"BRIGHT" AEOLIAN DUNES ON MARS: VIKING ORBITER OBSERVATIONS. K. S. Edgett[1,2] and T. J. Parker[3], [1]Department of Geology, Arizona State University, Box 871404, Tempe, AZ 85287-1404, USA (ken.edgett@asu.edu); [2]*New Address Effective February 1998:* Malin Space Science Systems, P.O. Box 910148, San Diego, CA 92191-0148 USA; [3]Jet Propulsion Laboratory, M/S 183-501, 4800 Oak Grove Dr., Pasadena, CA 91109 USA.

Introduction

Aeolian dunes, composed of the sediment size fraction that is capable of saltation and traction, are useful as tools of scientific inquiry. On Mars, dunes provide relatively dust-free surfaces that have potential for providing information on the composition of lithic and crystalline material. For the past 25 years, it has been assumed that all aeolian dunes on Mars are dark (have a low albedo) relative to their surroundings. Indeed, all of the largest martian dune fields have low albedos (0.15). This picture recently began to change. In terms of albedo relative to the terrain surrounding a dune field, there are three classes of dunes on Mars: (1) lower albedo, (2) albedo indistinct from the surroundings, and (3) higher albedo. The latter, dunes with a higher albedo than their surroundings, were not noticed until 1997.

This paper discusses *Viking* observations of bright dunes found in the region west of Schiaparelli Basin, Mars (**Fig. 1**). This work was stimulated by the search for *Mars Surveyor '01* and *'03* landing sites, and by new observations from *Mars Global Surveyor*, *Mars Pathfinder*, and *Sojourner*.

Background and Historical Perspective

(A) Dark and Indistinct-Albedo Dunes, *Mariner 9* and *Viking*, 1972-1997. The first Mars dunes were seen in *Mariner 9* images [1]. Nearly all dunes described from *Mariner 9* and *Viking* orbiter images have albedos that are low relative to their surroundings [*e.g.*, 1–4]. From *Viking* orbiter images, some of the smaller dunes and dune-like bedforms that occur in troughs, channels, and among lava flows, appear to have albedos that are not dark, but are instead indistinguishable from their surroundings [*e.g.*, 5, 6].

(B) Bright Dunes, *Viking*, 1997. The first dunes that are bright relative to their surroundings were recognized by K. S. Edgett in *Viking Orbiter 1* images from orbit 747 in August 1997 (**Fig. 2**). The images were obtained in July 1978. These bright dunes were shown in a talk about aeolian features in Sinus Meridiani presented to the Geol. Soc. America meeting in Salt Lake City, Utah, on 21 October 1997 (the abstract [7], written June 1997, does not mention the dunes).

(C) Bright Dunes, *Mars Global Surveyor*, 1997. More bright dunes were recognized by M. C. Malin (and team) when they released (on 10 November 1997) an image obtained 18 October 1997 by the *Mars Global Surveyor* camera (MOC) on orbit 23 (frame 6). The MOC image shows a bright dune field on the floor of a channel on the southeast rim of Schiaparelli Basin [8].

(D) Bright Dune-like Drifts, *Sojourner*, 1997. The possibility of bright dunes on Mars was bolstered by an observation that was made by *Sojourner* rover on 19 September 1997, when images were obtained that show bright drifts (resembling miniature dunes) located behind some rocks (the "Rock Garden") south of the *Mars Pathfinder* lander [9, 10]. The brightness of these drifts was suggested to indicate that they are not composed of dark, mafic sediment [10].

(E) Bright Dune-like Drifts, *Mars Pathfinder*, 1997. Finally, the *Mars Pathfinder* imaging team claimed in December 1997 that two of the three 15 cm-high drifts visible to the multispectral imager (IMP) appeared to be relatively bright [11]. It was suggested that these drifts, "Roadrunner" and "Jenkins," might be composed of "light"-colored grains (*i.e.*, possibly felsic rather than basaltic material) [11].

Bright Dunes Southwest of Schiaparelli Basin

(A) Setting of Dunes in *Viking* Orbiter 747A Images. The first dunes that are brighter than their surroundings were observed by *Viking Orbiter 1* on orbit 747 in 1978. Images 747A #31–58 are all about 15 m/pixel and are focused on a set of valleys that apparently drained northwest toward a broad, relatively smooth, bright plain located west of Schiaparelli Basin (**Fig. 1**). The smooth plain was proposed by Rice [12] to be a possible lacustrine deposit.

(B) The Dunes in 747A Images. Bright dunes are resolved on the floors of channels imaged on orbit 747A (*e.g.*, **Fig. 2**). The dunes are transverse and appear to be traveling up the valleys (*i.e.*, north to south), consistent with present wind conditions. Some low-albedo material is present, and provides a stark contrast with the bright dunes. The presence of both low-albedo material and bright dunes suggests that the dunes may be active. Dunes occur not only on channel floors, but also in depressions around an impact crater on the otherwise smooth-surfaced deposit north of the channels. Where the channels contact the smooth deposit, the channel surface is topographically lower than the smooth deposit, suggesting that deflation has occurred. It is possible that deflation of the smooth deposit is the source of the bright, saltatable grains that comprise the dunes.

(C) Constraints on Albedo from *Viking* IRTM. The dunes in the 747A images appear to be as bright or brighter than the smooth-surfaced deposit to their north (**Figs. 1, 2**). The *Viking* infrared thermal mapper (IRTM)-derived albedo (from [13]) of the surface of the smooth deposit is about 0.21. Most dunes elsewhere on Mars have been reported to have much lower albedos, on order of 0.15. The albedo of the dunes in the 747A images might be higher than 0.21.

Additional, Possible Bright Dunes Near Schiaparelli

(A) *Viking* Orbiter 411B Images. A set of *Viking Orbiter 2* images from orbit 411 cross diagonally from southwest to northeast across the smooth-surfaced bright unit west of Schiaparelli (**Fig. 1**). These images have a ground resolution of about 26 m/pixel, but drop-outs in the data give an effective resolution closer to 75 m/pixel. Regardless, one of the more intriguing images from this set is 411B91, which shows a channel that drained westward into an 80 km-diameter crater (**Fig. 1**). The image (**Fig. 3**) shows a surface of sharp bright and dark contrasts. The channel walls are dark except for a few bright, apparently layered outcrops. The channel floors are bright. No dune shapes are present.

(B) Interpretation of 411B Images. Prior to recent observations of bright dunes, the standard interpretation of

411B91 would be that the dark surfaces are areas of active aeolian sand transport, and the bright surfaces are areas of modern-day bright dust deposition. However, the occurrence of bright dunes on channel floors seen elsewhere near Schiaparelli Basin (described above and from MGS images [8]), it is reasonable to speculate that the bright channel floor material in 411B91 (Fig. 3) is also attributable to aeolian dunes.

Activity and Composition of Bright Dunes

The bright dunes described here occur in Sinus Meridiani, a low-albedo region that has been presumed to have sufficient aeolian activity that bright dust does not accumulate there [7]. To find bright dunes among these dark surfaces suggests that the bright dunes, also, might be active and composed of bright sand rather than being coated by dust.

The relatively high albedo of the dunes suggests that they are composed of something other than the mafic sands commonly assumed for most martian dune fields. In the cases presented here, the bright dunes are associated with channel floors and a possible lake deposit. The bright dunes might therefore be composed of minerals that were relatively resistant to chemical and mechanical weathering during the Noachian Epoch, when liquid water was probably flowing in the channels. Such minerals might include quartz and, perhaps, feldspars. Alternatively, the dunes could contain minerals that precipitated from the proposed lacustrine environment, such as evaporites or carbonates.

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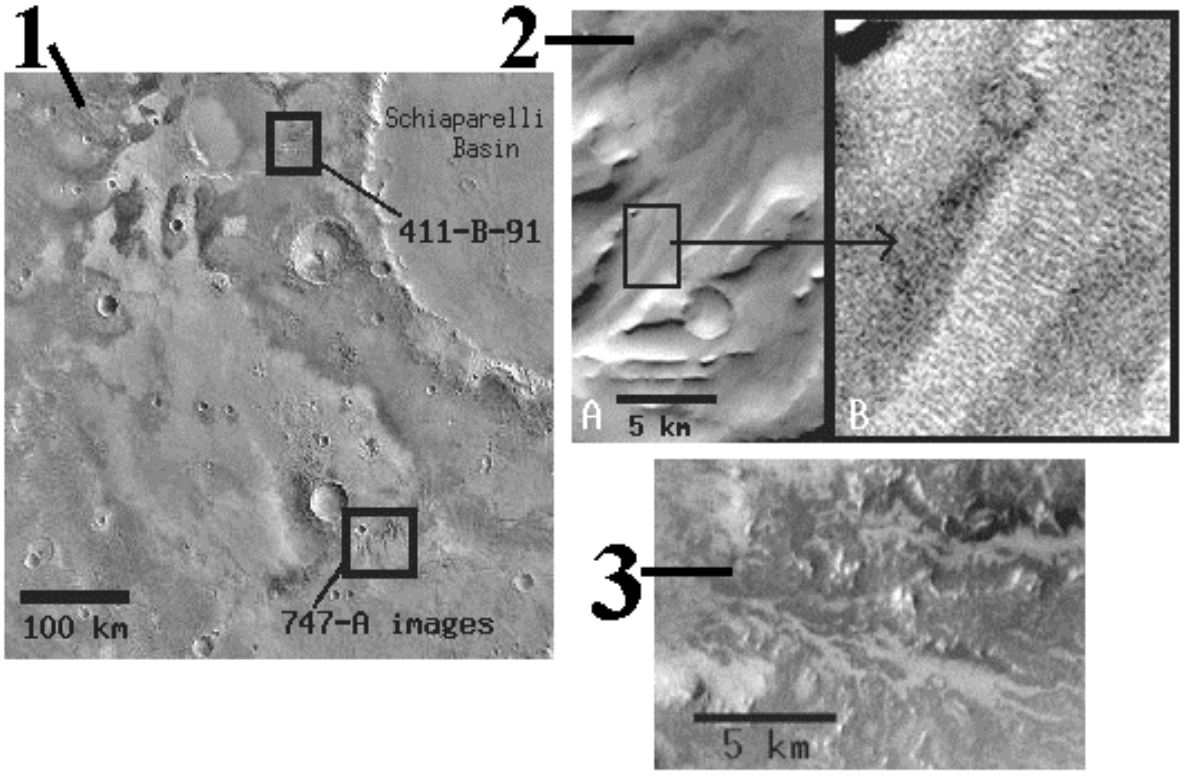

Figure 1. Region west of Schiaparelli Basin where several bright dune fields are seen in Viking orbiter images. Boxes indicate general locations of **Figs. 2** and **3**. North is up, photomosaic of *Viking* orbiter images from U.S. Geological Survey.

Figure 2. Portion of *Viking* image 747A49, with example of bright dunes in and among channels southwest of Schiaparelli. Image A shows context for the magnified, stretched view in B. North is toward upper right, illumination from upper left.

Figure 3. Portion of *Viking* image 411B91, showing bright channel floors interpreted to be possible bright dune fields. Some bright material is seen in outcrops on channel walls. North is up, illumination is from left.

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