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COMPARISON OF CHOSEN SANDS FROM ALGERIAN QUARRY AND DUNE AEOLIAN AS PROPPANTS USED IN HYDRAULIC FRACTURING ENGINEERING

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ABSTRACT

Sand as proppants are synthetic or natural grains used for holding fractures open around the wellbore in the gas / oil well drilling industry to enhance fluid extraction after hydraulic fracturing. These proppant must have an ideal spherical shape with two values defined: roundness and sphericity. The supporting agent's other important characteristic is its solubility in acid. The acid solubility test determines a supporting agent's suitability for use in fracturing process where the supporting agent may come into contact with acids as well as the resistance to strengh. The results swhows that In all tests of sphericity and roundness dune sands proppants performed better than sand from the quarries. Also, results indicate that quarry sands are more solubility tolerant and do not exceed the 3% standard's criterion. Finally, We found that aoelian sands are resistant to the exerted stresses, except for one which has no good resistance to crushing.

Keywords: Quarry and Aoelian sands; roundness; sphericity; solubility;stress.

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1. INTRODUCTION

The Algerian energy sector continues its efforts to develop its energy resources, taking into consideration economic issues and contractual obligations. Hydrocarbon production meticulously benefits from a strategic interest that funds the SONATRACH national group, which is Africa's largest gas company, the world's fourth largest exporter of LNG, and the world's sixth largest exporter of natural gas. To ensure the continuity of its titles the economic strategy developed for each of the missions needs to be improved. In the case of hydrocarbon production by hydraulic fracturing, it is anotated that large quantities of proppants, originally natural sand, are used in the composition of the fracturing fluids with an average of 9 million, these are of the order of hundreds of tons per well or even thousands of tons. Hydraulic fracturing is a method widely used to promote the development of hydrocarbons by creating a network of highly conductive fractures in the region around a wellbore [1-3]. The created fracture network not only improves the reservoir rock's hydraulic conductivity, but also increases the surface area that contributes to the production of hydrocarbons [4,5]. It is possible to apply this technique in both vertical and horizontal wells. The significant increase in the production of hydrocarbons arising from the vast network of fractures produced during the process has made it economically feasible for the oil and gas industry to tap the abundant hydrocarbon reserves in previously undeveloped deep unconventional reservoirs [6,7]. A drilling solution is pumped under high pressure to hydraulically break the rock open in order to create cracks in reservoir rock [8]. The fracturing process begins by inserting the fluids to open the reservoir rock under pressure [8,9]. The fracturing fluid reaches the holes once the reservoir rock is fractured and starts to spread fractures away from the wellbore. The important function of the fracturing fluid is to take proppants into the crack and transport them into it [10,11]. At the end of the fracturing cycle, the proppants form a thin layer between the fracture faces to hold the fractures intact [12]. River sand was used as the proppant for the very first fracking work. Apparently, 20/40 mesh sand is the most widely used proppants, accounting for around 85% of the industry's proppant usage. Many widely used proppants include resin-coated rock, proppants of medium strength, ceramic proppants, and proppants of high strength such as bauxite sintered and zirconium oxide [13,14]. The cracks will close without proppants after the draining of drilling liquids under high pressure is halted, resulting in little or no benefit in production of hydrocarbons [15]. In Algeria, ceramic balls are imported as the proppants used in the vast majority of sites. The cost of production is horrific, the value per ton can be as high as 1000$, not including transport and storage costs. Another consideration, the Algerian mining sector deploys a wide range of knowledge in the field of siliceous sand extraction. Algerian sand has been used for decades in the manufacture of glass, foundry, construction, electrometallurgy, ceramics, chemistry, paints, mineral fillers, glass, glues, abrasives, etc. . . However, limitless geological deposits across the country refer to the following question : Could Algerian natural sand play the role of proppant during hydraulic fracturing and what would its effect on fracturing help be?

2. METHODOLOGY

In this work, the ISO 13503 is approved by API and is commonly used by proppant manufacturers for manufacturing quality assurance as well as oil service providers. This includes standard test procedures for testing proppants used in operations of hydraulic fracturing and gravel processing. However, the main mission was to select the sand sample that will be the better proppant during the hydraulic fracturing fluid formulation, we were given a sand samples from quarries and Aeolian sands. Quarry sands are materials produced in an aggregate production line that can be either in surplus for the desired supply (gravel): rolled sand that results from the primary screening of an all-comer or crushing sand which is very often the excess of the quarry production. As for the Eolian sands, they consist of sand grains of any origin and are present in several desert regions in the form of dunes that cover vast areas (southern Algeria). They are taken and dispersed by the wind, their source is very different. According to many shocks between them, they are distinguished by a uniform grain size, rounded grains and frosted. The only considerations that decide the grain size are wind speed, carrying capacity and transportation distances.

2.1 The selected sand

Based on ISO 13503 standard, this requires that a minimum of 90% of the test material sample tested passes through the designated coarse sieve (or first primary sieve) and is retained on the designated fine sieve (or second primary sieve) (ie screens 12/20, 20 / 40,40

/ 60, etc.). For particle sizes of 40/70 (212/425 µm), a minimum of 90.0% of the test material sample must pass through the mesh screen 40 µm and must be retained on the 70 mesh screen. Throughout our analysis, we obtained samples collected directly on site at natural state without prior processing or collection, this is why the purpose of this experiment is to classify samples with a prevailing grain size class closest to the 90 % ISO standard requirment. This would mean that the deposit in question has interesting characteristics of grain size and that the sand is homogeneous over a given range. It will not be interesting to select samples that are heterogeneous and do not have a dominant class because the sand should be treated to the desired size, which will make the mission even more expensive and delicate. A sieve column with decreasing opening lengths from top to bottom with a lid on the first sieve and a receptacle on the bottom of the column was stacked at least seven sieves. The results are shown in the figures below:

3 RESULTS AND DISCUSSION

3.1 Quarry sands:

The sieving method reveals that the sand sample #1 has an average grain preponderance that falls within the range of 40/70 (212/425 µm). The proportion of this class is 80.86 % with an average diameter of about 324.879 µm. The sieving process indicates also that the sample #2 is a composite sand in a range of 40/70 (212/425 µm) with a ratio of 79.12 % and an average diameter of 331.136 µm, characterized by a small fine and coarse proportion. Hence, this sand is quite well graded. Similarly, the sand sample #3 test reveals a large grain size distribution with a marked tendency towards the 16/30 coarse category with a 74.69 % and an average grain size of about 852,548 µm and the sieve analysis indicates that this grain has a middle-class grain predominance. This middle class is characterized by 40/70 (212/425 µm) range grains and the proportion of this grain population with medium grain is 79.452 % and with a diameter around of 306,949 µm. The sieving analysis shows that the sample #5 is very poorly graded and is geared towards medium to coarse sand in its granulometric pattern. The 16/30 range is present with a 33,657 % and an average of 811,979 µm diameter. Nevertheless, the middle class that fits into the range of 40/70 (212/425 m) is slightly more prevalent with about of 34,871 % and an average grain of 324,879 m.

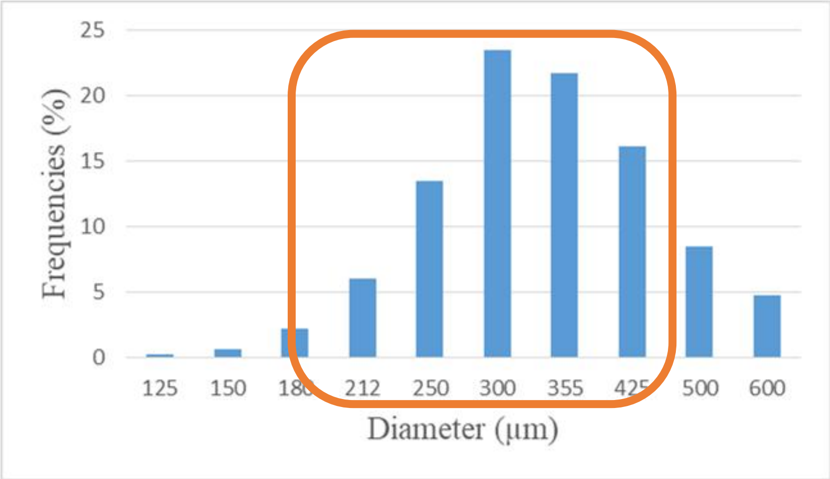


Fig.1. Frequency distribution vs sample diameter indicating the grain size distribution for sample #1

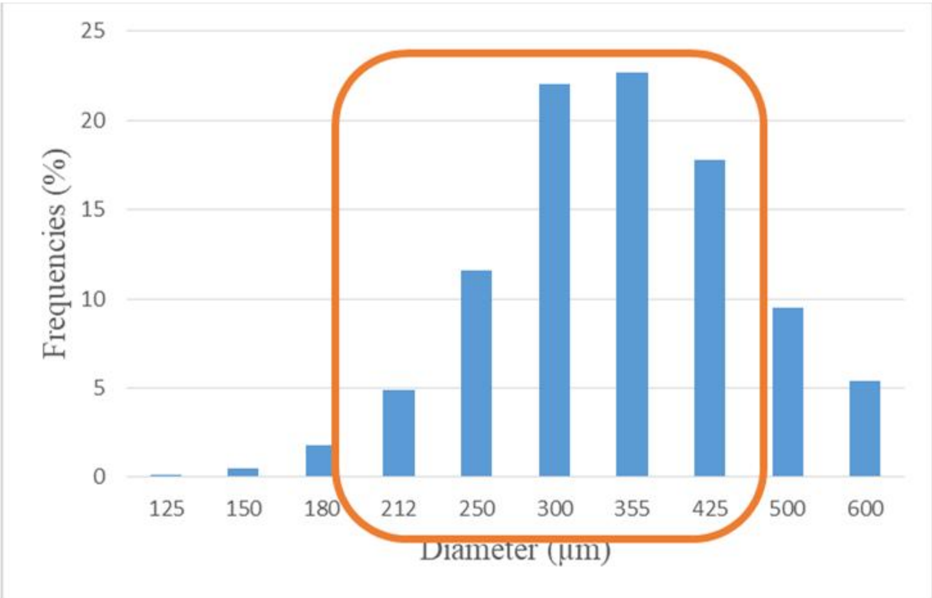


Fig.2. Frequency distribution vs sample diameter highlighting the grain size distribution for sample #2

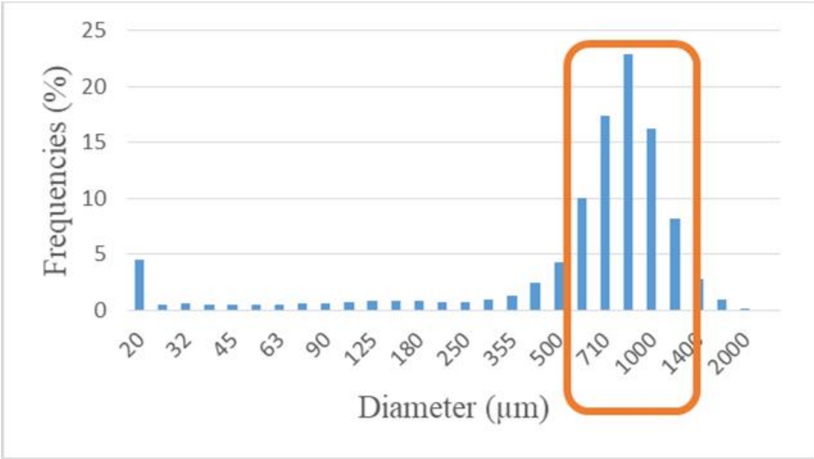


Fig.3. Frequency distribution vs sample diameter indicating the grain size distribution for sample #3

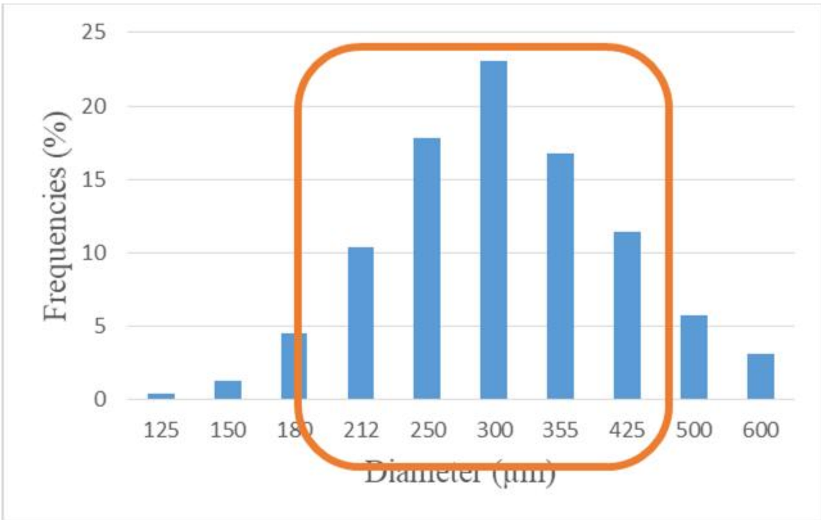


Fig.4. Frequency distribution vs sample diameter indicating the grain size distribution for sample #4

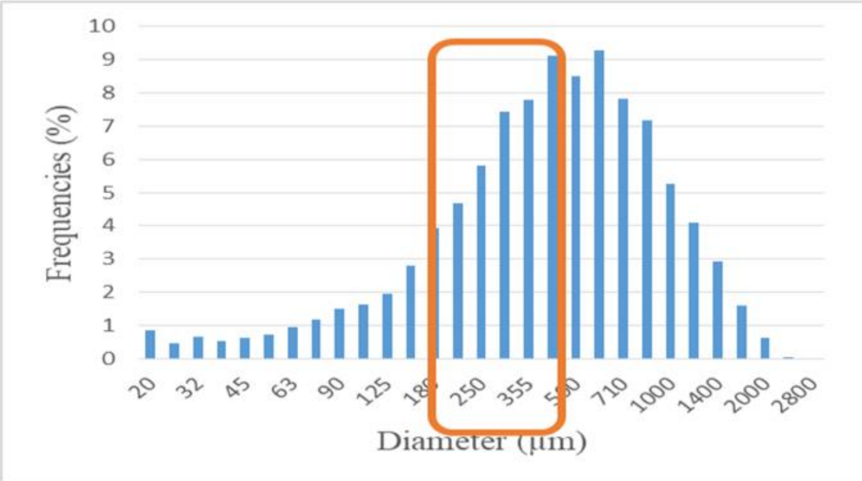


Fig.5. Frequency distribution vs sample diameter indicating the grain size distribution for sample #5

3.2 Aeolina sands

igures 6 to 10 show that unlike quarry sands, aoelian sand appears to have an identica mesh size with a different provenance with an average range about of 40/70 (212/425 µ m) for all samples. This effect can be explained by the climatic conditions to which this material has been subjected. In this situation, aeolian sand is a sand dune, so it was especially subject to disintegration and transportation by water and wind, so that the sand grains have a small size which makes all the samples very homogeneous.

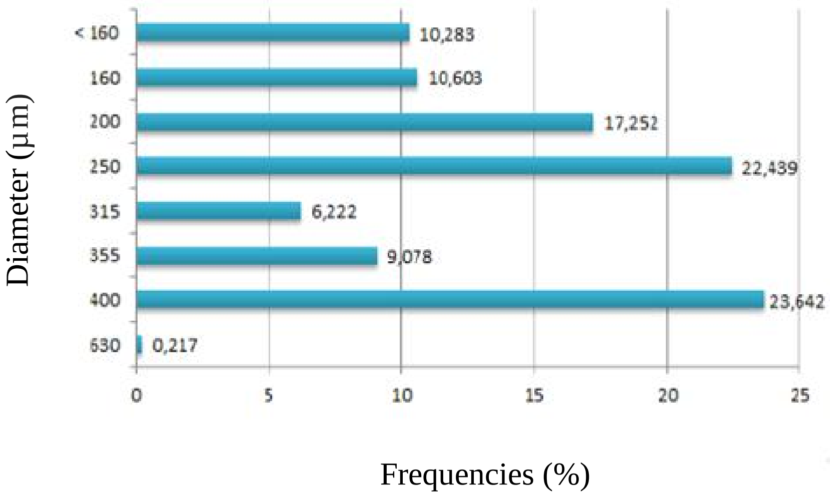


Fig.6. Frequency distribution vs sample diameter indicating the grain size distribution for Aoelian sample #6

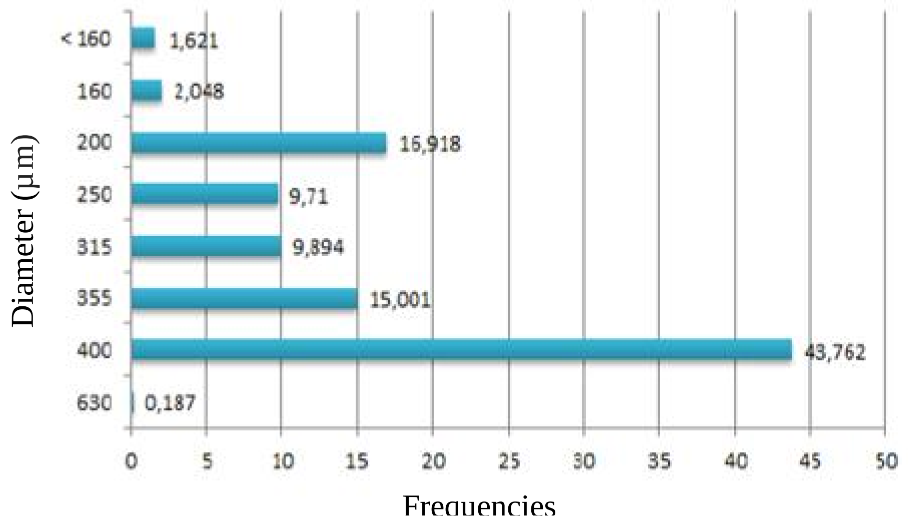


Fig.7. Frequency distribution vs sample diameter indicating the grain size distribution for Aoelian sample #7

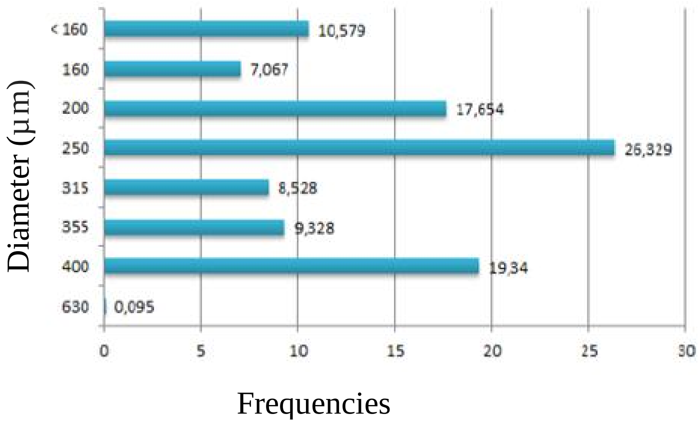


Fig.8. Frequency distribution vs sample diameter indicating the grain size distribution for Aoelian sample #8

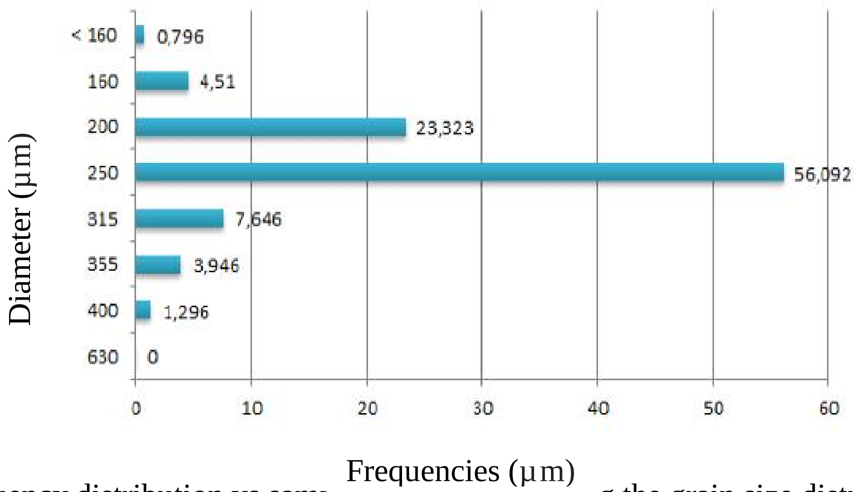


Fig.9. Frequency distribution vs sample diameter indicating the grain size distribution for Aoelian sample #9

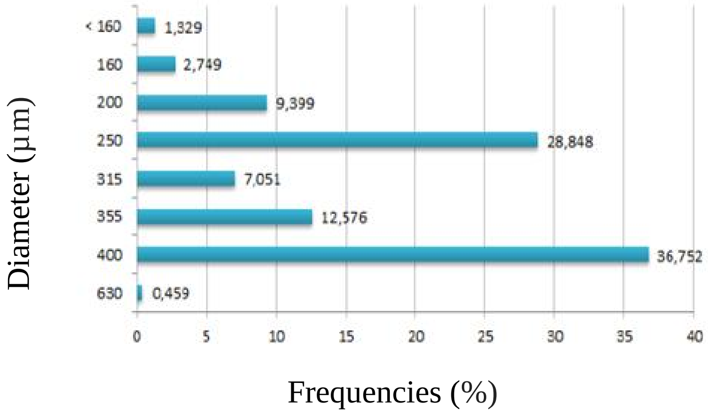
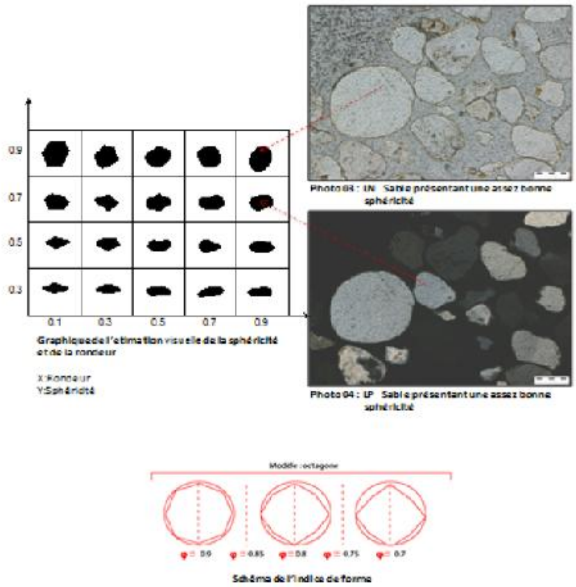


Fig.10. Frequency distribution vs sample diameter indicating the grain size distribution for Aoelian sample N°10 (m)

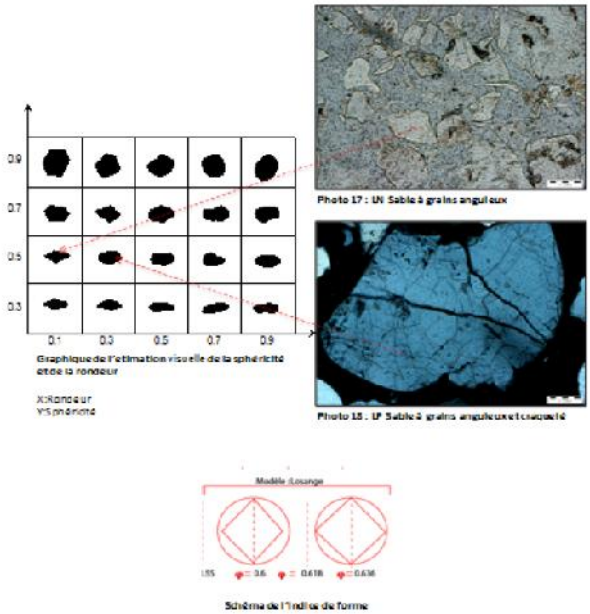
3.2 Effect of roundness and sphercicity

Sphericity and roundness determined for samples #1 and #5 respectively from quarry sands are shown in the figure 11. The resulting images under the microscope observation made it possible to identify the grain shape in question more accurately. The most evident particles display a particular relationship according to the Krumbien/Sloss chart (see Figure11 a) [16] . The results of the microscope investigation show that the sphericity value is estimated at about 0.9 and the roundness value varies from 0.7 to 0.9 (see Figure 11a). This shows the good roundness and sphericity of the sand particle. The shape index makes it possible to choose the geometric size closest to the general appearance of the particle. This index expresses the proportion of the particle's predicted area to that of the sphere formed from the exo-diameter, i.e. from Féret's maximum diameter [17]. For the sand sample # 5, the sphericity and roundness are shown on the figure 11b. The obtained sphericity is about of 0.7 and the roundness value varies between 0.3 and 0.5. Compared to the Krumbien/ Sloss chart, these results allow the sphericity to be shown to be quite good while the roundness is bad. Test results indicate that sample #1 has superior properties (roundness and sphericity) to the sample #5. The average values of roundness and sphericity are in the range of 0.80 to 0.9, indicating a sphere-like shape, which gives them a good character in fracturing fluids to be selected as a propant [18-20].

The shape parameters for aoelian (dune) sands such as sphericity and roundness determined for sample #8 and #7 respectively are shown in the figure 12a and 12b. As shown on the figures, a very strong sphericity was found after the visual investigation of the particles, leading to a value averaging to 0.9. These rather high roundness and sphericity values are related to the chemical and mineralogical composition of dune sands, of which silica and pheldspar are the most prominent [21-23].

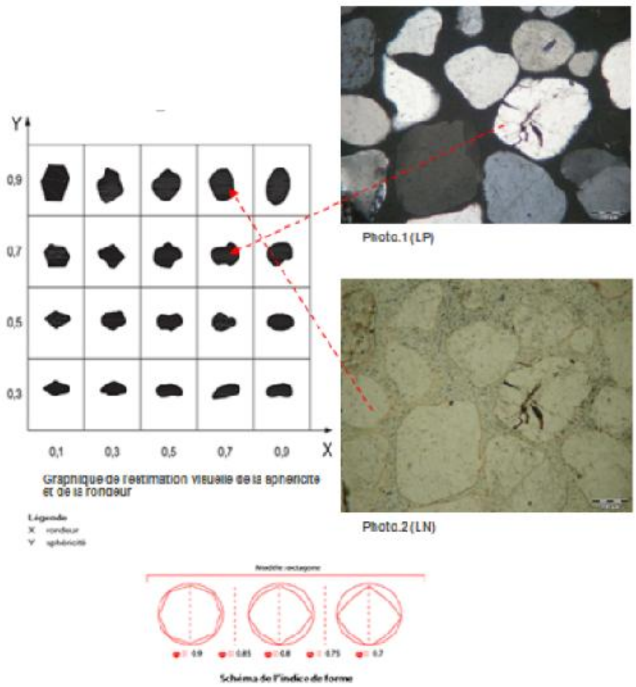


a



b

Fig.11. The basic elements used for estimating the roundness and sphericity of sample #1 and #5 respectively from quarry sands



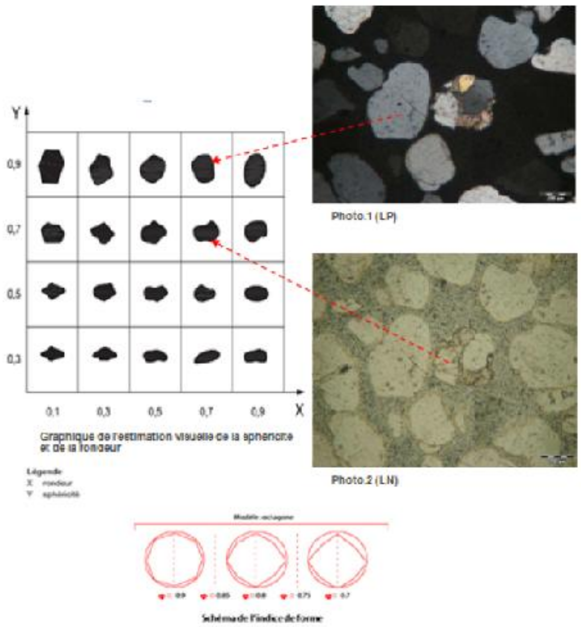


Fig.12. The basic elements used for estimating the roundness and sphericity of sample #7 and #8 respectively from Aolian sands

The following table 1 gives the average roundness and sphericity of the grains according to the Krumbien / Sloss graph whose the minimum requires each of the sphericity and roundness values must be at least 6. Depending on these findings, dune sands have roundness and sphericity characteristics closer to 1, compared to thiose sand from quarry where they are more variable.

Table 1. Analysis Results of Sphericity and Roundness for Sands from Quarry and Aoelian Samples.

Sample N^{o}	Sphericity	Rondness
1	0,9	0,8
2	0,9	0,8
3	0,9	0,8
4	0,9	0,7
5	0,2	0,5
6	0,8	0,4
7	0,8	0,9
8	0,9	0,8
9	0,7	0,5
10	0,8	0,8

3.3 Solubility effect on the sand samples

This method is used to assess a proppant's suitability for use in fracturing fluids applications where it may come into contact with acids as indicating ISO standard 13503-2: 2006. A proppant's solubility in a HCl/HF (12:3) solution: is an indication of the amount of soluble content found in the proppant (i.e. carbonates, feldspars, iron oxides, clays, etc.). HCl:HF (12:3) acid solutions [density = 1.08 to 15.6 ° C (60 ° F)] were prepared at the laboratory treatment of Sonatrach. Tables 5.9 and 5.10 classify the obtained results. Before the crash test, this analysis must be carried out on an intact proppant specimen. A proppant's acid-soluble proportion must not surpass the values stated in the specification. This value basically depends on the retention material's grain size. In this case, natural sands, such as:

-The maximum solubility in percentage mass fraction is equal to 2.0 for a mesh greater than or equal to 30/50.

-The average solubility in percentage mass fraction is equal to 3.0 for a mesh less than 30/50.

In our case, the 40/70 group is less than 30/50, so the maximum value is 3.0.

Table 2. Analysis Results for solubility tests for Sands from a) Quarry and b) Aoelian

Sample N°	Solubility (%)
1	3.862
2	2.745
3	2.961
4	2.414
5	1.72

a

Sample N°	Solubility (%)
6	12.091
7	7.401
8	8.063
9	3.843
10	5.711

b

Results of acid solubility assayed that none of the proppants (sands) is proper for applications where the use of acids in fracturing fluid is required. As a rule, for all frac sand larger than or equal to 30/50 mesh, the acid-soluble material in proppants should not exceed 2% [18]. Solubility results show that all Aeolian sands less than 30/50 mesh exceed the 3% solubility threshold required by the ISO standard. However, the samples from quarry sands have a solubility of less than 3%. In this case, it is clear that the quarry proppants are sufficiently resistant to acid solubility.

3.4 Effect of crashing on the sand samples

This test is useful to assess and evaluate the proppant's crush strength. The experiments were conducted on samples that have been exposed to an inspection of the sieve scale so that all measured particles fall within the specified particle size limit. The quantity of compressed backing material is measured at each stress level. Test results evaluation should provide evidence of the stress level at which the proppant crush is extreme and the maximum recommended stress for the proppant. A measurement of the highest stress level, rounded up to 6.9 MPa (1000psi), to which a support material does not produce more than 10% of the material being crushed, indicates the maximum strain that the material can endure without reaching 10% crushing. By determining the category that corresponds to this maximum strain, the table can be used to determine the 10% crush classification of the support material. The samples can tolerate a pressure of 5000 psi (34.5 MPa) in the case of natural sand-based proppants, so we will only take samples with a crushed mass fraction of less than 10%, all others do not respond to the standard and are therefore not valid for use in fracturing fluids.

The results show that samples #3 and #5 are well above the threshold value, while samples #1 and #2 are at the 10% threshold (see Figure12). The sample #4, on the other hand, has a very good crushing resistance. We found that aoelian sands are generally resistant to the exerted stresses, except for sample #6 which has no good resistance to crushing.

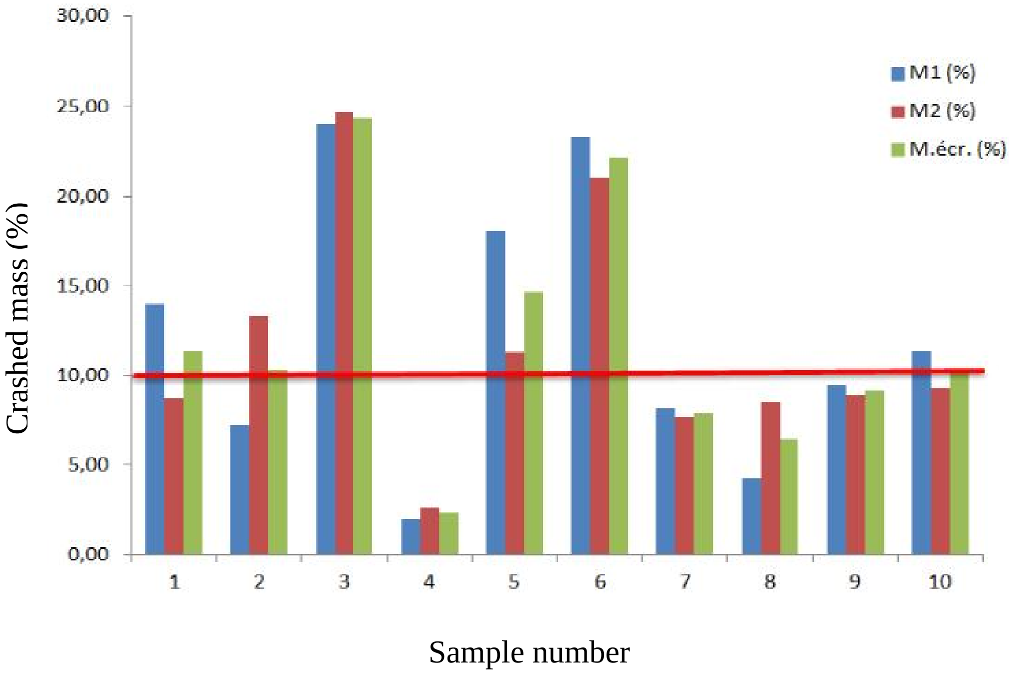
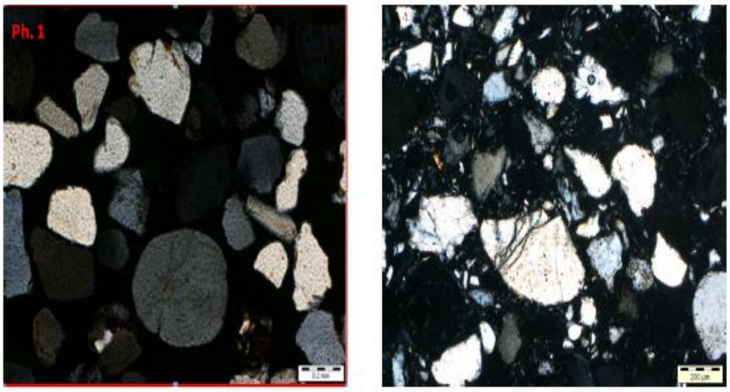


Fig.13. Results of the crush resistance tests for samples quarry and Aeolian sand

These results are well elucidated by the images of the petrographic analyses. These tests clearly show that petrographic analysis of sample #1 showed that the grains are well graded and with subrounded to rounded morphoscopy (see Figure 13 a). In addition, we can notice that most of the quartz grains are fractured and even dislocated after the crushing test. However, the petrographic analysis of sample #2 showed that the grains are well classified with subrounded to rounded morphoscopy (Figure 13b). In addition, this sand sample is more resistant to the crushing test than the previous one because we can see that only a few quartz grains are fractured.



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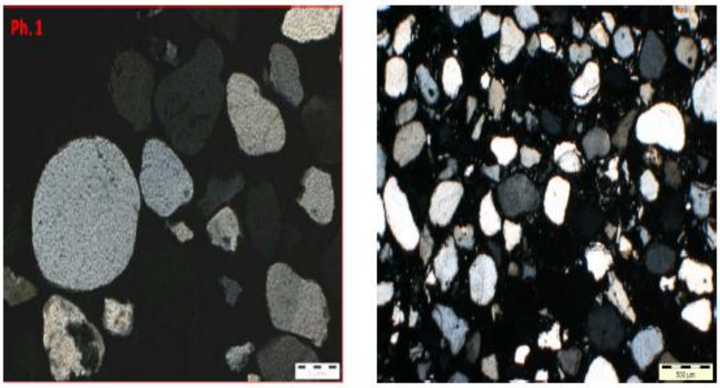

b

Fig.14. Microscope analysis after crushing of samples from quarry and Aeolian sands

4- CONCLUSION

We compared two sands of different origins in the present work, one coming from the quarries, while the other comes from sand dunes. The comparison was made in this analysis based on natural sieving properties, two essential properties of the proppants, namely roundness and sphericity and acid solubility as well as crush strength. In all tests of sphericity and roundness dune sands proppants from south of Algeria performed better than sand from the quarries in different regions in Algeria. Thes two properties are closer to 0.9. In a second step, we carried out experiments with the mixture of the two solvents Hcl: HF with a ratio of 2: 3 to test the solubility tolerance of the two classes of sands. Results indicate that quarry sands are more solubility tolerant and do not exceed the 3% standard's criterion. In order to assess the suitability of a substance as a proppant, other checks must be carried out and one of the most important is the proppant compressive strength, which is particularly important to high-depth reservoirs such as shale reservoirs in Algeria. Thes results shows that, one sample from quarry has a very good crushing resistance. We found that aoelian sands are generally resistant to the stresses exerted, except for one which has no good resistance to crushing.

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