

SIMILAR MICROTEXTURES IN WATCHTOWER AND COMANCHE CLASS ROCKS AT GUSEV CRATER. S. B. Cole¹, K. E. Herkenhoff², R. A. Yingst³, and S. W. Squyres¹, ¹Department of Astronomy, Cornell University, 425 Space Sciences Bldg, Ithaca, NY 14853 (shoshe@astro.cornell.edu), ²USGS Astrogeology Science Center, Flagstaff, AZ; ³Planetary Science Institute, Tucson, AZ.

Introduction: The Mars Exploration Rover Spirit examined numerous rock types during her traverse across “Husband Hill” in Gusev Crater. The wide range of geochemical and mineralogical assemblages and macro- and microscopic textures attest to a variety of depositional materials and diagenetic processes across this region.

Two rock types, Watchtower Class and the Comanche Subclass of the Algonquin Sequence, in addition to being notable in their own right [1,2], demonstrate remarkable similarities in the dataset of one (and only one) of the rover’s instruments: the Microscopic Imager (MI), which can resolve features as small as 0.1mm across [3].

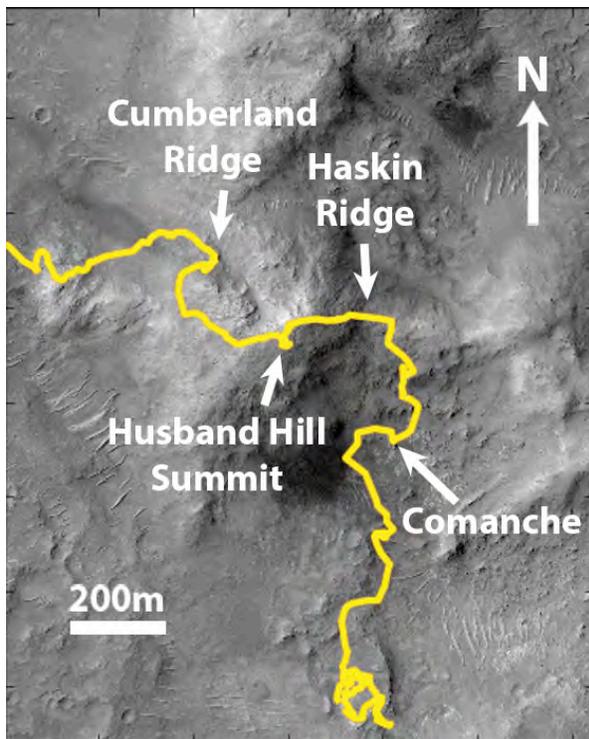


Figure 1. Spirit's traverse across Husband Hill and the Inner Basin. The rover encountered Watchtower Class outcrops at Cumberland Ridge, the Husband Hill summit, and Haskin Ridge, and Comanche Subclass outcrops at the southeastern base of Husband Hill.

Watchtower: Rocks of this class were primarily encountered as outcrops at Cumberland Ridge, the Husband Hill summit, and Haskin Ridge (see Fig. 1). Watchtower Class rocks are believed to have been derived from a Wishstone Class progenitor due to their

compositional similarity to Wishstone but with a higher degree of alteration [1,4]. Members of this class have been divided into various subclasses based on iron mineralogy [5-7] and Pancam VNIR spectroscopy [8]. The Cumberland Ridge outcrops – Methuselah, Jibsheet, and Larry’s Lookout – vary greatly in mineralogy and iron oxidation state but display a striking chemical similarity; this is consistent with aqueous alteration under low water-to-rock conditions.

Geochemistry. Watchtower Class rocks are notable for their high Ti, high P, and extremely low Cr; Cr is often below the APXS detection limit [7,9]. They are enriched in Mg compared to Wishstone Class, and enriched in Al, Ti, K, S, Cl, Br, and P and depleted in Fe, Mn, Ni, and Cr compared to the Adirondack Class basalt that characterizes the Gusev plains [7,10]. The iron oxidation state Fe^{3+}/Fe_{total} of Watchtower Class rocks ranges from 0.43 to 0.94 [5,6].

Mineralogy. All members of Watchtower Class contain ilmenite and substantial amounts of nanophase iron oxide (npOx). Olivine, pyroxene, magnetite, goethite, and hematite are present in some, but not all, targets [5-7]. Detailed analyses of the variation in bulk mineralogy are forthcoming; a wind event deposited dust on the Mini-TES pointing mirror on Sol 420, complicating the interpretation of thermal emission spectra after that date. Mini-TES thermal emission spectra of the Larry’s Lookout outcrop on Cumberland Ridge obtained prior to the wind event are consistent with 35-50% amorphous phase of basaltic composition; 20-25% Na-plagioclase; 5-15% sulfate; and minor orthopyroxene, olivine, phosphate, and secondary silicates [11].

Macroscopic morphology. Watchtower Class outcrops display diverse morphology and textures. They are typically layered and pitted, to varying degrees and on varying scales. The degree of pitting on the Larry’s Lookout outcrop increases from east to west. From afar, it appears that the Methuselah outcrop is massively layered, but in images obtained within a few meters of the outcrop the distantly-seen linear features are clearly joints, with 1-2mm-thick layers evident. There are layers of a similar scale but different morphology on one region of Larry’s Lookout, though the rest of the outcrop is more massive. These outcrops are inclined, with dip directions similar to the local topography though dip angles are significantly steeper [12].

Comanche: This rock subclass was encountered as two neighboring outcrops, Comanche and Comanche Spur, at the southeastern base of Husband Hill (see Fig. 1), and was the first in-situ detection of carbonate rock on Mars. Only Comanche Spur was investigated with the Instrument Deployment Device (IDD), upon which the Alpha Particle X-ray Spectrometer (APXS), Mössbauer Spectrometer (MB), Rock Abrasion Tool (RAT), and MI are mounted. Mini-TES spectra of Comanche and Comanche Spur indicate a relatively uniform composition across the two outcrops [2].

Geochemistry. Comanche Subclass is most notable for containing significant amounts of carbonate. It is considerably depleted in Si, Ti, and Al and enriched in Mg compared to all other rock classes examined by Spirit. It is depleted in Ca, Na, K, and P and enriched in S and Cl compared to Adirondack Class. Comanche's Al, Ca, K, P, and Cl abundances are similar to Innocent Bystander Subclass [2,7].

Mineralogy. Comanche Subclass rocks are 16-34 wt% carbonate. They are composed of roughly equal amounts of Mg-Fe carbonate, Mg-rich olivine, and an amorphous phase of basaltic composition. The Mg-Fe carbonate's composition is well-constrained as $Mc_{0.62}Sd_{0.25}Cc_{0.11}Rh_{0.02}$, where Mc = magnesite, Sd = siderite, Cc = calcite, and Rh = rhodochrosite [2].

Macroscopic morphology. The Comanche and Comanche Spur outcrops are morphologically complex, with both nearly-horizontal and steeply inclined planar features, multiple lobes, and fine-scale pitting. Regions between the nearly-horizontal planes have differentially eroded into rounded protuberances. Some fractures have been filled with deposits that are more resistant to erosion than the surrounding material, observed as raised fins.

Microscopic Textures: Both Watchtower Class and Comanche Subclass rocks display a nodular texture when viewed with the MI (see Fig. 2). Microscopic textures vary greatly between Watchtower Class outcrops, with Methuselah displaying smaller grains and more distinct laminations than Larry's Lookout. Outcrops on the Husband Hill summit are similar in texture to Larry's Lookout, though more distinctly layered. Watchtower grain sizes fall in the range ~0.3-1.2mm. The Comanche Spur targets Horseback and Palomino both display fine laminations, though there is greater spacing between the Horseback laminations. We interpret Comanche as individual grains in a clast-supported matrix, with grain sizes ranging ~0.3-2.2mm. The uncertainty in size is greater for Watchtower targets than for Comanche targets due to a greater proportion of cementing agent in Watchtower Class rocks, making individual grains more difficult to resolve.

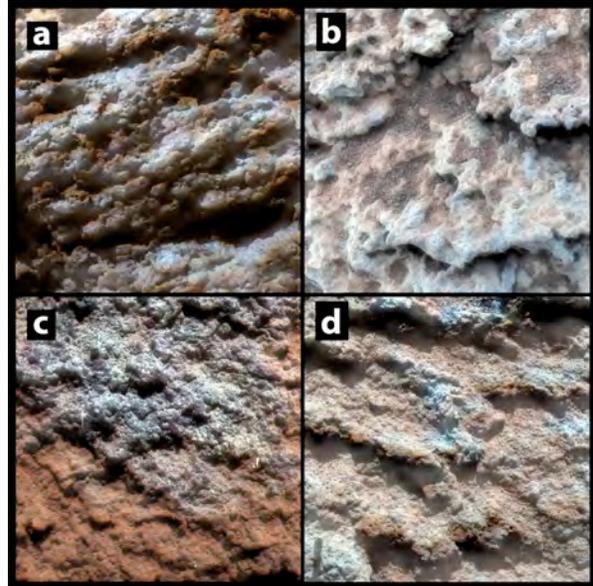


Figure 2. Merge of Pancam enhanced L257 color and MI images of a) Paros, Larry's Lookout; b) Keystone, Methuselah; c) Palomino, Comanche Spur; and d) Horseback, Comanche Spur. Each image is about 3cm across. NASA/JPL/Cornell/USGS.

References: [1] Squyres S. W. et al. (2006) *JGR*, *111*, E02S11, doi:10.1029/2005JE002562. [2] Morris R. V. et al. (2010) *Science*, *329*, 421-424, doi:10.1126/science.1189667. [3] Herkenhoff K. E. et al. (2004) *Science*, *305*, 824-826, doi:10.1126/science.1100015. [4] Hurowitz J. A. et al. (2006) *JGR*, *111*, E12S14, doi:10.1029/2006JE002795. [5] Morris R. V. et al. (2006) *JGR*, *111*, E02S13, doi:10.1029/2005JE002584. [6] Morris R. V. et al. (2008) *JGR*, *113*, E12S42, doi:10.1029/2008JE003201. [7] Ming D. W. et al. (2008) *JGR*, *113*, E12S39, doi:10.1029/2008JE003195. [8] Farrand W. H. et al. (2008) *JGR*, *113*, E12S38, doi:10.1029/2008JE003237. [9] Gellert R. et al. (2006) *JGR*, *111*, E02S05, doi:10.1029/2005JE002555. [10] Ming D. W. et al. (2006) *JGR*, *111*, E02S12, doi:10.1029/2005JE002560. [11] Ruff S. W. et al. (2006) *JGR*, *111*, E12S18, doi:10.1029/2006JE002747. [12] Cole S. B. et al., in prep.