SOUTHERN WATERSHED AND FLUVIAL HISTORY OF THE PEACE VALLIS FAN SYSTEM, GALE CRATER, MARS: H. E. Newsom[1], L. A. Scuderi[1], Z. E. Gallegos[1], T. P. Nagle-McNaughton[1], L. L. Tornabene[2], F. J. Calef III[3], M. E. Schmidt[4], J. Churchill[4], R. C. Wiens[5]. J. A. Grant[6], M. C. Palucis[7], [1]U. New Mexico, Albuquerque, NM 87131, USA (Newsom@unm.edu); [2]U. Western Ontario, CN; [3]JPL, Pasadena, CA; [4]Brock Univ., CN, [5]Los Alamos Nat. Lab.; [6]National Air and Space Museum, Smithsonian Inst., Washington, DC; [7]Dept. Earth Sci. Dartmouth College, NH.

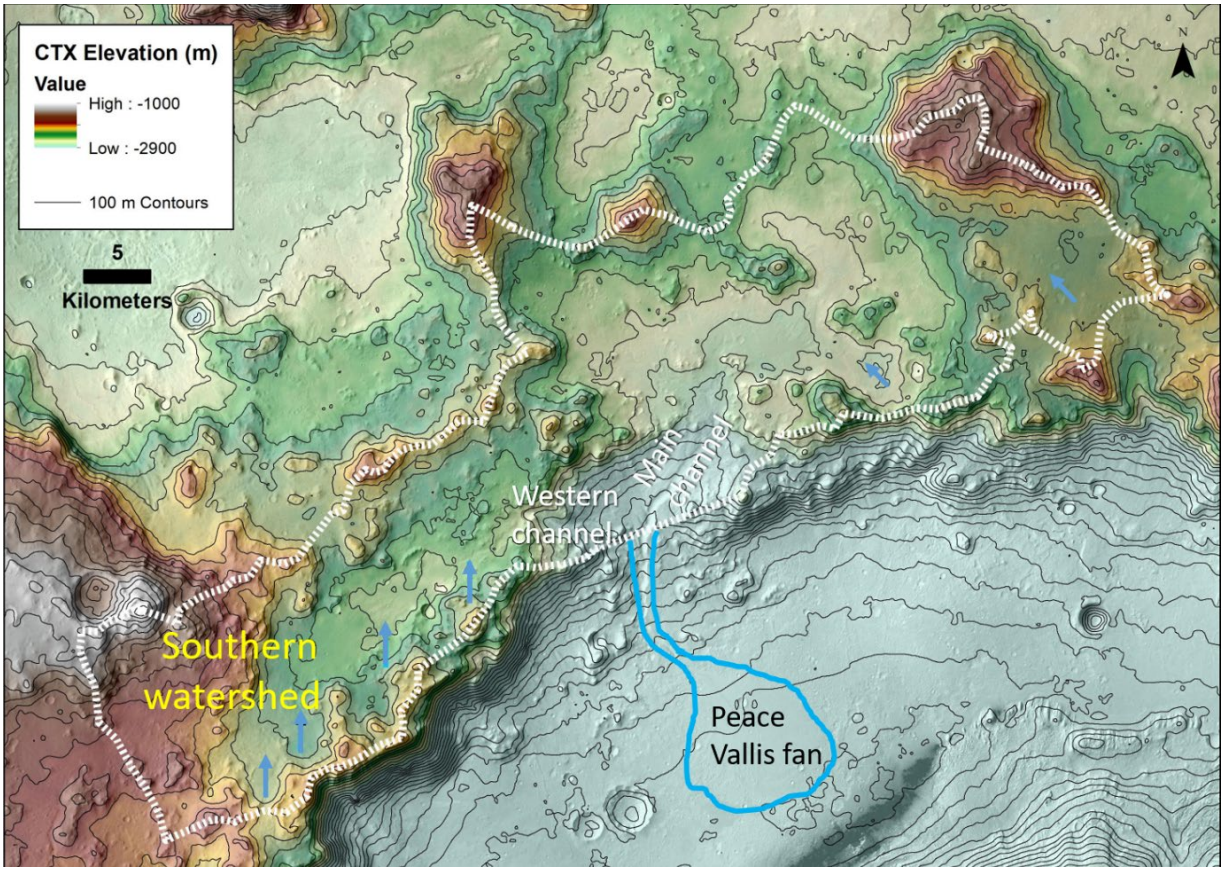

Fig. 1. Northern Gale crater wall with location of the Peace Vallis Fan and the watershed basins feeding the fan. The newly identified Southern watershed drains to the western Peace Vallis channel. Blue arrows show water flow directions away from the crater rim except for the Peace Vallis location. CTX DEM data used for topography.

Introduction: The Peace Vallis (PV) channel and alluvial fan has received great attention due to the proximity to the MSL (Curiosity) landing site [1-3 and older references]. The upper PV fan (AF) unit, distinctly visible in orbital images, is younger than the lower Peace Vallis fan and post-dates the more significant Hesperian aqueous period associated with a lake in Gale crater [4].

Observations: CTX and HiRISE images (including two new HiRISE), and topography suggest:

1. An extension of the Peace Vallis watershed (Southern watershed, Fig. 1) with an area of ~ 400 km^2, that expands the original watershed area identified by Palucis et al [1] to ~ 1500 km^2.

2. Fluvial modification occurred over time (e.g. Fig. 3) with a hierarchy of channel cutting and inverted channel deposition, both above and below the crater rim, with both early and later generations of channels. Early channels sourced from the crater rim onto the crater floor were probably early ground water spring-sourced, as many have limited watersheds, but melting of snow high in the alcoves is also possible.

3. Later Amazonian erosion in the watershed region resulted in deposition of light toned materials into the craters and floors of channels and depressions (Fig. 4A.). This episode is consistent with deposition of the AF fan making up the upper northern portion of the PV fan, interpreted to be mostly fine-grained materials, and probably includes shallow late groundwater sourced fluvial discharge events on the PV fan [4, 5]. This late stage of fluvial activity also resulted in ubiquitous small sinuous channels less than 1 m wide (Fig. 4B).

Discussion: The recognition of an extension of the PV watershed to the south, above the topographic rim of Gale, increases the PV watershed area by almost

40%, consistent with the large PV channels and fan, and evidence for relatively recent fluvial activity, deposition, and limited discharge events on the fan [4]. The record of fluvial activity in this rim area and regionally along the dichotomy boundary, suggests substantial evolution of the channel networks..

The earliest channels may include features like a scarp (Area 2, Fig. 3)[6] probably due to a waterfall within an early 60 m wide channel. This feature may have been preserved due to stream capture of the flow into the main PV channel. Several other locations may be where basin capture occurred (e.g. Fig. 2). The channel network further evolved as stream capture integrated the stream networks. Area 1 (Fig. 1) is the location of an example of channels and inverted channel deposits formed by flows from northeast to southwest (blue) across a scarp; the scarp, seen in HiRISE ESP_055578_1760, was misinterpreted as an early channel by [6].

Some of the inverted channel deposits on the crater floor (e.g. Fig. 2, east of the PV fan), appear to have only been active early, consistent with their much smaller watersheds, in contrast to the PV fan. Furthermore, the absence of large watersheds for many of these early fans suggest water from early springs from the rim wall played a role in their formation.

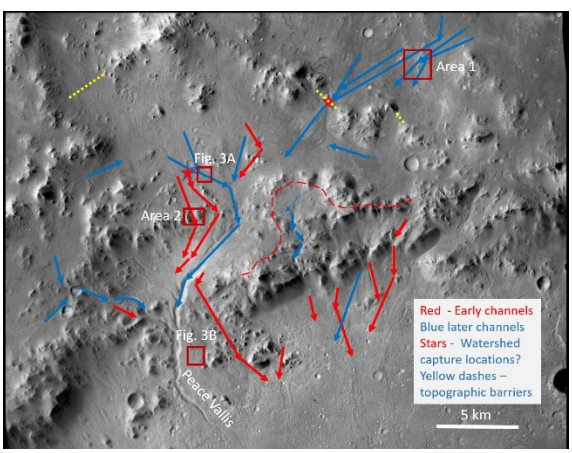

Fig. 2. Speculative interpretation of channel history on the Gale Crater rim, including, early (red) and late (blue) channels and channel deposits, major watershed captures (red stars) and a portion of the crater rim watershed boundary (red dashes). Approximate locations of other figures are not shown to scale. CTX: D03_028269_1752_XI_04S222W.

The 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 [5]. The recent HiRISE images show a mottled terrain where fine-grained material (Fig. 4), has filled the craters, presumably consisting of aeolian dust and altered regolith that would be easily mobilized by a late fluvial episode. Such material could include pitted terrain from volatile-rich impact melt deposits [7] and volcanic deposits from the likely North Gale Landform feature just north of the PV watershed [8].

Another piece of evidence for late fluvial activity, due to precipitation or snow melt in the watershed, is the existence of small channels found in many areas of the PV fan watershed (e.g. Fig. 3B). To preserve these small channels there must have been less than ~2-3 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 ~ 2 x 10^{-3} m/Ma. This rate is in the middle of the compilation of rates for the Hesperian through Amazonian of ~0.5-15 x 10^{-3} m/Ma [9].

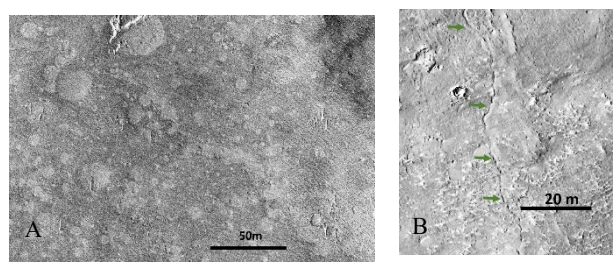

Fig. 3. A. Mottled terrains in PV watershed. Note light-toned material filling craters and channels. HiRISE: ESP_055644_1760. **B.** Example of a small channel, part of the most recent small scale fluvial record. HiRISE: PSP_010283_1755.

Conclusions: The recognition of the larger size of the watershed for Peace Vallis confirms the importance of this watershed as a source for the Gale Crater lake and PV fan deposits, but especially for the late fine grained PV fan deposits of Amazonian age [4, 5]. The proximal crater rim provided a surprisingly effective barrier for flow into the crater, except at one location over a rim length of ~50 km. Some integration of the channel network in the watershed did involve down cutting through topographic barriers and stream capture.

References: [1] Palucis et al., (2014) J. Geophys. Res. Planets 119:705–728. [2] Ehlmann and Buz (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), LPSC #5043 and this meeting. [6] Newsom et al., (2019) LPSC, #2568. [7] Tornabene et al. (2012) Icarus, 220, 348-368. [8] Churchill et al. (2017) LPSC #2411. [9] Golombek et al. (2014) J. Geophys. Res., 111:E12S10.