THE SEDIMENTARY ROCKS OF MERIDIANI PLANUM, IN CONTEXT. K. S. Edgett and M. C. Malin, Malin Space Science Systems, PO Box 910148, San Diego, CA 92191-0148 USA.

Introduction: The sedimentary rocks examined by MER-B, the Mars Exploration Rover, Opportunity [1], are part of a stratigraphic sequence of > 1 km thickness that covers a broader area than previous investigators [2-5] recognized. These rocks are not superimposed on heavily cratered terrain, but rather are an integral part of it. They record a rich, diverse, and complex history. Similar rocks occur on the plains cut by the Valles Marineris chasms, Ius, Melas, and Candor.

8°N, 7°W Crater: To understand the context of the sedimentary rocks at the MER-B site, we begin more than 500 km away, at a crater in Arabia Terra at 8°N, 7°W (Fig. 1). Mars Orbiter Camera (MOC) images show hundreds of layers of similar thickness and physical properties (implying similar composition) exposed within this crater [6]. Each layer apparent at MOC image scale might actually be a grouping of layers too fine to resolve from orbit, and each is thicker than the sequence examined by MER-B in Endurance Crater. The uniformity and repeated nature of these layers suggests that deposition persisted for some considerable, although unquantifiable, period in this crater [6].

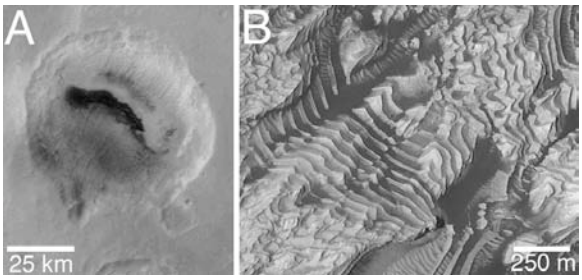

Fig. 1. (A) Crater at 8°N, 7°W. **(B)** Sedimentary rock outcrops in 8°N, 7°W, crater (MOC E05-00804). This crater was once buried beneath at least 600 m of strata that include the time-stratigraphic equivalent of rocks at the MER-B site.

8°N, 7°W, Crater is Exhumed: Edgett and Malin [7] examined MOC and Mars Orbiter Laser Altimeter (MOLA) observations for a region that covers the light-toned, layered, sedimentary rock outcrops of northwest Sinus Meridiani and parts of southwestern Arabia Terra. In that work, they found that > 600 m of sedimentary rock—all of it with different bedding and physical properties than the rocks inside the crater at 8°N, 7°W, once covered that crater. This interpretation was based on the elevation of the crater rim and the observation that the strata exposed in the intercrater areas of southwest Arabia and Sinus Meridiani are horizontal, and that other, nearby craters of similar size (50–70 km diameter) are interbedded with these same strata.

Horizontal Bedding: The rocks exposed in the region studied by Edgett and Malin [7] are just a small part of a regional occurrence of light-toned sedimentary rocks that outcrop all across northern Meridiani and underlie the hematite-bearing Meridiani Planum [6, 2-5, 8]. All of the rock units that extend across Sinus Meridiani are horizontally-bedded at regional scale. For example, in Fig. 8 of Malin and Edgett [6], a sequence of the same three rock layer units was identified in two locations in northern Meridiani that are separated by > 100 km. Using the MOLA topographic profiles acquired at the same time as the MOC images in that figure, we find that the rocks are close to horizontal today—the dip is only about 0.02°. The flatness of the plains upon which MER-B has been operating is another testament to the horizontality of the rocks.

MER-B Rocks Relative to 8°N, 7°W, Crater: Given the horizontality of the bedrock in the Meridiani/western Arabia region, we find that the rocks exposed at the MER-B site lie stratigraphically above those that once covered the rim and buried the crater at 8°N, 7°W. Remnants of the strata that once covered the crater at 8°N, 7°W, are still found today in the region studied by Edgett and Malin [7]. Whether these include rocks with the same lithology as those at the MER-B site, or whether they are of a different facies is unknown.

MER-B Rocks Not At Top of Sequence: The rocks at the MER-B site are not at the top of the stratigraphic sequence preserved in the region. Craters such as Endurance and Victoria have been exhumed—at Endurance, the original ejecta blanket lies below later, light-toned, layered, hematite concretion-bearing rock; at Victoria, the original crater rim is still buried and erosion is undermining the layers that lie above that rim to form the scalloped, U-shaped alcoves that give the crater its distinct appearance. The amount of rock that once covered the MER-B site could have been as much as 200–300 m; evidence comes from the topography of Meridiani Planum in areas near 1.1°N, 359.8°W (*e.g.*, in MOLA profile acquired with MOC image M09-05732) and the pedestal crater at 7.2°N, 1.8°W. At the latter, the uppermost rocks preserved beneath the

crater ejecta blanket stand > 300 m higher than the MER-B site (*e.g.*, MOLA profile acquired w/MOC M08-03015).

Meridiani Planum Rocks Extend Further West and East: As initially noted by Malin and Edgett [6], sedimentary rocks outcrop all across northern Sinus Meridiani. They cover an area that exceeds that of the Colorado Plateau in North America [7]. Rocks that are part of the same stratigraphic sequence, which exceeds 1 km in thickness, extend north into the intercrater terrain of western Arabia Terra [7] and under the hematite-bearing Meridiani Planum [2-5, 6]. Outcrops of light-toned, layered rock that are lower in the stratigraphic sequence outcrop in intercrater areas west of Meridiani Planum, and similar strata probably once buried craters such as nearby Crommelin. The rocks also extend further east than previous authors have mapped, into cratered terrain covered by dark mantling material. East of the main body of sedimentary rock outcrops, there exist smaller windows through the low-albedo mantle that reveal light-toned sedimentary rocks (Fig 2a).

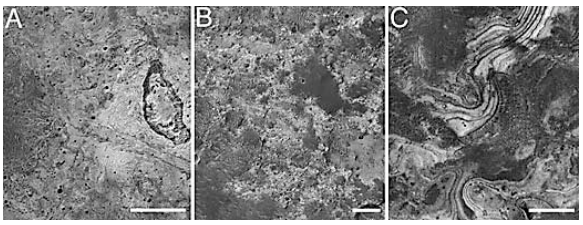

Fig. 2. Sedimentary rock outcrops on intercrater plains **(A)** east of Meridiani Planum, 2.3°S, 357.1°W (S01-00728); **(B)** south of Meridiani Planum, 5.0°S, 5.6°W (R20-00800); **(C)** cut by Melas Chasma, 11.2°S, 78.1°W (R15-00758). Scale bars = 300 m.

Diversity of Rocks, Erosional Unconformities, Filled, Buried, and Exhumed Craters and Valley Networks: The sedimentary rocks of Sinus Meridiani are more diverse than those found at the MER-B site. Different layered rock units exhibit different bedding properties (*e.g.*, many layers vs. few), albedos, and erosional expressions. Impact craters of diameters from < 50 m to > 100 km have been filled and buried by and within the strata. Some craters have been exhumed. Valleys are also incorporated into the rock. Their presence indicates periods of erosion and removal of strata—*i.e.*, erosional unconformities in the sequence. Some exhumed valleys have been inverted by erosion. An example is seen in Fig. 1 of Williams and Edgett [9].

Relation to Heavily Cratered Terrain: The sedimentary rocks of Sinus Meridiani are not superimposed on heavily cratered terrain. They are an integral part of it. Impact craters such as the one at 8°N, 7°W, and its neighbors are within the stratigraphy [7]. The rocks in Meridiani extend north, west, and eastward into and are a part of the region's heavily cratered terrain. The one problematic area is to the south. A distinct geomorphic change occurs where the relatively flat, hematite-bearing Meridiani Planum meets the rugged, eroded, cratered upland to its south. This contact seems to contradict what is observed to the north, west, and east—that the rocks are an integral part of the heavily cratered terrain. Instead, it seems as if the bedrock beneath Meridiani Planum is superimposed on top of the cratered upland. However, this is not the case. MOC images show several good examples of light-toned bedrock outcrops that occur 10s of kilometers south of this contact (Fig. 2b), and one area along the contact is a scarp facing northward (*e.g.*, MOC M00-02021). The presence of this scarp may imply that the bedrock of the rugged, cratered upland lies stratigraphically higher than the rock beneath Meridiani Planum, or at least it suggests that the stratigraphic relations previously proposed [2-5] are oversimplifications.

Meridiani Sedimentary Rocks Not Unique: The occurrence of light-toned, layered, plains-forming, sedimentary rock in Sinus Meridiani is not unique to the region. Some of the strata in Meridiani can be traced northward into western Arabia Terra. The light-toned, layered, sedimentary rocks exposed in Mawrth Vallis may be even lower in the stratigraphic sequence; the Meridiani rocks may have once extended all across western Arabia and buried craters such as Trouvelot and Becquerel. In addition, similar rocks occur elsewhere on Mars, particularly on the plains cut by the Valles Marineris chasms, Ius, Melas, and west Candor (Fig. 2c). If the rocks at the MER-B site imply deposition and diagenesis in a water-rich environment, what do similar rocks exposed on the plains cut by the Valles Marineris imply about the history of that region?

References: [1] Squyres S. W. et al. (2004) *Science, 306*, 1698–1703. [2] Arvidson R. E. et al. (2003) *JGR, 108*, doi: 10.1029/2002JE001982. [3] Christensen P. R. and Ruff S. W. (2004) *JGR, 109*, E08003, doi: 10.1029/2003JE002233. [4] Hynek B. M. et al. (2002) *JGR, 107*(E10), doi: 10.1029/2002JE001891. [5] Hynek B. M. (2004) *Nature, 431*, 156-159. [6] Malin M. C. and Edgett K. S. (2000) *Science, 290*, 1927-1937. [7] Edgett K. S. and Malin M. C., *GRL, 29*, doi: 10.1029/2002GL016515. [8] Christensen P. R. et al. (2003) *Science, 300*, 2056-2061. [9] Williams, R. M. E. and Edgett K. S. (2005) *LPSC XXXVI.*