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MICROMORPHOLOGY OF QUARTZ SAND GRAINS FROM SOILS OF PAKISTAN AND SAUDI ARABIA

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The micromorphological investigations of the quartz sand grains from a soil each from Pakistan and Saudi Arabia revealed the following microtcxtural features: 1. angular, irregular and rounded shapes; 2. conchoidal fractures; 3. Si-precipitation; 4. rough grain surface; 5. oriented v-shapcd, dish shaped and crcsccntic chipping and upturned plates ctc .. H is concluded that in the soil from Pakistan solution of quartz and other sand grains and the subsequent precipitation of Si are the main mechanisms which bring out the microtextural changes on the sand grains, whereas by contrast in the Saudi Arabian soil abrasion and mechanical fracture are the main modifiers of the surface textures.

INTRODUCTION

Quartz sand grains are almost universally present in soils. The mineral is relatively resistant to chem ical and physical weathering processes (Wikling *ct al., 1977).* IL is one of the most abundant minerals and occurs as an essential constituent of many igneous, sedimentary and metamorphic rocks. Quartz is one of the important member of the tcktosilicatcs,

The micromorphological features of the sand grains may give considerable insight into the environmental history of the deposit from which the grain has been brought. . The results of these environments are usually found on the sand grains surface e.g. solution and precipitation are the most important (Margolis and Krinsley, 1971). IL is suggested (Krinsley and Doornkamp, 1973) that glacial, fluvial, acolian and chemical agencies all impose their own recognisable characteristic features and etch pattern on grain surfaces. Micromorphology of sand grains can also allow estimation of the relative age of the soils (White, 1981) and soil parentage (Shahid *et al., 1990).*

Apart from the micromorphological features, the shape of the mineral as seen under the Scanning Electron Microscope (SEM) in particular can provide useful information about their sedimentary history.

In Pakistan the lack of such facilities has been a major handicap in previous studies. Not much has been published on the micromorphology of the sand grains of Pakistan soils, and only in one paper such investigations have been emphasized (Shahid *et al.,* 1990). IL was, therefore, planned to study the micromorphology of quartz sand grains from Pakistan. Few quartz grains have also been included from Hofuf, Saudi Arabia for comparison. This will give information on the micromorphology of quartz grains from contrasting climatic and soil parental conditions and may give an insight

into the past environmental history, and differences of micromorphological features developed under these conditions.

MATERIALS AND METHODS

Surface soil samples collected at 0-5 cm of the Khurrianwala soil series *(Natrie camborthids},* and 0-25 cm of the profile 2 (Torrifluvent/Torripsammcnt) from Hofuf, Saudi Arabia (Shah id, 1989). These were air-dried and sieved through 2 mm sieve. The physical and chemical measurements suggest the soil from Pakistan as saline-sodic and the one from Hofuf as saline. The soil texture was silt loam (Pakistan soil) and clay loam (Hofuf soil).

In order to identify the minerals and to study their surface morphology, the obscuring soil clay was removed ultrasonically. The fine and medium sand fractions were immersed in methyl salicylate (Refractive index = 1,54) and the quartz species identified under the polarizing microscope. The quartz grains were then separated from other minerals by suction up a fine capillary. These were washed with acetone and hand picked under binocular microscope (Wild M3Z Heerbrugg, Switzerland).

The separated quartz grains were then mounted on carbon stub. Later the whole surface of the samples was coated with carbon (in an evaporator), a few nanometer thick.

Studies by SEM/Micro})hotogra})hy: The mounted grains were thoroughly studied under the SEM (Hitachi S-520). The SEM was operated at an accelerating voltage of 15-25 kv. The magnification was progressively stepped up as this helps in the selection of sub-area for more detailed observations.

RESULTS AND DISCUSSION

A number of quartz sand grains were studied from Pakistan and Saudi Arabia. A few representative are reported in this paper.. Multiple microtcxtural features were observed in the quartz surface. These are described here in detail..

A number of micromorphological features occur on quartz grain surfaces. Heterogeneity was observed in shapes of the quartz grains from Pakistan compared to those from Saudi Arabia. Oftenly, two or more types of surface textures were apparent on the same quartz grain. The main features are illustrated in the following figures. Briefly these are: 1. Angular, irregular and rounded shapes; 2. conchoidal fractures; 3. Si-precipitation; 4. rough grain surface; 5. oriented V-shapcd, dish shaped and crescentic chipping and upturned plates etc ..

Figures 1 a and b show chatternarks on an elongated quartz grain from Pakistan. The marks are oriented and collectively form a V. The selective dissolution (V-formation) relate to difference in chemical resistance within the grain (Krinsley and Doornkamp, 1973) or this may be the application of the principle of Riecke (1895) whereby a mineral grain under stress has an increased solubility, or the abrasion solution may also' be responsible for the creation of microtextural features on quartz grain. On the basis of the present observations it can be concluded that if a grain is stressed inhomogeneously it will be dissolved at stressed points and precipitation may occur on the surface of lower stress. The grain shown in figures 1 a and b was found to have its surface almost completely frosted.

Among all the quartz grains studied from Pakistan, very few were found devoid of Si-precipitation, their surfaces always being smoothed. Fresh conchoidal fractures, however, have been also observed on quartz

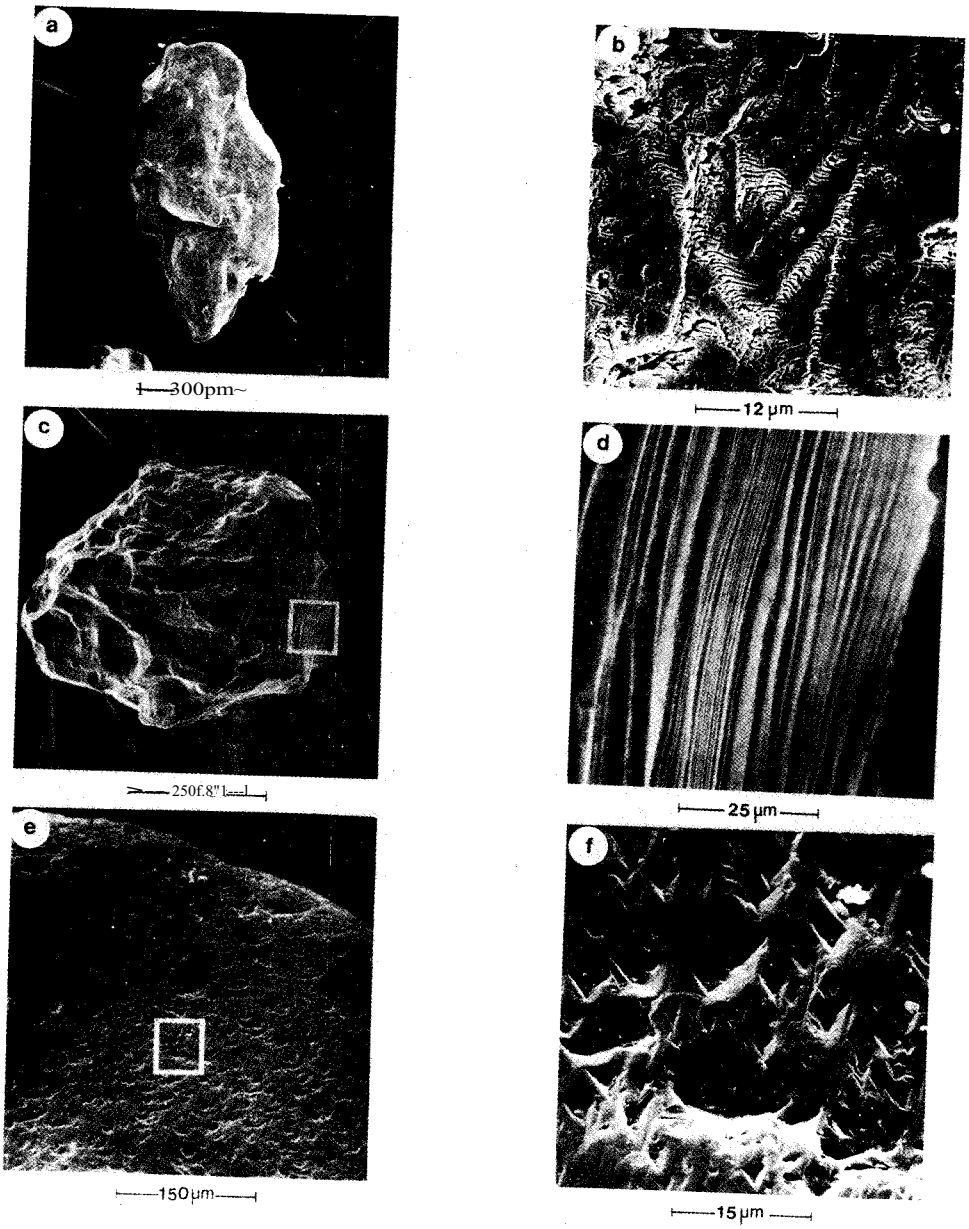

Fig. 1.

a. Elongated quartz grain.

b. "Chevron" chattermarks on an elongated quartz grain.

c. Quartz grain showing conchoidal fractures.

d. Details of conchoidal fractures.

e. Surface of a rounded quartz grain from Hofuf, Saudi Arabia.

f. Cleaned oriented *V-etched* pit pattern.

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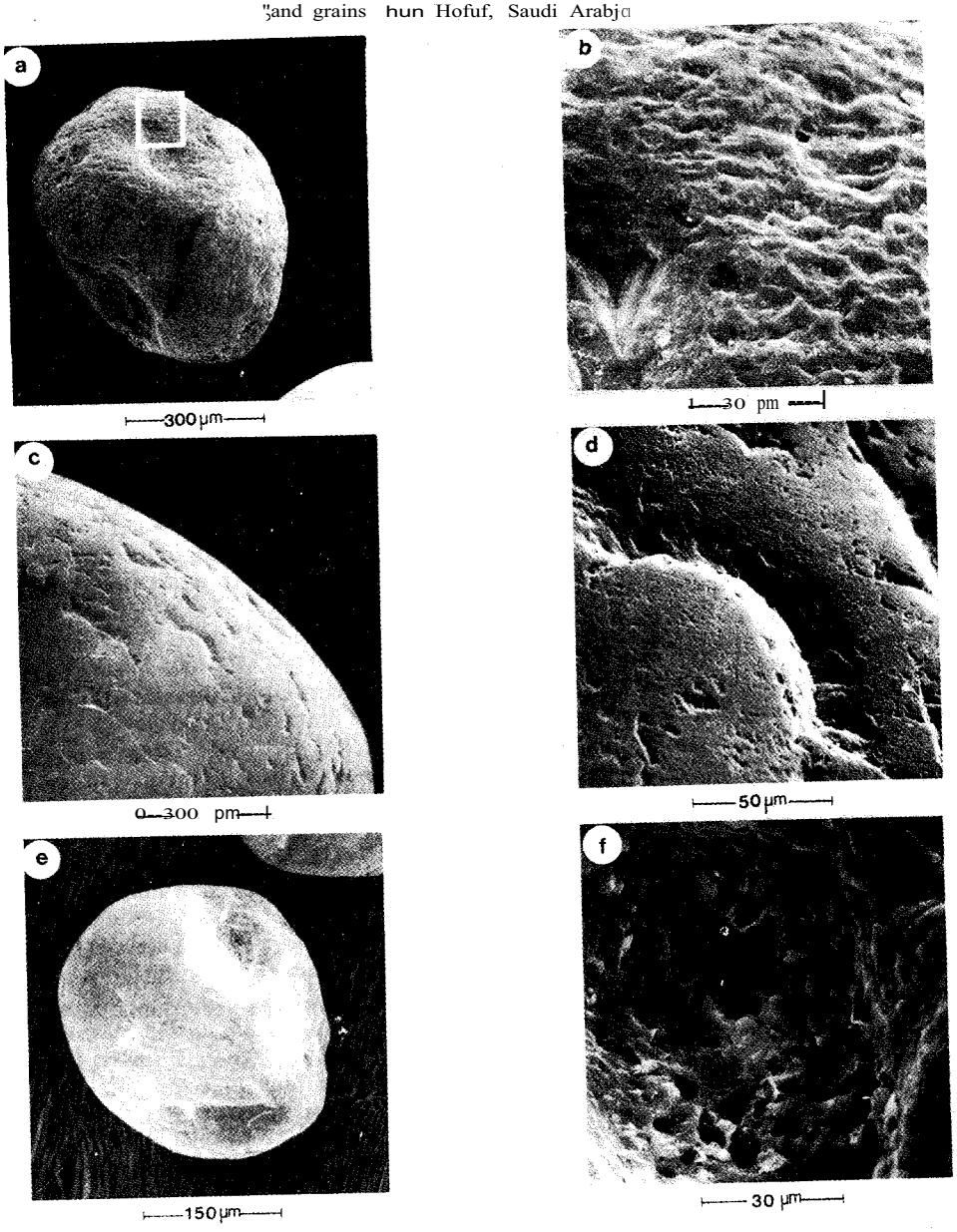

Fig. 2.

a. A round quartz grain.
b. Details from "a" showing platey etching.
c. Surface of a round quartz grain showing crescentic chipping.
d. Details of the crescentic chipping showing a V-shaped etching.
e. Round quartz grain with a cavity.
f. Details from' e" showing the infilling of weathered pit by layer silicates.

grains (Figs. 1 c & d). Figure 1 c also revealed the grain to be pitted, pits are curved and platy in nature.

On the basis of the resulLs obtained from the present study, it has been suggested that in hot environment like Pakistan, during the day/night cycles the pH of the soil water rises due to the presence of dissolved evaporites during the evening which leads to the removal of small amount of Si- and other nutrients/elements depending upon the mineral under stress. This removed Si- is rcdcposited (Kuenen & Pcdro k, 19(2) on the grain surfaces as an irregular layer of either opal or silicic acid which smooths out or subdues the pre-existing mechanical fracture pattern (Figs. 1 a & b).

A few grains from the Saudi Arabian soil have also been examined. The morphology of these grains reveals that these are either rounded without edges or elongated but still rounded. By contrast, the grains from Pakistan soils are irregular in shape. The difference in their morphologics reflects the rounding of grains from Saudi Arabia under aeolian condition. This exposes the new surfaces. In the grains from Pakistan, the corners are preserved due to the cushioning effect of water as the soils are alluvial in nature.

The micromorphology of quartz grains from Hofuf, Saudi Arabia revealed surfaces with: a frosted appearance; smoothed surface; perfectly oriented V's and patterns similar to that as given by Shah id *et al.* (1990), but without Si-precipitation (Figs. 1 e & f); platy etching (Figs. 2 a & b), crcsccntic chipping with a solution pit (V) also observed in the crescent (Figs. 2 c & d). Closely spaced chemically etched Vvshapcd triangles formations are suggested to be by "abrasion and solution" or during diagcncsis when grains are exposed to high pH solution (Margolis and Kcnnctt, 1(71). The frosted surfaces probably result from mechanical and chemical processes that are active in the acolian environment The orientation of V-shaped triangular pits and/or rounding and flattening of surfaces are suggested to be due to chemical etching. The other features observed were filling of weathered parts by layer silicates (Figs. 2 e & f) and frosted surface (Figs. 2 a & b).

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