Sinus Meridiani Landing Site for Human Exploration—A Mesoscale Fluvial System

EZ: SW Sinus Meridiani, centered 6.4335degW 2.2526degS, Fig. 1 Regional stratigraphy, Miyamoto Crater, Opportunity Traverse, Hematite concentrations, raised ridges -- flat landing zone

Sinus Meridiani was selected as the *Opportunity* exploration region for many reasons, including its geological evidence of a relatively thick, sedimentary stack 800-900 m thick, with its surficial layer of hematite nodules. One of the competing theories underlying the choice of the Exploration Zone (EZ) below (Fig.1) is the fluvial theory of emplacement of the Meridiani units [1]. Fluvial depositional environments *at the mesoscale* ($2x10^4 – 10^5$ km^2) are still poorly understood on Earth [2]. The large fan model (or *fluvial fan, megafan*, or incorrectly, the *inland delta* model) of continental fluvial sedimentation appears to provide a coherent set of explanations at this scale, for several characteristics of the Sinus Meridiani rock suite. Large fans (>100 km) have been classed as alluvial fans, but their significantly larger area sets them apart from the well-known desert alluvial fan in terms of process [3]. More importantly, global mapping reveals the ubiquity of large fans (nearly 200 on all continents) and very large areas that they underlie (e.g., nested large fans cover 0.75 million km^2 in S America). Although still little recognized, the maps in turn reveal unexpected patterns and relationships [3] that appear to be particularly useful in understanding the Meridiani rock suite [1].

The mesoscale, fluvial-fan model specifically provides explanations for: (i) the layered character of the Meridiani sediments; (ii) the dense, network of curvilinear ridges of the ridged plains (cemented river channels cover entire surfaces of large fans on Earth); (iii) the concentration of hematite deposition nearest the dichotomy (relating to known high water tables in large fan zones near upland margins); and (iv) the widespread inundation by sediments of impact craters within the Meridiani rock mass [4] (partly by sediment from rivers flowing on neighboring intercrater plains).

The large fan model also applies to the Meridiani layered rocks at a wider scale (i.e., at the EZ scale): (v) the extent of the layered units (1200 km east-west along the southern boundary, 1000 km north from the boundary) is at the same scale as the large fan systems that emplace the sediment bodies of contiguous large fans; (vi) the close geographic connection between the southern highland fluvial systems and the layered units, assuming that some of the Meridiani sediments were delivered by north-flowing rivers of the valley networks immediately to the south; and (vii) the probable absence of a waterbody connected to the layered units (layered sediments of Meridiani dimensions are routinely laid down *subaerially* at the foot of terrestrial highlands by rivers sourced even in uplands of low topography—ninety megafans in Africa emanate from low uplands demonstrating that major mountains are not a prerequisite for the development of large fans).

Despite much scientific attention, including a rich data set supplied by the rover, several theories still compete to explain the origin of the Meridiani units. Several major science questions can be addressed by observations in the proposed ROIs, through the lens of the large fan model.
(a) *Detailed examination of the regional sedimentary stack*: to elucidate the materials, sedimentary structures and internal architectures of units and subunits (unit mNh is global, unit HNhu is regional/Meridiani-wide); and provide a window onto the cratered terrain rocks beneath (the best exposures in the zones as denoted were employed for measurement of the regional slope of the Meridiani layered strata [5]);
(b) *Miyamoto Crater sedimentary stack:* Meridiani layered units and phyllosilicate outcrops both occur within the confines of the crater.

(c) *Connection between, and comparison of, intercrater and crater sedimentary stacks*: Miyamoto and other craters display obvious or probable connections to external units on the intercrater plains. The phenomenon of crater inundation by sediment is more easily explained if at least some fluvial sediment is laid down as large fans across wide areas, as suggested by the fluvial model.
(d) *Hematite distribution over a wider geographic area*: extending findings from the rover traverse may yield answers to the origin of this intriguing unit. Highest hematite concentrations along the southern zone of the Meridiani units suggest connections to the southern highlands.
(e) *Enigmatic ridges of the ridged plains*: networks of light-toned ridges are widely displayed on exposed intercrater surfaces, but also some crater units: e.g., the Miyamoto raised ridges interpreted as probable relict stream channels and show CRISM phyllosilicate responses. With several terrestrial analogs now available, examination of the ridges is likely to provide a satisfactory explanation.
(f) *Connection between Meridiani units and rocks and channel systems of the southern highlands*: this is another debated issue: access to one of few locations where these landscapes almost meet.
(g) *Access to Opportunity's Traverse Path*: reasons may arise to re-examine some parts of the traverse path, and for further data collection.

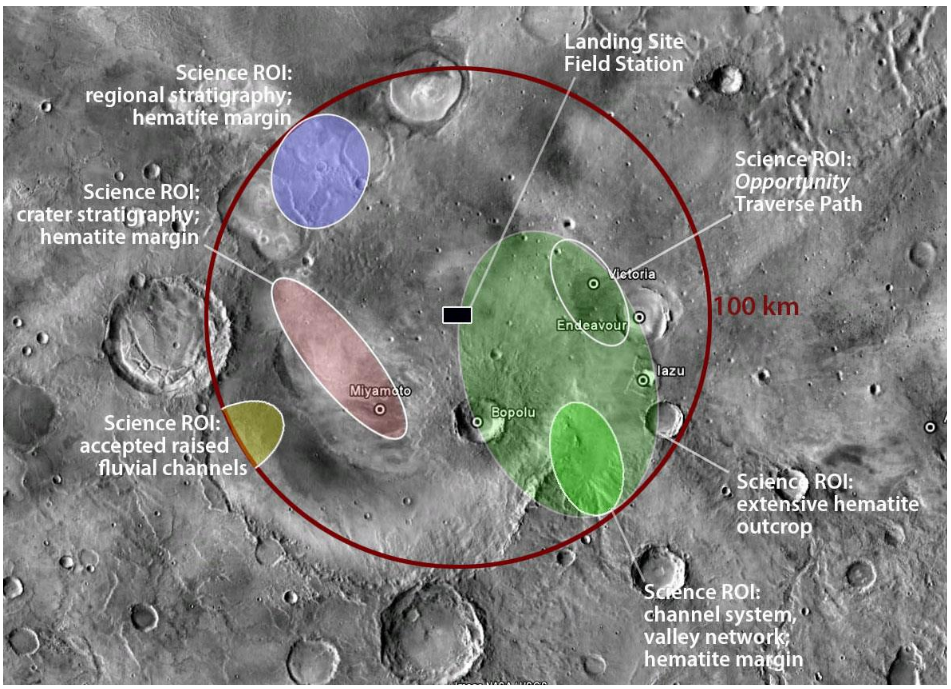

Figure. 1 EZ SW Sinus Meridiani: ROIs with main research elements

References: [1] Wilkinson MJ et al., 2007, *Eos Trans. AGU, 88(52), Fall Meet. Suppl.,* Abs #P12C-03; Wilkinson MJ et al., 2008, *LPS XXXIX,* Abs #1392; Wilkinson MJ et al., 2009, *Workshop on Modeling Martian Hydrous Environments (LPI),* Abs #4034*;* Wilkinson MJ, McGovern PJ, 2010, *LPS XLI,* Abs #2253; Wilkinson MJ, 2010, *First Intl. Conf. on Mars Sedimentology & Stratigraphy*, El Paso, TX, Abs #6065. [2] Wilkinson MJ et al., 2006, *J. South American Earth Sci.* 21: 151-172; Wilkinson MJ et al., 2010, In Hoorn & Wesselingh (ed.) *Amazonia, Landscape and Species Evolution*, Blackwell, Ch. 10. [3] Wilkinson MJ, 2015, *Large Fluvial Fans, AAPG-ACE Conf*., Denver CO. [4] Edgett KS, 2005, *Mars* 1: 5-58. [5] Hynek et al., 2008, Earth & Planetary Sci. Letters 274: 214–220.