

# Surface Textural Analysis of Quartz Grains from Modern Point Bar Deposits in Lower Reaches of the Yellow River

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**Abstract.** The surfaces of quartz grains contain characteristic textures formed during the process of transport, due to their stable physical and chemical properties. The surface textures include the information about source area, transporting force, sedimentary environment and evolution history of sediment. Surface textures of quartz grains from modern point bar deposits in the lower reaches of the Yellow River are observed and studied by scanning electron microscopy (SEM). Results indicate that there are 22 kinds of surface textures. The overall surface morphology of quartz grains shows short transporting time and distance and weak abrasive action of the river water. The combined surface textures caused by mechanical action indicate that quartz grains are transporting in a high-energy hydrodynamic condition and suffer a strong mechanical impact and abrasion. The common solution pits prove that the chemical property of transportation medium is very active and quartz grains receive an obvious chemical action. The combination of these surface textures can be an identification mark of fluvial environment, and that is: quartz grains are main subangular outline, whose roundness is higher with the farther motion distance; Surface fluctuation degree of quartz grains is relatively high, and gives priority to high and medium relief; V-shaped percussion marks are very abundant caused by mechanical action; The conchoidal of different sizes and steps are common-developed with paragenesis relationship; Solution pits are common-developed as well. The study makes up for the blank of surface textures analysis of quartz grains from modern fluvial deposits in China. It provides new ideas and evidence for studies of the sedimentary process and environmental significance, although the deep meanings of these micro textures remain to be further researched.

## 1. Introduction

Electron microscopy makes great breakthroughs in the limit of traditional optical microscope. As a powerful tool to explore the world of microscopic material, it's playing a big role in geological domain [1-7] and has been applied in many fields such as gas geology, sedimentology, mineralogy, fluid inclusion, microbiology and tectonic geology. Quartz has stable physical and chemical properties under the surface. It is widely distributed and easy to collect. After the quartz particles are removed from the host rock, they will form unique morphological features on the surface, which can be used to reflect the material sources, transport mechanism and sedimentary environment [8-12]. In 1951, Folk and Weaver began studying sediment particles using a penetrating electron microscope (TEM) [13]. The first study of the sand surface morphology using electron microscope was published in 1962. But it was not until



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1968 that scanning electron microscope (SEM) has been widely used in particle morphology observation [14-16], after which the study related has developed rapidly. For many years, the scholars at home and abroad have applied scanning electron microscopy (SEM) to study quartz particles surface morphology of various kinds of sedimentary environments in the geological history period [1-3, 6, 12, 17-20]. However, the research of quartz particles surface morphology in the modern sedimentary environment has been rarely reported. This article deals with the structure characteristics of modern river sedimentary environment in quartz sand grain surface and environmental significance based on modern sediment quartz particles in the lower reaches of the Yellow River, Jiao Zuo, Henan Province of China, using the analysis and statistics of quartz sand particles surface morphology by the emission of scanning electron microscope.

## 2. Overview of Research Area and Sample Collection

The sample preparation steps for this study are as follows: (1) The samples collected in the right amount were respectively 30 and 120 test sieve. Then the samples were taken out of 5g for standby. (2) Put the sample into the beaker, and add HCl solution of 20% concentration, soak, shake 8h, and then rinse to neutral with distilled water. (3) Use H<sub>2</sub>O<sub>2</sub> of 20% concentration to soak, shake 8h, then rinse to neutral with distilled water; (4) Dry samples; (5) 50 granules were randomly selected under double eyepiece; (6) The copper conductive is adhesive to the loading platform. Vacuum and spray plating film. The injection current is 8mA. The front, left and right sides of the sample are sprayed about 30s, a total of 90 s. Then a Quanta250FEG field was used to observe the scanning electron microscope. In this study, 41 quartz granules were observed and 69 photographs were taken. The surface morphological characteristics of quartz particles with 35 kinds of quartz particles could well reflect the sedimentary environment [21]. (Figure 1)

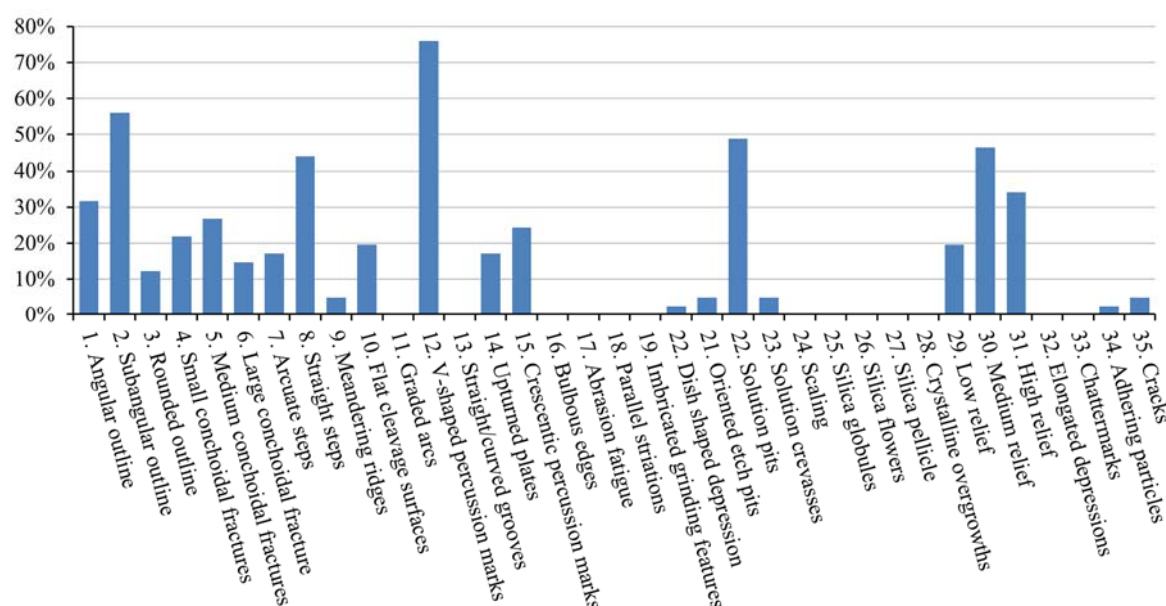


**Figure 1.** Frequency distribution diagram of quartz grains' surface textures.

## 3. Analysis of Surface Morphological Characteristics of Quartz Particles

### 3.1. The Overall Characteristics of Quartz Grain Morphology

Quartz particles are characterized by irregular granular. Most parts have half edge profile (figure 2, b, c), some parts are angular (figure 2, a), a small number of them are circular contour (figure 2, d). The surface level of the quartz particle has the medium level of relief (figure 2, d), followed by the high relief (figure 2, a, b), and again for low relief (figure 2, c).

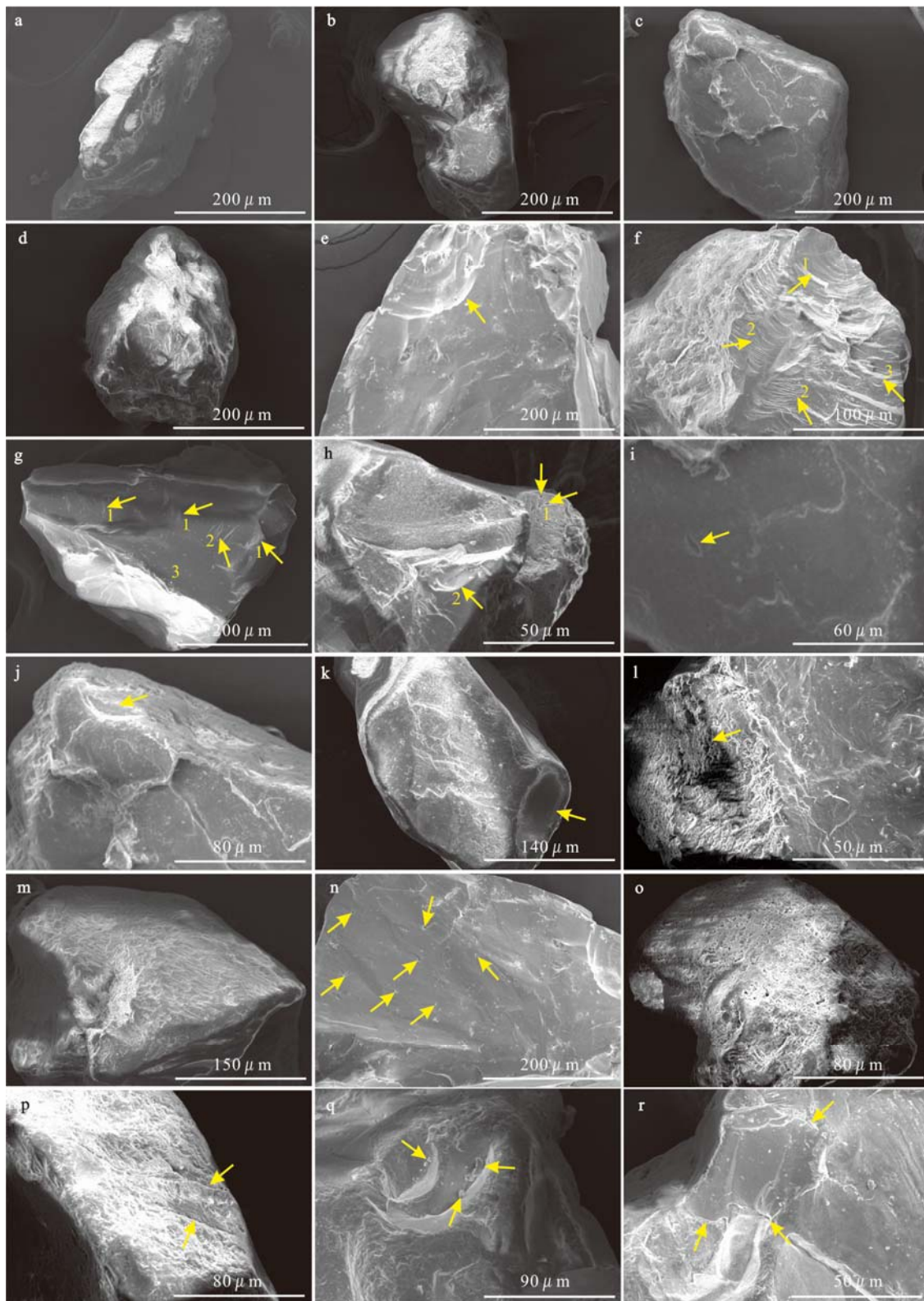


**Figure 2.** The surface micro textures of quartz grains

a: angular outline, high relief; b: subangular outline, high relief; c: subangular outline, low relief; d: rounded outline, medium relief; e: large conchoidal fractures, high relief; f: medium conchoidal fractures (1), arcuate steps (2) and straight steps (3); g: arcuate steps (1), straight steps (2) and flat cleavage

surfaces (3); h: V-shaped percussion cracks (1) and crescentic percussion marks (2); i: V-shaped percussion cracks; j: crescentic percussion marks; k: dish shaped depression; l: upturned plates; m: oriented etch pits; n: round solution pits; o: a large area of intense solution pits in quartz grain surface are arranged in honeycomb; p: solution crevasses; q: adhering particles in crescentic percussion marks; r: irregular cracks.

### 3.2. The Morphological Features of Quartz Particle Mechanical Action

(1) Conchoidal fractures: Generally it is shown as a disc or fan with parallel cleavage pattern (figure 2, e), and a lot of concentric lines are presented on the curved surface (figure 2, f). The quartz granules in the sediment of the Yellow River bank are under development. It has the shell-shaped fractures of the shell. The large conchoidal fracture is visible, and the fracture is clear and fresh.

(2) Ladder-like fractures: It often appears in the conchoidal fracture and cleavage plane intersect with the arc shape (Arcuate ladder-like) or flat (Straight ladder-like) (figure 2, f), on the Flat cleavage surfaces (figure 2, g). The causes are related to the violent strike of the underwater environment particles.

(3) Flat cleavage surfaces: Quartz is generally considered to be uncleavable in the macroscopic sense, with typical shell fracture. However, under the scanning electron microscope, it can be seen that the quartz surface is more like cleavage (figure 2, g), which is flat and often appears with the Arcuate ladder-like and the Straight ladder-like.

(4) V-shaped impact crater: It is a notch cut from the top of the cleavage after colliding with smaller particles. Samples of the v-shaped crater development can appear on the edge of the particles (figure 2, h), or in particles on a flat surface (figure 2, l), the size between 1 ~ 20  $\mu\text{m}$ , triangular

(5) Crescentic percussion marks: Crescentic percussion mark is also called nail mark, shaped like a new moon, less developed, and is a high-speed impact formation between the finer particles of roundness (figure 2, j), and its length is generally 1~30  $\mu\text{m}$ .

(6) Dish shaped depression: It is a large and well-rounded particle that collides with each other and is considered to be a good sign of the wind environment. Through careful observation and analysis, individual Dish shaped depression (figure 2, k) were found in this sample, with a diameter of about 70  $\mu\text{m}$ , and a circular crater. It shows that under strong hydrodynamic conditions, a small number of butterfly pits are produced.

(7) Upturned plates: It is some parallel flat cleavage surfaces, folding the particle surface and forming an angle into a shape of jag. It often appears on surface piece (figure 2, l), with 17% of particles being in the surface morphology.

### 3.3. Chemical Action Morphological Characteristics of Quartz Grains

(1) Oriented corrosion pits: This kind of corrosion pit has experienced both mechanical and chemical periods, which has a consistent direction and has something to do with lattice dislocation and defect. In this sample, a linear directional corrosion pits (figure 2, m) are developed. The length is about 5~30  $\mu\text{m}$ , and the frequency is about 5%.

(2) Corrosion pits: Generally its shape is like the circular, oval, triangle or irregular type, with its diameter below 10  $\mu\text{m}$ . The depth is larger and has irregular distribution (figure 2, n), or more corrosion pits developed into corrosion crevasses further. The corrosion pits in this sample are fully developed, with a frequency about 50%. Few sample particles have a strong corrosion and the surface is honeycombed (figure 2, o).

(3) Corrosion crevasses: About 5% of the sample particles can be observed due to the dissolution of corrosion cracks (figure 2, p, q). The crack appears in irregular lines. The length is generally between 50 ~ 200  $\mu\text{m}$ , and the depth is less than 10 microns in general.

### 3.4. The Morphological Characteristics of Quartz Granule Machinery + Chemical Action

About 2% of the sample particles can be observed in the small particles that are adhered to adsorption (figure 2, q). The irregular crack (figure 2, r) can be observed in about 5% of the sample particles. It is obviously deeper than the crack formed by corrosion. The quartz particles are transported in high-energy

flowing water and have a violent high-speed impact, which can form irregular cracks in the process. The dissolution will first start at the surface of the particle surface and gradually expand, which is the result of the joint formation of mechanical and chemical action.

#### 4. Discussion

Although the surface characteristics of quartz are considered to be of significance to the study of sedimentary environment, some surface morphology is not limited to one environment. Therefore, in the interpretation of sedimentary environment, various surface morphological characteristics must be combined. Statistical analysis of various quartz surface morphological features can eliminate the one-sidedness of interpretation to a certain extent and make the results more reliable.

Newsome and Ladd[22] consider that the surface characteristics of quartz appear to be more than 75% of the time, and between 25% and 75% are normal, and between 2% and 25% are small, and less than 2% are rare or absent. There are 22 kinds of surface morphological features of quartz granules in the sediments of the Yellow River bank, and only the v-shaped impact crater is abundant; a small amount of Rounded outline, Small conchoidal fractures, Large conchoidal fracture, Arcuate steps, Meandering ridges, Flat cleavage surfaces, Upturned plates, Crescentic percussion marks, Oriented etch pits, Solution crevasses, Low relief, arch - shaped polygonal cracks have appeared; Dish shaped depression and adhesion particles are very small; Other features do not appear.

This quartz particle is generally half angle-shaped and medium - high relief, indicating that its transport time and distance are relatively short, and when the water abrasion is poorer, the Angle is more reserved, and the surface has a higher degree of fluctuation. A large number of v-shaped crater, sand various conchoidal-sized fractures are clear and fresh, with the combination of all kinds of ladder and parallel cleavage planes. This indicates that quartz particles are in high-energy hydrodynamic conditions of handling. They had experienced strong mechanical impact and abrasion. There are many dissolution pits, which show that the chemical properties of the transporting water are active, and the chemical action is also obvious in the process of strong mechanical action.

Beach is the most important river in the environment of sedimentary microfacies. The above combination of quartz grain surface morphology can be considered a typical river in the identification of sedimentary environment, and are different from other sedimentary environment. In general, the quartz sand particles in the river environment are generally rounded, with a semi-angular contour. The more rounded the distance is, the higher the degree of roundness has. The surface has a high degree of fluctuation, with high and medium relief. A numbers of v-shaped impact crater have appeared. Various sizes of shell fracture and ladder symbiotic live together normally. The dissolution phenomenon is obvious and the dissolution pit normally appears.

#### 5. Conclusion

(1) There are 22 kinds of surface morphological characteristics of quartz granules in sediment of Yellow River beach. The overall morphological features show that the time and distance of the transportation are relatively short, and the water erosion is poor. The mechanical morphological features indicate that the quartz particles have had a violent collision and abrasion when they were carried under high-energy water power. Many dissolution pits prove that the carrying water is chemically active and the dissolution is obvious.

(2) The typical morphological combination of river sedimentation is characterized by the following features: The granule generally has the grinding circle. The main shape is half angular outline. The more rounded the distance is, the higher the degree of roundness has and the higher degree of fluctuation the surface has. Most of them are high and medium reliefs. A number of v-shaped impact crater have appeared. Various sizes of shell fractures and ladder symbiotic live together normally.

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