GUSEV CRATER: A LANDING SITE FOR MER A. N. A. Cabrol[1], E. A. Grin[1], and David Fike[2]. [1]NASA Ames Research Center, Space Science Division and Center for Mars Exploration. MS 245-3, Moffett Field, CA. Email1: ncabrol@mail.arc.nasa.gov; Email2: egrin@mail.arc.nasa.gov. [2]Scott Polar Research Institute, UK. Email: dfike@uiuc.edu.

Introduction: The final two MER sites will be selected in order to maximize the mission science return within the constraints of the Mars Exploration Project (MEP), which include engineering constraints, schedule and payloads [1]. The goal for each MER is to determine the aqueous, climatic, and geologic history of a site on Mars where conditions may have been favorable to the preservation of evidence of possible pre-biotic or biotic processes. Scientific criteria used in the identification and selection of landing sites include location showing clear evidence for surface processes involving ancient water [2]. All final candidate sites (Terra Meridiani, Gusev Crater, Melas Chasma) and their back up (Isidis and Eos Chasma) down-selected during the Pasadena Workshop in October 2001 meet these criteria while encompassing a wide range of possible settings that include former lacustrine and/or hydrothermal environments (*Summary of Pasadena Landing Site Workshop*, Grant and Golombek Eds.).

Our poster will present: (a) what makes Gusev crater an outstanding candidate for achieving the 2003 mission goal and science objectives, (b) the hypotheses that the MER Science Team will be able to test with the Athena payload within the MER A landing ellipse, and (c) the science return we expect from the investigation of Gusev in terms of knowledge about the water history of Mars and its potential to have harbored life and preserved it as fossils and/or surviving micro organic communities.

Testing Hypotheses About Water & Life on Mars in Gusev: The lacustrine hypothesis proposed for Gusev in the past years through the analysis of Viking images finds support in the MGS data. For instance, the MOLA profiles of Ma'adim's floor are altimetrically concordant with the MOLA profiles of the mesa topset located at the outlet of the channel as expected in a deltaic setting. The morphology of the mesas is consistent with a Gilbert-type delta [3-4] and a formation in a sublacustrine environment [5]. This landform is to-date the largest presumed deltaic structure identified on Mars. The convergence of observations encourages to consider a sustained, although likely episodic, fluvial activity of Ma'adim Vallis [6-7]. Typically, terrestrial delta analogues would take $n \cdot 10^4$ years to form. The existence of a series of lakes in Gusev is supported by evidence of shorelines and contacts confirmed in MOC images and argue for extended bodies of water. Examples of testable hypotheses and science questions to be documented in the MER A landing ellipse include: (1) Was there a lake? (2) Was the lake ice-covered [5]? (3)Did Thyra produced hydrothermal processes [8] and are by-products still exposed? (4) What was the relative frequency and duration of the lacustrine activity? (5) Did the paleolake deposit preserve a fossil record? (6) What does the mineralogical assemblage of sediments and their structure (grain-size, direction, shape) tell about the residence time of the sediments in the lake, their origin, and their modification? (7) Did the deposited sediments evolve into sedimentary rocks? and (8) A long record of lacustrine history being suggested, what was the influence of impact cratering (a) in the physical and chemical modification of the sediments, and (b) in diagenetical processes?

Adressing Hypotheses and Questions *in situ* with the Athena Payload and Providing Context with Orbital Data: Combining *in situ* MER investigation with orbital data (MGS and MO) will be particularly rewarding in the case of Gusev. Orbital data will be critical to reconstruct the context of the landing site. The reasons this process will be especially paying off with Gusev is that, unlike the two other primary candidates, it *is the only one* with a unambiguously recognized source of water, namely the ~1000-km long Ma'adim Vallis and *deposits that can be directly related to the action of water and source regions*. In Terra Meridiani, although four out of five hypotheses for the formation of hematite involve some sort of water action [9-11], no direct water supply or obvious hydrological context exists for the deposits. In Valles Marineris, canyons are likely to have supplied water but the lake hypothesis is mainly based on the presence of layered deposits which origin could be other than lacustrine [9, 12-18].

As we know that the primary water source for the basin was Ma'adim, we know the direction of the incoming sediments and the extent of the vast hydrogeological watershed [6-7, 19-21]. Depending on where MER A lands, the rover will be exploring either the fluvio-lacustrine Stages Three (more recent), Two (intermediate), or One (ancient) [6-7, 22-23] or contacts between these Stages. Each Stage is stratigraphically correlated to terraces in Ma'adim Vallis. The stratigraphic concordance is visible on MOC images and MOLA profiles and can be followed from the basin deep into the valley providing feedback information for discoveries made in the basin. A survey of the geological regions crossed, relationships of the terraces with order 1 streams for localization of parent-rock origin will be possible. If, as suggested by Christensen [24] Mars was dominated by volcanic processes, with little chemical weathering and no evidence for carbonates or significant clays, upstream tracking of the terraces to the regions of the sediment origin might not bring more knowledge than specifying that this region shows units and material consistent with, i.e. volcanic processes and deposits. Acknowledging this possible limitation, it is important to consider that (a) Mars Odyssey might modify this current vision of the Martian mineralogy, and (b) this survey will have the merit to establish a link between the watershed geology and the downstream basin sedimentology, mineralogy, and composition. If all sediments observed are, for instance, basaltic-derived muds, their identification will tell about their parent-rocks and the watershed, weathering and transport processes, and their modification within the confines of Gusev. They will provide clues to established the context of investigated science targets at the MER A site.

Search for Clues: Gusev will be an exploration site where a dynamical investigation can be performed. Depending on the location of the landing, various environmental and hydrodynamics models proposed for the three main Stages can be tested. (1) The morphology of the most recent Stage Three deposit is ambiguous and cannot be conclusively interpreted with MOC images only. The sharp deposition angle could be either due to a late sublacustrine episode or to the subaerial deposition of sediments without involving a lake [23]. Each hypothesis has a specific sedimentary signature: (a) gravel-size clasts embedded in abundant matrix for a subaerial deposition, and (b) fine sand, mud and silt for a lake; (2) Stage Two is where Grin and Cabrol [5-25] place the highest probability of ice-covered lake episodes based on the deposit morphology. At larger scale, scoured rocks, push marks and convoluted lamination will be clear indicators that a body of ice weighted on the sediments. At finer scale, varves are a common product of glacial lakes but do not constitute a definitive evidence. Evidence from PanCam, MI, the type of weathering resulting from an increased input of fresh water from ice melt relatively to salty lakes, and the mineralogy will be combined to strengthen the case; and (3) Stage One shows remnants of the earliest accessible lacustrine episode. It was hypothesized that crater lakes could have been heated by hydrothermal activity [26] favoring pre-biotic and biotic processes [23, 26-32]. PanCam could (a) document the stratigraphic relationships between the deposits and the 20-km Thyra crater structure located at the east end of the landing ellipse to assess the possibility of a contemporaneous activity between lake and heat processes, and (b) return color information about hydrothermally altered rocks and sediments provided that they were quickly buried and preserved from erosion and only recently exposed. MI will generate the microscale information about the minerals, cements, and possible biotic evidence.

Mission Science Return: Because of its hydrogeological and limnological history, Gusev is an outstanding candidate to fulfill MER's objectives and achieve mission success. 1. *Geological Diversity*: Gusev has collected sediments from varied parent-rocks of the $\sim 10^6$ km^2 watershed region of Ma'adim Vallis over a period of two billion years that will provide clues to document the mineralogical diversity of the martian rocks which remains to-date an open question. 2. *Search for Life:* Because of its lacustrine history, the site has been recognized for many years to be a favorable location to sample potentially fossiliferous sediments. As the interaction between Ma'adim Vallis and Gusev spans over two billion years, it encompasses periods of Mars when conditions were judged favorable to pre-biotic and biotic processes. 3. *Climate Record:* Rivers and lakes are particularly environments which respond immediately to local, regional and global changes. The size and shape of the clasts and the composition of the sedimentary rocks will reveal the atmosphere and climate changes throughout the lifetime of Gusev.

References: [1] Mars Exploration Program, MER PIP, August 2001; [2] Golombek et al., 2001. Engineering constraints and potential landing sites; [3] Cabrol and Grin, 2000. *Icarus* 142, 160; [4] Ori et al., 2000.*JGR* 105, 17629; [5]Grin and Cabrol 1997. *Icarus* 130, 461; [6](Cabrol et al., 1998a; *Icarus* 133, 98; [7] Cabrol et al., 1998 b. *Icarus* 132, 362; [8] Newsom et al.,1996. *JGR*, 101, 14951; [9] Chapman and Tanaka 2000; *LPSC 31*, 1256; [10] Noreen et al., 2001. LS Workshop, NASA Ames, 9014; [11] Edgett and Parker 1997. *GRL* 24, 2897; [12] McCauley et al., 1972. *Icarus* 17, 289; [13] Nedell et al., 1987. *Icarus* 70, 409; [14] Lucchitta, 1989. *Icarus* 86, 476; [15] Lucchitta, 1994. *JGR* 99, 3783; [16] Peterson, 1981.*LPSC* 12, 1459; [17] Weitz 1999. *LPSC* 30, 1277; [18] Malin and Edgett, 2000. *Science*, 290, 1927; [19] Cabrol, 1991. *Ph-D Thesis*; [20] Landheim, 1995. *Master Thesis*; [21] Cabrol et al., 1996. *Icarus*123, 269; [22] Kuzmin et al., 2000. LS Workshop, NASA Ames, 47; [23] Cabrol 2001, *pers. com.*, Pasadena); [24] Christensen, 2001, *pers. com.*, Pasadena; [25] Grin et al., 2002a,b. *This LPSC*; [26] Newsom et al., 2001. *Astrobiology* 1, 71; [27] Farmer, 1995. *Palaios 10, 197*; [28] Farmer 1996.*Ev. Hydrotherm. Syst. On Earth (and Mars?)*, 273; [29] Farmer 1998. *JGR* 103, 28457; [30] Farmer and Des Marais 1994. *LPSC* 25, 367; [31] Farmer and Des Marais 1999. *JGR* 104, 26977; [32] Cabrol and Grin 1995. *Plan. Space. Sci.* 43, 179.

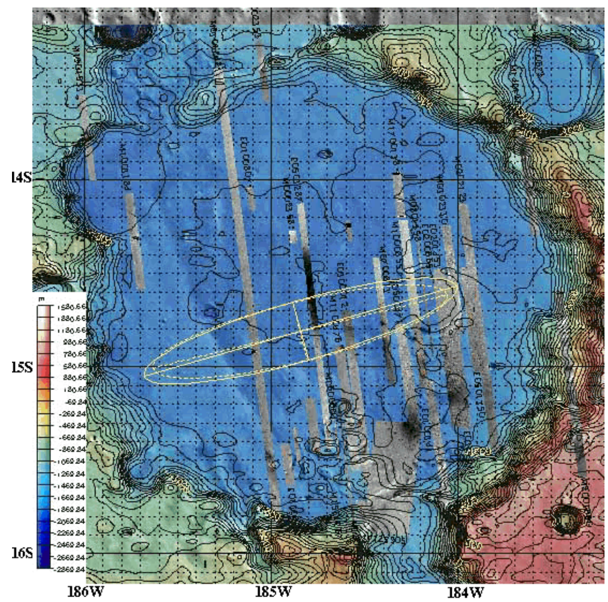

Figure 1: *MER A Landing ellipse in Gusev and MOC coverage as of 12/01.*

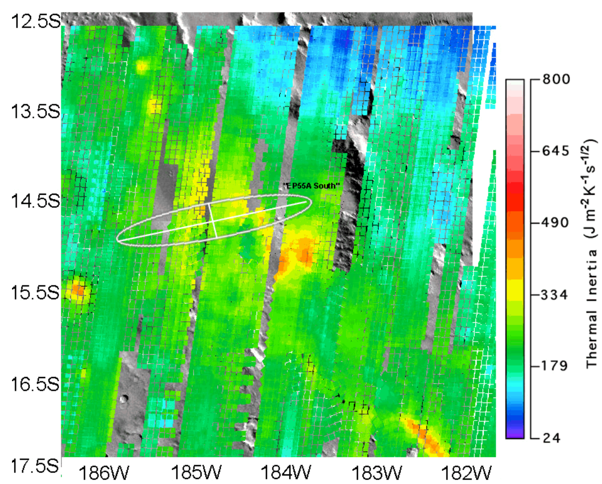

Figure 2: TES thermal inertia measurements of Gusev landing ellipse.