Introduction: Illumination geometry plays an important role in the interpretation of morphology and texture from images of planetary surfaces. Images acquired with low sun angles (i.e., near sunrise and sunset, when shadowing is more pronounced) contain significantly more morphological/textureal detail and are more visually dramatic than images acquired with high sun angle (i.e., near noon, when shadows are minimal). A series of Mars Exploration Rover (MER) Spirit Navcam images of the surface acquired at different solar elevation angles helps to illustrate the relationship between time of day and visible textureal detail. This information will help define observation requirements for future rover/lander missions.

The MER rovers utilize solar panels for energy, which limits the periods of maximum rover power (maximum opportunity for rover activities) to times when the sun is high in the sky. As a consequence, the large majority of MER images are acquired between 10:00 and 14:00 Local True Solar Time (LTST). As of Sol 2000, approximately 90% of Mars Exploration Rover (MER) images have been acquired with solar elevation angles greater than ~40 degrees (Figure 1). Because of greater power availability (lower latitude), Opportunity is slightly less energy-constrained than Spirit, and thus has acquired more images in the 10:00-11:00 LTST time period. However, both rovers have taken predominantly high-sun images.

Results: Images with solar elevation angles below 40 degrees (figure 3) show significantly more morphological detail and texture than images acquired with solar elevation angles higher than 40 degrees (figure 4). Morphological/textureal differences between morning (figure 3) and afternoon (figure 5) low sun views (e.g., ripples on the right side of the image show slightly different apparent orientations) illustrate a long known phenomenon where illumination orientation affects perception of aligned surface elements.

Conclusions: Inspection of the full sequence (illustrated in Fig. 6) permits the qualitative (and potentially quantitative) estimation of the sun angle best suited to examining detailed scene morphological content. As has been commonly recognized in aerial photography and in planetary orbiter observations, sun elevation angles between 15° and 40° appear optimum, though observations are rarely made at such low sun angles on the MER missions due to the power constraints mentioned earlier. In the trade between high sun images most useful for photometric studies and low sun images most useful for morphology and texture, engineering constraints have generally favored the former. Although the Mars Science Laboratory mission is not solar powered, it still is constrained by power and thermal limitations that are likely to favor high sun observations. Foreknowledge of this bias in opportunity will permit appropriate planning to insure a wider temporal distribution of science imaging observations.
Figure 3: 07:57 LTST, solar elevation angle = 32 degrees.

Figure 4: 11:55 LTST, solar elevation angle: 84 degrees.

Figure 5: 17:28 LTST, solar elevation angle: 12 degrees.

Figure 6: Full sequence of illumination conditions (denoted by solar elevation angle).