Characteristic of Dar Blend Crude Oil Relevant to Pipeline Transport and Storage

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ABSTRACT- The study was conducted in Malute Basin, Block 3and 7 located in the South of Sudan. Samples of crude oils originated from 8 Oil Gathering Manifolds (OGM) of Palouge Field in, Malute Basin. Tests done for ^{0}API (American Petroleum Institute Degree) was in the range of 13.70 up to 24.42، and tests for total acid number varying in the range TAN of1.11 up to8.23 mg KOH/g , and Density in the range of 0.9007 up to 0.9723.Viscosity was 124 in South West where in North Ogm was 8000 (cPoise). Pour Point was in the range 30^{0}C 42^{0}C. Then samples was collected from other three Fields (Adar Field, Gummry Field, and Moleeta Field).These Fields with Palouge Field were composed DAR Blend .The results of the study represents that crude oils from different locations in Palouge Field varied accordingly even the 8 OGMs has same source of Melute. Palouge crude oil according to API^0 its quality is moderates that's due to formations and depth of well from where oil was produced. Then the increased of viscosity and pour point leads to face troubles in transporting through pipeline within the seasons where temperatures decreased, and increasing in TAN leads corrosives of transport and storage equipments.

***Keywords**: Malute Density, Viscosity, API^0.*

***المستخلص-** اجريت هذه الدراسه في حوض ملوط النفطي، مربع 7 الذي يقع في اقصي شمال جنوب السودان . تم تجميع العينات للنفط الخام من 8 مواقع تجميع وزعت جغرافيا بالنسبه الى حقل فلوج في حوض ملوط.خلصت الدراسه الي النتائج التاليه الكثافة النوعية 13.70 الي 24.42 .و الرقم الحامضي الكلي 1.11 الى 8.23 ملج هيدروكسيد البوتاسيوم/جم. الكثافه 0.9007 الي 0.9723 .اللزوجه 124 الي 8000 سنتي بواز) .درجة الانسكاب 30 الى 42 (درجه مئويه) .كذلك تم تجميع عينات من ثلاث حقول اخري (حقل عدار،حقل قمري،وحقل موليتا)،هذه الحقول الثلاثه بالاضافه لحقل فلوج تكون مزيج دار. خلصت الدراسه الى ان الزيت الخام المستخرج من الابار الموزعه جغرافيا يختلف باختلاف المواقع التي استخرج منها بالرغم من ان المصدر واحد هو حوض ملوط النفطي .يعتبر خام حقل فلوج من حيث الجوده حسب تصنيف معهد البترول الامريكي وسط –ثقيل ويعزي ذلك الي الصخور الرسوبيه التى استخرج منها.كذلك ارتفاع اللزوجه ودرجة الانسكاب مما يؤدي الي مشاكل الانسياب في موسم انخفاض درجات الحراره ,بالاضافه الي ارتفاع الرقم الحامضي الكلي الذي يؤدي الي تاكل معدات النقل والتخزين.*

INTRODUCTION

The Melut Basin is located to the south of Central African Shear Zone (CASZ) [1, 2, and 3]. It is an intra-continental Cretaceous-Tertiary rift basin formed due to the strike-slip and associate pull-apart along the Melut rift basin extends across at least 33,000 km^2, is up to 100km wide, over 310km long and locally contains up to 10km of Cretaceous-Tertiary sediments. It may coalesce southeastward and link up with the Anza rift in Kenya map (1) Simplified tectonic map of Central African Rift System, showing the major features discussed in the text and location of the Melut Basin [4,5] Based on the interpreted regional bouguer gravity and aeromagnetic data, six sub-basins can be identified: northern sub basin, eastern sub-basin, central sub-basin, southern sub-basin, western sub-basin, eastern subbasin and Central High, three major episodes of extensional tectonism arerecognized in the Melut Basin [6,7,8].

Sudan and South Sudan produce three crude oil blends: Dar, Nile, and Fula. The Dar blend (25.0° API gravity, 0.11% sulfur) is a heavy paraffinic type of crude oil that has a high acid content and

must be heated during transport to avoid congealing in ship tanks.[9] The Dar blend is produced at Blocks 3 and 7 in the Melut Basin, which is controlled by South Sudan.[10] The Nile blend (33.9° API gravity, 0.06% sulfur) is produced in the Muglad Basin at Blocks 1, 2, 4, and 5A; it is a medium, low-sulfur waxy crude oil and is a more attractive blend to refiners because of its high fuel and gasoil yields. [11] The Fula blend is a highly acidic crude oil that is produced in the Muglad Basin at Block 6 and is transported via pipeline to the Khartoum refinery, where it is processed for domestic use rather than for export [12].

The Petrodar (PDOC) pipeline transports crude oil from Palogue and Adar Yale oil fields (Blocks 3E and 7E) in the Melut Basin to the Bashayer Marine Terminal in Port Sudan. The pipeline is approximately 850 miles long with a design capacity of 500,000 b/d, and it has several heating units to facilitate the movement of the Dar blend crude oil along the pipeline [13].

The pour point and viscosity **[14,15,16]** ,of crude oil are important physical properties **[17,18]** High pour point and high viscosity crude oil cause deposits at the critical wellbore**,** and in the tubing, flow-lines and pipelines. Deposits in the wellbore reduce production. Deposits in pipelines can have disastrous consequences, both in lost oil and in environmental costs caused by pipeline ruptures. Waxy crude oils are also extremely difficult to transport in pipelines, especially in cold weather.

Dar Blend is composed of four field [Palouge Field, Adar Field, Gummry Field and Moleeta Field] with very low sulphur, medium heavy, extremely paraffinic crude oil. As such it has an unusually high-viscosity high pour point [19, 20, 21], which will lead to some handling difficulties [22, 23, 24]. More significantly, and unlike the Nile Blend crude oil already in production, Dar Blend crude oil has a high Total Acid Number (TAN) **[25, 26, 27, 28]**, which certain potential users will find unacceptable. Such crude oils are typically discounted somewhat in price compared to their theoretical value based on refined product yield because the customer base for them is limited.

The studied crude oils over the world have been classified into four groups: I group – light, low sulfur one (30 – 40.0 API); II group – light, sulfur one (30-40.0API; S= 0, 5 - 1.5 % mass); III group – heavy, high sulfur one (15-30.0API; S=1.5 - 3.1% mass); IV group – extra-heavy, high sulfur one (15.0API, S ≥3 % mass). It has been established that extra-heavy crude oils (IV group) are characterized by light fraction low content, diesel fractions low cetane index, vacuum gas oil fractions low K-factor and vacuum residue fractions high Conradson carbon content.

It also has been found on the base of crude oil averaged prices for June 2018 (Brent crude oil price = 70 US $/ barrel) that the difference of the Ist and IVth group crude oil prices was about 9 US $/ barrel. This difference amounts up to 22 US $/ barrel, as the crude oil price rises up to 14.0 US $/ barrel. The high acid crude oil price (such having TAN > 0.5 mg KOH/g oil) may be approximately 9 US $/ barrel lower than one determined on the base of density and sulfur content for the corresponding group. The objective of this study, to Study the characteristics of crude oil in Melute Basin regarding to Viscosity, Pour Point, ^{0}API,Specific gravity, and Total Acid number variation in different locations for the same (basin) and there effects.

Materials and Methods

Area of Study

Palouge field is located in Block 7E in the Melute Basin, approximately 650 km south of Khartoum, to the west lies the White Nile and Nuba Mountains whilst to the east is the Ethiopian border. Palouge field is located Northeast part of Melute Basin, to the south is Central sub-basin Agordeed field and Adar-Yale field, to west is north-basin and block 1/2/4/6.

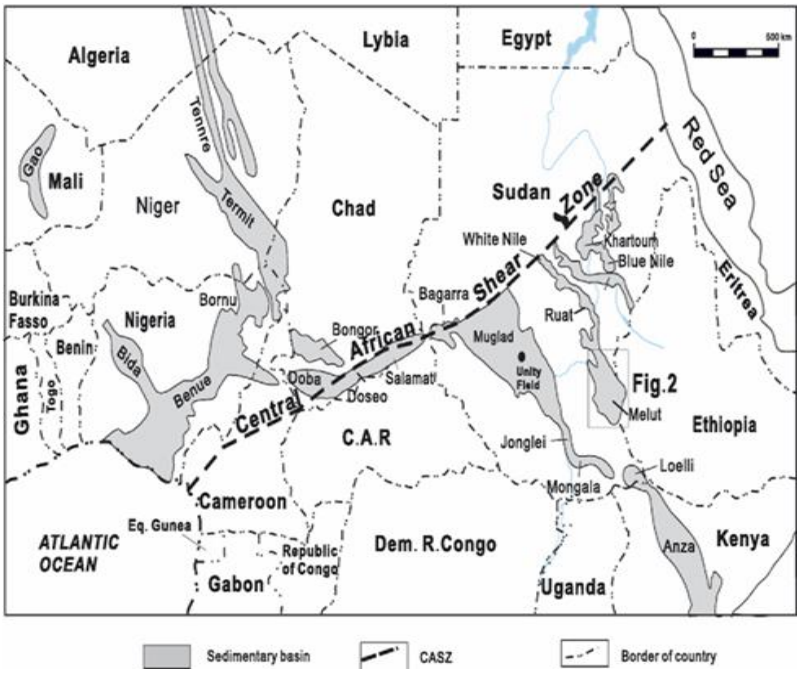
Test Procedure

Sample collection and analysis of oil sample was carried out in line, with recommended procedures of the American Society of Testing and Materials-ASTM. During sampling all glassware were rinsed properly with water and properly air-dried. The wares were later rinsed with the crude oil to be sampled before the sample for analysis was collected. Samples were obtained in triplicates. Also, all the chemical reagents used in this study were of analytical reagent grade.

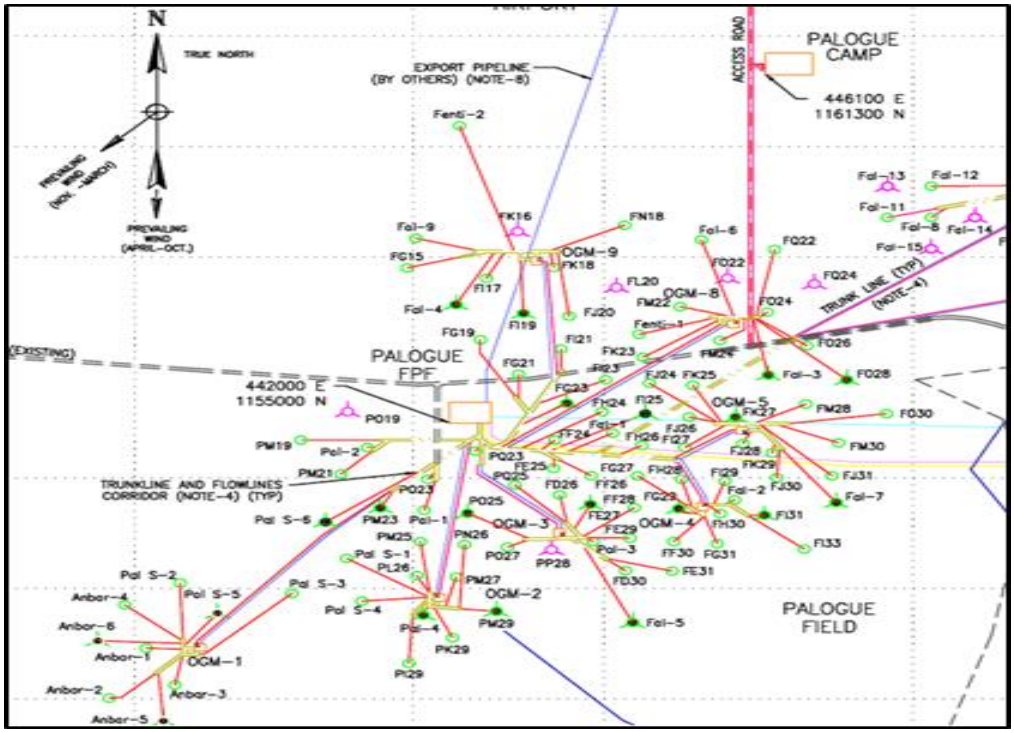
The following physical and chemical properties of samples of crude oils were determined following well established procedures: API gravity, density, viscosity, pour point, total acid number.

Samples of crude oil, were collected in 1Liter plastic bottles sample representative of the bulk

material from oil gathering manifolds (OGM) Map (2), at different location and directions according geographical distribution, but included the main reservoir.



Map (1) Simplified tectonic map of Central African Rift System, showing the major features discussed in the text and location of the Melut Basin.



Map (2): OGM at different location and directions according geographical distribution

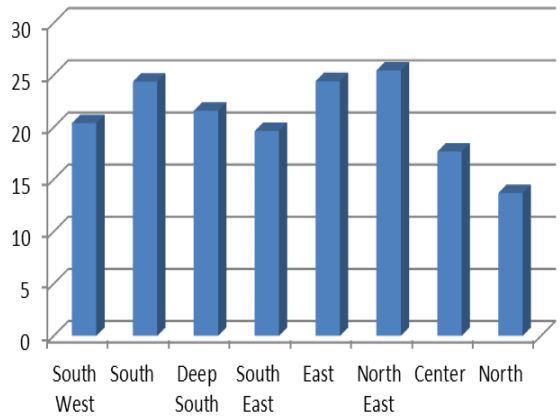


Figure 1: Density in term of API gravity ^{0}API

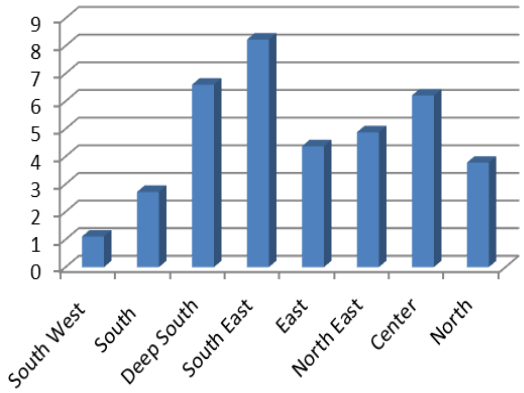


Figure 2: Total Acid Number (TAN)

Figure 2 revealed that the Total Acid Number (TAN) of 8 OGMS varies from 1.1mg KOH/g South west OGM of lowest TAN to South East OGM of 8mg KOH/g as a highest TAN. The increased availability of high TAN crudes has alerted refiners not only to their commercial opportunities but also to the potential hazards that their corrosive behavior can create.

Given that refineries without corrosion protection will normally limit feeds to around 0.3 or at most 0.5 TAN, Dar crude is likely to be a borderline candidate for blending with other grades to achieve a satisfactory acid number: dilution with around 6-10 times as much low acid crude would be necessary, which is not a feasible operation for some refiners.

The main reason for high TAN in crude oils is the presence of naphthenic acids. These are formed when biodegradation of crude oils occurs during oil formation in the subsurface. The most quickly biodegraded molecules are light paraffins, so crude oils with higher naphthenic acid contents tend to be relatively heavy or high specific gravity. Total Acid Number, however, also measures the presence of any other organic acids and also inorganic acids that may have been used during well drilling and production operations.

Certain naphthenic acids are relatively harmless in refineries; others can be highly corrosive, especially on plant constructed with mild steel, at pipe bends and other points of collision. The naphthenic acids may be concentrated in certain boiling ranges and therefore the corrosion may be confined to particular areas of refining plant. Extensive testing is therefore necessary to establish the degree of difficulty of processing: a high TAN figure can only provide a broad indication of potential difficulties. Acidity is most damaging in the vacuum gasoil fraction, as the upgrading processing of this fraction occurs under high temperature conditions.

The equation of total acid number (TAN) of sample is used which is calculated in milligrams of potassium hydroxide per gram of sample (mg KOH/g),

$$TAN=56.1\times C\times(VKOH-VB)/m \qquad (2)$$

Where, c = concentration in moles per litre, of standard volumetric potassium hydroxide solution. VKOH = volume in mililitres, of titrant required for blank test. VB = volume in mililitres, of titrant required for determination. m = mass in grams, of the test portion.

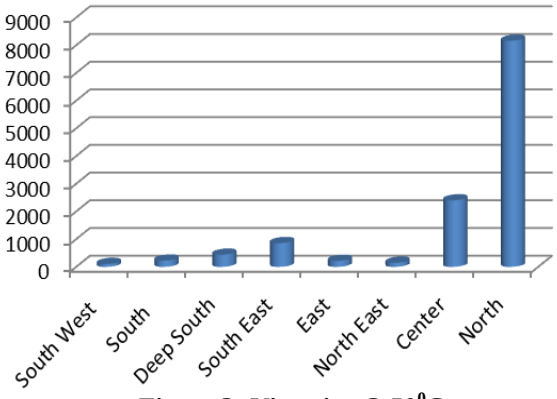


Figure 3: Viscosity @ 50^{0}C

Viscosity of crude oil in Palouge field, varied from 125 in OGM South West as the lowest Value to Ogm in the North 8000 as highest reading of 8Ogm.Viscosity of the produced fluid increases

causing loss of pressure Figure 3. Wax deposits on the pipe surface, increasing the surface roughness of the pipe wall leading to an increase in frictional pressure drop and turbulent flow. Wax layers also reduce the cross-sectional area of the pipe and throughput of the line [33, 34, 35]. During any planned or unplanned shutdown, the static oil contained within a pipe could cool below the pour point, gel structure develops and high yield stresses may cause difficulties with line restart-ability.

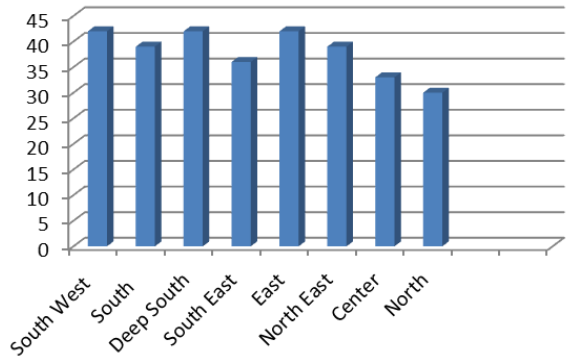


Figure 4: Pour Point C

The pour point of a crude oil, was originally applied to crude oil that had high wax content. More recently, the pour point, like the viscosity, is determined principally for use in pumping and pipeline design calculations. Difficulty occurs in these determinations with waxy crude oils that begin to exhibit irregular flow behavior when wax begins to separate. These crude oils possess viscosity relationships that are difficult to predict in pipeline operations.

Typically, for a highly paraffinic crude oil, the PDOC Dar crudes have a very high pour point of 41 degree C. This means the crude oil will require significant heating throughout storage and transportation, probably to around 50 deg C in loading and 60 deg C for discharge. Heating in Transit: the crude oils need to be kept above their pour points from the point of loading in Sudan to the point of discharge.

The incremental bunker fuel consumed in such operations will be for the account of the charterer of the tanker. Most tankers with heating coils are able to maintain cargo at temperatures up to 66 deg C. It may well be necessary to do this in the case of Dar Blend, to avoid it gelling in pockets of the tanks in transit as well as in time to ensure its discharge. Inland refineries that import their crude oil through long pipelines from coastal ports may be constrained in their ability to take high pour point crude oils, especially if such pipelines are only operated on a transient basis and the possibility exists that a high pour point crude might cool in line and gel up or at least deposit significant amounts of wax**.**

TABLE 1: DAR BLEND COMPOSED OF PALOUGE, ADAR, GUMMRY, AND MOLEETA OILFIELD

Location	^{0}API	Density g/cm^3@15 c^0	PourPoint(ºC)	Viscosity@50ºC(cp)	Viscosity@40ºC(cp)
Palouge	24.01	0.9091	39	996	1535
Adar	30,87	0.7070	39	25	42
Gummry	33.27	0.8580	42	24	52
Moleeta	20.30	0.9310	36	261	382

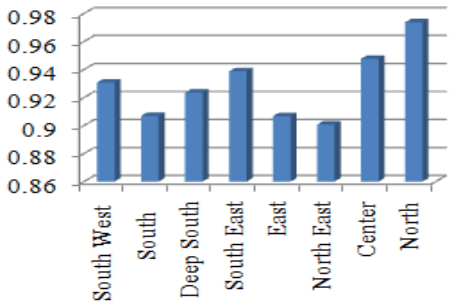


Figure 5: Density kg/m^3

Density of Palouge field, was varied for the seven samples where in Ogm of North East was 0.092kg/m^3 then increased in North Ogm by 9.7kg/m^{3}Density (ρ), of any liquid is the mass per unit volume. It is a temperature and pressure dependent property, where the density of a liquid decreases as the temperature increases, and vice versa. In general, the pressure affects the density of liquid, but the change is not as profound as temperature. Figure 5. The ^{0}API of DAR Blend, is lower even it was blended of Adar crude oil, Gummry, Moleeta, and Palouge oilfield illustrated in the Table 1.

CONCLUSIONS

The result of this study, has shown that the crude oil sample obtained from DAR BLEND contains low level of sulphur. The sample is also of moderates-heavy crude oil category grade. Therefore, it can be classified as heavy crude oil. The High values of viscosity and pour point obtained for the sample indicate that, this oil sample cannot flow easily. This makes troubles for transportation through pipelines with the necessary addition heating regular intervals often associated with heavy crude oil samples.

On the whole, the high levels of acids, and pour point observed for the oil sample coupled with other physiochemical parameters show that, the crude oil has characteristics which decreases its preferences in the oil market and refineryv operations.

These characteristics prevail in the crude oil produced by Petrodar company causing some very serious technical problems affectively the transfer of crude which is transported long distances from production fields to the port export terminal. Recommended that to use specific and performance additives to treats high pour point and total acid number to increases its preferences in the oil market and refinery operations.

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