STRATIGRAPHY AND STRUCTURE OF INNER BASIN OUTCROPS IN THE COLUMBIA HILLS FROM THE SPIRIT ROVER. K. W. Lewis[1], O. Aharonson[1], M. E. Schmidt[2] and the ATHENA Science Team, [1]Division of Geological and Planetary Sciences, Caltech, 1200 E. California Blvd. Pasadena, CA 91125, [2]Dept. of Mineral Sciences, National Museum of Natural History, Smithsonian Institution, Washington DC, 20560.

Introduction: The Mars Exploration Rover Spirit has been exploring the "Inner Basin" of the Columbia Hills since descending from Husband Hill early last year. Since the onset of Martian winter at Gusev, Spirit has been carrying out investigations near a small topographic feature known as Low Ridge [1]. At this location, Spirit has carried out investigations of several layered outcrops and float rocks. Low Ridge is partly covered by talus, with a few prominent layers which outcrop. Chemical and mineralogical analyses have shown the materials analyzed thus far exhibit some compositional differences from Home Plate, a prominent layered pedestal immediately to the northwest [2-6], offering new clues in reconstructing the geologic history of the Inner Basin and the Columbia Hills. This study focuses primarily on physical relationships between these Inner Basin outcrops.

Observations at Low Ridge: Spirit first imaged Low Ridge (sol 778) after leaving Home Plate, and began its winter campaign there shortly after, on sol 805. At this location, layers on the northern side of Low Ridge were extensively imaged. After the winter campaign, Spirit traversed a short distance to study the vesicular basalt Esperanza, also imaging an outcrop of bright, layered rock on the eastern side of the ridge. More recently (sol 1069), Spirit has begun to analyze an outcrop immediately to the north of Low Ridge known as Troll, which exhibits at least two distinct layered units (Figure 1).

Stratigraphy: Low Ridge exhibits two morphologically distinct layered rock types in the outcrops imaged by Spirit. The ability to study the rocks at Low Ridge is limited by several factors, including rover accessibility and obscuration by loose dust and erosional debris. Therefore portions of the stratigraphic section have not been reconstructed for one or both of these reasons. However, the rocks which Spirit has been able to analyze have been chosen as representative of the major units within the sequence. In addition, the abundant vesicular basalts on Low Ridge may constitute another, higher unit of the stratigraphy, though they are not addressed here.

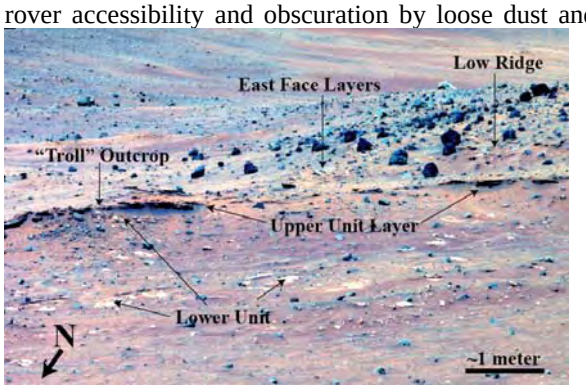

Fig. 1: *Pancam false color view of Low Ridge from sol 778, with major stratigraphic units indicated.*

Upper Unit. The upper unit of Low Ridge is exposed as a thin layer near the base of the northern side, in an outcrop over 10 meters in length. This outcrop typically shows several thin, parallel beds when imaged in detail. Individual layers can not typically be traced for more than a few tens of centimeters, due to dust cover. The lower unit was studied by the rover's suite of in situ analysis instruments at a representative location known as King George Island. At microscopic scales this rock was found to have a clearly clastic texture (Figure 3). Highly rounded and sorted grains of millimeter size comprise the outcrop. Clast support dominates the rock, with little or no visible matrix. Although the sediment is highly sorted, no grading is exhibited within the section of the outcrop imaged with the Microscopic Imager (MI). This may be attributed to the fact that the exposure is parallel to bedding.

There are indications that the upper unit at Low Ridge is continuous with the upper part of the nearby outcrop Troll, but further study is required. Two additional exposures exposed higher along the north and east faces of Low Ridge are inferred to be part of this unit.

Lower Unit. The largest intact section taken to represent the lower unit occurs at the Troll outcrop. Here, the exposure is clearly layered, with thin, parallel bedding at centimeter scales. MI observations show the outcrop to be massive at the 100 micron scale, in contrast to the upper unit.

The lower unit in the region of Low Ridge is typically brighter and redder than the upper unit, as seen by Spirit's multispectral Panoramic Camera (Pancam). This unit may underlie much of the flat terrain around Low Ridge, expressed by clasts which outcrop from beneath a thin cover of loose material in many locations around the winter campaign site. Unfortunately, a clean exposure of the contact with the upper unit has not yet been found.

East Face Low Ridge Layers. A third important outcrop of layered material at Low Ridge occurs on the eastern side. However, this outcrop has not yet been studied in detail by Spirit, and hence the stratigraphic context has been determined.

Structure: The geometry of the layers at Low Ridge constrains their formation and relationship to other structures in the Inner Basin, particularly the nearby layered rocks of Home Plate.

The most striking attribute of the layers at Low Ridge is that they vary greatly in their orientation between outcrops. Most notably, the outcrops on the east side of Low Ridge show a consistent westward dip, while the upper unit on the north side shows a generally eastward dip. The mean dip of the eastern Low ridge layers is roughly 12 degrees to the west, while the upper unit layer on the north face dips more shallowly to the northeast (Figure 2).

The Low Ridge layers show no obvious structural relationship to those at Home Plate. At Home Plate, layers at several outcrops were observed to have radial inward dips for the third of the circumference traversed by Spirit. In contrast, the layers at Low Ridge do not dip toward the center of Home Plate, but instead are oriented in at least two oblique directions.

Interpretations: The diverse structural and sedimentological characteristics of the layered rocks found in the Inner Basin of the Columbia Hills suggest a similarly complex formation process(es). The lack of an obvious structural relationship between Low Ridge and Home Plate, as well as the presence of apparently unconformable units within the ridge could imply one or more of the following geologic scenarios: 1) Separate formation events for each of the layered units at Home Plate and Low ridge, interspersed with periods of erosion. 2) Deposition of the layered materials on an uneven substrate, which led to the layers inheriting orientations based on the underlying topography. Emplacement of layers conforming to preexisting topography has also been invoked for Home Plate and this hypothesis is compatible with a pyroclastic origin for the sediment. 3) Disruption of layers by impact processes or tectonic activity. However, no clear evidence of faulting has been observed thus far and impact craters have not disrupted structural organization on the scale of Home Plate.

Further rover observations will aim to determine the importance of each of these mechanisms in the formation and modification of Low Ridge and the surrounding area. In particular, chemical and mineralogical studies will help to further elucidate the relationship between Low Ridge and Home Plate.

References: [1] Arvidson, R. (2006) *Eos Trans.* 87(52), AGU Fall Meet. Suppl., Abstract #P44A-01. [2] Rice, J. et al. (2006) *Eos Trans.* 87(52), AGU Fall Meet. Suppl., Abstract #P41B-1274. [3] McSween, H. Y. (2006) *Eos Trans.* 87(52), AGU Fall Meet. Suppl., Abstract #P44A-08. [4] Schmidt, M. E. et al. (2006) *Eos Trans.* 87(52), AGU Fall Meet. Suppl., Abstract #P44A-07. [5] Ruff, S. W. (2006) *Eos Trans.* 87(52), AGU Fall Meet. Suppl., Abstract #P44A-04. [6] Squyres, S. et al. *Science* (submitted).

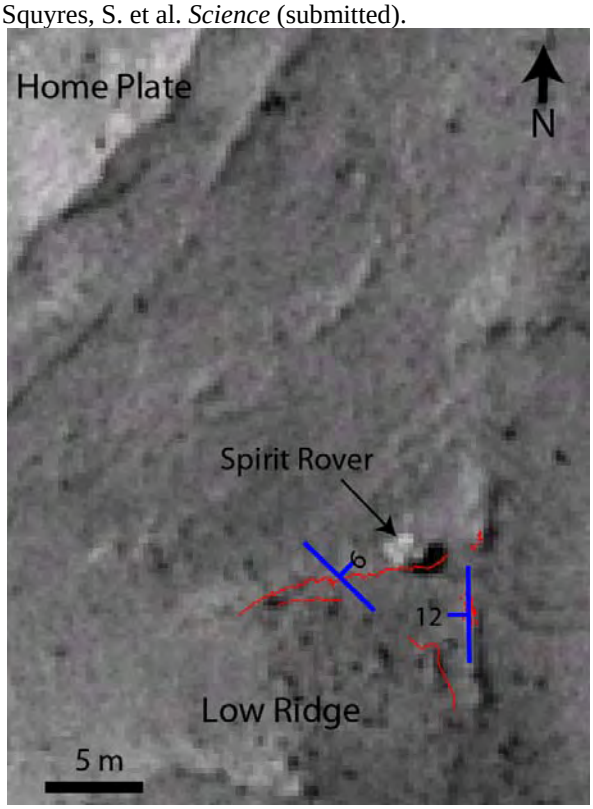

Fig. 2: *HiRISE orbital image of Low Ridge and surroundings. Red lines mark locations of layers observed by the rover. Representative dips of some layers are shown.*

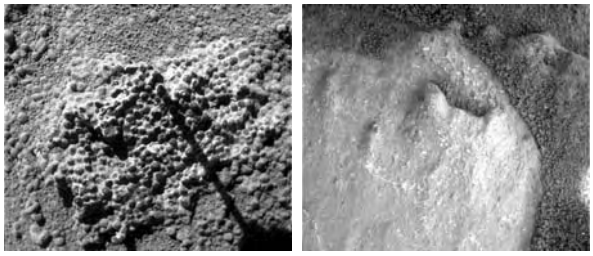

Fig 3: *Microscopic Imager (MI) views of two layered rocks in the Low Ridge area. Left: Image of upper unit rock King George Island, exposed on Low Ridge. Well rounded and sorted, mm-size clasts comprise the rock. Image 2M217894227EFFAS20P2936M2M1. Right: Image of a lower unit rock known as Montalva, on the Troll outcrop, taken on sol 1070. No clastic texture is seen at this scale, indicating a fine-grained nature. Image 2M221357060EFFASCGP2957M2M1. Images are 3 cm across.*