

## RESEARCH ARTICLE



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## An accurate and practical analysis for Neogene-marls in Central regions of Iran

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### Abstract

**Objectives:** To study the erosion and erosion forms of soils resulting from marls and their relationship with soil losses in Qom and Tehran regions. Also to study about sediment production, identification and classification of various types of the erosion (sheet, groove, millennial or badland, ditch, etc.) on the marls. **Methods:** The study was conducted in two areas south of Varamin and south of Hassanabad in Iran; in order to compare different marl units in terms of sedimentation and erosion, first the appropriate marls units were determined for testing and then confirmed by the desert visit. Finally, 20 stations were identified for testing which are mentioned in this paper; As well, the dimensions of the surface of the device are 20 cm \* 20 cm, by dividing the volume of precipitation by the surface, the intensity of precipitation can be calculated. In addition, the authors consider the time of the first excavated soil and the generator of runoff as the erosion threshold. **Findings:** In the previous works, did not mentioned to the properties of the mentioned regions in Iran (special parts of Qom and Tehran regions); Actually, there are a special semi-arid type among Iran's regions; so, this study is a new research in this field about Neogene-marls in central regions of Iran. As well as, maps produced with the most robust models in the paper can be a useful tool for sustainable management, watershed conservation, and the reduction of soil and water loss for the semi-arid other regions of Iran too. **Novelty:** This study determined the effective rainfall intensity of the unpublished research about Tehran and Qom regions, first the statistics with the current 30-year return period were examined and the 30-minute rainfall intensity of the region was 19 mm. **Keywords:** Climatic effects; sediment; physical properties; SPSS; geology analysis

### 1 Introduction

Soil erosion determines landforms, soil formation and distribution, soil fertility, and land degradation processes<sup>(1)</sup>. In arid and semi-arid ecosystems, soil erosion is a key process to understand, foresee, and prevent desertification<sup>(2,3)</sup>. Also, the advancement of accurate models for soil erosion susceptibility and hazard assessment is of utmost importance for enhancing mitigation policies and laws<sup>(4)</sup>.

In semiarid regions, such as Iran, soil erosion is a significant crisis and can be considered to be one of the critical problems concerning agricultural development, natural resources, and the environment. In such regions, water is limited, and there are many sources of sediment<sup>(5)</sup>. The high input of sediment in upstream rivers increases the water turbidity, reduces the lifespan of dams owing to reservoir siltation, and negatively affects water quality and biological activity<sup>(6,7)</sup>.

Due to the abundance of marl formations in Iran and excessive the soil erosion in this climatic region, the place for very detailed and more detailed studies on marls in Iran is empty. Recently, however, significant work has been done by various research institutes<sup>(8)</sup>. If the marls of different Iran's regions are accurately identified and their physical characteristics are zoned, effective steps can be taken to control soil erosion<sup>(9)</sup>.

In the mentioned regions, there are a special semi-arid type among Iran's regions; In the previous works, did not mentioned to the properties of the mentioned regions in Iran (special parts of Qom and Tehran regions); so this study is a new research in this field about Neogene-marls in central regions of Iran. As well as, maps produced with the most robust models in the paper can be a useful tool for sustainable management, watershed conservation, and the reduction of soil and water loss for the semi-arid other regions of Iran too.

In this study, the erosion and erosion forms of soils resulting from marls and their relationship with soil losses in these lands<sup>(10,11)</sup>, as well as the production of sediment, identification and classification of the erosion types (sheet, groove, millennial or badland, ditch, etc.) on marls have been studied. To perform the experiments required for the idea presented in the article, the authors used a simulated rainfall model similar to a portable rainfall model. In the paper, the authors have analyzed the physical results of the necessary measures to implement the main objectives mentioned. It should be noted that data analysis has been performed to achieve an accurate and practical analysis using SPSS software.

The rest of the paper is categorized as follows: In the second part, it deals with main features of marls. The third part describes how to conduct operations and the supposed area. The physical properties of the marl samples and the results of the simulated rainfall are provided in the fourth part. Finally, the conclusion is stated.

## 2 Main features of marls

Marls are generally sedimentary rocks that are classified as destructive sedimentary rocks and chemical rocks; their chemical component consists of calcium carbonate which in some marls (type 2 marls) contains calcium carbonate along with one or more saturated minerals such as salt, gypsum and anhydrite.

In fact, a mixture of clay and calcium carbonate with a carbon content of between 35 - 65 percent is defined as marl which turns to marble after the birth and hardening process. The marl is impermeable and the accumulation of rainwater and groundwater causes it to loosen. In this case, its upper layers become unstable and are driven by gravity or seismic force<sup>(12,13)</sup>.

In general, Iranian marls are classified into two main categories based on the presence or absence of salts in the two main categories of evaporative marls (type 2) and non-evaporative marls (type 1). In terms of age, Iranian marls are divided into two categories: Non-evaporative marls (type 2) and evaporative marls (type 2)<sup>(14,15)</sup>.

## 3 About the supposed process and region

For comparing different marl units of central regions of Iran in terms of sedimentation and erosion, first the appropriate work units were determined for testing and then confirmed by the desert visit. Finally, 20 stations were identified for testing, some of which are mentioned in this paper. It should be noted that data analysis with SPSS software regarding the effect of physical parameters of marls on runoff and sediment production. To perform the required experiments for the proposed hypothesis, a simulated rainfall was required, and a portable rainfall model was used among the various types of the rainfalls. To measure runoff and sediment, a portable desert rainfall built at Wageningen Agricultural University in the Netherlands was used. The rainfall generator can be used in both laboratory and desert conditions for soil erosion studies. In the laboratory method, the soil sample is transferred from the region to the laboratory and after being crushed and reaching the specific gravity of each sample under normal conditions, the rain is simulated. One of the advantages of this carrier is its portability which makes it possible to use it in nature and on untouched soil<sup>(16,17)</sup>.

In the studied area of the formations, there were different units, in each of which 3-4 samples were taken. Sampling method is such that first the appropriate area with a slope of 20 degrees is selected. Then a small pit is dug and the plot is placed inside the ground by the sledgehammer, then the plastic wall is placed on it, and after ventilating the sprayer and filling the tank with water; it is placed on the plastic wall and after re-adjusting the slope by the handle. Compass and time are allowed to fall. After testing and collecting the sample and separating the plot from the soil, the permeability of the soil was measured.

## 4 Simulation and study result

For determination the effective rainfall intensity of the region, first the statistics with the current 30-year return period were examined and the 30-minute rainfall intensity of the region was 19 mm. Since the dimensions of the surface of the device are 20 cm \* 20 cm, by dividing the volume of precipitation by the surface, the intensity of precipitation can be calculated. In addition, the authors consider the time of the first excavated soil and the generator of runoff as the erosion threshold. The following is a description of the measurement stations with test repetitions<sup>(18)</sup>.

In the paper, the authors of seven marl stations in the Qom and Tehran (Hassanabad and Varamin) regions review each repetition at each station. The slope of all experiments is considered to be 20 degrees.

### 4.1 Determining the physical properties of samples

After separating a number of lumps to measure the equivalent moisture, the samples were dried in the open air in the shade for 24 hours, then passed through a 2 mm sieve and the percentage of soil gravel was measured. The distribution of soil particle size was measured after physical distribution by pipette and sand components to pass through standard alkalis. In order to accurately determine the silkworm, in addition to measuring the amount of clay, silt and sand as a total percentage of destructive, the percentage of clay content of the sample from the whole sample was determined after removing lime from the samples<sup>(19)</sup>.

Distributable clay in water was determined by pipette-based clay measurement in samples that had been shredded for only one hour and had not been chemically treated. The apparent specific gravity of paraffin was determined on clumps. The soil moisture in the saturated state was obtained by drying the saturated mud in the dryer<sup>(20)</sup>. Soil pH was measured in a 1: 1 ratio of water to soil and electrical conductivity of the soil in saturated mud extract. The soil-soluble cations including sodium and potassium were measured by photometric film, calcium and magnesium using an atomic absorption device, and then the Sodium Absorption Ratio (SAR) was calculated. The soil organic matter was measured using a more oxidizing method (both alkyl and block).

Soil lime content was determined by reversible acid and base titration and soil Cation Exchange Capacity (CEC) by pH sodium acetate method equal to 7.

### 4.2 Atterberg limits

Atterberg limits include dough indicators, psychological limits, and dough indicators. To perform the test, the samples must first be thoroughly dried and crushed and then passed through a 200 mesh sieve. The most common way to determine the psychological limit in Iran is to use a Casagrande device. To test, a sample of soil paste is placed in the cup and made by a groove in the middle of the groove dough. The groove on the bottom of the cup (13 cm long) is noted and then the amount of moisture in the soil is determined<sup>(12), (13)</sup>; To determine the amount of dough, the test soil is mixed with some distilled water and made into a paste. Then a portion of the sample (approximately 2.5 grams) is woven with fingers on a polished plate to a diameter of 6 mm and then tried to reduce its diameter to 3 mm. This is repeated continuously until the sample is gradually reduced in moisture and when the wick reaches a diameter of 3 mm and does not leave the length and width. Now the moisture of the crushed parts is determined and considered as the dough limit.

The dough index parameter is also obtained from the difference between the psychological and the dough limit ( $PI = WL - WP$ ). In the following, the author analyzed the physical results:

### 4.3 Obtained physical results

#### 4.3.1 Checking the granulation

After granulation experiments, the results for each unit forming the domain were recorded on semi-logarithmic papers. The particle size is on the horizontal axis where the particle size increases from left to right. At the top of the chart, the size of the sieves is given in inches per unit of measurement, and the vertical axis on the right shows the percentage of grains passing through the sieve.

#### 4.3.2 Drawing histogram diagrams of the harvested samples

In this part, the authors pay to Drawing histogram diagrams of the harvested samples in supposed study.

As on the figures 2-22 and based on the obtained results from the analysis of the samples, it is possible to determine their location in the folk triangles. Folk (1979) presented two triangles. The first triangle is used to name the larger grains that contain gravel, and the second triangle is used for finer grains.

As well as, in order to determine the percentage of clay and silt particles in the mud range, the gravel section was excluded from the calculations, and the fine-grained parts of sand, clay and silt were shown in the second triangle of Folk (fine-grained). They are located in the silt stone range.

Patti John (1987) on the percentage of lime and sediment and the location of marls in this chart. According to Petty John's (1987) theory and the above diagram, marls contain 35-65 percent lime. Accordingly, the points of the samples taken on the diagram are specified.

The results of the Patti John diagram show that only one specimen is located in the marl region, and that it is not logical for the Neogene deposits to use the name marl. These sediments can be called gypsum and salt stents. It is worth mentioning that the only sample taken from Qom formation is in the standard definition of marl and the reason is the high amount of clay and lime.

**Table 1.** Specifications of  $25 \times 25$  cm rain simulated rainfall [Collected by the authors]

The height of the drop drops above the slope	375 (millimeter (mm))
The diameter of drop	5.6 (mm)
The kinetic energy of rainfall	35.4 (Joules per mm)
The level of the experimental plot	0.625 (square meters)
The drop weight	0.106 (grams)
The first intensity	30 (mm per hour)
The second intensity	60 (mm per hour)



**Fig 1.** Satellite image of the study area south of Hassanabad (left image), satellite image of the study area south of Varamin (right image) in the Marl regions [Collected by the authors]

**Table 2.** Name of geological units and percentage of grains in each unit [Collected by the authors]

Example number	Unit name	Sand percentage	Slit percentage	Clay percentage	Gravel percentage
1	First marl (Pliocene marl)	25	60	10	5
2	First marl (Pliocene marl)	24	55	20	1
3	Fourth marl (M3 Unit)	5	80	15	0
4	Third (M2 Unit)	5.5	77	15	2.5
5	Fourth marl (M3 Unit)	55	35	5	5
6	Second marl (M1 Unit)	10	62.5	20	7.5
7	Fifth marl (Qom Unit)	1	71.5	27.5	0

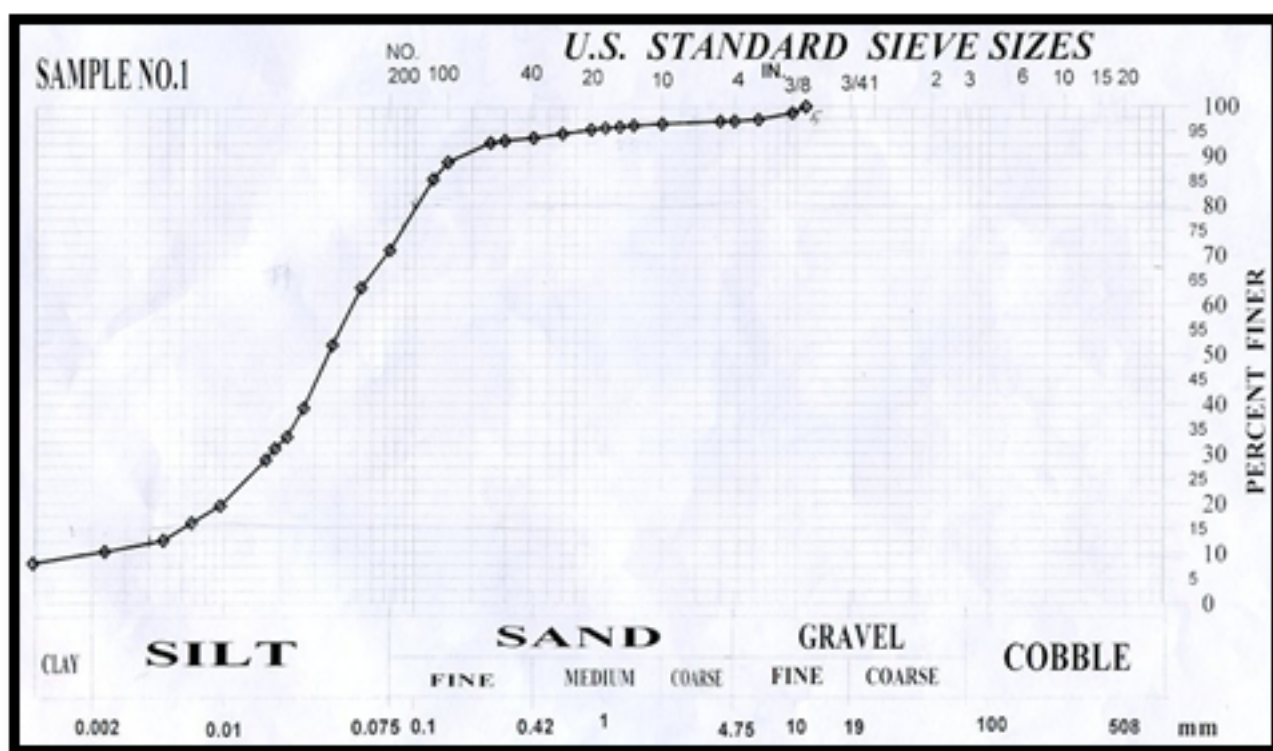


Fig 2. The size and percentage of grains in the first marl unit (Pliocene marl) [Collected by the authors]

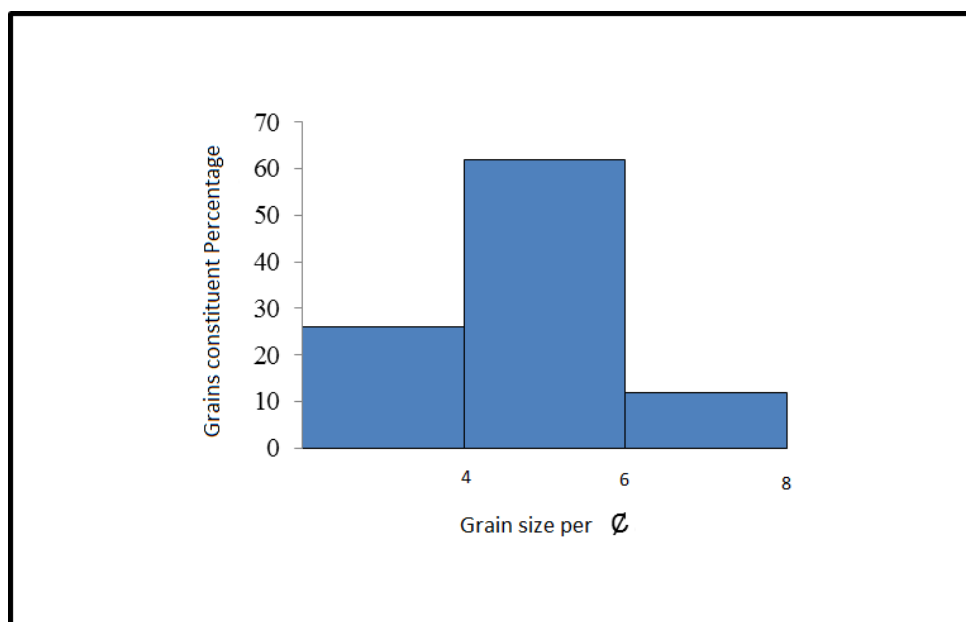


Fig 3. Grain abundance [Collected by the authors]



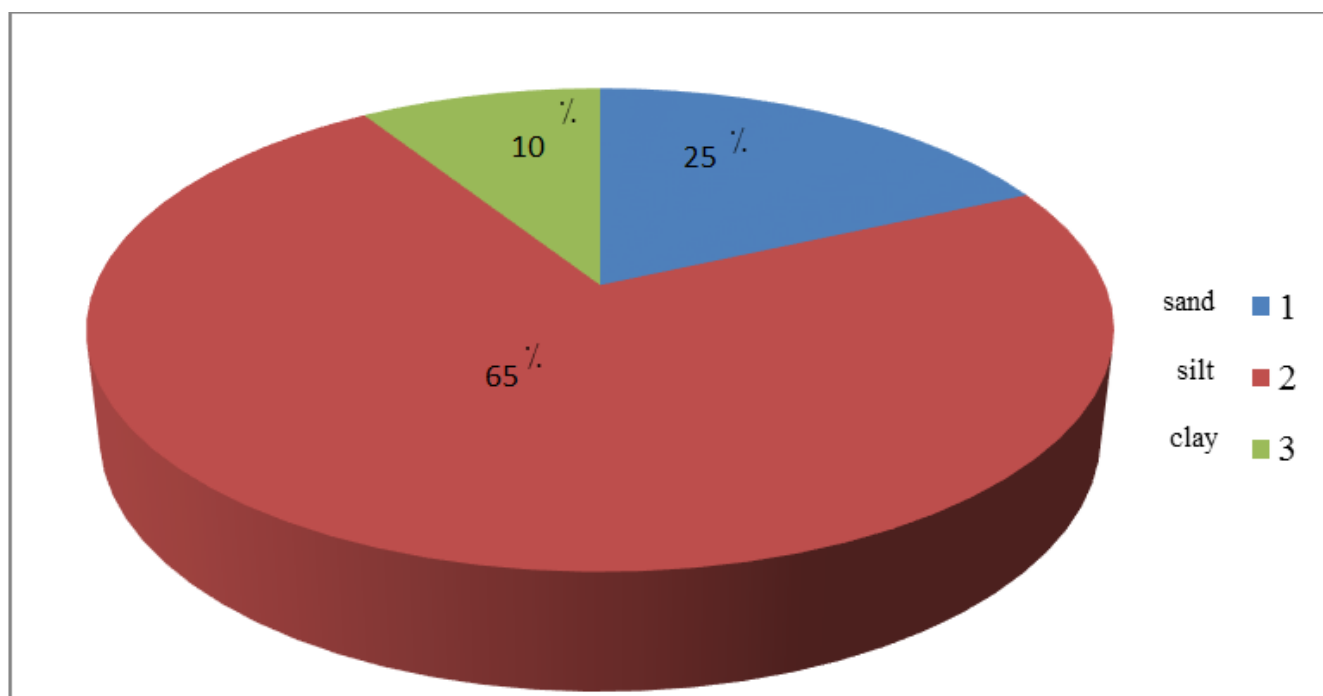


Fig 4. Grains that make up the first marl unit (Pliocene marl) [Collected by the authors]

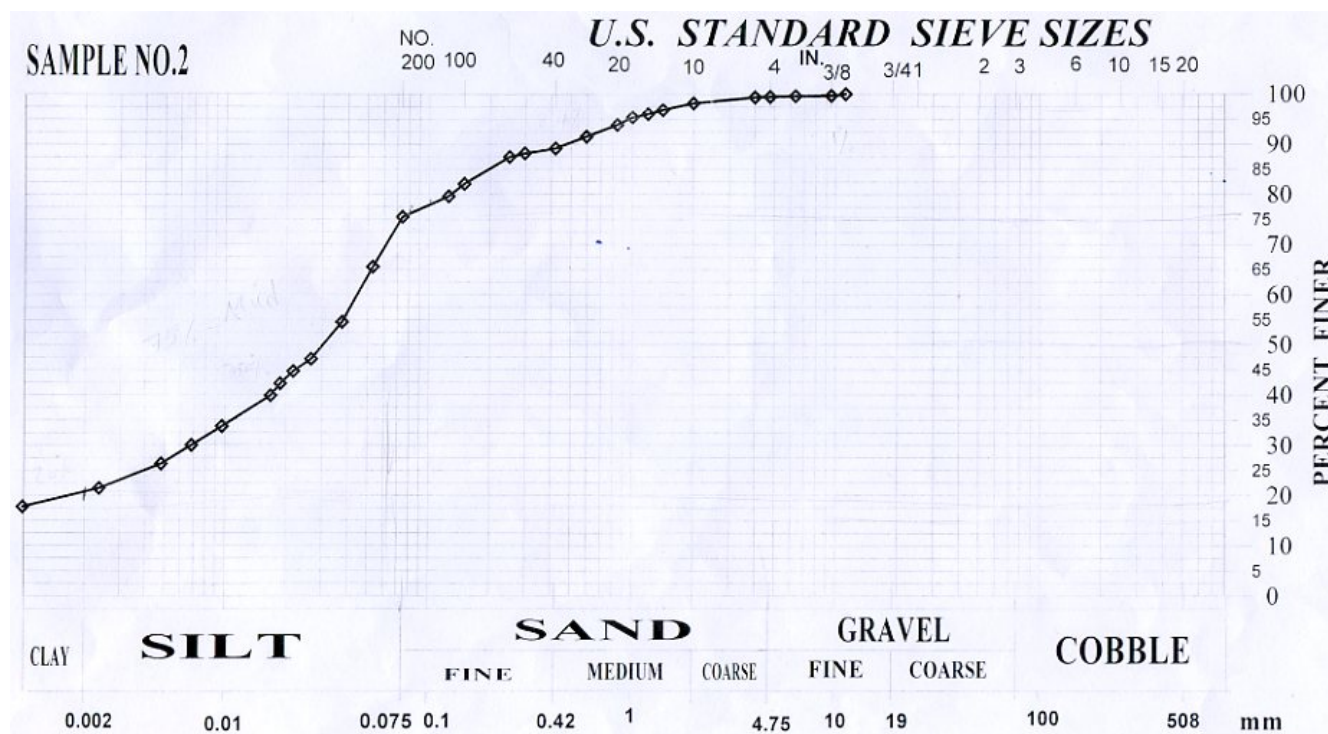


Fig 5. Size and percentage of grains in the first marl unit (Pliocene marl) [Collected by the authors]

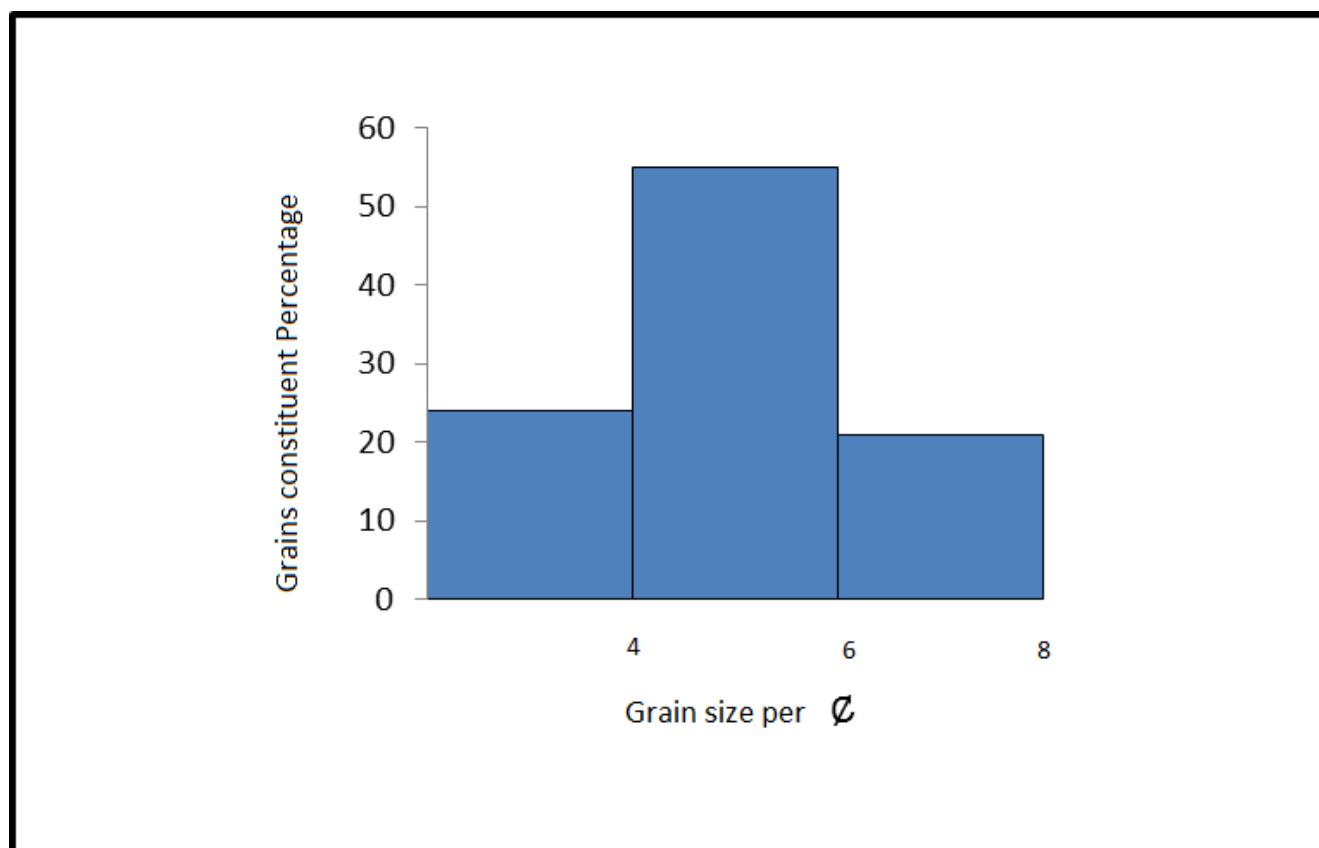


Fig 6. Frequency of grains [Collected by the authors]

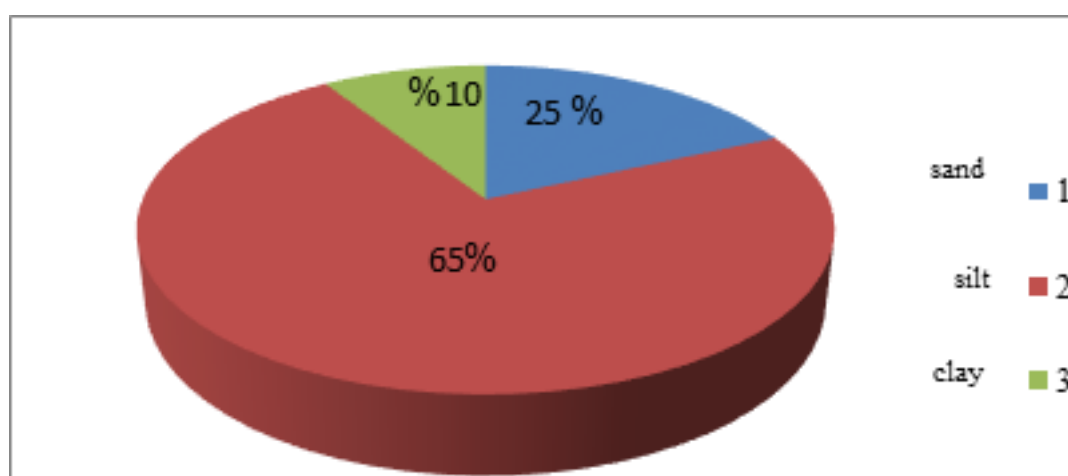


Fig 7. Granular constituents of first marl unit (Marlon Pliocene) [Collected by the authors]

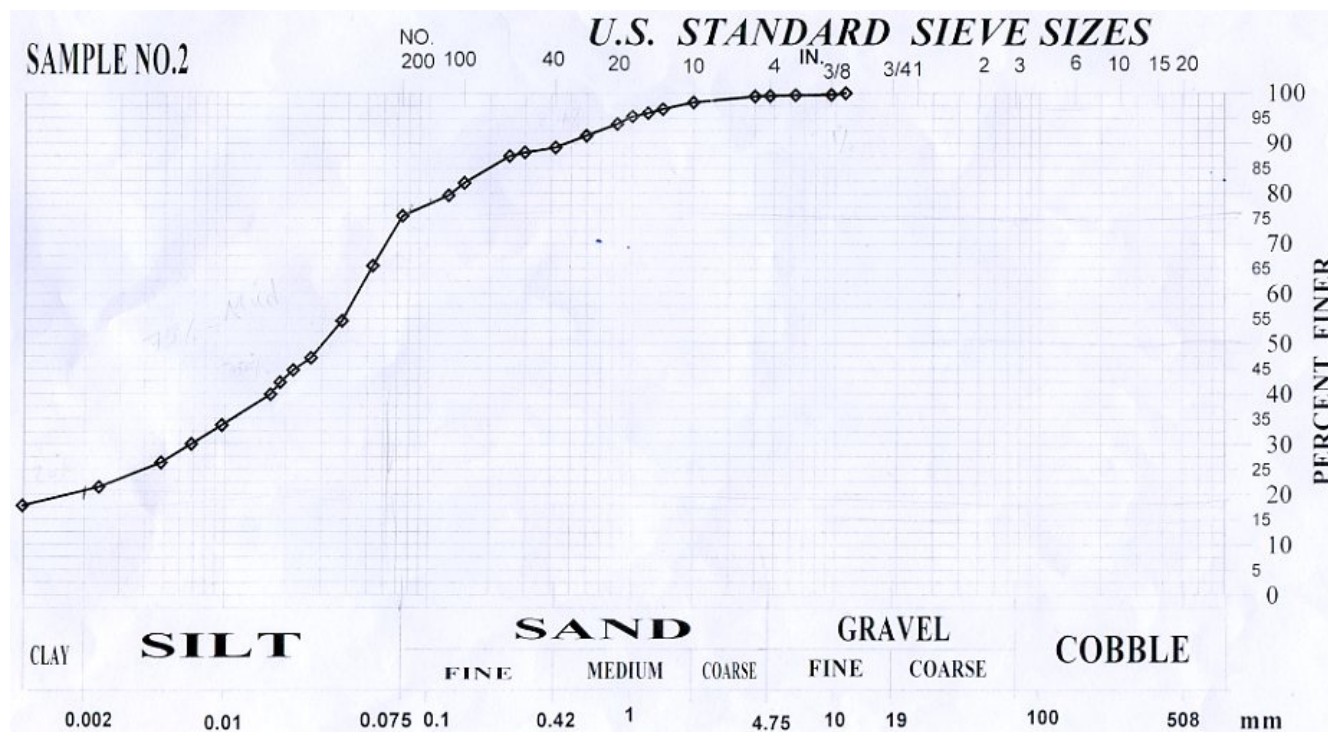


Fig 8. Size and percentage of grains in the fourth unit of marl (M3 unit) [Collected by the authors]

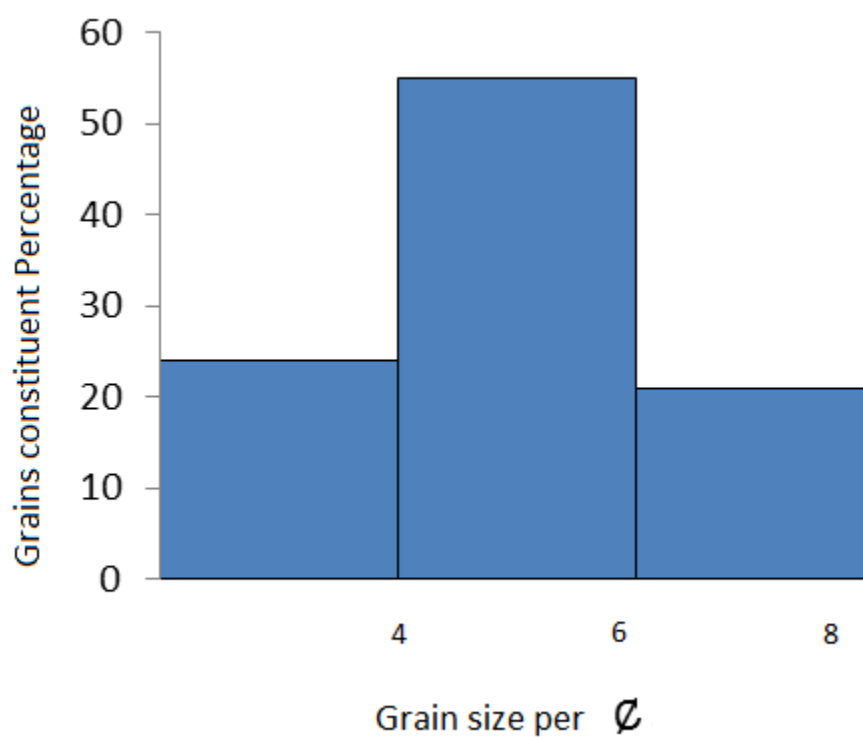


Fig 9. Abundance of grains [Collected by the authors]



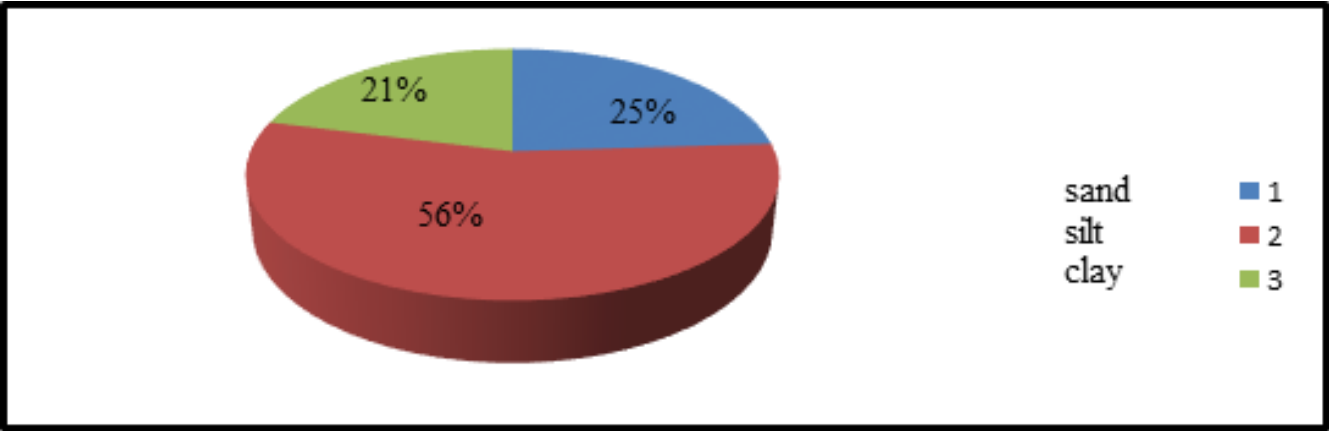


Fig 10. Grains of the fourth unit of Marne unit (unit M3) [Collected by the authors]

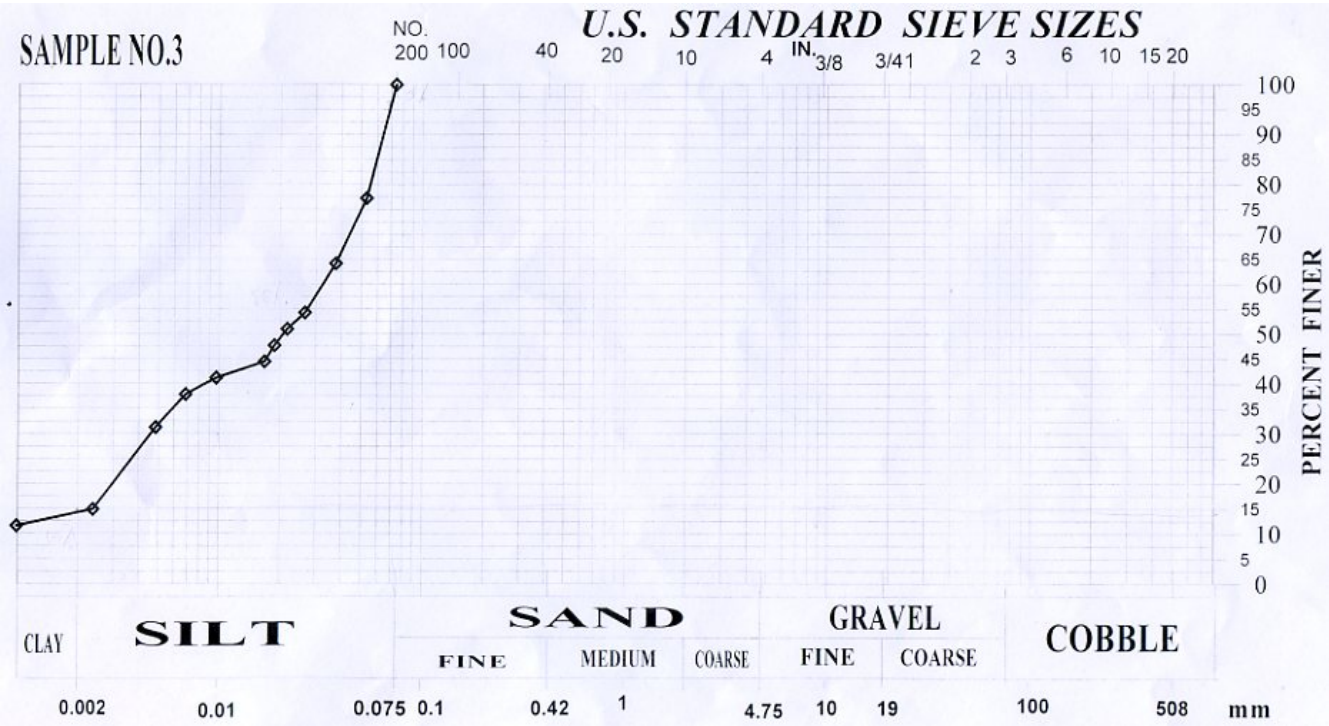


Fig 11. The size and percentage of grains in the third marl unit (M2 unit) [Collected by the authors]

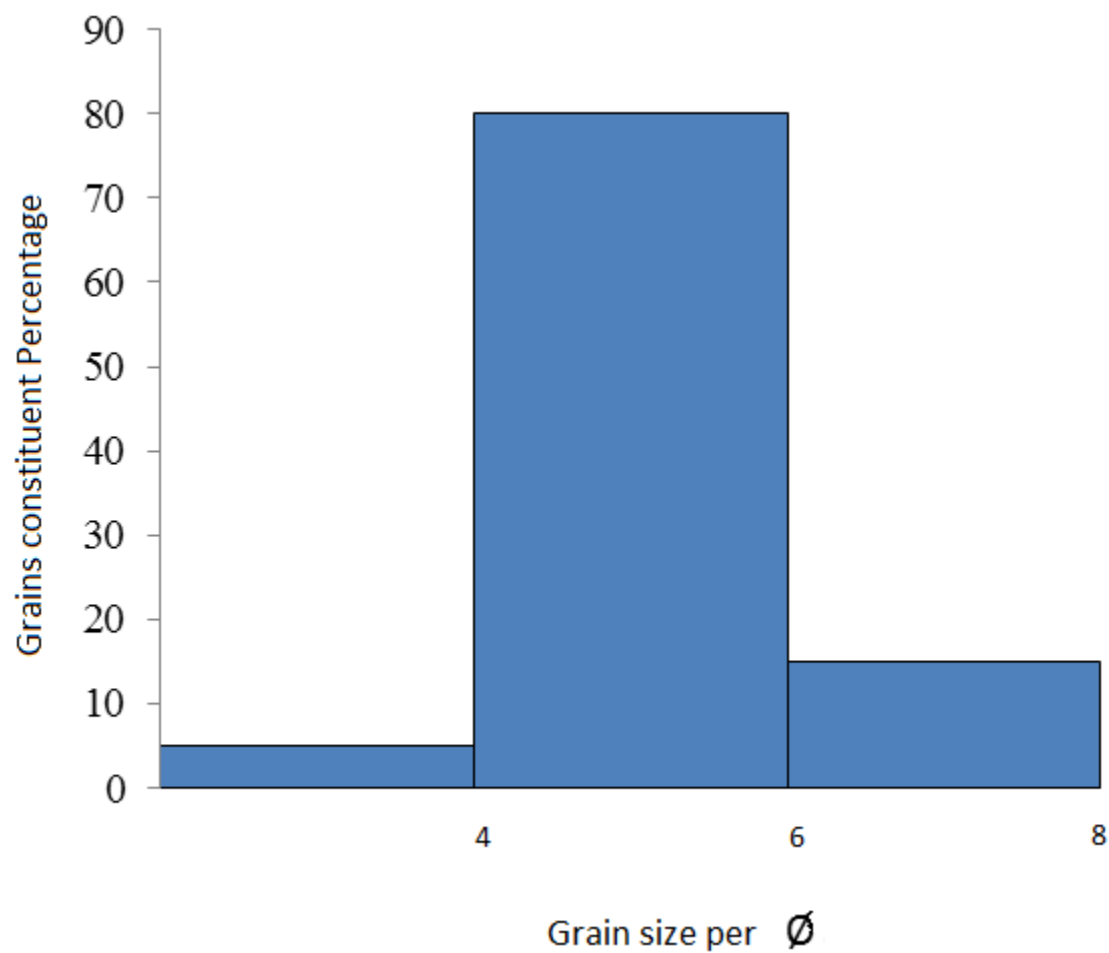


Fig 12. Abundance of grains [Collected by the authors]

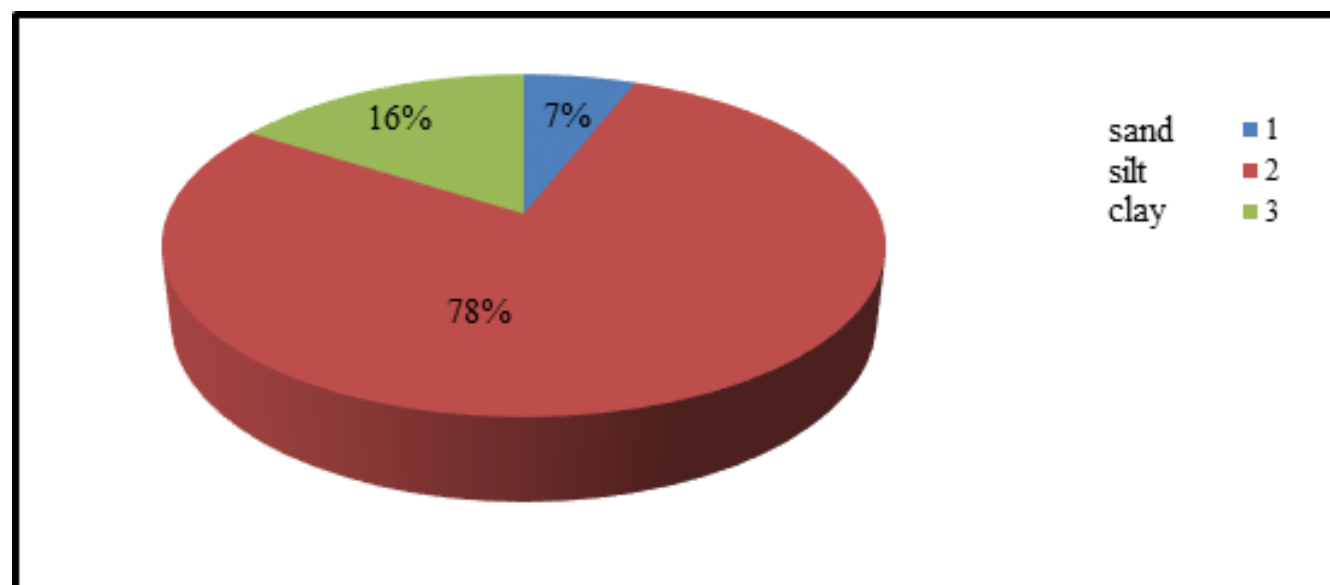


Fig 13. Grains that make up the third unit of marl (M2 unit) [Collected by the authors]

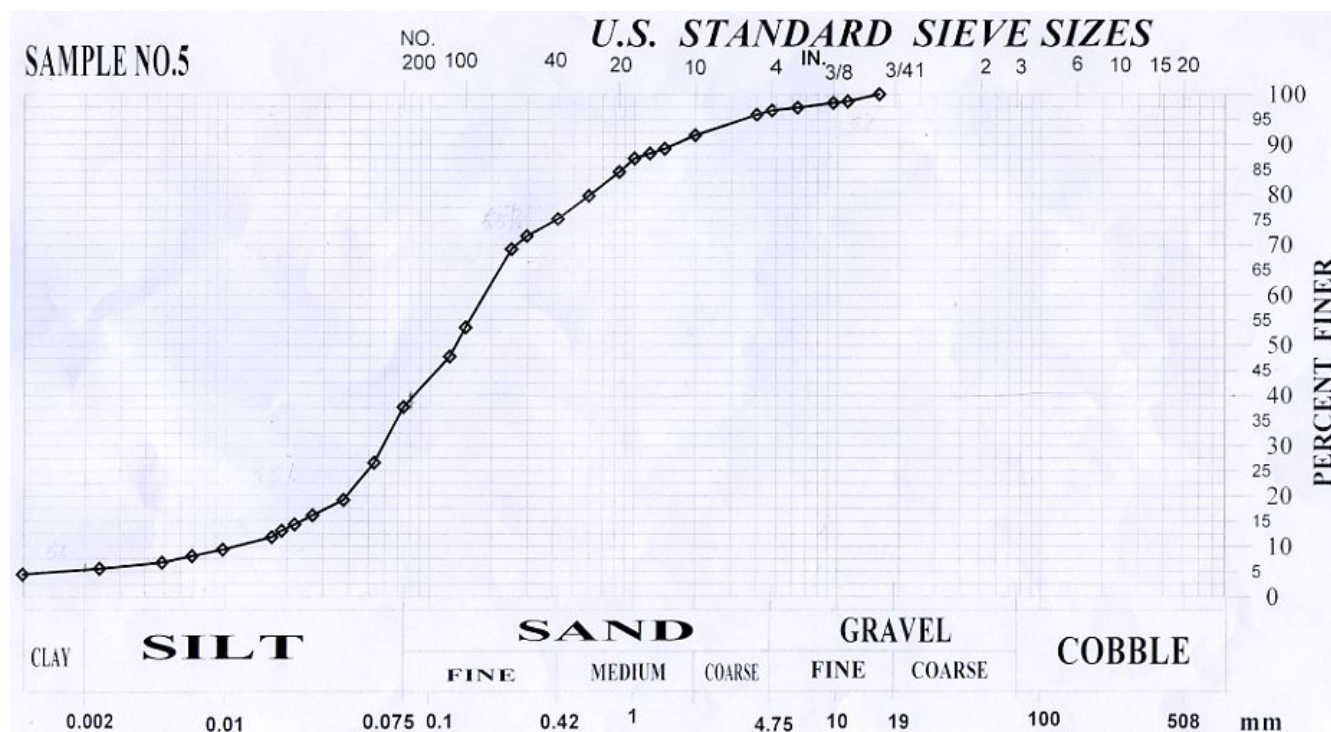


Fig 14. Size and percentage of seeds in the fourth marl unit (M3 unit) [Collected by the authors]

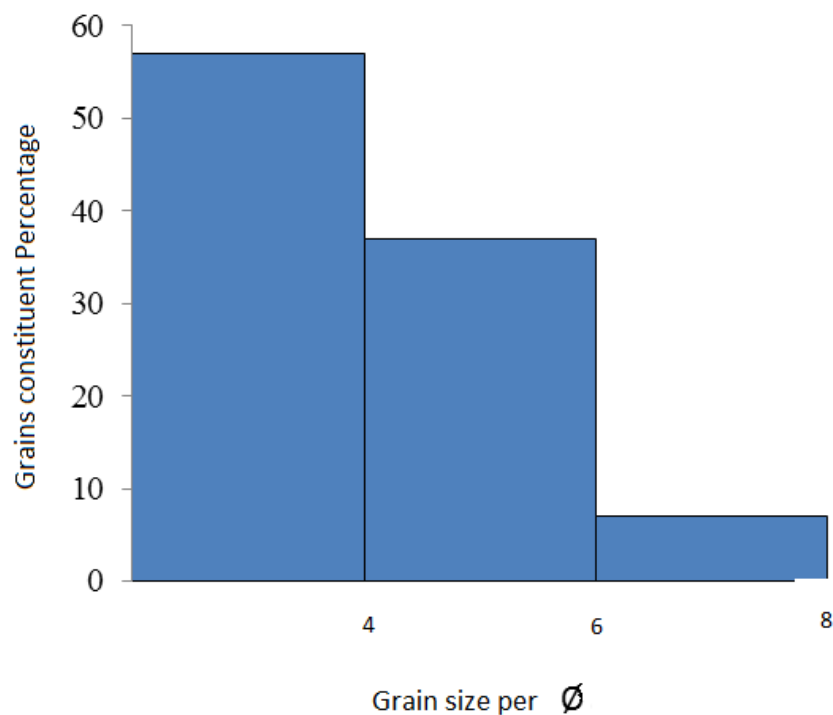


Fig 15. Abundance of grains [Collected by the authors]

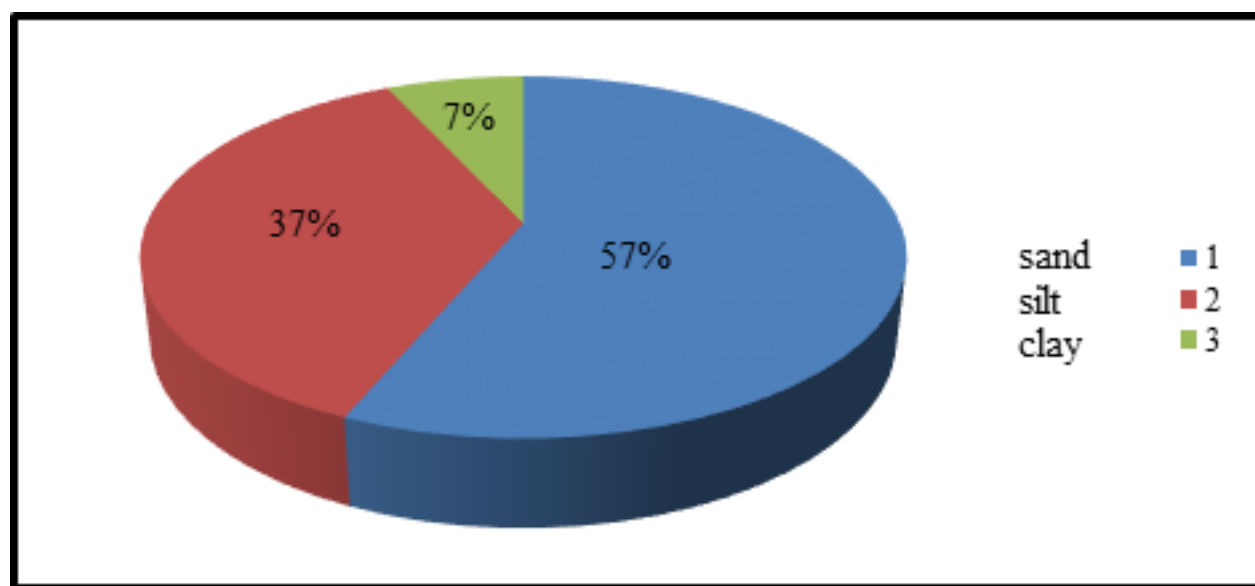


Fig 16. Grains of the fourth marl unit (M3 unit)[Collected by the authors]

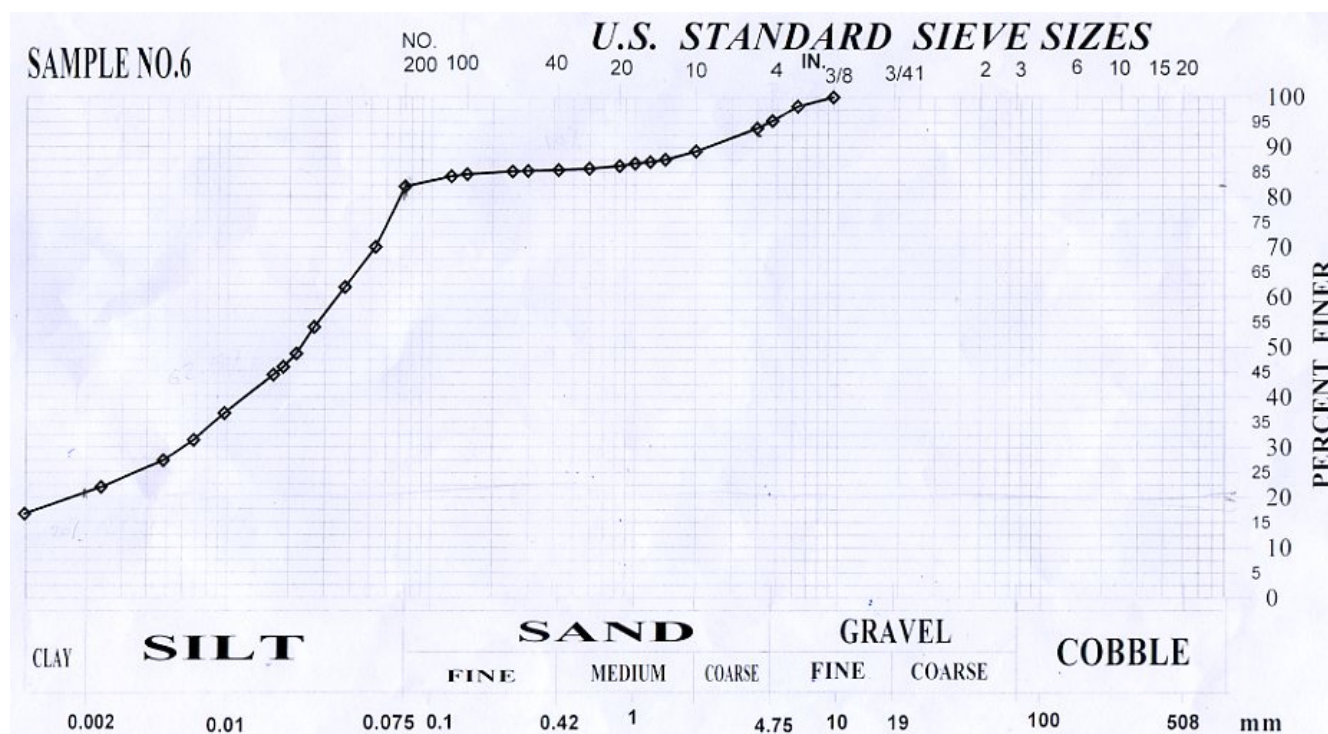
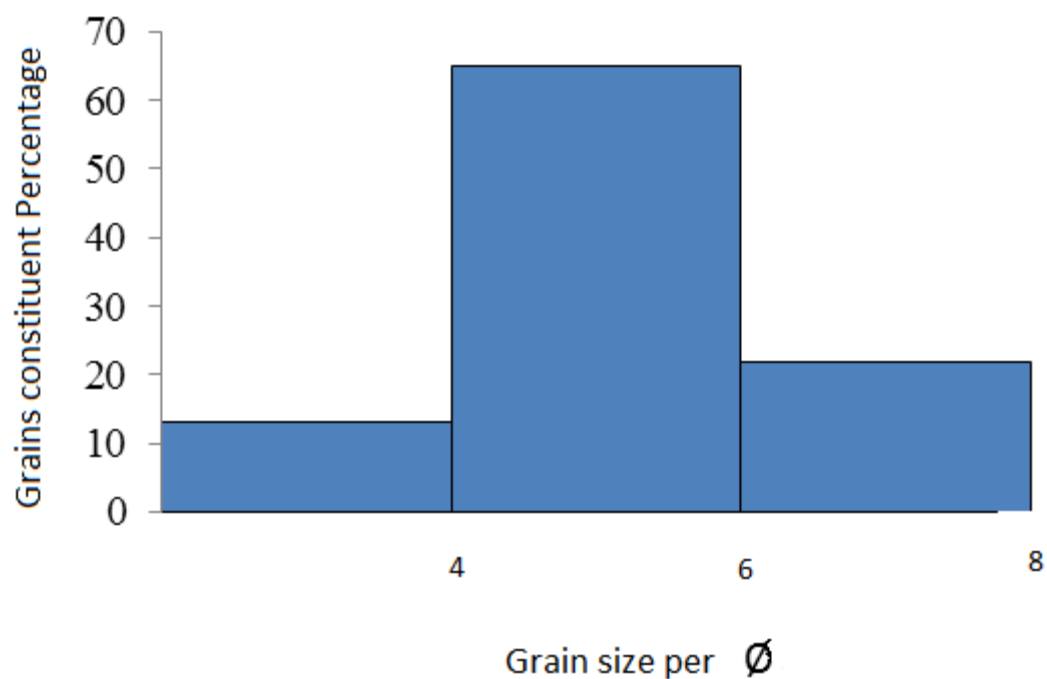
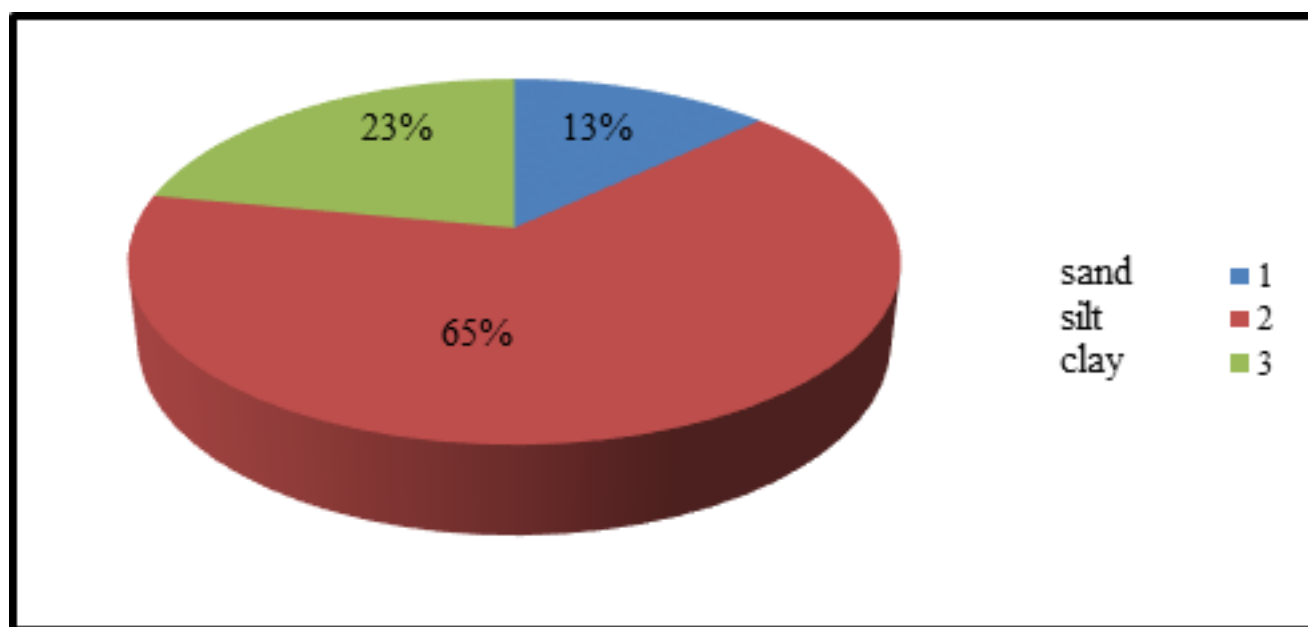


Fig 17. The size and percentage of seeds in the second marl unit (M1 unit) [Collected by the authors]



**Fig 18.** Abundance of grains [Collected by the authors]



**Fig 19.** The size and percentage of grains in the second marl (M1 unit) [Collected by the authors]



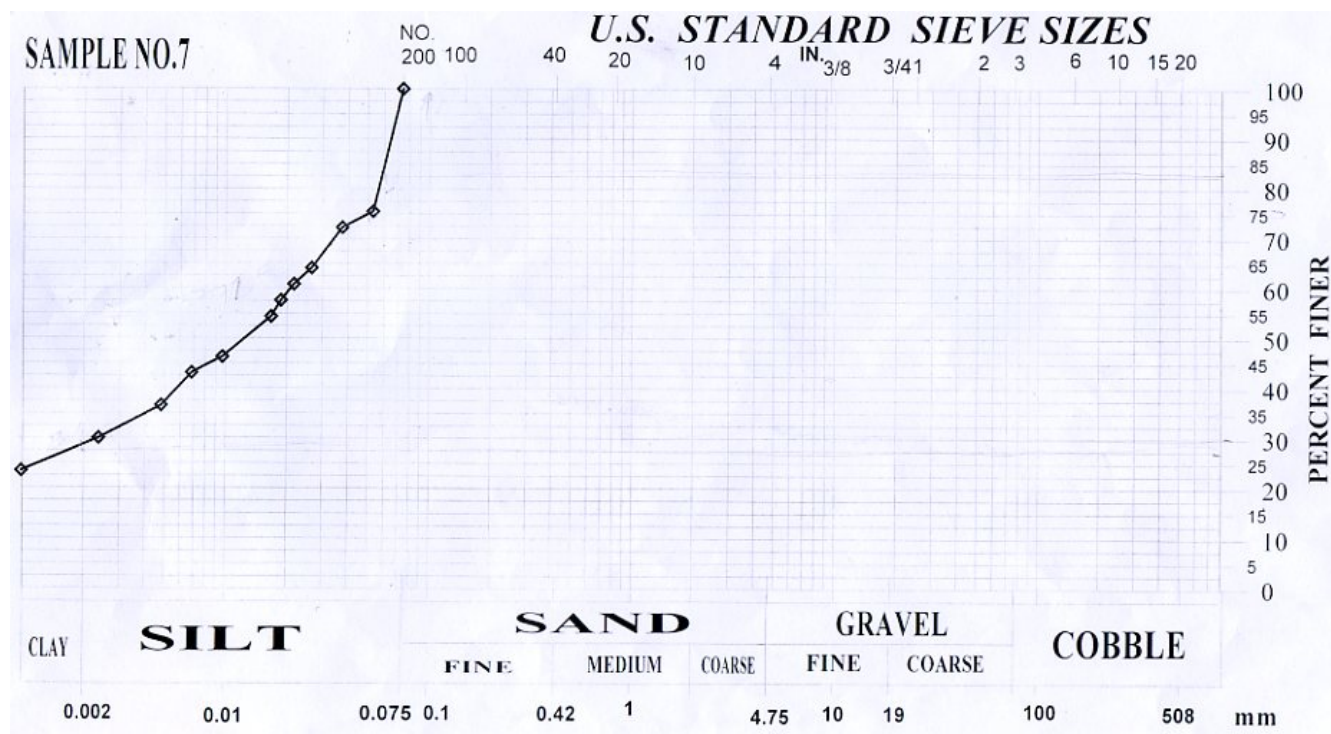


Fig 20. Size and percentage of seeds in the fifth marl unit (Qom formation marl) [Collected by the authors]

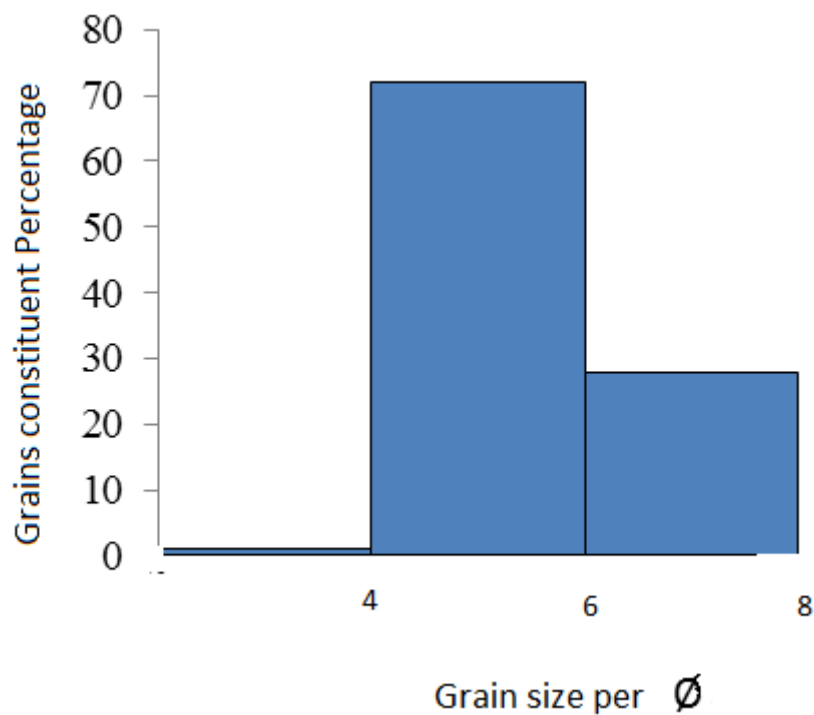


Fig 21. Abundance of grains [Collected by the authors]

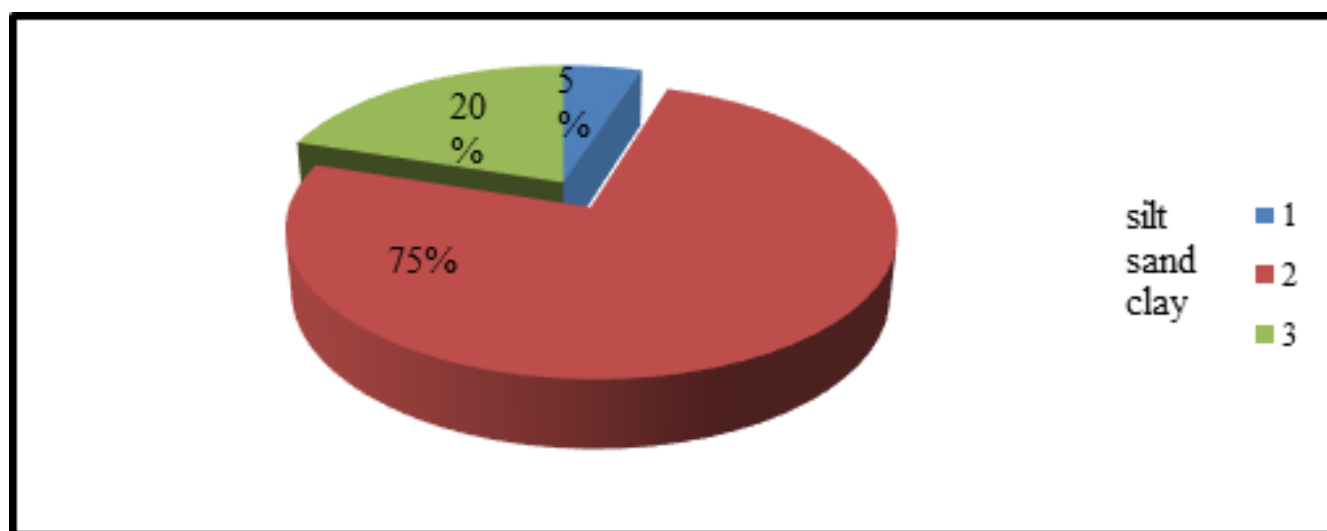


Fig 22. Grains forming the fifth marl graph (Qomformation marl) [Collected by the authors]

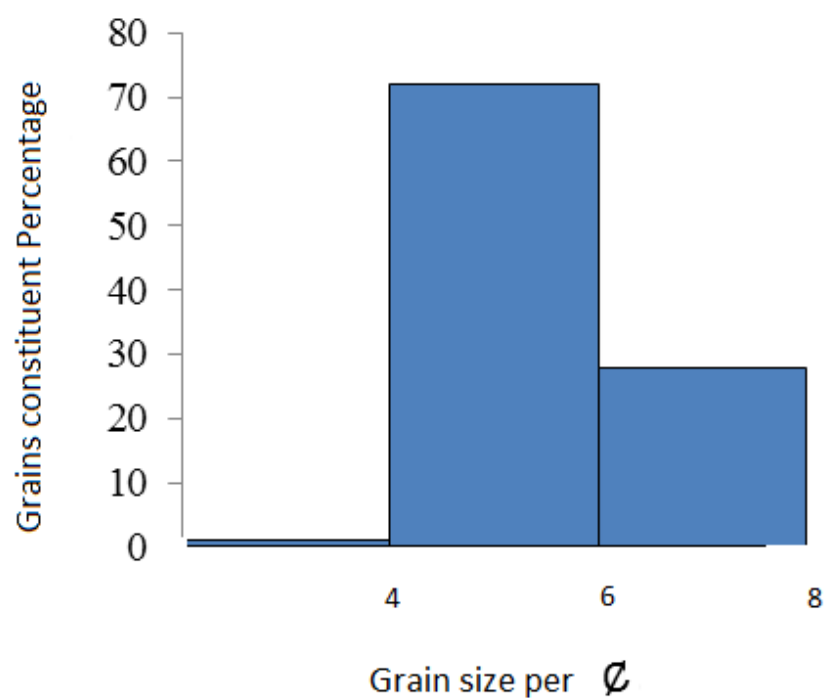


Fig 23. Abundance of grains [Collected by the authors]

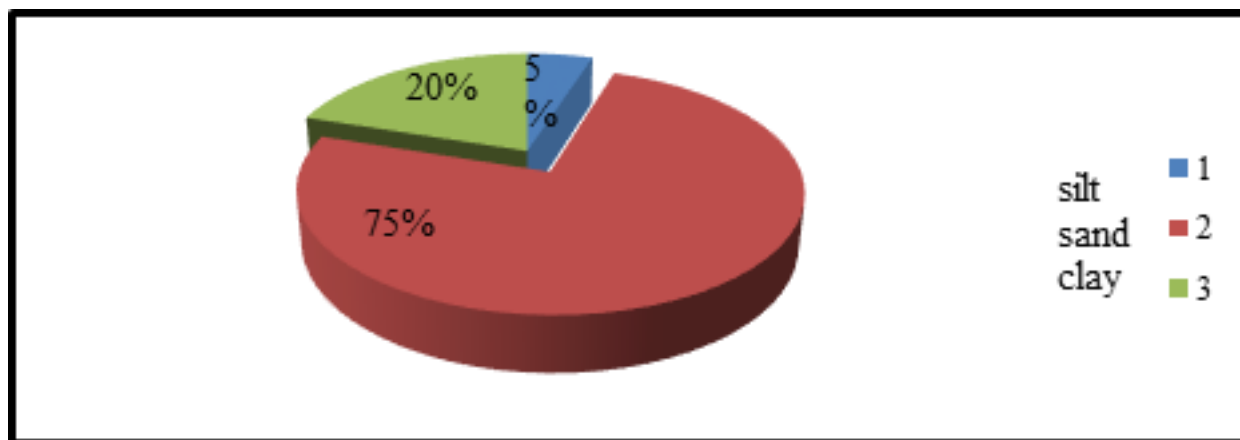


Fig 24. Grains forming the fifth marl graph (Qomformation marl) [Collected by the authors]

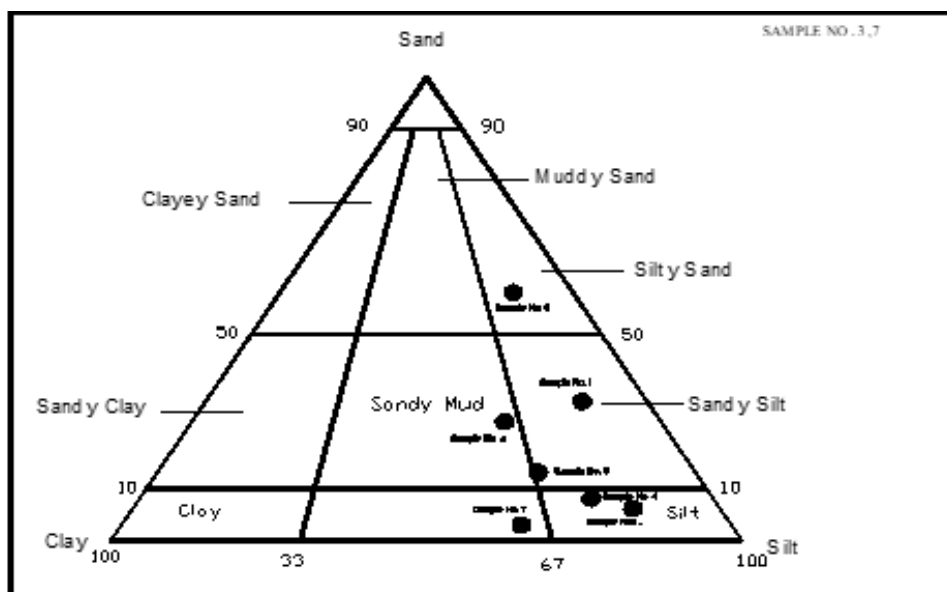


Fig 25. Particle size and sediment name determination [Collected by the authors]

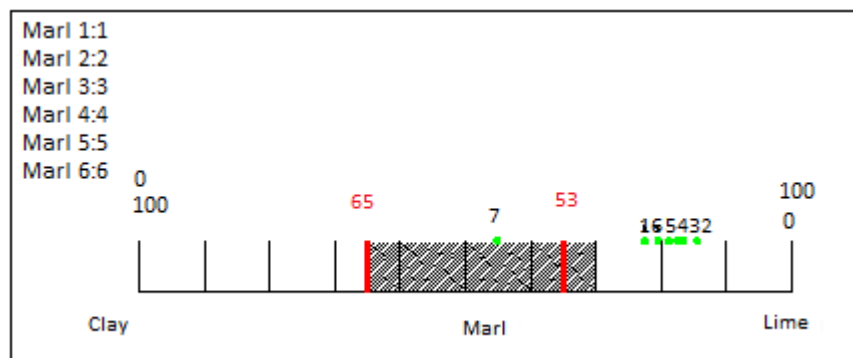


Fig 26. Marls location range [Collected by the authors]

## 5 Conclusion

This study focused on the probability of water erosion occurring in the semi-arid sensitive regions (Qom and Tehran regions) of Iran. This study has paid a portable simulated rainfall and reached to a good and logic result in the mentioned regions for the marls units; and then analyze the physical results of the implementation of the main objectives mentioned in the above parts.

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