BRIGHT SAND/DARK DUST: THE IDENTIFICATION OF ACTIVE SAND SURFACES ON THE EARTH AND MARS

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Aeolian features are common on Mars. Although wind streaks are known to be active features, controversey has arisen regarding the activity of sand sheets and dunes, particularly in the north polar erg. In the absense of *in situ* measurements, remote sensing techniques must be relied upon to address the problem. Field studies and analysis of LANDSAT Thematic Mapper data in the Gran Desierto, Mexico (Blount et al., 1986) may shed light on a technique to distinguish active from inactive (relict) sand surfaces. Active sand bodies are here defined as those with saltation surfaces on which wind-induced ripple marks and/or slipfaces are observable in field outcrop. Inactive sands are those surfaces which do not show evidence of wind movement; sand drapes and fluvial sands being the best examples. Active sand bodies in the study area are consistently brighter (by an average of 20%) at visual and near-infrared wavelengths (0.45-2.35μm) and darker at thermal infrared wavelengths (10.3-12.5μm) than compositionally similar inactive sands. The Gran Desierto study area covers more than 5,500 km^2 and includes major transverse, longitudinal and star dunes.The area is the largest sand sea in North America and has been described in detail by Lancaster et al. (in press). Sands are primarily of quartz composition (80-99%) with varying amounts of amphibole, biotite, carbonate fragments and volcanic detritus as assessory grains.

The reasons for the albedo difference between active and inactive sands are partly explained by a textural analysis of the two terrains. Active surfaces are composed of relatively higher percentages of saltation-sized grains; their higher reflectivity is in agreement with Gerbermann (1979) who found that reflectivity increased directly with weight % sand in sand/silt/clay mixtures. Material in the coarse size fraction (>250μ) is dominated by fragments of amphibole and opaque volcanic lithics (basalt). This size-fraction is generally absent from samples of active sand but makes up as much as 5-10 weight % of many inactive samples. Saltation-sized particles (62.5-250μ) are primarily quartz with minor amphibole and biotite. Active sands are highly unimodal (90-99 wt.%) in this size range. The silt-sized and smaller fraction (<62.5μ) also contains abundant quartz but with relatively more amphibole and aggregated opaque lithics present. Active sands are depleted with respect to inactive sands in both the smallest and largest size fractions present. Inactive sands contain small but conspicuous amounts of coarse sand and silt; the sizes which are dominated by darker materials. It has long been known that minute inclusions of dark material can drastically reduce the reflectance of a mixture (Singer, 1981; Clark, 1983) leading to the conclusion that the apparent darkness of inactive sands is caused by the inclusion of these darker size fractions in small quantities. In the northeastern portion of the Gran Desierto however, darker inactive sands were observed which also lacked a coarse-size fraction; all of the darkening being attributeable to the higher weight percent of darker silt-sized grains. In the TM images, low albedo (at VNIR wavelengths) corresponds to regions of higher silt/clay content. After seiving at one phi intervals both active and inactive samples show a decrease in visual reflectance with particle size. The apparent darkening of these sands with decreasing grain size is apparently contradictory to the characteristic silicate behavior of increasing reflectance with decreasing grain size (Salisbury and Hunt, 1968). While the "normal" situation holds true for the individual components of Gran Desierto sands (primarily quartz and amphibole), it does not describe the mixture of the two end-members. As darker lithic fragments break down to smaller grain sizes, their effective surface area increases in relation to the quartz component. Decreasing grain size then results in a lowering of the overall albedo for the mixture. These results are compatible with laboratory spectral work by Clark (1983), who showed that the overall reflectance in a light/dark mixture (montmorillonite + charcoal) decreases with the particle size of opaques, though the effect was attributed to opaque coatings on otherwise bright grains rather than the increased surface area of opaques present in smaller particle sizes. Opaque coating have not been observed in the Gran Desierto samples however inactive sand samples always contain quartz/lithic aggregates in their smallest size fraction (<62.5μ). Saltation-size particles of opaques are depleted in both the active and inactive samples. Aeolian sorting may be responsible for this phenomenea, although the presence of lithic opaques in the silt/clay fraction indicates that any saltation-sized fragments are rapidly abraded into smaller-sized grains.

The mixing model of Johnson et al. (1983) has been investigated for tracing the provenance of active and inactive sands based on albedo and spectral variations. If work in other field areas (Kelso Dunes, Ca. and Mohawk Dunes, Az.) confirms that each size fraction indeed possesses a unique reflectivity (assuming constant bulk composition) then a self-mixing model may develop in which each size fraction of the mixture can be considered an independent end-member. It is therefore not simply the weight percent of opaques, but also the weight percent and cross-sectional area of a given size fraction present which will control the total reflectance of a sand/silt mixture. Active sands are found to be brighter than inactive sands, not only because they contain fewer opaques but because the opaques they contain are larger in size and are contributing less to the total sand body radiance.

The Mars Observer (scheduled for launch in 1990) will image the surface at wavelengths from 0.4 to 5.2 μm with the Visual Near-Infrared Mapping Spectrometer (VIMS) and from 6.25 to 50 μm with the Thermal Emission Spectrometer (TES). Portions of these wavelength regions correspond to the Thematic Mapper data which was used to detect albedo differences between active and inactive surfaces. The identification of active sands on Earth, with *a priori* knowledge of bulk composition and grain size distribution, may allow the remote mapping of active sand surfaces on Mars. In conjunction with thermal infrared remote sensing for composition, it may also provide a method for the remote determination of grain size distributiuons within sand/silt mixtures.

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