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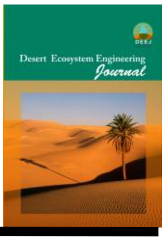

Fractal Analysis of Post-Deposition Changes of the Golestan Province's Loess Texture

Somayeh Ghandhari[1], Arash Amini[2]*, Ali solgi[3] , Hamed Rezaei4

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Expanded abstracts

Introduction: Particle size distribution (PSD) is one of the sediments' most important physical properties, affecting other physicochemical properties. Fractals are the objects or processes that show a similar appearance or behavior on some large, spatial, or temporal scale. Each fractal can be divided into several parts, each of which resembles the main body. Many natural phenomena and processes are based on fractal models. Loess particles maintain good self-similar properties even when modified through pedogenesis so that the fractal dimension of their particle size is considered as a new indicator of particle size. The loess sequences, produced by aeolian under the influence of past weather changes, have been transported, deposited, and undergone many changes by pedogenesis, whose information is recorded in loess particles. By studying the PSD loess, which is a natural fractal, one can discover data about the past environment. Therefore, PSD changes can be used to indicate the pedogenesis intensity and process or the soil age.

Post-depositional pedogenesis, including chemical and biological weathering, causes further particle crushing, the extent of which may vary in different locations due to deposition PSD and the time and intensity of pedogenesis or some other factors. Typically, intense pedogenesis or poor to very poor sorting occurs in warm and humid climates, while poor pedogenesis occurs in cold and dry climates. Changes in the loess texture reflect its post-deposition conditions. Thus, this study sought to analyze Golestan's loess texture developments via fractal PSD for the first time, which could interpret the extent of tissue changes at different points. The results were then compared to the fractal geometry obtained from the electron microscope images.

Materials and methods: This study was conducted in Golestan province. The study area is located at latitudes of 38° 8' to 36° 30'N and longitudes of 53° 57' to 56° 22' E. Based on three types of loess texture, including sand

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[1]. Department of Earth Sciences, Science and Research Branch, Islamic Azad University, Tehran, Iran.

[2]. Assistant Professor, Department of Geology, Faculty of Sciences, , Golestan University, Gorgan, Iran; a.amini@gu.ac.ir

3. Associate Professor, Department of Earth Sciences, Science and Research Branch, Islamic Azad University, Tehran, Iran

4. Assistant Professor, Department of Geology, Faculty of Sciences, , Golestan University, Gorgan, Iran

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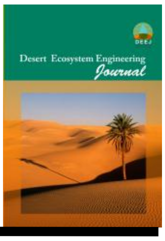

loess, silt loess, and clay loess, sixteen samples were totally collected from three zones. Moreover, the fractals were measured using differential box-counting and PSD. The PSD fractal was calculated by sieve-hydrometric (DbH) and laser (Dbl) methods.

Result: The mean DbH for region 1 was 2.64 and region 2 was 2.30. DbH in region three differed in two values. For two regions S12 and S13, the values of DbH are 2.74 and 2.70 and for S 14, S15 and S16 are 2.62,1.06 and 2.24 respectively. Also, the results showed a mean of 4.37 microns and sorting is very poorly (mean φ = 2.96) for region one, a mean of 14.35 microns and sorting is very poorly (mean φ = 3.17) for region two and a mean of 49.56 microns with two different sorting values show very poorly sorting (mean φ = 2.28) at S13 and S12 stations and sorting poorly (mean φ = 1.78) at stations S16, S15, S14 for zone three. The average fractal grain dimension in region one is 0.673 in region two is ٠0.788 and in region three is 0.850.. The fractal dimensions of the grain surface in region one have an average of 0.51 in region two is 0.49 and in region three is 0.50. The average value of fractal geometry of grain density arrangement (DFf) is 1.94 in region one, 1.87 in region two and 1.91 in region three.The average fractal arrangement of pore fabric density (DFp) in region one is 1.47 in region two and 1.5 in region three is 1.59.. The fractal geometry of the cement fabric density arrangement is 1.33 in region one, 1.43 in region two and 1.52 in region three.

Discussion and conclusion: The results of examining DbH dimensions in the loess of Golestan province show that the percentage of sand decreases and the clay content increases with the increase of DbH. Comparison of fractal with sediment textual parameters indicate that the number of sorting increases and the sorting of particle decreases with the increase of DbH. This means that the samples have a better gradation of PSD and a larger volume of particle size classes. The kurtosis index decreases with the increase of DbH and the curvature broadening increases as a result of the increase of the particle size classes.

The results of examining DbL fractal dimensions in the loess of Golestan province show that the percentage of sand decreases and the silt and clay contents increase with the increase of DbL. Based on the results of laser sizing, the increased silt and clay contents lead to a better gradation of sediments. The negative trend of particle sorting against DbL means that the sorting index decreases and the particle sorting increases with the increase of DbL. The positive trend of kurtosis against DbL means that the kurtosis index increases and the curvature broadening decreases with increase of DbL.

Three stations of AlmaGol, AlaGol and Agh Ghala Belt in zone 3 had lower DbH and DbL, better sorting, and the highest median size. This may be due to the differences in the sediments' origins or forming environment and retransfer. This implies that the fractal values can be useful for identifying the transfer mechanism in different sediments.

The fractal geometry changes with the changes in loess texture. Therefore, a higher fractal dimension content indicates a higher soil formation and higher fine particle ratios. According to the results, if particle distribution is well graded, it can be claimed that fractal geometry demonstrates the changes after loess deposition. According to the fractal results obtained from electron microscope images in Golestan loess, the fractal dimensions of the grain increased with the increase of diameter. This confirms that near the source, grains are deposited with higher order and away from the source, the fractal number becomes smaller as the grain size decreases. The fractal dimensions of the grain decrease with the increase of particles roundness from zone 3 (near the source) to zone 1 (away from the source). This implies that the sedimentss order decreases and the texture undergoes less changes with the increase of particles roundness. On the other hand, the fractal grain dimensions increase with the increase of sphericity. Since the sphericity decreases from zone 3 to zone 1, the fractal number of grain dimensions decreases. This means that a higher sphericity leads to a higher initial order of the sediment and less texture exposure to changes.

The fractal geometry values of the grain fabric density of the fabric in different parts of Golestan province are not equal. Zones 3 and 1 have a higher order than zone 2. Zone 3, with the fractal number close to 2, has a high order during the deposition due to its proximity to the source. In zone 2, with a farther transfer, the particles have been highly subjected to changes in size and arrangement, and thereby the fractal number and order have been subjected to changes and decline. The highest fractal number is seen in zone 1. This can be due to the humid climate in zone 1, which induces the formation of secondary clay and increases the fractal numbers and sediment order. These results show that the content of clay can determine the order and homogeneity of the sediment texture. It can be concluded that fractal and its related parameters, as an efficient tool in analysis of loess

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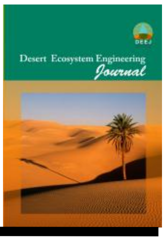

sediment, can justify the zone of texture changes, distance from the main source, pedogenesis and climate and The results of DbH dimensions analysis in Golestan province's loess showed that the percentage of sand decreased, and the clay content increased with an increase in DbH. Comparing the fractal with textual sediment parameters indicated that the number of sorting increased and the particle sorting decreased with an increase in DbH, suggesting that the collected samples had a better PSD grading and a larger volume of particle size classes. Moreover, it was found that the kurtosis index decreased with an increase in DbH, and the curvature broadening increased with an increase in particle size classes.

The results of Dbl fractal dimensions analysis in Golestan loess showed that the percentage of sand decreased, and the silt and clay contents increased with an increase in DbL. Furthermore, according to the results of laser sizing, the increased silt and clay contents led to a better sediments gradation. A negative trend of particle sorting against DbL means that the sorting index decreased and the particle sorting increased with an increase in DbL. on the other hand, a positive trend of kurtosis against DbL means that the kurtosis index increased and the curvature broadening decreased with an increase in DbL.

Three stations, including AlmaGol, AlaGol, and Agh Ghala Belt in zone 3, had lower DbH and DbL, better sorting, and the largest median size, which could be due to the differences in the sediments' origins or the environment's form and retransfer, implying that the fractal values could help identify the transfer mechanism in different sediments.

The fractal geometry would change with the changes made in loess texture. Therefore, a higher fractal dimension content indicates a higher soil formation and higher fine particle ratios. According to the study's results, should the particle distribution is well graded, it can be claimed that fractal geometry demonstrates the post-deposition changes in the loess. Based on the fractal results obtained from electron microscope images in Golestan loess, the grain's fractal dimensions increased with an increase in diameter, indicating that the grains are deposited with higher-order near the source, and the fractal number becomes smaller with the decrease in the grains' size away from the source. It was also found that from zone 3 (near the source) to zone 1 (away from the source), the grains' fractal dimensions decreased with an increase in particles roundness, implying that the sediments' order decreased and the texture underwent fewer changes with an increase in particles roundness. On the other hand, the grains' fractal dimensions increased with an increase in sphericity. Therefore, as the sphericity decreased from zone 3 to zone 1, the fractal number of grain dimensions decreased too, indicating that higher sphericity led to a higher initial order of the sediment and less texture exposure to changes.

The fractal geometry values of the grain's fabric density in different parts of Golestan province are not equal. Therefore, zones 3 and 1 had a higher order than zone 2. Due to its proximity to the source, zone 3, with the fractal number close to 2, had a high order during the deposition. In zone 2, with a farther transfer, the particles were highly subjected to changes in size and arrangement, and thereby the fractal number and order were subjected to changes and decline. Moreover, zone 1 was found to have the highest fractal number because of its humid climate, inducing secondary clay formation and increasing the fractal numbers and sediment order.

These results suggest that the content of clay can determine the order and homogeneity of the sediment's texture. Therefore, it can be concluded that as an efficient tool in analyzing loess sediment, fractal and its related parameters can justify the zone of texture changes, distance from the main source, pedogenesis, and climate, and determine the model of post-deposition changes.

keywords: Texture analysis, Fractal particle size distribution, Defferenial Box counting, Loess.