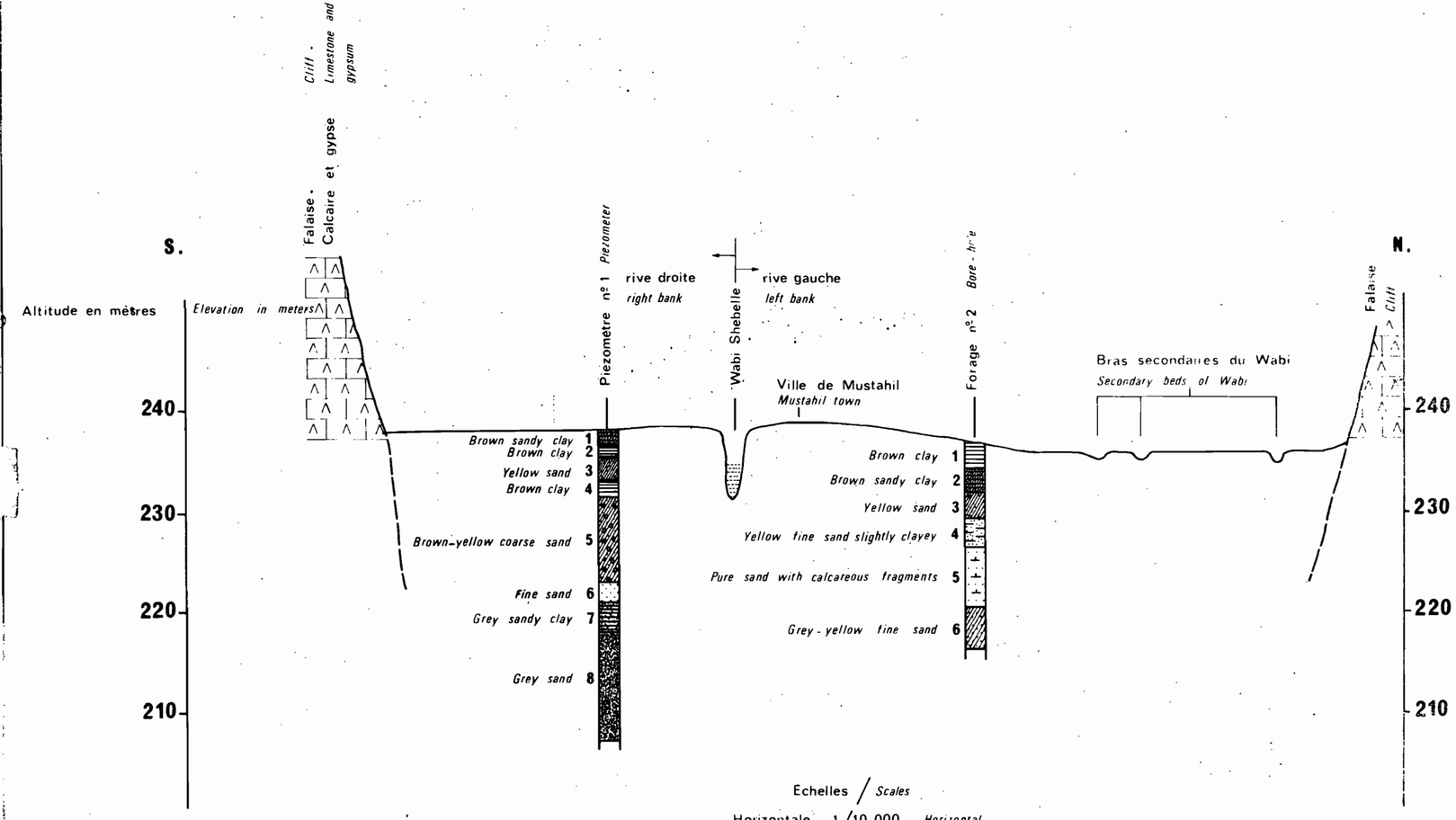
Coupe de la plaine alluviale à MUSTAHIL *Cross-section of the alluvial plain of MUSTAHIL*



Echelles / *Scales*

Horizontale 1/10 000 *Horizontal*

Verticale 1/400 *Vertical*

Les altitudes sont rattachées au profil en long du Wabi Shebelle

The elevations are relative to the Wabi Shebelle longitudinal profile

- LEGENDE -

	Piézomètre n° 1		Forage n° 2
1	Argile sableuse brune	1	Argile brune
2	Argile brune	2	Argile sableuse brune
3	Sable jaune	3	Sable jaune
4	Argile brune	4	Sable fin jaune légèrement argileux
5	Sable jaune et brun grossier	5	Sable pur à débris calcaires
6	Sable fin	6	Sable fin gris-jaune
7	Argile sableuse grise		
8	Sable gris		

O.R.S.T.O.M. Service Hydrologique 26.5.72 J.G

a) Specific character of the alluvial deposits

In order to study the alluvial water table, three lines of piezometers were placed in the valley at GODE, KELAFO and MUSTAHIL. Bore holes, usually 30 meters deep, were made in order to instal these piezometers, and enabled to acquire some knowledge on the nature of the alluvial sediments.

- At GODE (graph n° 9)

Four piezometers were placed on the right bank of the WABI SHEBELLE in the large alluvial plain of GODE which is 15 km wide. Another piezometer on the left bank does not cut through this alluvium but only through the deposits of temporary rivers.

On graph n° 9 a cross section of the Valley represents the alluvial deposits for each bore-hole.

The alluvia are particularly heterogeneous and consist of alternating silt, clay and sand of various colours and origins. The sandy or scarcely clayey yellow and grey deposits are weathered materials originating from the high cristalline or volcanic plateaus, whereas the red and brown and usually more clayey deposits are derived from the weathered limestone or gypsum rocks. The deposits were brought by the WABI SHEBELLE or by local tributaries during the filling in of the valley.

Bore hole n° 5 almost entirely cuts through the brown clay colluvium of the alluvial fan of a local tributary.

- At KELAFO (graph n° 10)

The alluvial deposits stretch along 4 km at KELAFO. Four bore-holes reconnoitred these deposits, one on the right bank of the WABI SHEBELLE, the other three on the left bank.

The alluvial deposits do not vary much from those observed at GODE and are as heterogeneous but on the whole more sandy. A layer of pebbles, at least 20 m. thick may be observed in drilling n°4.

- At MUSTAHIL (graph n° 11)

The alluvial plain at MUSTAHIL is narrower between the limestone plateaus and only 2,5 km wide. The essentially sandy alluvial deposits were reconnoitred by means of two bore holes.

Finally, from GODE to MUSTAHIL, alluvial deposits consist of alternated soil-textural material , the composition of which varies in relation to sedimentary phases and to the origin of the material. Two types of sediments exist : those derived from the weathering of usually sandy and scarcely saline cristalline rocks, and sediments derived from the decomposition of more clayey and saline carbonated and gypseous rocks.

Upstream from GODE and following the usual sedimentation process, alluvial deposits are probably coarser.

b) Extent and thickness of alluvial deposits

The total area occupied by alluvial deposits represents 3.000 km2 corresponding to five large regions :

- The Lower Valley downstream from IMI
  . Total area : approximately 590 km2.
  . Mean width of the alluvial plain : 5 to 7 km.
- GODE plain :
  . Total area : approximately 850 km2
  . Mean width of the alluvial plain : 15 km.
- ILG UEN plain upstream from KELAFO .
  . Total area : approximately 490 km2.
  . Mean width of the alluvial plain : 10 km.
- The SHEBELLE plain downstream from KELAFO and down to MUSTAHIL.
  . Total area : approximately 620 km2.
  . Mean width of the alluvial plain : 12 km.
- BURKUR plain down to the frontier :
  . Total area : approximately 590 km2.
  . Mean width of the alluvial plain : 7 km.

The alluvial deposits are very thick : always more than 30 meters. The bore holes (undertaken for the placing of piezometers) when no deeper than 30 meters, do not reach the substratum.

3.1.7.2. Local deposits or deposits transported along very short distances.

This formation includes the alluvia of the FAFEN and of the tributaries of the WABI SHEBELLE and FAFEN, the alluvial fans of temporary rivers as well as the colluvial and the slope and foothill deposits. All these deposits were formed locally or transported along short distances. Their specific features are consequently relative to the nature of the substratum from which they are derived.

Depending on the nature of the substratum, two types of deposits may be observed :

a) scarcely saline deposits on the KEBRI DAHAR and MUSTAHIL limestone.

They consist of red sandy silt with limestone crusts and mainly constitute :

- The FAFEN alluvia from DEGAHBOUR to the DOBAWEIN basin,
- The FAFEN alluvia and alluvia fans, upstream from KORAHE.
- The DANAN, SEGEG, DEGAH-MEDO basins resting on KEBRI DAHAR limestone.
- The Basins on MUSTAHIL limestone between LAZOLALE and SHILAVO.

b) The saline deposits on the main gypsum formations and on FERFER gypsum.

Most of them are red gypseous soils.

They are present in the Basin, South of a line : IMI - DANAN - KORAHE and form in particular the last depression of the FAFEN or FAF depression (see : 2.2.5.2. f).

3.1.7.3. Weathered layers

The weathered layers are composed of red decalcification clay on KEBRI DAHAR limestone and of gypsum crusts on gypsum formations.

3.2. Structure of OGADEN

The formations of Secondary age described in previous paragraphs have a monoclinal aspect with small angle of dip (a few degrees) and a S.E. direction.

All the angle of dips vary from 5° to 10°,

This simple structure reveals the progressively more recent substrata, from KEBRI DAHAR limestone to JESSOMA sandstone, as one goes from the NW to the SE.

The fracture system is generally weakly developed and the faults observed present moderate throws and scarcely affect the general structure. The two main directions are NW-SE and NE-SW.

Some specific features allow to believe that the practically rectilinear NW-SE direction of the WABI SHEBELLE from IMI to the frontier is probably due to a zone of faults affecting secondary formations, these faults being usually hidden by alluvial deposits.

These features are as follows :

- The presence of a fault structure visible at the surface with a total throw of approximately 100 m in the KELAFO region. This structure was studied in detail because of its probable influence on the dynamics of the alluvial water-table (see chapter 4.3.3 concerning the alluvial aquifer).

- The presence of a longitudinal fault parallel to the valley between KELAFO and BURKUR.

- The presence of basaltic outcroppings marking out the left bank of the WABI SHEBELLE, fromIMI to GODE. At GODE some basalt even outcrops through the alluvial cover and reveals the existence of an important fault system affecting secondary rocks. Basalt also exists between SEGEG and DEGAH MEDO.

The fault system is probably a secondary manifestation and a consequence of important tectonic movements which resulted into the formation of the Rift Valley during the Miocene age. The WABI SHEBELLE Valley is consequently a small tectonic basin filled in with alluvial deposits and perpendicular to the Rift Valley.

3.3. Geomorphology of OGADEN

The geomorphology of OGADEN depends of the lithologic series and of the general dip to the South East.

From the NW to the SE, six large morphologic regions may be observed, as follows :

a) KEBRI DAHAR limestone plateau

It occupies the North-Eastern part of OGADEN and presents quaternary basins such as the DANAN or DEGAH MEDO basins. It is cut by the beds of the FAFEN and its tributaries to the North of KEBRI DAHAR.

b) Central gypsum zone

In this zone, gypsum outcrops and forms "haloes" or "cockades" and quaternary weathering deposits are largely developed. The WABI SHEBELLE flows on this formation from IMI to the frontier.

c) MUSTAHIL dolomitic limestone bluff

This bluff is a major morphological feature of OGADEN and stretches on all the Southern part of a line : KORAHE-GODE. It is cut 100 meters deep by the WABI SHEBELLE Valley, from GODE to the frontier, and by the FAFEN Valley, from KORAHE to DOBAWEIN.

Two different zones can be observed :

- To the South of the WABI SHEBELLE and in the region between this river and the FAFEN, MUSTAHIL limestone forms plateaus which are broken up by weathering and sometimes covered with FERFER gypsum.

To the East of the FAFEN, this limestone forms a continuous plateau covered with FERFER gypsum, and at the Eastern border of the basin, with JESSOMA sandstone.

d) Eastern bluff in a N.S. direction, composed of JESSOMA sandstone and more to the South, of BELET UEN calcareous nodules.

e) Basins and depressions

On all the formations exist flood spreading basins and depressions filled in with quaternary deposits.

f) WABI SHEBELLE and FAFEN Valleys

The WABI SHEBELLE and FAFEN valleys are filled in with alluvial deposits. The direction of flow is often in relation to the fault system. The drainage features are described in detail in paragraphs 2.2.5.

4. GROUND WATER OF OGADEN

The lithologic series and geomorphology of OGADEN reveal the presence of five types of ground water reservoirs which are, following the order in which they were studied :

1°) - The KEBRI DAHAR limestone containing a deep water table which constitutes confined ground water below the main gypsum formation.

2°) - The MUSTAHIL limestone with a shallow water table

3°) - The WABI SHEBELLE alluvial deposits

4°) - The FAFEN and JERER alluvial deposits

5°) - The water spreading basins and alluvia of local temporary tributaries.

These reservoirs are separated by scarcely permeable formations, the latter mainly consisting of marlstone, clay and gypsum. The presence of gypsum and salts has a predominating influence on the general geochemistry of OGADEN ground water.

The semi-pervious main gypsum formation also includes salt saturated water tables. Observations and measurements undertaken on these scarcely utilizable aquifers are mentioned in a special chapter.

JESSOMA sandstone only occupies a marginal area to the East of OGADEN and the corresponding ground water has not been surveyed.

As no general levelling was available and because of the low density of water points and of deep bore holes, no general survey of pressure surfaces and their fluctuations could be undertaken.

Consequently, each aquifer is studied from a hydrodynamic and geochemical point of view, starting on existent water points and on new observation points (limes of piezometers in the alluvial water table and deep bore holes at KEBRI DAHAR and GODE).

The analysis of the data collected allows to know the characteristics of each aquifer as regards its storage and its chemical quality.

4.1. Water table of KEBRI DAHAR limestone

4.1.1. Structure, recharging conditions and fracture system of the reservoir.

a) Hydrogeological structure

The KEBRI DAHAR limestone outcrops on 95.000 km2, i.e. : more than half of the total surface area of the Basin.

In OGADEN, the outcropping surface corresponds to 22.000 km2 and is situated in the N.N.E. part South of the KORAHE - DANAN line for the Eastern part of OGADEN and South of DUHUN for the western part, the KEBRI DAHAR limestone disappears under the main gypsum.

This general display leads to the formation of free ground water in the outcropping part of the limestone, and confined ground water under the main gypsum, the latter forming the impervious top wall of the confined water table.

The first geological observations made on the OGADEN outcroppings led to the conclusion that the formation was mainly composed of sub-lithographic limestone beds with very few marlstone intercalations ; consequently this formation is relatively favourable for the constitution of a large ground water reservoir. Geological prospections throughout the basin as well as reconnaissance drillings revealed on the other hand, that the formation is scarcely homogeneous. Though the hard lithographic limestone beds usually constitute its outcroppings, the formation consists in fact of alternated lithographic limestone, marly limestone, marlstone and gypsum layers from the top to the lower part. The presence of impervious marly layers consequently reduces possibilities as regards the formation of an important aquifer.

Ground water flows and is stored in the cracks and stratification joints of limestone beds. Except for several zones of faults with moderate throw, the structure is simple as the strata slopes steadily down to the South East with a small angle of dip : 5° to 10°. Synclinal structures which could have determined privileged zones for ground water storage do not exist.

These structural conditions result into the formation of an aquifer which generally flows following the N.W - SE dip. In the free part of the aquifer, lateral flows can be observed near narrow and deep valleys and water spreading basins.

b) Recharging conditions

The general conditions for the recharging of the water table are favourable and the aquifer can rely on a large intake area (95.000 km2). Rainfall is relatively high : between 800 and 300 mm distributed in two periods. The lack of abundant vegetation as well as the limestone nature of outcroppings are also favourable factors for suitable recharging, especially in the Northern part of the outcrop zone.

In the South, ground water is not recharged by rainfall or runoff water, the upper beds composed of marlstone, clay and gypsum being an obstacle to direct infiltration.

c) Fracture system of reservoir

The first geological documents usually presented the KEBRI DAHAR formation as being composed of cracked and karstified limestone and consequently suitable for deep water circulation and for the forming of a deep aquifer.

Observations carried out on outcroppings as well as on the reconnaissance drillings of KEBRI DAHAR and on the dam site located 45 km to the South of the WABI SHEBELLE - DAKETA junction, do not confirm these first statements but on the contrary, they reveal that the general cracking of reservoir is probably very weakly developed.

These conclusions result from the following observations :

- No karstification and no circulation system exist

No sign of important karstification has been observed on the outcrop zone. The caverns seen in the sides of the WABI SHEBELLE canyons are due to erosion conditions in the Valleys. Their extent is very limited and no communication exists with the karst system. Furthermore, the decalcification wells observed on plateaus and improperly called "avens" are not more than a few meters deep.

Resurgences and exsurgences of ground water are seldom seen but some permanent springs with low rate of flow exist in the HAMARO-HEDAD region and in the SULLUL valley at SEGEG. The hydrographs of the DAKETA, JERER and FAFEN floods also prove that a large aquifer with open fractures and karstic circulation does not exist. The flood hydrographs are generally very sharp and interflow only lasts a few days after each flood. The regulative effect of an important ground water reservoir in the limestone should be revealed by a lowering of peak discharges and a largely superior minimum flow discharge.

- Very moderate cracking and permeability

The cores of reconnaissance drillings at KEBRI DAHAR (see figure n° 6) also indicate a weak cracking as no trace of open faults and no sign of a noticeable deep circulation can be observed.

Besides, the permeability tests undertaken in six drillings at the dam sites give mean values from 4 to 5 LUGEON, or very low permeabilities : less than 10^{-7}m/s.

Finally, despite favourable recharging conditions, the KEBRI DAHAR limestone, because of its weak cracking and its heterogeneous composition (presence of marly and gypseous layers) does not present suitable conditions for the forming of an important aquifer.

Under the main gypsum formation, the limestone which is not subject to the action of atmospheric agents should be still more compact and less cracked.

4.1.2. Observation points and piezometric levels

Deep wells and bore holes for water intake from limestone ground water are scarce and are all located in the outcrop zone of the formation. These six wells and drillings are all in the FAEEN valley, three of them being in KEBRI-DAHAR town.

The other wells located on the KEBRI DAHAR formation are not very deep. They usually draw water from the alluvial water table of temporary rivers or of water spreading basins which are mainly supplied by overland flow. The limestone water-table can communicate with the alluvia of these temporary rivers and basins, which explains why some wells are never dry. This is the case in particular for the wells located in the SULLUL, FAFEN and JERER Valley. These alluvial water tables are studied in paragraph 5 of this chapter (4.5).

The bore holes placed in the main gypsum formation were meant to reach confined ground water but did not succeed , for instance : the bore holes of DANAN (113 meters), SHILAVO (354 m) and GODE (250 m).

The location and summary characteristics of the deep wells and bore holes observed are mentioned below :

a) DEGAHBOUR well

- Coordinates..... : 8°12' N and 43°33' E.
- Approximate altitude : 1,130 meters
- Location : in DEGAHBOUR village
- Characteristic : hand dug well
  diameter : 1.50 m
  undetermined depth.
- Utilization : by population and livestock

- Mean pressure head : 40 meters
- Geological log : unrecorded
- Dewatering : with skin bottles.

b) DEGAHBOUR - Bore hole

- Coordinates : 8°12' N and 43°33' E.
- Approximate altitude : 1, 130 m.
- Location : in DEGAHBOUR village.
- Characteristics : percussion drill carried out in 1971
  Total depth : 145 m
- Mean pressure head : 128 m
- Geological log : Unrecorded.

c) SHEKOSH Bore hole (Water Resources Department)

- Coordinates : 7°30' N and 43°47' E.
- Approximate altitude : 800 m
- Location : near SHEKOSH village
- Characteristics : percussion drill
  total depth : 140 m
- Equipped with : superficial handle pump.
- Use : population and livestock.
- Mean pressure head : 110 to 120 m.
- Geological log
  - from 0 m to 120 m : no details
    : yellowish white lithologic limestone is dominant.
  - from 120 m to 140 m : Bluish-grey detritic limestone.

d) Bore hole n° 1 at KEBRI DAHAR (Water Resources Department)

- Coordinates : 6°44 N and 44°17° E.
- Approximate altitude : 450 m
- Location : near the KEBRI DAHAR military camp.
- Characteristics : percussion drill carried out in 1968.
  total depth : 60.5 m.

- Not utilized
- Mean pressure head : 35 to 40 m.
- Geological log : (graph n° 12) alternated limestone marly-limestone, marlstone and gypsum.

e) KEBRI DAHAR bore hole n° 2 (Water Resources Department)

- Coordinates : 6°44' N and 44°17' E
- Location : below KEBRI DAHAR village at the limit of FAFEN alluvial deposits
- Characteristics : percussion drill undertaken in 1968. total depth : 45,70 m
- Equipped with : submersible pump
- Utilization : population and livestock
- Mean pressure head : 30 meters
- Geological log : (graph n° 13) limestone alternated with marly-limestone ; gypsum bed from 10 m down to the base.

f) Reconnaissance bore hole n° 3 at KEBRI DAHAR (WABI SHEBELLE Project)

- Coordinates : 6°44' N and 44°17' E
- Location : Near bore hole n° 2
- Characteristics : Rotary boring through uninterrupted core drilling.
  - Started on 26.11.1970
  - Achieved on 11.2.1971
  - Successive diameters of bore hole from :
    - 0 to 2,80 m = 168 mm
    - 2,80 to 21 m = 150 mm
    - 21 to 57,20 = 145 mm
    - 57,20 to 168,50 m = 116 mm
    - 168,50 to 212 m = 100 mm
    - cemented from 28 to 57 m
- Mean pressure head : 27,50 meters
- Geological log : graph n° 6
  - limestone alternated with marly-limestone, clay and gypsum.
  - A 1 m thick cavern dolomitic bed.

COUPE GEOLOGIQUE DU FORAGE — GEOLOGICAL LOG OF KEBRI-DAHAR

DE KEBRI-DAHAR Nº1 — BORE-HOLE Nº 1

Coordonnées / *Coordinates*: Latitude 6° 44' N; Longitude 44° 17' E

D'après le Water Resources Departement / *From Water Resources Departement*

Echelle verticale 1 / 200 *Vertical scale*

Profondeur en mètres / *Depth in méters*	Figuré / *Symbol*	Lithologie / *Lithological description*
0		Calcaire altéré blanc-jaune et argiles / *White-yellow weathered limestone and clay*
6,1		Calcaire calcitique rouge-brun / *Red-brown calcitic limestone*
7,6		Calcaire blanc-jaune / *White-yellow limestone*
10		
16,6		Calcaire calcitique brechoïde / *Brechoid calcitic limestone*
20		
24,2		Calcaire dolomitique blanc-jaune caverneux / *White-yellow cavernous dolomitic limestone*
30		
31,8		Alternance de calcaires gris-blanc et de marnes / *Grey-white limestone and marl alternated*
40		
45,5		Calcaire gris-quelques niveaux de gypse / *Grey limestone-some gypsous layers*
50		
50,0		Gypse massif blanc / *White compact gypsum*
59,0		Marnes / *Marl*
60		
60,5		

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COUPE GEOLOGIQUE DU FORAGE — GEOLOGICAL LOG OF KEBRI-DAHAR

DE KEBRI-DAHAR Nº2 — BORE-HOLE Nº2

Coordonnées / *Coordinates*: Latitude 6° 44′ N; Longitude 44° 17′ E

D'apres le Water Resources Département / *From Water Resources Département*

Echelle verticale 1/200 *Vertical scale*

Profondeur en mètres / *Depth in méters*	Figuré / *Symbol*	Lithologie / *Lithological description*
0		
		Calcaire altéré blanc jaune et argiles / *White-yellow weathered limestone and clay*
6,1		
		Calcaire calcitique brechoïde / *Brechoid calcitic limestone*
10		
15,2		
		Calcaire marneux gris-brun / *Grey-brown marly limestone*
20		
24,3		
		Calcaire calcitique jaune-blanc et gris / *Yellow-white, grey calcitic limestone*
30		
36,5		
		Lacune / *Gap*
40		
42,4		Gypse massif blanc marneux au sommet / *White massive gypsum marly at the top*
45,7		

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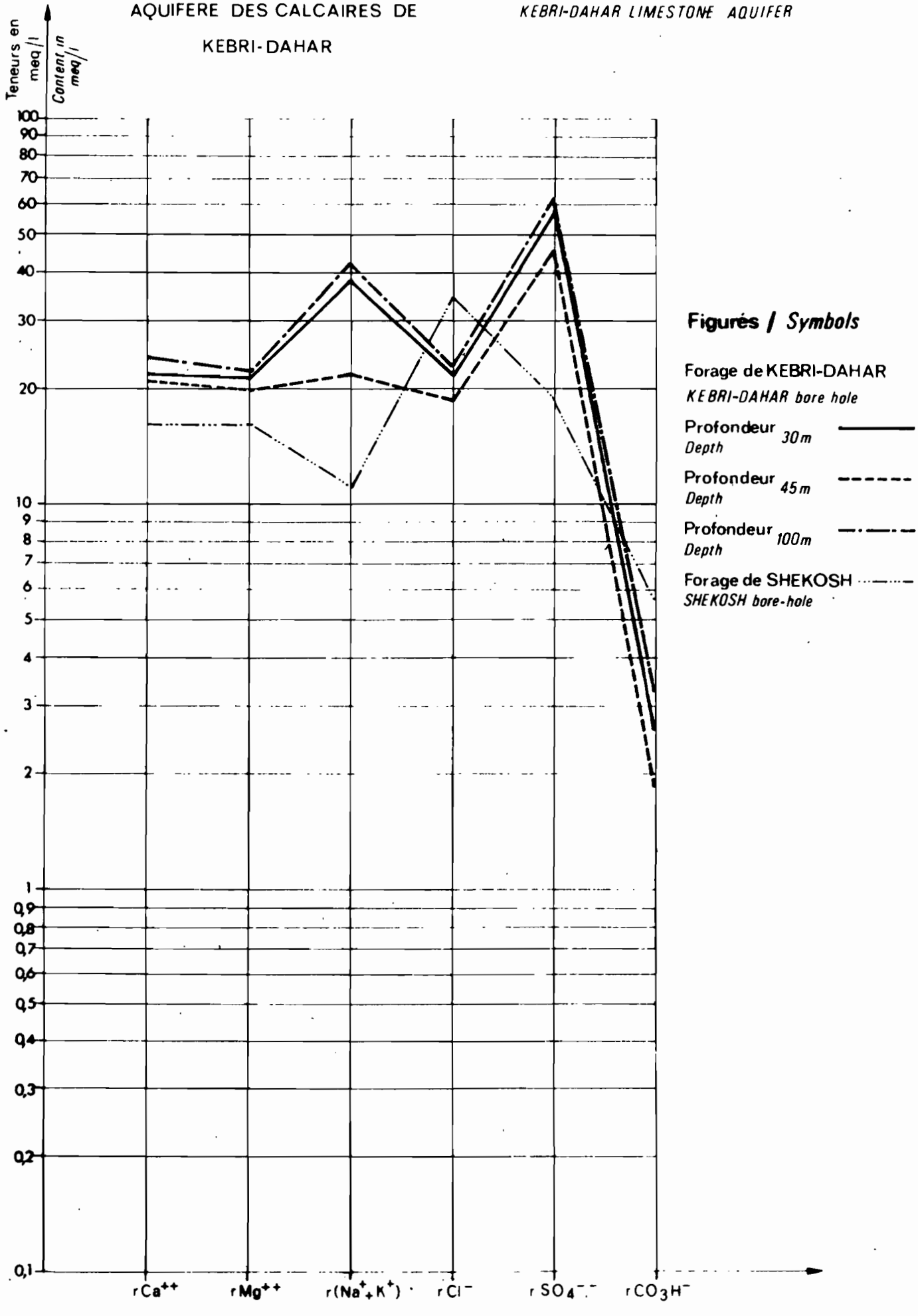
AQUIFERE DES CALCAIRES DE KEBRI-DAHAR

KEBRI-DAHAR LIMESTONE AQUIFER



Figurés / *Symbols*

Forage de KEBRI-DAHAR
KEBRI-DAHAR bore hole

Profondeur 30m
Depth

Profondeur 45m
Depth

Profondeur 100m
Depth

Forage de SHEKOSH
SHEKOSH bore-hole

The piezometric levels are relatively deep and indicate an inadequate recharging of the water table due to a low infiltration rate. This indication confirms the previous observations on the cracking of reservoir.

4.1.3. Geochemistry of the water-table

Water samples were collected in the SHEKOSH bore hole and at three different levels in the KEBRI DAHAR reconnaissance bore hole. A quantitative analysis of the main elements composing each sample was made. The results are given in mg/l on the following table.

The gradient of the lines of the logarithmic diagrams immediately reveal the ratios between elements, these ratios characterizing the chemical facies of water.

The millilitre equivalent is obtained by dividing the weight of the element in a solution expressed in milligrams per litre, by its chemical equivalent, the latter being the quotient of the atomic weight of the element considered in its valency.

TABLE N° 4

WATER ANALYSIS OF THE WATER TABLE OF KEBRI DAHAR LIMESTONE

(in mg/l)

Bore hole	Date of sampling	Conductivity in mmhos/cm	pH	$CO_3^= + CO_3H^-$	Cl^-	$SO_4^=$	K^+	Na^+	Ca^{++}	Mg^{++}
SHEKOSH	16.2.70.	4,0	7,10	298	1240	865	164	160	320	192
KEBRI-DAHAR										
30 m	Déc. 1970	5,82	7,45	156	765	2800	32,6	870	462	252
45 m	Déc. 1970	4,66	7,55	111	655	2200	30,0	480	432	242
100 m	Déc. 1970	5,82	7,40	176	800	2950	37,8	950	507	256

These results clearly reveal the high conductivities and consequently the high salt content for SHEKOSH as well as for KEBRI DAHAR waters. The total content of dissolved salts is 3,3 gr/l at SHEKOSH and it rises to a mean content of 5 gr/l in the KEBRI DAHAR bore-hole. These high concentrations are due to the existence of thick marly and gypseous saline layers in the reservoir. The presence of briny springs in the HAMERO-HEDAD region (which in the somali language means "bitter spring") confirms this ascertainment.

The relatively quick increase of salt concentration from the North to the South in which direction ground water flows, indicates that the circulation of water is very slow. Confined ground water is progressively more concentrated as one goes Southward.

The distribution of dissolved salts is appreciably different between SHEKOSH water and KEBRI DAHAR water. At SHEKOSH, water with chloride calcium and magnesium can be observed with :

$$r\ Cl > r\ SO_4 > r\ CO_3H \geq \text{and} > r\ Ca > r\ Mg > r\ Na.$$

At KEBRI-DAHAR, sulphated and sodic water can be observed with :

$$r\ SO_4 > r\ Cl > r\ CO_3H \geq \text{and} > r\ Na > r\ Ca > r\ Mg.$$

The water first dissolves the chlorides and is progressively more loaded with sulphate from the upstream part to the downstream part, this feature revealing the abundance of gypsum in the ground water reservoir.

4.1.4. General conclusions

The KEBRI DAHAR formation is the most important ground water reservoir of OGADEN.

Nevertheless, observations and measurements reveal that the aquifer presents two major inconvenients which considerably limits utilization possibilities : it is scarcely cracked and consequently not very permeable and contains a large amount of soluble salts.

Utilizing this ground water requires deep bore holes reaching the aquifer very far down. This implies great expenses and can only be justified if the quality of water is suitable for domestic use.

Below the main gypsum formation, the water table cannot be used as it is very deep and contains a large amount of soluble salts (more than 5 gr/l). Furthermore, it would be necessary to isolate the upper gypsum bed which contains water levels with an excessive salinity degree.

In the outcropping part of the KEBRI DAHAR limestone, the aquifer may be utilized if deep bore-holes are placed at the Northern border of OGADEN.

Though salinity is still high in this zone nevertheless it is probably less than 3 gr/l.

These bore-holes should penetrate deep enough under the ground-water piezometric level in order to obtain a sufficient yield.

4.2. Ground water of MUSTAHIL limestone

4.2.1. The reservoir and its recharging conditions

MUSTAHIL limestone presents at the top a 8 to 10 meters thick dolomitic limestone bed. This cracked limestone may, depending on its recharging conditions and its geomorphological situation, locally contain an aquifer.

As previously seen, two distinct geomorphological units can be determined for this formation.

South of the WABI SHEBELLE and in the triangle : KEBRI DAHAR - GODE - FERFER located between the FAFEN and the WABI SHEBELLE, the limestone surmounts barren tabular plateaus which are very broken up by weathering. In this region, the reservoirs and catchment basins being small do not allow the formation of a storage aquifer.

Conversely, to the East of the FAFEN, the MUSTAHIL limestone covered with broken up FERFER gypsum and with sediments of various origins such as weathered JESSOMA sandstone and FERFER gypsum, forms a large uninterrupted plateau on 4.000 km2 stretching from the South of KORAHE to the frontier, and constitutes a ground water reservoir.

The catchment basin is not very large and is usually covered with impervious gypseous formations. Furthermore, in this region rainfall is not abundant (300 to 100 mm) and is very irregular, therefore, the ground water is never directly recharged by rainfall but only by the water spreading basins located at the outlet of small endhoreic hydrologic basins. Runoff water is collected in these basins where it seeps into the soil and is drained by the subjacent cracked dolomitic limestone which consequently may form a permanent aquifer.

However, considering that the limestone bed is thin and the recharging weak and irregular, only a poor aquifer with a small storage may be expected.

4.2.2. Piezometric levels

Many hand dug wells on the FERFER - SHILAVO - MERERALE plateau reach the MUSTAHIL limestone water table after sinking through the overlaying FERFER gypsum and weathered sediments. These wells are usually located in the water spreading plains of local floods. Their mean depth corresponds to 10 to 12 meters and they are used for the watering of livestock. Several observation - wells selected along the KEBRI-DAHAR - FERFER and SHILAVO - MUSTAHIL axes were periodically visited. During these visits, measurements of the piezometric level and sampling for chemical analysis were carried out (see well-data file in annex).

The study of the fluctuations of piezometric levels reveals the preponderating influence of the regime of rainfall on the recharging of the water-table. A general recovery may be observed after each rainy season, that is to say twice a year in April-May and in October-November.

Table 5 shows the amplitudes of the water-table recovery after the first rainy season in 1970 and for several characteristic wells.

TABLE N° 5

PIEZOMETRIC LEVELS OF THE MUSTAHIL LIMESTONE WATER TABLE

Observation well	Coordinates	Total depth of well from the surface (in m.)	Piezometric level - Mid-February 1970 (in m.)	Piezometric level - End of May 1970 (in m.)	Recovery of piezometric level from February to May 1970 (in m.)
BARGUN	5°26' N 44°59' E	10,0	-	9,66	-
LAMMABAR	5°34' N 44°57' E	9,22	9,09	5,0	4,09
DAMBAR	5°59' N 44°46' E	7,83	7,71	+ 0,50 *1	8,20
SHILAVO	6°04' N 44°45' E	11,20	11,20	6,60	4,60
AFTOL	5°59' N 44°42' E	13,0	-	12,40	-
IGLOLE II	5°45' N 44°34' E	10,30	-	6,40	-
IGLOLE I	6°09' N 44°45' E	12,73	12,36	11,40	0,96
BELLEKOSHI	6°07' N 44°44' E	9,15	8,15	-	-
LAZOLALE	6°17' N 44°43' E	12,39	10,87	10,95	(-0,08) *2

1*- At DAMBAR, on 27.5.70., the well was in the centre of a pool, the piezometric level being 0,50 m above ground.

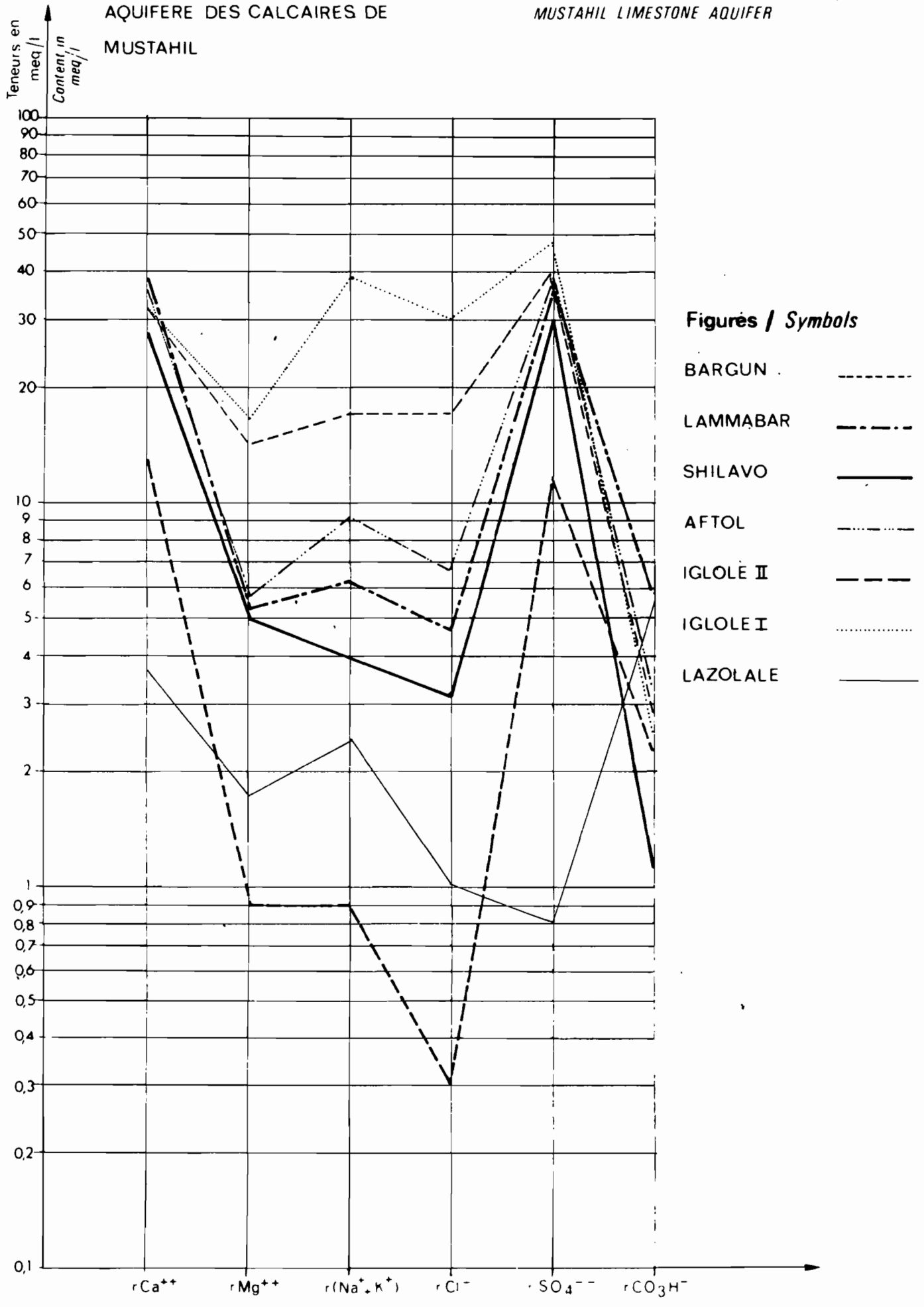
2*- Unreliable data.

DIAGRAMME D'ANALYSES D'EAUX / *WATER ANALYSIS DIAGRAM*

Gr_15

AQUIFERE DES CALCAIRES DE MUSTAHIL

MUSTAHIL LIMESTONE AQUIFER



O.R.S.T.O.M. Service Hydrologique	date	des.	ETR_291605
	5-72	D-LB	

The piezometric levels and their fluctuations clearly reveal the recharging and working mechanism of the water table.

The local recovery of the piezometric level after the rainy seasons is variable : from a few decimeters to more than 8 m, and depends on the more or less abundant rainfall on the various recharge areas.

After this recharge period, the piezometric levels decline quickly, the MUSTAHIL limestone being the draining level of ground water. The piezometric level is then stabilized or declines very slowly during the dry season. It may vary from 10 to 12 meters below ground.

These observations show once again the precarious character of the recharging of the water-table and of the formation of small reservoirs.

4.2.3. Geochemistry of the water-table

Water was sampled in seven observation wells for two different periods. The first samples taken in February 1970 were only used for conductivity measurements, but complete chemical analysis were made on the second samples of May 1970. The results are grouped in table n° 6 and are transferred on the logarithmic graph (gr.n°15).

Conductivity and salt concentration

The conductivity of water greatly varies and consequently, so does its salt concentration.

For a same series of samples (May 1970), conductivities vary from 0,8 mmhos/cm in LAZOLALE to 6,4 mmhos/cm in IGLOLE I, and salinity from 500 mg/l to 5 gr/l.

The results do not show in which direction the total amount of salt progresses in the water table. Concentrations for each observation point are completely independent from one another and are only linked to the lithologic character of catchment and infiltration basins as well as of the reservoirs.

Furthermore, at all the observation points, the conductivity and consequently the salt contents increase when the piezometric levels decline, without any greater homogeneisation in the concentration being observed. This shows that water is locally loaded with soluble salts and that lateral circulation is weak in the MUSTAHIL limestone.

Ionic content

The water analysis diagram shows that two main types of water may be determined in relation to their degree of salinity, as follows :

a) Medium-loaded waters of AFTOL (2,7 gr/l), LAMMABAR (2,7 gr/l), SHILAVO (2 gr/l) and IGLOLE II (0,8 gr/l) are calcic and sulphated with the following distribution of ions :

$$r\ SO_4 > r\ Cl > r\ HCO_3 > \text{and } r\ Ca \geqslant r\ Na > r\ Mg$$

TABLE N° 6

WATER ANALYSES OF THE WATER TABLE OF MUSTAHIL LIMESTONE

IN mg/l

Observation wells	Coordinates	Date of sampling	Conductivity in mmhos/cm	pH Labo	CO_3H^-	Cl^-	SO_4^{--}	K^+	Na^+	Ca^{++}	Mg^{++}
BARGUN	5°26' N 44°59' E	27.5.70	4,1	7,6	139	620	2 000	28,2	380	645	176
LAMMABAR	5°34' N 44°57' E	11.2.70 27.5.70	4,6 3,1	7,3	288	167	1 720	42	120	705	64
SHILAVO	6°04' N 44°45' E	12.2.70 27.5.70	6,0 2,7	7,3	54	114	1 450	35	72	540	61
AFTOL	5°59' N 44°42' E	27.5.70	3,0	7,8	164	240	1 750	45	185	650	70
IGLOLE I	6°09' N 44°45' E	14.2.70 27.5.70	12,0 6,4	7,5	126	1 110	2 350	290	735	630	205
IGLOLE II	5°45' N 44°34' E	27.5.70	1,2	7,2	115	11	560	15	11,5	275	11
LAZOLALE	6°17' N 44°43' E	14.2.70 27.5.70	2,6 0,8	8,4	292	36	40	45	30	75	21,4

b) Heavily loaded waters at BARGUN (3,6 gr/l) and IGLOLE I (5,1 gr/l) present the same ionic distribution but the chloride content is higher.

These salt contents show well enough that the catchment basins mainly consist of gypseous material. The quantity of sulphate or chloride depends on the relative abundance of this material.

LAZOLALE water must be considered apart. It is scarcely loaded (0,5 gr/l) and its composition is different from the former. This water is calcic and carbonated :

$$r\ CO_3H > r\ Cl > r\ SO_4 \text{ and } r\ Ca > r\ Mg > r\ Na$$

This exception as regards the LAZOLALE well may be explained by the fact that the catchment basin is probably mainly composed of sandstone material from the JESSOMA formation.

Finally, the concentration and composition of the MUSTAHIL limestone aquifer is not homogeneous. The lithologic character of the materials overlaying the limestone which constitute infiltration zones, condition the chemical quality of subjacent ground water.

4.2.4. General conclusions

Owing to the unfavourable recharging conditions and to the weak circulation of underground water, the MUSTAHIL limestone only constitutes a poor aquifer with a very inadequate storage. The available volume of water to be expected is not considerable, the quality of water is usually poor and consequently, the very high salinity makes this water only fit for livestock.

In order to utilize this aquifer in a rational way, the water intake installations already located in the water-table recharging areas should first be improved. If existent wells were made approximately 5 meters deeper a better yield would be available.

Other wells could also be installed. The best would be to place these wells in the water-table recharging areas (water spreading depressions) where the storage is probably the most considerable.

4.3. WABI-SHEBELLE alluvial water table

4.3.1. Reservoir

As previously seen in paragraph 3.1.7.1., the WABI SHEBELLE alluvial deposits spread continuously on either bank of the WABI SHEBELLE, from the North of IMI to the frontier, over approximately 3.000 km2. They consist of alternated silt, clay and sand resulting from the weathering of cristalline rocks, and from limestone and gypsum formations. They are more than 30 m thick and rest on the impervious substratum of the main gypsum formation. These alluvia can contain an important and continuous aquifer in the large plains where they spread.

The storage of this aquifer depends on its recharging conditions and on the permeability of the alluvial material. The considerable extent of alluvial deposits as well as the fact that wells are practically non-existent does not enable studying the mechanism of the water table throughout the valley. Consequently, the study was undertaken at sites with different hydromorphologic features characterizing a given area. In this end, piezometric profiles were placed in the cross-sections of alluvial plains, i.e. :

- At GODE, in the centre of the large ADAMBOI plain which is never overflooded.
- At KELAFO, at the outlet of the ILO UEN basin which continues the ADAMBOI plain and is periodically overflooded.
- At MUSTAHIL, in the gully bordering the SHEBELLE alluvial plain which is permanently overflooded.

4.3.2. Piezometric levels at GODE

At GODE (5°55' and 43°55' E) the large ADAMBOI plain (850 km2) stretches on the right bank of the WABI SHEBELLE and is 12 km wide. The river is embanked in its alluvium and does not overflow.

The profile includes four piezometers relative to the general levelling of the Lower Valley and placed in a NNE - SSW direction. The lithologic section of the alluvia is represented on graph n° 9. The location and elevation of these piezometers are noted in the following table:

Piezometers	Distance to the river	Elevation at the top of the piezo-meter (in meters)	Ground elevation (in meters)
Piezometer N° 1	1 km - left bank	311,08	309,85
Piezometer N° 2	260 m - right bank	304,81	303,55
Piezometer N° 3	3,8 km - right bank	305,15	304,12
Piezometer N° 4	8,5 km - right bank	302,17	301,23

Weekly measurements of the water level for a complete hydrologic cycle were carried out from August 1969 to August 1970.

Only piezometers N° 3 and N° 4 give significant results characterizing the evolution of the water table. Piezometer N° 2 did not operate normally owing to the clogging of its screen-strainer, whereas piezometer N° 1 which reaches the alluvial water table of a local temporary river, is placed outside the general alluvial formation.

FLUCTUATIONS DE LA NAPPE ALLUVIALE A GODE - *FLUCTUATIONS OF ALLUVIAL WATER TABLE IN GODE*

D'Août 1969 à Août 1970

From August 1969 to August 1970

Les niveaux piezometriques sont rattachés au nivellement général de la Basse Vallée

The water level elevations are relative to the lower Valley general levelling

Altitude du sol { Piézometre N° 3 : 304,12 m: *Piezometer N° 3* / Piézometre N° 4 : 301, 23 m: *Piezometer N° 4* } *Ground elevation*

Cote du plan d'eau en mètres
Water level elevation in meters

295

Cote approchée du fond du Wabi Shebelle: 291.00m
Approximate elevation of Wabi Shebelle bed: 291.00 m

291

290

Piézometre N° 3
Piezometer N° 3

Piezometre N° 4
Piezometer N° 4

Précipitation à Godé
Rainfall in Godé

285

50 mm
40 mm
30 mm
20 mm
10 mm

A S O N D J F M A M J J A

1969 1970

O.R.S.T.O.M. Service Hydrologique	date	des.	ETR-291606
	6-72	D-JP	

The fluctuations of phreatic water in piezometers N° 3 and N° 4 are recorded on graph n° 16.

This graph enables to make the following observations :

a) Apart from some low recoveries in piezometer N° 4, the phreatic water level is practically the same during the hydrologic cycle and is therefore not affected by the WABI SHEBELLE floods. This observation shows that diffusity is low as well as transmissibility in the alluvial deposits owing to the heterogeneous nature of the latter and to the presence of clay beds.

b) the piezometric levels are deep (13,70 m at piezometer N° 3 and 15 m deep at piezometer N°4) and always lower than the bed of the WABI SHEBELLE. Besides, the water table being lower in piezometer N° 4 than in piezometer N° 3, is consequently recharged by the river though this recharge is very weak as floods do not cause any recovery. The very high pressure gradient between the two piezometers (1 %) confirms that the alluvia are scarcely permeable.

c) Slight recoveries of the piezometric surface only affect piezometer N°4 during the two rainy seasons : October-November and March-April : These recoveries are due to infiltration of overland runoff from local tributaries.

From these observations may be drawn several conclusions concerning the recharging system and ground water resources in ADAMBOI plain. This plain has a relatively important alluvial water table, the piezometric level of which is balanced by additional water from the river. However, the permeability of the alluvia being insufficient there is no seasonal recharging of the water table which presents a steady level all year round. Recharging due to other sources is negligible as direct rainfall seepage is non-existent and only local recharging by local tributaries may occur. The aquifer is poor and insufficiently supplied.

4.3.3. Kelafo alluvial water-table

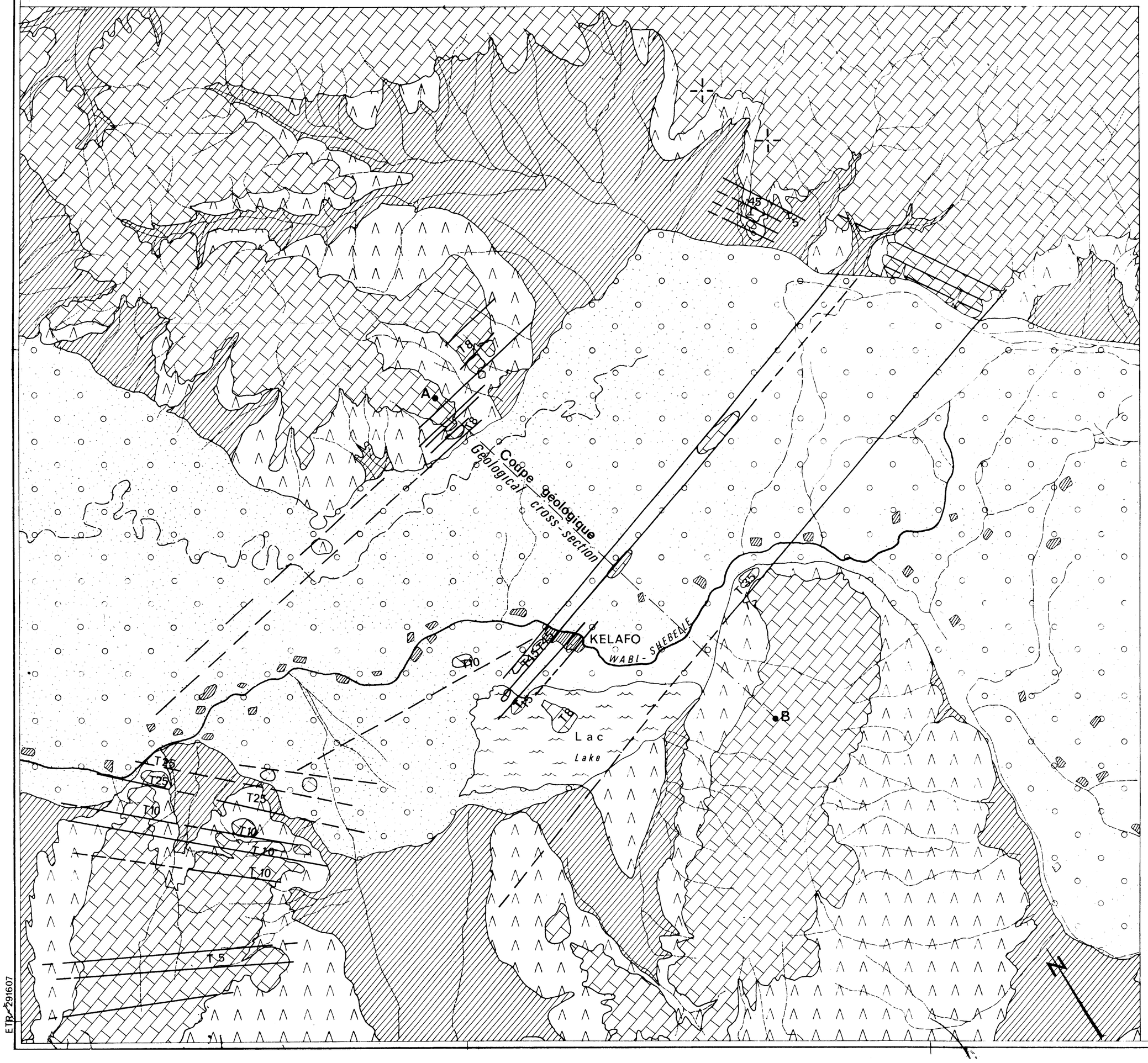
4.3.3.1. Geomorphologic aspect of the alluvial depression

The KELAFO region (5°35' N and 44°12' E), situated at the Southern border of the ILO UEN alluvial depression, presents a very particular geomorphologic structure which is represented at the surface by distinct fault lines and the existence of a permanent lake. The first reconnaissances led to believe that a tectonic basin existed and that recoveries of ground water of the KEBRI DAHAR limestone confined aquifer probably occurred. This would explain in a first approximate estimation, the abundance of water in this area and the existence of the lake.

In order to complete these data, a detailed geological study of the region was undertaken and at the same time a line of piezometers was installed perpendicularly to the valley. The geological study led to the drafting of a geological and tectonic map at a scale of 1/50.000 (map N° 17) and a cross-section of the valley (graph N° 18). The fault areas are distinctly seen on the MUSTAHIL limestone plateaus rising above the alluvial plain. The plateaus to the North-West of GODE are broken up by five strike-slip faults of 30 meters.

CARTE GÉOLOGIQUE et STRUCTURALE de la RÉGION de KELAFO

GEOLOGICAL AND STRUCTURAL MAP OF KELAFO AREA



LEGEND / LÉGENDE

Wabi Shebelle alluvium
Alluvions du Wabi Shebelle

Quaternary local deposits
Dépots quaternaires locaux

Main gypsum serie
Formation gypseuse

Mustahil limestone
Calcaires de Mustahil

SYMBOLS FIGURES

Geological contact
Limite geologique

No dip
Pendage nul

Strike and dip
Direction et pendage

Définite fault
Faille sûre

Probable fault
Faille probable

Géological cross-section
Coupe géologique

Permanent river
Fleuve permanent

Temporary river
Rivière temporaire

Towns, villages
Villes, villages

Scale : 1/50 000
Échelle :

0 500 1000 2000 3000 4000 m

ETR-291607

The angles of dip are 8° to 10° in a SW direction. To the North-East four NW-SE faults cause the collapse of the formations. The angles of dip (45° near the alluvia, and then 5°) have a NE direction. The hills in the South-East are cut by nine NW-SE faults with a weak strike slip of 10 m and decreasing angles of dip (from 25° to 5°) towards the South West.

Finally, MUSTAHIL limestone outcrops can be seen jutting through the river alluvia along the two NE-SW faults which stretch across the whole plain. The angles of dip of these outcrops (sometimes reaching 45°) indicate a furrow back of layers at the contact with faults. The presence of a limestone outcrop in the lake also reveals the existence of a fault system under the latter.

These structural elements show that the KELAFO alluvial plain forms a small tectonic basin which is limited by faults mainly following NW-SE and NE-SW directions. A collapsed wall of approximately 100 m is also broken up and forms the substratum of the valley.

The fault system, when it is developed in depth, may affect the subjacent KEBRI DAHAR limestone and be a favourable element for recoveries of its confined ground water in the alluvial water table. The value of this assumption will be examined after the variations of ground water level in piezometers have been studied.

4.3.3.2. Piezometric levels

These piezometers were placed in the valley along an axis : 170° NNW-SSE. Their location plan is represented on graph N° 19 and their elevation is indicated in the following table.

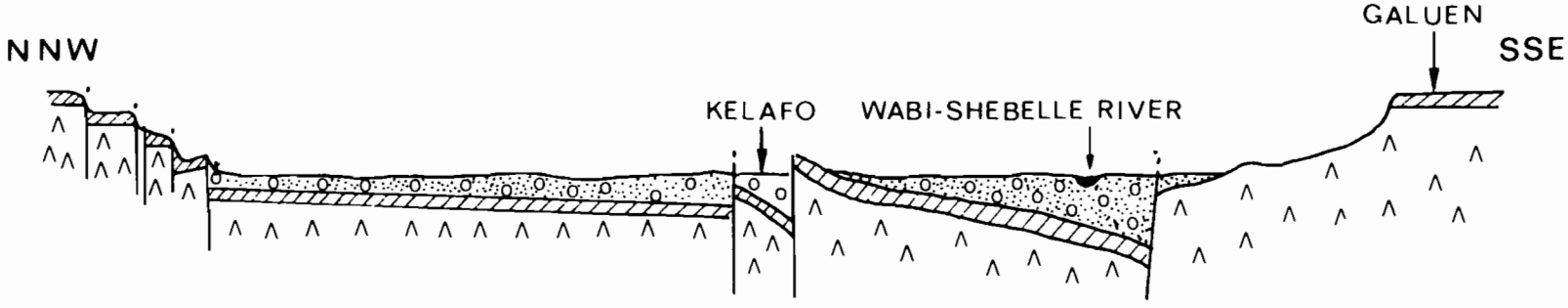
Piezometers	Distance to the river	Elevation at the top of the piezometer (in meters)	Ground elevation (in meters)
Piezometer N° 1	500 m - right bank	269,52	268,50
Piezometer N° 2	500 m - left bank	271,00	270,84
Piezometer N° 4	4,5 km - left bank	269,40	268,28

It was impossible to instal piezometer N° 3 owing to drilling difficulties.

The weekly measurements of water levels carried out between September 14. 1969 and January 1971 are noted on graph N° 20 as well as the curve of the river fluctuations during the same period.

COUPE GEOLOGIQUE DE LA VALLEE A KELAFO

GEOLOGICAL CROSS-SECTION OF KELAFO VALLEY



Alluvions — *Alluvial deposits*

Calcaire de Mustahil — *Mustahil limestone*

Formation gypseuse principale — *Main gypsum serie*

Faille — *Fault*

ECHELLES - *SCALES*

Horizontale 1/50 000 *Horizontal*

Verticale 1/50 000 *Vertical*

Gr_18

O.R.S.T.O.M. Service Hydrologique

date 6_72 | des. D_JP

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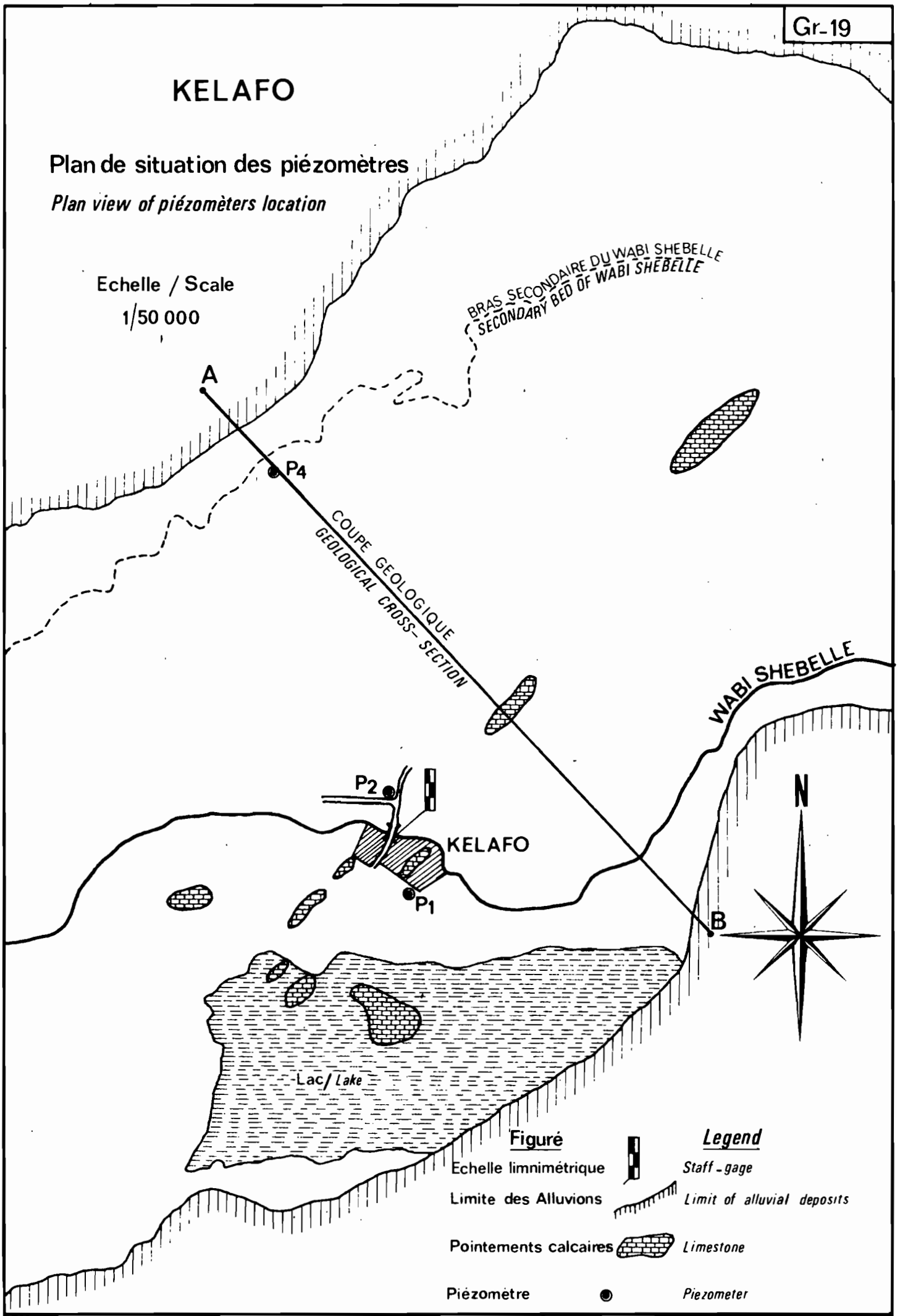
KELAFO

Plan de situation des piézomètres

Plan view of piézomèters location

Echelle / Scale
1/50 000



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Gr-20

INFLUENCE DU WABI SHEBELLE SUR LE NIVEAU DE LA NAPPE A KELAFO

De Septembre 1969 à Janvier 1971

INFLUENCE OF WABI SHEBELLE ON WATER TABLE AT KELAFO

From September 1969 to January 1971

Les côtes du plan d'eau sont rattachés au nivellement général de la basse vallée

The water level elevations are relative to the lower valley general levelling

Altitude du sol { Piézomètre N° 1 : 268.50m : *Piezometer N° 1* / Piezometre N° 2 : 270.84m : *Piezometer N° 2* / Piezometre N° 4 : 268.28m : *Piezometer N° 4* } *Ground elevation*

Côte du zéro de l'échelle : 263.15m *Gauge datum*

Côte du plan d'eau en mètres — *Water level elevation in meters*

270 — 269 — 268 — 267 — 266 — 265 — 264 — 263 — 262 — 261 — 260

WABI-SHEBELLE

Piézomètre N° 1 — *Piezometer N° 1*

Piézomètre N° 2 — *Piezometer N° 2*

Piezomètre N° 4 — *Piezometer N° 4*

Précipitations — *Rainfall in Kelafo*

50mm — 40mm — 30mm — 20mm — 10mm

S O N D J F M A M J J A S O N D J F

1969 — 1970 — 1971

O.R.S.T.O.M. Service Hydrologique	date	des.	ETR- 291610
	6.72	D_JP	

This graph brings out the narrow relationship existing between the regime of subsurface water and the WABI SHEBELLE floods.

The fluctuations in piezometers 2 and 4 are relative to the seasonal floods of the WABI SHEBELLE in the ILO UEN plain, these floods occurring approximately 30 km downstream from KELAFO.

The fluctuations in piezometer N° 1 on the right bank are more often related to the levels of the lake which receives WABI SHEBELLE floods as well as the overland runoff from a local tributary.

The floods of September and October 1969 not being very strong the flooding was weak and localized and the recoveries in the three piezometers were not very considerable.

The floods of April-May 1970 caused a general flooding of the ILO UEN plain and the level of the lake reached piezometer N° 1. The recharge level of the water table was 1,50 m in piezometer N° 2 and 3,50 m in piezometer N° 4.

Finally, the floods of August and September 1971 occurring after a short and not very pronounced minimum flow period, gave other floodings. The level of the lake did not vary much nor did the level of piezometer N° 1. The piezometric levels which slightly declined during the low water period in June-July showed a considerable recovery of 2,50 m at piezometer N° 2 and of 5 m at piezometer N° 4. The piezometric surface was practically at the level with the valley.

Between the flood periods, the level of the water table declines very quickly and all the more so as one goes farther from the river. These observations show well enough the working mechanism of the water table :

a) On the right bank of the river, the water table is sustained by the lake. The piezometric level depends on the head of the lake. There is effluent seepage from the lake to the river.

b) On the left bank of the WABI SHEBELLE, influent seepage may be observed from the river to the aquifer. During the minimum flow or mean flow periods of the WABI SHEBELLE, the piezometric surface is relatively deep (5,25 m below ground at piezometer N° 2 and 5,75 m at piezometer N° 4 at the end of February 1970) and the pressure gradient is approximately 0,5 ‰.

The water table is recharged during the flood period by infiltration in flooded areas. The latter being larger at the Northern end of the plain, the recovery of piezometric levels is quicker but they decline steadily during the low flow period showing that the ground water flows towards the downstream part and that the recharging by the river is weak. The horizontal permeability of the alluvia is consequently not very high.

Conversely, the swiftness of the lagtime of piezometric levels to the floods shows that the vertical permeability is greater.

c) The assumption that recoveries of the water table of KEBRI DAHAR limestone might eventually occur cannot be confirmed by piezometric observations. This accretion, if it really exists, is at all events insignificant as it does not modify the minimum flow of the water table.

4.3.4. Piezometric levels in MUSTAHIL

MUSTAHIL (5°14' N and 44°44' E) is located at the outlet of the large flood plain of the SHEBELLE (see graph N° 11). The alluvial valley is 2,3 km wide and hemmed in by the cliffs of the main gypsum formation surmounted with MUSTAHIL limestone. The WABI SHEBELLE, embanked in its own alluvial deposits no longer overflows. To the North, the alluvial plain is lower and several channels with a temporary flow are used by ground water as drains.

Only one piezometer could be placed. It is located on the right bank at a 320 meters'distance from the river and its elevations are as follows :

- Elevation of the piezometer at the top : 239,19 m
- Ground elevation : 238,17 m

The fluctuations of the piezometric level for the period from September 20. 1969 to February 1971 are represented on graph N° 21 as well as the water levels at the BURKUR water level recording station located 25 km downstream from MUSTAHIL.

As at KELAFO, a correspondence may be observed between the WABI SHEBELLE floods and the ground water regime. The large SHEBELLE basin located immediately upstream from MUSTAHIL where the floods of the WABI SHEBELLE spread, plays the role of catchment basin of the water table which flows from the upstream part to the downstream part. Taking into account the duration and volume of floods, a more or less considerable recharge may be observed.

Unlike what occurs at KELAFO during the minimum flow seasons of the river (from November to February and from June to July), the piezometric level never declines below the water level of the river. During these periods, there is effluent seepage from the aquifer to the stream. Nevertheless, this flow is probably negligible as no considerable increase of the minimum flow from the upstream part to the downstream part is observed. Here, as well as at KELAFO, the vertical permeability of alluvial deposits seems greater than the horizontal permeability.

4.3.5. Geochemistry of the alluvial water-table

The results of analysis made on samples from the piezometers are given in table N° 7 and are represented on logarithmic graph N° 22.

- Total content of dissolved salt

The conductivies measured are generally relatively high and apart from the unusually high value for February 1970 at piezometer N° 4 at KELAFO, they vary from 5,1 to 2 mmhos/cm. Corresponding salt contents are between 3,8 and 1,5 gr/l. These values confirm the existence of gypseous material in the alluvial deposits.

Gr_21

FLUCTUATIONS DES NIVEAUX D'EAU DANS LE PIEZOMETRE DE MUSTAHIL ET SUR LE WABI-SHEBELLE A BURKUR

De Septembre 1969 à Fevrier 1971

WATER FLUCTUATIONS IN PIEZOMETER IN MUSTAHIL AND WABI SHEBELLE IN BURKUR

From September 1969 to February 1971

Côtes du plan d'eau (m)
Water level elevation in meters

235
234
233
232
231
230
229
228
227
226
225

Hauteur d'échelle à Burkur (m)
Stage at Burkur in meters

6
5
4
3
2
1
0

S O N D J F M A M J J A S O N D J F

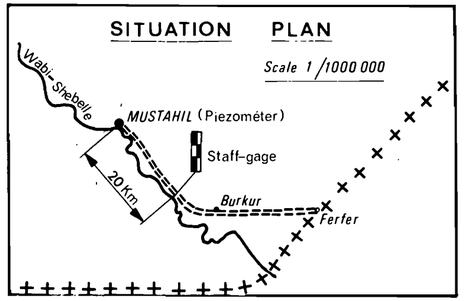
1969 1970 1971

Piézomètre
Piezometer

Wabi-Shebelle

238.17m Altitude du sol au piézometre
Ground elevation at piezometer

231.0 m Cote approchée du fond du Wabi Shebelle à Mustahil
Approximate elevation of Wabi Shebelle bed at Mustahil



ORSTOM Service Hydrologique | date 6-72 | des. D. JP | ETR - 291611

TABLE 7 : WATER ANALYSIS OF ALLUVIAL WATER-TABLE

IN mg/l

Piezometers	Date of sampling	Conductivity in mmhos/cm	Total salinity in gr/l	pH Labo	GO_3H^-	Cl^-	SO_4^{--}	K^+	Na^+	Ca^{++}	Mg^{++}
GODE Piezo 2	02.09.1969	4,1	3,1	7,4	45	375	1 870	19,1	405	660	70
	18.11.1969	4,0	3,1	7,5	68	375	1 830	19,6	400	630	61,4
GODE Piezo 3	02.09.1969	3,8	2,8	7,5	87	264	1 690	10,6	500	450	82,7
	18.11.1969	3,7	2,9	7,4	88	308	1 700	11,4	507	405	74,1
	February 1970	4,6	3,5								
	May 1970	5,1	3,8								
GODE Piezo 4	02.09.1969	2,6	1,8	7,5	58	136	1 140	7,9	215	360	60,3
	18.11.1969	2,3	1,5	7,2	102	225	730	8,2	250	280	23,3
	February 1970	4,0	3,0								
	May 1970	3,2	2,4								
KELAFO Piezo 2	February 1970	3,5	2,6								
	May 1970	3,3	2,5	8,6	594	530	8	53	610	3	32
KELAFO Piezo 4	February 1970	7,4	5,6								
	May 1970	3,1	2,3	7,2	139	156	1 600	42	225	475	87
MUSTAHIL Piezo 1	February 1970	3,0	2,3								
	May 1970	2,8	2,1	7,0	62	280	870	11,5	395	143	49

For each series of measurements a decreasing salinity may be observed from GODE to MUSTAHIL.

This decreasing mineralization of the water-table is linked to the recharging mechanism.

- At GODE, the insufficiently recharged water table has a low flow and is loaded with salt in the reservoir. Piezometer N°4 at GODE is located in the recharge area of the aquifer which is supplied by local tributaries and presents a lower salt concentration.

- At KELAFO and MUSTAHIL, the water table is seasonally recharged by the scarcely loaded WABI SHEBELLE water. Its salinity is lower than at GODE.

- Ionic content (graph N° 22)

On the whole, the alluvial water table presents the same geological facies. It consists of sodic sulphated water with a high Cl content and the ions are distributed as follows, i.e. :

$$r\ SO_4 < r\ Cl < r\ CO_3H < r\ Na < r\ Ca < r\ Mg$$

The water in GODE piezometer N° 2 only, is completely different with sodic chloride and a very low sulphate content.

High sulphate contents in the alluvial water table brings out the preponderating influence of gypsum existing in the reservoir.

4.3.6. General conclusions

Taking into account their low permeability, the alluvial deposits form a poor reservoir and the stored volumes are not considerable.

The recharging of this reservoir is important only in the flood areas of the river, namely in the large basin stretching from KELAFO to MUSTAHIL and at a lesser degree, in the IMI basin. Apart from these flood areas, the water table is weakly recharged and its piezometric level is steady owing to the addition of water from the river. Only a few zones are recharged by the floods of temporary rivers, but this does not affect the general piezometric level of the water table because of an inadequate transmissivity of the alluvia. Besides, the ground water flow is probably also very weak.

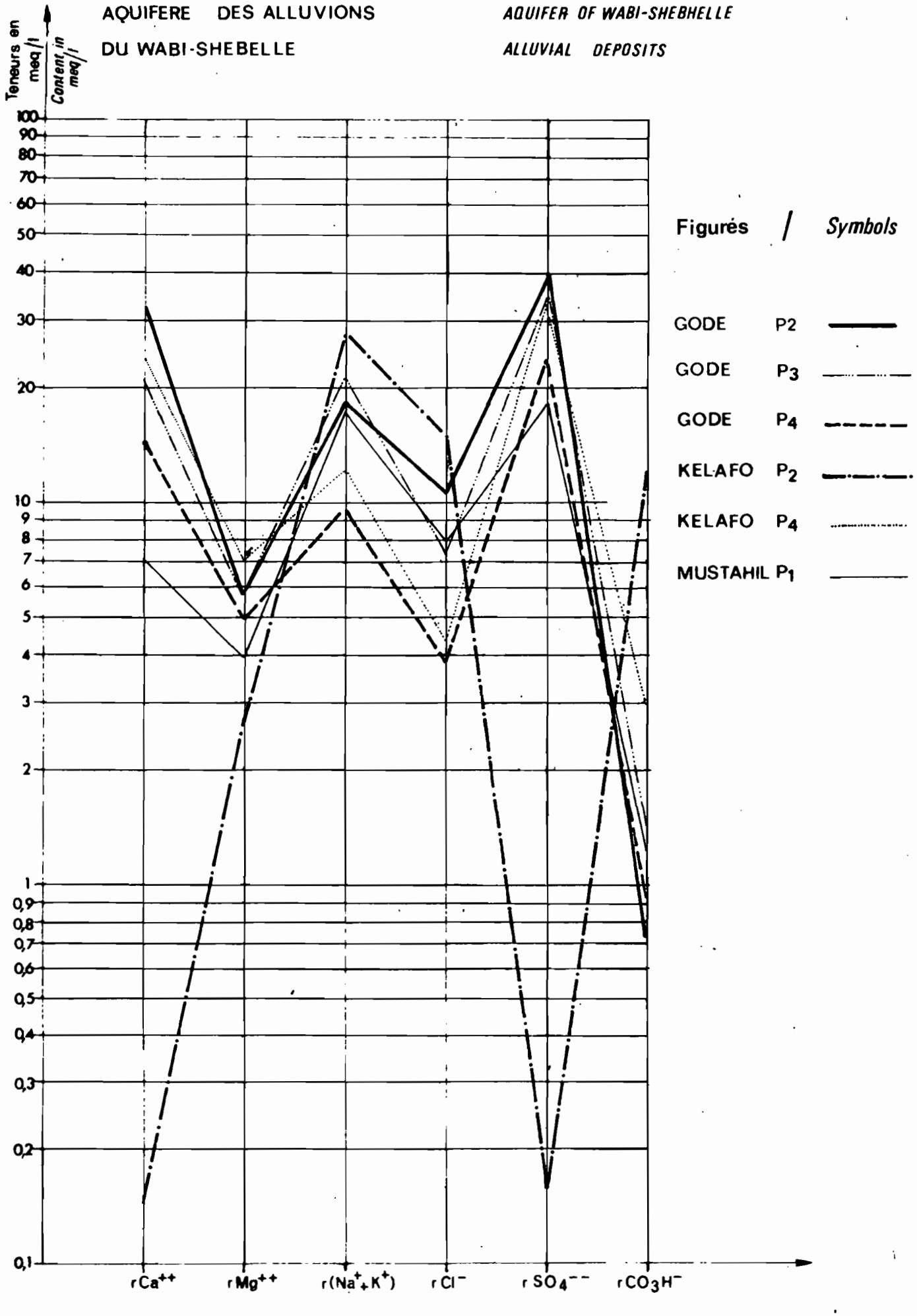
The quality of water is poor owing to the fact that the latter is relatively loaded with salt (from 2 to 5 gr/l) and because of the low rate of flow and of the presence in the reservoir of gypseous sediments.

DIAGRAMME D'ANALYSES D'EAUX / *WATER ANALYSIS DIAGRAM*

Gr-22

AQUIFERE DES ALLUVIONS DU WABI-SHEBELLE

AQUIFER OF WABI-SHEBHELLE ALLUVIAL DEPOSITS



O.R.S.T.O.M. Service Hydrologique	date 5-72	des. D-JP	ETR_291612

4.4. FAFEN and JERER alluvial water table

4.4.1. Reservoir

Between DEGAHBOUR and the last alluvial depression, the FAFEN and JERER alluvia occupy approximately 2.000 km2. They are scarcely developed from DEGAHBOUR to FANHAD where they form a narrow strip resting on the KEBRI DAHAR limestone, and are well represented South of FANHAD in large alluvial plains on the main gypsum formation.

These alluvia are 15 m thick at KEBRI DAHAR and probably approximately the same in all the valley.

The alluvial deposits present at the surface variable lithologic compositions depending on their location. To the North of FANHAD, they consist of red sandy silt mainly deposited by local temporary rivers. In the plains between FANHAD and KORAHE, grey or yellowish-grey sandy silt from the FAFEN predominate. These deposits are usually permeable and consequently allow the formation of a suitable reservoir. In the plain South of KORAHE and in the DOBAWEIN plain, brown and more clayey alluvial deposits probably form a poor reservoir.

Finally, in the last depression or IGLOLE plain, grey or red saline alluvial deposits form a poor reservoir. These reservoirs are usually mainly recharged by local overland runoff.

North of KORAHE, there is practically no flooding by the FAFEN, but local temporary rivers flood the alluvial plain. The seasonal floodings in the alluvial plain are considerable, from the JERER FAFEN junction down to the South of SHEKOSH.

South of KORAHE, the alluvial water table is mainly recharged by the FAFEN floods which disappear by overland runoff in the basin South of KORAHE and in the DOBAWEIN basin. Certain parts of the basins are also flooded by local temporary rivers.

4.4.2. Piezometric levels

Many wells which are mainly used for the watering of livestock catch the FAFEN alluvial water table. They are often directly dug into the beds of the FAFEN and JERER. These wells are shallow and the bottom corresponds to the lowest level of the piezometric surface. Generally grouped in areas where surface water is abundant, some of these wells dry up between the recharging periods. The following list indicates the most important wells classed according to the location areas :

a) JERER and FAFEN valley before the junction of these rivers

- DEGAHBOUR (8°12' N - 43°33' E).

Many wells are dug in the JERER bed or on the banks. Four masonry wells located on the banks are 8 to 10 m. deep. The wells in river beds are 3 m. deep.

- BULALE (7°54' N - 43°47' E)

Three groups of wells corresponding to a 15 meters' mean depth are dug in the JERER bed.

- SESEBENE (7°52' N - 43°41' E)

These wells located in the FAFEN bed have a mean depth of 3 m. They are dug deeper in proportion as the water table declines.

b) FAFEN valley situated between the FAFEN-JERER junction and the KEBRI DAHAR plain

- HANANNLEY (7°40' N - 43°48' E)

Not very deep wells are dug in the bed at the FAFEN-JERER junction.

- BIRCOT (7°37' N - 43°47 E)

The mean depth of the wells in the FAFEN bed and on the bank is 7 meters.

- GALADINE (approximate coordinates : 7°00'N - 44°10' E)

This well is located 58 kilometers to the North of KEBRI DAHAR and 2 kilometers away from the FAFEN in the alluvial plain. It is 20 m. deep.

c) KEBRI DAHAR alluvial plain

- KEBRI-DAHAR (6°44' N - 44°17' E)

Numerous wells are dug in the bed and on the banks of the FAFEN and some of them are masonry wells. Their mean depth varies from 10 to 15 meters depending on their location.

The KEBRI DAHAR town well is 30 m. deep and is recharged by the alluvial water table as well as by the subjacent limestone aquifer.

- KORAHE (6°35' N - 44°22' E)

The depth of wells in the FAFEN bed varies, according to their location, from 6 to 15 m.

d) FAFEN water spreading plains (South of KORAHE and DOBAWEIN)

- MAHARATO (6°29'N - 44°26' E)

The mean depth of the wells in the water spreading Basin South of KORAHE is 8 m.

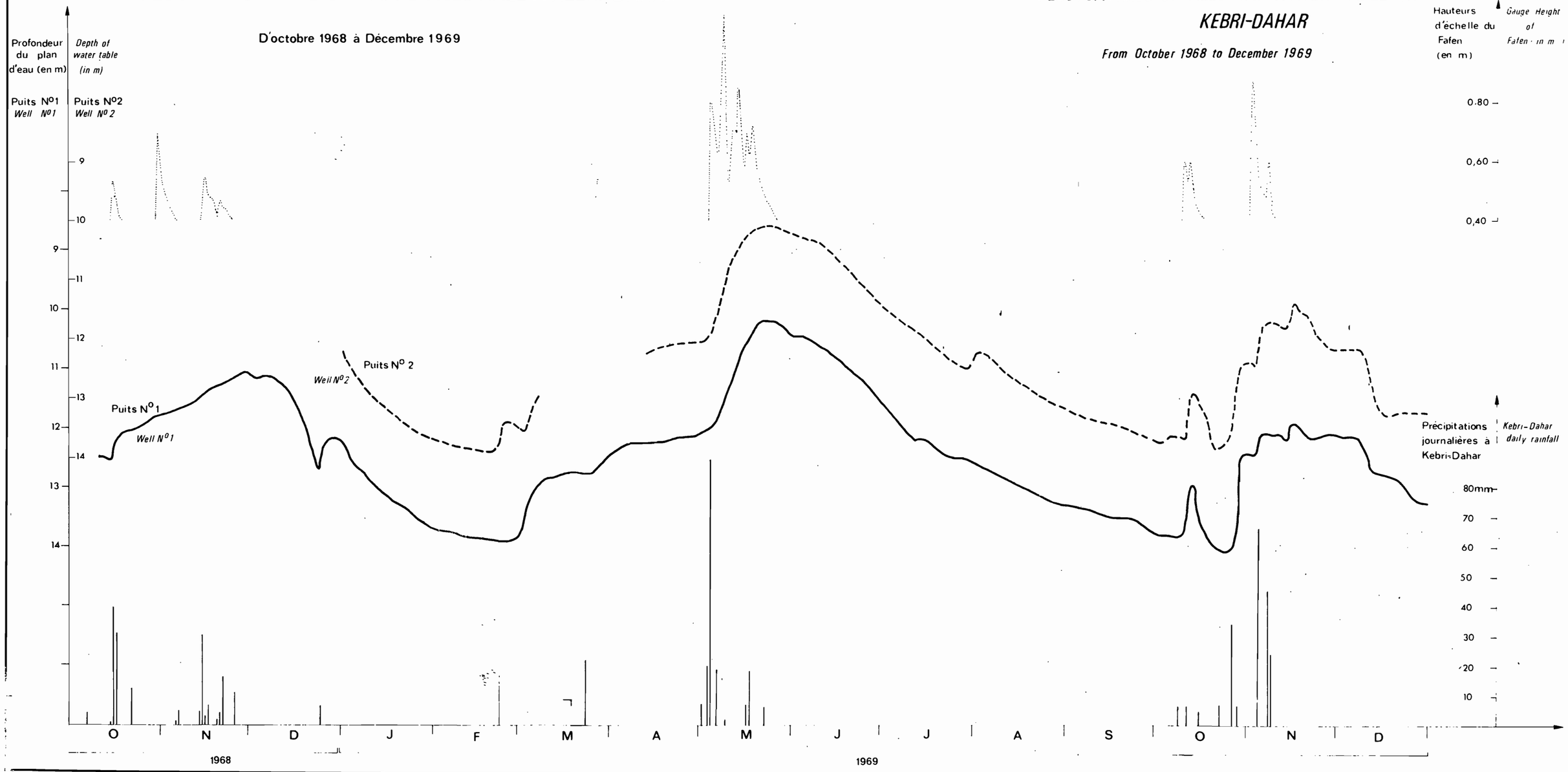
Gr_23

FLUCTUATIONS DE LA NAPPE ALLUVIALE A KEBRI-DAHAR

D'octobre 1968 à Décembre 1969

FLUCTUATIONS OF ALLUVIAL WATER TABLE IN KEBRI-DAHAR

From October 1968 to December 1969



O.R.S.T.O.M. Service Hydrologique	date	des.	ETR-291613
	6-72	D. JP	

Gr_24

FLUCTUATIONS DE LA NAPPE ALLUVIALE A KEBRI-DAHAR

FLUCTUATIONS OF ALLUVIAL WATER-TABLE IN KEBRI-DAHAR

De Janvier 1970 à Février 1971

From January 1970 to February 1971

Profondeur du plan d'eau (en m) / *Depth of water-table (in m)*

Puits N°1 / *Well N°1*

Puits N°2 / *Well N°2*

9 10 11 12 13 14

Puits N°2 / *Well N°2*

Puits N°1 / *Well N°1*

Hauteurs d'échelle du Faten (en m) / *Gage Height of Faten (in m)*

1,00 0,80 0,60 0,40

Précipitations journalières à Kébri_Dahar / *Kebri-Dahar Daily rainfall*

50mm 40mm 30mm 20mm 10mm

J F M A M J J A S O N D J F

1970 1971

O.R.S.T.O.M. Service Hydrologique	date 6-72	des. D-JP	ETR-291614

- GHIR D'HALE (6°12' N - 44°23' E)

40 wells ; 8,50 m to 9 m deep in DOBAWEIN Basin

- GOBLE (6°09' N - 44°21' E)

10 permanent wells in DOBAWEIN Basin

- MAHARRIS (6°07' N - 44°21' E)

3 permanent wells in DOBAWEIN Basin.

The piezometric variations of the water table were observed at KEBRI DAHAR in two observation wells very near each other and located on the FAFEN banks. The daily fluctuations of the water table for the period : November 1968 to February 1971 are represented on graphs n° 23 and n° 24. On these graphs are also noted the water levels of the FAFEN as well as the rainfall for the same period at the KEBRI DAHAR rainfall station.

The water table recharging periods correspond to the flow periods of the FAFEN and the amplitude of these recharges depend on the number of days of flow.

The same observation was made on the DEGAHBOUR and KORAHE wells.

- At DEGAHBOUR, the recovery of the piezometric level was 3,02 m between February and June 1970.

- At KORAHE, the recovery exceeded 6 meters during the same period.

Consequently, the FAFEN alluvial water table is shallow and is mainly recharged by the FAFEN and its tributaries. Owing to the considerable interannual irregularity of the FAFEN regime of flow, the storage varies from one period to another.

The permeability of alluvial deposits probably also varies considerably. In the KEBRI DAHAR region, the relative swiftness of the lag-time of the water table to the FAFEN flood shows that the diffusivity is suitable and consequently, permeability is good. This permeability is probably lower in flood basins covered with a more clayey material.

A pumping test carried out in the KEBRI DAHAR town well during the recharging period (May 31.1970) gave the following results :

Pumping period	: 7 hours
Initial yield	: 6 m3/h
Final yield	: 5,1 m3/h
Drawdown at the end of pumping	: 1,16 m
Recovery period observed	: 3 h
Drawdown afer recovery observed	: 0,59 m

TABLE N° 8

WATER ANALYSIS OF THE FAFEN AND JERER ALLUVIAL WATER TABLE (in mg/l)

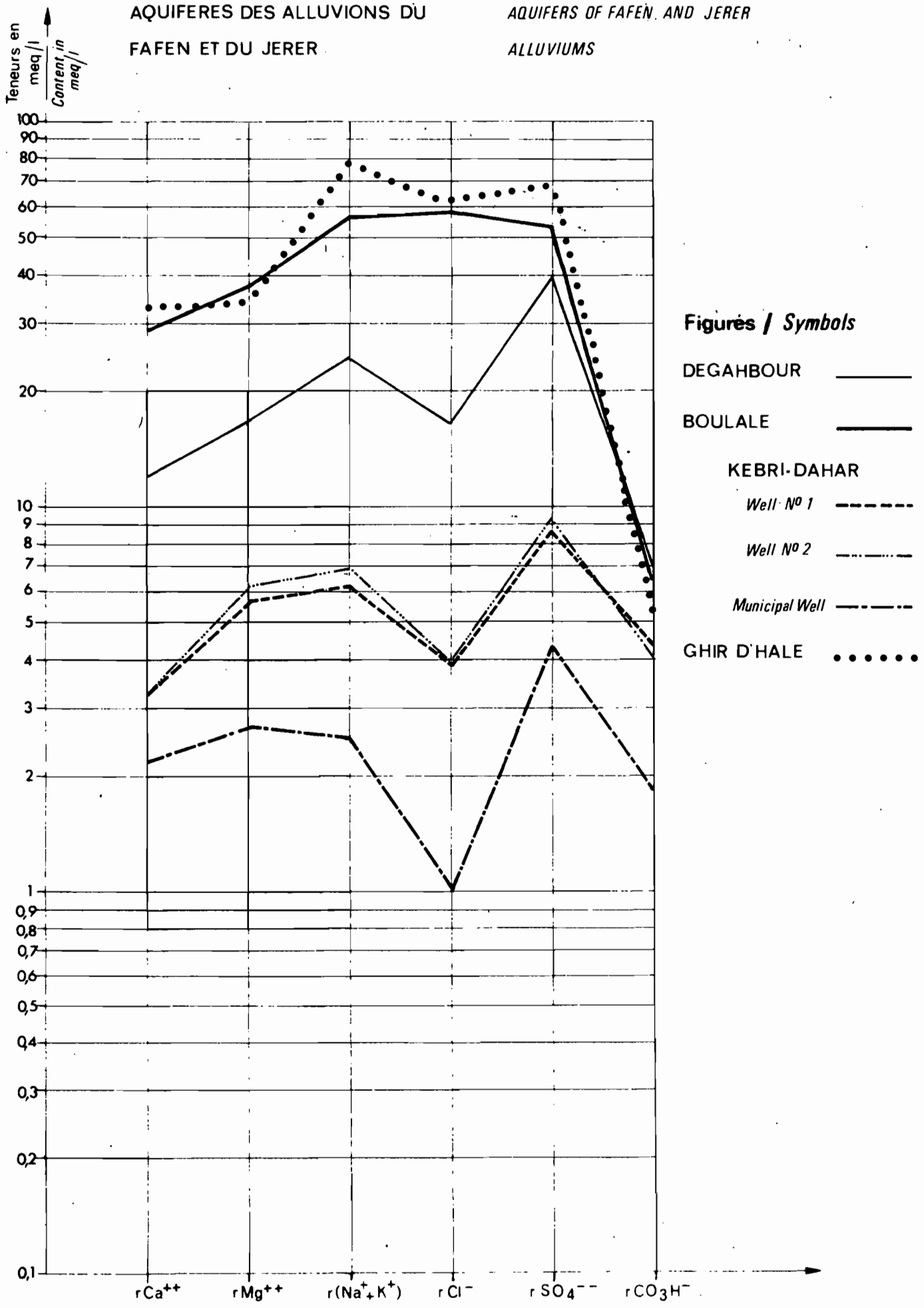
Location	Coordinates	Date of sampling	Conductivity in mmhos/cm	Total salinity gr/l	pH	CO_3H^-	Cl^-	$SO_4^=$	K^+	Na^+	Ca^{++}	Mg^{++}
DEGAHBOUR	8°12' N 43°33' E	17.2.70 4.6.70	5,3 4,0	4,0 3,8	7,8	347	590	1 900	19	550	256	206
BULALE	7°54' N 43°47' E	12.1.68	10,3	7,7	7,9	393	2 127	2 134	56	1 280	580	440
KEBRI-DAHAR TOWN-WELL n° 1	6°44' N 44°17' E	15.2.70 May 1970	3,0 1,7	2,3 1,0	7,6	224	138	420	15	133	65	69
KEBRI-DAHAR TOWN-WELL n° 2	6°44' N 44°17' E	15.2.70 May 1970	4,6 1,6	3,5 1,1	8,0	206	139	450	15	150	64	76
KEBRI-DAHAR TOWN-WELL	6°44' N 44°17' E	May 1970	0,81	0,45	7,6	92	37	210	7	52	45	33
KORAHE	6°35' N 44°22' E	14.2.70	3,5	2,6								
GHIR D'HALE	6°12' N 44°23' E	9.2.68	11,2	9,5	7,8	317	2 200	3 252	100	1 800	660	415

DIAGRAMME D'ANALYSES D'EAUX / *WATER ANALYSIS DIAGRAM*

Gr_25

AQUIFERES DES ALLUVIONS DU FAFEN ET DU JERER

AQUIFERS OF FAFEN AND JERER ALLUVIUMS



The values of the transmissivity and of the storage coefficient cannot be determined accurately as the discharge was not constant during the test. Nevertheless one may say that the alluvial deposits are not very transmissive owing to their thinness which is an unfavourable factor for the formation of an important aquifer.

4.4.3. Geochemistry of the water-table

The results of water analysis grouped in table N° 8 are obtained from the sampling carried out during three different periods.

Samples were taken at BULALE and GHIR D'HALE in February 1968 (dry season).

The other samples were made in February 1970 (dry season) and in May 1970 (end of the rainy season). Only conductivity measurements were carried out on the samples of February 1970.

Conductivities

The measured conductivities are very high during the dry season (February). They vary from 3, mmhos/cm at KEBRI DAHAR to 11,2 mmhos/cm at GHIR D'HALE. The corresponding total salt contents vary from 2,3 gr/l to 9,5 gr/l. No conductivity gradient was observed in the valley, which indicates that there is scarcely no movement of water and that the variable salinity is linked to the composition of alluvial deposits.

The recharging of the water table during the two annual rainfall seasons is the cause of a general decrease of concentrations. The conductivities measured in May-June vary from 40 mmhos/cm at DEGAHBOUR to 0,81 mmhos/cm at the KEBRI DAHAR town-well. The salt concentration in the water table consequently varies in time and space and depends on two main factors, namely :

- the lithologic nature of alluvial deposits and catchment basins.

- the length of the recharging period of the water table. Besides, the results of analysis reveal that the quality of water is better in the KEBRI DAHAR plains, whereas it is poor in the DOBAWEIN alluvial basin and in the JERER alluvia.

- Ionic contents (graph N° 25)

In general, the waters have the same chemical facies. They are sodic sulphated and magnesian waters :

$$r\ SO_4 > r\ Cl > r\ CO_3H \text{ and } r\ Na > r\ Mg \quad r\ Ca$$

During the water table recharging period, sulphates are dominant ; the ratio $\frac{r\ SO_4}{r\ Cl}$ varies from 2,3 to 4,3.

During the dry season the chloride content is greater. The $\frac{r\ SO_4}{r\ Cl}$ ratio is 0,8 at BULALE and 1,1 at GHIR D'HALE.

The increasing salt content and the variations of ionic contents between the rainy and dry seasons, show that the water table is recharged by sulphated water loaded with chloride in the reservoir.

4.4.4. General conclusions

The FAFEN alluvia contain an uninterrupted but not very deep aquifer, the storage of which is not considerable and depends on the more or less abundant seasonal recharging by the FAFEN and its tributaries.

The water quality varies according to the duration of the recharging period and to the lithological nature of the alluvial material and of the catchment basins.

The quality of water is very poor North of KEBRI DAHAR and in the depressions stretching South of KORAHE. It improves in the water spreading plain which stretches from FANHAD to KORAHE.

This aquifer is nevertheless very suitable for livestock breeding purposes. In order to obtain sufficient available yields it would be necessary to dig a great number of deep enough wells to catch the alluvial aquifer right down to the bed-rock.

4.5. Local ground water of alluvial deposits and spreading basins

4.5.1. Reservoirs

The geomorphology of the OGADEN valley with alluvial plains due to narrowings and faults and the formation of the water spreading basins at the outlet of endhoreic rivers, enables to locate small hydrogeologic basins containing shallow ground water.

The lithology of these basins, covered with recent locally formed or scarcely transported sediments, is directly linked to the nature of sub-jacent rocks.

These particularized hydrogeologic basins are recharged by flood water and overland runoff. In certain cases, they may also be recharged by the limestone aquifer. The storage is often limited and varies according to the importance of the reservoir and to the surface of the catchment basin. Many of these aquifers are only temporary and dry up the rest of the year.

The water spreading basins with a shallow aquifer are mainly located in soft gypsum formations or on the marly limestone outcrops which constitute the top of the KEBRI DAHAR limestone formation. On this massive limestone, ground water mainly concentrates in local alluvia of temporary rivers.

4.5.2. Observation points and piezometric levels

The piezometric fluctuations of the aquifers of water spreading or alluvial basins essentially depends on the regime of overland flow. Consequently, they are linked to the regime and abundance of local rainfall.

As for the FAFEN alluvial water table, the aquifers are recharged twice a year during the rainy seasons.

Table N° 9 sums up the observations made on the main wells before and after the first rainy season of 1970.

The recoveries of the piezometric level between February and June 1970 are variable and affect all the wells except the TUCUB, BUBE and DOURRE wells where, on the contrary, the piezometric level declines during the same period.

Seasonal recharging of the water tables depends on the spatial distribution of rainfall and are consequently very irregular.

4.5.3. Geochemistry of ground water

The water quality is in relation to the lithology of catchment basins, alluvia and depressions which provide sediments as well as runoff water.

The results of water analysis grouped according to the geological nature of the substratum are given in table N° 10.

Conductivities and salt contents

The conductivities observed greatly vary according to the hydrogeologic basins and to the date of sampling but they are always relatively high.

On the KEBRI DAHAR limestone substratum during the low flow period (January-February), the total measured salt contents vary from 0,9 gr/l (DEGAH-MEDO WELL) to 4,2 gr/l (SEGEG well).

On the main gypsum formation, conductivities are higher : from 2,4 gr/l (DUHUN) and 12,1 gr/l (MERERALE).

These salinities are usually lower during the water table recharging period.

Ionic composition

The distribution of salts also depends on the nature of sediments and on the period of the year.

Graphs N°26, 27, 28 and 29 represent the ionic compositions.

The water of the alluvia or depressions formed on the KEBRI DAHAR limestone have different compositions depending on their location.

TABLE 9

PIEZOMETRIC LEVELS OF LOCAL ALLUVIAL OR DEPRESSION WATER TABLES

Well	Coordinate	Type of reservoirs	Nature of substratum	Depth of well from ground (in meters)	Piezo-level (in meters) February 1970	Piezo-level (in meters) May-June 1970	Variations of water table from February to June 1970
DEGAH-MEDO	7° 58 N 43°01'E	SULLUL alluvium	KEBRI-DAHAR limestone	15,38	12,90	12,28	+ 0,62
SEGEG	7°40'N 42°50'E	SULLUL alluvium	KEBRI-DAHAR limestone	0,80	0,57	0,50	+ 0,07
DADIN	6°40'N 44°11'E	Water-spreading basin	KEBRI-DAHAR marly-limestone	-	3,10	0	+ 3,10
DALAD	6°37'N 44°06'E	Water-spreading basin	KEBRI-DAHAR marly-limestone	8,25	6,15	4,78	+ 1,37
KAPTINAG	6°34'N 43°55'	Temporary river alluvium	KEBRI-DAHAR marly-limestone	2,50	1,50	+ 0,10	+ 1,60
EL HAR	6°46'N 44°27'E	Water-spreading basin	main gypsum	13,91	12,06	-	-
MERERALE	6°36'N 44°31'E	Water-spreading basin	main gypsum	8,09	7,20	6,50	+ 0,70
DAMBE ROUENE	6°30'N 43°37'E	Temporary river alluvium	main gypsum	1,60	1,40	-	-

TABLE N° 9 (continued)

PIEZOMETRIC LEVELS OF LOCAL ALLUVIAL OR DEPRESSION WATER-TABLES

Well	Coordinates	Type of reservoirs	Nature of substratum	Depth of well from ground (in meters)	Piezo-level (in meters) February 1970	Piezo-level (in meters) May-June 1970	Variations of water tables from February to June 1970
DANAN	6°30'N 43°29'E	Temporary river alluvium	main gypsum	2,90	2,80	1,27	+ 1,53
SHILILE	6°41'N 43°32'E	Water spreading basin	main gypsum	7,70	5,90	4,95	+ 0,95
ADEYA	6°13'N 43°36'E	Water spreading basin	main gypsum	2,65	2,15	1,00	+ 1,15
DUHUN	7°13'N 42°42'E	Temporary river alluvium	main gypsum	7,18	7,08	3,88	+ 3,20
TUCUB	7°03'N 42°44'E	Temporary river alluvium	main gypsum	1,73	1,23	1,70	- 0,47
EL FUD	7°15'N 42°52'E	Temporary river alluvium	main gypsum	4,47	3,69	-	-
BUBE	6°39'N 44°35'E	Water spreading basin	JESSOMA sandstone	15,73	5,34	8,15	- 2,81
DOURRE	6°39'N 44°39'N	Water spreading basin	JESSOMA sandstone	19,86	12,05	16,06	- 4,01
FERFER	5°05'N 45°05'E	Temporary river alluvium	FERFER gypsum	-	1,79	0,55	+ 1,24

TABLE 10

WATER ANALYSIS OF ALLUVIAL AND DEPRESSION WATER-TABLES (in mg/l)

Nature of substratum	Well	Date of sampling	Conductivity in mmhos/cm	Total salinity gr/l	pH Labo	CO_3H^-	Cl^-	SO_4^-	K^+	Na^+	Ca^{++}	Mg^{++}
I. KEBRI-DAHAR limestone	DEGAH-MEDO	20.2.70	1,2	0,9								
		4.6.70	2,3	1,7	8,5	515	108	550	3,1	485	6	19,5
	SEGEG	16.1.68	5,6	4,2	8,2	317	1 728	658	25	855	140	232
		21.2.70	4,2	3,2								
		4.6.70	11,3	8,4	7,9	134	2 700	3 050	20,5	1 950	196	445
	DADIN	4.2.70	2,6	2,0								
	DALAD	4.2.70	2,7	2,1								
		4.6.70	2,4	2,6	7,4	80	28	1 800	25,6	19	655	48
	KAPTINAG	4.2.70	3,3	2,5								
II. Main gypsum	EL HAR	13.1.68	14,7	11,1	7,8	830	2 340	3 336	103	1 530	740	378
	MERERALE	11.1.68	17,2	12,1	7,7	378	3 990	2 780	103	1 865	840	658
		14.2.70	15,7	11,9								
		20.7.70	11,2	8,8	7,7	160	3 130	2 650	352	1 435	700	452
	DANAN	23.2.70	3,4	2,7								
		2.6.70	2,6	2,7	7,4	44	41	1 850	21,4	30	655	78
	SHILILE	2.6.70	5,2	4,4	7,7	232	630	2 600	18,7	338	670	345
	ADEYA	23.2.70	6,4	4,9								

TABLE 10 (continued)

WATER ANALYSIS OF ALLUVIAL AND DEPRESSION WATER-TABLES (in mg/l)

Nature of substratum	Well	Date of sampling	Conductivity in mmhos/cm	Total salinity gr/l	pH Labo	CO_3H^-	Cl^-	SO_4^-	K^+	Na^+	Ca^{++}	Mg^{++}
	DUHUN	21.2.70	3,2	2,4								
		3.6.70	2,7	2,5	7,2	104	17	1 650	10,4	18,5	615	50
	TUCUB	22.1.68	11,6	9,8	7,9	354	1 914	3 670	52	1 500	660	512
III. JESSOMA limestone	BUBE	14.2.70	5,3	4,0								
		29.5.70	2,2	1,9	8,3	296	128	870	140	80	305	49
	DOURRE	14.2.70	3,0	2,3								
		29.5.70	2,7	2,6	7,3	310	62	1 350	25,6	39	710	50
IV. FERFER gypseum	FERFER	11.2.70	3,7	2,8								
		27.5.70	2,7	2,7	7,3	51	115	1 750	18,6	53	685	59

- The water contained in sediments derived from the KEBRI-DAHAR limestone presents different facies according to the period of the year.

During the water table recharging period, water is usually sulphated, calcic and magnesian.

During the minimum flow period of the water table (high conductivities) the chloride content increases. Sodic chloride or sodic-chloride sulphated water can then be observed.

4.5.4. General conclusions

The local water tables of alluvia and water spreading basins only contain localized and not very considerable ground water storage.

These reservoirs are very irregularly recharged as they essentially depend on local rainfall conditions.

Moreover, they are characterized by usually high salt contents due to the presence in the catchment basin of gypsum material.

Negligible yields may only be expected from these water-tables and they can only be used for local pastoral needs.

4.6. Ground water of the main gypsum formation

4.6.1. Reservoir

The main gypsum formation occupies a large area in OGADEN (approximately 40.000 km2) and plays an important role as regards the regime and quality of ground water.

The clayey and marley layers form the impervious substratum of alluvial or depression water tables and of the MUSTAHIL aquifer. They contaminate all the surface water and ground water to the South West of the line : KORAHE - DANAN - DUHUN.

This impervious formation generally includes limestone or dolomitic intercalations which form interstratified aquifers with confined flow and containing saline water.

4.6.2. Piezometric levels

The presence of confined aquifers in the gypsum was revealed in two deep wells located in the Air Force camp of GODE.

In well n° 1, which is 80 m deep, the mean piezometric level is 15 meters below the ground surface.

In well n° 2, 140 m deep, the mean piezometric level is 5m. below ground.

DIAGRAMME D'ANALYSES D'EAUX / *WATER ANALYSIS DIAGRAM*

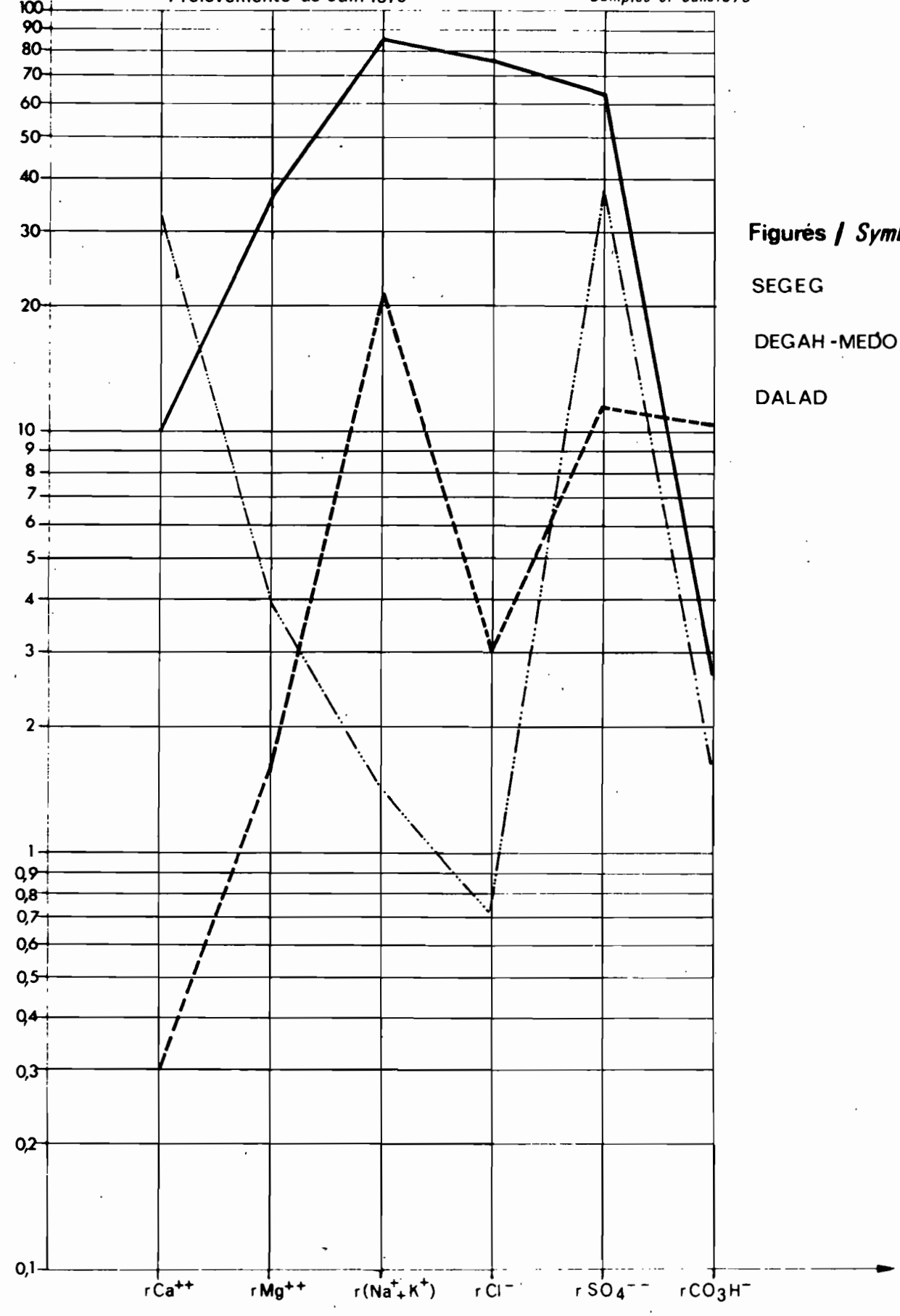
Gr_26

AQUIFERES DE DEPOTS LOCAUX
SUR CALCAIRES DE KEBRI-DAHAR

AQUIFERS OF LOCAL DEPOSITS
ON KEBRI DAHAR LIMESTONE

Teneurs en meq/l / *Content in meq/l*

Prélèvements de Juin 1970 — *Samples of June 1970*



Figurés / *Symbols*

SEGEG ——————

DEGAH-MEDO – – – – –

DALAD —·—·—·—

O.R.S.T.O.M. Service Hydrologique	date	des.	ETR – 291616
	5-72	D-JP	

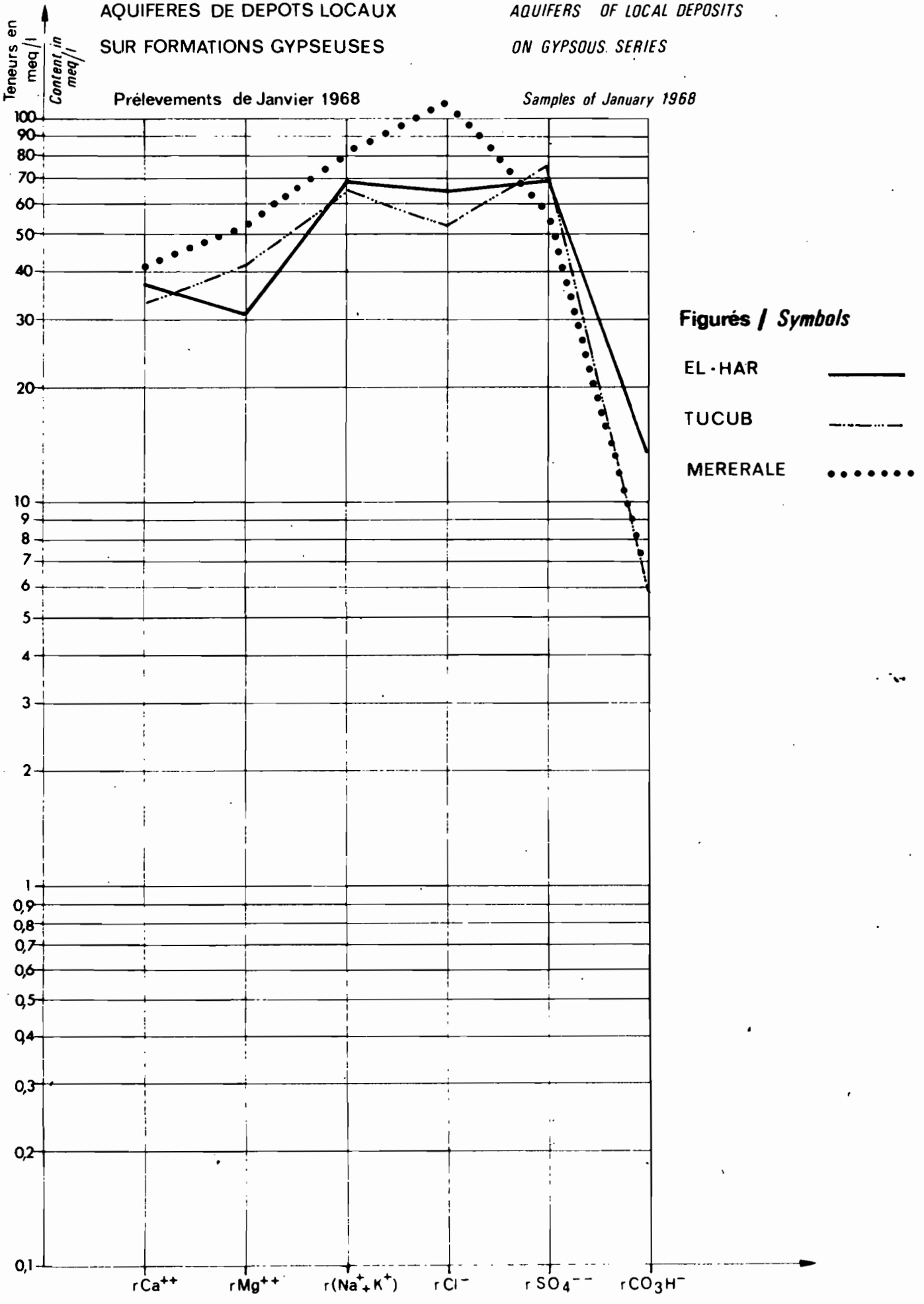
DIAGRAMME D'ANALYSES D'EAUX / *WATER ANALYSIS DIAGRAM* | Gr_ 27

AQUIFERES DE DEPOTS LOCAUX
SUR FORMATIONS GYPSEUSES

AQUIFERS OF LOCAL DEPOSITS
ON GYPSOUS SERIES

Prélevements de Janvier 1968

Samples of January 1968



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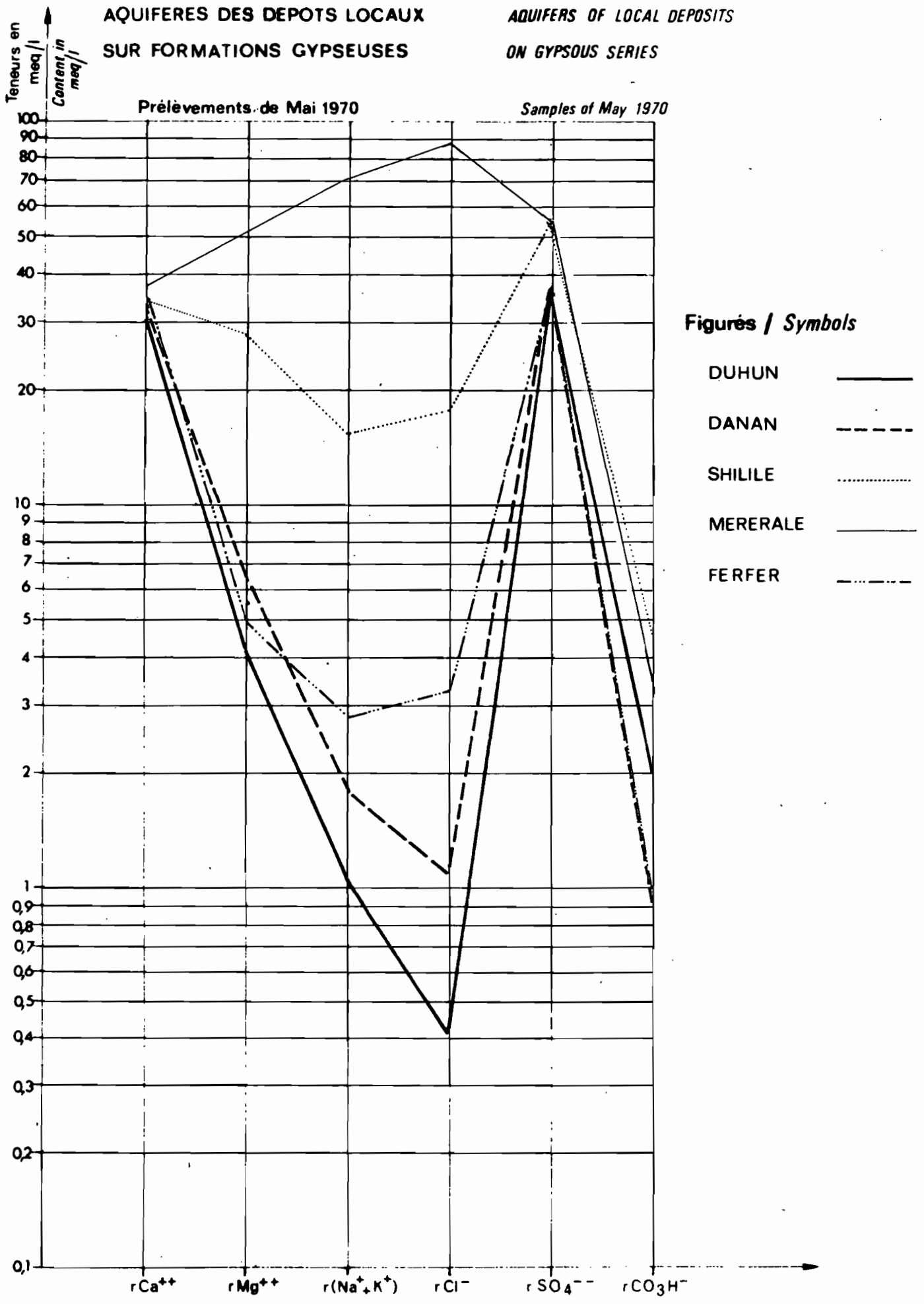
	5-72	D-JP	

DIAGRAMME D'ANALYSES D'EAUX / *WATER ANALYSIS DIAGRAM*

Gr. 28

AQUIFERES DES DEPOTS LOCAUX
SUR FORMATIONS GYPSEUSES

AQUIFERS OF LOCAL DEPOSITS
ON GYPSOUS SERIES



O.R.S.T.O.M. Service Hydrologique	date	des.	ETR- 291618
	5-72	D-JP	

DIAGRAMME D'ANALYSES D'EAUX / *WATER ANALYSIS DIAGRAM*

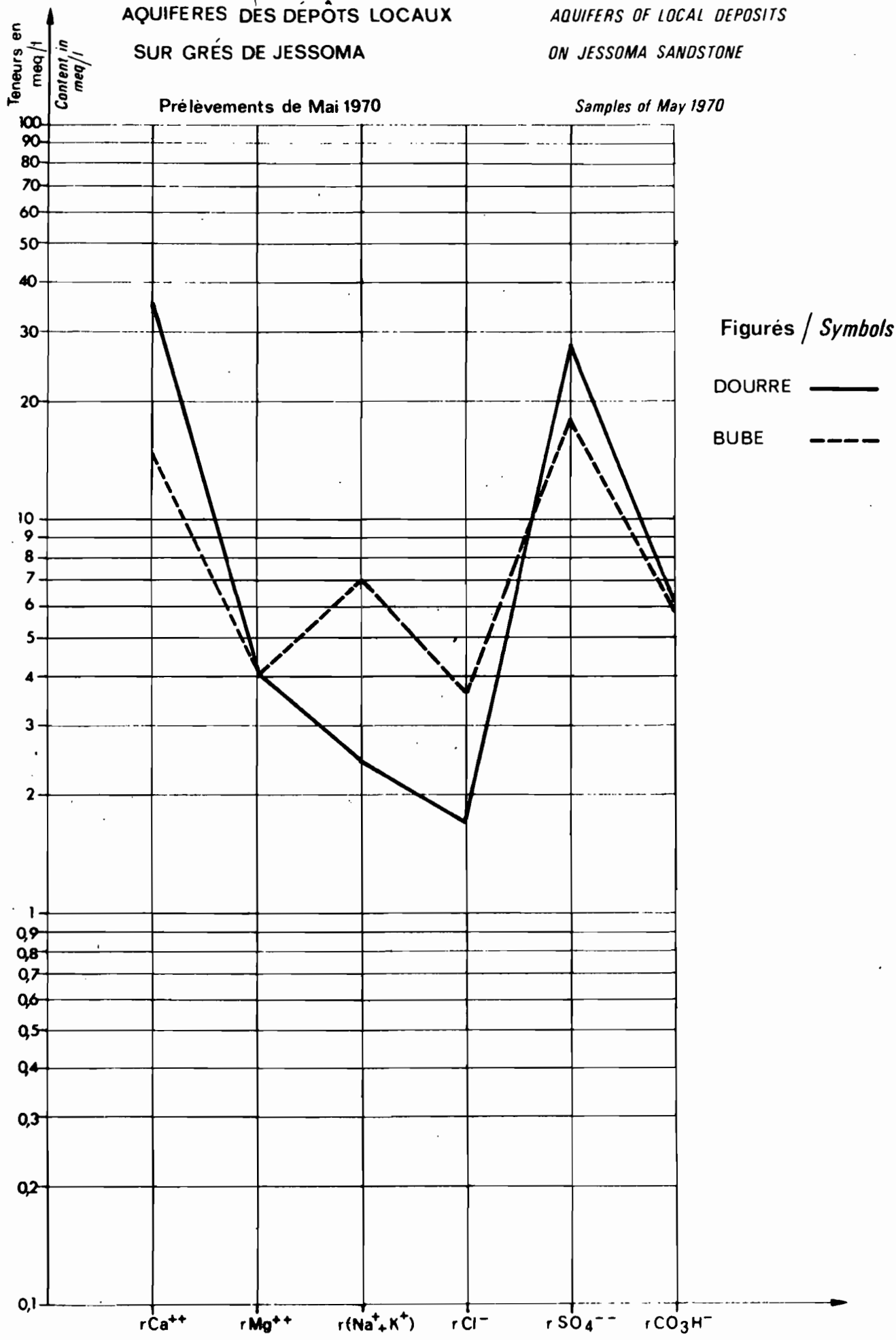
Gr_ 29

AQUIFERES DES DÉPÔTS LOCAUX SUR GRÉS DE JESSOMA

AQUIFERS OF LOCAL DEPOSITS ON JESSOMA SANDSTONE

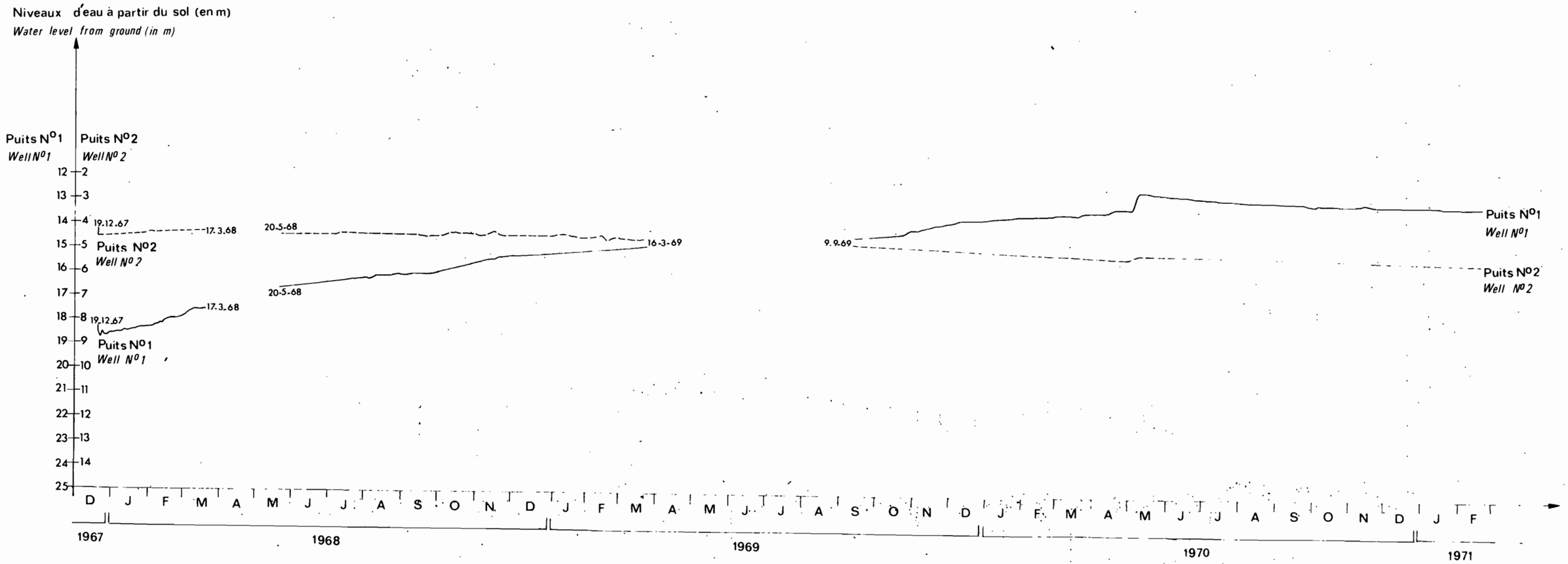
Prélèvements de Mai 1970

Samples of May 1970



FLUCTUATIONS DES NIVEAUX D'EAU DANS LES GYPSES PRINCIPAUX A GODE

WATER TABLE FLUCTUATIONS IN MAIN GYPSUM FORMATION IN GODE



O.R.S.T.O.M. Service Hydrologique	date	des.	ETR- 291620
	6-72	D-JP	

Well N° 2 was continued down to a 250 m depth and the piezometric level was observed at 20,5 m below ground.

The main gypsum formation contains a series of more or less confined water tables which are isolated by impervious beds.

Piezometric fluctuations were observed on both wells during the period from December 1967 to January 1971 with two interruptions : from March 17 to May 20, 1968, and from March 16 to September 9. 1969 (see graph N°30).

It is to be noted that the water tables are subject to pluriannual variations certainly linked to the alternating rainfall cycles.

The transmissivity of these aquifers is very low. According to the documents of the Water Resources Department, the SHILAVO well which cuts through these formations gave an insignificant available yield of 30 m3 per day.

4.6.3. Geochemistry of ground water

Sampling was carried out in both GODE wells. The results of analysis (in mg/l) are as follows :

Wells	Conductivity in mmhos/cm	Total salinity in gr/l	pH	CO_3H^-	Cl^-	SO_4^{--}	K^+	Na^{++}	Ca^{++}	Mg^{++}
GODE N° 1	39,2	40,9	6,6	97	21.600	3.900	160	13.300	1.175	710
GODE N° 2	23,3	19,0	6,9	160	8.800	3.500	95	5.075	787	575

Owing to the high soluble salt content in the reservoir (Cl Na and SO_4Ca) water is saturated with salt. Total dissolved solids correspond to 40 gr/l.

This water being mainly loaded with chlorides and sulphates cannot be utilized at all.

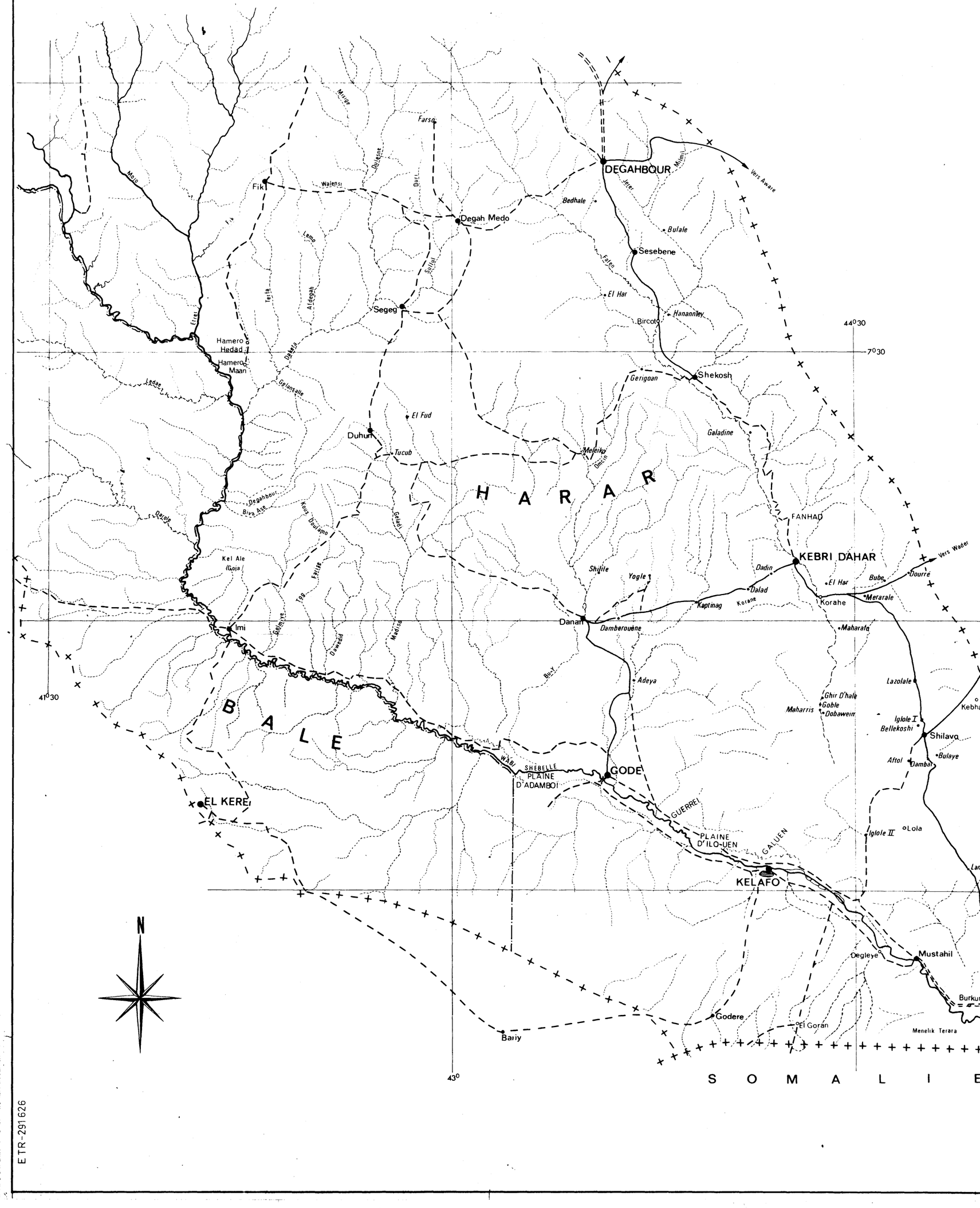
4.6.4. General conclusions

The main gypsum formation contains interstratified confined aquifers with a very low transmissivity. These waters are saturated with soluble salts and are consequently absolutely useless.

Gr- 31

Carte générale de l'OGADEN

General map of OGADEN



LEGEND / LÉGENDE

Limit of state	+ + +	Limite d'état
Limit of province	_____	Limite de province
Limit of study	– + –	Limite de l'étude
Capital of sub province	● GODE	Chef lieu de sous province
Capital of district	● Duhun	Chef lieu de district
Village	○ Dagal	Village
Wells	• Bulaye	Puits
Permanent river	~~~~	Cours d'eau permanent
Temporary river	.....	Cours d'eau intermittent
Main road	═══	Route principale
Secondary road	=======	Route secondaire
Main track	———	Piste principale
Secondary track	- - - - -	Piste secondaire

ETR-291626

CONCLUSION

The studies undertaken by the Franco-Ethiopian hydrogeological team from 1969 to 1971, enabled, on the one hand, to acquire a more accurate knowledge of the regional lithology : maps at 1/250 000 and at 1/1000 000, and on the other hand, to establish a first estimate of the aquifer (from a more qualitative point of view) as well as of the utilization possibilities.

The main gypsum formation is thick and largely extended but confined ground water is too saline to be utilized. Besides it contaminates the small tempory aquifers of alluvial basins and of the MUSTAHIL limestone.

This MUSTAHIL limestone aquifer is not well recharged (low rainfall) and not very important, nevertheless, it could be utilized for the watering of livestock despite its high salt content.

Alluvial water tables do not either constitute considerable storage aquifers, whether in the FAFEN Valley or in the WABI SHEBELLE Valley : this recharging is linked to floods and is only really important in the KELAFO-MUSTAHIL plain. Though the quality of these waters is poor, they may be used for pastoral and local needs, like the MUSTAHIL limestone aquifer.

The only important reservoir in OGADEN is that of the KEBRI DAHAR limestone. Unfortunately its fault system is not so well developed as was expected at first, and its water is loaded with salts, especially when the limestone is covered with the main gypsum formation (South East of OGADEN). Elsewhere the quantity of salts is not so great ; this water is available and a more important yield than that of the other acquifers may be expected. However, the expense will be high owing to the depth (below 200 meters) required for intake.

Geophysical studies and other bore holes are necessary in order to know with some accuracy the conditions for a maximum yield of the KEBRI DAHAR limestone aquifer.

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1 1972 - "Explicative note of the geological map of OGADEN at the scale of 1/250.000"
ORSTOM - PARIS - Multigr. 7 p. + 1 graph.

2 1972 - "Explicative note of the geological map of the WABI SHEBELLE basin at the scale of 1/1.000.000.
ORSTOM - PARIS - Multigr. 8 p. + annexe.

3 AUROUZE (J.) 1968 - "Hydrogeological reconnaissance in OGADEN
Mission report - January - February 1968
ORSTOM - PARIS - Multigr. 9 p.

4 CASTANY (G.) 1969 - "Report of the mission carried out from July 4 to July 23. 1969.
Hydrogeological description of the OGADEN basin".
Multigr. 46 p. + annexes + 11 maps.

ANNEX

WELL CARD FILE

The well card-file groups the water points where measurements were carried out. For each of these, a well card index was established with the following informations :

- Location and characteristics

- Measurements of levels

- Results of chemical analysis.

These wells are generally used for the watering of livestock and are often grouped together in a same area. In some watering points, more than a 100 wells were numbered. When such is the case, one or two observation wells are selected in the considered area.

Wells which are dug manually are generally not very deep. Water is drawn by means of pots and leather bottles. Some of the wells are propped by logs down to a certain depth. Masonry wells are unfrequent.

Only several wells (KEBRI DAHAR - SHEKOSH) are equipped with a pumping installation.

The water points of the file were grouped for each aquifer, following the classification method used in the present study.

Thirty six observation-wells were thus inventoried and described in this file.

MISSION D'ÉTUDES DU WABI-SHEBELLE - *Wabi-Shebelle project*

FICHE DE PUITS - *WELL CARD-INDEX N° 1*

1 - LOCALISATION DU PUITS - *WELL LOCATION*

Nom du lieu :
S H E K O S H

Name of place:

Coordonnées :
Latitude : 7° 30' N
Longitude : 43° 47' E

Coordinates :

Numéro du puits :

Well number :

Situation : Sur la piste KEBRI-DAHAR - DEGAHBOUR, à 93 km de KEBRI-DAHAR

On KEBRI-DAHAR - DEGAHBOUR road, 93 km from KEBRI-DAHAR

2 - CARACTÉRISTIQUES DU PUITS - *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
0

Height of curb or casing to the ground (in m.) :

Diamètre (en m.) :

Diameter (in m.) :

Profondeur totale (en m.) :
140

Total depth (in m.) :

Utilisation : Forage équipé d'une pompe - Population et bétail -

Bore - Hole with pump - Population and cattle

3 - ROCHE AQUIFÈRE - *WATER-BEARING DEPOSIT*

Calcaires de KEBRI-DAHAR

KEBRI-DAHAR limestone

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*

5 - ANALYSES CHIMIQUES (en mg/L) - *CHEMICAL ANALYSIS (in mg/L)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
16-2-70	7,1	4,0	298	865	1 240	320	192	160	164

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi - Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 2*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
B A R G U N

Name of place:

Coordonnées :
Latitude : 5° 26' N
Longitude : 44° 59' E

Coordinates :

Numéro du puits :

Well number :

Situation : Puits italien cimenté à gauche de la route FERFER - SHILAVO, à 50 km de FERFER -
Cemented italian well, on the left of FERFER - SHILAVO road, 50 km from FERFER -

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
0

Height of curb or casing to the ground (in m.) :

Diamètre (en m.) :
1,0

Diameter (in m.) :

Profondeur totale (en m.) :
10

Total depth (in m.) :

Utilisation : Population et bétail
Population and cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Calcaires de MUSTAHIL
MUSTAHIL limestone

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
27- 5-1970	9,66	9,66
19- 7-1970	6,30	6,30
18- 8-1970	9,29	9,29

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
27-5-70		4,1	159	2 000	620	270	176	380	28

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi-Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 3*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
Name of place: L A M M A B A R

Coordonnées :
Coordinates :
Latitude : 5° 34' N
Longitude : 44° 57' E

Numéro du puits :
Well number :

Situation : A gauche de la piste FERFER - SHILAVO, à 66 km de FERFER -
Zone de puits de 150 x 300 m
On the left of FERFER - SHILAVO road, 66 km from FERFER
Well area of 150 x 300 m

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
Height of curb or casing to the ground (in m.) : - 5

Diamètre (en m.) :
Diameter (in m.) : Puits carré de 1 m de côté
Square well of 1 m side

Profondeur totale (en m.) :
Total depth (in m.) : 4,22

Utilisation : Bétail
Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Calcaires de MUSTAHIL
MUSTAHIL limestone

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
11- 2- 1970	4,09	9,09
27- 5- 1970	0,00	5,00
19- 7- 1970	2,40	7,40
18- 8- 1970	4,14	9,14

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
11-2-70	7,2	4,6							
27-5-70		3,1	268	1 720	167	320	64	120	42

MISSION D'ETUDES DU WABI-SHEBELLE _ *Wabi - Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 4*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :

D A N B A R

Name of place:

Coordonnées :

Latitude : 5° 59' N

Longitude : 44° 46' E

Coordinates :

Numéro du puits :

Well number :

Situation : A gauche de la route FERFER - SHILAVO à 125 km de FERFER
Puits italien au milieu de nombreux puits
On the left of FERFER - SHILAVO road, 125 km from FERFER
Italian well among other wells

2 _ CARACTERISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :

+ 3,50

Height of curb or casing to the ground (in m.) :

Diamètre (en m.) :

Trou carré de 1,50 m de côté

Diameter (in m.) : Square well of 1,50 m side

Profondeur totale (en m.) :

4,33

Total depth (in m.) :

Utilisation : Bétail

Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Calcaires de MUSTAHIL

MUSTAHIL limestone

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
12- 2-1970	4,21	7,71
27- 5-1970	-	+0,50 (puits inondé)
19- 7-1970	-	0,60
17- 8-1970	2,50	6,00

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
12-2-70	7,1	5,0							

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi-Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 5*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
S H I L A V O
Name of place:

Coordonnées :
Latitude : 6° 04' N
Longitude : 44° 45' E
Coordinates :

Numéro du puits :
1
Well number :

Situation : Puits principal de SHILAVO situé à 115 km au Sud de KEBRI-DAHAR
Main well of SHILAVO . At 115 km in the South of KEBRI-DAHAR

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
0,50
Height of curb or casing to the ground (in m.) :

Diamètre (en m.) :
2,50
Diameter (in m.) :

Profondeur totale (en m.) :
11,70
Total depth (in m.) :

Utilisation : Population et bétail
Population and cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Calcaires de MUSTAHIL
MUSTAHIL limestone

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
6- 3-1969	11,37	10,87
12- 2-1970	11,71	11,20
27- 5-1970	7,10	6,60
20- 7-1970	8,10	7,60
17- 8-1970	9,28	8,78

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
12-7-70	7,0	6,0							
27-5-70		2,7	54	1 450	114	175	61	72	35

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi - Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 6*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
S H I L A V O
Name of place:

Coordonnées :
Latitude : 6° 04' N
Longitude : 44° 45' E
Coordinates :

Numéro du puits :
2
Well number :

Situation : Zone de puits de 150 x 400 m au N - W du puits municipal de SHILAVO
Wells area of 150 x 400 m , in N - W of municipal well of SHILAVO

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
0
Height of curb or casing to the ground (in m.) :

Diamètre (en m.) :
0;80
Diameter (in m.) :

Profondeur totale (en m.) :
7,50
Total depth (in m.) :

Utilisation : Bétail
Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Calcaires de MUSTAHIL
MUSTAHIL limestone

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
2- 3-1970	7,10	7,10
3- 3-1970	7,00	7,00
4- 3-1970	7,00	7,00

5 - ANALYSES CHIMIQUES (en mg/L) - *CHEMICAL ANALYSIS (in mg/L)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi-Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 7*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
Name of place: SHILAVO

Coordonnées :
Coordinates :
Latitude : 6° 04' N
Longitude : 44° 45' E

Numéro du puits :
Well number : 3

Situation : Dans même zone de puits que le puits de SHILAVO n° 2
In the same well area as SHILAVO well n° 2

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) : 0
Height of curb or casing to the ground (in m.) :

Diamètre (en m.) : 0,80
Diameter (in m.) :

Profondeur totale (en m.) : 8,80
Total depth (in m.) :

Utilisation : Bétail
Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Calcaires de MUSTAHIL
MUSTAHIL limestone

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water - level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water - level from ground (in m.)*
2- 3-1970	8,20	8,20
3- 3-1970	8,10	8,10
4- 3-1970	8,10	8,10

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi - Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 8*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
A F T O L
Name of place:

Coordonnées :
Latitude : 5° 59' N
Longitude : 44° 42' E
Coordinates :

Numéro du puits :

Well number :

Situation : Zone de puits située à droite de la piste SHILAVO - KELAFO -
A 11 km de SHILAVO
Well area on the right of SHILAVO - KELAFO road -
11 km from SHILAVO

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
+ 2
Height of curb or casing to the ground (in m.) :

Diamètre (en m.) :
0,70
Diameter (in m.) :

Profondeur totale (en m.) :
11,0
Total depth (in m.) :

Utilisation : Bétail
Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Calcaires de MUSTAHIL
MUSTAHIL limestone

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
27-5-1970	10,40	12,40

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
27-5-70		3,0	164	1 750	240	235	70	185	45

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi - Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 9*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
Name of place: IGLOLE I

Coordonnées :
Coordinates :
Latitude : 6° 09' N
Longitude : 44° 45' E

Numéro du puits :
Well number : 1

Situation : A 7 km au Nord de SHILAVO à gauche de la piste vers KEBRI-DAHAR -
Puits italien avec tour -
On the left of SHILAVO - KEBRI-DAHAR road -
7 km on the North of SHILAVO - Italian well with tower -

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
Height of curb or casing to the ground (in m.) : + 3

Diamètre (en m.) :
Diameter (in m.) : 0,80

Profondeur totale (en m.) :
Total depth (in m.) : 9,73

Utilisation : Bétail et population
Cattle and population

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Calcaires de MUSTAHIL
MUSTAHIL limestone

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
6- 3-1969	9,20	12,20
14- 2-1970	9,36	12,36
27- 5-1970	8,40	11,40
20- 7-1970	9,70	12,70
17- 8-1970	9,15	12,15

5 - ANALYSES CHIMIQUES (en mg/L) - *CHEMICAL ANALYSIS (in mg/L)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
14-2-70	6,5	12,0							
27-5-70		6,4	126	2 350	1 110	235	205	735	290

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi-Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 10*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
Name of place: IGLOLE I

Coordonnées :
Latitude : 6° 09' N
Longitude : 44° 45' E
Coordinates :

Numéro du puits :
Well number : 2

Situation : Zone de puits de 150 m x 400 m - A 7 km de SHILAVO sur la piste SHILAVO - KEBRI-DAHAR
Well area of 150 x 400 m - At 7 km of SHILAVO on SHILAVO - KEBRI-DAHAR road

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
Height of curb or casing to the ground (in m.) : 0

Diamètre (en m.) :
Diameter (in m.) : 1,0

Profondeur totale (en m.) :
Total depth (in m.) : 11,40

Utilisation : Bétail
Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Calcaires de MUSTAHIL
MUSTAHIL limestone

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
23-2-1970	11,0	11,0
24-2-1970	10,90	10,90
25-2-1970	10,90	10,90

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi-Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N°* 11

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
I G L O L E II
Name of place:

Coordonnées :
Latitude : 5° 45' N
Longitude : 44° 34' E
Coordinates :

Numéro du puits :
Well number :

Situation : A 48 km de SHILAVO sur la piste vers KELAFO -
Les puits sont à gauche de la piste -
On the left of SHILAVO - KELAFO road -
at 48 km of SHILAVO

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
0
Height of curb or casing to the ground (in m.) :

Diamètre (en m.) :
1,0
Diameter (in m.) :

Profondeur totale (en m.) :
10,30
Total depth (in m.) :

Utilisation : Bétail
Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Calcaires de MUSTAHIL
MUSTAHIL limestone

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
27-5-1970	6,40	6,40

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
27-5-70		1,2	115	560	11	110	11	11,5	15

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi-Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 12*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
Name of place: BELLE KOSCHI

Coordonnées :
Coordinates :
Latitude : 6° 07' N
Longitude : 44° 44' E

Numéro du puits :
Well number :

Situation : Zone de puits de 150 x 250 m à 5 km de SHILAVO, à l'Ouest de la piste SHILAVO - KEBRI-DAHAR
Well area of 150 x 250 m, at 5 km of SHILAVO on the West of SHILAVO - KEBRI-DAHAR road

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
Height of curb or casing to the ground (in m.) : 0

Diamètre (en m.) :
Diameter (in m.) : 0,70

Profondeur totale (en m.) :
Total depth (in m.) : 9,15

Utilisation : Bétail
Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Calcaires de MUSTAHIL
MUSTAHIL limestone

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
5- 3-1970	8,15	8,15
6- 3-1970	8,00	8,00
7- 3-1970	8,10	8,10

5 - ANALYSES CHIMIQUES (en mg/L) - *CHEMICAL ANALYSIS (in mg/L)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	CL^-	Ca^{++}	Mg^{++}	Na^+	K^+

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi - Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N°* 13

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
L A Z O L A L E
Name of place:

Coordonnées :
Latitude : 6° 17' N
Longitude : 44° 43' E
Coordinates :

Numéro du puits :

Well number :

Situation : A gauche de la piste SHILAVO - KEBRI-DAHAR
A 93 km au Sud de KEBRI-DAHAR
On the left of SHILAVO - KEBRI-DAHAR road
At 93 km on the South of KEBRI-DAHAR

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
0
Height of curb or casing to the ground (in m.) :

Diamètre (en m.) :
1,05
Diameter (in m.) :

Profondeur totale (en m.) :
12,39
Total depth (in m.) :

Utilisation : Population et bétail
Population and cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Calcaires de MUSTAHIL
MUSTAHIL limestone

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
12- 1-1969	12,0	12,0
6- 3-1969	12,22	12,22
14- 2-1970	10,87	10,87
27- 5-1970	10,95	10,95
20- 7-1970	11,18	11,18
17- 8-1970	11,44	11,44

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
14-2-70	6,9	2,6							
27-5-70		0,8	292	40	36	29,5	21,4	30	45

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi - Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 14*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu : DEGAHBOUR

Name of place:

Coordonnées :

Latitude : 8° 12' N

Longitude : 43° 33' E

Coordinates :

Numéro du puits :

Well number :

Situation : Puits maçonné en bordure du JERER près du village de DEGAHBOUR

Cemented well on the bank of JERER river near DEGAHBOUR

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) : 0

Height of curb or casing to the ground (in m.) :

Diamètre (en m.) : 2,50

Diameter (in m.) :

Profondeur totale (en m.) : 8,61

Total depth (in m.) :

Utilisation : Population et bétail

Population and cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Alluvions du JERER

Alluvial deposits of JERER river

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
17-2-1970	8,36	8,36
4-6-1970	5,34	5,34

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
17-2-70	7,2	5,3							
4-6-70		4,0	347	1 900	590	155	206	550	19,2

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi - Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 15*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
Name of place: KORAHE

Coordonnées :
Latitude : 6° 35' N
Longitude : 44° 22' E
Coordinates :

Numéro du puits :
Well number :

Situation : Dans le lit du FAFEN à 18 km au Sud de KEBRI-DAHAR _ Zone de puits de 200 m de long en amont du pont
In the FAFEN bed - 18 km on the South of KEBRI-DAHAR - Well area of 200 m of length upstream the bridge

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
0
Height of curb or casing to the ground (in m.) :

Diamètre (en m.) :
1,20
Diameter (in m.) :

Profondeur totale (en m.) :
6,12
Total depth (in m.) :

Utilisation : Bétail
Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Alluvions du FAFEN
Alluvial deposits of FAFEN

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
5-3-1969	5,67	5,67
14-2-1970	6,61	6,61
28-5-1970	0	0 (crue du FAFEL)
20-7-1970	6,0	6,0

5 - ANALYSES CHIMIQUES (en mg/L) - *CHEMICAL ANALYSIS (in mg/L)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
14-2-70	7,2	3,5							

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi - Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N°16*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
Name of place: K E B R I - D A H A R

Coordonnées :
Coordinates :
Latitude : 6° 44' N
Longitude : 44° 17' E

Numéro du puits :
Well number : Puits-témoin n° 1

Situation : Sur le bord du FAFEN près de KEBRI-DAHAR
On the bank of FAFEN river near KEBRI-DAHAR

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
Height of curb or casing to the ground (in m.) : 0

Diamètre (en m.) :
Diameter (in m.) : puits carré de 0,50 m de côté
square well of 0,50 m side

Profondeur totale (en m.) :
Total depth (in m.) :

Utilisation : Bétail
Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Alluvions du FAFEN
Alluvial deposits of FAFEN

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water - level from curb or casing (in m)*	Niveau d'eau à partir du sol (en m.) *Water - level from ground (in m.)*
Mesures bi-journalières du 10 octobre 1968 au 22 février 1971	voir graphiques n° 23 n° 24	
Daily measurements (two times a day) from 10 october 1968 to 22 february 1971	graph n° 23 n° 24	

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
15-2-70	7,2	3,0							
27-5-70		1,75	224	420	138	36	69	133	14,6

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi-Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 17*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
KEBRI-DAHAR
Name of place:

Coordonnées :
Latitude : 6° 44' N
Longitude : 44° 17' E.
Coordinates :

Numéro du puits :
Puits-témoin n° 2
Well number :

Situation : Sur la bord du FAFEN près de KEBRI-DAHAR
à 50 mètres au Sud du puits-témoin n° 1
On the bank of FAFEN river near KEBRI-DAHAR
at 50 meters on the South of well n° 1

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
0
Height of curb or casing to the ground (in m.) :

Diamètre (en m.) :
puits rectangulaire (1 x 0,50 m)
Diameter (in m.) : rectangular well (1 x 0,50 m)

Profondeur totale (en m.) :
15,0
Total depth (in m.) :

Utilisation : Population et bétail
Population and cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Alluvions du FAFEN
Alluvial deposits of FAFEN

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
Mesures bi-journalières du 1er janvier 1969 au 22 février 1971	voir graphiques n° 23 n° 24	
Daily measurements (two times a day) from 1 january 1969 to 22 february 1971	graph n° 23 n° 24	

5 - ANALYSES CHIMIQUES (en mg/L) - *CHEMICAL ANALYSIS (in mg/L)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
15-3-70	7,2	1,6							
27-5-70		1,5	206	450	139	31,5	76,5	150	14,6

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi-Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 18*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
Name of place: MAHARATO

Coordonnées :
Coordinates :
Latitude : 6° 29' N
Longitude : 44° 26' E

Numéro du puits :
Well number :

Situation : Zone de puits de 100 x 300 m à 10 km au Sud de KORAHE - Accès par large piste de bétail
Well area of 100 x 300 m at 10 km on the South of KORAHE - Access by a wide track of cattle

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
Height of curb or casing to the ground (in m.) : 0

Diamètre (en m.) :
Diameter (in m.) : 1,0

Profondeur totale (en m.) :
Total depth (in m.) : 7,80

Utilisation : Bétail
Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Alluvions du FAFEN
Alluvial deposits of FAFEN

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
13-2-1970	7,0	7,0
14-2-1970	7,20	7,20
15-2-1970	6,90	6,90

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi-Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 19*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
Name of place: D E G A H - M E D O

Coordonnées :
Coordinates :
Latitude : 7° 58' N
Longitude : 43° 01' E

Numéro du puits :
Well number :

Situation : Nombreux puits dans la rivière SULLUL près de DEGAH-MEDO, au Nord de la piste DEGAHBOUR - DEGAH-MEDO
Numerous wells in SULLUL river , near DEGAH-MEDO, on the North of DEGAHBOUR - DEGAH-MEDO road

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) : - 1,0
Height of curb or casing to the ground (in m.) :

Diamètre (en m.) : 1,0
Diameter (in m.) :

Profondeur totale (en m.) : 14,38
Total depth (in m.) :

Utilisation : Bétail
Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Alluvions de la rivière SULLUL
Alluvial deposits of SULLUL river

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
20-2-1970	11,90	12,90
4-6-1970	12,28	13,28

5 - ANALYSES CHIMIQUES (en mg/L) - *CHEMICAL ANALYSIS (in mg/L)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
20-2-70	7,4	1,2							
4-6-70		2,3	515	550	108	2	19,5	485	3,1

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi-Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 20*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
S E G E G
Name of place:

Coordonnées :
Latitude : 7° 40' N
Longitude : 42° 50' E
Coordinates :

Numéro du puits :
Well number :

Situation : Nombreux puits dans la rivière SULLUL près de la piste SEGEG - DEGAH-M
Numerous wells in SULLUL river near the road SEGEG - DEGAH-MEDO

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
0,10
Height of curb or casing to the ground (in m.) :

Diamètre (en m.) :
1,0
Diameter (in m.) :

Profondeur totale (en m.) :
0,90
Total depth (in m.) :

Utilisation : Bétail
Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Alluvions de la rivière SULLUL
Alluvial deposits of SULLUL river

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
21-2-1970	0,67	0,57
4-6-1970	0,60	0,50

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
16-1-68		5,6	317	658	1 728	140	232	855	25
21-2-70	7,2	4,2							
4-6-70		11,3	134	3 050	2 700	105	445	1 950	20,5

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi-Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 21*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
Name of place: DADIN

Coordonnées :
Coordinates :
Latitude : 6° 40' N
Longitude : 44° 11' E

Numéro du puits :
Well number :

Situation : A 50 mètres à gauche de la piste KEBRI-DAHAR - DANAN -
Vaste zone de puits à 12 km de KEBRI-DAHAR
Wide area of wells, at 12 km from KEBRI-DAHAR,
at 50 meters on the left KEBRI-DAHAR - DANAN road

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
Height of curb or casing to the ground (in m.) : + 2,0

Diamètre (en m.) :
Diameter (in m.) : 2,0

Profondeur totale (en m.) :
Total depth (in m.) :

Utilisation : Bétail
Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Cuvette d'épandage sur calcaires de KEBRI-DAHAR
Local deposits on KEBRI-DAHAR limestone

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
4-2-1970	1,10	3,10
2-6-1970	-	0 (zone inondée)
23-7-1970	-	1,0
25-8-1970	0,45	2,45

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
4-2-70	7,2	2,6							

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi-Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 22*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
Name of place: D A L A D

Coordonnées :
Coordinates :
Latitude : 6° 37' N
Longitude : 44° 06' E

Numéro du puits :
Well number :

Situation : Vaste zone de puits à droite de la piste KEBRI-DAHAR - DANAN -
A 25 km de KEBRI-DAHAR
Wide area of wells on the right of KEBRI-DAHAR - DANAN road -
25 km from KEBRI-DAHAR

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
Height of curb or casing to the ground (in m.) : 0

Diamètre (en m.) :
Diameter (in m.) : 1,0

Profondeur totale (en m.) :
Total depth (in m.) : 8,25

Utilisation : Population et bétail
Population and cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Cuvette d'épandage sur calcaires de KEBRI-DAHAR
Local deposits on KEBRI-DAHAR limestone

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
29- 6-1968	3,51	3,51
20- 7-1968	3,62	3,62
10- 8-1968	3,03	3,03
20-10-1968	2,95	2,95
12-11-1968	3,00	3,00
26-12-1968	2,15	2,15
11- 1-1969	6,50	6,50
4- 2-1970	6,15	6,15
2- 6-1970	4,78	4,78
23- 7-1970	4,55	4,55
25- 8-1970	4,67	4,67

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
4-2-70	7,5	2,7							
2-6-70		2,45	80	1 800	28	245	48	19	25,6

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi-Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N°* 23

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
Name of place: K A P T I N A G

Coordonnées :
Coordinates :
Latitude : 6° 34' N
Longitude : 43° 55' E

Numéro du puits :
Well number :

Situation : Plusieurs puits dans la rivière CAPTINAG à 50 km de KEBRI-DAHAR, sur la piste KEBRI-DAHAR - DANAN
Many wells in KAPTINAG river at 50 km from KEBRI-DAHAR on KEBRI-DAHAR - DANAN road

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
Height of curb or casing to the ground (in m.) : 0

Diamètre (en m.) :
Diameter (in m.) : 4,0

Profondeur totale (en m.) :
Total depth (in m.) : 2,50

Utilisation : Bétail
Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Alluvions sur calcaires de KEBRI-DAHAR
Alluvial deposits on KEBRI-DAHAR limestone

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
4-2-1970	1,50	1,50
2-6-1970	-	+0,10 (écoulement)
25-8-1970	0,38	0,38

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
4-2-70	7,1	3,3							

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi-Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N°* 24

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
EL HAR
Name of place:

Coordonnées :
Latitude : 6° 46' N
Longitude : 44° 27' E
Coordinates :

Numéro du puits :

Well number :

Situation : Zone de puits de 2 km de longueur - Située à 20 km à l'Est de KEBRI-DAHAR
Well area (2 km of length) at 20 km on the East of KEBRI-DAHAR

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
0
Height of curb or casing to the ground (in m.) :

Diamètre (en m.) :
0,75
Diameter (in m.) :

Profondeur totale (en m.) :
13,91
Total depth (in m.) :

Utilisation : Bétail
Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Cuvette d'épandage sur formation gypseuse principale
Local deposits on main gypsum formation

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
12- 2-1970	12,06	12,06
13- 2-1970	12,04	12,04
14- 2-1970	12,10	12,10

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
19-1-68		14,7	850	1 [illegible]6	2 340	740	378	1 530	103

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi-Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 25*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
MERERALE
Name of place:

Coordonnées :
Latitude : 6°36' N
Longitude : 44°31' E
Coordinates :

Numéro du puits :

Well number :

Situation : Près de la piste KEBRI-DAHAR - WARDER à 1 km après la jonction avec la piste KEBRI-DAHAR - SHILAVO
Near the KEBRI-DAHAR - WARDER road, at 1 km after the junction with KEBRI-DAHAR - SHILAVO road

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) : 0,37
Height of curb or casing to the ground (in m.) :

Diamètre (en m.) : 1,37
Diameter (in m.) :

Profondeur totale (en m.) : 8,46
Total depth (in m.) :

Utilisation : Bétail
Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Cuvette d'épandage sur formation gypseuse principale
Local deposits on main gypsum formation

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
5- 3-1969	7,78	7,41
14- 2-1970	7,57	7,20
20- 7-1970	6,87	6,50

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
11-1-68		17,2	378	2 780	3 990	840	658	1 865	103
14-2-70	7,0	15,7							
20-7-70		11,2	160	2 550	3 130	260	452	1 435	352

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi-Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 26*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
DAMBEROUENE
Name of place:

Coordonnées :
Latitude : 6°30' N
Longitude : 43°37' E
Coordinates :

Numéro du puits :
Well number :

Situation : A 200 m à gauche de la piste allant de KEBRI-DAHAR à DANAN
à 83 km de KEBRI-DAHAR
At 200 m on the left of KEBRI-DAHAR - DANAN road -
83 km from KEBRI-DAHAR

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
0
Height of curb or casing to the ground (in m.) :

Diamètre (en m.) :
1,0
Diameter (in m.) :

Profondeur totale (en m.) :
1,60
Total depth (in m.) :

Utilisation : Bétail
Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Alluvions d'oued sur formation gypseuse principale
River alluvial deposits on main gypsum formation

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
4- 2-1970	1,40	1,40

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi-Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 27*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
Name of place: DANAN

Coordonnées :
Latitude : 6° 30' N
Longitude : 43° 29' E
Coordinates :

Numéro du puits :
Well number :

Situation : Nombreux puits dans le village de DANAN
Numerous wells in DANAN village

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) : 0
Height of curb or casing to the ground (in m.) :

Diamètre (en m.) :
1,50
Diameter (in m.) :

Profondeur totale (en m.) :
2,90
Total depth (in m.) :

Utilisation : Bétail
Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Alluvions d'oued sur la formation gypseuse principale
River alluvial deposits on main gypsum formation

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
11-1-1969	2,60	2,60
20-1-1970	2,70	2,70
21-1-1970	2,75	2,75
22-1-1970	2,70	2,70
23-1-1970	2,80	2,80
2-6-1970	1,27	1,27
25-8-1970	2,80	2,80

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
23-2-70		3,4							
2-6-70		2,6	44	1 850	41	210	78	30	21,4

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi-Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 28*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
S H I L I L E

Name of place:

Coordonnées :
Latitude : 6° 41' N
Longitude : 43° 32' E

Coordinates :

Numéro du puits :

Well number :

Situation : Zone de puits à 20 km au N-N.E de DANAN

Well area at 20 km on N-N.E of DANAN

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
0

Height of curb or casing to the ground (in m.) :

Diamètre (en m.) :
1,0

Diameter (in m.) :

Profondeur totale (en m.) :
7,70

Total depth (in m.) :

Utilisation : Bétail

Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Cuvette d'épandage sur formation gypseuse principale

Local deposits on main gypsum formation

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
27- 1-1970	5,70	5,70
28- 1-1970	5,90	5,90
29- 1-1970	5,90	5,90
2- 6-1970	4,95	4,95
9- 7-1970	6,25	6,25

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
2-6-70		5,2	232	2 600	630	220	345	338	18,7

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi - Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 29*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
Name of place: H A D O L A M O

Coordonnées :
Latitude : 6° 31' N
Longitude : 44° 41' E
Coordinates :

Numéro du puits :
Well number :

Situation : Sur la piste KEBRI-DAHAR - DANAN à 80 km de KEBRI-DAHAR
On the KEBRI-DAHAR - DANAN road at 80 km from KEBRI-DAHAR

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) : 0
Height of curb or casing to the ground (in m.) :

Diamètre (en m.) :
Diameter (in m.) : triangle de 2 m de côté environ
triangle with around 2 m side

Profondeur totale (en m.) :
Total depth (in m.) :

Utilisation : Bétail
Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Sur formation gypseuse principale
On main gypsum formation

4 _ MESURES DU NIVEAU D'EAU _ *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
11- 1-1969	1,60	1,60
4- 2-1970	1,50	1,50
2- 6-1970	0	0 (écoulement)
25- 8-1970	0,35	0,35

5 _ ANALYSES CHIMIQUES (en mg/l) _ *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi-Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 30*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :

A D E Y A

Name of place:

Coordonnées :

Latitude : 6° 13' N

Longitude : 43° 36' E

Coordinates :

Numéro du puits :

Well number :

Situation : Zone de puits à gauche de la route DANAN - GODE à 36 km de DANAN

Well area on the left of DANAN - GODE road - 36 km from DANAN

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :

-0,50

Height of curb or casing to the ground (in m.) :

Diamètre (en m.) :

2,0

Diameter (in m.) :

Profondeur totale (en m.) :

2,15

Total depth (in m.) :

Utilisation : Bétail

Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Zone d'épandage sur formation gypseuse principale

Local deposits on main gypsum formation

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
11- 1-1969	0,60	1,10
23- 2-1970	1,65	2,15
6- 6-1970	0,50	1,00
9- 7-1970	0,90	1,40
25- 8-1970	1,40	1,90

5 - ANALYSES CHIMIQUES (en mg/L) - *CHEMICAL ANALYSIS (in mg/L)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
23-2-70	7,0	6,4							

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi-Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 31*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
D U H U N
Name of place:

Coordonnées :
Latitude : 7° 13' N
Longitude : 42° 42' E
Coordinates :

Numéro du puits :
Well number :

Situation : Puits dans le lit d'un oued près du village de DUHUN
Well in a temporary river bed near DUHUN village

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
0,80
Height of curb or casing to the ground (in m.) :

Diamètre (en m.) :
1,50
Diameter (in m.) :

Profondeur totale (en m.) :
6,38
Total depth (in m.) :

Utilisation : Bétail
Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Alluvions d'oued sur formation gypseuse principale
Alluvial deposits of temporary river on main gypsum formation

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
21- 2-1970	6,28	7,08
3- 6-1970	3,08	3,88

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
21-2-70	7,2	3,2							
3-6-70		2,7	104	1 650	17	215	50	18,5	10,4

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi - Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 32*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
Name of place:
T U C U B

Coordonnées :
Coordinates :
Latitude : 7° 03' N
Longitude : 42° 44' E

Numéro du puits :
Well number :

Situation : Zone de puits d'environ 30 m de diamètre située à 18 km au Sud-Est de DUHUN
Well area of about 30 m of diameter at 18 km on the South-East of DUHUN

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
Height of curb or casing to the ground (in m.) :
0

Diamètre (en m.) :
Diameter (in m.) :
1,0

Profondeur totale (en m.) :
Total depth (in m.) :
1,73

Utilisation : Bétail
Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Alluvions d'oued sur formation gypseuse principale
Alluvial deposits of temporary river on main gypsum formation

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
8- 2-1970	1,38	1,38
9- 2-1970	1,30	1,30
10- 2-1970	1,33	1,33
22- 2-1970	1,23	1,23
3- 6-1970	1,70	1,70

5 - ANALYSES CHIMIQUES (en mg/L.) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
22- 1-68		11,6	354	3 670	1 914	660	512	1 500	52
22- 2-70	7,4	8,7							

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi-Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N°* 33

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
Name of place: E L F U D

Coordonnées :
Coordinates :
Latitude : 7° 15' N
Longitude : 42° 52' E

Numéro du puits :
Well number :

Situation : Zone de puits de 200 m x 50 m située à 15 km au Nord-Est de DUHUN
Well area of 200 x 50 m at 15 km on the North-East of DUHUN

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
Height of curb or casing to the ground (in m.) : 0

Diamètre (en m.) :
Diameter (in m.) : 0,90

Profondeur totale (en m.) :
Total depth (in m.) : 4,47

Utilisation : Bétail
Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Cuvette d'épandage sur formation gypseuse principale
Local deposits on main gypsum formation

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
12- 2-1970	3,73	3,73
13- 2-1970	3,74	3,74
14- 2-1970	3,69	3,69

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi-Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 34*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
Name of place:
BUBE

Coordonnées :
Coordinates :
Latitude : 6° 39' N
Longitude : 44° 35' E

Numéro du puits :
Well number :

Situation : A 4 km au Nord de la piste KEBRI-DAHAR - WARDER et à 38 km à l'Est de KEBRI-DAHAR
At 4 km on the North of KEBRI-DAHAR - WARDER road and at 38 km on the East of KEBRI-DAHAR

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
Height of curb or casing to the ground (in m.) :
- 0,50

Diamètre (en m.) :
Diameter (in m.) :
1,0

Profondeur totale (en m.) :
Total depth (in m.) :
15,23

Utilisation : Bétail
Cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Epandage des grès de JESSOMA
Deposits of JESSOMA sandstone

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
29-10-1968	3,20	3,70
26-11-1968	3,15	3,65
27-12-1968	2,45	2,95
14- 2-1970	4,84	5,34
29- 5-1970	7,65	8,15

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
14-2-70	7,1	5,3							
29-5-70		2,2	296	870	128	165	49	80	140

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi - Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 35*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
Name of place: DOURRE

Coordonnées :
Coordinates :
Latitude : 6° 39' N
Longitude : 44° 39' E

Numéro du puits :
Well number :

Situation : Zone de puits d'environ 50 m de diamètre sur la piste KEBRI-DAHAR - WARDER à environ 48 km de KEBRI-DAHAR
Well area of about 50 of diameter on KEBRI-DAHAR - WARDER road, at about 48 km from KEBRI-DAHAR

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) : 0
Height of curb or casing to the ground (in m.) :

Diamètre (en m.) :
Diameter (in m.) : rectangulaire (1 m x 0,50 m)
rectangular (1 m x 0,50 m)

Profondeur totale (en m.) : 19,68
Total depth (in m.) :

Utilisation : Population et bétail
Population and cattle

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Epandage de grès de JESSOMA
Deposits of JESSOMA sandstone

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
14- 2-1970	12,05	12,05
29- 5-1970	16,06	16,06

5 - ANALYSES CHIMIQUES (en mg/l) - *CHEMICAL ANALYSIS (in mg/l)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
14-2-70	7,3	3,0							
29-5-70		2,7	310	1 350	62	210	50	39	25,6

MISSION D'ÉTUDES DU WABI-SHEBELLE _ *Wabi - Shebelle project*

FICHE DE PUITS _ *WELL CARD-INDEX N° 36*

1 _ LOCALISATION DU PUITS _ *WELL LOCATION*

Nom du lieu :
FERFER
Name of place:

Coordonnées :
Latitude : 5° 05' N
Longitude : 45° 05' E
Coordinates :

Numéro du puits :

Well number :

Situation : Puits maçonné dans le lit d'un oued près du pont

Cemented well in a temporary river bed near the bridge

2 _ CARACTÉRISTIQUES DU PUITS _ *WELL CHARACTERISTICS*

Hauteur de margelle ou de tubage par rapport au sol (en m.) :
0,75
Height of curb or casing to the ground (in m.) :

Diamètre (en m.) :
2,0
Diameter (in m.) :

Profondeur totale (en m.) :

Total depth (in m.) :

Utilisation : Population

Population

3 _ ROCHE AQUIFÈRE _ *WATER-BEARING DEPOSIT*

Alluvions d'oued sur les gypses de FERFER

Alluvial deposits of temporary river on FERFER gypsum formation

4 - MESURES DU NIVEAU D'EAU - *WATER LEVEL MEASUREMENTS*

Date de mesure *Date of measurement*	Niveau d'eau à partir de la margelle ou du tubage (en m.) *Water-level from curb or casing (in m.)*	Niveau d'eau à partir du sol (en m.) *Water-level from ground (in m.)*
11-2-1970	2,54	1,79
27-5-1970	1,30	0,55
19-7-1970	2,15	1,69
18-8-1970	2,44	1,40

5 - ANALYSES CHIMIQUES (en mg/L) - *CHEMICAL ANALYSIS (in mg/L)*

Date du prélèvement *Date of collection*	PH Terrain *Field*	Conductivité *Conductivity* mmhos/cm	CO_3H^-	SO_4^{--}	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
11-2-70	7,8	3,7							
27-5-70		2,7	51	1 750	115	245	59	53	18,6