Study on the Microstructural Features of the Soil Formed by the mixture of soft rock and sand

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Abstract. The scanning electron microscope was used to observe the microstructure of vermiculite soft rock, sand, and compound soil. Based on the observation results, the interaction relationship between vermiculite and sand particles was found during the formation of the compounded soil. The microscopic process reveals the sand-fixing mechanism of the composite soil, and quantitatively measures the sand-fixing effect of the composite soil. To provide a scientific reference at the micro-scale for improving the theory and technology of rapid mixing of soft rock and sand in the Mu Us Sandy Land.

1. Introduction
Soil microstructure characteristics determine the characteristics of soil water and fertilizer retention, aeration and water permeability, and then affect the soil structure stability and land productivity at the macro level. Scanning electron microscopy can clearly observe micro-morphological information such as the size, shape, composition and arrangement of particles in the soil, and the shape, size, and number of pores. It is found that the interaction between different levels of particles is conducive to the interpretation of soft rock from a micro level The scientific nature of the soil compounded with sand also helps explain the macroscopic characteristics of the soil.

Quantitatively characterize the soil porosity, particle size distribution, and aggregate content of different types of soils, explore the microstructural differences between compound soils and other soft rocks, aeolian sands, and farmland soils, and focus on analyzing the above-mentioned soil microstructure characteristics and protection of sand fixation and agriculture Production and other macro-functional characteristics, so as to improve the comprehensive understanding of the micro-mechanism of compound soil formation.

2. Experimental method
When scanning electron microscope experiments were performed, the original soil samples were air-dried naturally, and then the soil samples were randomly adhered with a copper conductive tape and
then adhered to the sample stage. After being coated with an ion sputtering apparatus (E-1010, Japan), the Czech TESCAN company The produced 5136SM scanning electron microscope was used to observe the microstructure characteristics of the soil samples and take photos to record them. The acceleration voltage was 10kV.

2.1. Pore feature analysis method
Use Adobe Photoshop CS6 and ImageJ software to obtain the shadow occupancy parameters (soil porosity of the test sample) in the scanning electron microscope image. The specific steps are as follows: ① Open the image in Adobe Photoshop CS6 and use the "magic stick" tool to select pixels Areas with similar values (tolerance is set to 1 or 2), and then use the "dropper" and "paint bucket" tools to unify the pixel values of the selected area to the smallest pixel value in the image, and store them in TIF format and JPEG format for later use ② Open the stored TIF image in Image J software, use the Wand Tool tool to select the black shadow area (soil pores), use the Measure tool in Analyze to measure the shadow area, and then use the Area Selection Tools to select the entire soil image area, and perform again Measure calculation and output processing result.

2.2. Particle size analysis
In general, soil particle size statistics can be performed in Image J, but Measure calculation is required for each soil particle measurement, which is tedious and inefficient. Nano Measurer 1.2 software is a software that specializes in particle size statistics. The operation is relatively simple. After many attempts and explorations, it is intended to select this software for soil particle size statistics. The specific method is as follows: Open the JPEG image stored in step ① when opening the pore analysis in Nano Measurer 1.2, first set the ruler in the settings to be consistent with the actual size, then underline the maximum diameter of each soil particle, and finally check Report and output statistical results.

2.3. Reunion feature analysis method
Regarding the measurement of soil aggregates, the commonly used methods at home and abroad mainly include dry sieve method, wet sieve method, pressure method, water droplet method, disintegration method and infiltration method, these methods do not involve the actual shape of the agglomerates. In this study, the agglomerates are discriminated based on SEM images, and the number of agglomerates in a certain field of view needs to be determined. Specific judgment criteria need to be formulated. The agglomerates are formed by repeated agglomeration and cementation of the soil particles, which are approximately spherical, with a diameter between 0.25 and 10 mm, and are loose and porous. Less than 0.25mm is called micro-agglomerates, and can also be called secondary agglomerates, which are intermediate products formed from single particles to agglomerates. Through studying the multiple characteristics, formation process and micro-formation mechanism of aggregates, and referring to the existing graphic information, the final determination criteria for aggregates in SEM images are as follows: ① The surface of soil particles is rough and adhere. There are cohesive particles, humus and other materials, and there is a certain connection relationship with the surrounding soil particles. The structure has well-developed pores, coexisting small and large pores, and reasonable distribution of particle groups, which can be judged as agglomerates; ② there are plant roots in the structure and connect them. It can be judged as agglomerates; ③ Due to the limitation of the observation field and magnification of the scanning electron microscope during the experiment, in this study, the number of micro-agglomerates was mainly determined. Discriminate one by one in the image according to the above criteria to determine the number of aggregates.
3. Results and analysis

3.1. Qualitative analysis of SEM images

3.1.1. Aeolian sand particles have high roundness and non-capillary pores. Scanning electron microscopy was used to observe aeolian sandy soil images at different magnifications, and their general properties were analyzed at the micro level (Figure 1 left). Observing the scanning electron microscope image at a magnification of 100 times, it can be found that the soil particles of the aeolian sand have a single composition and a uniform texture. According to the Chinese soil particle classification standard, most of the soil particles are fine sand particles, and there are a small number of powder particles. The soil particles of the aeolian sand are not bonded to each other and the soil is loose. There is no agglomerate in the left of image 1. The soil particles are widely spaced and the pores are developed. They are mainly non-capillary pores. They have good ventilation effects but are difficult to be effective. Keep water, so it will leak water and fertilizer, which is not good for plant growth. Combined with an image magnified 1000 times (right of Figure 1), from the appearance of a single soil particle, the shape of the sand particles is irregular, but the degree of rounding is high, there are basically no sharp edges and corners, and there is no obvious side surface, indicating that the sandy soil has long The structure is extremely unstable, the soil fluidity is large, and the soil particles collide with each other and scour, gradually forming morphological characteristics similar to pebbles. It can be roughly judged from the microscopic morphology and structural characteristics of aeolian sandy soil observed by scanning electron microscope that plants are difficult to grow in aeolian sandy soil area. Improper protection will also cause desertification of the surrounding environment and affect ecological security. Basic reasons for the formation of soil characteristics such as water leakage and fertilizer leakage, and dust and sand. The process of soil desertification is usually a process of clay loss. Therefore, comprehensive management and development and utilization of aeolian sandy soil can start by changing the viscosity and thereby changing the microstructure characteristics of aeolian sandy soil to promote its development to benign soil structure.

![Figure 1. SEM image of aeolian sandy soil](image1)

(left magnification is 100 times, right magnification is 1000 times)

3.1.2. A large number of mucous membranes are distributed on the surface of the soft rock particles, and the structure is complementary to the aeolian sandy soil. It can be seen from the scanning electron microscope image of ocher soft rock with a magnification of 100 times (Figure 2 left) that the particle
size span of the ocher soft rock soil particles is large, and it is distributed from clay particles to sand particles, mainly powder particles. But limited by the content of clay, the degree of cementing is also low. At the same time, it can be seen from the high-magnification electron microscope image (Figure 2 right) that the shape of the soft rock particles is extremely irregular, and the surface is uneven, and there are a large number of overlapping and endogenous aggregates distributed. This is the formation of micro-aggregates and aggregates. The basic unit shows that the soft rock has the foundation for forming aggregates. Based on the microstructure characteristics of soft rock and aeolian sand in the Mu Us sandy land, it can be generally found that there is a certain complementarity between the two in soil characteristics. It is possible to use the soil characteristics of the two by combining experiments with different proportions. Reconstruct new soils, so as to rationally use the "two hazards" and promote the ecological environment management and land resource development and utilization in the Maowusu Sandy Land.

![Figure 2. SEM image of soft rock](image)

(left magnification is 100 times, right magnification is 1000 times)

3.1.3. Farmland soil has a rich aggregate structure and strong structural stability. The soil conditions of the local farmland were observed by scanning electron microscope (Figure 3). The soil particles, morphology, and size were different. Sand, powder, and clay particles were distributed. Under the cementation action of soil, soil biology, etc., different size soil particles are cemented into agglomerates, but due to the magnification, in the scanning electron microscope image of 100 times, the main observation is micro aggregates with a diameter of less than 0.25mm, only a few large aggregates are distributed. The rich agglomerate structure makes the farmland soil pores developed, and the distribution of capillary pores and non-capillary pores tends to be reasonable, which is conducive to the exchange and coordination of water, fertilizer, gas and heat, and the improvement of soil fertility. It can be seen from the high-resolution scanning electron microscope image that a large number of clay particles are distributed on the surface of the soil particles in the farmland. The different particles are connected together under the cementation of the clay particles, which greatly increases the stability of the soil. Good soil structure is a necessary condition for farmland to be suitable for farming. It is the basis for forming and maintaining soil fertility and directly affects the stability of soil structure. The key to using soft rock to improve aeolian soil in the Mu Us Sandy Land is to make the soil structure of the compound soil develop towards the arable soil and enhance the stability of the soil structure, which is conducive to fertilization, planting, and accelerated soil maturation and stability.
Figure 3. SEM image of farmland soil

(left magnification is 100 times, right magnification is 1000 times)

3.1.4. The structure of compound soil is similar to that of farmland soil, but there is still room for improvement and improvement. From the scanning electron microscope image of the compound soil, it can be clearly observed that the compound soil has the composite characteristics of aeolian sand and vermiculite (Figure 4 left): some single grains have a higher degree of roundness, no adhesion between the single grains, and a smooth surface. It has some characteristics of aeolian sandy soil; there are also some rough and cohesive soil particles that already have the characteristics of agglomerates, this feature mainly comes from ocher soft rock; in addition, the compound soil of cultivated crops gradually appears in some farmland soil characteristics, the presence of a small number of crop roots in the electron microscope image, accelerated the formation of aggregate structure. It can be seen from the high-magnification electron microscope image (right of Fig. 4) that the soil particles on the surface of the compounded soil begin to appear clumps, which is beneficial to the benign transformation of the compounded soil structure. The reason for the formation of this structure can be summarized into three types: 1. When the two soils are mixed, the silt particles in the ocher soft rock contact the sand particles in the aeolian sand, and the silt particles are gradually adsorbed around the sand particles; 2. During the artificial improvement process in addition, irrigation, organic matter, etc. increase the cementing material in the compound soil, and the cementation promotes the formation of soil aggregates. 3. Various external stresses such as crop root activity, wet and dry alternation, and freezing and thawing promote the soil aggregate structure. Comparing the difference between SEM images of compound soil and farmland soil, it can be found that the soil pore composition is still mainly non-capillary pores, and the pore matching is not reasonable. Although aggregates are beginning to appear, the gap is obvious compared with farmland soil. It can be seen that due to the short years of compounding and planting, the soil structure of compounded soil is still gradually developing, and there is still a certain gap with the farmland soil, which is consistent with the comparison of potato yields between the two. Studies have shown that the composite soil formed by mixing soft rock and aeolian sand at a mass ratio of 1:5 on the Mu Us Sandy Land has soil texture, saturated hydraulic conductivity, pore status, aggregate content, soil water holding capacity, and grain composition significant improvement, suitable for planting potatoes. In 2015, the average yield of potato in the compound soil test field exceeded 45 t / hm². Although there is still a gap compared with the yield of about 70 t / hm² in the potato high-yield demonstration field in Yulin, it is far higher than the average yield of about 15 t / hm² in China in recent years.
4. Conclusion

The detection of soil microstructure and micromorphological features is an important part of soil physics research, and it has important practical significance for guiding the research of land remediation technology and engineering practice. In this study, based on SEM images, comprehensive use of image processing software such as ImageJ, Photoshop, Nano Measurer, etc. was used to compare the qualitative and quantitative micro-structural characteristics of aeolian sandy soil, soft rock, compound soil, and farmland soil in the Mu Us Sandy Land. A direct interpretation of SEM images found that, compared with farmland soils, aeolian sand and ocher soft rock do not have the background conditions required for normal crop growth, but the two are structurally complementary, and their compound soils are both The comprehensive characteristics of the two.

Quantitative analysis found that:

1. In terms of pore characteristics, compared with ocher soft rock, the soil pore condition of the compound soil after 2 years of cultivation has improved significantly, and aeolian sandy soil has enhanced the permeability and permeability of ocher soft rock;
2. Affected by soft rock, clay and fine grains began to appear in the compound soil, which has a tendency to develop into farmland soil;
3. In terms of agglomeration characteristics, the dispersion of the compound soil formed by dilution of the aeolian sand decreased, and the structure improved. The number of aggregates has increased, although there is still a certain gap compared with farmland soil, but it has the basis for healthy development.

The above studies have analyzed the internal mechanism of arborite and sand compounded soil from a microscopic scale, and preliminary established the relationship between typical soil microstructural characteristics and macroscopic functional characteristics.

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