MRO's HIGH RESOLUTION IMAGING SCIENCE EXPERIMENT (HiRISE): POLAR SCIENCE EXPECTATIONS. A. McEwen[1], K. Herkenhoff[4], C. Hansen[2], N. Bridges[2], W.A. Delamere[3], E. Eliason[4], J. Grant[5], V. Gulick[6], L. Keszthelyi[4], R. Kirk[4], M. Mellon[7], P. Smith[1], S. Squyres[8], N. Thomas[9], and C. Weitz[10]. [1]LPL, University of Arizona, [2]JPL, [3]Ball Aerospace and Tech. Corp., [4]USGS, [5]CEPS, Smithsonian Ins., [6]NASA Ames/SETI, [7]University of Colorado, [8]Cornell University, [9]University of Bern, Switzerland, [10]PSI/NASA HQ.

Introduction: The Mars Reconnaissance Orbiter (MRO) is expected to launch in August 2005, arrive at Mars in March 2006, and begin the primary science phase in November 2006. MRO will carry a suite of remote-sensing instruments and is designed to routinely point off-nadir to precisely target locations on Mars for high-resolution observations. The mission will have a much higher data return than any previous planetary mission, with 34 Tbits of returned data expected in the first Mars year in the mapping orbit (255 x 320 km).

The HiRISE camera [1] features a 0.5 m telescope, 12 m focal length, and 14 CCDs (Table 1).

Table 1. HiRISE Capabilities

Ground Sampling Dimension (GSD)	30 cm/pixel (at 300 km altitude)
Swath width (Red bandpass)	6 km (at 300 km altitude)
3-Color swath width	1.2 km (at 300 km)
Maximum image size	20,000 x 65,000 pixels
Signal:Noise Ratio (SNR)	>100:1
Color Bandpasses	Red: 550-850 nm Blue-Green: 400-600 nm NIR: 800-1000 nm
Stereo topographic precision	~20 cm vertical precision over ~1.5 m^2 areas
Pixel binning	None, 2x2, 3x3, 4x4, 8x8, 16x16; each CCD separately commanded.
Compression	Fast and Efficient Lossless Image Compression System (FELICS)

We expect to acquire ~10,000 observations in the primary science phase (~1 Mars year), including ~2,000 images for 1,000 stereo targets [2]. Each observation will be accompanied by a ~6 m/pixel image over a 30 x 45 km region acquired by MRO's context imager. Many HiRISE images will be full resolution in the center portion of the swath width and binned (typically 4x4) on the sides. This provides two levels of context, so we step out from 0.3 m/pixel to 1.2 m/pixel to 6 m/pixel (at 300 km altitude). We expect to cover ~1% of Mars at better than 1.2 m/pixel, ~0.1% at 0.3 m/pixel, ~0.1% in 3 colors, and ~0.05% in stereo. Our major challenge is to find the key contacts, exposures, and type morphologies to observe.

Science Objectives and Capabilities. The key HiRISE science capability goals are:

(1) Achieve the best possible spatial resolution and detection of surface features.
(2) Achieve high-resolution topographic data from stereo images and Digital Elevation Models (DEMs).
(3) Acquire observations in up to 3 colors with high radiometric fidelity, for photometric studies such as identification of color/albedo units and photoclinometry.

Landing Site Safety and Trafficability. A prime objective of HiRISE is to identify potential hazards to landed missions. The size and shape of boulders and other topographic obstacles considered dangerous varies from mission to mission, but, for example, 0.5-meter high boulders were considered potentially fatal to the 2001 lander (which may land in the north polar region via the Mars Scout mission called Phoenix [3]). MOC is able to detect giant boulders or detached chunks of bedrock larger than ~5 m diameter, but boulder counts are probably incomplete for objects smaller than ~10 m. Such large objects only occur in limited geologic settings such as near the base of steep slopes that are less than a few km high or near the rims of impact craters. For MER landing site studies it has been necessary to rely on extrapolations based on observed giant boulders using the size-frequency distribution of boulders at previous Mars landing sites and at Earth analog terrains, along with estimates of rock abundance from thermal models [4]. HiRISE will directly map out the distribution of boulders larger than 1 m diameter (typically 0.5 m high).

Mars Polar Science Issues. HiRISE will address many important polar science issues; a few examples are given below.

How recently did the mid-latitude gullies form? Malin and Edgett [5] proposed that the gullies are young (probably less than 10^6 yrs) because there are usually no superimposed impact craters and because gully materials are superimposed over dunes and polygonally-patterned ground, which are young features on Earth (10^3 to 10^6 yrs for patterned ground [6]). This leaves open the possibility that gullies are forming today, and that liquid water may exist very near the surface. HiRISE can search for changes in the surface topography (compared with previous MOC or HiRISE images) that would indicate current activity of gullies. Evidence for current formation of dunes (possible) or patterned ground (less likely) would also help address this issue.

Can we trust small craters for age constraints? There are almost no resolved craters on some polar deposits and high-latitude units such as gullies and debris flows, suggesting that they are extremely young. However, there are several major problems with the statistics of small craters: (1) primary craters may be confused with secondary craters [7]; (2) small craters are easily eroded or buried by eolian processes; (3) small craters may have endogenic origins, and (4) the atmosphere must screen out small and/or low-density bodies and affect the crater distribution. The improved spatial resolution and topographic capability of HiRISE will help address these issues via better discrimination between primaries and secondaries, improved understanding of eolian processes, and improved ability to discriminate between impact and endogenic craters. Extending crater counts to smaller diameters may also reveal clear evidence for atmospheric screening of small bodies, perhaps varying with altitude or time (e.g., climate change).

Were there vast ice sheets? Kargel and Strom [8] first proposed that thick, continent-sized ice sheets were present over the polar regions of Mars. If correct, this hypothesis has major implications for paleoclimates. Glacial moraines are characterized by poorly-sorted mixtures of particle sizes up to large boulders, so HiRISE should see clear evidence for this type of deposit, as well as the rich suite of other meter-scale morphologies associated with glaciers.

What was the origin of the Vastitas Borealis Formation? The northern plains are covered by poorly-understood materials; one interpretation is that these are ocean sediments [e.g., 9]. If correct, the sediments should have fine grain sizes except for widely scattered ice-rafted boulders. The detection of abundant boulders in these deposits might favor direct deposition from floods or mudflow deposits. HiRISE will certainly provide a rich set of observations on periglacial processes in the northern plains [10]. It may be possible to correlate morphologies to surface ice abundances mapped by other experiments.

What is the recent climate history recorded in polar layered deposits? MOC images resolve beds in the polar layered deposits (PLD) down to the resolution limit of the camera [11]. HiRISE images of the PLD are therefore likely to show stratigraphy at finer scales than previously observed, potentially addressing the major uncertainty in the timescales of layer formation. Similarly, higher-resolution images of the PLD will be useful in studying the deformation (faulting and folding) of the PLD [12].

What is the efficacy of current eolian activity? Dune migration has not been seen in MOC-Mariner 9 comparisons over several decades [13] nor in MOC-MOC comparisons over a few years [14]. Failure of slip faces of the dunes has been noted [11]. With higher resolution, we might very well see dune motion, thereby providing calibration of the efficacy of aeolian processes on Mars in the present day.

What is the polar CO_2 inventory? The "swiss cheese" terrain on the residual south polar ice cap has been observed to retreat 1 to 3 meters in 1 Mars year, apparently via sublimation of CO_2 ice [15]. Continued monitoring of these changes and high-resolution topographic measurements will enable us to better quantify rates of CO_2 loss and the total CO_2 inventory available to facilitate periodic climate change.

Monitoring seasonal change. HiRISE has the ability to image in very low light levels. With pixel binning up to 16x16 combined with 128 lines of Time Delay Integration (TDI), HiRISE can acquire good images under twilight conditions, thus better monitoring the polar regions during their winters.

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