THE EARLY HISTORY OF GUSEV CRATER REVISITED. S. W. Ruff[1], [1]Arizona State University, School of Earth and Space Exploration, Tempe AZ 85287-6305, steve.ruff@asu.edu.

Introduction: Observations from the Spirit rover and orbital instruments have provided the most detailed look yet at the geology of Gusev crater. Although many of the discoveries by Spirit were unanticipated and some appear to contrast with the putative paleolake, it is now possible to recognize and begin to reconstuct an era prior to the early Hesperian plains-basalt emplacement during which major deposition and erosion occurred and perhaps an ephemeral playa or regolith aquifer existed.

Observations: The Columbia Hills represent an island or kipuka around which flood basalts were emplaced. Observations from Spirit demonstrate that the now disaggregated flow on the west side is composed of olivine-rich basalt known as Adirondack class, which also has been recognized on the east side [1]. The flow(s) are analogous to mare lava flows on the Moon and have been dated at 3.65 b.y., which appears to be among the latest rocks units emplaced on the crater floor [2]. Additional kipukas are clustered within ~10 km of the Columbia Hills that share common characteristics with the most widespread geologic unit found there. Described as “rubble terrain” by [3], this material is present as an onlapping unit at the southwest end of the Columbia Hills. It displays a notably boulder-rich surface of knobs and rubble piles that have higher thermal inertia than the surrounding plains. These morphologic and thermal characteristics are found amongst the other kipukas that were previously mapped by [4] as the high thermal inertia, morphologically rough (HTIR) unit representing the oldest terrain exposed in Gusev crater (Figs. 1 and 2).

Within the Columbia Hills where Spirit traversed are examples of bouldery knobs with elevated thermal inertia that may be unmapped outliers of the HTIR unit based on HiRISE and THEMIS images, respectively. They occur on Haskin Ridge and are represented by the Algonquin-class clastic, olivine-rich rocks that make up an apparent olivine fractionation sequence of increasing Mg composition that drapes preexisting topography [5-7]. Among these rocks are the Mg-Fe carbonate-rich Comanche outcrops that are the stratigraphically highest member [8]. [9] demonstrated that Comanche rocks are spectrally matched by the addition of Mg-Fe carbonate to Algonquin rocks, with evidence for compositional zoning of the carbonate. Other examples of possible carbonate-enriched Algonquin rocks have been identified in a location that appears stratigraphically intermediate between the recognized Comanche and Algonquin outcrops, and also in an outcrop on Allegheny Ridge and boulders on McCool Hill [10]. An additional exposure of Mg-Fe carbonate has now been identified south of the Comanche outcrops using orbital data [11].

Interpretations: If the Algonquin class rocks that mantle Haskin Ridge and are evident elsewhere in the Columbia Hills are an outlier of the HTIR unit, then they share a common origin and history with the now isolated kipukas on the floor of Gusev crater that display similar morphologic and thermal characteristics. A history is suggested in which deposition of increasingly Mg-rich volcaniclastic materials occurred across the crater floor, mantling preexisting terrain like the Columbia Hills. Given that the Algonquin-class rocks are clastic and fractionated, they likely were produced by explosive volcanism from an evolving magma chamber. The introduction of Mg-Fe carbonates would have followed the deposition of the stratigraphically highest and most Mg-rich member as demonstrated by the spatial and spectral relationships between Algonquin and Comanche outcrops.

Although [8] invoked a hydrothermal origin for the Comanche carbonate, I propose that evaporative precipitation of surface or subsurface brines infiltrating the uppermost Algonquin class rocks could have produced the carbonate, as suggested for the Mg-Fe carbonate globules in the ALH84001 Martian meteorite [12-14]. This is consistent with the wider distribution of the carbonate bearing rocks that is now observed and the evidence for compositional zoning of the carbonate.

Whether additional deposition occurred following the emplacement of carbonate is unknown. But at some point erosion dominated, stripping most of the Columbia Hills and surrounding plains of Algonquin class rocks including the carbonate-bearing member, and leaving behind isolated remnants that ultimately were embayed in the early Hesperian by Adirondack class basalts.

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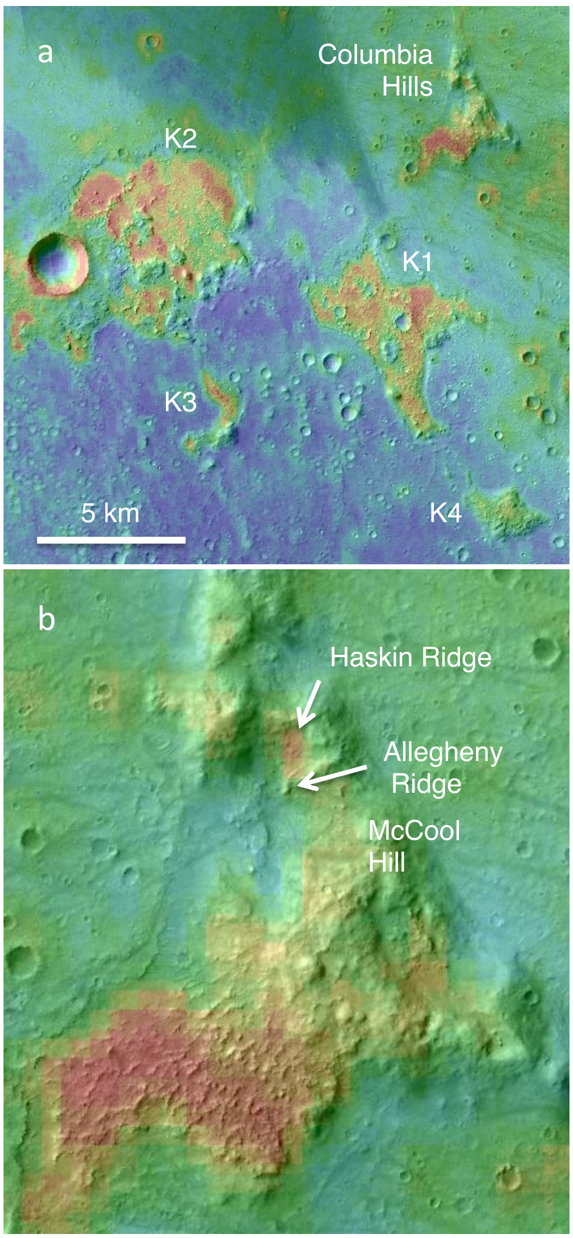

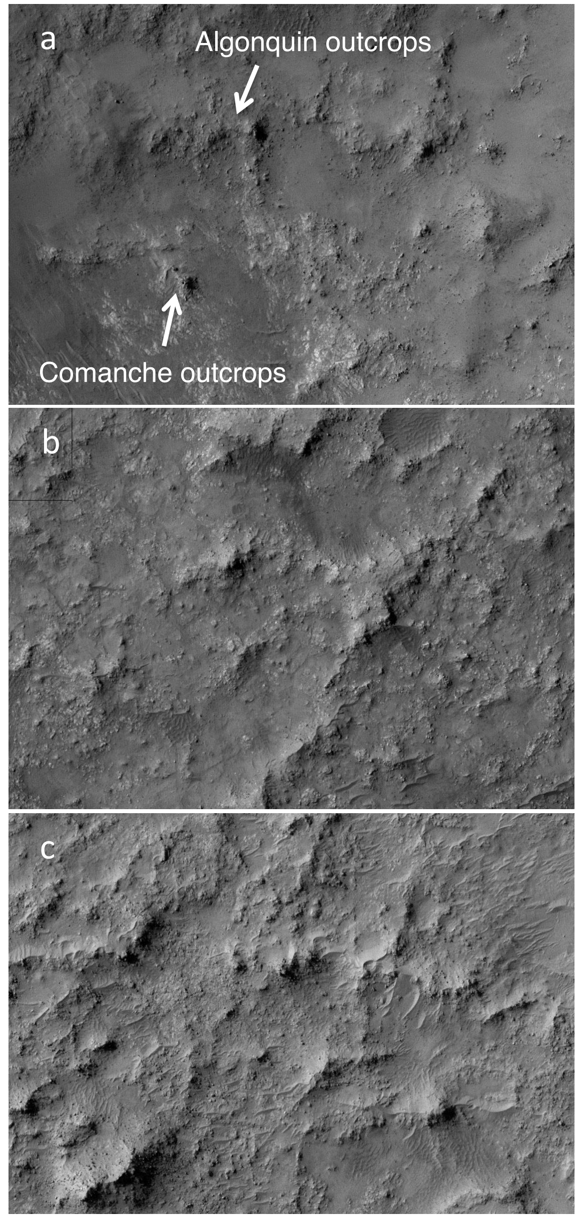

Figure 2. Outcrop scale morphology of the HTIR unit and an unmapped candidate. (a) Bouldery knobs examined by Spirit on Haskin Ridge are remarkably similar to those of the main HTIR unit mapped in (b) the SW Columbia Hills and (c) the feature K1 from Fig. 1a. All scenes are ~250 m across and come from HiRISE PSP_001513_1655_RED

Figure 1 (left). Merged CTX and THEMIS nighttime IR images reveal islands (kipukas) of similar terrain in the region of the Columbia Hills. (a) The annotated features and SW portion (red) of the Columbia Hills were mapped as the HTIR unit by [4]. (b) A HiRISE/THEMIS image of the Columbia Hills shows the prominent HTIR unit and smaller candidates not previously mapped, including one on Haskin Ridge.