

Where is Viking Lander 2? Recovered Landing Site in MRO Images Not in Agreement with Earlier Predictions!

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Introduction: Landers on the surface of Mars constitute unique landmarks for geodetic control point networks. Typically, their positions with respect to prominent surrounding surface features and their Mars-fixed coordinates, derived from radio tracking, are well established. Unfortunately, Viking 2 landed in a vast desert, which lacked prominent surface markings in its neighborhood. Hence, though this lander's Mars-fixed coordinates are precisely known [6,8], its location with respect to surroundings was heavily disputed among various study teams. The Mars Reconnaissance Orbiter and its onboard camera HiRise [<http://hirise.lpl.arizona.edu/>] recently obtained image data in which the Lander was finally found. Surprisingly, the location of the site is not in agreement with any of the earlier predictions.

Landing Site Predictions: Stooke [2] and Parker et al. [3] had revisited the panoramic images, taken by the lander to correlate features seen near the horizon with features seen in Viking Orbiter and MOC (Mars Orbiter Camera) images. Image processing techniques –not available in the Viking era– were used to improve recognition of features in the images. A number of new features were identified in the images and used in the correlation. Both authors agree that the crater Goldstone is visible in the panoramic images in the northeastern direction. However, while Stooke proposes that the landing site is at a distance of 13 km from this crater, Parker et al. suggested that the landing site is at some greater distance, about 20 km (see Fig. 1). More recently, in 2004, the Mars Global Surveyor's MOC camera had taken images of the lander area [http://www.msss.com/mars_images/moc/2

006/09/03/], and the Lander was tentatively identified near a small crater.

Our estimate [1, 4] of the lander location had been made on the basis of Control Point Network analysis, for which approx. 1100 Viking Orbiter images and image line/sample measurements for 3300 control points had been used. In this process, accurate pointing data for the images of the network were computed; these data effectively tied images to the Mars-fixed coordinate system to within 1-3 km for most places on the planet [5]. With this much improved "map-tie", it was possible to make an accurate prediction for the location of the landing site in images on the basis of the known Mars-fixed coordinates of the lander (47.668°N, 134.28°E, geocentric, in the IAU 2000 system) [6]. The network images had resolutions between 800-1100 m/pixel, and therefore were not adequate to resolve surface details near the VL2 landing site. Two higher-resolution (80 m/pixel) images of the lander area (F009B14, 15) were therefore chosen to serve as a lander area reference map (Fig. 1). Because of the drastic difference in the resolutions, images of intermediate resolution (F807A32, 34) were also considered in the analysis. All images involved were finally tied to the control point network images by block adjustments and converted to map space. According to our prediction, the lander location was 25 km southwest of the crater Goldstone with an estimated one sigma error of 750 m.

Comparisons with MRO and HRSC: By visual inspection of the MRO images with previous landing site plots [1], we find that the recovered landing site is off from all predictions (see Fig. 2). Specifically, the

estimates of Stooke [2] and Parker et al. [3] are off by approx. 5.3 and 2.3 km, respectively. Likewise, our estimate from control point analysis is offset by approx. 3.6 km to the South-West. Furthermore, it appears that in the MOC images, the Viking lander 2 back shell was mistakenly identified to be the Lander. In fact, the shell had impacted the ground approx. 420 m off the actual landing site.

We wish to investigate the reasons for the discrepancy between the lander location and our early control point network analysis. While we tacitly assume that the lander is correctly identified in the MRO images we wish to verify that the Mars-fixed coordinates of the Lander [6, 8] are correct. As we currently have no means to reference the MRO images to the Mars-fixed coordinate system, we adopted the images obtained by HRSC (High Resolution Stereo Camera) to relate the landing site to Mars-fixed coordinates. The orthorectified HRSC image obtained in orbit 1394 was used. An attempt was made to pinpoint the Viking landing site as seen in the MRO images in the HRSC counterpart, in spite of the difficulties associated with the difference in the image resolutions and the low texture in the area. The Viking lander 2 coordinates were recently updated by Konopliv et al. [8] (47.668093°N, 134.282101°East). It

appears that the landing site is in agreement with the Mars-fixed coordinates on the order of 100 m. This attests to the excellent (!) geometric accuracy of the data from the HRSC experiment – but also to a possible error in our earlier control point analysis. We will further discuss the issue at the meeting.

References: [1] Oberst, J. et al. (1998) *J. Geophys. Res.*, Vol. 104, No. E4, 8927-8933. [2] Stooke, P.J. (1998) *Lunar and Planetary Science XXIX*, Abstract #1024, Lunar and Planetary Institute, Houston (CD-ROM). [3] Parker, T.J., and R.L. Kirk (1999) In the Fifth International Conference on Mars, Abstract #6124, LPI Contribution No. 972, Lunar and Planetary Institute. [4] Zeitler, W. and J. Oberst (1998), *J. Geophys. Res.*, Vol. 104, No. E4, 8935-8941. [5] Oberst, J., W. Zeitler, and T. Parker (1999) *EOS Trans. AGU*, Vol 80, No. 46, 549, 553. [6] Folkner et al. (1997) *Science* 278, 1749-1752. [7] Oberst, J. et al. (2000) *Lunar and Planetary Science XXIX*, Abstract #1074, Lunar and Planetary Institute, Houston (CD-ROM). [8] Konopliv, A. S. et al. (2006) A global solution for the Mars static and seasonal gravity, Mars orientation, Phobos and Deimos masses, and Mars ephemeris, *Icarus*, 182, 23.

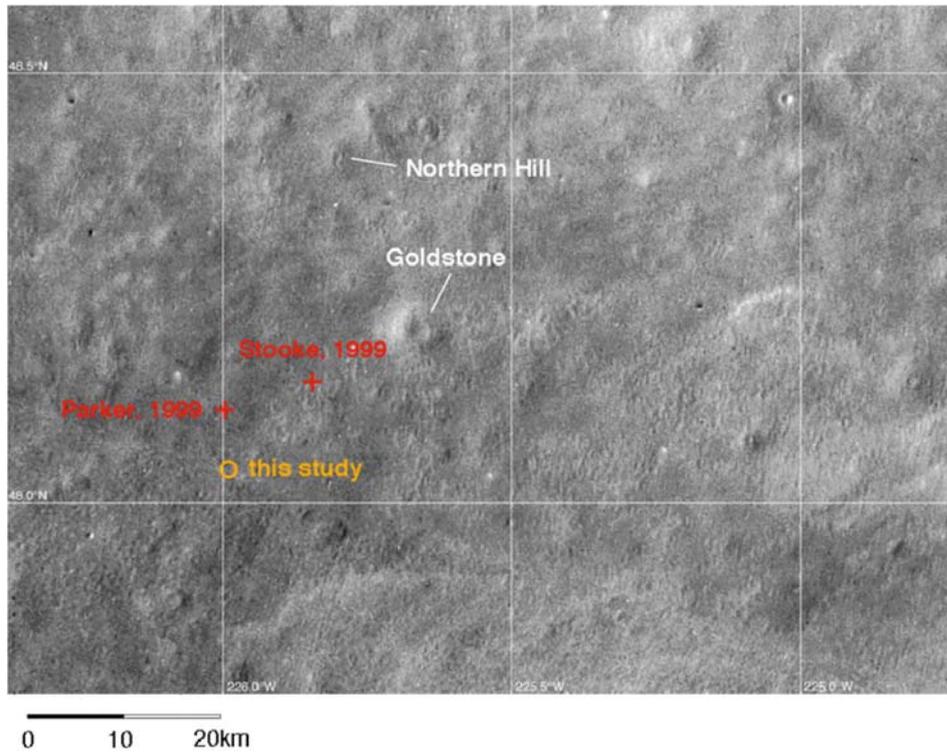


Fig. 1: VL2 on Viking images with the predicted landing site coordinates, image copied from [7]. Note: the coordinate grid is planetographic, IAU1994.

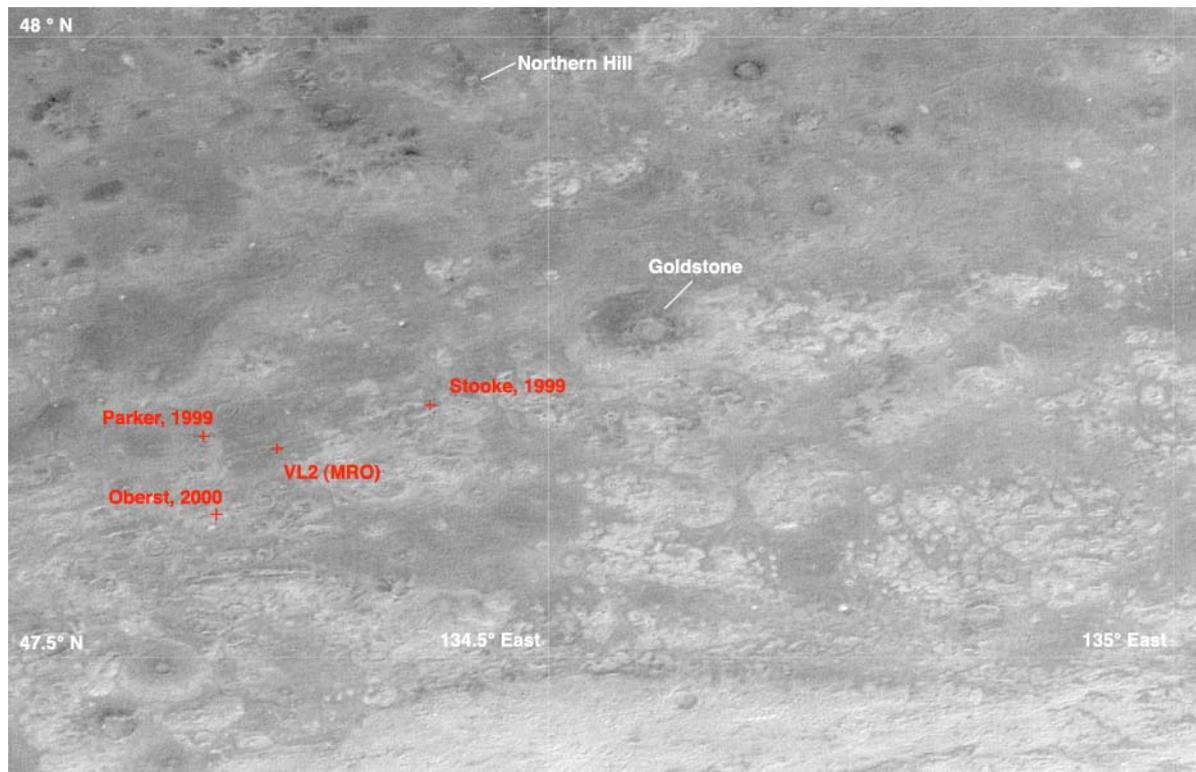


Fig. 2: Orthorectified HRSC image taken during orbit1394, showing the location of Viking lander 2 as it was found in MRO images, and the predicted locations by different authors. Coordinate system is IAU2000.