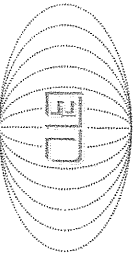


REPUBLIC OF LEBANON
MINISTRY OF ENERGY AND WATER

**GEOLOGICAL AND HYDROGEOLOGICAL STUDY
WITHIN METRIT REGION**

Final Report

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1 GEOLOGY OF METTRIT AREA

The geological investigation of the study area is originally based on the previous work done on north region. The bulk of information has been analyzed from stratigraphical work done by L. Dubertret and on the geological map made by Mr. A. Guerre in 1971 in the Amioum area. In addition, several techniques were utilized to modify the geological map and, hence, better understand the geology. These are particularly the remote sensing methods of MAPS photo satellite, aerial stereographic photographs with a scale 1/25000 (1963). Fieldwork also took an important share of the investigation. The final result is an up to date geological map with a 1/10000 scale (**Figure I**) covering the study area and the proper understanding of the different geological aspects of this area such as: geomorphology, lithostratigraphy and structural geology.

1.1 GEOMORFOLOGY

The study area is characterized by a relatively moderate topography, and consists of the Senonian marl Formation, Turonian Formation and the Cenomanian Formation with an altitude between 600 and 900m above the sea level.

1.2 LITHO-STRATIGRAPHY

The outcropping rock formations in the study area extend from the Cenomanian Formation (C4) to the Senonian marl formation (C6) through the Turonian rock formation (C5). Furthermore, recent Quaternary alluviums and slope deposits especially in the plains, valleys, and along toes of the slopes.

1.2.1 Cenomanian Formation (C4)

This formation can be subdivided into 3 lithological units from bottom to top these are:

- 1) The lower Cenomanian rocks (C4a) which includes bioclastic limestones, yellowish marls and cherty limestones, thick bedded limestones, dolomites, and dolomitic limestones.
- 2) The middle Cenomanian rocks(C4b) that consists of a considerable limestone and interbedded of limestones and marly limestones. The (C4b) rocks outcrop in small patch at the SE edge of the study area.
- 3) The upper Cenomanian rocks(C4c) which constituted of narrow beds of limestones with siliceous beds, thick beds of limestones and dolomitic limestones, and locally stratified light creamy limestones characterized by thin interbeds of cherty bands and nodules. The Upper Cenomanian formation covers almost all the study area. The average thickness of this formation is about 600m.

1.2.2 Turonian Formation (C5)

The Turonian rock formation has been divided into two different units since the beginning of the 20th century (1910 Douville and 1955 Dubertret). The stratigraphical investigations by SAINT-MARC, led to the refining of these two subdivisions: Basal Turonian Member and Terminal Turonian Member.

The former consists of dolomitic marls, dolomitic rocks, and dolomitic limestone rocks. It is characterized by the presence of Ammonites mega fossils. The latter, on the other hand, is characterized by the presence of Hippurites. In terms of lithology, the Terminal Member is made up of dolomites limestones and dolomitic limestone rocks. Limestone outcrops exhibit different facies: oolitic, detrital, crystalline, lensoid, and silicified. The dolostones are coarse grained, light-brown color, they have a sugary texture and are fairly compacted. Upon weathering they become friable and form dolomitic sand in several places. Turonian formation outcrops on relatively wide surface area in the middle and the northern part of the study area. The average thickness of this formation is about 250m.

1.2.3 Senonian formation (C6)

The Senonian formation outcrops on a small patch, at the north western part of the study area. Lithologically speaking this formation consists of white marls, limy-marlstone, and marly limestone rocks. The average thickness of Senonian formation in the study area is about 100 m.

1.2.4 Quaternary Deposits (Q)

These deposits are recent in age and consists of loose sandy clay in the plains, and gravel sin the valleys and along the toes of the slope. These deposits originated from older formations by gravity and running water.

1.3 STRUCTURAL GEOLOGY

The general structure configuration describing the study area is related to the western flexure of Mount-Lebanon. The Cenomanian formation dip towards the north-west direction, with a dip angles that vary between 8 and 14 degrees.

The study area is crossed by several faults but the over all structure is characterized by a regular aspect since the faults do not have major throws. These faults trend either roughly SE-NW, or E-W. These faults were caused by the periodic adjustment during the uplift of the western flexure of Mount Lebanon.

1.4 HYDROGEOLOGY

The study area consists of different hydrogeological units. These are Cenomanian-Turonian aquifer, and Senonian aquiclude.

1.4.1 Cenomanian Aquifer (C4)

The Cenomanian aquifer represents one of the main aquifers in Lebanon and is the most productive aquifer in the Cretaceous sequence. It is characterized by its high secondary porosity causing ground water to flow mainly through fractures, joints, and channels which is a typical occurrence in karstic aquifers.

1.4.2 Senonian (C₆) aquiclude

The clay and marl horizons within the Senonian formation act as relatively impermeable zones that minimize the flow between the different underlying and overlying aquifers.

As a result, the water precipitation that falls on the limestones of the Cenomanian formation infiltrates underground follows the fractured and faulted zones and moves towards the NW and forms what we call an aquifer.

1.5 DESIGN OF THE WATER WELL

1.5.1 Metrit well

1.5.1.1 Borehole location

The well is located on public land in Ech Cherfe locality to the east of Metrit village at the following coordinates (Fig. 2):

X = -303849 km
Y = +11528 km
Z = 807 m
(Amioun map, 1/20.000)

1.5.1.2 Access to Borehole

Access to the site is easy on a main road. Some clearing and excavation for the well site is necessary in order to park the drilling machines.

1.5.1.3 Depth

600 m

1.5.1.4 Expected discharge

432-605 m³/day (or 5-7 l/s).

1.5.1.5 Static water level

250 m below ground level.

1.5.1.6 Geology

The well is located along the edge of NW-SE fault to the east of Metrit village.

The beds that will be penetrated by the drilling rig are:

- a) The limestones and dolomitic limestones of the Upper Cenomanian (C4c) Formation (150 m).

- b) The marls and marly limestones of the Middle Cenomanian (C4b) Formation (250 m).
- c) The dolomites and limestones of the Lower Cenomanian (C4a) Formation (200 m).

1.5.1.7 Schedule of drilling, casing and grouting

The Contractor shall present the schedule for drilling in order to have a final casing and screen diameter of 10". The well is to be drilled with a rotary rig and provide for all additional equipment such as water and fuel, as well as treating collapsing rocks at his own expense.

Nevertheless, the schedule of the proposed works could be as follows (Fig. 3):

- Drilling by rotary methods with a 17.5" bit from 0 to 20m, with samples collection as described in the general specifications from this depth and onwards.
- Installing 15.5" I.D. casing (black steel, thickness 5mm)
- Grouting the annular space as described in the general specifications, from the bottom to the surface, then waiting between 36 to 48 hours for the cement to set, and then continue the drilling works.
- Drilling with a 14.75" bit from 20 to the depth of 200 m.
- Installing 12.5" ID casing (steel, thickness 6mm).
- Drilling with 12.25" bit from 200 to the total depth of 600 m.
- Installing 10" casing and screens as shown below:
 - a) Casing:
 - Diameter: 10" ID
 - Type: Carbon steel
 - Thickness: 6 mm
 - Total length: 550 m
 - b) Screens:
 - Diameter: 10" OD
 - Type: Carbon steel, bridge slotted 12.2% void, 1.5-2mm slots.
 - Thickness: 6 mm
 - Total length: 50 m.

The installation of the casing and screens will be in accordance with the general specifications, and in particular, the welding and closure of all openings such that the water only enters the well through the screen openings, in order to minimize the pollution from zones above the SWL.

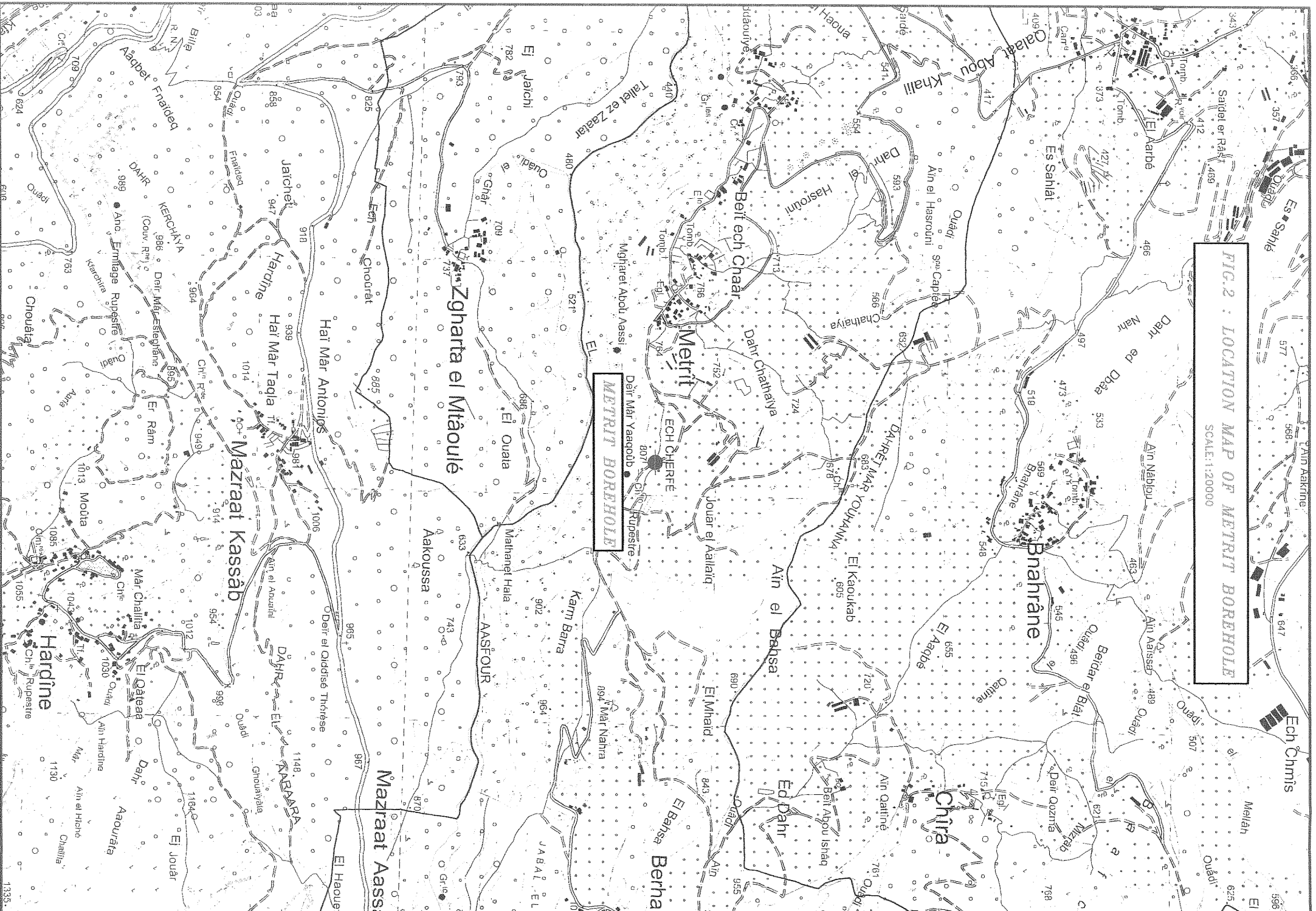


FIG.2 : LOCATION MAP OF METRIT BOREHOLE
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FIG. 3 : VERTICAL CROSS SECTION OF METRIT BOREHOLE

