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MINISTRY OF ENERGY AND WATER

GEOLOGICAL AND HYDROGEOLOGICAL STUDY WITHIN JEZZINE REGION

Final Report

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TABLE OF CONTENTS

1 GEOLOGY OF JEZZINE AREA 1
1.1 GEOMORFOLOGY 1
1.2 LITHO-STRATIGRAPHY 1
1.2.1 THE UPPER APTIAN FORMATION (C_{2B}) 1
1.2.2 THE ALBIAN FORMATION (C_3) 1
1.2.3 CENOMANIAN FORMATION (C4) 2
1.2.4 QUATERNARY DEPOSITS (Q) 2
1.3 STRUCTURAL GEOLOGY 2
1.4 HYDROGEOLOGY 2
1.4.1 CENOMANIAN AQUIFER (C4) 2
1.4.2 ALBIAN (C_3) AQUICLUDE 3
1.5 DESIGN OF THE WATER WELLS 3
1.5.1 JEZZINE WELL 3

1 GEOLOGY OF JEZZINE 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 BTD. 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 1**) 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 Aptian Formation, Albian Formation and the Cenomanian Formation with an altitude between 1050 and 130m above the sea level.

1.2 LITHO-STRATIGRAPHY

The outcropping rock formations in the study area extend from the Upper Aptian Formation (C2b) to the Cenomanian formation (C4) through the Albian formation (C3). Furthermore, recent Quaternary alluviums and slope deposits especially in the plains, valleys, and along toes of the slopes.

1.2.1 The Upper Aptian Formation (C_{2b})

The Upper Aptian Formation (C_{2b}) outcrops in small patch at the North West edge of the study area. The total thickness of this formation does not exceed 70 m. The boundary between the Lower and Upper Aptian formations is marked by a friable marly limestone layer about 2m thick, which is the extreme top of the (C_{2a}) Formation below the massive micritic limestone of the Upper Aptian Formation (C_{2b}). This boundary is very clear due differential weathering of the incompetent marly limestone underlying the highly competent C_{2b} cliff. This forms a rock shelter few meters wide at the foot of the cliff. Oyster shells are observed in the marly limestone layer. The limestone of the Upper Aptian Formation has a light grey fresh color and is micritic. It has a very high strength and presents fairly high secondary fracture porosity and permeability.

1.2.2 The Albian Formation (C_3)

This formation exposed in some patches at the middle and the western part of the study area. The total thickness of the Albian Formation approximates 100 m in the study area. The (C_3) Formation presents an alternation of marl, limestone, and marly limestone beds. The marl beds have a creamish white color and fine silt sized grains. The marly limestone beds have moderate strength and are more fractured and jointed than the limestone beds having a higher strength, which makes them easily friable into silt sized material.

1.2.3 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. In the study area it outcrops in the Middle and Western Part of the map.

2) The middle Cenomanian rocks(C4b) that consists of interbeddings of Limestones, Marls and marly Limestones. The (C4b) formation out crops in the Middle North and Eastern part of the map.

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 outcrops on wide surface area on the middle of the map. The average thickness of the whole Cenomanian formation is about 600m.

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 and the presence of South Jezzine syncline.

The axis of South Jezzine syncline is oriented SW-NE and it is located to the south-east of Jezzine village.

The beds of the eastern flank of this syncline which consist of the Middle and Upper Cenomanian Formations (C4b) and (C4c) are dipping by 15-30° toward the west, while the western flank of this syncline are dipping by 30° toward the east these are Midane and Sahl Aadouss Faults.

The South Jezzine syncline structure seem to be the dominant structural mechanism in the study area. Moreover the study area is crossed by 2 major E-W trending faults.

1.4 HYDROGEOLOGY

The study area consists of different hydrogeological units. These are Cenomanian aquifer, and Albian 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 Albian (C_3) aquiclude

The clay and marl horizons within the Albian 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 South Jezzine crosses the South East Jezzine village with the Upper Cenomanian (C4c) Formation outcropping at its top and on its flanks. The beds on the eastern flank of this syncline are dipping by 15-30° toward the west, and the western flanks are dipping by 30° toward the east.

We have to remind here, that the project area lies on the Cenomanian dolomitic limestone formation. These rocks are highly fissured and the density of fissures increases in the vicinity of the major faults.

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 Cenomanian 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 beside the Sahel Aadouss Major Fault or to its western flank.

1.5 DESIGN OF THE WATER WELLS

1.5.1 Jezzine well

1.5.1.1 Borehole location

The well is located on plot No. 3510 to the left side of the road leading to Ain Majdaline village in Sahel Aadouss locality to the south of Jezzine, at the following coordinates (Fig. 2):

X = -330957 km
Y = -70334 km
Z = 1155 m
(Jezzine 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

750 m

1.5.1.4 Expected discharge

1000 m^3/day (or 11.6 l/s).

1.5.1.5 Static water level

200 m below ground level.

1.5.1.6 Geology

The syncline axis of South Jezzine, crosses the South of Jezzine village with the Upper Cenomanian (C4c) Formation outcropping at its top and on its flanks. The beds on the eastern flank of this syncline are dipping by 15-30° toward the east. The well has been located at the axis of the syncline and along the Sahle Aadouss major fault. It will cross at the beginning the dolomitic limestones of the Upper Cenomanian (C4c). These limestones are highly karstified and might contain many karstic voids.

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

a) The limestones and dolomitic limestones of the Upper Cenomanian (C4c) Formation (450 m).
b) The marls and marly limestones of the Middle Cenomanian (C4b) Formation (~ 200m).
c) The dolomites and limestones of the Lower Cenomanian (C4a) Formation (~100 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 12". 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 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 total depth of 750 m.

- Installing 12" casing and screens as shown below:
  a) Casing:
  Diameter: 12" ID

Type: Carbon steel
Thickness: 6 mm
Total length: 650 m

b) Screens:
Diameter: 12" 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.

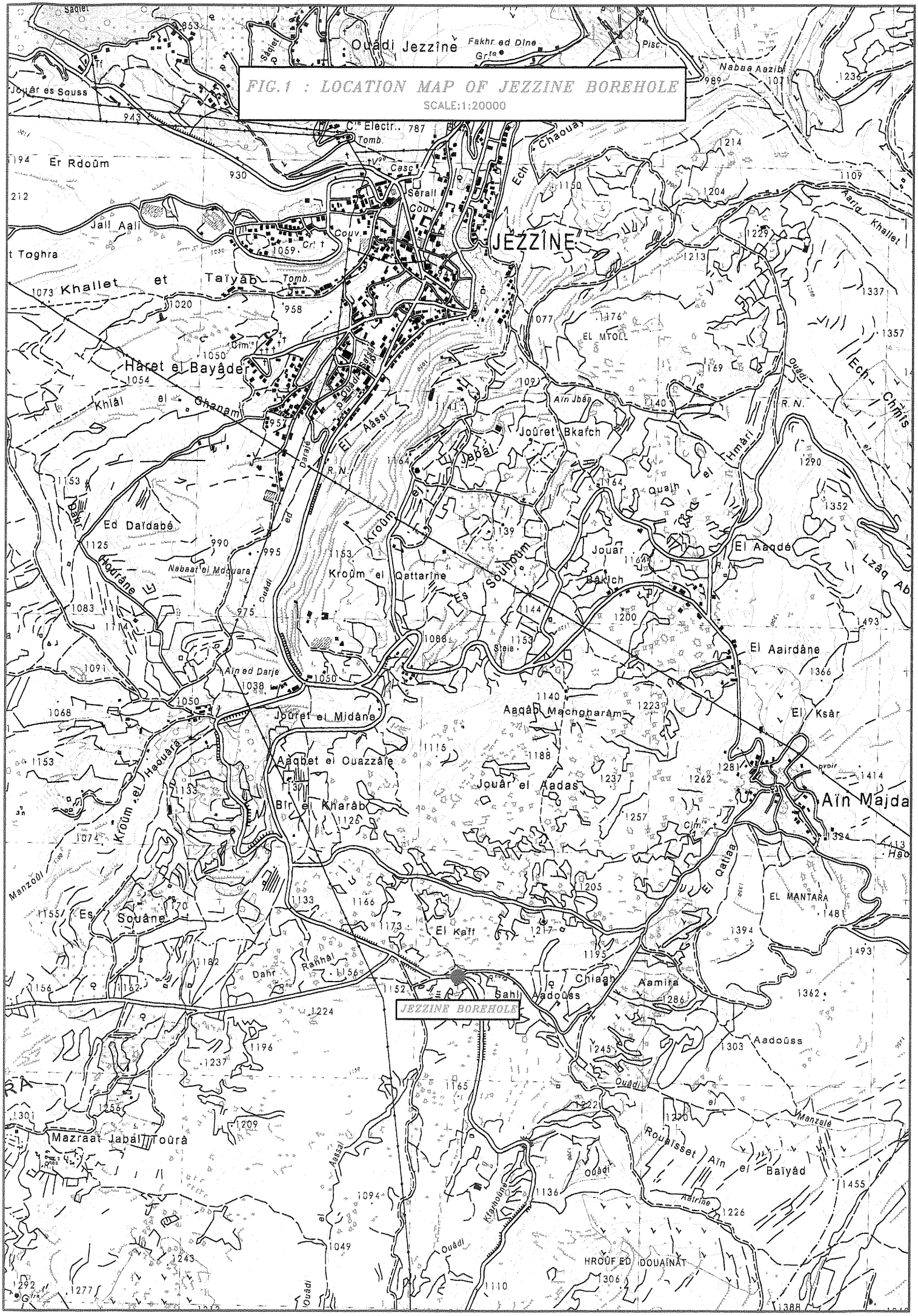
FIG.1 : LOCATION MAP OF JEZZINE BOREHOLE
SCALE:1:20000
JEZZINE BOREHOLE
JEZZINE
Ouâdi Jezzîne
Fakhr ed Dine
Cie Electr.
Er Rdoûm
Jaïl Aali
Khallet et Taïyâb
Hâret el Bayâdet
Khlâl el Ghanam
Ed Dardabé
Kroûm el Qattarîne
Souhoûm
Jouret Bkarch
Jouar Bakich
El Aaqdé
El Aairdâne
Aaqâb Machoharâm
El Ksâr
Aïn Majda
Jouret el Midâne
Aaqbet el Ouazzâne
Jouâr el Aadas
Bîr el Kharâb
Aïn ed Darje
Es Souâne
El Kaff
Chiaah Aadoûss
Aamira
Aadoûss
EL MANTARA
EL MTOLL
Jouret Bkarch
Mazraat Jabal Toûra
HROUF ED DOUAINAT
Aïn el Baïyâd
Rouaïsset
Manzelé
Ech Chaoua
Ech Chmis
Aaïd Khallet
Nabaa Aazibi
Nabaat el Mdouara
Kroûm el Haouâra
Manzoûl
Dahr Rahhal
Ouâdi
R.N.

FIG. 3 : VERTICAL CROSS SECTION OF JEZZINE BOREHOLE