

UPPER DRAINAGE AND WATERSHED OF THE MULTI-STAGE PEACE VALLIS ALLUVIAL FAN SYSTEM, GALE CRATER, MARS: H. E. Newsom¹, L. A. Scuderi¹, Z. E. Gallegos¹, T. Nagle-Mcnaughton¹, L. L. Tornabene², R. C. Wiens³. ¹U. New Mexico, Albuquerque, NM 87131, USA (Newsom@unm.edu); ²U. Western Ontario, CN ³Los Alamos Nat. Lab, NM.

Introduction: The history of fluvial activity in Gale Crater has been examined by numerous authors [recently 1-3]. The Peace Vallis (PV) channel and alluvial fan received the most attention due to the proximity to the MSL (Curiosity) landing site. An initial watershed area (or catchment) of about 1000 km² that may drain to the Peace Vallis (PV) fan was identified [1]. The determination that an upper PV fan unit may be substantially younger than the majority of deltas and fan surfaces in Gale has led us to begin reexamining the upper PV channel network and watershed [4]. Although new HiRISE images have helped with the interpretations, coverage is still very limited, there are no HiRISE stereo pairs, and the lack of HiRISE DEMs makes quantitative analysis difficult. However, the following observations and preliminary interpretations seem plausible:

1. Fluvial modification occurred over a large amount of time; a hierarchy of channel cutting and inverted channel deposition both above and below the crater rim began with an early generation of channels followed by a later generation (e.g. Figs. 1, 2).
2. Drainage from the northern watershed through the crater rim occurred at multiple locations, with later stream capture leading to concentration of flows in the PV main channel, and an increase in the watershed area by as much as a few hundred km², especially NE of the main Peace Vallis channel (e.g. Fig. 1, Fig. 3).
3. Late stage erosion in the water shed region resulted in deposition of light toned materials into the craters and floors of channels and depressions. This episode is consistent with latest deposition of the AF fan making up the upper northern portion of the PV fan, interpreted to be mostly fine-grained materials [4, 5].
4. Late stage of fluvial activity resulted in very small sinuous channels – Consistent with latest stage flow, possibly including groundwater sourced outflow depressions on the PV fan [5].

Observations: Available imagery for the whole area in question includes CTX and some HiRISE imagery. Although Gale Crater has been intensively targeted by HiRISE due to the MSL project, only limited coverage of the crater rim has been acquired.

The crater rim of Gale and large areas surrounding Gale and nearby craters along the dichotomy boundary have experienced substantial modification due to the early formation of channel networks. Careful examina-

tion of images and topographic data is allowing recognition of the source basins and evolution of the channel systems. Evidence of the presence of fluvial activity consists of large channels like the main channel of Peace Vallis. There are also abundant inverted channel deposits at different stages of degradation and thin small channels, that seem to represent the latest fluvial activity. An important geomorphic evidence of topographic channels is the ubiquitous presence of dune forms, that may also obscure late smaller channels within larger ones.

The evolution of the fluvial channel network is clearly due to the irregular post-impact topography that was integrated by early fluid runoff into pathways of least resistance down the crater rim to the bottom of the crater floor. This channel evolution was further affected by the interplay between deposition resulting in the inverted channel deposits and fan deposits and avulsion, channel erosion and channel head cutting.

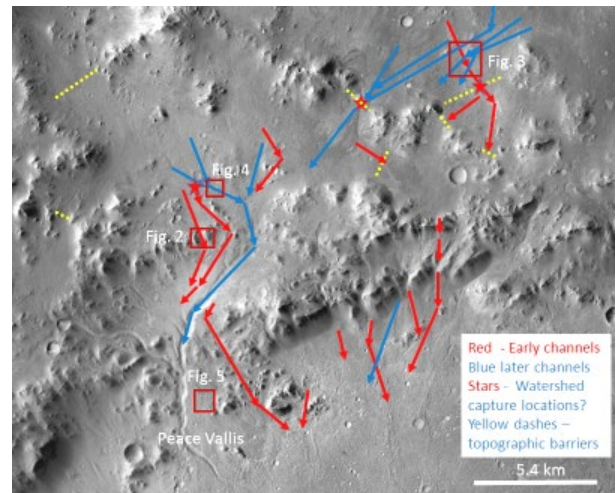


Fig. 1. Speculative interpretation of channels on the Northern Gale Crater rim. Early (red) and late (blue) channels and inverted channel deposits. Major watershed capture (red star). Approximate locations of other figures are not shown to scale. CTX: D03_028269_1752_XI_04S222W.

The earliest channels may include features like a scarp (Fig. 2,) probably due to a waterfall within what seems to be an early dune filled channel strongly suggests that this was a significant channel early in the post-impact history of the basin. This feature may have been preserved due to stream capture of the flow into the main PV channel. In this way, the sequence of evi-

dence for channel directions has allowed for the identification of locations where basin capture may have occurred (e.g. Fig. 1, 2). The channel network further evolved as stream capture integrated the stream networks. A spectacular case of stream capture is seen (Fig. 1, 3) where large early inverted channels draining south to the crater rim east of the PV channel, are cut by channels and inverted channel deposits draining west through a draw into the PV watershed.

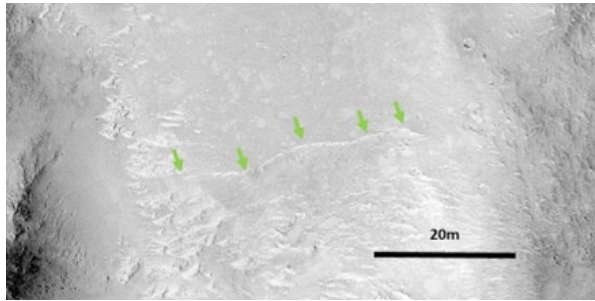


Fig. 2. Example of a possible waterfall scarp (green arrows at top of scarp) in an early channel right at the break in slope at the crater rim. Above the scarp is an area with light-toned material filling craters (e.g. Fig. 4). HiRISE: ESP_055644_1760.

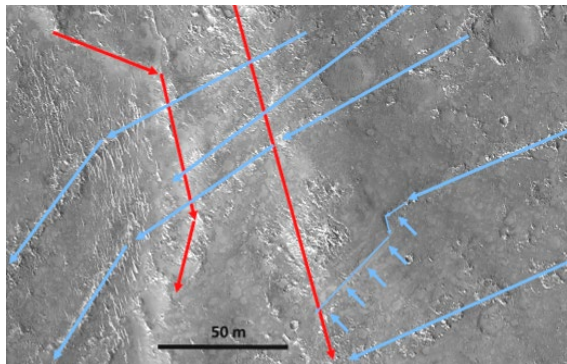


Fig. 3. Example of early inverted channel deposits (speculative) flowing from north to south (red). Later channels flowing from east to west cover the early channels with inverted deposits and in one area created a channel cutting through the earlier deposits (thick blue arrows). HiRISE: ESP_055578_1760.

This later Hesperian/Amazonian episode of fluvial activity became progressively more spatially localized, deposited chlorides in a nearby watershed (Sharp Knobel) and Fe/Mg phyllosilicates in fans [2]. This may correspond to the Gale material dated at ~ 1.4 Ga., and the latest resurfacing of the PV fan. Of great interest is the evidence for mobilization in the watershed of the fine-grained surface material seen on the upper PV fan. The new HiRISE images show a mottled terrain where fine-grained material (Fig. 4), has filled the cra-

ters (possibly including pitted terrain from volatile-rich impact melt deposits?[6]) and channels, presumably consisting of aeolian dust and altered regolith that would be easily mobilized by a late fluvial episode.

The final evidence for fluvial activity is the existence of small channels (e.g. Fig. 5). These channels are found in many areas of the PV fan watershed. One issue for these small channels is the potential for erosion of these channels, which could rapidly erase them. To preserve these small channels there must have been less than $\sim 2\text{--}3$ m of deflation since their formation. Assuming a formation age of ~ 1.4 Ga from crater counts, 3m of erosion implies an erosion rate of $\sim 2 \times 10^{-3}$ m/Ma. This rate is in the middle of the compilation of rates for the Hesperian through Amazonian of $\sim 0.5\text{--}15 \times 10^{-3}$ m/Ma [7].

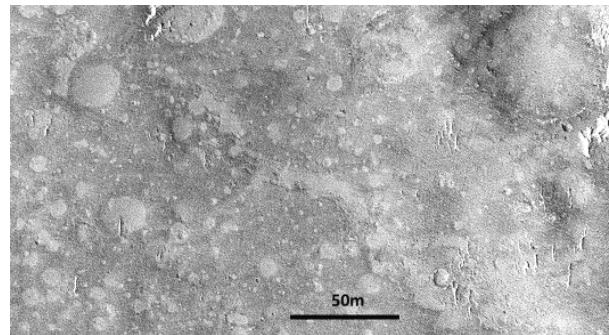


Fig. 4. Mottled terrains in PV watershed. Note light-toned material filling craters and channels. HiRISE: ESP_055644_1760.

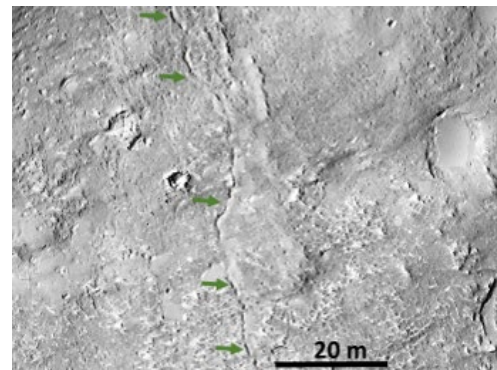


Fig. 5 Example of a small channel, part of the most recent small scale fluvial record. HiRISE: PSP_010283_1755.

References: [1] Palucis et al., (2014) J. Geophys. Res.: Planets 119:705–728. [2] Ehlmann and Buzz (2015) Geophys. Res. Letters 42(2):264–273. [3] Buzz et al., (2014) Geophys Res: Planets 122(5):1090–1118. [4] Grant et al., (2014) Geophys. Res. Lett. 41:1142–1148. [5] Scuderi et al. (2019), this conf. [6] Tornabene et al. (2012) Icarus, 220, 348–368. [7] Golombek et al. (2014) J. Geophys. Res., 111:E12S10.