POTENTIAL MARS 2001 SITES COINCIDENT WITH MAGNETIC ANOMALIES.

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Introduction. Of the areas that meet the engineering criteria for MSP 01, only two are coincident with magnetic anomalies measured by the MAG/ER instrument on MGS [1,2]. Area A is centered on ~10°S, 202°W and extends from ~7.5°S to 15°S. This area is associated with three bands of magnetic anomalies, two with positive values surrounding an area with negative values. Area B corresponds with a circular high positive magnetic anomaly and is centered at 13.5°S, 166°W. In addition to magnetic anomalies, the proposed sites have other attributes that make then attractive from of standpoint of meeting the objectives of the Mars Program.

The landing site candidates meet the engineering requirements outlined on the Mars '01 landing site page http://mars.jpl.nasa.gov/2001/landingsite. These are (source of data in parentheses): latitude between 3N and 12S, rock abundance between 5-10% (IRTM), fine-component thermal inertia > 4 cgs units (IRTM), topography <2.5 km (MOLA). There are three exceptions: 1) Area B contains sites that lie up to ~15°S, 2) some sites are considered that have rock abundance values of 3-13%. 3) High resolution Viking coverage may not be available. These exceptions will be noted below.

Area A. This area (Fig. 1) offers the opportunity to land at the highland/lowland boundary. From south to north, a positive magnetic anomaly correlates with the extensive Noachian cratered unit (Npl1, 3) and dissected unit (Npld). The anomaly becomes negative northward, where the highest negative values roughly correspond to the knobby plains material (Apk) at the HH/LL boundary. The proposed landing site is within the knobby plains material, in the center of what can be seen as an older crater remnant, likely part of Npl1. Inferring from the color scale bar provided by the MOLA team [4], the site lies ~1 km below the highlands to the south and may offer views of the boundary if the spacecraft lands close to the boundary. Local knobs and mesas may offer views of the stratigraphy of the area and examples of Noachian materials. Two channels can be seen in the Viking EDR (596A26; 8.29°S, 202.1°, 225m/px) to flow northward from the highlands into the landing site area; one channel continues through the area. The site is smooth and crater-free on this scale. Channels, knobs and some polygonal terrain in the smoother areas are visible and are present within a 20 km landing ellipse.

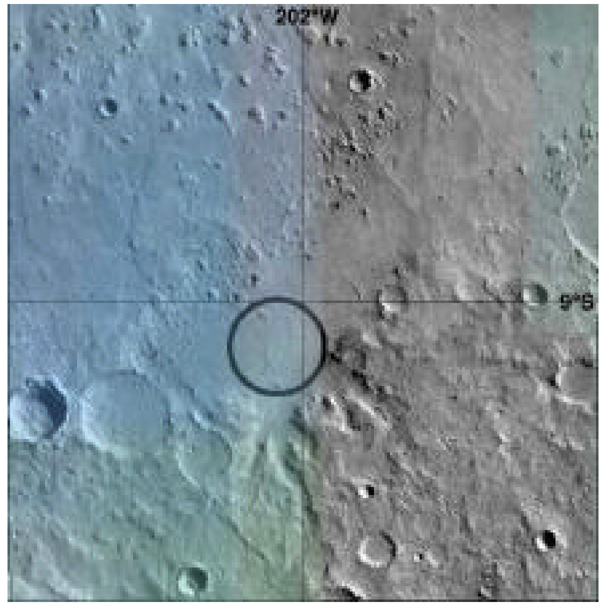

Figure 1. **MDIM of Area A, with overlay of magnetometer data. Colors are from [2], where blues indicate negative values of the radial component of the magnetic field. A 20 km landing ellipse is indicated.**

Area B. (Only qualifies in the 3-13% rock abundance range). A semicircular positive anomaly is present in this area centered on ~13.2°S, 165.2°W. The values are within the darkest red of the colorbar provided in [2], and thus may include values as high as 1500nT. These high values are present within an area that satisfies the 01 constraints (3-13%) at ~13°-15°S, 165°-165.8°W (Fig. 2). This range encompasses two Noachian units, the cratered unit, Npl1, and the ridged unit, Nplr. The maximum values for the magnetic anomaly roughly correspond with the limits of the cratered unit. MDIM resolution (231m/px) images show the site to be smooth, with the largest crater ~3km diameter. Broad ridges trend N, NNE and are ~5km across. Numerous channels are visible and flow into several local craters. A high-resolution Viking EDR (441S13; 13.47°S, 165.4°, 56m/px), within the MDIM shows numerous ridges, channels, and etched terrain An area smooth at the 56 km scale is entirely within a 20 km landing ellipse and contains ridges and at least one buried crater. In sum, this site offers a high probability of sampling and characterizing Noachian aged rocks including channel deposits and excavated materials.

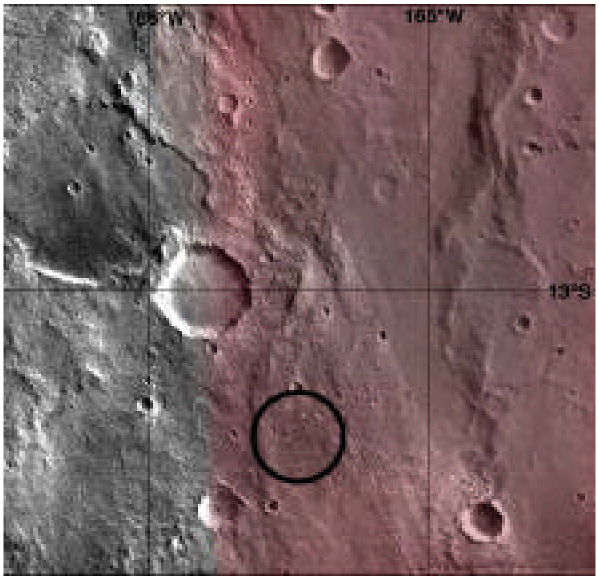

Figure 2. MDIM of Area B with overlay of magnetometer data. Colors are from [2], where the red hues may include values as high as 1500nT. A 20 km landing ellipse is indicated.

Landed science investigations. While ’01 does not have a magnetometer, it may be possible to test some of the ideas emerging from the magnetometer data using the instruments on ’01. One hypothesis suggests the magnetic anomalies are coincident with ancient seafloor spreading of some kind; this can be investigated at site A, contained within one full magnetic reversal. Several types of morphologies and rock chemistry are typical of spreading centers on the Earth. Morphologies such as sheeted dikes, gabbro dikes within harzburgite or dunite, and gabbros that display magmatic foliation are typical of terrestrial ophiolites [5]. Realizing the extreme difficulty in landing on Mars and observing bedrock exposures, we may have to rely on impact cratering in Noachian terranes to expose layers and distribute a representative sample of the crust within observation of the lander and rover. The observation of a boulder containing cumulate layered gabbro sequences is strong indicator of a large magma chamber predicted to be associated with both seafloor spreading and with large volcanoes.

Confirmation of the presence of martian spreading center rocks will be difficult, if not impossible to derive from APXS measurements. Basalts, dunite, harzburgite and pyroxenites, all typical of mid-ocean ridge assemblages, are represented in the SNC meteorites, but we have no way, to my current knowledge, of classifying these rocks as a martian MORB vs. a flood basalt or some other local magmatic phenomenon. If we landed at Mars and identified an orthopyroxenite like ALH84001, the only Noachian aged SNC, we could only confirm a plutonic origin.

Both Sites A & B offer the opportunity to search for anomalous compositions that could produce the very high magnetic values; site B contains values that may be as high as the 1500 nT range.

The discovery of magnetic anomalies at Mars argues for the placement of a magnetometer on the ’03 and ’05 rovers. Such a rover-deployed magnetometer could be placed against rocks and orientation and magnitude of magnetism could be measured. Such measurements of rocks from which samples are cached and returned will provide invaluable information about the timing of the magnetic field at Mars. I further suggest that if the ‘01 engineering requirements also constrain ‘03 and ‘05, these two areas should be targeted by MOC for more detailed investigation.

References. [1] Acuña M. H. et al., (1999) *Science 284*, 790-793. [2] Connerney J. E. P. et al., (1999) *Science 284*, 794-798. [3] Scott D. H. and Tanaka K. L. (1986) *USGS Misc. Ser. Map I-1802-A*. [4] Smith et al. (1999) *Science 284*, 1495-1503. [5] Nicolas et al. (1994) in *Magmatic Systems*, 77-95.