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Shale Oil as Feedstock for Libyan Conventional Crude Oil Existing Refineries

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ABSTRACT

Shale oil (light tight oil) refers to Hydrocarbon (HC) trapped in the formations whereas oil and gas cannot easily flow-out into the string pipe as the conventional oil and can be access using horizontal drilling and hydraulic fracking technique using a plenty of water, sand and chemicals at high pressure down to open the rocks fissures and allow the oil to flow-out. The Global shale oil resources are estimated at between 330 - 1,465 billion bbls and the global shale oil production is expected to reach up to 14 million bbls/day by 2035 which is equivalent to about 12% of the world's total oil supply. Shale oil once is extracted ~~is~~ processed & refined into more useful products utilizing the traditional process wise of refining mechanism. Libyan's shale oil reserves is estimated between 48 to 74 billion barrels (bbls) and that Libya occupies fifth place in global shale oil reserves after Russia, US, China & Argentina. The new amount is added to the inventory to lift the life duration of Libyan oil production from 70 years to 112 years. This paper focuses on studying the possibility that the current Libyan refineries that use conventional oil as feedstock to handle and accommodate unconventional oil (shale oil) from the fields adjacent to the Murzuq Basin. Considering that Al-Zawia Oil Refinery (case study) is currently using conventional oil as feedstock from Sharara Field belongs to Rebsol Oil Operations (concession NC-115). It can be concluded that as a result of the prevailing belief among experts in reservoir engineering and geosciences, that shale oil may have the same chemical and physical properties as conventional oil, so the refinery that uses conventional oil may not need any improvement, development or upgrading operations on its current facilities. Therefore and once the reservoir studies of Murzuq Basin are completed in the future and shale oil production begins using horizontal drilling and hydraulic fracturing technology from the targeted wells, it is possible to start directly pumping the produced quantities of shale oil towards Al-Zawiya Refinery for oil processing whether through the existing pipeline network or that is supposed to be designed for this particular purpose. Libya's future success in producing and refining shale oil from which it has large reserves, and the entry of Libyan oil industry into this challenge will be a great achievement considering the recent reports and studies issued by energy research centers and global stocks that confirm the decline and depletion of conventional oil production in the most world's countries.

Keywords:
Shale oil.
Hydraulic.
Fracking.
Oil refinery.
Libyan shale oil.

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1. INTRODUCTION

Shale oil is refers to those hydrocarbons trapped in the formations that are not very porous (Figure 1 shows a typical shale rock) which means that the oil and gas cannot easily flow-out

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into the string pipe as the conventional oil does in the traditional oil wells[1]. Table (1) shows a Comparison between Crude Oil and Shale Oil.

Global shale oil resources are estimated at between **330 - 1,465** billion bbls and global shale oil production is expected to reach up to 14 million bbls/day by **2035** which is equivalent to about **12%** of the world's total oil supply[3].

Table (2) shows a Comparison between the composition of crude oil and shale oil.

Figure.1 Typical shale rock [9]

Table (1) Comparison between crude oil and shale oil [6]

Property	**Crude Oil**	**Shale Oil**
Occurrence	Naturally occurs in liquid state in underground at high pressure & temperature	Naturally occurs in solid state in underground trapped in rocks
Composition	Typical crude oil contains less N_2 & O_2 & high S	Typical shale oil contains more N2 & O2 & less S
Fluidity	Crude oil has high fluidity, and it is pourable at high temperature range between -60 to 30°C	shale oil is less fluidity, and It is pourable at temperature range between 24 to 27°C
Usage	Crude oil produces many fuel transportation and can be used as raw material for chemical products	hale oil is mainly used as heating oil, marine fuel or chemical for railroad wood preservative

Table (2) Comparison between the composition of crude oil and Shale Oil [6]

Property	**Crude Oil**	**Shale Oil**
API	Shale oil gravity approaches water. Require diluents to separate water from HC.	Water / Oil separation
Nitrogen	High nitrogen levels require H2 for removal & producing NH3.	Corrosion
Sulphur	Low sulphur levels requiring hydro treatment.	Corrosion

Viscosity	Too high to pump across the pipelines	High transportation / pumping cost
Metals as Ni&V&Fe	High catalyst replacement	Catalyst deactivation
Metals as Na&Ca&As	Alkaline metals, special guard bed / catalysts for removal.	Corrosion / catalyst deactivation.
Chlorides	Typically associated with alkaline metal	Corrosion

Shale oil & gas exploration is a capital-intensive process requires technical technology using **horizontal drilling & Hydraulic fracturing** across the deposit using a mixture composed of plenty of water, sand, and chemicals at high pressure down to open the rocks fissures and allow the oil to flow-out [(1)]. Fig (2) shows a process for shale oil production [(2)].

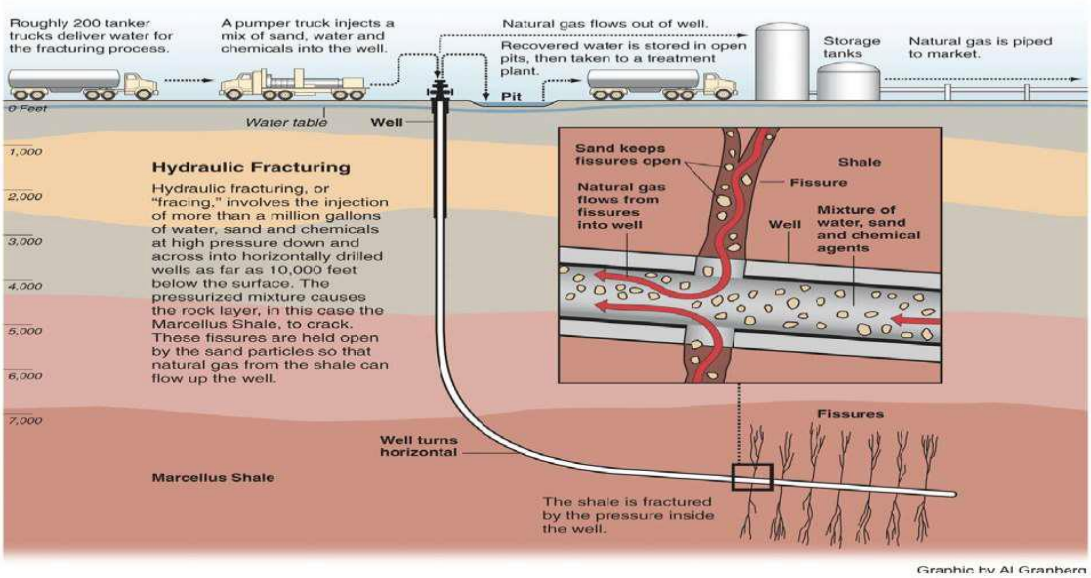

Fig (2) Process for shale oil production [(2)]

Shale oil is normally extracted by pyrolysis process and the pyrolysis of the rock is performed in a retort, situated either above ground or within the rock formation itself.

Although raw shale oil can be immediately burnt as a fuel oil, many of its applications require to be upgraded. The differing properties of raw oils call for correspondingly various pre-treatments before it can be sent to a conventional oil refinery [(4)].

Shale oil once is extracted is processed & refined into more useful products and the process of refining shale oil can be done different ways like Distillation – Cracking – Pyrolysis - Chemical treatment or filtering – Reheating.[(4)]

1 LIBYAN'S SHALE OIL

Libyan's shale oil reserves is estimated between 48 to 74 billion barrels (bbls) and that Libya occupies fifth place in global shale oil reserves after Russia, US, China & Argentina while Libya's gas reserves expect to boost 3 times to reach **177** TCF (Trillion Cubic Feet) after it was **55** TCF with addition of **122** TCF of recoverable reserves of rock. The huge Libyan shale oil stock is distributed on north Libya west and south.[5]

Table (3) shows the technically recoverable shale oil resources in billions barrels.

Table (3) Technically recoverable shale oil resources (billions bbls) [5]

	Country	**(billions bbls)**
1	Russia	**75**
2	USA	**48**
3	China	**32**
4	Argentina	**27**
5	Libya	**26**
6	Australia	**18**
7	Venezuela	**13**
8	Mexico	**13**
9	Pakistan	**9**
10	Canada	**9**
	Total	335

2 MURZUG BASIN RESERVOIR PROPERTIES

Murzuq Basin is bounded on the east by the Tibisti Arch, on the west by the Tihembada Arch (which separates it from the Illizi Basin in Algeria), on the north by the Qurcal Arch (which separates it from the Ghadames Basin), and on the south by the Libya and Chad borders. In the NC-115 (N for National Oil Corporation and C for concession – NC-115 is the contract area of Sharara Field – Rebsol Oil Operations Company) license area, 146 m of core was taken from 22 wells. The table (4) shows the characterization of Murzuq basin reservoir.[5]

Core analysis from a second well, F3-NC174 (N for National Oil Corporation and C for concession – NC-174 is the contract area of El-Feel Field – Mellitah Oil & Gas B.V), recorded TOC (Total Oil Content) values that ranged from 3.7% to 4.7% (average 4.0%), with thermal maturity of 0.7 Ro.

A detailed analysis of the E1-NC174 well, drilled in 1997, provides further information on the properties of Tannezuft "hot shale" in the Awabari Trough. The core data shows the presence of Type II (oil prone) kerogen with TOC values of up to 13%. [5] The crude oil assay of El-Feel field I showed in table (5).

Table (4) The Characterization of Murzuq basin reservoir [5]

Basic Data	**Basin/Gross Area**		**Murzuq (97,000 mile^2)**
	Shale Formation		**Tannezuft**
	Geologic Age		**L. Silurian**
	Depositional Environment		**Marine**
Physical Extent	**Prospective Area (mile^2)**		**5,670**
	Thickness (ft)	**Organically Rich**	**67**
		Net	**60**
	Depth (ft)	**Interval**	**3,300 – 10,000**
		Average	**6,500**
Reservoir Properties	**Reservoir Pressure**		Mod. Over press.
	Average TOC (wt. %)		**7.0 %**
	Thermal Maturity (% Ro)		**0/90 %**
	Clay Content		**Medium**
	Gas Phase		**Associated gas**
	GIP Concentration (Bcf/mile^2)		**6.5**
	Risked GIP (Tcf)		**18.6**
	Risked Recoverable (Tcf)		**1.9**

Table.5 El-Feel Crude Oil Assay[10]

Test Method	Test Description	Result
ASTM D 40521	Density @15.6 ºC Specific gravity @60/60 F API Gravity	0.8360 0.8368 37.60
ASTM D 445	Kinematic viscosity in cSt @25.0 ºC @37.8 ºC @50.0 ºC	 4.61 3.50 2.78
Shell method	Hydrogen Sulphide in ppm	408
ASTM D 97	Pour Point in ºC	<-30
ASTM D 2386	Freezing point in ºC	<-33
UOP	Paraffin wax in wt %	2.2
IP 143	Asphaltenes in wt %	0.91
ASTM D 4294	Sulphur content in wt %	0.1376
ASTM D 1796	Water & sediment in vol. %	0.1
IP 77	Salt content in Ptb	7.7
ASTM D 482	Ash content	0.010

4. Discussion

The leading refinery in Libya is Zawiya Refinery which was started-up in 1974 with a capacity of 120,000 bbl. /day (5 million tons/year). The refinery usually runs Sharara crude (API ± 43.95) & very low sulphur content (<0.07 wt. %) & very low salt content (< 2 ppm). It is hydro-skimming type refinery consists of atmospheric distillation & associated stabilizers, LPG recovery unit, naphtha, hydrotreater, catalytic reformer and kerosene hydrotreater. The crude oil is first distilled which is followed by conversion in more complex refineries and the most important distillation processes are atmospheric distillation & vacuum distillation and Different conversion processes are available using thermal or catalytic processes using a catalytic reformer, where the heavy naphtha produced in the crude distillation unit is converted to gasoline, and the fluid catalytic cracker where the distillate of the vacuum distillation unit is converted. Newer processes, such as hydrocrackers, are used to produce more light products from the heavy bottom products. Finally, all products may be treated to upgrade the product quality such as sulphur removal using a hydrotreater. The refinery runs with dual fuel using a mixture of fuel oil & fuel gas.[7]

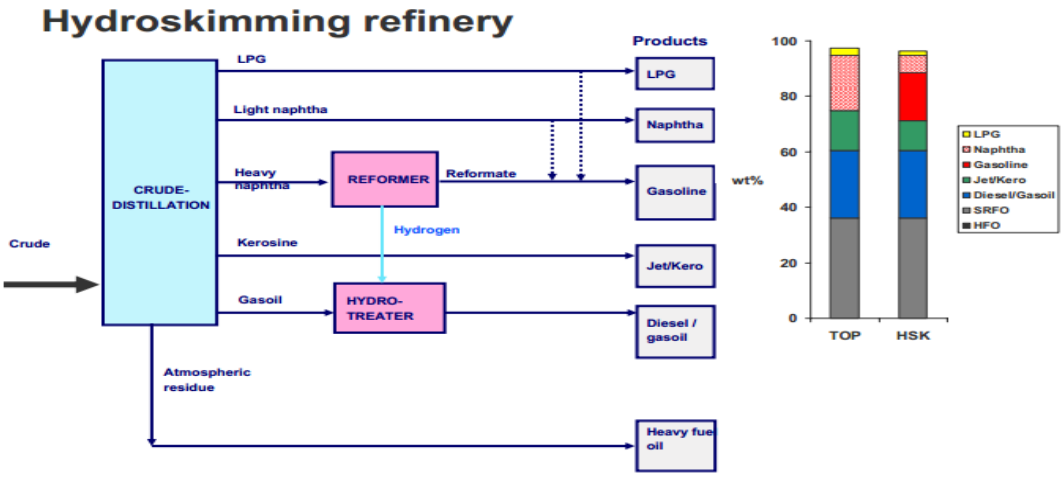

Fig (3) Schematic diagram for Al-Zawiya Refinery [8]

5. Results

- The study aims to feasible the utilization of Libyan shale oil in the existing refineries using conventional crude oil without any upgrading or development since the shale oil quality is similar to the conventional oil.
- The study is not concentrating in geological of the reservoir or formation & sedimentary composition, so, the wellhead upstream facility will not be discussed in this paper, and only the study is focus on the wellhead upstream facility to deliver the produced oil to the existing refinery.
- The study includes the utilization existing piping system network to transport the produced shale oil from oil wells drilled at Murzuq basin to **Al-Zawia** oil refinery as well as using the existing facility of the refinery itself considering that shale oil quality is similar to the original feedstock (light), therefore, no further processing is required to reduce the viscosity of the crude (visbreaking process) or any other treatment process.
- The transportation cost will not be taken in consideration if the produced oil is foreseen to use the existing piping system network, but shale oil production cost shall be estimated considering the conventional crude oil transportation.
- The study will study both **CAPEX** & **OPEX** in case **NOC** decided to start the production of shale oil in Libya in commercial quantities.

6. CONCLUSIONS

- Shale oil can be produced from Murzug basin and delivered towards Zawiya refinery for further processing.

- Existing crude oil refinery can be utilized to accommodate the new feedstock of shale oil for product finishing.
- Existing piping system network cab be utilized to transport the produced shale oil to minimize the transportation cost.
- Existing refinery surface facility can be used too since the shale oil quality is similar to the conventional crude oil quality as feedstock.

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