SYRIAN ARAB REPUBLIC
ATOMIC ENERGY COMMISSION (AECS)
DAMASCUS, P.O.BOX 6091

REPORT ON SCIENTIFIC FIELD STUDY
DEPARTMENT OF GEOLOGY

GEOLOGY, HYDROLOGY, SEISMOLOGY AND GEO-TECHNIQUE OF AL- JAFRA SITE (NORM REMEDIATION PROJECT)

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AECS – G \RSS 440

JULY 2002

الجمهورية العربية السورية
هيئة الطاقة الذرية
دمشق - ص.ب ٦٠٩١

تقرير عن دراسة علمية ميدانية

قسم الجيولوجيا

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الدكتور بولس أبو زخم
الجيولوجي رضا سبيناتي
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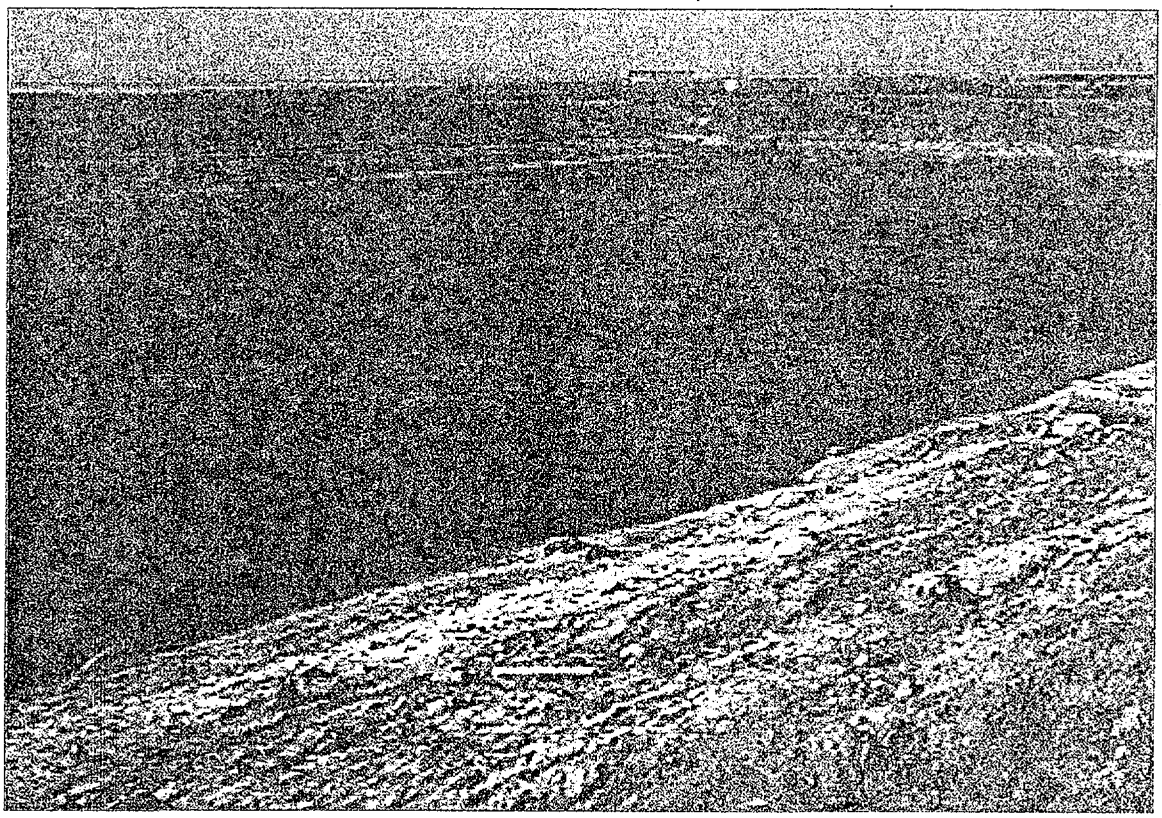

Atomic Energy Commission of Syria,
Department of Geology
Damascus, P. O. Box 6091, SYRIA

NORM Remediation Project for Der Ezzor Petroleum Company (DEZPC) Oilfields in Der Ezzor Area, Syrian Arab Republic

Geology, Hydrology, Seismology and Geo-Technique of Al-Jafra Site

Prepared

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Department of Geology

2002

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Chapetre One

Geology and Tectonics of Al-Jafra Field Site

Geologist Youssef Radwan

1. Location of Al-Jafra Field Site

The site of Jafra field is located 35kms to the east-southeast of Der Ezzor town, stretching between (N 35 17 – N 35 18) and (E 040 26 – E 040 27), at an elevation of 250 m a.s.l.. The dominating weather is desert-dry i.e. cold in winter and very hot in summer with a meager 250 mm annual precipitation.

2. Tectonic Setting

Jafra field site is located in Der Ezzor Depression, one of the depressions developed within the northern extremities of the mobile part of the Arabian platform at the northeastern- most extension of the Palmyra Folded Belt's closure. (Fig. 1). The Euphratean Fault trending SE/ESE, runs to the west of Jafra field site. A regional NE trending faulting zone i.e. the Southern Palmyrean Faulting Zone intersects the Euphratean Fault perpendicularly close to the town of Der Ezzor.

The gypsum and clayey Pliocene rocks, outcropping in the site, are either horizontal or dip very gently 5° eastward. This indicates when taking in account their high ductility, very week vertical tectonics. Nevertheless, during Q_3 (i.e. the time interval extending from 1.2 my B.P. to the last 10 ky B.P.), an extension strain oriented WNW-ESE prevailed due to active tectonic processes which resulted in the formation of NNE faults, through which basaltic lava ascended whose products covered vast area. Fault traces are mapable by following the manifestation of the volcanic cones. The nearest of which to Jafra field site is located at the Euphrates western bank, specifically in Tell Brouq, which is 45 km far from it, where extruded basalt via a NNE, 4km-long fault covered an area attaining approximately 30 km^2. Furthermore, it is widely accepted that the current Euphrates' course is tectonically controlled by ESE, SE and NNE faults traces.

Lineaments mapped from a spot imagery of the area were plotted on a rose diagram. Four major trends were dominant: ESE, E-W, NE, and NNE (fig. 2), they correspond with the general trend of the Euphratean Fault, Sinjar-Twal Al Aba anticlines' axis, the southern Palmyridean faulting zone's direction and with the extension faults which were behind ascending the basaltic extrusive in Jabal Qleb Hamma and Tell Brouq respectively.

3. Geological Setting

Two major rock types outcrop in Jafra field site, they are namely:

3.1. Lower Pliocene Evaporites (Upper Fars formation) N_2^a:

They are represented by 2m thick massive white gypsum (photo 1) interbedded by thin green, reddish brown 0.5m thick clay (photo 2), and by centimeter-decimeter thick marl, clay, gypsum and far less chalky limestone outcropped in the 25m high cliffs bound the Euphrate banks.

Gypsum beds suffer from deep weathering and intensive alteration due to its high soluability. Rain water percolates downwards during rainy months, and ascends in dry months due to capillary potential precipitating its load of dissolved salts as white patches developing friable salty gypsiferous soil covering Jafra field site and the surrounding areas.

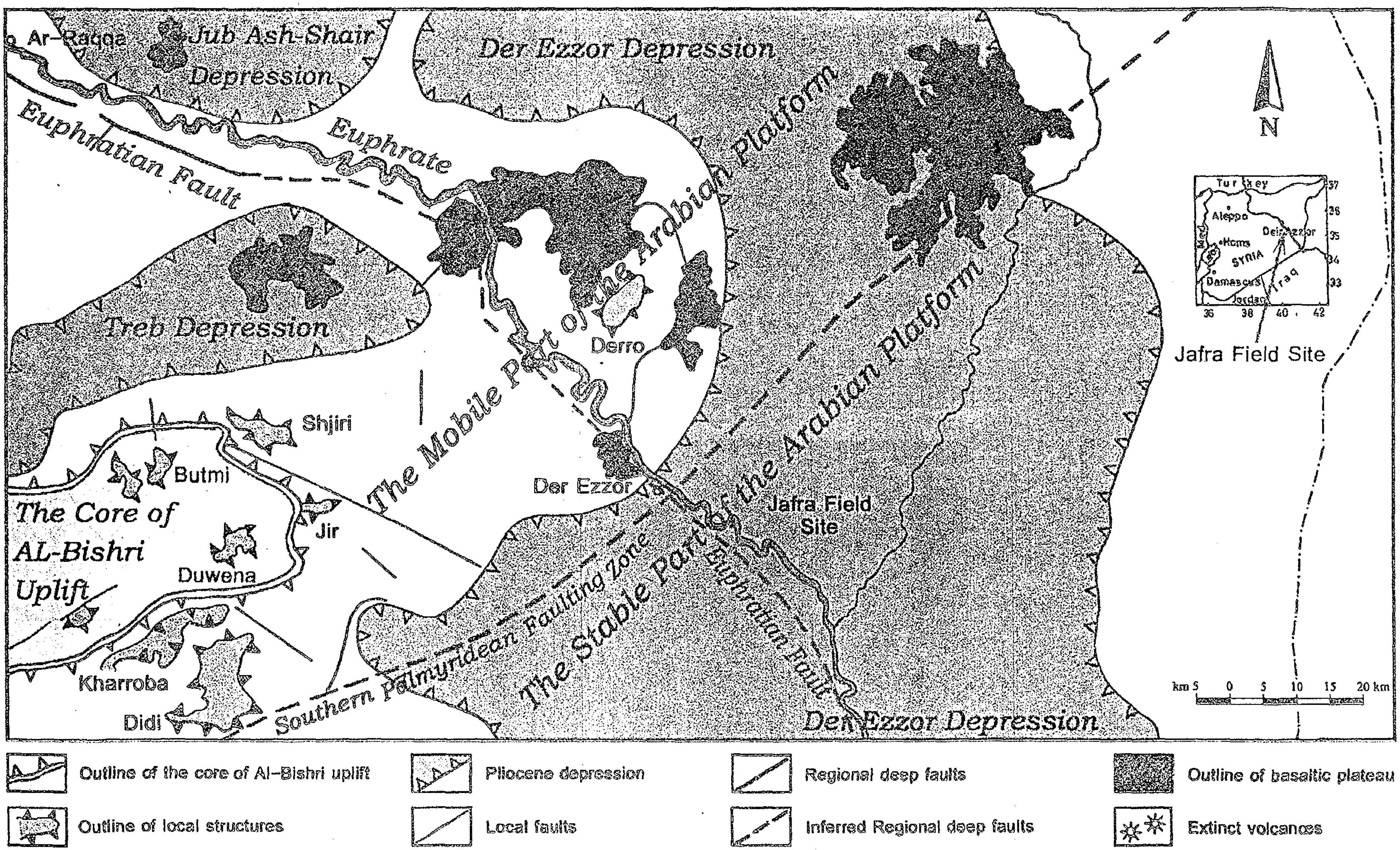


Fig. 1: Simplified tectonic scheme of the area encircling the Jafra field site.

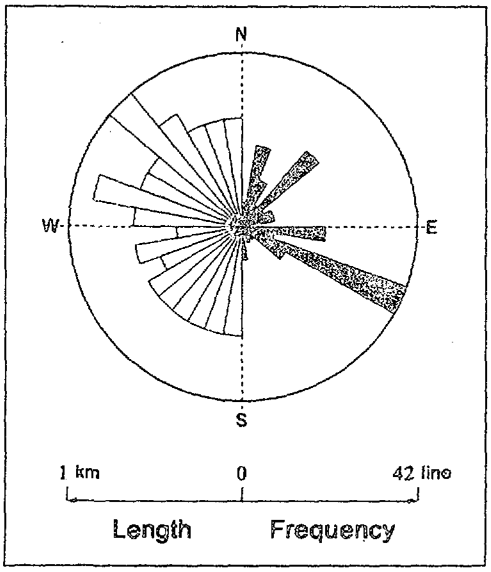
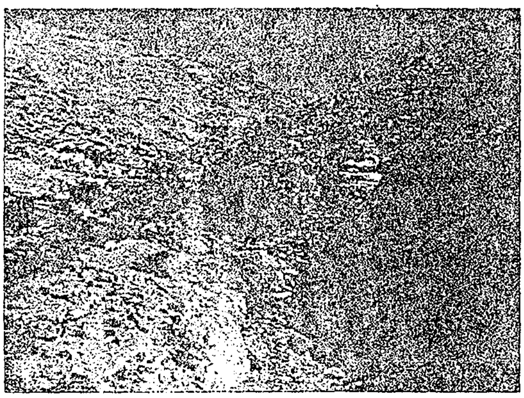


Fig. 2: Rose diagram of the lineaments inferred from SPOT imagery of the area encircling Jafra field site.



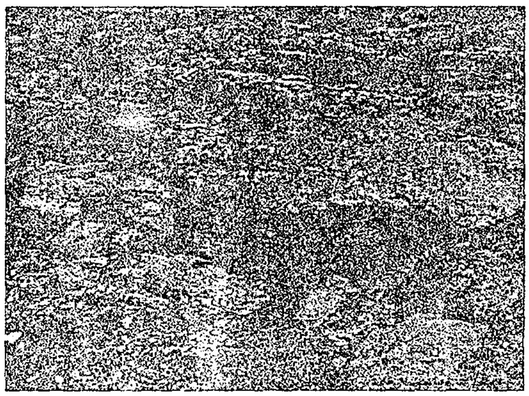


Photo 1: Lower Pliocene gypsum.

Photo 2: Lower Pliocene green clay.

Additionally, due to gypsum's low hardness, measured 2 by Mohs scale, grooving (photo 3), down-deepening and caves-networking are very common phenomena. The downward percolating gravity water, during rainy months, widen the available joints, which are controlled by the major lineaments' trends,

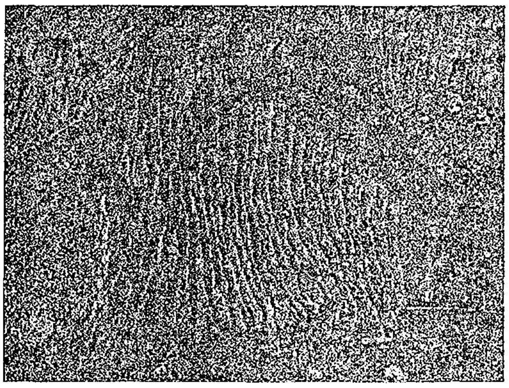


Photo 3: Characteristic grooves formed by running water due to gypsum low hardness and high solubility.

gradually to develop subsurface caves interconnect each other through subsurface drain. This drain becomes surface one before reaching Euphrates due to the presence of impermeable green clayey bed (photo 2), which prevents water from down-percolating. In the same time it plays the role of a slippery surface due to clay high viscosity once saturated with water.

3.2. Lower Quaternary Clastic Rocks Q1:

These rocks outcrop through the excavation works of a drinkable-water supplying canal 3 km far from Jafra field site. They are represented by conglomerate, sandstone, friable sands and gypsiferous soil (photo 4).

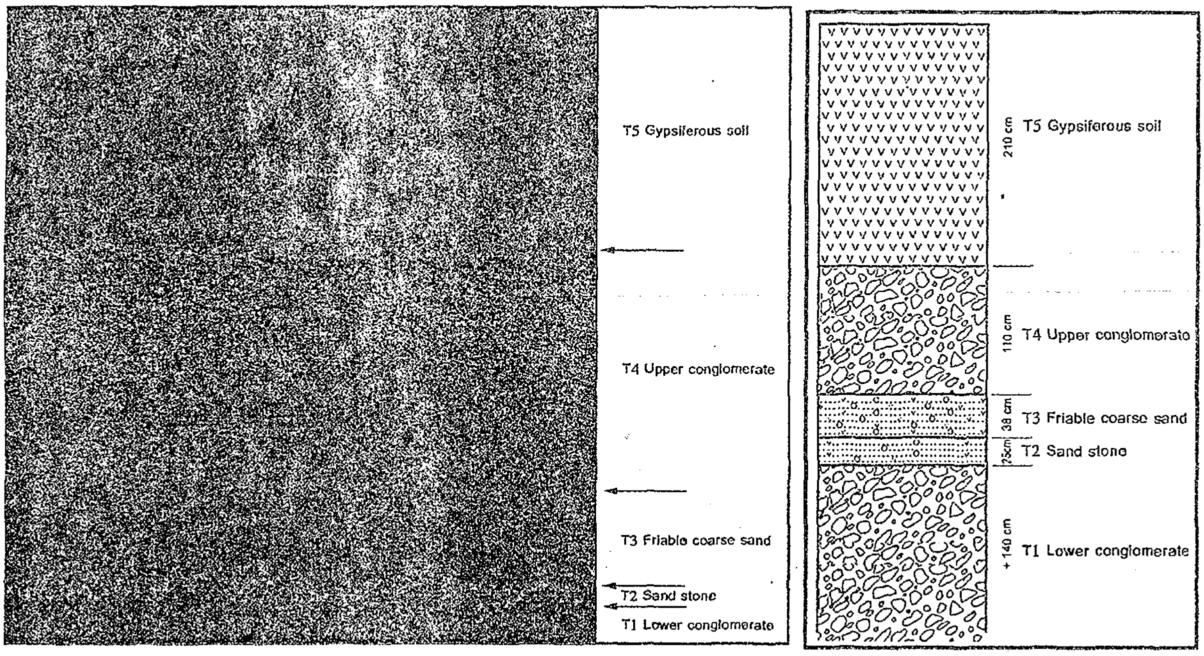


Photo 4: Lower Quaternary clastics outcropped by the drinkable-water-supplying canal.

The following clastic rocks outcrop in the drinkable-water-supplying canal from bottom to top:

T1: Lower conglomerate: Its components are mainly well rounded cobbles of (10 cm) black and brown chert, quartz, and basic and/or ultra basic rocks. X-ray analyses performed in the department of geology, SAEC, reveals that its cement is composed of 47% quartz, 23% gypsum, 16% amphibole, 8% feldspar grains white to grey in color, whose dimensions range between 0.02-1 mm (photo 5).

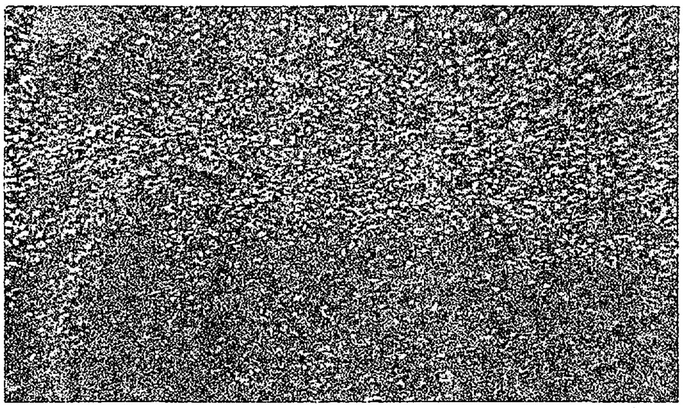


Photo 5: Q_1 lower conglomerate.

T2: Very fine greyey yellow sandstone: Its thickness attains 25cm. The X-ray analysis indicates that the cement is composed of white to grey 44% feldspar, 31% quartz, 9% calcite, 9% dolomite, 7% gypsum grains ranging between 0.02-1mm, in diameter, (photo 6).

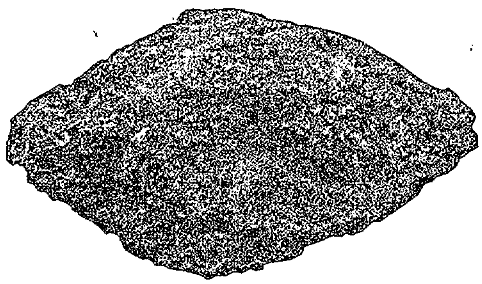


Photo 6: Q_1 very fine sandstone.

T3: Coarse friable sand: Its thickness is approximately 38cm. Its grey- white components, which vary in dimensions between 0.5-2 mm, are composed of 60% quartz, 19% feldspar, 16% calcite and small amount of clay 3% and gypsum 2% (photo 7).

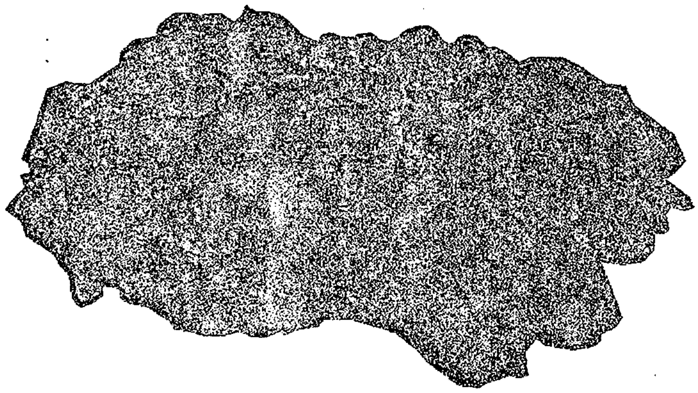


Photo 7: Q_1 coarse friable sand.

T4: Upper conglomerate: Its thickness is around 110cm consisting of brown to black quartz, chert, basic and ultrabasic rock fragments ranging in size from few mm to 10cm. Its cement is composed of 66% quartz, 21% gypsum and minor amounts of clay 5%, feldspar 4% and calcite 4% (photo 8).

Photo 8: Q_1 upper conglomerate.

T5: Gypsiferous soil: Grey in color with a thickness of 210cm it is composed of few mm big gypsum crystals clustered randomly. Some traces of quartz 9%, calcite 7% and clay 2% are found (photo 9).

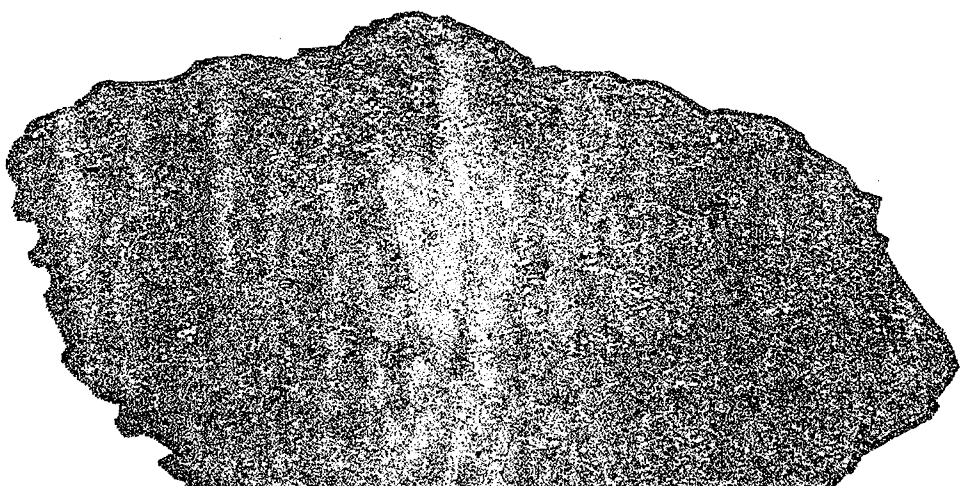


Photo 9: Q_1 gypsiferous soil.

It is worth mentioning, that Q_3 massive basalt with a distinctive chilling cracks is exposed in Tell Brouq which is located to the northwest of Der Ezzor town. The basalt forms a pronounced up to 10m sheet covering Upper Tortonian gypsum beds (photo 10).

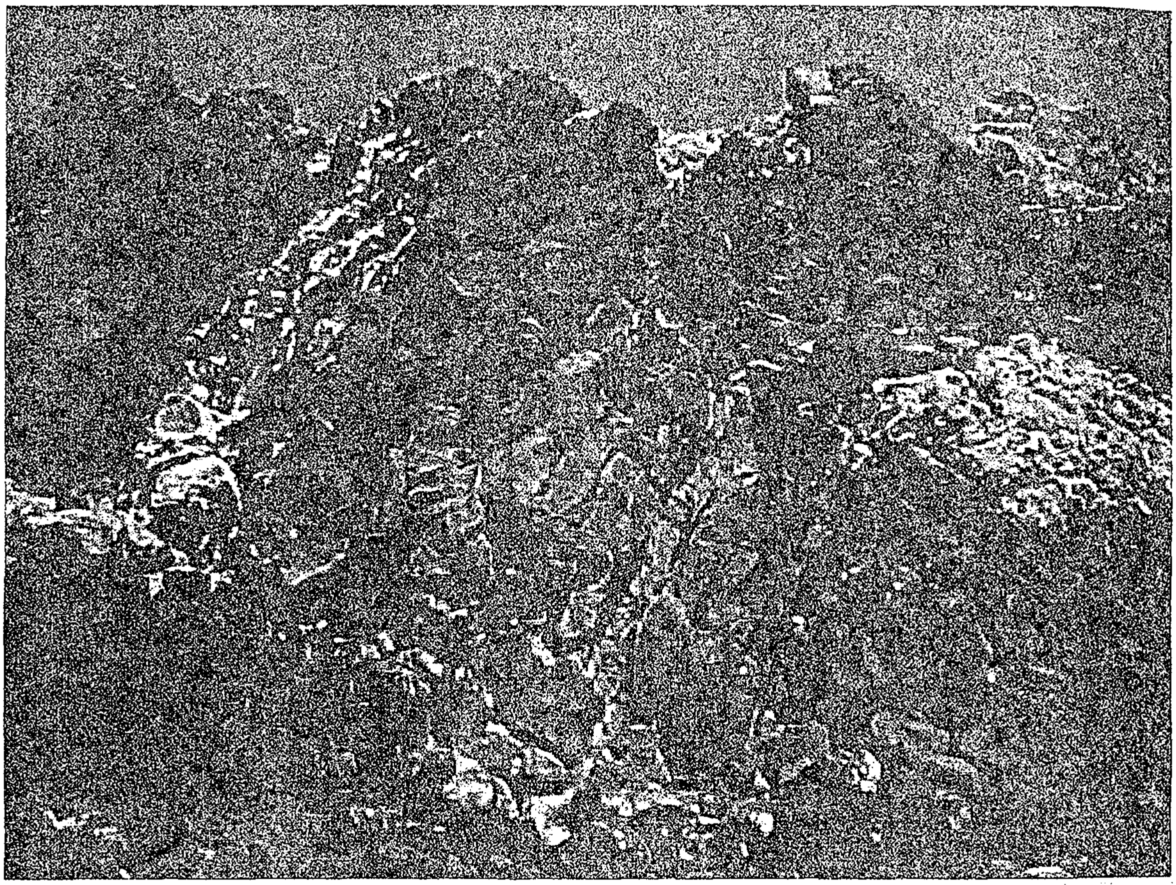


Photo 10: Q_3 massive basalt.

Physical properties of the rock exposed in Jafra field site

Through previous studies performed by the Geology Department's staff, rock samples were collected from different Tortonian rock variaties outcropping in Der Ezzor area and analyzed in Soil and Foundation Laboratory, Mechanical Engineering Faculty, Damascus University. Its physical properties are summarized in the following table:

Field observation in Jafra field site and the analysis of the Pliocene rocks outcropped at the Euphrates banks in the nearby reveals close facies resemblance to the Tortonian rocks outcropped near the town of Der Ezzor.

Table of the physical properties of Tortonian rocks outcropping in Der Ezzor area, which are equivalent to Lower Pliocene evaporites exposed in Jafra field site.

Rock types	Unit Weight g/cm^3	Specific Weight g/cm^3	Young Module kg/ cm^2	Poisson's Ratio	Compre-ssive Strength kg/ cm^2	Bearing Capacity kg/ cm^2	Internal Friction angle Degree	Electric Resista-nce ohm/m
Clay	1.84-1.85	2.14-2.26	1-2 *10^3	0.25-0.35	27.43-94.69	2.5-4.0	30-40	100-150
Gypsum	1.96-2.08	2.27-2.29	4-6 *10^3	0.25-0.3	61.67-250	3.0-4.5	35-40	200-300
Gypsiferous soil	1.72	2.21	1-2 *10^3	0.25-0.35	22.58	2.0-3.0	30-35	20-30

4. Recommendations

From the tectonics and geology of the area in general and of the Jafra field site in particular, in addition to field check, it is recommended to take seriously in account the gypsum high solubility which can lead to cave-networking or collapsing. The presence of the slippery impermeable green clay, and the lineaments' directions and bed's local dips in addition to the physical properties of the Jafra field site's rocks and soil should also be highly considered, when designing and constructing any facility in it in order to mitigate latent future risk.

5. References:

1- Ponikarov, V. P. (ed.), 1966. The Geological Maps of Syria, scale 1:200.000, sheet Ar-Raqqa I-37-XXII, Ministry of Industry, Damascus, Syrian Arab Republic.

2- Ponikarov, V. P. (ed.), 1966. The Geological map of Syria, scale 1:200.000, explanatory notes on sheet Ar-Raqqa I-37-XXII, Ministry of Industry, Damascus, Syrian Arab Republic.

Chapter Two
Hydrogeology of Al-Jafra Site

Dr Boulos ABOU ZAKHEM

1. Climate

The studied area is characterized by cold dry winter and hot summer. The average minimum temperature in winter is 1.8 °C in Jan., while it increases to the average maximum temperature of 39.6 °C during June, and the absolute temperature is 50 °C while the minimum absolute temperature is –10 °C. The area is classified under the fifth stable part according to the annual rainfall (the Syrian classification) where the average annual rainfall reaches 144 mm/y. the rainfall happens usually between Nov. and March. Generally, the relative humidity is low in summer and reaches 75 % in Jan.

The area is affected by strong winds during the transmission season (autumn and spring) where it caries desert sands and dust that improve the aeolean erosion process which is the characteristic of the desert. The annual evaporation rate reaches 2141 mm/y and it is 16.4 mm/day for June while it decreases to 1.8 mm/day in Jan. (Table. 1).

This area is characterized by salty crusts on the ground surface and when the groundwater of the shallow aquifer rises to the soil surface by capillary effect, it evaporates causing salt accumulation on the soil surface.
This phenomenon is dominated in Euphrates valley especially in the quaternary plains that is surrounding the river in the Bed River, whereas the groundwater level is less than 2.5-m depth in general.

Table. 1 Climatic data of Der Ezzor research station of Arab Center (1955-1995)

Parameter	Jan.	Feb.	Mar	Apr	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	The Ave.
Min. T °C	1.8	2.3	6.6	11.6	16.4	21.6	24.8	23.9	19.3	13.1	6.7	2.8	12.6
Max.T °C	12.3	14.3	19.3	25.6	30.9	36.6	39.6	39	35.8	28.3	20.4	14	26.4
Ave. T °C	6.6	9	12.8	18.6	24.7	28.8	32.1	31.3	27.1	20	13.3	7.8	19.3
Prec. mm	22.9	23.4	30.2	19.5	7.3	6.4	0	0	0.3	7.0	11.6	22	144.6
Eva.mm/d	1.7	2.7	4.4	6.8	10	14.8	16.4	14.2	10.2	6.5	3.5	1.8	8.1
R. H. %	75	63	59	49	37	28	28	31	34	47	59	74	49
Winds m/s	2.2	2.5	2.9	3.0	3.3	4.2	4.6	3.8	2	1.9	1.7	1.9	2.8
ET mm/m	47.0	64	99	168	229	324	347	316	252	161	75	59	2141

A low yearly amount of precipitation (100-200 mm/y), pronounced continental climate, high evaporation and wide distribution of Gypsum deposits. All these facts resulted in low water yield and high salinity of groundwater of Neogene formation.

2. Water-bearing formations in the studied area

It is composed of conglomerates, grigstones, gravels and sands especially in the lower Pliocene (Pliocene water-bearing shown in Fig. 1), where it spreads on the both sides of Euphrates valley. This aquifer is mainly fed by direct recharge by precipitation through unsaturated zone and secondly by infiltration of Euphrates water river through Quaternary and Neogene formations in certain area. The Paleocene water-bearing horizon is struck by numerous wells at depths of 12-25 m. The discharge and salinity of water in the wells depend upon the season. The greatest discharge is known in spring time after the rainy season, when water is less mineralized.

3. Water quality

Salinity of Pliocene water varies from 1-2 g/l to 8-10 g/l. According to its chemical composition, Pliocene water is mainly of sulfate and Chloride-sulfate type and Sodium- Calcite. The chemical composition is given by the formulae (after Ponikarov, 1966).

$$M3\frac{SO_{25}^{4}Cl_{21}NO_{2}^{3}HCO_{2}^{3}}{Na_{28}Ca_{12}Mg_{9}}$$

The Pliocene water is extensively fit for watering livestock. Waters of some wells with large discharge are also used for irrigation of fields. Wells with large discharge and considerably low salinity are known on the right and left banks of Euphrates River (Beer El-Hadab).

4. Mineral composition of the soil

One soil profile was drilled with depth of 250 cm between 22 to 24/10/2001 in Al-Jafra field that is belong to DEZPC. The mineralogy composition is shown in Fig. 2. In this Fig. the Gypsum is the main mineral with a ratio of 80-90 %, quartz ratio is between 5-10 % and clay is found in the upper part of the profile with 5-10, whereas, the phyldespar has the same ratio of clay in the lower part of the profile, there is a relation between the two minerals. The calcite is found in some horizon with depth and surface. Generally, the humidity in the profile is low and have a ratio of 2-10 %.

5. Recommendation for the groundwater in Jafra area :

The field and biblographical work indicated that the drilled wells in Neogene formation surrounding the site are located at about 8-12 Km far. The shallow water is found in 20-30 m depth, whereas, the second water-bearing in Neogene is at 80-90 m depth. On the hydrogeological map (Fig. 1), it is indicated that for the first horizon of Pliocene formation, the water levels were between 15-25 m depth.

It is suggested to drill one investigation well in the area of 50 m depth in order to study the groundwater in the first horizon of Pliocene formation and to be an observation well of the proposed site.

N 35° 17' 50''

A E 40° 26' 52''

Alt 245 m (a.s.l)

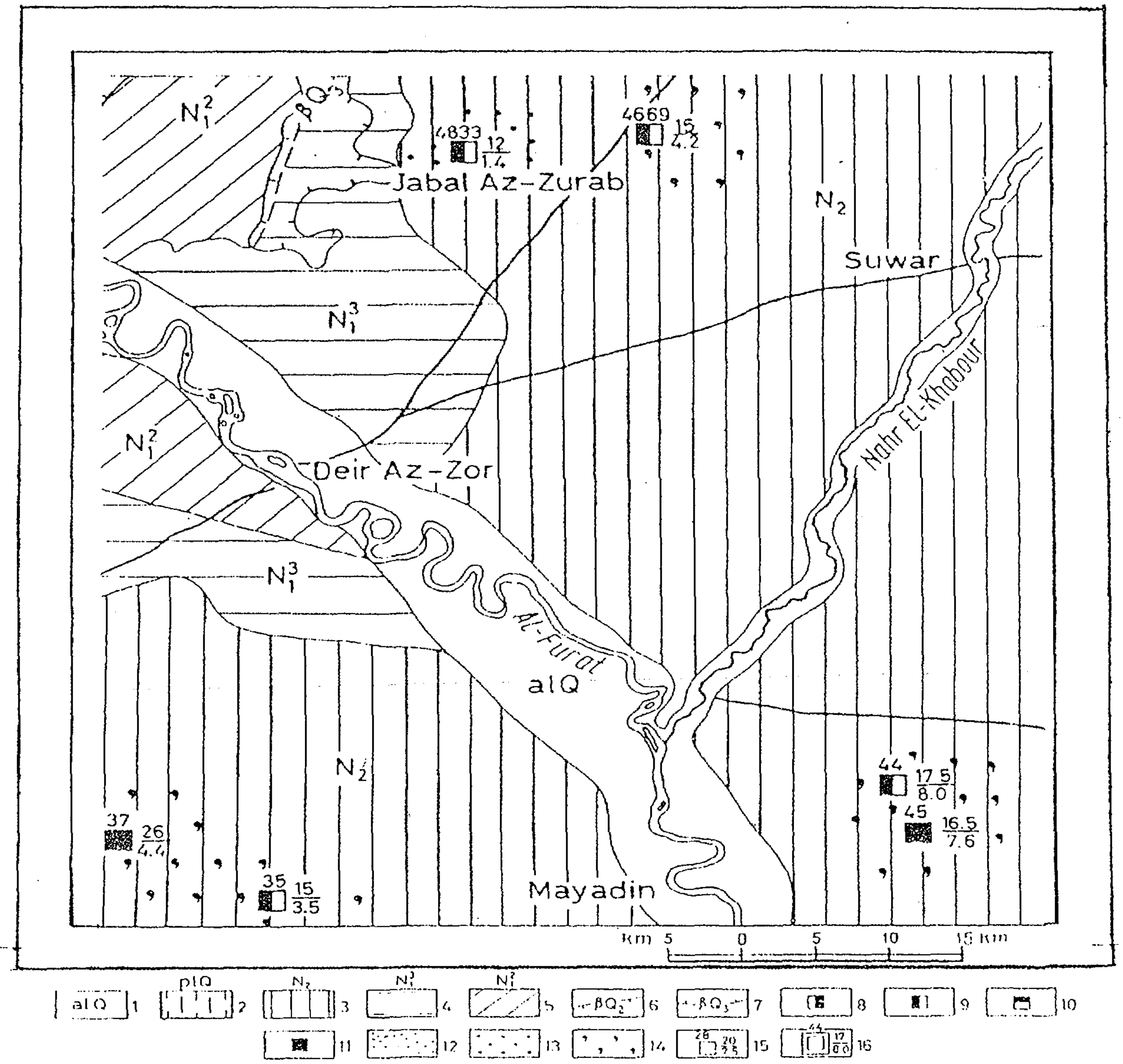


Fig. 1-Hydrogeological map (Ponikarov, 1966)

Geological age and lithology of water-bearing rocks of the 1st horizon below the surface: *1* — Quaternary alluvial deposits. Pebbles, sands; *2* — Quaternary proluvial deposits. Gypseous loams, sandy loams, pebbles; *3* — Pliocene deposits. Sands, sandstones, pebbles, conglomerates, marls; *4* — Upper Miocene deposits. Siltstones, sandstones; *5* — Middle Miocene deposits. Gypsum, limestones, sandstones. *Distribution contour of water-pervious rocks, overlaying the 1st water-bearing horizon:* *6* — Middle Quaternary basalts; *7* — Upper Quaternary basalts. *Chemical composition:* *8* — where major anion is hydro-carbonate; *9* — where major anion is sulphate; *10* — where major anion is chloride; *11* — mixed composition. *Mineralization of water:* *12* — less than 1 g/l; *13* — from 1 to 3 g/l; *14* — over 3 g/l. *Water sources:* *15* — well, *16* — group of wells. At top its number, on right depth in m, mineralization in g/l

Soil profile A

Location: N 35* 17' 50"
E 40* 26' 52"
Al =245 m (asl(

I JAF

1	6cm	00-12 cm	Fine sandy gypsum soil
2	25	38-12	Gypsum Crust with 20 cm thickness
3	41	45-38	Fine sandy gypsum with higher humidity
4	52	60-45	Gypsum soil
5	65	70-60	
6	75	80-70	
7	85	90-80	
8	95	100-90	Increasing of gypsum with depth
9	115	120-110	
10	135	140-130	
11	155	160-150	
12	175	180-170	
13	195	200-190	
14	225	230-220	White gypsum crust
15	245	250-240	Hard gypsum crust (white gray color)

For Mineralogy analyses (XR. D.).

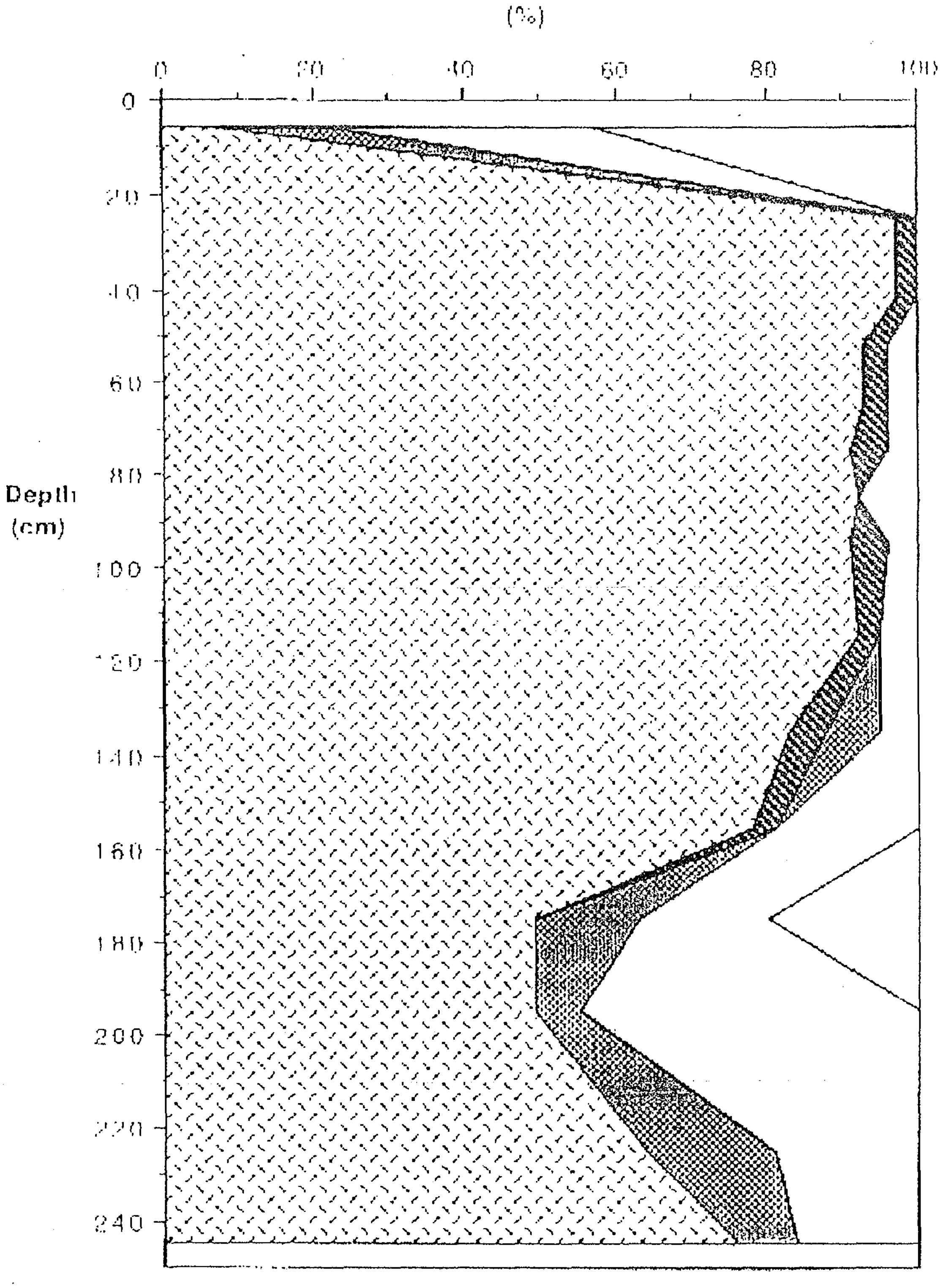
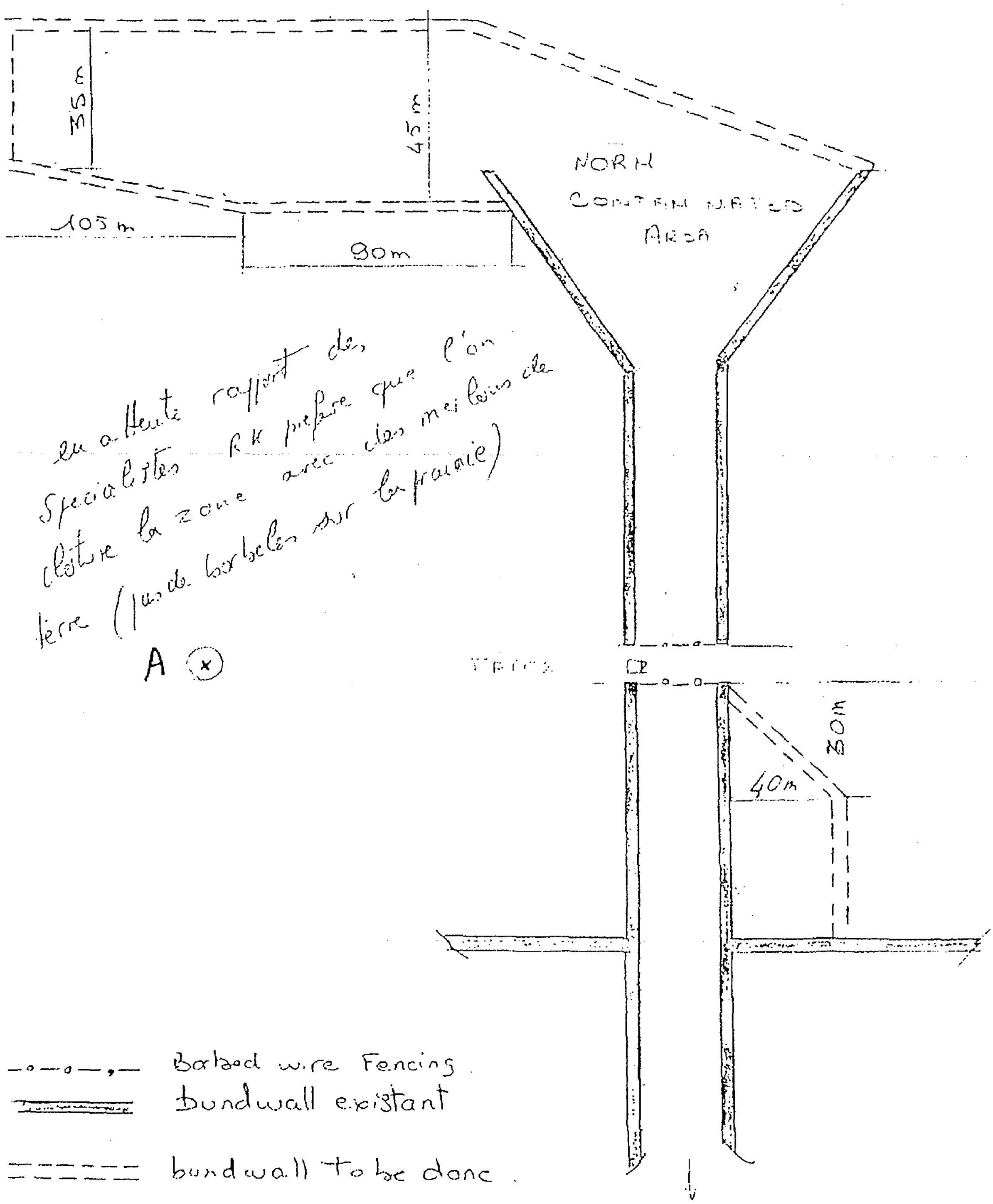


Fig.2- Minerale composition "X-R. D", profile JAF 1.

DRAWING FOR FENCING THE CONTAMINATED AREA



Chapter Three

Seismic Hazard Assessment of Al-Jafra Site

Geophysicist M. Reda Sbeinati

1. Introduction

Estimation of the seismic hazard at a particular site for erecting any engineering structure for special purposes is one of the most essential safety requirements. And to do this estimation or assessment, it is necessary to study both the earthquake and seism tectonic settings of the region encircling that site.

This preliminary study of the seismic hazard assessment is usually performed, on regional and sub-regional scale, using historical earthquake data (i.e., earthquakes occurred before 1900 AD) and information derived from instrumental earthquakes (i.e., those earthquakes recorded after 1900 **AD) that** are both available on the region surrounding the related site, adding the information related to the geological and active tectonic setting of the site region. This will, in turn, lead to assess peak ground acceleration on the bedrock level, the most important quantitative value in designing the earthquake resistant structures. While the detailed study of the site and site vicinity, is depending on the current seismic activity and the local effects of local geological conditions of the site. So, regarding the above mentioned, this report has been performed on regional scale and partly on site vicinity scale.

It is worth mentioning some definitions that will be used in this report:

Potential: A possibility worthy of consideration for Safety.

Region: A geographical area, surrounding and including the Site, sufficiently large to contain all the features related to a phenomenon or to **the effects of** particular event. A circle centered in the site and it has 150 Km of diameter.

Seismically active structure: A geological structure which exhibits seismicity at a level which indicates significant coherent activity on the structure or fault.

Site: The area containing the engineering structure, defined by a boundary and under effective control of the structure management. In our case Al-Jafra site is about 50 Km S-E of Deir Ezzor city.

2. Methodology

Studying Al-Jafra Site is based on the analysis of the historical and instrumental earthquake data, and of seismotectonic characteristics on regional scale that surrounds Al-Jafra Site. The region is defined by the coordinates from 34.28 N to 36.28 N and from 39.43 E to 41.43 E. Also, a seismic station was installed in the Site for 2 months, in order to monitor the current seismic activity in the site vicinity. The analysis will help in:

Identification of the seismogenic fault systems' effect at Al-Jafra Site.

Assessment of the maximum seismic intensity at the Al-Jara Site.

Assessment of the peak ground acceleration at Al-Jafra Site.

3. Seismotectonics

In the region, where Al-Jafra Site is located, there are two major faults that would govern the seismicity of the Site. These faults are briefly described below:

- Euphrates Faults System (EF): According to [Alsdorf et al., 1995; Sawaf et al., 1993], this fault is a NW-SE intraplate deeply one that extends, as a series of right-lateral strike slip faults, for a distance of 640 km from the Iraqi border in the south-east to the Turkey border in the north-west.
- Al-Bishri Faults (BF): These are the most northeastern extreme segments of the Palmyrides faults. Generally speaking, these NE-SW faults are a series of left-lateral strike slip faults that intersect perpendicular to the Euphrates faults north west of Deir Ez-Zor [Sawaf et al., 1993]. The South Al- Bishri fault is one

of these faults. In this regard, the October 5, 1970 earthquake (mb ~ 4.8) and the November 20, 1994 earthquakes are both evidences for its active nature.

4. Historical earthquakes

Reviewing catalogue of historical earthquakes in and around Syria for the period between 1365 BC and 1900 AD, prepared by the Syrian Atomic Energy Commission (SAEC) [Sbeinati et al., in progress], it can be concluded that Al-Jafra Site area was hit by the following earthquakes:

160 AD October

The earliest known earthquake to have struck Doura Europos (modern As-Salihiyeh), located ~136 km SE of the Site.

8th Century AD

A strong earthquake occurred in Ar-Rasafeh transferring its houses to ruins. Note that Ar-Rasafeh is located to the west of the Site at a distance of ~ 90 km.

859 December 30-860 January 29

During this period, a 7.4 magnitude earthquake occurred in northern Syria including Palis (modern Maskaneh), Ar-Raqqa and Ras Al-Ein. In Palis, at a distance of ~165 km NW of the Site, there was large damage.

Table 1 shows parameters of the historical earthquakes affected the area.

Table 1: **Parameters of the historical earthquakes affected the area.**

Date	Latitude N	Longitude E	Focal Depth (km)	Magnitude (*Ms*)
160 AD, Oct.	34.70	40.70	18	6.5
8th C. AD	35.70	38.70	12	6.5

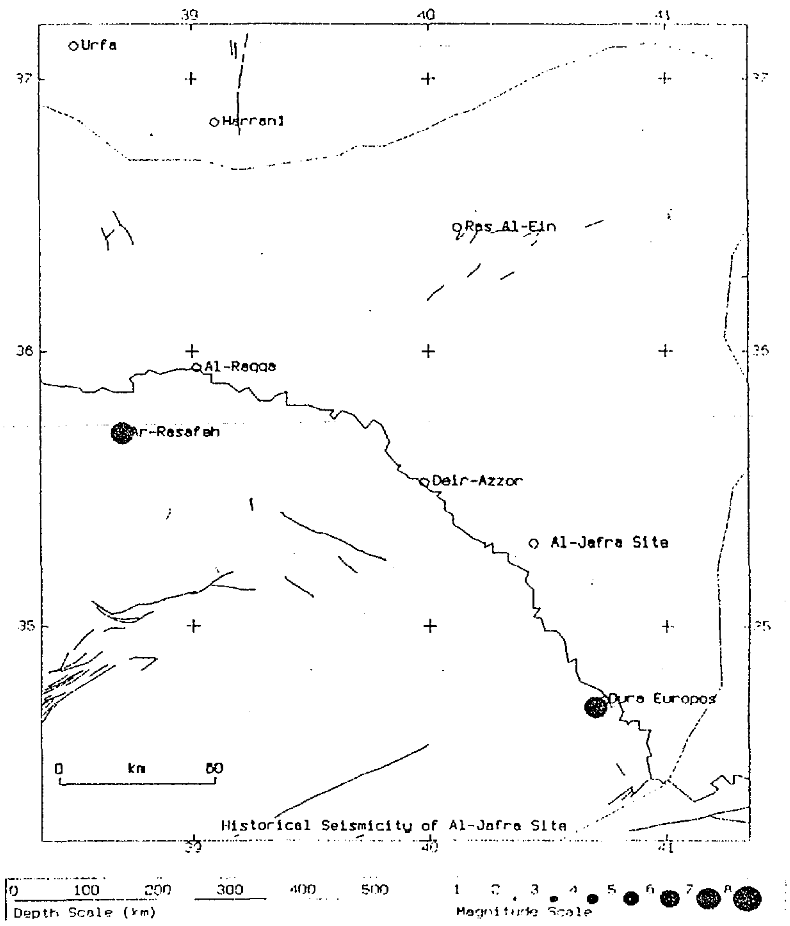


Figure 1: **Map showing the epicenters of the 160 AD and the 8th Century earthquakes in the region.**

٥. Instrumental earthquakes

Studying the catalogue of 1900-1994 Century earthquakes for Syria and its vicinity that was compiled by SAEC [Sbeinati, 1994], a list of instrumental earthquakes for the region encircling the Site has been prepared. Table 2 shows parameters (i.e., Date, Origin Time, Latitude and Longitude and Magnitude) of the 1900-1994 earthquakes in the area, while Figures 2 a&b reveal their distributions.

Table 2: **List of parameters of 1900 – 1994 earthquakes in the region.**

Date Year/Month/Day	Origin Time HH:MM:SS (GMT)	Lat. – Long. (N – E)	Focal Depth (km)	Magnitude (M)
1911/11/06	-	36.60 – 37.80	-	4.6
1911/11/13	01:--:--	36.60 – 40.70	30	5.0
1911/11/14	13:--:--	36.00 – 40.70	-	5.5
1930/07/20	-	36.60 – 40.80	09	4.5
1959/08/29	10:--:--	35.55 – 41.29	50	4.8
1960/03/19	14:53:--	36.64 – 41.27	10	4.5
1962/08/01	16:38:--	36.19 – 41.41	20	4.5
1968/09/23	21:27:--	36.49 – 40.68	49	4.6
1969/09/04	17:--:--	35.20 – 39.15	45	4.5
1970/10/05	14:53:--	35.04 – 39.00	34	4.8
1970/12/29	21:03:--	36.03 – 38.34	26	4.5
1974/01/09	--:50:--	35.43 – 40.09	30	4.1
1975/12/22	19:50:--	35.83 – 40.46	38	5.0
1978/02/15	05:47:--	36.69 – 39.67	42	4.5
1983/01/07	07:25:--	36.14 – 41.10	33	4.8
1987/05/20	23:--:--	35.43 – 38.08	33	4.8
1994/11/20	16:31:01	35.33 – 39.60	23	5.1
1994/12/18	16:38:15	35.28 – 39.75	10	4.6

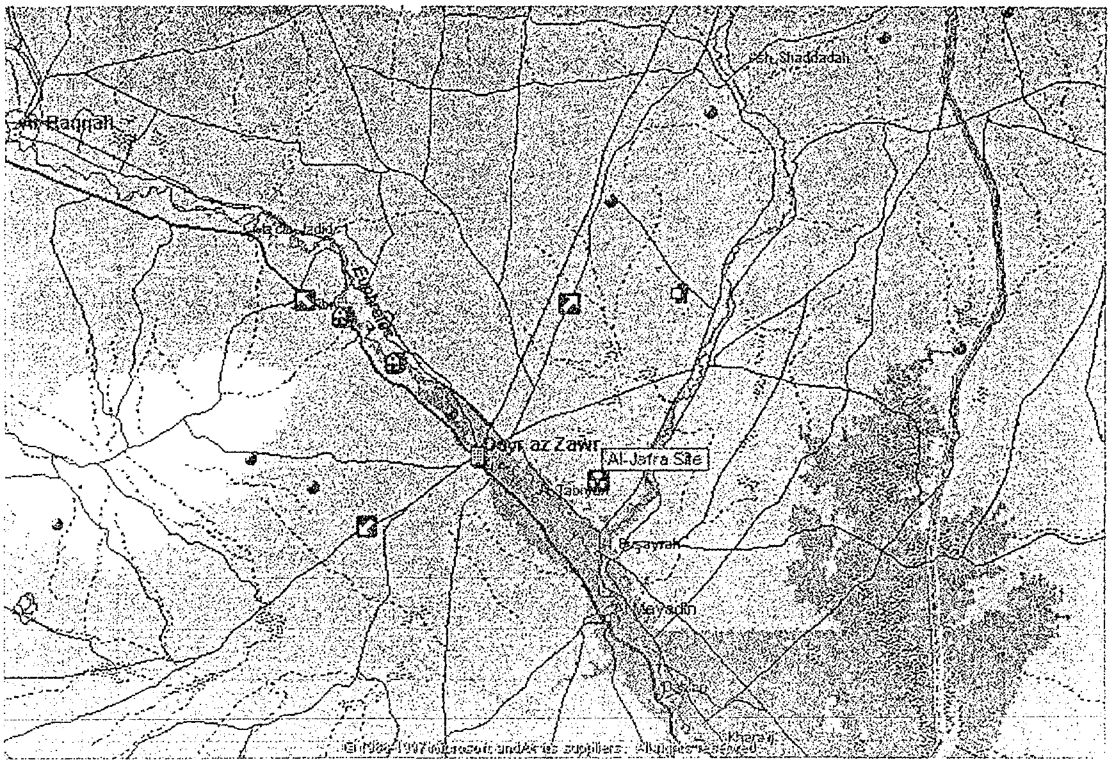


Figure 2a: Map showing distribution of 1900 –1994 earthquakes in the region.

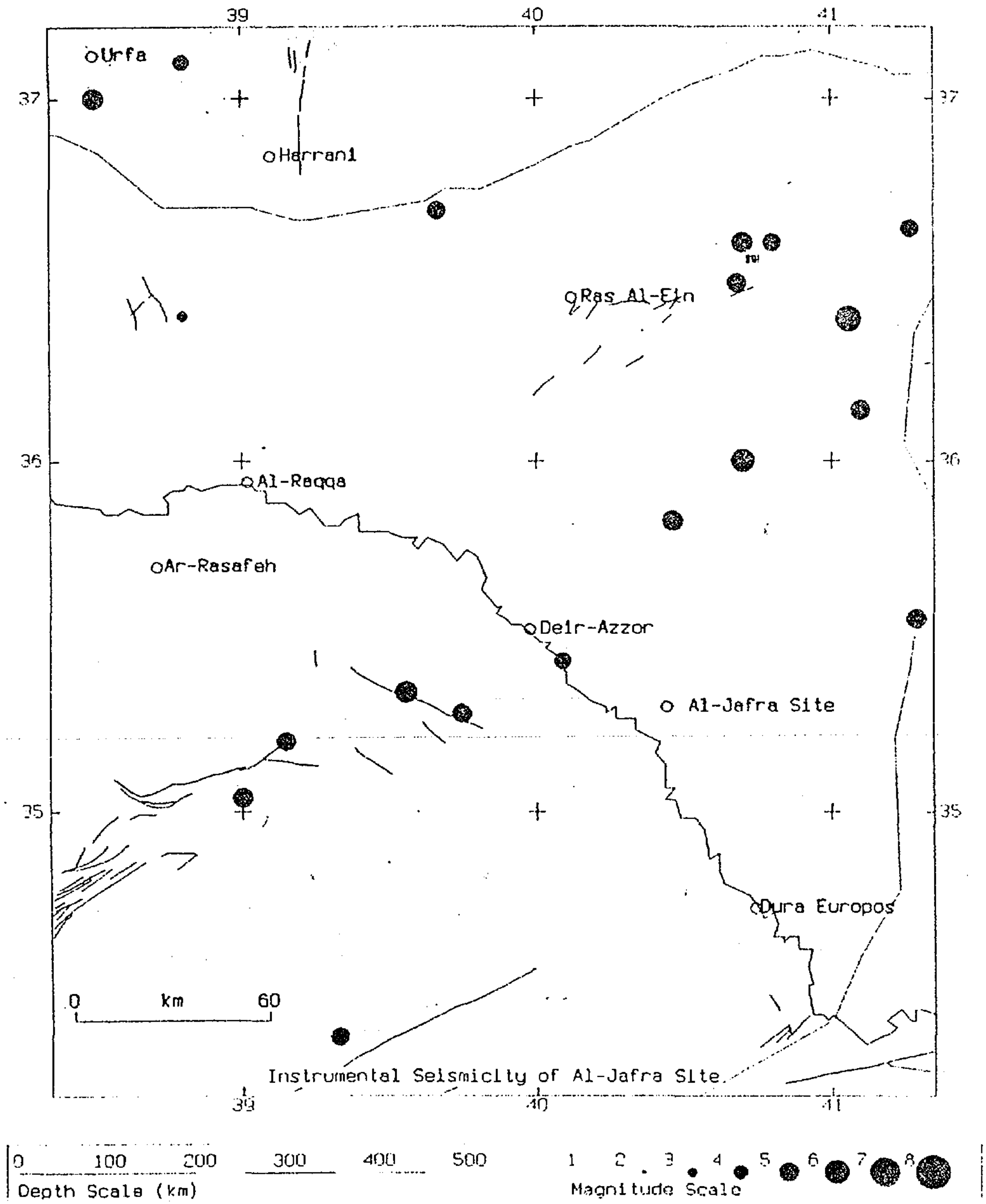


Figure 2b: **Map showing distribution of 1900 –1994 earthquakes in the region.**

In Table 2, 18 earthquakes that struck Al-Jafra Site region, with magnitude values ranging between 4.1 and 5.5 are listed.

The November 20, 1994 earthquake represents one of most important events occurred in the vicinity of Al-Jafra Site. It happened at 16:31:01 (local time) and was felt throughout the NE Syria, and in particular along the Euphrates River. It caused a great panic, but without damage. Macroseismic investigations performed shortly after the earthquake in the affected region integrated with analysis of the related seismogram recorded by the SAEC' seismic station has led to an accurate assessment of the earthquake's parameters (No. 17 in Table 2), which coincide precisely with those published in the International Seismological Center [ISC, 1996].

On the other hand, this earthquake caused huge rock-falls along the Ar-Raqqa - Deir Az-Zor road near the village of Al-Masrab. Figure 3 shows Al-Jafra Site, the 1994 earthquake' epicenter and Al-Masrab village. While Figures 4 and 5 show its related rock-falls.

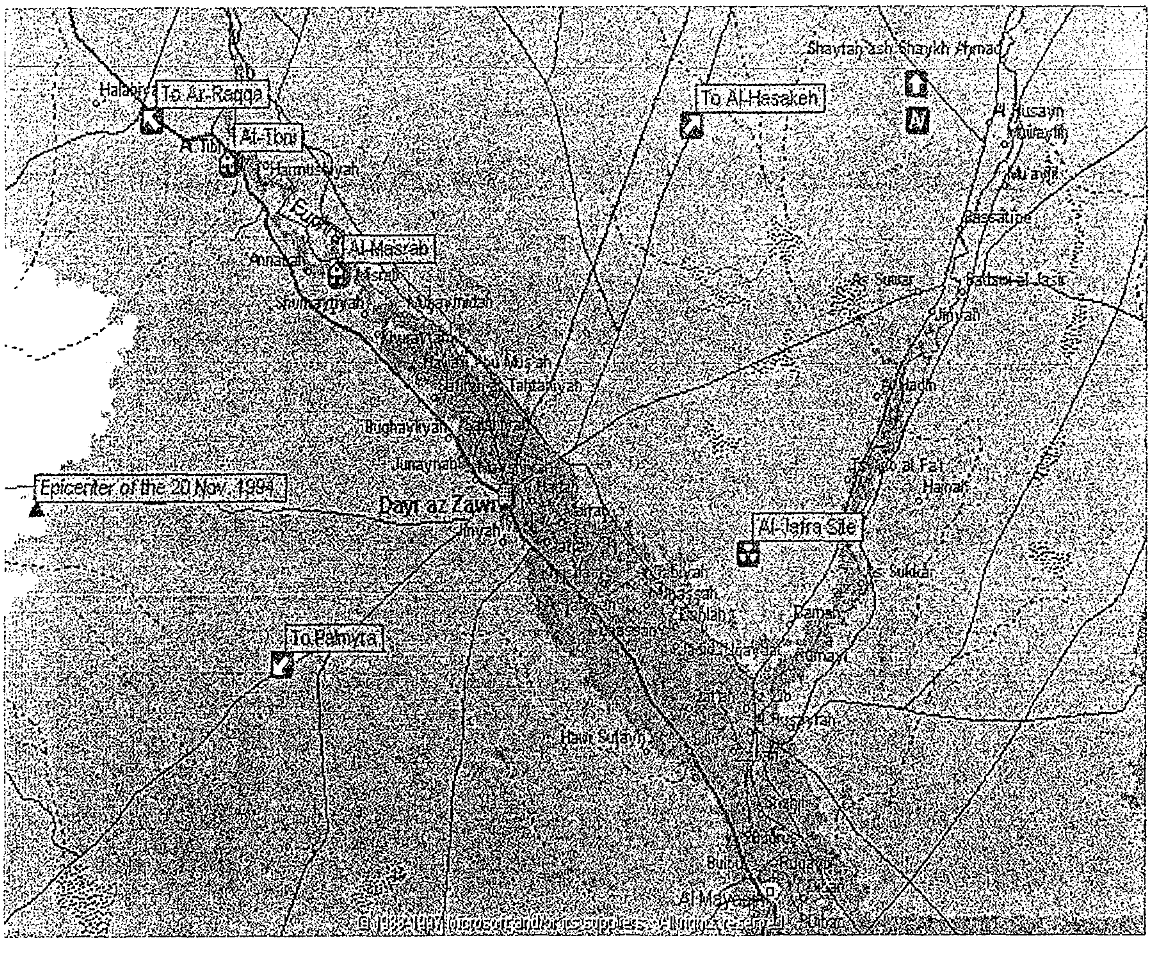


Figure 3: **Map showing the 20 Nov. 1994 earthquake's epicenter, Al-Masrab village and Al-Jafra Site location.**

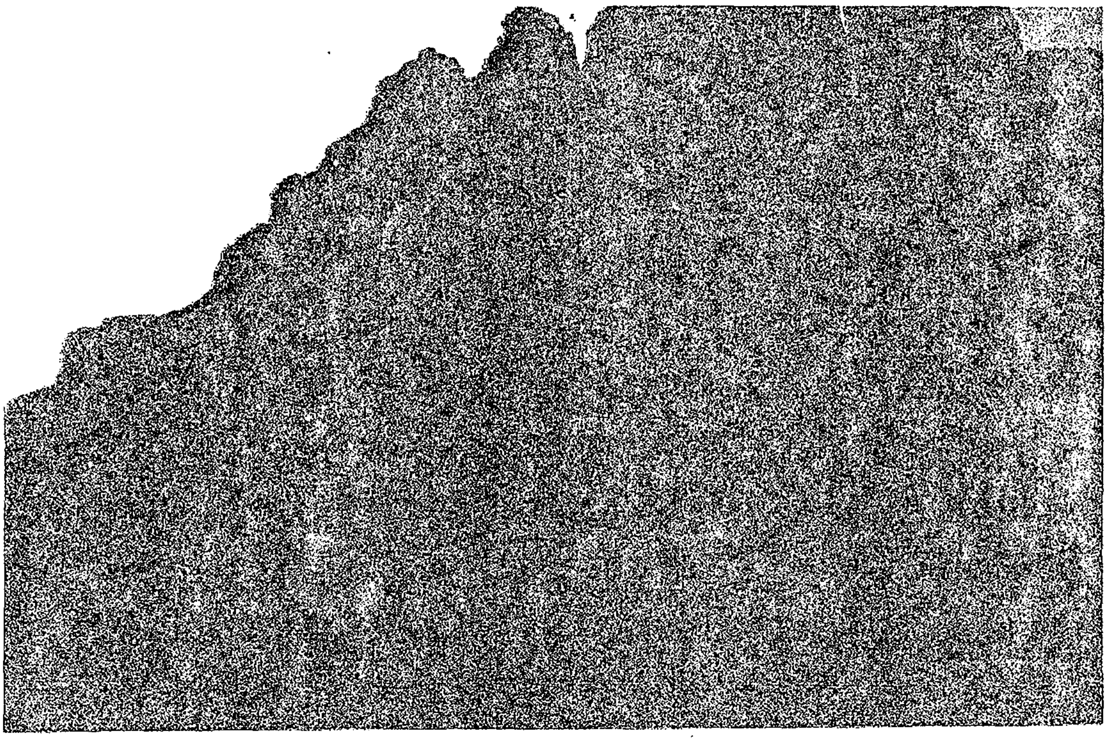


Figure 4: **Huge rock-falls due to the 20 Nov. 1994 earthquake near Al-Masrab village.**

Figure 5: **Huge rock-falls due to the 20 Nov. 1994 earthquake near Al-Masrab village.**

6. Current seismic activity in the site vicinity:

Since there is no neighboring seismic station was found in the site region, A portable seismic station, from the Atomic energy commission, has been installed in Al-Jafra site during the period of this preliminary study (from 23/10/2001 to 30/12/2001) of 1 Hz natural period and 1 vertical component. The purpose of this station was to monitor any seismic activity in this region.

The results of the station were amazing because of the following:

1- We have recorded 13 events, the maximum magnitude MD=4.7 of 320 Km far from the Site. This lead us to estimate the intensity in the Site about III degrees on (EMS-92) scale.

2- The nearest event was about 4 Km from the Site with MD=0.8.

3- The domain event magnitudes were MD=1.8-2.2 with 16 Km from the site.

Regarding the above obtained results, the evidence of seismic activity along the Euphrates fault zone is clear, and it could be activated by the effect of oil discharging or water injunction in the productive oil fields.

Table 2: is showing the parameters of the recorded earthquakes.

No.	Date yyyy/mm/dd	Time hh:mm:ss	Duration (Sec.)	Distance from theSite (Km)	Magnitude MD
1	2001/11/17	18:10:39.5	16	20	1.8
2	2001/11/18	09:38:19.0	95	96	3.5
3	2001/11/20	01:47:54.0	10	20	1.4
4	2001/11/27	08:54:13.0	260	320	4.7
5	2001/12/05	04:14:08.8	16	20	1.8
6	2001/12/05	07:17:26.0	15	24	1.8
7	2001/12/06	01:36:21.0	22	40	2.2
8	2001/12/11	10:28:38.0	14	20	1.7
9	2001/12/13	19:38:04.5	6	4	1.0
10	2001/12/15	07:00:52.5	25	16	2.2
11	2001/12/15	16:14:40.5	10	28	1.4
12	2001/12/20	13:57:55.0	5	4	0.8
13	2001/12/25	20:49:07.5	20	16	2.0

7. Conclusions

Analysis of the historical and 1900-1994 earthquakes data, and seismotectonic setting in the region surrounding Al-Jafra Site reveals the following:

Two seismogenic fault systems are dominant in the region. They are Euphrates (EF) and Al-Bishri (BF) faults. It is worth mentioning that Al-Jafra Site is close to the Euphrates central segment. Therefore and from seismogenic point of view, Al-Jafra Site can be classified to be belonging to the Euphrates seismogenic fault system.

In order to estimate the maximum seismic intensity at Al-Jafra Site, the following Shebalin empirical formula [Polyakov, 1985] has been applied:

$I = \beta M - v \, Log (\Delta 2 + h2) \, 0.5 + C$

Where I and M are intensity and magnitude of the earthquake respectively. Δ is the distance (in km) on the Earth' s surface between the earthquake epicenter and a particular site, h is the depth of the earthquake hypocenter (in km), and finally β, v and C are constants. Therefore, the maximum estimated intensity (Imax) at Al-Jafra Site from historical and instrumental earthquake data is equal to Imax=V-VI on the EMS-92 Scale. Table 3 summaries results of the intensity estimation at the Site.

Table 3: **Estimated intensities at the Site.**

Date	*Ms*	H (km)	Δ (km)	I_r (EMS-92)
160 AD, Oct.	**6.0**	**18**	**70**	**V-VI**
8th C. AD	**6.5**	**12**	**164**	**V**
1994/11/20	**5.3**	**23**	**79**	**IV**

Considering that Al-Jafra Site is located within the Euphrates fault of M_{max} = 6.0, the maximum estimated intensity (Imax) at Al-Jafra Site can attain Imax = VI-VII.

1) Returning to Figure 2, the distribution of instrumental seismicity points to a seismic activity continuation of the dominating seismogenic fault systems during the 20th Century. On the other hand, the area shows low seismic activity (18 events during 94 years) with a medium values of magnitude (M < 5.5).

2) The peak ground acceleration (PGA, in g = 9.8 m/sec2) generated at a particular site is another measure of hazard [Ambraseys, 1996]. To assess the PGA at Al-Jafra Site generated by both the 1994 earthquake and by the historical earthquakes date as well, Leed's Acceleration-Intensity relationship [Pinter, 1996] was used. Considering the local geological and lithological column's conditions at the S2 Site, it has been found that the PGA generated at the Site by the 1994 earthquake and by historical earthquakes data attained A = 0.03 - 0.05 g and A = 0.07 – 0.10 g, respectively, and A can attain Amax.= 0.15 g according to the seismogenic conditions as mentioned in the foregoing.

8. Recommendations

Regarding the previous results, the following points are recommended to be performed:

1) Seismic microzonation study of Al-Jafra Site in order to estimate the seismic response spectra.

2) Geophysical investigations for identifying possible karst phenomena in gypsum and their extensions, as well as identifying underground water level's fluctuation.

3) Geotechnical field experiments at Al-Jafra Site.

4) Erecting a micro-earthquake monitoring network, consists of 6 portable 3 components digital seismic stations, for six months at least and one accelerometer for longer time, in order to distinguishing the naturally tectonic seismic events from induced seismicity related to fluid discharging and injunction process in the oil fields in the region.

9. References

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Chapter Four

Disposal Pit Construction in Al-Jafra Site

1. Brief Description of the Situation

Surface and depth distributions of Radium 226 at the contaminated sites of Al-Jafra oilfields have been defined by AECS. Volumes of contaminated soil that needs disposal as radioactive wastes according to the Syrian Clean- up and Disposal Criteria have been also estimated by the AECS, to be 3161m^3. In the report they concluded and recommended the following:

1. The mud pit needs to be treated on site by mixing the contaminated soil with clean soil (Dilution) followed by covering the treated soil with clean soil layer to reduce the exposure to 100μSv/a provided that the layer should be impacted.
2. Design a disposal pit to accommodate about 3161m3 of contaminated soil.
3. Remove the contaminated soil defined as radioactive waste from the surface water pit and the run off channel to the disposal pit.
4. Treat on site the remaining part of the surface water pit and the channel using a similar method described for the mud pit.

This document is a proposal for implementing the second recommendation mentioned above to design a permanent disposal pit to accommodate NORM-contaminated soil at Al-Jafra site and remediation of site to be approved by DEIR EZ ZOR PETROLEUM COMPANY.

2. Proposed Solution

The plan is to remove contaminated soil from the lagoons(surface water pit and run off channel) to an engineered disposal pit constructed in suitable impervious strata.

The contaminated soil within the lagoons will be excavated until clean-up criteria are met and hauled to the engineered disposal pit.

The engineered disposal pit is expected to be located outside the bund wall in southern of the surface water pit and in eastern the catchments drain. The underlying rock strata are judged to be sufficiently impermeable. The Al-Jafra Site located on the exposed geological formation of lower Pliocene Na2 that assembled from marls, siltstones, gypsum, sands and pebbles.

The eng. Disposal pit will be excavated in solid, impermeable rock formation.

The geological barriers of the engineered cell (top, Slope and bottom) will be made by a compacted mixture of natural clay and bentonite at 10% volume (target permeability in the order of 10-7m/sec). All thickness of liners will have a minimum of 0.60m.

The eng. Disposal pit will be covered by 1.25m of compacted clean soil. Radon hazard is expected to be minimal with this configuration.

The compacted clean soil will be covered by 0.80m coarse rock buttress as an intruder and erosion barrier.

The evaporation surface water pit and the run off channel and the other pits in the site will be backfilled with clean soil from adjacent area, graded and contoured. A monitoring program will follow. The maximum, in-situ volumes of contaminated soil are estimated at 3161m3. Most of the contaminated soil has been excavated. Assuming a balk-factor of 25%, these volumes are estimated at 3951,25 ≈ 4000m3. For planning purposes, it is recommended to expect up a volume of up to 5000m3.

3. Engineered Disposal Pit Construction

The long-term performance requirements for the NORM disposal facility at Al-Jafra are as follow:

- Provide isolation of the waste from the surrounding environment.
- Inhibit surface water infiltration into the waste.
- Inhibit erosion of the cover over the waste.
- Maintain a separation between the waste and the groundwater.
- Promote the drainage of water that infiltrates the waste, out of the waste.
- Inhibit human and animal intrusion through the cover into the waste.
- Maintain stability under foreseen subsurface and geological conditions.

Performance requirements during construction include the provision of adequate disposal volume, use of reasonably available materials and machinery, optimization of waste movement and keeping radiation doses to workers As Low as Reasonably Achievable (ALARA).

The eng. disposal pit will have engineered liners a 0.60m with the same thickness at the sides. These liners will be made of compacted clay and bentonite at 10%. The contaminated soil will be disposed in layers (total thickness 3.0m). The top liner will be covered by 1.25m of clean soil from the nearness. The liners and the top cover will act as radon barriers, minimizing radon exhalation from the eng. disposal pit to background levels. 3 radon-monitoring stations will be required, particularly in the prevailing wind path for the area (North West). Four monitoring wells (in corners of the disposal cell) will be required, for a permanent analysis of groundwater samples. Appendix (I) shows Table 1 and the detailed Figures of the suggested solution.

4. Site Selection for Engineered Disposal Pit

This study could be fully implemented whenever the geological and hydro-geological data become available. The location of the suggested-engineered disposal pit will be defined later after visiting the site and getting the results of the suggested exploration well. It is expected that the location will be out side the Al-Jafra field to the south of surface water pit and east of run-off channel.

5. Reference

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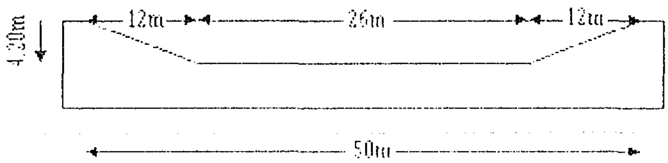
Estimate of maximum volumes to be handled

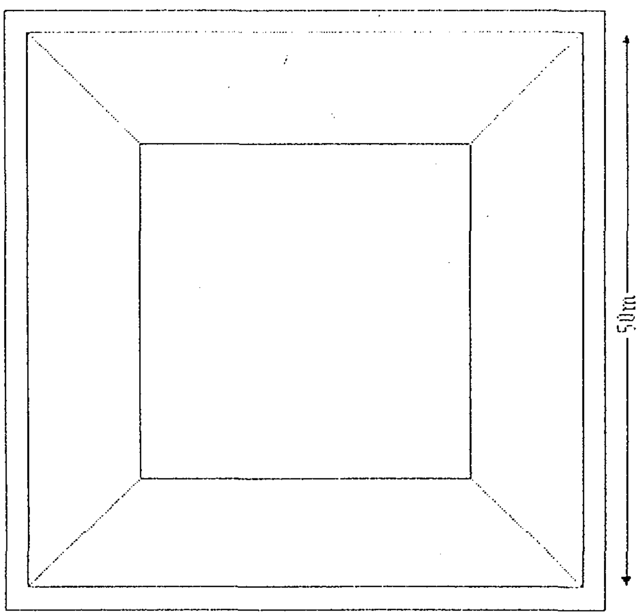
	Areas m²	Max. volumes m³
I. Contaminated Soil :		
Surface Water Pit		
Run Off Channel		
TOTAL		**3161**
II. Liner for Disposal Pit		
Solpe, Floor and Top		
Liners :		
0.60m of Clay/Bentonite		
Clay	2(52x52x0.60) at 90%	2920.32 ~ 3000
Bentonite	2(52x52x0.60) at 10%	324.48 ~ 325
TOTAL		**3325**
III. Soil for Clean Cover		
Eng. Disposal Pit		
TOTAL	(62x62x1.25)	**4805**
IV. Coarse Rock Buttress		
TOTAL	(72x72x0.80)	**4147.2 ~ 4140**

Scope of Work for the Al-Jafra Side

Al-Jafra Disposal Pit-Excavation

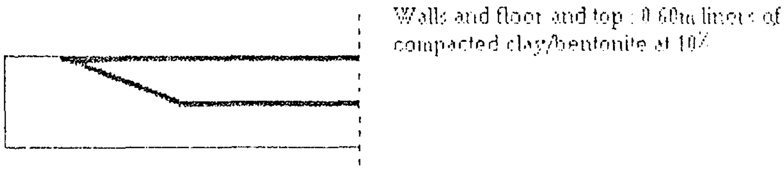


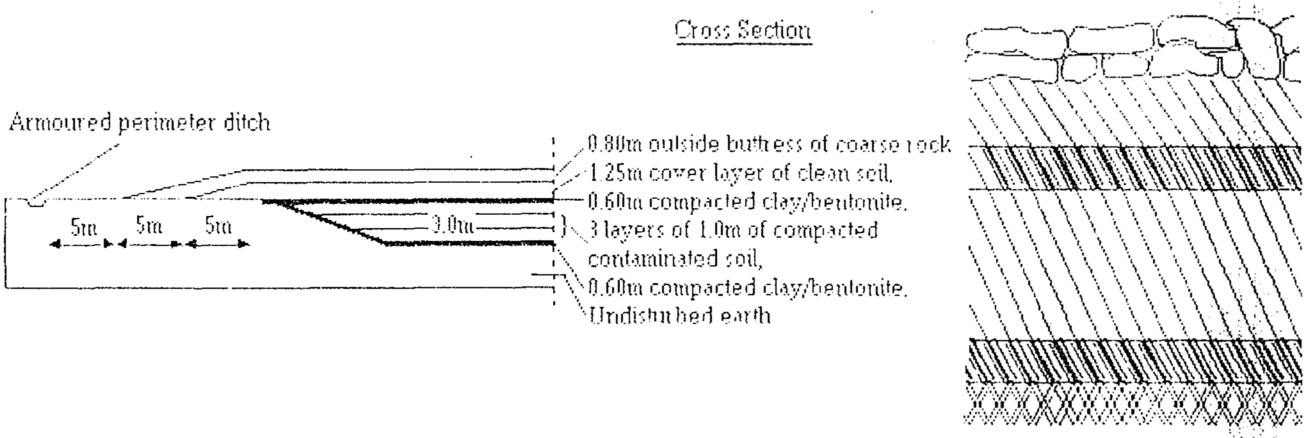
Cross-Section: V-shaped pit, 21° inclined rampas on side; the engineered disposal pit will be located on the lower part of N_2^2 Pliocene (marls, siltstones, gypsum, sands, pebbles)



Horizontal view: quadratic pit 50mx50m, 4m deep.

Al-Jafra - Conceptual Design Construction





Al-Jafra Conceptual Design

Closure and Monitoring