GLACIAL PALEOMORPHOLOGIES IN GALE CRATER, MARS. A. G. Fairén[1,2], A. F. Davila[1,2], E. R. Uceda[2], J. M. Dohm[3], V. R. Baker[3], C. P. McKay[2] and C. R. Stokes[4]. [1]Carl Sagan Center, [2]NASA Ames Research Center, [3]University of Arizona, [4]Durham University. alberto.g.fairen@nasa.gov

Introduction: Glacial modification at the highlands-lowlands transition appears to have been pervasive at least since the Hesperian, and possibly earlier [1,2]. Gale crater (5.4S, 137.7E), the selected landing site for the ongoing Mars Science Laboratory (MSL) rover mission, is a 150-km-diameter impact crater formed during the Late Noachian/Early Hesperian [3], and located near the dichotomy boundary and the Medusae Fossae Formation, in the Aeolis quadrangle. Here we show evidence for glacial activity and modification in Gale crater. In several other craters near the dichotomy, features of glacial origin can similarly be identified. Glacial activity in Gale can be recognized both at large and small scales. In this work we (1) identify glacial morphologies in Gale at large scale, and (2) propose to use MSL instrumentation to search for and identify small-scale glacial features.

Large-scale glacial morphologies at Gale: We show here (Figs. 1 and 2) geological evidence that knobs and valleys debouching from the central mound of Gale may have been glacially altered, including the potential formation of glacial cirques and glacial valleys with lateral, medial, terminal and barrier moraines, eskers, kames, and the final emergence of rock glaciers. Our interpretations are supported by morphological observations using high-resolution datasets, particularly HiRISE images. Interestingly, some glacial valleys are located along the northwestern margin of the central mound and near the edge of the MSL landing ellipse, therefore close to some potential traverse routes. The identification of large-scale glacial morphologies presented here point to prime MSL targets of morphological and geochemical interest.

***In situ* MSL investigations:** We propose using MSL capabilities to search for morphological traits of glacial deposition/erosion at a small scale, similar to those identified on glacial environments on Earth, assuming that some of these features might have survived multi-billion years of Martian weathering. This should include angular to sub-angular boulders and grain-size distributions, striated boulder pavements, mechanical abrasion marks on boulders, boulder trains, and formation and sedimentary properties of subglacial till. In addition, the glaciers emanating from higher up on the central Gale mound would necessarily deliver lithologies from their source areas to the glacial termini, which could well have been calving into the glacio-lacustrine environment on the crater floor. There would then be ice-rafted erratics to be found by the MSL instruments. The potential direct accessibility to phyllosilicates, sulfates, salts and other aqueous minerals transported to the glacial termini from up in the mound is equally appealing. The preliminary analyses of orbital datasets searching for regional evidences of ancient glaciated landscapes inside Gale, presented here, may help to decide which are the most promising areas to preserve small-scale glacial features, and ultimately to suggest traverse plans for MSL.

Conclusions: Investigations with MSL will contribute to observe a number of regional phenomena at the landing site, including not only the 5-km-thick stratigraphic record of the central mound of Gale, but also possibly the Medusae Fossae Formation and the dichotomy boundary morphologies in general. We propose to consider looking for local, small-scale glacial paleomorphologies at Gale crater, which would contribute to understanding the climatological and hydrogeological histories of this region of Mars.

References: [1] Fairén A.G. et al. (2011) *Nature Geos*. 4, 667–670. [2] Davila. A.F. et al., submitted. [3] Greeley, R., and Guest, J.E. (1987) USGS Map I-1802-B. [4] Davies N.S. and Gibling M.R. (2011) *Nature Geos*. 4, 629-633.

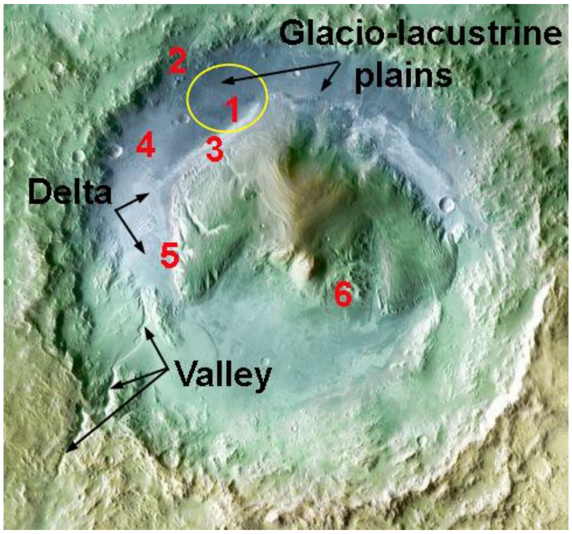

Fig 1: Map of Gale crater showing the location of the glacial features described in Fig. 2. Labels indicate a possible paleo-fluvial feature, including a valley incising the south crater rim and conducing water and water ice into the glacio-lacustrine plains on the crater floor. The valley may be a subglacial channel or a supraglacial stream. The MSL landing ellipse is indicated in yellow.

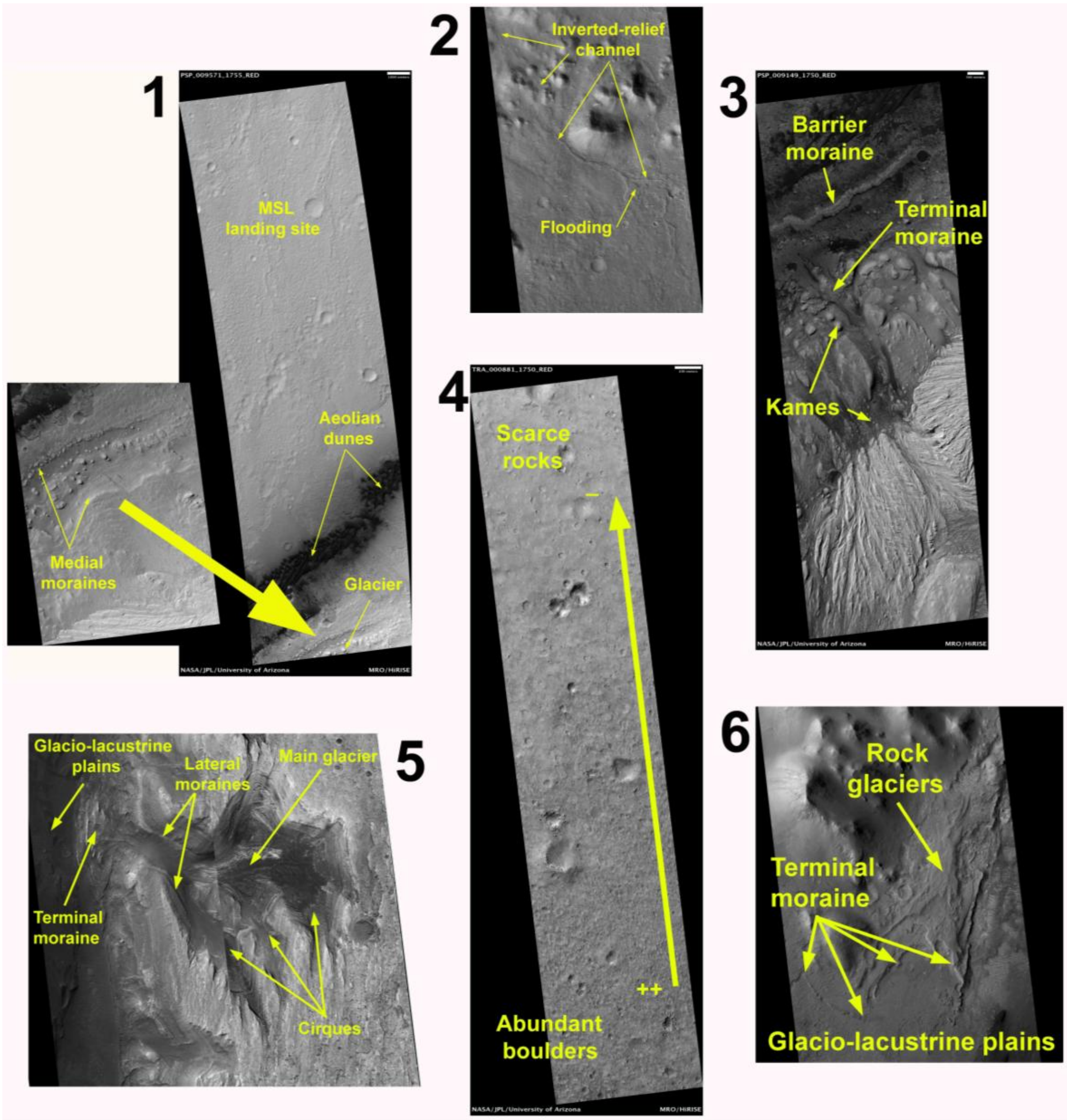

Fig. 2: Glacial paleomorphologies in Gale, as identified in Fig. 1. **(1)** HiRISE images PSP_009571_1755 and PSP_009861_1755, showing potential evidence for glacial activity inside the MSL landing ellipse. **(2)** HiRISE image ESP_021900_1755, showing lateral flooding in low-slope areas, which may be associated with a lack of vegetation, similar to non-vegetation rivers on Earth before the spreading of land plants [4]. Evaporites may be found in the flooded areas, a potential interesting target for MSL investigations. **(3)** HiRISE image PSP_009149_1750. This canyon is the preferred route for MSL to climb up Gale's central mound. The large concentration of sediments deposited near the terminus of the canyon forms a positive-relief glacial outwash plain on the floor of Gale, possibly formed by glacier meltwater depositing sand and gravel in the glacio-lacustrine plains that likely covered Gale's floor. Eventually the ice disappeared, leaving the old deposits dry and high-standing, likely including an extensive sampling of diverse materials from higher up on the mound. The barrier moraine separating the glacier front from the glacio-lacustrine plains could also be interpreted as an esker from a different ice flow direction. In that case, it would be part of a more extensive glaciated landscape sourcing in the valley + outwash plain shown in Fig. 1. **(4)** HiRISE image TRA_000881_1750. Boulders are more abundant in the southern (bottom) part of this image, and their density decreases towards north. This image covers an area north of the possible big fluvial system comprising a valley and possible delta in the southwest part of Gale, including a breach in the crater rim (see Fig. 1). The boulder and rock gradient shown here could be associated with glacial activity in the valley and into the plains, rather than fluvial activity alone. **(5)** HiRISE images ESP_013052_1745, ESP_013540_1745 and ESP_017786_1745. This is possibly the most complete glacial structure preserved inside Gale. **(6)** HiRISE image PSP_002464_1745. Paleoglacial morphologies can also be found far away from the MSL landing ellipse. **Overall interpretation:** The boulder transition highlighted in (4) would indicate till gradation at the paleoglacier front, (1) would indicate the advance of a main glacier on the crater floor, and the glaciers sourcing from the central mound of Gale shown in (3), (5) and (6) would be lateral glaciers calving into the glacio-lacustrine environment on the crater's floor.