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THICKNESS OF COATINGS ON QUARTZ GRAINS FROM THE GREAT SAND SEA, EGYPT

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INTRODUCTION

The presence of a thin coating on the surface of quartz sand grains is very common in terrestrial environments and imparts the reddish color to aeolian sand. These coatings have been studied in some detail in Simpson Desert sands by Folk (1), in Libya by Walker (2) and in the Western Desert of Egypt by our own group (3, 4). All workers agree that the coating contains both clay minerals and iron oxides. This coating strongly influences the spectral reflectance properties of these sand grains. We are investigating the characteristics of such coatings in order to assess whether they might be important on Mars and might influence the spectral reflectance data from Viking and from earth-based telescopic observations.

METHOD

We have determined coating thickness on quartz sand grains from two samples with the Great Sand Sea of the Western Desert of Egypt (Fig. 1). Both samples were taken from active dunes, approximately 400 km apart. One purpose of the study was to establish whether coating thickness varied with location and whether it increases with the distance of aeolian transport (5).

We fractured a number of representative quartz grains from each sample, cleaned them ultrasonically, and examined them with the Scanning Electron Microscope (SEM). Stereo photography was used to position fractured grains so that the fractured edge of the coatings was oriented normal to the view direction. The thickness of the coatings was then measured at from one to eleven locations on each grain.

THICKNESS RESULTS

Figure 2 shows a typical coating in cross section. Thickness results are presented as histograms (Fig. 3). Distribution of thicknesses could be roughly described as log normal although the Siwa sample shows a superimposed bimodal tendency. Thicker coatings were associated with depressions on the grain; thinner coatings were sometimes associated with areas which appeared to be relatively freshly fractured. None of the grain surfaces was free of coating material. Coating on samples from area B (Fig. 1) are slightly thicker (log mean of 0.8 micrometers) than those on samples from area A (log mean of 1.2 micrometers). This difference correlates with travel distance from source rocks which is greater for sand at location B.

TEXTURE AND COMPOSITION

The coating usually displayed a clear sharp contact with the underlying quartz grain (Fig. 2). In some cases the coating fills in rough topography producing a smoother outer surface. The coatings on grains used in this study tended to be massive rather than porous when viewed in cross section.
At lower magnification, the coatings appeared to be smooth and slightly dimpled, similar to the "turtle-skin" texture described by (1) for Simpson Desert sands. However at very high magnification the surface of the coating could usually be resolved into individual grains, many of which are platelets. The texture and morphology suggests a coating made up of a network of clay mineral platelets, usually oriented approximately parallel to the surface.

In some cases the platelets appear to be interlocking and to have grown around or on top of other platelets. The texture is not compatible with a simple detrital origin of the coating particles. If these particles were originally detrital they have recrystallized on the quartz grain surfaces. An amorphous silica component may be present in the coating (1) but it is not the primary component and may simply help cement clay minerals and iron oxide grains.

Energy dispersive x-ray analyses shows that the major elements in the coating (other than Si) are Al and Fe. For Siwa samples, K is an important component and Mg is usually present, but for Great Sand Sea samples (Location B), K and Mg are much less abundant and Al is more abundant. These results are compatible with a coating made of a mixture of clay minerals and an iron oxide. The Siwa composition suggests that illite, montmorillonite, and hematite may be present whereas the Great Sand Sea composition is compatible with a coating made mostly of kaolinite and hematite. This mineralogy was found on sand grains from Gilf Kebir farther to the south of the Great Sand Sea (3, 4).

In conclusion, the quartz sand grains which we have studied have a ubiquitous coating apparently consisting of clay minerals and an iron oxide. The coating thickness has an approximate log normal distribution with a mean of about one micrometer. The texture is not detrital and clearly shows signs of recrystallization, or of authigenic growth of minerals. Mineralogy apparently varies from place to place. These coatings clearly influence spectral reflectance signature of the sands (R. Norris, unpublished data). It is significant that these complex coatings are forming in the driest region on earth. Our preliminary data show that sand grains in the Dry Valleys of Antarctica also have complex coatings. These results support our contention that mineral grains on Mars are likely to be covered with complex coatings which may strongly influence the physical and spectral properties of the Martian regolith.

REFERENCES:

Figure 1. Location map of two sand samples from the Great Sand Sea in the Western Desert of Egypt. Sample A was collected from a complex, barchanoid dune just south of Siwa Oasis. Sample B was taken from the crest of a self dune atop a whaleback dune southwest of Abu Minqar, which is at the southern entrance of the Farafra depression and on the eastern margin of the Great Sand Sea. Straight line distance between two locations is about 400 km.

Fig. 3 (top) Coating and coating contact with underlying fractured quartz grain. Width of field is 16 micrometers.

Fig. 3 (bottom) Closeup of typical coating showing platy clay minerals, some of which are euhedral. Width of field is 1.3 micrometers.