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OIL SHALE DEPOSITS IN CENTRAL JORDAN

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ABSTRACT

Known oil shale deposits in Central Jordan occur in sedimentary rocks of Campanian-Maastrichtian to Danian ages and mainly exist at El-Lajjun, Jurf Ed-Darawish, Sultani, Attarat Umm Ghudran and Wadi Mughar.

These deposits are regarded as the richest organic bituminous marls and limestones which occur at shallow depth and extend over an area of 500 km².

These deposits are uniform in character with an oil yield of shale oil by Fischer Assay of 8.3%. On the basis of field evidence and laboratory analysis it was concluded that these deposits contain about 37 billion tons of oil shale with an oil content of 3 billion tons of oil.

Furthermore, the geological conditions, e.g. its thickness and the structural setting, the chemical and mineralogical composition are favourable for exploitation.

All these factors together with the low mining and infrastructure costs render these deposits quite suitable for industrial utilization.

INTRODUCTION

In view of the increasing burden being imposed by the oil import bill on the foreign exchange resources of Jordan; and given the superior

quality of its oil shale; N.R.A. was justified in assessing the potential for exploiting the oil shale to meet part of the country's future energy demands. However, at the outset, N.R.A. realized that the implementation of a pilot scheme for determining the potential commercial exploitation of the oil shale involves substantial risks, both technical and financial. Therefore, in formulating plans for the development of oil shale resources the objectives were to select the schemes which would minimize the financial risk and reduce the burden on the technical and human resources of the country. The suggested plan entailed a thorough assessment of the resources and available technologies. The assessment of the technology would involve research and development study with a bench scale unit, then pilot plant testing and ultimately with tests in commercial size retorts.

N.R.A. formulated and put into practice longterm plans to fully assess the optimal strategy in exploiting the oil shale resources. The formulation of such a plan involved the following three elements which were addressed in sequence:

(a) An assessment of the options for the exploitation of the oil shale resources using state of the art technology.

(b) An evaluation of the technology to be employed under each of the options which are considered economic.

(c) Finally, determination of the time-scale required to reach the commercial phase of the technology selected.

OIL SHALE DEPOSITS OF CENTRAL JORDAN

1. General Geology

Known oil shale deposits occur in sedimentary rocks of Campanian-Maastrichtian to Danian age and are mainly present at El-Lajjun, Jurf Ed-Darawish, Sultani, Attarat Umm Ghudran and Wadi Mugar.

These deposits were selected for detailed study based on the following guidelines:

(a) Favourable conditions for surface mining.

(b) Adequate reserves.

(c) The availability of reasonable infrastructure including adequate groundwater for industrial utilization.

(d) Adequate properties of oil shale for processing and favourable characteristics of the oil shale layers.

2. Location

El-Lajjun, Jurf Ed-Darawish, Sultani, Attarat Umm Ghudran and Wadi Mughar oil shale deposits are located approximately 110, 150, 130, 150 kms respectively to the south of Amman near the desert highway.

3. The Reserves

In order to evaluate the above mentioned oil shale deposits more than 300 boreholes were drilled over an area of 500 km².

The reserve determinations were calculated using the following geological and economical criteria:

--Average bitumen content 8.3%.

--Minimal average thickness of bituminous bearing layers 30m.

--The stripping ratio 0.9:1 (for El-Lajjun), 2.2:1 (for Sultani), 1.44:1 (for Jurf Ed-Darawish), 1.18:1 (for Attarat Umm Ghudran) and at last 1:1 (for Wadi Mughar).

The field studies and laboratory analysis provide the following results:

Name of Deposit	Area Km ²	Ave. Thick- ness (m)	Ave. Oil Content %	Quality of Reserves		No. of drilled boreholes
				Geol. 10 ⁶ t	Proven 10 ⁶ t.	
El-Lajjun	20	29.6	10.5	1,196.8	1,165.9	135
Jurf Ed-Darawish	150	68.3	5.7	8,056.3	2,486.3	50
Sultani	75	31.6	9.7	942.1	942.1	57
Attarat Umm Ghudran	226	53.3	11	11,300.0	10,700.0	41
Wadi Mughar	29	40	6.8	31,600.0	21,500.0	20

MINING

1. Topography and Access

The investigated deposits are easily accessible and traversed by

asphalt roads. The Hijaz railway also passes the deposits.

The highest topographic point on the mountains in these areas is 965m a.s.L., but generally the elevation ranges from 800-870m a.s.L.

2. Proven Reserves

From the known reserves $36,397.3 \times 10^6$ tons are exploitable by surface mining (open-cast mining).

3. Structure

The investigated oil-shale deposits occur in graben-like structure bounded mostly by faults.

4. Overburden

The bituminous marl is overlain by rocks of Cretaceous/Tertiary and Quaternary ages (Hufnagel 1985).

The complete rock succession is composed of superficial deposits which overlie chalk and marl with a few chert intercalations (Haddadin, M.1987).

5. Exploitation Methods

The Central Jordan oil shale deposits are suitable for open pit mining. The size of the mining operation will depend on the type and capacity of the proposed industrial methods of utilization (Retorting, Direct Combustion or Combined Retorting and Direct Combustion).

PHYSICO-CHEMICAL PROPERTIES OF THE OIL SHALES DEPOSITS OF CENTRAL JORDAN

Based on laboratory analysis and investigation of hundreds of core samples from the different deposits, the following average characteristics were calculated to assess the quality of the oil shales; oil, organic matter and moisture content, the calorific values, bulk density values and finally the mineralogical and chemical composition.

1. Quality of oil shales

Name of Deposit	Oil Yield by F.A. %	Moisture Content %	Ash Content %	CO ₂ %	S %
El-Lajjun	10.5	2.5	54.7	18.9	3.1
Jurf Ed Darawish	5.7	5.4	58.4	20.2	2.2

Sultani	9.7	5.5	55.5	19.2	2.4
Attarat Umm Ghudran	11.0	3.25	53.2	18.9	2.6
Wadi Mughar	6.8	2.9	57.5	19.9	2.4

2. Mineralogical Composition

From X-ray diffraction studies it was concluded that the oil shales of Central Jordan are mainly composed of calcareous marl with calcite as the main component and varying amounts of quartz, clay and occasionally phosphatic material.

3. Mean Chemical Composition of the Oil Shales of Central Jordan

% by wt.	El-Lajjun	Sultani	Jurf	Attarat	Mughar
SiO ₂	16.13	26.30	9.3	21	24.5
Al ₂ O ₃	3.80	2.90	3.76	2.7	2.3
Fe ₂ O ₃	1.50	1.12	1.55	1.7	1.2
MgO	0.85	0.95	0.22	1.35	1.5
CaO	30.43	26.30	38.78	25.7	28.18
P ₂ O ₅	3.31	3.50	1.5	2.5	2.2
SO ₃	4.83	4.4	4.3	5.6	5.6
AS ppm	n.d.	17	10	n.d.	n.d.
Cu	92	115	68	100	75
Mo	73	94	20	50	73
Ni	167	139	102	75	75
Sr	1015	707	1187	500	750
U	29	25	17	20	22
Zn	451	649	190	150	250
Ba	113	46	35	60	45
Cr	431	267	226	275	325
V	162	268	101	100	120

4. Bulk Density, Organic Matter and Gross Calorific Values of Central Jordan Oil Shales

Name of Deposit	Gross Calorific Value KJ/Kg	Organic Matter %	Bulk Density g/cm ³
El-Lajjun	6906	28	1.81
Jurf Ed Darawish	4630	18	2.1
Sultani	6380	25	1.96
Attarat Umm Ghudran	7235	29	1.8
Wadi Mughar	4773	20	2.03

EXPLOITATION OF OIL SHALE PREVIOUS ACTIVITIES

1. Cooperation with the BGR

In 1979 and 1982, N.R.A. commissioned studies by BGR for the evaluation of the reserves at El-Lajjun, Junf Ed Darawish and Sultani. The studies which were completed in 1983, concluded that the oil shale deposits in Central Jordan are of sufficiently good quality to justify further activities in assessing the potential for its exploitation for power generation by Direct Combustion and the production of shale oil by retorting.

2. In 1980 the Government of Jordan commissioned a prefeasibility study by Technoprom Export (USSR) to determine the feasibility of direct burning the oil shale in a 300MW conventional combustion unit. The study was divided into two phases: Phase I recommended the immediate construction of a 200MW unit. However, the results contained in the report were not conclusive as to the impact on some of the oil shale properties, so N.R.A. decided to defer the implementation of both Phases I and II.

3. Two other prefeasibility studies were awarded to Lurgi-Klockner (FRG). The objective of the first study was to assess the possibility of using the oil shale for direct combustion and the objective of the second was to determine the viability of constructing a retorting plant for the production of shale oil.

Both studies were concluded in 1982, and both options were considered viable. However, it was recommended that N.R.A. concentrate its efforts on retorting.

In 1985, N.R.A. commissioned further studies with the same consortium for updating the prefeasibility study and pilot plant test. The results were encouraging and proved the viability of the retorting process.

4. In 1985, an agreement was signed with the China Petr-Chemical International Company to carry out a proving test in order to determine whether a Fushun-Type retort is technically feasible for processing El-Lajjun oil shale.

The study was conducted in 1986 and the results emphasized that the

Fushun-Type retort was quite suitable for processing El-Lajjun oil shale, and the results were promising.

Study is still in progress for installing a prototype Fushun Retort in Jordan.

5. In 1987, JEA and N.R.A. commissioned direct combustion studies in the Sultani oil shale with BBC, Engineering Combustion (Lummus Canada) and Pyropower USA. The studies are still in progress.