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GRANULOMETRIC ANALYSIS OF THE SARMATIAN SANDS FROM THE MOESIAN PLATFORM DESCRIBING ASPECTS OF THE DEPOSITIONAL ENVIRONMENT

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ABSTRACT

The Moesian Platform pertaining to Romania gathers numerous petroleum and gas reservoirs of various sizes and types of hydrocarbons, from black oil to shallow gas reservoirs. They are sited in reservoir rocks having different lithologies (limestone, sand, sandstone, microconglomerate etc) belonging to different ages from the Cretaceous up to the late Pliocene, all formations being characterized by the Paleogene hiatus. Sand formations studies for certain reservoirs indicate oceans rivers and deltas as depositional environments although lithologic analysis, and especially paleontological analysis, are very limited (sometimes missing) and could not be used to re-enact a detailed image. Using granulometric analysis performed on sand cored from different wells, clarification is brought onto the paleoecology of the zone and thus it was discovered which wells belonged to the ocean riverbed and riverbank. Paleoenvironmental studies require large quantities of data which in many cases are not available, but they help in clarifying further aspects such as regional geology, depositional environments and ultimately reservoir heterogeneity which would, in term, justify different production behaviors of the oil reservoirs. Production data has not been studied for this application, but it is confirmed to have ample fluctuations and wells on this structure require workover intervention very often. For data interpretation the classic Udden-Wentworth scale is used along with granulometries from different surface sites and artificial sand having one of the conclusions that the analyzed sand fits almost on the dot on the assumed paleoenvironment.

Keywords: paleoenvironment, granulometric sieving, production potential resumption, mean, standard deviation, skewness, kurtosis

INTRODUCTION

The Moesian platform includes areas on both banks of the Danube River and the Romanian part is bounded to the north by the Precarpathic Fault, to the south by the Prebalkanic Fault and to the east is limited by North-Dobrogea Mountain [5]. In terms of sedimentology the Moesian platform is characterized by four stratigraphic cycles: (i) mid-Cambrian – Upper Carboniferous, (ii) Upper-Permian – Triassic, (iii) Liasic (mid-Jurassic) – Cretaceous and (iv) Badenian (mid-Miocene) – Pleistocene [12]. It spans numerous reservoirs of oil and gas alike in its almost unfolded and horizontal stratum belonging to all series like Triassic, Jurassic, Cretaceous, Miocene and Pliocene [1], [10].

The oil reservoir in discussion is placed in the center of the platform at a rough distance of 50 km away from the capital city Bucharest. This area beholds hydrocarbon reservoirs belonging to stratigraphic cycles (iii) and (iv) and presents limestones followed by a series of clay, sandstones, and glauconitic sands. The Sarmatian series debuts with combined river and delta arenitic formations having alternate short sequences of shales and marls. Early Pliocene is comprised of clays, silts and marls having the Levantine made up of arenites (sands, sandstones, and microconglomerates) and the Pleistocene of loess and bench and cliff deposits [13].

This paper analyses granulometric composition references from three wells located in the Sarmatian in trying to reenact paleoenvironmental depositional conditions. Reported oil production shows high fluctuations and wells often need workover interventions because of sand clogging in the perforations, one reason to believe the sand has different granulometric properties and belongs to different depositional places within the paleoenvironment.

Judging by the regional geology, former rivers and sea riverbeds make up the depositional environments, believing that wells drilled in the first will present a more chaotic production whereas from the latter will show a smoother and more predictable one. To analyze this aspect, granulometric sieving has been performed and the data obtained has been plotted using the Udden [16]-Wentworth [17] scale. Because this classic scale is comprehensive and covers all clastic sediments, thus having lesser closeness to the addressed reservoir rock, two interpretations presented by Folk [7] and [8] will be used to bring a more covering light in establishing the paleoenvironmental whereabouts.

The central part of the Moesian platform holds numerous abandoned oil reservoirs, most of which have had production shut down for decades. Studying the potential resumption production [3] would be a very profitable alternative as opposed to drilling new wells. One of the hypotheses is that the more uniform the porous media, the greater the chance of oil to resume its position and re-accumulate to a certain horizon and re-open production easily [4].

MATERIALS AND METHODS

A number of three wells have supplied sand cores which from the beginning need to pe pointed out as insufficient, leading towards incomplete conclusions.

Dry sieving was applied and samples weighing 100 grams from each well were passed through a series of eight sieves covering the span from 2 *mm* to 0,063 *mm* as proposed by Udden and Wentworth.

The wells were numbered #1, #2 and #3 and have the positioned on the structural map according to figure 1.

Upon weight measurements carried out on the sieves, the input data has been grouped in table 1 on each well accordingly. Each sieve refusal makes up the frequency which represents the percentage of initial sand mass placed onto the system.

Table 1 *Input Data*

	Well #1		**Well #2**		**Well #3**	
Sieve Diameter *mm*	Frequency	Cumulative Weight %	Frequency	Cumulative Weight %	Frequency	Cumulative Weight %
0,063	4	4	2	2	1	2
0,125	5	9	5	7	1	3
0,18	3	12	6	13	3	6
0,25	19	31	16	29	6	12
0,5	31	62	29	58	25	37
0,6	35	97	40	98	31	68
1	2	99	1	99	24	92
2	1	100	1	100	8	100

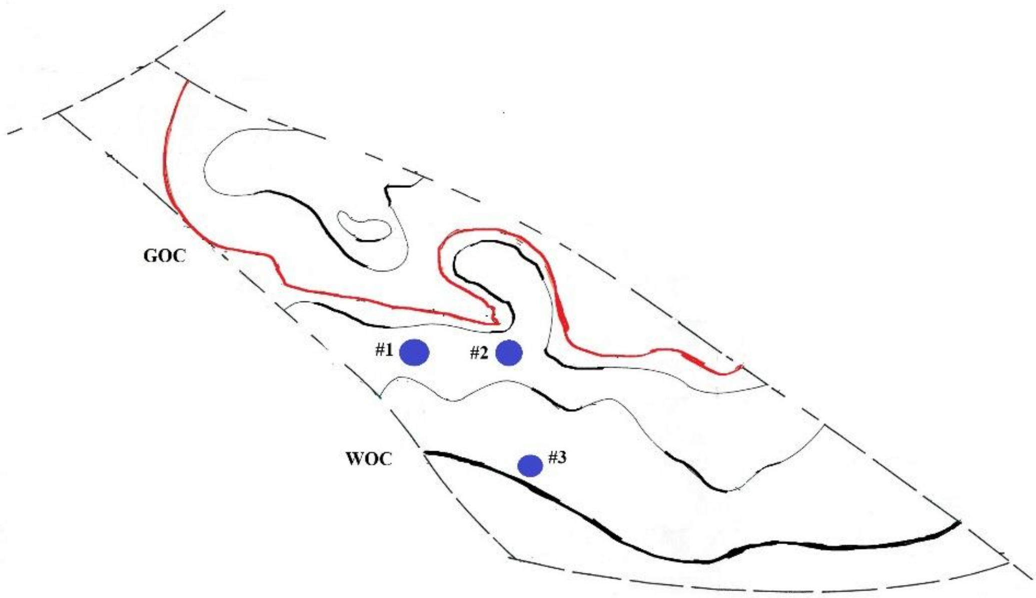
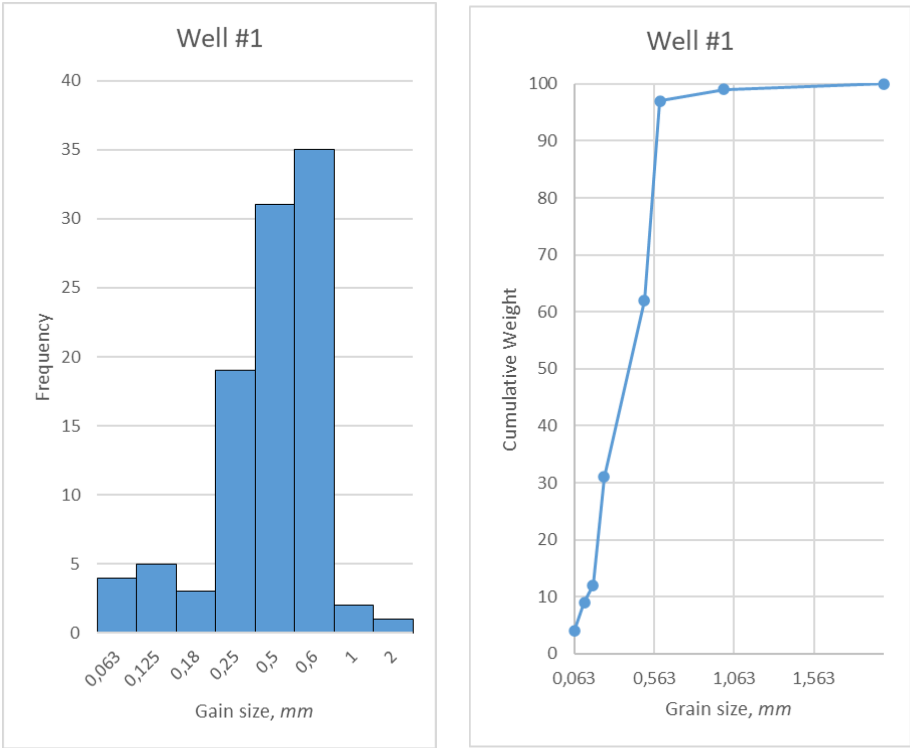


Fig. 1. *Structural map fragment illustrating the positioning of the three wells in regards to WOC and GOC*

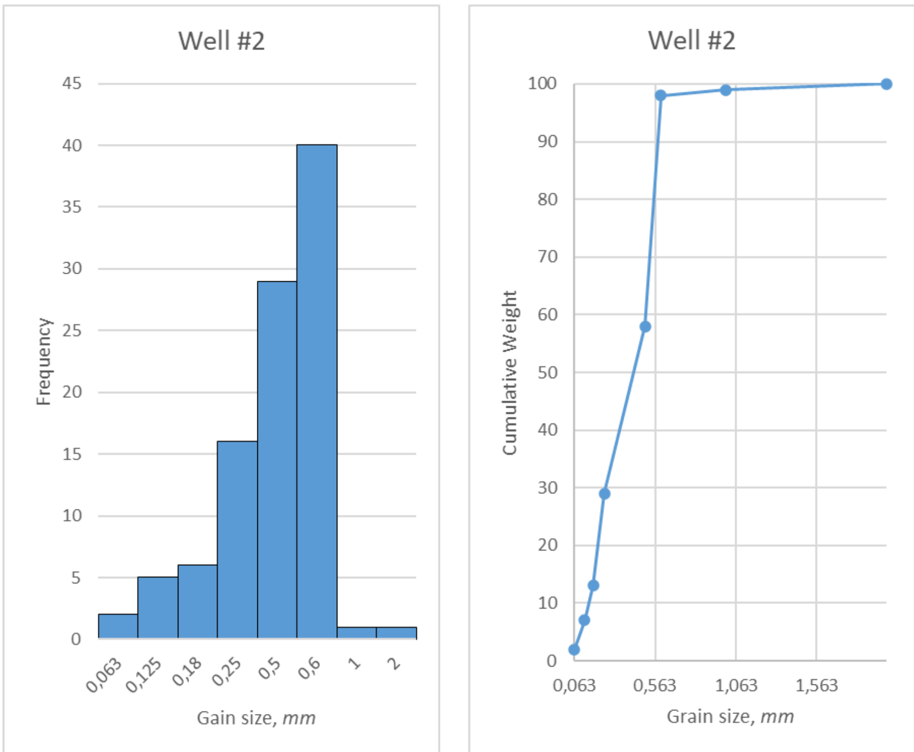
RESULTS AND DISCUSSIONS

Following the analysis, frequency of each mass fraction and the cumulative weight were obtained in relation to grain size, the sieves used having the diameters of 0,063 *mm*, 0,125 *mm*, 0,18 *mm*, 0,25 *mm*, 0,5 *mm*, 0,6 *mm*, 1 *mm*, respectively 2 *mm*. The plots are presented in figures 2, 3 and 4.



a) *b)*

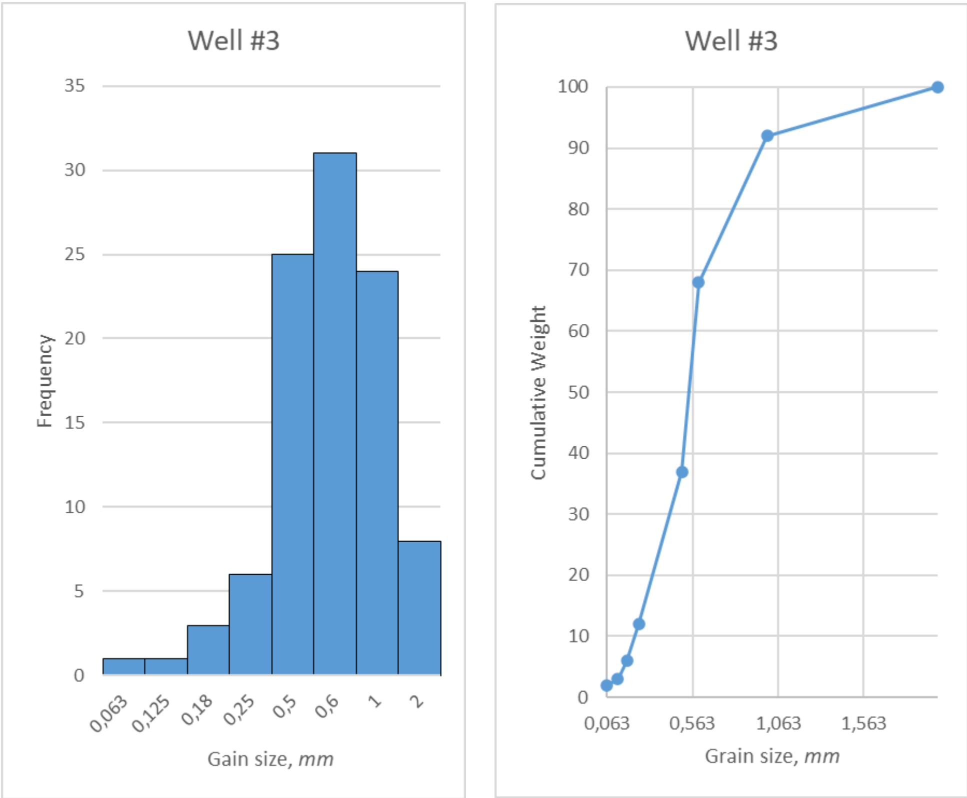
Fig. 2. *Frequency (a) and cumulative weight (b) for the sand in Well #1*



a) *b)*

Fig. 3. *Frequency (a) and cumulative weight (b) for the sand in Well #2*

According to Udden [16] and Wentworth [17] well #1 would have a coarse-to-medium sand with an uneven distribution of fine clasts summing up 5% of the analyzed sample, well #2 shows a more prominent coarse sand whereas well #3 indicates a very coarse sand with an almost-absent fine clasts.



a) *b)*

Fig. 4. *Frequency (a) and cumulative weight (b) for the sand in Well #3*

However, to establish a more descriptive paleoenvironment graphic mean GM, standard deviation SD, Inman skewness ISK [11], Folk skewness FSK [9] and kurtosis KG were used.

Graphic mean GM was defined by [6], represents the overall size of the sand grains and is enounced as:

$$GM = \frac{\emptyset_{16} + \emptyset_{50} + \emptyset_{84}}{3} \tag{1}$$

Standard deviation SD is used to appreciate sorting [2], [14] and is enounced as:

$$SD = \frac{\emptyset_{84}+\emptyset_{16}}{4} + \frac{\emptyset_{95} + \emptyset_{5}}{6,6} \tag{2}$$

Inman skewness ISK is defined as:

$$ISK = \frac{\emptyset_{84} + \emptyset_{16} + 2\emptyset_{50}}{\emptyset_{84} - \emptyset_{16}} \tag{3}$$

Folk skewness FSK is defined as:

$$FSK = \frac{\emptyset_{84} + \emptyset_{16} + 2\emptyset_{50}}{2(\emptyset_{84} - \emptyset_{16})} + \frac{\emptyset_{95} + \emptyset_{5} + 2\emptyset_{50}}{2(\emptyset_{95} - \emptyset_{5})} \tag{4}$$

Kurtosis KG [9] is defined as follows:

$$KG = \frac{\emptyset_{95} + \emptyset_{5}}{2{,}44(\emptyset_{75} - \emptyset_{25})} \tag{5}$$

After applying the mentioned indicators, the results were grouped in table 2.

***Table 2** Statistical indicators regarding the sands*

	Well #1	**Well #2**	**Well #3**
Standard deviation (SD)	0,47	0,78	0,39
Inman skewness (ISK)	0,11	0,1	-0,06
Folk skewness (FSK)	0,15	0,22	-0,12
Kurtosis (KG)	1,32	1,15	1,26

CONCLUSIONS

Upon interpretation of the indicators from table 1 well #1 and well #2 would be part of an ancient riverbed. They are well sorted sands, slightly positive skewed and slightly leptokurtic distributed. Well #3 however would be part of an ancient sea or ocean bed due to its negative skewness, is a better sorted sand compared to the other wells and the kurtosis is similar [15]. A reconstruction of the paleoenvironment is shown in figure 5.

In conclusion, the first two wells would justify the increased number of workover interventions as well as uneven and unpredictable production. The last well reported lesser workovers and also has an established production decline which corresponds to production data.

Another conclusion regarding production resumption on abandoned oil reservoirs can be extrapolated and proposed to other wells drilled in sea beds as these types of formations present an increased potential for oil repositioning towards a viable and efficient resumption of exploitation.

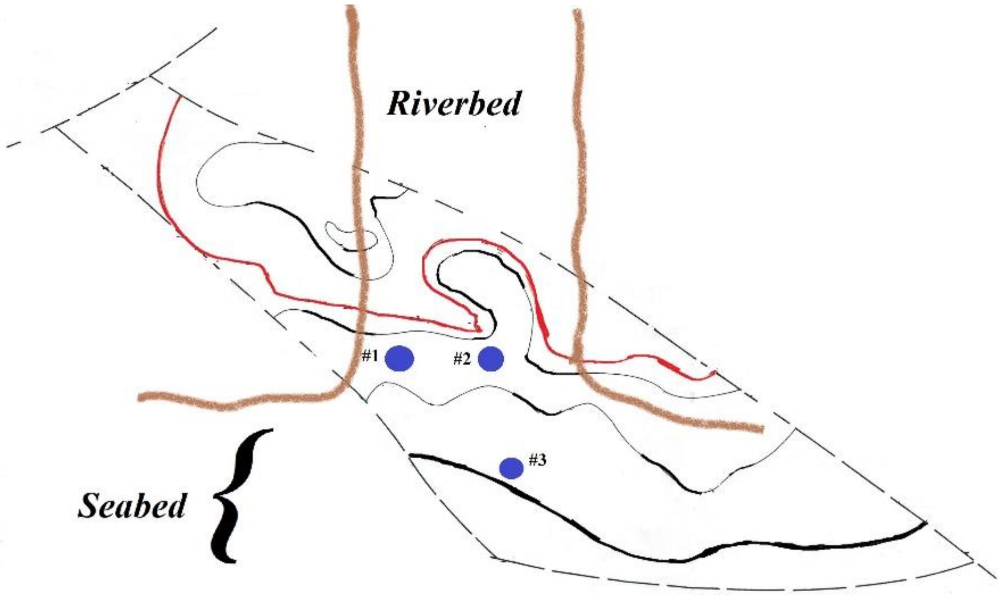


Fig.5. *Reconstruction of the ancient river and the mouth watering*

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