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Investigation of Microtextures on the Surface of Mesozoic Quartz Grains to Study the Prevailing Paleoenvironmenal Conditions on Silica Sand, Elwadi Elgedid, Western Desert, Egypt

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ABSTRACT

Microtextures recorded on quartz sand grain surfaces provide evidence of past environment. Environmental processes, such as transport by fluvial, eolian and mass wasting create unique microtextures on sand grain surfaces that can be observed under high magnification with a scanning electron microscope. These microtextures and their proportions infer to the environmental conditions which sediments have been exposed. Microtextural evidence also allows inferences about the history of sediments of unknown origin. This study determines the qualitative microtextural fingerprint of quartz sand grains deposited in Elwadi Elgedid, and compares that fingerprint to the fingerprints sediments of uncertain genesis, Aeolian, fluvial, mass-wasting, and other processes all create combinations of microtextures on quartz sand grain surfaces that are unique in the types. These combinations of microtextures record the paleoenvironmental history of the study area from which the grains were derived; the various forms of fractures and post-fracture surface alterations found on quartz sand grain surfaces should therefore provide useful evidence of climate and other environmental aspects of the sand grain's history. Variations in quartz surface textures were detected due to the texture created by mechanical processes was predominating. Abundant abrasion features like V-shaped pits, and linear and curved grooves usually give evidence of transport in a fluvial medium. On levels with intensive reworking and redeposition preliminary relief of grains was smoothed and obliterated. The diagnostic dissolution features were more, where intercalation of dolomites and siliciclastic rocks is common. Possible chemical etching in quartz was observed and fluid effects were responsible for barite precipitation as inclusion in quartz grain. The variability helps to clarify the history of basin evolution and to distinguish different conditions in deposition.

Keywords: Microtextures, Quartz, Silica sand, Western desert, Egypt

1. Introduction

The present investigations deal with the glass sand occurrences in the Governorate of the New Valley, located at (25º 07´ 37´´ N, 29º 05´ 36´´ E) south Dakhla oasis road at about 45km south of the oasis in the western desert of Egypt (Fig 1). At this location, vast extensions of this formation are exposed and are penetrated by the Dakhla-Owinat asphalt road.

The reconnaissance silica sand sample investigates as the various types of Quartz analyzed in SEM studies, techniques of heavy liquid separation to isolate quartz mineral types, study of SEM operation which the study focused on one distinct type of mineral. The inherent hardness of quartz and its chemical resistance combine to make it microtextures resistant to erosion (Mahaney 2002). The study is going on the microtextures of 500-250 and 250–125 µm grains ("medium and fine sand" on the Wentworth scale). The investigated grains established guidelines to ensure that all grains were viewed at the same SEM magnification.

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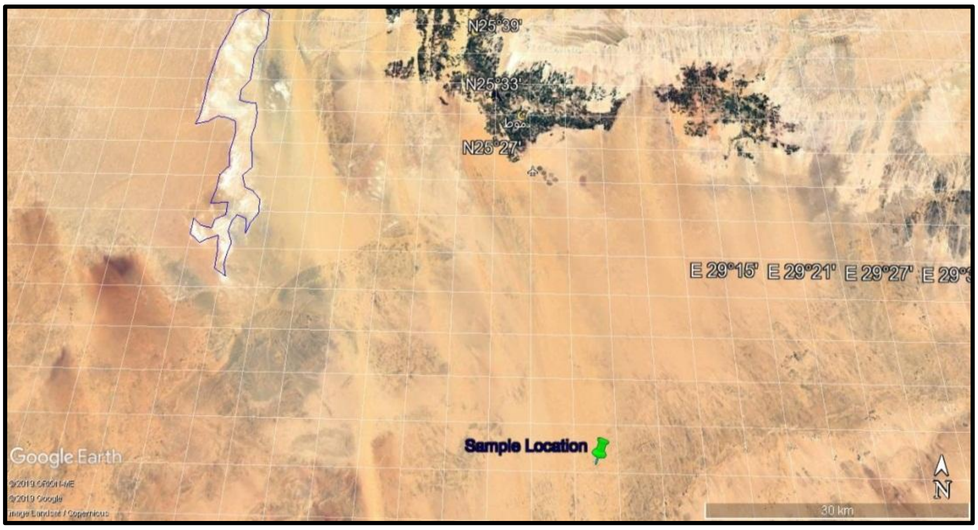

Fig. 1: Location of the studied silica sand sample Elwadi Elgedid, western desert of Egypt.

The micromorphological of quartz surface textures indicate the geologic source, transportation process, and depositional environment and geological settings. Aeolian, fluvial, mass-wasting, and other processes create combinations of microtextures on sand grain surfaces.

These record combinations of microtextures inferred to the paleoenvironmental history of the area from which the grains were derived; the various forms of fractures and post-fracture surface alterations found on sand grain surfaces should therefore provide useful evidence of climate and other environmental aspects of the sand grain's history.

The different mechanical and chemical processes effect in quartz sand grains that is apparent in the surface features. These features are described and catalogued according to depositional environment (Krinsley and Doornkamp, 1973). The weathering climate and processes were deciphered (Higgs 1979). Significant contributions are made by Krinsley and Donahue (1968) and Krinsley and Margolis (1971) about quartz grain surface texture and their transport and depositional environment. The present study aims to characterize the microtextures of quartz grains from Elwadi Elgedid.

Geology

The silica sand formations in Egypt are described to belong to the Nubian sandstones in general. The Nubian built is represented by the Paleozoic-Mesozoic sandstone layers and upper Cretaceous rock units (Taref and Kiseiba Fm). In addition, that deposit of silica sand belongs to Cretaceous age (Taref Fm) in the western desert. The basement rocks form the base of succession, while the Dakhla Fm acts as a confining bed of the succession. The lithostratigraphic succession is built up of the following rock units from base to top as follows (El Sayed 2005): 1- Precambrian basement; 2- Paleozoic – Mesozoic sandstones and shale; 3- Upper Cretaceous from top to bottom: Taref Fm. Is sandstone with gray shale intercalations; Qusier Fm claystone alternate with siltstone, sandstone and interaformational conglomerates; and Kiseiba Fm., which is sandstone and ferruginous sandstone with grey shale intercalations. Both of the Taref and Kiseiba Fms represent the main part of the Nubian Sandstone built. 4- The Quseir Formation surroundings Kharga, is the uppermost unit of the former ''Nubia Sandstone'' succession (Youssef, 1957; Klitzsch *et al.*, 1979).

2. Methodology

Reconnaissance sample was randomly collected from the surface of silica sand within size were measured using standard sieving and sedimentation technique Mineral separation was carried on silica sand glass studied sample by using bromoform to exclude heavy minerals. The main physical properties taken into consideration in analyzing the sample are color, shape, roundness, particle of Elwadi Elgedid. The sample was collected from top 5 cm of the surface. Particle morphology, and surface area. Mineral separation is used bromoform in the nuclear material authority lab. to separate heavy mineral from light mineral (mainly quartz).

Investigate and analyses quartz mineral with an environmental scanning electron microscope (ESEM). This instrument is supported by an energy-dispersive spectrometer unit (model Philips XL 30). The applied analytical conditions involved 30 kV as the accelerating voltage, 1–2 mm beam diameter during 60 to 120 s as the counting time, and a minimum detectable weight concentration ranging from 0.1 to 1 wt%, housed in the Nuclear Materials Authority in Qattamiya. Each individual grain was imaged at a magnification level of approximately 50–100X. Quartz microtextures visible at that scale were analyzed in detail at magnification levels between 100X.

Sieve Analysis

The study, one kilogram sample representing the sands from the lithostratigraphical unit at the Elwadi Elgedid area was subjected to dry sieve analysis. Two sizes were chosen for studying quartz microtextures, where their weights and proportions are relative to a study one kilogram. The results obtained are given in Table 1. These studied two sizes quartz grains are medium and fine sand. The main quartz grain size is fine sand in ratio 85.21% and the medium sand are 8.96% (fig.2).

Table 1: Averages of the grain size of the studied quartz sand fractions.

Size	Wt. Value	Wt%
<0.5->0.25	92.5	8.96
<0.25->0.125	879.1	85.21

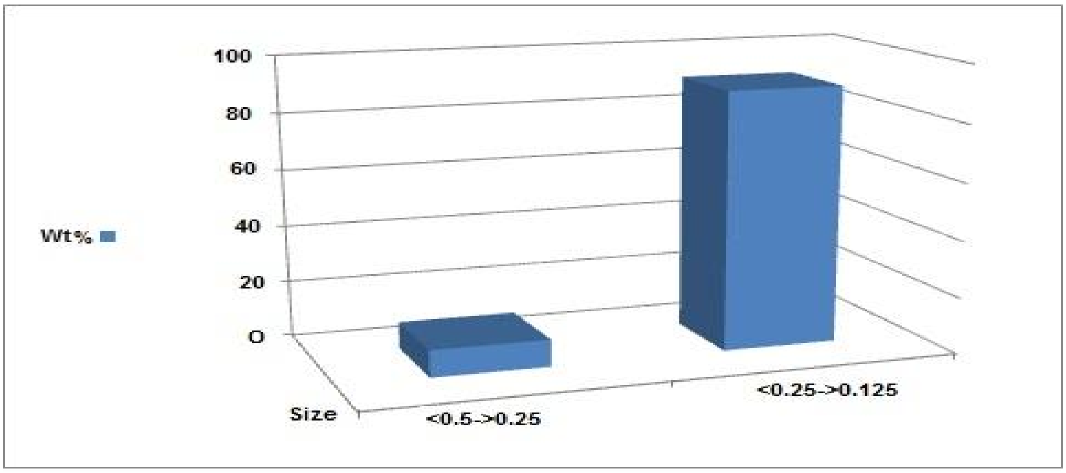

Fig. 2: Grain size distribution of quartz mineral in studied silica sand sample from Elwadi Elgedid area.

Mineralolopy

The usefulness of SEM microtextural analysis for determining sediment signatures is well documented; no single researcher has established a universally accepted, precise sample size specific to the task of reliably distinguish environmental provenances of samples. In this study analyzed 200 uni-crystalline quartz sand grains selected at random from silica sand samples.

The quartz particle surface features to discriminating between different environments see photomicrographs in figure 3. EDX of quartz grain analysis showed there are two groups of quartz grains one is free from barite inclusion and the other is contained in barite inclusion (fig.4 A & B). Quartz sand grain has Triangular curved, straight scratches and many V-shaped percussion cracks with smoothed edges (fig.3A). The presence subrounded quartz sand grain has Abrasion scratches, pits, due to chemical dissolution or chemical weathering (fig. 3B). The subrounded quartz sand grain has Straight scratches, many V-shaped percussion cracks and pits with smoothed edges (fig.3C). Quartz sand grain overgrowth has scratched, dish-shaped and pits with boundary zone between two crystals, original crystal is surrounded the edge (fig.3D). Quartz sand grain has Groove, V-shaped cracks, pits, due to chemical dissolution (fluid flow) and precipitation material (fig.3E). Thus, quartz

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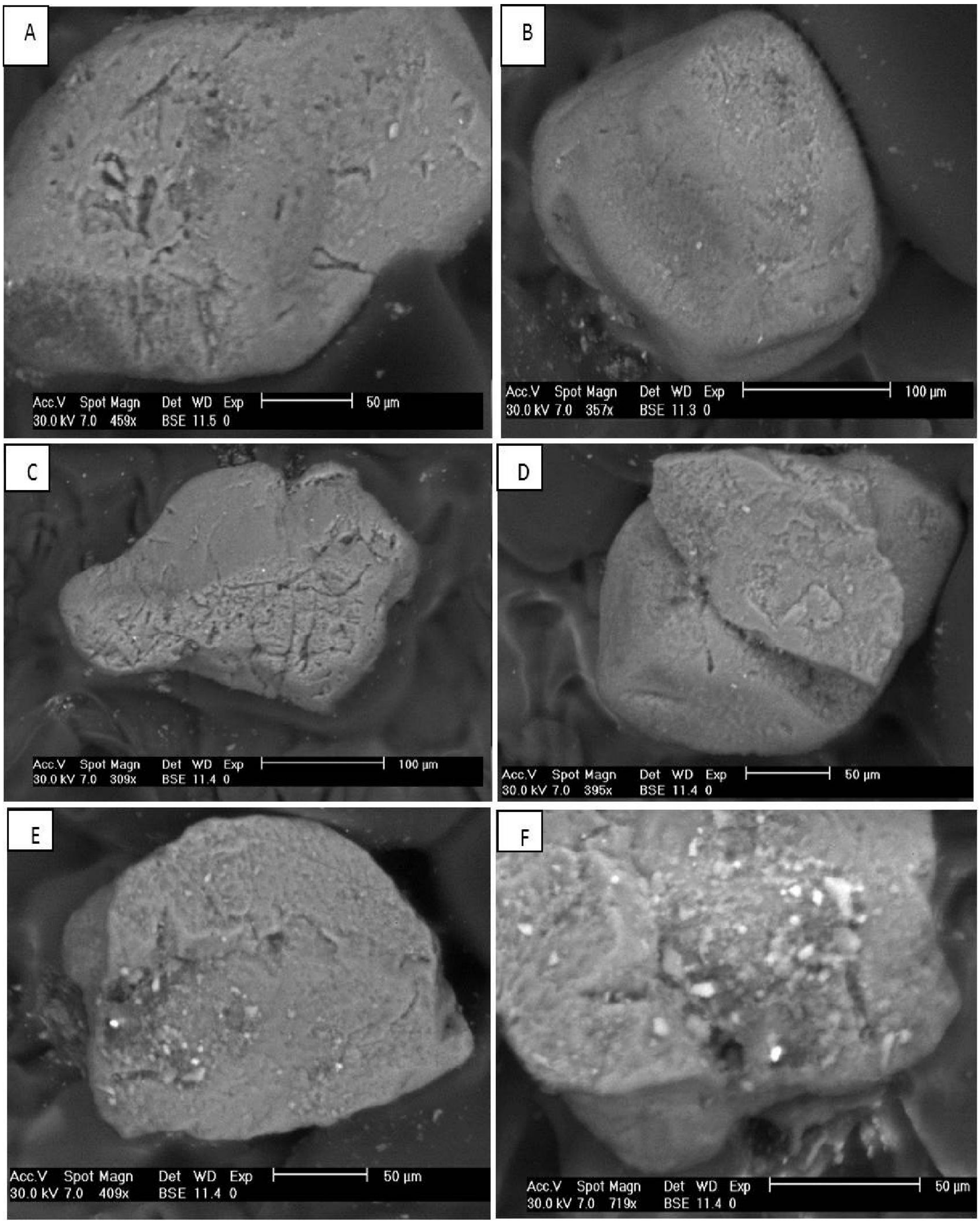
sand grain has Barite mineral which precipitated in quartz grain; focused zone in previous studied quartz grain (fig.3f).



A- Photomicrograph show triangular curved, straight scratches and many V-shaped percussion cracks with smoothed edges.
B- Photomicrograph show abrasion scratches, pits, due to chemical dissolution (chemical weathering)
C- Straight scratches, many V-shaped percussion cracks and pits with smoothed edge.
D- Quartz crystal overgrowth has scratched, dish-shaped and pits with boundary zone between two crystals, original crystal is surrounded edge.
E- Groove, V-shaped cracks, pits, due to chemical dissolution and redeposition material.
F- Barite mineral which redeposit in quartz grain; focused zone in previous studied quartz grain.

Fig. 3: Photomicrograph SEM of Quartz grains in silica sand in Elwadi Elgedid.

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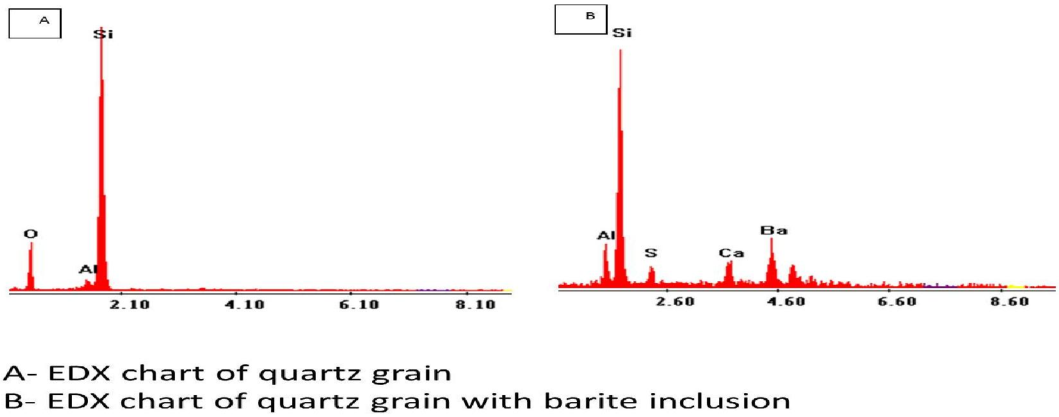

Fig. 4: EDX pattern of Quartz grains from silica sand in Elwadi Elgedid.

EDX pattern of study quartz grains from silica sand in Elwadi Elgedid can be classified into two groups. The one group, EDX chart reflected quartz mineral exists which has a chemical formula SiO_2 (fig.4A). The other EDX chart reflected quartz mineral existed and barite mineral is existed too which has a chemical formula BaS (fig. 4B).

3. Discussion

The studied sample contains grains that show several different types of microfeatures. Quartz grains are rounded to subrounded and mainly characterized by smoothing edges. These microfeatures are described and catalogued according to depositional environment (Krinsley and Doornkamp, 1973). The weathering climate and processes were deciphered (Higgs 1979). Significant contributions are made by Krinsley and Donahue (1968) and Krinsley and Margolis (1971) about quartz grain surface texture and their transport and depositional environment. The surface textures of quartz grains observed under the SEM refer to various sedimentation environments. The surface textures are mainly characterized by the dish-shaped depressions, striations, and V-shaped pits. One of the most important features that characterize quartz grains is barite precipitation. The V-shaped pits similar to on the present surface of quartz grains of the white sands are also common. Deep etching grooves as in Figure (3E) are frequently present as a result of chemical processes.

Examination of quartz grain surfaces from studying area in the boundary of the Abu Tartur plateau reveals the occurrence of mechanical and chemical surface features. From the relative frequency distribution of the various surface features of the quartz sand grains of the white sand studied sample, it is noticed that mechanical features are prevalent in white sand deposits. Chemical features are largely limited to this deposit.

Mechanically formed straight scratches are a predominant feature followed by impact V-shaped percussion cracks fractures. Rounding of the grains and smoothening of the edges indicates high energy zone. The grooves and solution pits are dominant features followed by precipitation of chemical processes. Evaporation and exposure of quartz as detrital grains pitted surfaces and rounding is indicative of chemical weathering, with partly corroded (Dickinson & Grapes, 1997). Quartz-grain surface showing triangular pits which are formed by solution and a covering of barite particles. This implies diversity in the sediment sources and in the transport agents before the last stage of sedimentation.

Thus, the rounded to sub rounded grain outlines likely resulted from long transport distance and time or a large amount of recycled sediments (Madhavaraju *et al.* 2009). Alternatively, the rounded to subrounded grain outline may reflect the original grain shape generated by the parent rock. As indicated in previous studies, grain outline is related to both the transportation process and the original grain shape of the source rock (Goudie and Watson 1981; Kleesment 2009; Costa *et al.* 2013). In this study, the geological settings of sampling area containing rounded quartz grain are basement rock around sampling area.

The scenario of diagenesis barite and precipitate in quartz pits which fluid is removing barite from clays in Qusier, Duwi and Dakhla formations during weathering then meteoric water transport it as a fine-grained waste, and other waste with different breaking and altered clay minerals. Meteorite water is an ideal way of removing some clay and subsoil, with the part produced as the waste as fines. This removes the lower specific gravity material and raises the specific gravity of the final barite product. Qusier, Duwi and Dakhla Formations are overlain Nubian sandstone which they indicated that their shales of these formations have relatively suffered low to moderate chemically weathered provenance (zidan&osman, 2014).

Kaolinite is generally produced by feldspars alteration. It requires an open and acidic environment, with extensive leaching of alkaline earths and ferrous ions and to some extent silica from the medium during the process Weaver (1989). Floyd, *et al.* (1989) has generally made kaolinite a common constituent that cannot be excluded. The origin of kaolinite in the shales overlie Nubian sandstone has been interpreted, for a long time, as a product of chemical weathering of feldspars. Kaolinite formation is favored under tropical to subtropical humid climatic conditions Hallam *et al.* (in Temraz, 2005). In addition to its detrital origin, kaolinite may also be developed by diagenetic processes due to the circulation of acid solutions Ghandour *et al.* (in Temraz, 2005). These kaolinites are believed to represent a continental weathering product at a warm and at least seasonally humid climate, being eroded and transported towards the sea by rivers.

The brief of all discussion is represented as the conceptual model. The model depicts the quartz grain history from production to deposition and the diversity of grain surface microtexture (fig. 5) is modified after Itamiya *et al.* (2019).

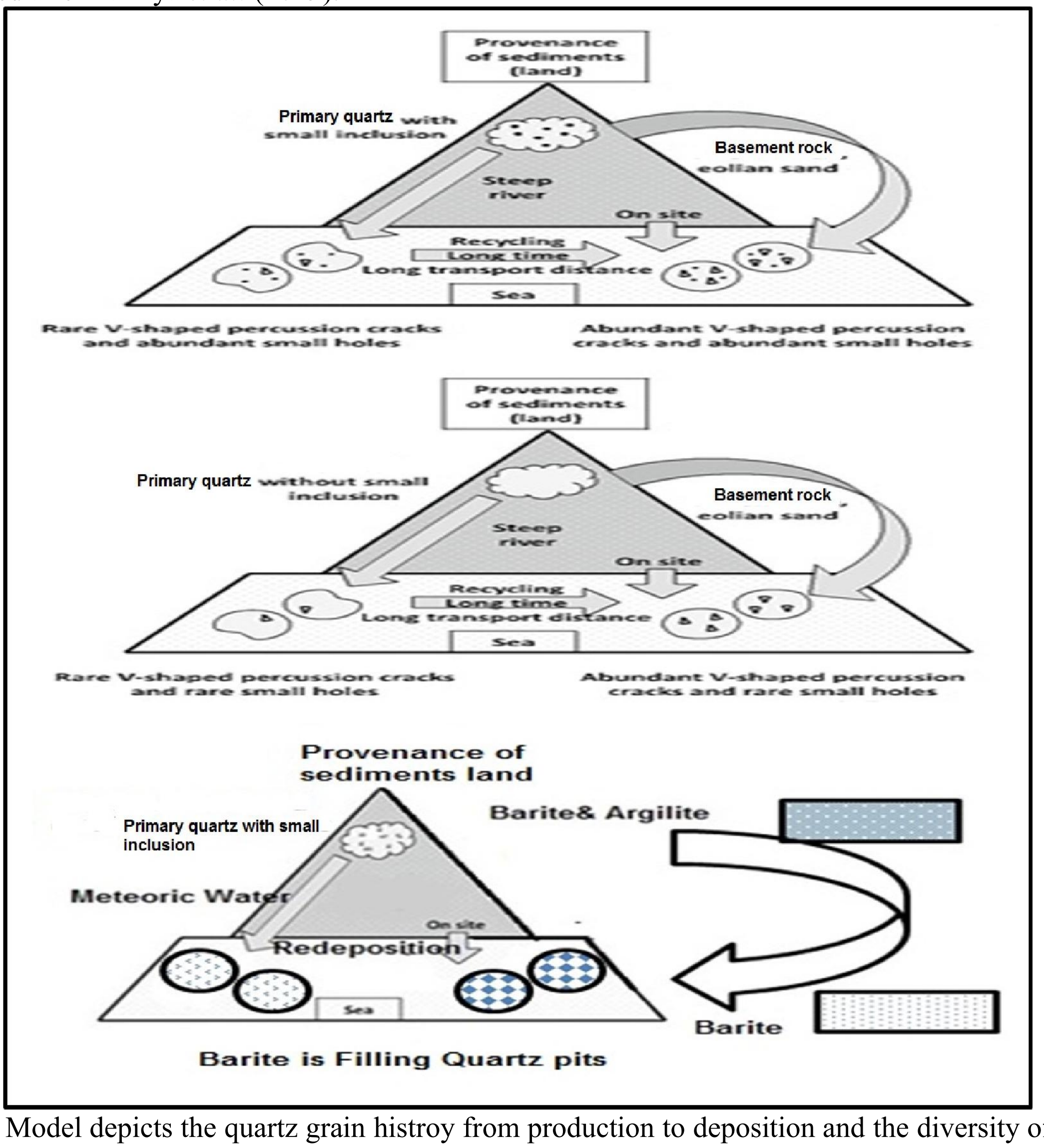

Fig. 5: Model depicts the quartz grain histroy from production to deposition and the diversity of grain surface microtexture: a) grains with abundant small inclusion, b) grains with few small inclusion and c) Barite microinclusion in quartz grain (modified after Itamiya *et al.*, 2019).

Summary

In this study, we attempted to apply quartz surface study in combination with a quartz shape study to estimate sediment provenance. Grain size and mineral composition were also analyzed. The study quartz in silica sand in general had a morphological diversity of i.e., (1) few V-shaped percussion cracks were observed from the fluvial supply beach (Margolis and Kennett 1971), and (2) features produced by chemical reaction were sparse owing to the high-energy of beaches (Margolis 1968).

In this studied area, three characteristic features reflected the sedimentary history: (1) Small holes derived from the remnants of small inclusions in the grains showed parent rock and (2) V-shaped percussion cracks produced by grain-to-grain collisions in the aqueous environment showed transportation process. (3)

Precipitation barite in quartz pits Figure (3 F) presents a conceptual model that explains the relation between the quartz morphological features.

The micro-morphological of quartz surface textures indicate the geologic source, transportation process, and depositional environment, namely the geomorphological and geological settings. Aeolian, fluvial, mass-wasting, and other processes all create combinations of microtextures on sand grain surfaces that are unique in the types exhibited and their statistical frequency.

These combinations of microtextures record the paleoenvironmental history of the area from which the grains were derived; the various forms of fractures and post-fracture surface alterations found on sand grain surfaces should therefore provide useful evidence of climate and other environmental aspects of the sand grain's history.

Variations in quartz surface textures were detected at different stratigraphical levels, whereas the texture created by mechanical processes was predominating. Abundant abrasion features like V-shaped pits, and linear and curved grooves usually give evidence of transport in a fluvial medium. On levels with intensive reworking and redeposition preliminary relief of grains was smoothed and obliterated. The diagenetic dissolution features were more, where intercalation of dolomitic and siliciclastic rocks is common. Possible chemical etching in quartz was observed and even precipitated barite as inclusion in quartz grain. The variability of microfeatures in quartz sand grain helps to clarify the history of basin evolution and to distinguish different conditions in deposition.

Conclusion

1-The studied sample contains grains that show several different types of microfeatures. Quartz grains are rounded to subrounded and mainly characterized by smoothing edges.

2-The surface textures are mainly characterized by the dish-shaped depressions, striations, and V-shaped pits. Deep etching grooves i.e.in Figure (3E) is frequently present as a result of chemical processes.

3- Examination of quartz grain surfaces from studying area in the boundary of the Abu Tartur plateau reveals the occurrence of mechanical and chemical surface features.

4-Mechanically formed straight scratches are a predominant feature followed by impact V-shaped percussion cracks fractures. Rounding of the grains and smoothening of the edges indicates high energy zone.

5-The grooves and solution pits are dominant features followed by precipitation of chemical processes. Quartz-grain surface showing triangular pits which are formed by solution and a covering of barite particles. This implies diversity in the sediment sources and in the transport agents before the last stage of sedimentation.

6- Thus, the rounded to sub rounded grain outlines likely resulted from long transport distance and time or a large amount of recycled sediments (Madhavaraju *et al.* 2009). Alternatively, the rounded to subrounded grain outline may reflect the original grain shape generated by the parent rock. As indicated in previous studies, grain outline is related to both the transportation process and the original grain shape of the source rock (Goudie and Watson 1981; Kleesment 2009; Costa *et al.* 2013).

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