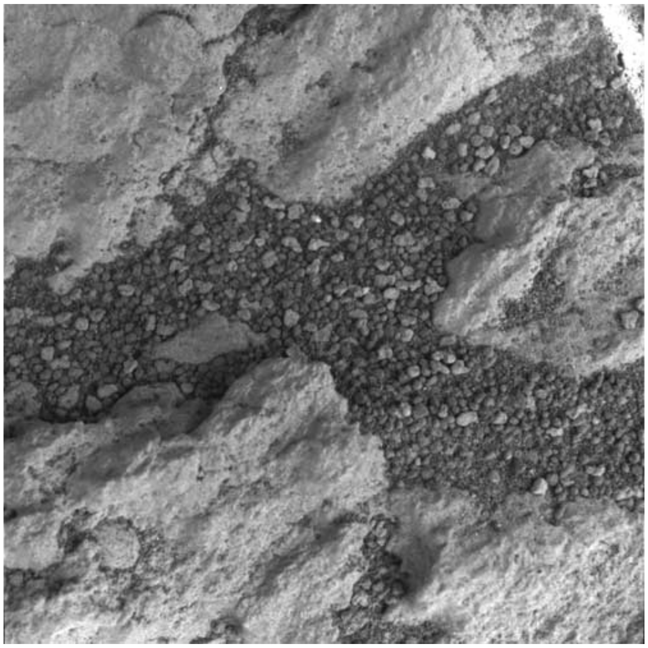

Figure 35. Radiometrically calibrated MI image 1M147006074 of target Munch on rock Escher, taken on sol 212 when mostly shadowed. Small grains can be seen in soil located between crevices in the outcrop. On the basis of Pancam spectra, the larger, brighter grains appear to be pieces of the outcrop while the smaller, darker grains are likely to be basaltic in composition. Area shown is 31 mm square.

quantifying the distribution of lamination thickness, which is readily measured from MI images of the stratification (Figure 30). In terrestrial systems this approach is helpful in distinguishing depositional mechanisms [*Rothman and Grotzinger*, 1995; *Carlson and Grotzinger*, 2001]. Here, we describe measurements of lamination thickness from the Burns formation and compare these to measurements for rocks from known terrestrial depositional environments. The goal is to evaluate whether we can discriminate among competing hypotheses for the origin of the Burns formation.

[77] The presence of thin, rhythmic, planar lamination has been interpreted to result from migration of wind ripples, and thus has been used to infer eolian deposition for this facies of the Burns formation [*Grotzinger et al.*, 2005, 2006; *Metz et al.*, 2008]. This interpretation is supported by other data including the presence of large-scale cross-stratification composed of uniformly fine grain size. However, other workers have suggested that these facies could have formed during volcanic or impact-induced base surges [*McCollom and Hynek*, 2005; *Knauth et al.*, 2005]. These alternative hypotheses have been based primarily on qualitative interpretations of the Burns formation middle unit and without consideration of the particular sedimentologic details of the deposits. In this paper we have measured lamination thicknesses of strata from the middle unit of the Burns formation and from terrestrial rocks known to have formed by base surge, eolian, and even fluvial processes. Lamination thicknesses were measured from images of terrestrial strata and compared with those from Martian sediments based on images returned by Opportunity (Table 1).

[78] Images acquired by Opportunity were selected so that the camera pointing direction was coplanar with the bedding, so no corrections for apparent dip were required in order to obtain true thickness. Thicknesses were acquired by measuring the distance between successive laminae, normal to bedding. A similar approach was used for terrestrial strata. We attempted to eliminate the problem of missing laminations by only measuring strata that were contiguous and were most clearly resolved in the images. However, there are some uncertainties in the minority of measurements where laminations are not parallel and the thickness between the two is variable. In these situations the average thickness between the two laminae was measured.

[79] Histograms were compiled for both Martian strata and each terrestrial example (Figure 31). Martian laminae from the Burns formation (exposed in Endurance and Eagle craters) are roughly normally distributed, with a mean thickness 0.20 ($1\sigma = 0.08$) cm, based on 75 laminae ($n = 75$). Results for terrestrial eolian deposits from the Jurassic Page Sandstone from the Colorado Plateau are also approximately normally distributed with a mean lamination thickness of 0.14 cm ($1\sigma = 0.05$ cm; $n = 427$). The fluvial, "upper plane bed" facies from the Mt. Shields formation from the Proterozoic Belt Supergroup, Montana, has a similar distribution with mean lamina thickness of 0.14 cm ($1\sigma = 0.05$ cm; $n = 190$). Finally, we measured lamination thicknesses for Pleistocene pyroclastic base surge deposits from Hunts Hole, New Mexico. The distribution of lamina thickness from Hunts Hole is significantly different from the others, with a mean thickness of 1.04 cm ($1\sigma = 0.84$ cm; $n = 156$).

[80] In a comparison of the Martian histogram to the terrestrial analogs (Figure 29) it is qualitatively and quantitatively apparent that the volcanic base surge deposit, which for our purposes also serves as an analog for an impact base surge, has a significantly different distribution (as well as mean) compared to the Martian strata. The terrestrial eolian and fluvial examples, on the other hand, have similar averages and distributions. With the acknowledgment that we have only examined a few environments, we suggest that the middle unit of the Burns formation was not formed by a volcanic base surge event or impact event. Although the distribution of lamination thickness by itself does not allow discrimination between fluvial and eolian origins, the broader context of these deposits does suggest a preference for eolian over fluvial deposition. Planar lamination at the scale observed in the Burns formation could form as a result of sediment transport in high-velocity, upper flow regime subaqueous flows [*Southard and Boguchwal*, 1990]. However, planar-laminated deposits formed in the upper flow regime are often on the order of tens of centimeters thick [*Metz et al.*, 2008], in contrast to the thickness of planar-laminated deposits in the Burns formation which is on the order of several meters thick at "Burns Cliff" [*Grotzinger et al.*, 2005]. While possible in terrestrial deposits, this is rare [*Metz et al.*, 2008]. Therefore, we suggest that an eolian origin for the planar- to low-angle-laminated deposits in the Burns formation is the most likely depositional process.