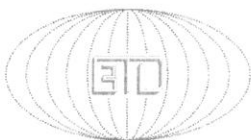


REPUBLIC OF LEBANON
MINISTRY OF ENERGY AND WATER

**GEOLOGICAL AND HYDROGEOLOGICAL STUDY
WITHIN BTAABOURA REGION**

Final Report

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1 GEOLOGY OF BTAABOURA 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. 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 (**Map A**) 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 and Turonian Formation with an altitude between 200 and 350m above the sea level.

1.2 LITHO-STRATIGRAPHY

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

1.2.1 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 small surface area at the south eastern part of the study area. The average thickness of this formation is about 250m.

1.2.2 Senonian formation (C6)

The Senonian formation covers about 80% 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 250 m.

1.2.3 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 and the presence of Btaaboura syncline.

The axis of Btaaboura syncline is oriented SW-NE and it is located to the north east of Btaaboura village.

The beds of the eastern flank of this syncline which consist of Turonian (C5) and Senonian (C6) formations are dipping by 13° toward the west, while the western flank of this syncline are dipping by 25° toward the east.

The Btaaboura syncline structure seem to be the dominant structural mechanism in the study area. Moreover the study area is crossed by a series of SW - NE trending faults, one of them is Qadicha – Jaouz major fault.

1.4 HYDROGEOLOGY

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

1.4.1 Cenomanian-Turonian Aquifer (C4)

The Cenomanian-Turonian 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 it has been said previously, the syncline axis of Btaaboura crosses the middle of Btaaboura village with the Turonian (C5) Formation outcropping at its flanks. The beds on the eastern flank of this syncline are dipping by 13° toward the west, and the western flanks are dipping by 25° toward the east.

In addition, the trend of the syncline flanks give an idea of the ground water flow direction since the ground water has a tendency to flow to the areas of least resistance.

As a result, the water precipitation that falls on the limestones of the Turonian formation infiltrates underground follows the fractured and faulted zones and moves eastward and westward toward the syncline axis and forms what we call an aquifer.

Therefore, the best productive site for the water well to be drilled is on the syncline axis or to its western flank.

1.5 DESIGN OF THE WATER WELLS

1.5.1 Btaaboura well

1.5.1.1 Borehole location

The well is located on plot No. 233 to the left side of the road leading to Kfarhata village to the west of Btaaboura, at the following coordinates (Fig. 1):

X = -312,572 km
Y = 13804 km
Z = 355 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 machine.

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

300 m below ground level.

1.5.1.6 Geology

The syncline axis of Btaaboura, crosses the west of Btaaboura village with a Turonian (C5) formation outcropping on its flanks. The beds on the eastern flank of this syncline are dipping by 13° toward the east. The well has been located on the syncline axis. It will cross at the beginning the marls and marly limestones of the Senonian formation (C6) to reach the reefy limestones of the Turonian (C5). These limestones are highly karstified and might contain many karstic voids.

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. 2):

- Drilling by rotary methods with a 22" bit from 0 to 20m, with samples collection as described in the general specifications from this depth and onwards.
- Installing 18" 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 17.5" bit from 20 to the depth of 200 m.
- Installing 15.5" ID casing (black steel, thickness 5mm).
- Drilling with 14.75" bit from 200 to the depth of 450 m.
- Installing 12.5" ID casing (carbon steel, thickness 6mm).
- Drilling with 12.25" bit from 450 to the total depth of 600m.
- Installing 10" casing and screens as shown below:
 - a) Casing:
 - Diameter: 10" ID
 - Type: Carbon steel
 - Thickness: 6 mm
 - Total length: 500 m
 - b) Screens:
 - Diameter: 10" OD
 - Type: Carbon steel, touch-cut slotted 12.2% void, 1.5-2mm slots.
 - Thickness: 6 mm
 - Total length: 100 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.1 : LOCATION MAP OF BTAABOURA BOREHOLE
SCALE:1:20000

BTAABOURA BOREHOLE

Btaaboura

Kaftoun

Dâr Chmizzîne

Boqsmaiya

Majdel

FIG. 2 : VERTICAL CROSS SECTION OF BTAABOURA BOREHOLE

