basalts or other igneous rocks, the interpretation of the volcanic evolution on Mars would be very different from current models. The disadvantage to the approach of landing on a homogeneous unit, such as the ridged plains, is that the measurements would be primarily for a single rock type (but of known geologic context) and would not address questions of compositional diversity on Mars.

The second approach is to select a site that potentially affords access to a wide variety of rock types. Because rover range is limited, rocks from a variety of sources must be assembled in a small area for sampling. Sedimentary deposits, such as channel deltas, derived from sources of various ages and rock types, potentially afford this opportunity. For example, a site in southeast Chryse Planitia (19.3°N, 35°W; –1.5 to –1.0 km elevation) is on outwash plains from Ares, Tiu, Shalbatana, and Simud Valles. Headwind regions for these channels include assemblages of ancient crust (Noachian plateau material) and Hesperian ridged plains, as well as modern eolian deposits indicated by local wind streaks. This general approach is demonstrated in Death Valley, where landing site studies were conducted, simulating Mars. A randomly located "touch down" was made on the Furnace Creek alluvial fan. Within a 1-m radius of the landing site, samples of rock included basalt, rhyolite, diorite, quartzite, limestone, and siltstone; within a 2-m radius, additional rocks included sedimentary breccia, carbonate siltstone, and gabbro. All these rocks were transported from the surrounding mountains. Although Death Valley is not a complete analog to Mars, the area shows that alluvial fans and river mouths may be good sites to collect a wide variety of rocks. The disadvantage of this approach on Mars is that the geological context of the rocks in the deposit is not known, and the compositions of the potential contributing source units must be inferred.

Regardless of the approach taken in site selection, the Pathfinder site should include eolian deposits and provisions should be made to obtain measurements on soils. It is important to note the fundamental difference between dust (known to exist on Mars) and sand (suggested to exist). Martian dust is <10 µm in diameter and is settled from suspension. The dust is probably derived from a wide variety of sources and is thoroughly mixed through repeated cycles of global dust storms. As such, dust represents a global "homogenization." In contrast, sand is deposited from transport in saltation and reflects mostly local and regional sources upwind from the site. Sand grains are probably a few hundred micrometers in diameter or larger. Wind streak orientations and general circulation models of the atmosphere provide clues to the sources for sand. In addition to sand and dust, soils may include material derived from local weathering. Thus, it is desirable to be able to handle and analyze all three potential components of martian soil: dust, sand, and locally weathered material.

Tests conducted in March 1994 at Amboy lava field in the Mojave Desert with the Russian Marsokhod rover provide insight into the scientific use and operation of small rovers. The range was <100 m and the imaging system was limited in resolution. "Descent" images (a series of progressively higher-resolution images from orbital scales down to ~20 cm/pixel) were available for planning the science tests and rover operations. Initial results indicate (1) without the context provided by the descent images, the geologic setting of the site would have been difficult or impossible to determine (Pathfinder, for example, will not have descent imaging); (2) the low height (~1 m) of the stereo camera on the rover gives a different perspective of the terrain than is obtained from standing in the field; (3) the stereo imaging system developed for navigation by the rover was inadequate for most science analyses; and (4) the use of a simulated hand lens (×10) and microscope (×100) was extremely valuable for analysis of sand, dust, and rock samples.

Based on these considerations, a recommended approach for selecting the Mars Pathfinder landing site is to identify a deltaic deposit, composed of sediments derived from sources of various ages and geologic units, that shows evidence of eolian activity. The site should be located as close as possible to the part of the outwash where rapid deposition occurred (as at the mouth of a channel), because the likelihood of "sorting" by size and composition increases with distance, decreasing the probability of heterogeneity. In addition, it is recommended that field operation tests be conducted to gain experience and insight into conducting science with Pathfinder.

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OBSERVATIONS BY THE MARS '94 ORBITER AND POSSIBLE CORRELATIONS WITH MARS PATHFINDER. H. U. Keller, Max-Planck-Institut für Aeronomie, D-37189 Katlenburg-Lindau, Germany.

The Mars '94 spacecraft will still be operational when Mars Pathfinder begins its observations. While it will probably not be possible to detect the lander directly, the terrain, including the landing error ellipse, can be covered in high resolution (10 m) in various color bands. The stereo capability of the high-resolution camera will provide a three-dimensional terrain map. The landing site of Pathfinder could possibly be chosen so that correlated observations of IMP and the remote sensing instruments onboard Mars '94 may be possible. We will discuss this scenario based on the presently adopted Mars '94 orbit and resulting enhancements stemming from correlations of data obtained by both spacecraft.

N95-16193

POTENTIAL LANDING SITES FOR MARS PATHFINDER. R. Kuzmin[1], R. Landheim[2], and R. Greeley[3], [1]Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, Kosygin Street, 19, Moscow, 117975, Russia, [2]Departments of Botany and Geology, Arizona State University, Box 871404, Tempe AZ 85287, USA, [3]Department of Geology, Arizona State University, Box 871404, Tempe AZ 85287, USA.

The last successful landing on Mars occurred in 1976 with the Viking mission. In the ensuing years, much has been learned about Mars and the characteristics of its surface. In addition to a better understanding of the geological evolution of Mars, new techniques for processing available data have emerged, new data have been acquired, and the engineering approaches for placing spacecraft on the surface have evolved. Selection of the Mars Pathfinder landing site must take these issues into account, along with mission constraints. In addition, consideration should be given to complementary sites chosen for the Russian Mars '94/'96 lander. The Mars '94 mission will establish a network of two small stations and two penetrators (Table 1) in Arcadia Planitia. Sedimentary and volcanic deposits are characteristic of the northern and southern regions respectively.

TABLE 1. Potential Mars Pathfinder landing sites.

Prior. #	Location	Lat./Long.	Elevation	Geology	MC Chart
1	Ares Vallis/Tiu Vallis	19.3°N, 35°W	−1.5 to −1 km	Fluvial dep. (delta?) (N, H, A)*	11 NW/Amazonis Planitia
10	Mawrth Vallis	27°N, 23°W	< 1 km	Fluvial dep. (delta?) (N, A)*	11 NE/Oxia Palus
11	Hypanis Valles	11.5°N, 45.5°W	0 to 1 km	Fluvial dep. (delta?) (N)*	10 SE/Lunae Palus
9	Kasei Valles	26°N, 48.5°W	−3 to 0 km	Fluvial dep. (delta) (N, H, A)*	10 NE/Lunae Palus
8	Maja Valles	17.5°N, 53°W	−1 to 0 km	Fluvial dep. (delta?) (N, H)*	10 NE/Chryse Planitia
2	Kasei Valles	21°N, 75.5°W	0 to 1 km	Fluvial and eolian mat. (N, H, A)*	10 NW/Lunae Palus
12	Arago Crater	10.2°N, 330°W	1 to 2 km	Fluvial and eolian mat. (N, A)*	12 SE/Arabia Terra
6	Marti Valles	6.5°N, 183.5°W	−1 to −2 km	Fluvial and volcanic mat.? (A)*	15 SE/Elysium Planitia
7	Marti Valles	2.5°N, 191°W	−1 to −2 km	Fluvial and volcanic mat.? (A)*	15 SE/Elysium Planitia
3	Medusae Fossae	1°N, 160°W	0 to 1 km	Eolian and volcanic mat.? (A)*	8 SW/Amazonis Planitia
4	Medusae Fossae	1°N, 146°W	1 to 2 km	Eolian and volcanic mat.? (A)*	8 SE/Amazonis Planitia
5	Lunae Planum	20°N, 61°W	0 to 2 km	Volcanic mat. (H)*	10 NE/Lunae Palus
			Mars '94/'96 Landing Sites *Small Stations*		
	Arcadia Planitia	40.6°N, 158.5°W	−1 to −2 km	Young sedimentary mat. (A)*	2SW,2SC/Diacria
	Northern Amazonia	30.5°N, 165°W	−1 to −2 km	Young volcanic mat. (A)* with eolian mantling	2SW,2SC/Arcadia
			Penetrators		
	Arcadia Planitia	38°N, 162°W	−1 to −2 km	Young sedimentary mat. (A)*	2SW,2SC/Diacria
	Arcadia Planitia	39°N, 154°W	−1 to −2 km	Young sedimentary mat. (A)*	2SW,2SC/Diacria

* N - Noachian system, H - Hesperian system, A - Amazonian system.

An advantage of Mars Pathfinder is the rover for sampling surface materials over a range of tens of meters. However, engineering constraints and the limited scientific payload of this mission require new approaches for landing site selection [1]. One approach is to select sites exhibiting a wide variety of rocks near the lander (e.g., Arago Crater, Site 12). An alternative approach is to select sites in which the regional geology consists of a single rock type representing a key datum for the geological study of Mars, and is uniformly distributed within the landing ellipse. Examples of this approach include (1) landing sites on rocks of Hesperian age, e.g., ridged plains (site 5), (2) sites that contain sedimentary deposits of Amazonian age with sharply distinct individual surface morphology, e.g., deposits of the Medusae Fossae Formation (sites 3 and 4), and (3) young volcanic deposits, e.g., Marti Vallis (sites 6 and 7).

Based on these approaches and consideration of landing safety, 12 sites were selected for Mars Pathfinder (Table 1). Of these landing sites, six sites (sites 1, 6, 7, 8, 9, and 10) are consistent with the nominal mission requirements. Three additional sites (sites 4, 5, and 12) can be considered if elevation constraints are increased to 2 km. Three other sites (sites 2, 3, and 11) are located between 0 and 1 km. Six of the sites (sites 2, 3, 4, 6, 7, and 12) are included in the area occupied by surface Unit 1 [2]. Another three sites (sites 5, 8, and 11) are located within Unit 3, and the remaining three sites (sites 1, 9, and 10) are located in the boundary zone between units 2 and 3. From the 12 proposed sites, nine sites (sites 2, 3, 4, 5, 6, 7, 8, 11, and 12) have a rock abundance of 3–8%. Three other sites (sites 1, 9, and 10) have a rock abundance of 8–15%. All selected sites are in regions with different surface roughness characteristics (meters to tens of meters scale) expressed as RMS slope values. From the 12 sites, only one site (site 3) is characterized by the highest RMS slope value (10°–15°), but exhibits the lowest values of thermal inertia ($<3 \times 10^{-3}$ cal/cm^{2}s$^{1/2}$K) and rock abundance (<6%). The remaining eleven sites have RMS values <8°.

Under nominal elevation constraints, especially with regard to Mars Pathfinder, we propose the Ares-Tiu Valles and Maja Valles delta areas (sites 1 and 8), and Marti Vallis (sites 6 and 7) as high-priority targets. If the maximum elevation constraints are increased to 2 km, the more favorable sites are the Ares-Tiu Vallis delta area (site 1), Kasei Vallis bend area (site 2), Medusae Fossae (sites 3 and 4), and Lunae Planum (site 5).

References: [1] Greeley R. and Kuzmin R., this volume. [2] Christensen P. R. and Moore H. J. (1992) in *Mars* (H. Kieffer et al. eds.), 686–729, Univ. of Arizona, Tucson.

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A PERSPECTIVE OF LANDING-SITE SELECTION. H. J. Moore, U. S. Geological Survey, Menlo Park CA 94025, USA.

The Viking '75 Project began examining the problems of landing two spacecraft on Mars immediately after project authorization in 1969. This examination resulted in the Viking-Mars Engineering Model [1], which addresses the interplanetary, near-Mars (>60 km), atmospheric (<60 km), and surface environments and astrodynamical data.

During the Mariner 9 Mission, a Viking Data Analysis Team examined images and other data in near-real time, assessed Earth-based radar echo data, and prepared terrain maps with the intent of identifying potential landing sites [2]. No sites were identified because of uncertainties in image interpretation engendered by a