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GROSS DEPOSITIONAL ENVIRONMENT ASPECTS OF THE UPPER HOLOCENE SANDS FROM PETROLEUM-GAS UNIVERSITY OF PLOIESTI AREA USING GRANULOMETRIC ANALYSIS

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ABSTRACT

Granulometric analysis conducted on four samples from the same Holocene depth (covering 1363.73 sqm) reveals strong evidence for a braided fluvial environment, consistent with channel bar, levee, and floodplain deposition. Upon analysis, statistics reveal significant spatial heterogeneity: mean grain sizes range from 0.124 to 0.226 mm, while standard deviations (0.161–0.212 mm) reflect variable sorting. Kurtosis spans from 0.717 to 2.99, with higher values indicating well-sorted, peaked distributions from low-energy suspended settling (levee/floodplain) and lower values marking broader, mixed sorting in active channel bars. Positive folk skewness and diverse uniformity coefficients further point to episodic fluctuations in hydraulic flow and rapid sediment pulses. The coexistence of fine and coarse fractions and contrasting sorting regimes – supported by the absence of marine influence in the Holocene – confirms alternating energy and sediment supply typical of a braided river. These textural signatures underpin a gross depositional environment map, highlighting dynamic channel migration and nuanced fluvial architecture.

Keywords: gross depositional environment, soil gradation, particle/grain size, sieve analysis, braided fluvial, variable energy, channel bar, levee.

INTRODUCTION

Following the studies carried out for the installation of new heat pumps on the Petroleum Gas University campus, part of the lithological column corresponding to the place where the water wells were drilled contains sand. From a geographical standpoint, the study area is located centre-north of the Romanian Plain in between Prahova and Teleajen rivers and situated on their corresponding dejection cones [16]. This surface corresponds to the alluvial plain Prahova-Teleajen-Cricov on which the Upper Holocene forms uniform deposits made up of fine sands and clayey-like formations situated on gravels with torrential stratification with thin lenses of coarse and small sands [20]. The thickness of these alluvial deposits can reveal values of 30 meters which indicates a rather intense subsidence activity. This latter particularity explains the shifting of Prahova meadow towards a former holm of Ialomita river [4],[15]. Also, due to this subsidence existence in the Upper Holocene of wide oscillations of Prahova, Teleajen and Cricov rivers has been observed which determined the formation of well-individualized morphological subunits by reunion of alluvial plains of the mentioned rivers [17]. The petrographic composition of the gravel in the alluvial plain area suggests the predominance of the original elements from the Early Cretaceous flysch to which the confluence areas of the Teleajen and Prahova add where many fragments of the Paleogene flysch are observed [18], [21]. Also, the Holocene deposits host the phreatic aquifer which is the shallowest in the area being situated at depths from 4 to 6 meters, aquifer which follows the Prahova valley gradient [5].

This study seeks to characterize aspects of the depositional system, how it was distributed across the Prahova-Teleajen-Cricov rivers area and to constitute initial information for Gross Depositional Environment (GDE) maps. Four sand samples were collected following drilling activities whose purpose was to install heat exchangers. Granulometric sieving has been applied [11] to obtain information helpful in reenacting the depositional environment and to obtain an approximation of the geological events that occurred. GDE maps are used to understand how depositional systems were distributed across a basin and how sediment supply, sea-level, and tectonics interacted to shape stratigraphy portraying regional-scale sediment distributions instead of fine facies changes [8], [9]. The results of this paper will show a change in the Tealejen river valley which will be illustrated schematically. Reenacting depositional environment aspects only from granulometric data holds limitations and is not sufficient to make a broad and clear image of the paleoenvironment. Granulometric data alone can distinguish broad energy regimes but often cannot unambiguously identify specific depositional settings, such as differentiating between fluvial channel and estuarine sand because they both have similar grain size spectra. Grain size may be hindered by a multitude of factors, such as weather, diagenesis, bioturbation and reworking which overwrite initial depositional characteristics and make interpretation more difficult. Different environments can present superpositions of grain size parameters because of the similarity in transportation energies, increasing the chances of a wrong classification. To complete more accurately such a reconstruction, supplementary information such as palaeontology, geochemistry and seismic data would be needed.

MATERIALS AND METHODS

Particle size separation was conducted with a vibratory sieve shaker describing a throwing motion with angular momentum. Selected sieves respect the Udden-Wentworth [25],[26] scale, and their values are focused on the sand category: 1000, 500, 325, 250, 125, 80 and 63 µm. Sand samples weighing 100 grams each were oven-dried beforehand at a temperature of 250 Celsius degrees for 4 hours and have undergone a binocular magnifying glass examination to remove impurities related to the drilling process [22].

The sampling location is sketched in the figure 1 and represents the inner area of the university campus. Distances between the sampling sites are between 40 and 90 meters and were chosen so that the largest possible space would be covered, given the limited area available, sampling depth being located between 90 and 105 m.

RESULTS AND DISCUSSION

Frequency, cumulative weight and statistical indicators have been obtained for the sand samples. Prior to displaying the results, presentation of the mathematical formulas of the statistical indicators is reasonable, therefore, they will be listed below.

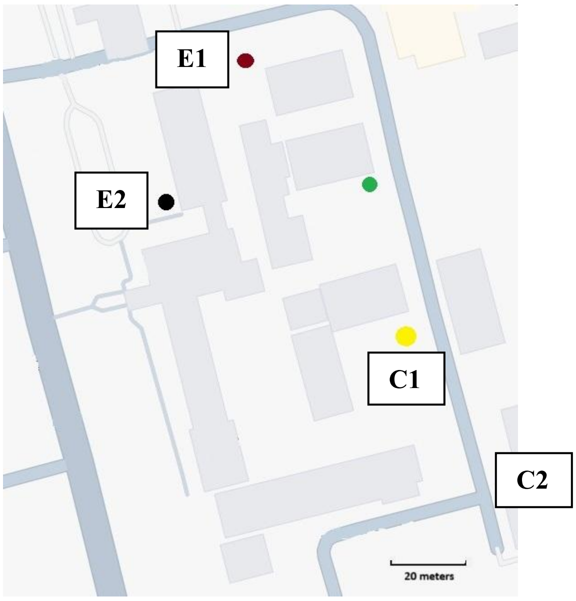

Figure 1. *Positioning of sand samples: E2 (black dot), E1 (burgundy dot), C2 (green dot) and C1 (yellow dot)*

Graphic mean (GM), or simply mean (M), represents the average size of the grains making up the sand [13], [23]:

$$M = \frac{\delta_{16} + \delta_{50} + \delta_{84}}{3} \quad (1)$$

Standard deviation (SD) [3], [19], used in sorting evaluation, is formulated as follows:

$$SD = \frac{\delta_{84} + \delta_{16}}{4} + \frac{\delta_{95} + \delta_{5}}{6.6} \quad (2)$$

Skewness, measured with Folk [12], [14] proposed equation, is defined as:

$$SKf = \frac{\delta_{16} + \delta_{84} - 2\delta_{50}}{2(\delta_{84} - \delta_{16})} + \frac{\delta_{5} + \delta_{95} - 2\delta_{50}}{2(\delta_{95} - \delta_{5})} \quad (3)$$

Kurtosis [7], [23] has the following form:

$$K = \frac{\delta_{95} - \delta_{5}}{2.44(\delta_{75} - \delta_{25})} \quad (4)$$

Coefficient of uniformity [2], [10] is formulated as:

$$C_u = \frac{\delta_{60}}{\delta_{10}} \quad (5)$$

Coefficient of curvature [6], [24] is defined as:

$$C_c = \frac{\delta_{30}^2}{\delta_{60} * \delta_{10}} \quad (6)$$

The first sorted sand was E2, and its frequency and cumulative weight graphics are presented in figure 2. According to the Udden and Wentworth classification, sample E2 would be a fine sand having constituents from medium and very fine subclasses. Fractions smaller than 63 µm represent 2.76% of the sample weight. The frequency and cumulative weight curve for sand sample E1 is presented in figure 3.

Sand from this well shows a better belonging in the class of fine to very fine sands, having almost no coarser particles. Fractions smaller than 63 µm represent 2.75% of the sand. Fractions and cumulative weight specifications for the sand from well C2 are presented in figure 4.

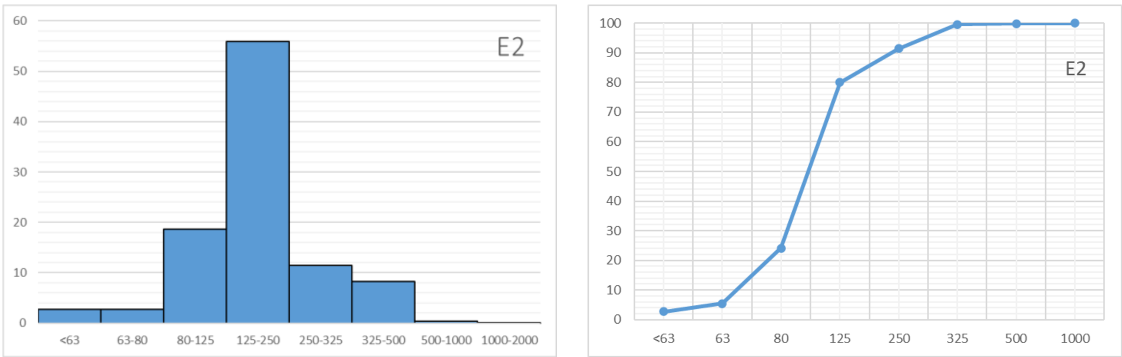

Figure 2. *Frequency (left) and cumulative weight (right) for well E2*

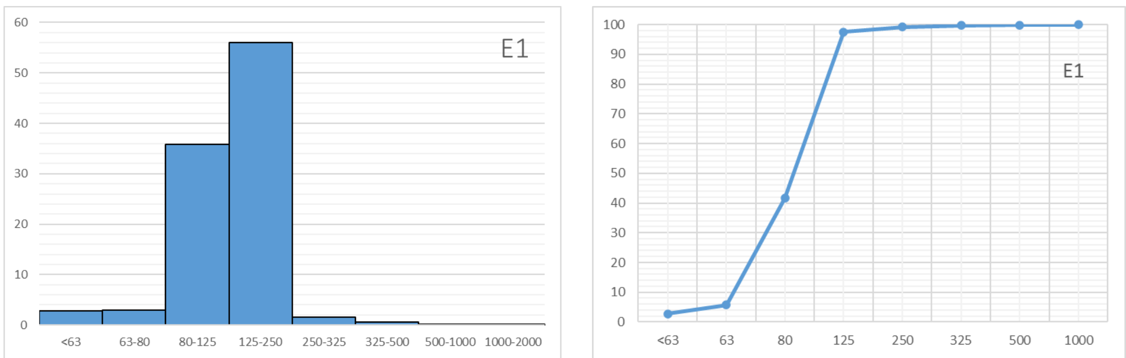

Figure 3. *Frequency (left) and cumulative weight (right) for well E1*

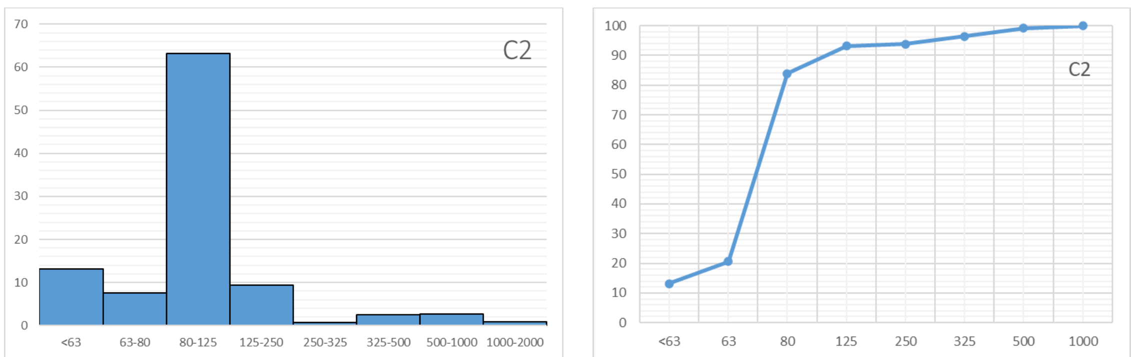

Figure 4. *Frequency (left) and cumulative weight (right) for well C2*

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Sand from well C2 suggest a belonging to the very fine sands but silt particles and very few coarse-subclass particles are present. 13.4% of the fragments recorded in this sample are smaller than 63 µm but the presence of coarser fragments would suggest an increase in turbidity.

The last granulometric sorted sample, C1, shows frequencies and cumulative weight curve as illustrated in figure 5.

Well C1 fits the very fine subclass of sands the best out of all four samples and has 8.82% of fragments belonging to the silt class (smaller than 63 µm). These results would suggest a calmer depositional environment with a greater depth. The statistical values presented earlier are grouped in Table 1.

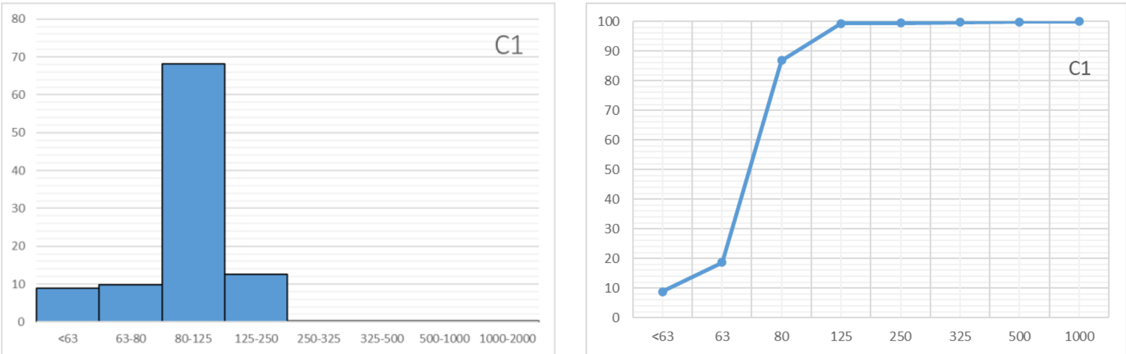

Figure 5. *Frequency (left) and cumulative weight (right) for well C1*

Table 1. *Statistical indicators for the four wells*

	E2	**E1**	**C2**	**C1**
M	0.214	0.124	0.226	0.135
SD	0.178	0.176	0.212	0.161
SKf	0.465	0.848	0.845	0.736
K	1.155	2.995	0.717	1.935
C_u	3.057	1.458	3.628	1.763
C_c	0.521	0.9006	0.662	0.663

The presence of wide range means grain size sorting and standard deviations indicate deposition from both higher energy channel (coarser, less well sorted) and lower energy floodplain or levee episodes (finer, better sorted). Skewness values, which are mostly positive, denote more fine sediment than coarse, consistent with frequent deposition from waning flood events and overbank flows. Kurtosis variations, from 0.71 to 2.99, support both well sorted (channel bar or mid-channel – leptokurtic) and poorly sorted (levee or floodplain – platykurtic) microenvironments that match braid plain heterogeneity.

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These findings are more suggestive of the depositional environment, E1 being narrow and presenting a uniform settling with possible low-energy sedimentation. C2 presents high uniformity which fits sustained transport or hydraulic sorting in active channels. Well E1 displays lower uniformity which matches fluctuating flow and sediment pulses typical of levee or floodplain settings. Using an adapted ternary diagram from the Udden-Wentworth scale [1] representing the proportions of clay-silt-sand, only well C2 exits the "sand" interval. More accurate measurements of granulometry have not been conducted, considering only the proportion of fractions that do not fit the sand class, which are as follows: well E1 - 2.75%, well E2 - 2.76%, well C1 - 8.82% and well C2 - 13.4%. Figure 6 shows the placement of the wells within the adapted ternary diagram.

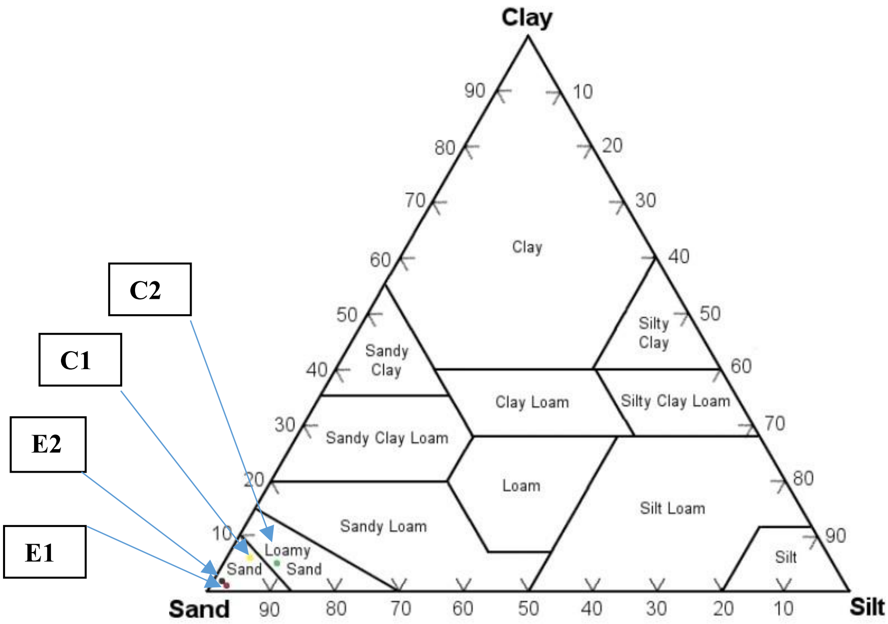

***Figure 6**. Fitting of the four sand samples within the C-S-A ternary diagram:*
E2 (black dot), E1 (burgundy dot), C2 (green dot) and C1 (yellow dot)

Figure 7 shows a possible image of the depositional conditions. In an attempt to spatially map the paleoenvironment, these results point toward a *braided fluvial environment* – with alternances of coarse and fine detrital deposits.

CONCLUSIONS

Four sand samples from the Upper Holocene have been sorted by dimensions and statistical indicators have been calculated with the purpose of reenacting the initial sedimentation layout. One of the most interesting findings is a pronounced spatial heterogeneity in depositional energy and flow. Well sands E2 and C2, whose statistical indicators reveal intermediate kurtosis, moderate mean and higher uniformity, would likely point to channel bar or floodplain interfaces, with alternating pulses of sediment during floods and waning finer deposition post-event. Sand from well E1, characterised by high kurtosis, small mean and low uniformity would possibly represent a zone of fine overbank levee deposition during stable water periods with episodic flood. Well C1, showing moderate kurtosis, small mean and intermediate uniformity suggest an abandoned channel fill or edge-of-bar environment, intermittently receiving sediment during transient flows. Final interpretations lead to a most probable braided fluvial paleoenvironment with coarse and fine-detrital alternances.

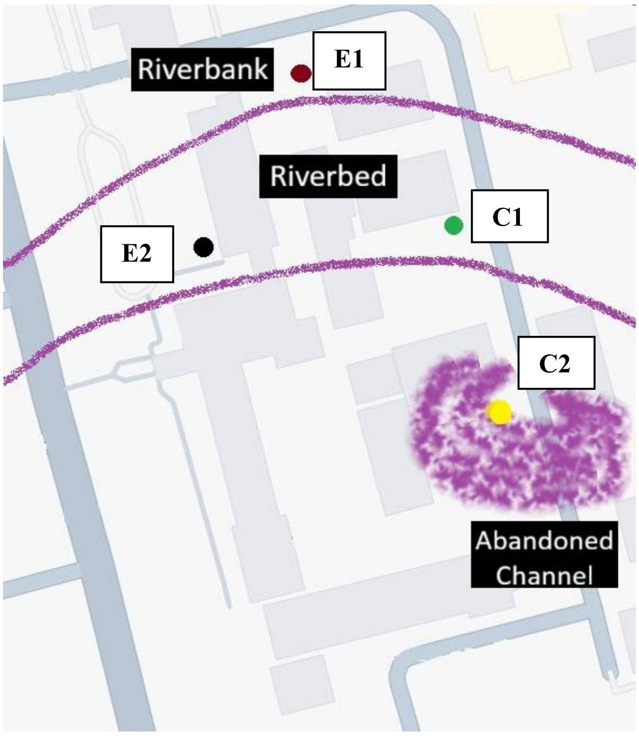

Figure 7. *Reconstruction of the depositional environment*

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