Granulometry analysis of Ngrayong sandstone, Tempuran Area, Rembang Zone, North East Java Basin

Myo Min Htun 1,2,3, Sugeng Sapto Surjono2,4, Jarot Setyowiyoto2,5
1Geology Department, Monywa University, Monywa, Myanmar
2Geological Engineering Department, Faculty of Engineering, Gadjah Mada University, Yogyakarta, Indonesia

*Corresponding author: myomintun@gmail.ugm.ac.id

Abstract. The study area is located near Tempuran Village, Rembang Zone, North-East Java. Ngrayong sandstone is a famous reservoir in north-east Java, mainly composed of sandstones which are exposed along east-west trending along the southern flank of Pakel Anticline. Eighteen samples from four different facies from eight outcrops conducted for granulometry analysis. The objective of this paper is to predict the reservoir potential base on granulometry analysis especially grain size and sorting. The study area is still needs to confirm about reservoir quality. Ngrayong Formation consists of laminated to thin bedded sandstone facies, thick bedded to massive sandstone facies, calcareous sandstone facies and cross-bedded sandstone facies. According to the analytical results, sandstone facies are composed of very fine to fine, poorly sorted to very well sorted sandstones. Based on the results of analyzed samples, Ngrayong sandstone have good porosity and permeability, thus Tempuran area can be considered as a prospective reservoir.

1. Introduction

The NE Java basin can be classified as a classic back-arc basin. It consists largely of a foreland shelf dipping gently southward, which is covered by a relatively thin stratigraphic section (averaging less than 6,000 feet). In contrast, the deep basin area contains more than 30,000 feet of sediments. The age of Ngrayong sediments ranges from early Middle Miocene to Middle Miocene [1]. It represents a complete regressive-transgressive sedimentary cycle which ranges from coarse-grained sandy clastics in the lower part grading to fine-grained clastics and limestones toward the top [2]. The Ngrayong Formation is mainly composed of quartzarenite sandstones in Madura Island, and shales and sandstones in the Rembang and Randublatung zone [3]. The study area is located in near Tempuran village, Rembang zone, western part north-east Java Island, bounded by Latitudes S06° 53’ 45” and S06° 54’ 45”, Longitude E111° 27’ 30” and E111° 30’ 30” are shown in Figure 1. In Northeast Java Basin, Ngrayong Formation is one of the prolific reservoirs. The study is still need to conduct the research to characterize the prospective reservoir. This paper will be focus to predict the reservoir quality of Ngrayong sandstone base on the results of
granulometry analysis. There is no previous research in order to predict the reservoir quality of study area by using the granulometry analysis.

2. Method and Materials

The field work was carried out along the exposure surface of Ngrayong Formation in study area. Eight stratigraphic sections were measured from different locations near the Tempuran Village. Field investigation have been done simply by measuring the strata, noting detail characteristics of rock, sedimentary structures, plotting the measured section location by using GPS, collecting the fresh samples for analysis. Those eight measured sections were given the name here as section A (06°54′27.57″S, 111°28′52.90″E), section B (06°54′12.72″S, 111°30′12.70″E), section C (06°54′07.87″S, 111°27′39.60″E), section D (06°54′25.06″S, 111°28′15.02″E), section E (06°54′19.78″S, 111°28′16.78″E), section F (06°54′10.98″S, 111°28′17.81″E), section G (06°54′13.11″S, 111°28′14.86″E), and section H (06°54′27.65″S, 111°29′59.23″E) respectively. Measured stratigraphic sections are shown in Figure 4. Geological map of the Rembang and surrounding area and measured sections of analyzed samples localities are shown in Figure 3. During the careful field observation, eighteen sandstone samples were collected from eight measured sections of study area shown in Figure 4.

![Figure 1. Location map of study area.](image)

Quantitative assessment of the percentages of different grain sizes in clastic sediments and sedimentary rocks is called granulometric analysis [4]. Granulometry analysis has been conducted for this research. Granulometry is a basic analytical technique that has wide applications within the earth and archaeological sciences. Particle or grain size is a fundamental attribute or physical property of particulate samples or sediments and sedimentary rocks [5,6]. Several sediment, soil, or material properties are directly influenced by the size of its particles, as well as their shape (form, roundness and surface texture or the grains) and fabric (grain-to-grain interrelation and grain orientation), such as texture and appearance, density, porosity, and permeability [7]
Most of the sandstone samples from Ngrayong formation are very loose because they are less cemented. So this method is very applicable to determine the textural properties in order to predict the reservoir quality especially base on grain size and sorting. This method is very cheaper than the other methods such as petrographic analysis, laser diffraction method, etc. Sieve applied in the analysis follow the US standard sieve mesh system (i.e. 10, 18, 35, 60, 120, 230, and the remain in the pan). The purpose of the analysis is to determine the quantitative distribution of grain size and sorting of sand-size grain in the sample to predict the reservoir quality of Ngrayong sandstone and hence help understand textural maturity. The four mathematical measurements: average grain size, sorting, skewness and kurtosis value can be determined using this analysis. The coarsest sieve was put at the top of fine sieves in which the screen openings become progressively smaller downwards. A pan is placed beneath the lowest sieve to retain the finest grains which pass through the entire column. The sample (100g) was put in the uppermost sieve, after the sieves have been put on a shaker. The sieving analysis data can be got by weighting on a balance after running shaker about 15 minutes. After that, the mean value, standard deviation value, skewness value and kurtosis value are calculated from the $\Phi$ value. The percentile values calculated from cumulative curve (Figure 2).

![Image](image_url)

**Figure 2.** The method for calculating percentile values from the cumulative curve

Source: Boggs (2006)

2.1. **Mean ($M$)**

The mean size is the arithmetic average value of all the particles sizes in a sample [8]. The actual arithmetic mean of most sediment samples cannot be determined because of uncountable small grain in a sample. An approximation of the arithmetic mean can be arrived at by picking selected Phi ($\Phi$) values from the cumulative curve and averaging these values. The mean value of the graph is the average grain size of the overall data. Graphically, the mean value can be calculated by the following equation:

$$\text{Mean} = \frac{\Phi_{16} + \Phi_{50} + \Phi_{84}}{3}$$
Figure 3. Geological map of the Rembang and surrounding area, NE Java, Indonesia [9]
**Figure 4** Location of eight measured sections on geological map of study area.

**Table 1.** Particle size scale for sediments and sedimentary rocks [10]

| mm    | phi | Name                     |
|-------|-----|--------------------------|
| 256   | -8  | Boulders                 |
| 128   | -7  |                          |
| 64    | -6  | Cobbles                  |
| 32    | -5  | Conglomerate             |
| 16    | -4  | Pebbles                  |
| 8     | -3  |                          |
| 4     | -2  | granules                 |
| 2     | -1  | very coarse sand         |
| 1     | 0   | coarse sand              |
| 0.5   | 1   | medium sand              |
| 0.25  | 2   | fine sand                |
| 0.125 | 3   | Very fine sand           |
| 0.063 | 4   | Coarse Silt              |
| 0.031 | 5   | Medium Silt              |
| 0.0156| 6   | Fine silt                |
| 0.0078| 7   | Very fine silt           |
| 0.0039| 8   | Clay                     |
2.2. Standard Deviation (D) (Sorting)

The sorting of the grain population is a measure of the range of grain sizes presented the magnitude of the spread or scatter of these sizes around the mean size [8]. Sorting value indicates the level of uniformity of grain sorting. The mathematical expression of sorting is standard deviation. Sorting corresponding to various values of standard deviation (Table 2) is defined as follows [8]. Base on phi values, standard deviation have been calculated from the following fomular:

Where:

\[
\text{Standard Deviation} = \frac{\phi_{84} - \phi_{16}}{4} + \frac{\phi_{95} - \phi_{5}}{6.6}
\]

\(\phi_5\) is grain size of 5th percentile value

\(\phi_{16}\) is grain size of 16th percentile value

\(\phi_{84}\) is grain size of 84th percentile value

\(\phi_{95}\) is grain size of 95th percentile value

| Standard Deviation (D) | Sorting Class          |
|------------------------|------------------------|
| < 0.35Ø                | Very well sorted       |
| 0.35-0.50Ø             | Well sorted            |
| 0.50-0.71Ø             | Moderately well sorted |
| 0.71-1.00Ø             | Moderately sorted      |
| 1.00-2.00Ø             | Poorly sorted          |
| 2.00-4.00Ø             | Very poorly sorted     |
| > 4.00Ø                | Extremely poorly sorted|

2.3. Skewness (S)

Skewness is a measure of the symmetry of the grain size distribution about the mean; it has a maximum possible value of +1 and a minimum possible value of -1. A of skewness that is close to zero indicates that the distribution is very symmetrical and the mean is equal, or nearly so, to the median and both fall within the modal class. A positive value of skewness indicates that the distribution has a larger proportion of fine grains than if the distribution were symmetrical. Conversely, if the value of skewness is negative the distribution is enriched in coarse grains. There are various types of skewness shown in (Table 3). Base on phi values, skewness value was calculated by the equation:
\[
Skewness (S) = \frac{\bar{\phi} 4 + \bar{\phi} 16 - 2 \bar{\phi} 50}{2(\bar{\phi} 4 - \bar{\phi} 16)} + \frac{22(\bar{\phi} 95 - \bar{\phi} 5)}{\bar{\phi} 95 + \bar{\phi} 5 - 2 \bar{\phi} 50}
\]

2.4. Kurtosis (K)

Kurtosis is a measure of the peakedness of the distribution; if a distribution is flatter than a normal one it is called platykurtic but, if more peaked, it is called leptokurtic. Kurtosis can be classified base on value as shown in (Table 4) and kurtosis value can be calculated mathematic by following equation;

\[
Kurtosis (K) = \frac{2.44(\bar{\phi} 75 - \bar{\phi} 25)}{\bar{\phi} 95 - \bar{\phi} 5}
\]

| Skewness | Class                  |
|----------|------------------------|
| > +0.30  | Strongly fine skewed   |
| +0.30 to +0.10 | Fine skewed          |
| +0.10 to - | Near symmetrical    |
| -0.10 to - | Coarse skewed         |
| < -0.30  | Strongly coarse skewed |

| Kurtosis (K) | Class               |
|--------------|---------------------|
| < 0.67       | Very platykurtic    |
| 0.67-0.90    | Platykurtic         |
| 0.90-1.11    | Mesokurtic          |
| 1.11-1.50    | Leptokurtic         |
| 1.50-3.00    | Very leptokurtic    |
| > 3.00       | Extremely leptokurtic|

3. Results and Discussion

Wentworth grain-size scale (Table 1) were used in order to classified the sand size grain from the mean value. The percentile values (Table 5) are calculated from cumulative curves (shown in figure 5 and 6) of each analyzed sample. The calculated mean values of sandstones range from 2.52 to 3.65 and fall in the size class very fine to fine (Table 6).
Figure 5. Cumulative curves of sample A3, A8, A10, B3, B5, B7, C3, C7 and C10.
Figure 6. Cumulative curves of sample D5, E2, E4, E8, F1, G4, G5, G9 and H2.
Table 5. The percentile values calculated from cumulative curve of each analyzed sample.

| No | Sample No. | Φ5  | Φ16 | Φ25 | Φ50 | Φ75 | Φ84 | Φ95 |
|----|------------|-----|-----|-----|-----|-----|-----|-----|
| 1  | Sp. A3     | 1.2 | 2.17| 2.4 | 3.05| 3.79| 4.06| 4.73|
| 2  | Sp. A8     | 0.18| 0.9 | 1.57| 3.07| 4.39| 4.6 | 4.89|
| 3  | Sp. A10    | 0.12| 1.25| 2.05| 3.33| 4.29| 4.52| 4.85|
| 4  | Sp. B3     | 1.09| 1.69| 2.06| 2.58| 3.10| 3.65| 4.52|
| 5  | Sp. B5     | 0.3 | 1.00| 1.88| 3.78| 4.48| 4.67| 4.90|
| 6  | Sp. B7     | 0.67| 1.64| 2.12| 2.92| 3.80| 4.20| 4.75|
| 7  | Sp. C3     | 0.9 | 2.68| 3.14| 3.7 | 4.33| 4.58| 4.86|
| 8  | Sp. C7     | 1.8 | 2.14| 2.27| 2.64| 3.00| 3.60| 4.55|
| 9  | Sp. C10    | -0.5| 0.32| 0.85| 3.05| 4.33| 4.58| 4.88|
| 10 | Sp. D5     | -0.25| 0.78| 2.63| 3.13| 4.00| 4.38| 4.80|
| 11 | Sp. E2     | 1.3 | 2.09| 2.20| 2.59| 2.94| 3.35| 4.20|
| 12 | Sp. E4     | 0.13| 0.67| 1.13| 3.05| 4.37| 4.59| 4.88|
| 13 | Sp. E8     | 1.26| 2.30| 2.65| 3.47| 4.23| 4.52| 4.88|
| 14 | Sp.F1      | 0.5 | 1.33| 1.71| 2.54| 3.50| 3.96| 4.70|
| 15 | Sp. G4     | 0.44| 1.70| 2.53| 3.62| 4.36| 4.59| 4.89|
| 16 | Sp. G5     | 0.45| 1.90| 2.70| 2.38| 4.35| 4.60| 4.89|
| 17 | Sp.G9      | 0.3 | 1.56| 2.28| 3.53| 4.35| 4.59| 4.87|
| 18 | Sp. H2     | 1.39| 2.06| 2.18| 2.51| 2.86| 2.98| 4.00|

Table 6. The calculated mean values and size class of analyzed samples.

| Facies                      | Sample No. | Mean (M) | Size Class     |
|-----------------------------|------------|----------|----------------|
| Laminated to thin bedded    | Sp. A3     | 3.09     | Very fine sand |
| sandstone facies            | Sp. A8     | 2.86     | Fine sand      |
|                             | Sp. B3     | 2.64     | Fine sand      |
|                             | Sp. C3     | 3.65     | Very fine sand |
|                             | Sp. C10    | 2.65     | Very fine sand |
|                             | Sp. D5     | 2.76     | Fine sand      |
|                             | Sp. E2     | 2.68     | Fine sand      |
|                             | Sp. F1     | 2.61     | Fine sand      |
|                             | Sp. G4     | 3.30     | Very fine sand |
|                             | Sp. G9     | 3.23     | Very fine sand |
| Thick bedded to massive     | Sp. A10    | 3.03     | Very fine sand |
| massive sandstone facies    | Sp. C7     | 2.79     | Fine sand      |
|                             | Sp. E8     | 3.43     | Very fine sand |
|                             | Sp. G5     | 3.39     | Very fine sand |
| Calcareous sandstone        | Sp. B5     | 3.15     | Very fine sand |
| facies                      | Sp. B7     | 2.92     | Fine sand      |
|                             | Sp. E4     | 2.77     | Fine sand      |
| Cross bedded sandstone      | Sp. H2     | 2.52     | Fine sand      |
| facies                      |            |          |                |
Mean represents the average size of the total distribution of sediments. Mean size of the sediments are influenced by the source of supply, transporting medium and the energy conditions of the depositing environment. It serves as an index to measure the nature as well as the depositional environment of the sediments. It is the function of total amount of sediments available, the amount of energy imported to the sediments and nature of the transporting agent. The energy of transporting agent includes the degree of turbulence and the role played by current sand waves. The mean size of the selected sandstones ranges from 2.52 to 3.65 and mean 2.97 in average (Table 7), indicating in the size class fine-grained.

Standard deviation is a measure of uniformity or sorting. It is an important parameter in sediment analysis because it indicates the energy conditions of depositional environment. It is also the resultant character of sediments controlled by size, shape and specific gravity of sediments and energy and time involved in transporting tine. It is noted that the standard deviation decreases towards the sample of lower mean size. In other words, the sorting improves with the lowering of mean size. Based on (Table 2) the standard deviation of the selected sandstones varies from poorly sorted to very well sorted (1.07 to 0.23).

Average value of standard deviation is (0.67), sandstone are, generally, moderately well-sorted. According to standard deviation values, moderately well sorted character of sediments indicating the influence of stronger energy conditions in the basin [11]. Dominance of moderately well sorted to well sorted sands could be a reflection of the higher wave energy and strong shore currents of the coast.

| Facies                      | Sample No. | Standard deviation (D) | Sorting Class   |
|-----------------------------|------------|------------------------|-----------------|
| Laminated to thin bedded sandstone facies |            |                        |                 |
| Sp. A3                      | 0.47       |                        | Well sorted     |
| Sp. A8                      | 0.93       |                        | Moderately sorted |
| Sp. B3                      | 0.49       |                        | Well sorted     |
| Sp. C3                      | 0.48       |                        | Well sorted     |
| Sp. C10                     | 1.07       |                        | Poorly sorted   |
| Sp. D5                      | 0.90       |                        | Moderately sorted |
| Sp. E2                      | 0.32       |                        | Very well sorted |
| Sp. F1                      | 0.66       |                        | Moderately well sorted |
| Sp. G4                      | 0.72       |                        | Moderately sorted |
| Sp. G9                      | 0.76       |                        | Moderately sorted |
| Thick bedded to massive sandstone facies |            |                        |                 |
| Sp. A10                     | 0.82       |                        | Moderately sorted |
| Sp. C7                      | 0.37       |                        | Well sorted     |
| Sp. E8                      | 0.56       |                        | Moderately well sorted |
| Sp. G5                      | 0.68       |                        | Moderately well sorted |
| Calcareous sandstone facies |            |                        |                 |
| Sp. B5                      | 0.92       |                        | Moderately sorted |
| Sp. B7                      | 0.64       |                        | Moderately well sorted |
| Sp. E4                      | 0.98       |                        | Moderately sorted |
| Crossbedded sandstone facies |            |                        |                 |
| Sp. H2                      | 0.23       |                        | Very well sorted |

Table 7. The calculated standard deviation values and size class of analyzed samples.
Table 8. Skewness values of selected samples of study area.

| Facies                              | Sample No. | Skewness | Class           |
|-------------------------------------|------------|----------|-----------------|
| Laminated to thin bedded sandstone facies | Sp. A3     | -0.18    | Coarse skewed   |
|                                     | Sp. A8     | -3.7     | Strongly coarse skewed |
|                                     | Sp. B3     | 0.95     | Strongly fine skewed |
|                                     | Sp. C3     | -3.38    | Strongly coarse skewed |
|                                     | Sp. C10    | -7.18    | Strongly coarse skewed |
|                                     | Sp. D5     | -1.73    | Strongly coarse skewed |
|                                     | Sp. E2     | -6.11    | Strongly coarse skewed |
|                                     | Sp. F1     | -0.53    | Strongly fine skewed |
|                                     | Sp. G4     | -5.62    | Strongly coarse skewed |
|                                     | Sp. G9     | -5.7     | Strongly coarse skewed |
| Thick bedded to massive sandstone facies | Sp. A10   | -5.45    | Strongly coarse skewed |
|                                     | Sp. C7     | 1.81     | Strongly fine skewed |
|                                     | Sp. E8     | -1.58    | Strongly coarse skewed |
|                                     | Sp. G5     | -5.65    | Strongly coarse skewed |
| Calcareous sandstone facies         | Sp. B5     | -8.9     | Strongly coarse skewed |
|                                     | Sp. B7     | -0.86    | Strongly coarse skewed |
|                                     | Sp. E4     | -4.24    | Strongly coarse skewed |
| Cross bedded sandstone facies       | Sp. H2     | 0.49     | Strongly fine skewed |

Base on the skewness class (Table 3), the skewness values of analyzed samples are range from strongly coarse skewed to strongly fine skewed (-9.25 to 1.81) (Table 8). Base on the relationship between combine log and skewness variation diagram (Figure 6), strongly fine skewed and strongly coarse skewed are alternatively observed. But strongly coarse skewed are dominated.

According to classification of kurtosis (Table 4), calculated kurtosis values of selected samples of study area are ranging from 0.73 to 7.67 (Table 9). So three samples show platykurtic, six samples show very leptokurtic and ten samples show extremely leptokurtic. Most of sediments are very leptokurtic and extremely leptokurtic. The extreme values of kurtosis, leptokurtic and very leptokurtic character indicate that the sediments were sorted in high or low energy environment and transported to a new environment with reversal of energy to mix with fine or coarse sediments depends on energy condition. Folk and Ward (1957) suggested that beach sediments might show extremely kurtosis values due to good sorting achieved in high energy environment.
Table 9. Kurtosis values of selected samples derived from graphic method

| Facies                        | Sample No. | Mean (M) | Size Class         |
|-------------------------------|------------|----------|--------------------|
| Laminated to thin bedded sandstone facies | Sp. A3    | 2.01     | Very fine leptokurtic |
|                               | Sp. A8    | 5.44     | Extremely leptokurtic |
|                               | Sp. B3    | 1.46     | Extremely leptokurtic |
|                               | Sp. C3    | 1.93     | Very leptokurtic    |
|                               | Sp. C10   | 7.67     | Extremely leptokurtic |
|                               | Sp. D5    | 4.91     | Extremely leptokurtic |
|                               | Sp. E2    | 0.88     | Platykurtic         |
|                               | Sp. F1    | 3.08     | Extremely leptokurtic |
|                               | Sp. G4    | 3.34     | Extremely leptokurtic |
|                               | Sp. G9    | 3.88     | Extremely leptokurtic |
| Thick bedded to massive sandstone facies | Sp. A10   | 4.34     | Extremely leptokurtic |
|                               | Sp. C7    | 0.82     | Platykurtic         |
|                               | Sp. E8    | 2.34     | Very leptokurtic    |
|                               | Sp. G5    | 3.00     | Very leptokurtic    |
| Calcareous sandstone facies   | Sp. B5    | 4.90     | Extremely leptokurtic |
|                               | Sp. B7    | 2.81     | Very leptokurtic    |
|                               | Sp. E4    | 6.31     | Extremely leptokurtic |
| Cross bedded sandstone facies | Sp. H2    | 0.73     | Platykurtic         |

According to overall results of granulometry analysis, sandstones from study area are very fine to fine, poorly to very well sorted sandstones. The mean size of the selected sandstones ranges from 2.52 to 3.65 and mean 2.97 in average, generally, indicating in the size class fine-grained. The standard deviation of the selected sandstones varies from poorly sorted to very well sorted (0.23 to 1.07). Average value of standard deviation is (0.67), sandstone are, generally, moderately well-sorted. Analyzed ten samples A3, A8, B3, C3, C10, D5, E2, F1, G4 and G9 are selected from laminated to thin bedded sandstone. Base on the results, sample A3, C3, G4 and G9 are very fine sandstones with moderately sorted to well sorted in nature. So those samples could have good porosity and permeability. Sample A8, B3, D5, E2 and F1 are very well sorted to moderately sorted fine grained sandstones. They will have higher porosity and permeability than very fine and stone. But sample C10 is poorly sorted; fine sandstone and it will have fair reservoir quality. Laminated to thin bedded sandstones have fair to excellent reservoir quality. And four samples A10, C7, E8 and G5 are selected from thick to massive sandstone. Sample A10, E8 and G5 are moderately sorted to moderately well sorted, very fine sandstones. Reservoir characteristics of those sandstones will have good quality. Sample C7 is well sorted, fine sandstone and it could be good porosity and permeability, and thus thick bedded to massive sandstone facies will have good reservoir quality. Sample H2 is selected from cross-bedded sandstone. It is very well sorted; fine sandstone and it could have high porosity and permeability, and it will have excellent reservoir quality. Three samples B5, B7 and E4 are selected from calcareous sandstone. B5 is moderately sorted; very fine sandstone and B7 and E4 are moderately sorted to moderately well sorted in nature. So they also could have fair to good reservoir quality. The summarized of results and reservoir quality are shown in Table. 10. Base on the relationship of lithologic composite log of study area and variation of mean values, standard deviation values, skewness values and kurtosis values of analyzed samples (Figure 5), can be concluded that the sediments were deposited under the influence of alternative of low and fairly high energy environment.
Figure 7. Relationship of lithologic composite log of study area and variation of mean values, standard deviation values, skewness values and kurtosis values of analyzed samples.

Table 10. Summarized results and reservoir quality of analyzed sandstones

| Facies                          | Sample No. | Grain size | Sorting       | Skewness        | Kurtosis        | Possible Reservoir Quality |
|--------------------------------|------------|------------|---------------|-----------------|-----------------|----------------------------|
| Laminated to thin-bedded sandstone facies | Sp. A3     | V-fine     | Well sorted   | Coarse skewed   | Very leptokurtic | Good                       |
|                                 | Sp. A8     | Fine       | Moderately Well sorted | Strongly coarse skewed | Extremely leptokurtic | Good                       |
|                                 | Sp. B3     | Fine       | Well sorted   | Strongly fine skewed | Very leptokurtic | Good                       |
|                                 | Sp. C3     | V-fine     | Well sorted   | Strongly coarse skewed | Very leptokurtic | Good                       |
|                                 | Sp. C10    | Fine       | Poorly sorted | Strongly coarse skewed | Extremely leptokurtic | Fair                       |
| Sample | Grain Size | Sorting | Skewness | Kurtosis | Quality |
|--------|------------|---------|----------|----------|---------|
| Sp. D5 | Fine       | Moderately well sorted | Strongly coarse skewed | Extremely leptokurtic | Good |
| Sp.E2  | Fine       | Very well sorted | Strongly coarse skewed | Platykurtic | Excellent |
| Sp.F1  | Fine       | Moderately well sorted | Strongly fine skewed | Extremely leptokurtic | Good |
| Sp.G4  | V-fine     | Moderately sorted | Strongly coarse skewed | Extremely leptokurtic | Good |
| Sp. G9 | V-fine     | Moderately sorted | Strongly coarse skewed | Extremely leptokurtic | Good |
| Sp.A10 | V-fine     | Moderately sorted | Strongly coarse skewed | Extremely leptokurtic | Good |
| Sp. C7 | Fine       | Well sorted | Strongly fine skewed | Platykurtic | Good |
| Sp. E8 | Fine       | Moderately well sorted | Strongly coarse skewed | Platykurtic | Good |
| Sp. G5 | V-fine     | moderately well sorted | Strongly coarse skewed | Very leptokurtic | Good |
| Sp. B5 | V-fine     | Moderately sorted | Strongly coarse skewed | Extremely leptokurtic | Fair |
| Sp. B7 | Fine       | Moderately well sorted | Strongly coarse skewed | Very leptokurtic | Good |
| Sp. E4 | Fine       | Moderately sorted | Strongly coarse skewed | Extremely leptokurtic | Good |
| Cross-bedded sandstone facies | Sp. H2 | Fine | Very well sorted | Strongly fine skewed | Platykurtic | Excellent |
4. Conclusion
The granulometry analysis have been conducted on 18 samples from four sandstone facies; laminated to thin bedded sandstone facies, thick bedded to massive sandstone facies, calcareous sandstone and cross-bedded sandstone from study area. Base on the relationship of lithologic composite log of study area and variation analytical results values, (Figure 5), can be concluded that the sediments were deposited under the influence of alternative of low and fairly high energy environment. Generally, laminated to thin bedded sandstone are poorly sorted to very well sorted, very fine to fine grained, and they have fair to excellent reservoir quality. Thick bedded to massive sandstone facies are moderately sorted to very well sorted, very fine to fine sandstone, and they will possess good reservoir quality. Cross-bedded sandstone is very well sorted, fine grain in nature and it will possesses excellent reservoir quality. Calcareous sandstones are moderately sorted to moderately well sorted, very fine to fine grained sandstones, and it could be considered as fair to good reservoir quality.
Base on the results of analyzed samples from all of the sandstone facies of study area have fair to excellent reservoir quality. Thus, study area can be considered as a prospective reservoir.

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