REPUBLIC OF LEBANON

MINISTRY OF ENERGY AND WATER

GEOLOGICAL AND HYDROGEOLOGICAL STUDY WITHIN KFARSAROUN REGION

FINAL REPORT

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1 GEOLOGY OF KFARSAROUN AREA

The geological study of the project area is based on the previous geological and hydrogeological investigations done by BTD in north Lebanon and more precisely in the cazas of Batroun and Koura. In addition, the bulk of information mentioned in this report is the result of works done by L. Dubertret, B. Hakim, and B.T.D. Moreover, several investigations were utilized to update the geological data and, hence, better understand the geology and hydrogeology of the project area. These are particularly the remote sensing interpretation of MAPS photo satellite and the photo interpretation of the aerial stereographic photographs at a scale 1/25000 (1963). Fieldwork also took an important share of the investigation. The final result is an up to date regional geological map at a scale of 1/10.000 (fig. 1). The following report therefore gives a description of the geomorphological, stratigraphical structural and hydrogeological aspects of the project area and give construction details of the well to be drilled.

1.1 GEOMORPHOLOGY

1.1.1 Geomorphology of Kfarsaroun area

The study area is characterized by a relatively moderate topography and consists of hills and small valleys formed in the Upper Cenomanian, Turonian limestone formation and the Senonian formation. The average altitude varies between 300 and 650m above the sea level.

1.2 STRATIGRAPHY

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

1.2.1 Cenomanian Formation (C4)

This geological formation has an overall thickness of 650 m. It is essentially made of dolomites, limestones, marly limestones and marl. It is subdivided into 3 litho-stratigraphical units from bottom to top these are:

1) The lower Cenomanian unit (C4a) which is made of bioclastic limestones, yellowish marls and cherty limestones, thick bedded limestones, dolomites, and dolomitic limestones. The average thickness of this sequence is 150m. It overlies the green impervious marls of the Albian (C3).

2) The middle Cenomanian unit (C4b) that consists of a massive limestone and dolomitic limestone block forming a cliff, with an average thickness of 150m.

3) The upper Cenomanian unit (C4c) which is constituted of thin beds of limestones and cherty limestones, thick beds of limestones and dolomitic limestones, and locally stratified light creamy limestones characterized by thin interbeds of cherty bands and nodules. The average thickness of this sequence is about 350m. The Upper Cenomanian formation covers almost all the studied areas.

The Cenomanian formation is overlain stratigraphically by the Turonian formation. In some places, these Turonian limestones and dolomite outcrops are overlain by the Senonian marls as it can be seen in the middle and the western part of the map (Fig. 1).

1.2.2 Turonian Formation (C5)

The Turonian or "Maameltain rock formation" has been subdivided into two different units since the beginning of the 20th century (1910 Douville and 1955 Dubertret). The stratigraphical investigations made by P. St. Marc led to the refining of these two subdivisions. These are the Basal Turonian Member and the 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 faces: 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. The Turonian formation outcrops on relatively wide surface in the south East, and South Western parts of the study area. The average thickness of this formation is about 300 m.

1.2.3 Senonian formation (C6)

The Senonian formation outcrops in the middle part of the study area. Lithologically speaking this formation consists of white marls, marly limestines and limy marls.

The average thickness of the Senonian formation in the study area is about 200 m.

1.2.4 Lower Eocene (e1-2a)

The rocks of this formation outcrop on the middle and western part of the study area, and consist of gray marls, chalky marls and marly limestones. The stratigraphic thickness of (e_{1-2a}) is more than 250 m in the study area, and forms an impermeable layer hydrogeologically.

1.2.5 Vindobonian (m2)

The Middle Miocene Layers, specially the Vindobonian (m2), are composed of limestones, marly limestones and sandy limestones interbeded with marly layers.
The average thickness of these layers is around 250 m. They form the most important aquifer in the Koura plain and extend to Tripoli and Mount Terbol to the north.

1.2.6 Quaternary Deposits

Above the Miocene layers stratigraphically, and in the structural depression that has been formed, different Quaternary deposits have been deposited as follows (See Fig. 1):

a- Conglomerates of the old Quaternary (q_{cg})
b- Conlluvial red clays of the Middle Quaternary (q_{ar})
c- Diverse fluvial alluviums of the recent Quaternary (q): sands, gobbles and clays.

These deposits have covered in variable ways and thicknesses the underneath limestone layers, so that the thickness of these deposits exceed sometimes 50 m, which make them suitable places for olive cultivation in Koura region.

1.3 STRUCTURAL GEOLOGY

The general structural configuration of the studied area is the presence of the western flexure of Mount-Lebanon and the presence of Kousba anticline, of NE-SW direction, as well as the very important Ain Aakrine major Fault of east-west trend. In fact, the whole Cretaceous strata plunge to the West, westward of Kousba anticline, and to the east eastward of the same anticline. However, these strata are clearly disturbed in the vicinity of the Fault zone.

Moving from east to west, the general bedding attitude of the Turonian Cenomanian formations in the studied area is the following:

- Beds are dipping to the west by about 20° then becoming steeper to reach 30 to 40 degrees.
- Moving westward, an anticlinal structure is identified which axis trends also in a NE-SW direction.
- To the west of this anticlinal structure, the beds dip normally towards the west by about 25° before plugging steeply by about 80° because of the western flexure which extends almost all over Lebanon.
- Westward of the flexure, the Turonian-Cenomanian formation is overlain by the Senonian marls which dips gently toward the Koura plain.

Finally, Ain Aakrine fault is considered as one of the major faults of Lebanon because it extends from Ehden (in the east) to Mseilha (Batorun in the west). The Kousba anticline stops at this fault.

1.4 HYDROGEOLOGY

The studied area consists of different hydrogeological units. The limestone formations are the major aquifers and form very important ground water reservoirs. Their thickness is suitable (more than 100 meters), fracturing is intensive and enhanced by karstification process. The main aquifer in the study area is the Cenomanian-Turonian unit. This is a karstic aquifer and characterized by very high secondary porosity and permeability as well as a large stratigraphic thickness. The Senonian deposits unit is impervious.

Hydrogeologically speaking, the Turonian-Cenomanian limestones, being, thick and karstified constitute a very important aquifer. The general westward dip direction of the layers makes the underground water flow westward. However, the presence of the anticlinal structure makes a kind of barrier to the underground water flowing in the lower unit (C4a) of the Cenomanian formation, because it puts the impervious marly unit in front of them, preventing part of the underground water to flow westward and accumulating it in the synclinal structure which forms a kind of underground water reservoir.

Kfarsaroun village is located to the West of the Western flexure where the Turonian and Cenomanian Layers dip steeply by about 80° towards the west. It is difficult to find a location within Kfarsaroun village with high groundwater potential. Consequently, we do not suggest to drill a well in and for Kfarsaroun locality.