TESTING LINKS BETWEEN IMPACTS AND FLUVIAL EROSION ON POST-NOACHIAN MARS. R. P. Irwin III, Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, MRC 315, 6th St. at Independence Ave. SW, Washington DC 20013, irwinr@si.edu.

Introduction: The valley networks and fan-shaped deposits on Mars reflect past conditions when liquid water flowed across the surface. Most crater counts on valley networks suggest a decline of fluvial activity around the Noachian/Hesperian transition [1,2]. However, a number of studies have indicated Hesperian to Amazonian ages for some valley networks or alluvial fans [3–6]. These age estimates have motivated modeling of possible water sources, including local, geologically short-lived precipitation and/or melting of ground ice following larger impacts [6–9].

The purpose of this study is to determine whether fluvial erosion of the largest post-Noachian impact craters occurred immediately after the impacts, or if geologically rare or long-lived events occurred between the impacts and subsequent erosion. Such events would indicate a later water source that was independent of the impact. A lack of interspersed events may be permissive of impact-generated runoff, provided that the process could account for similar, contemporary erosion elsewhere on Mars.

Methods: The largest impacts would be expected to have the greatest environmental effects [8,9], so we identified the youngest craters on Mars with diameter *D*>150 km. We examined all craters in that diameter range in the Robbins and Hynek [10] crater dataset and noted six with preserved ejecta blankets and secondary crater chains (Table 1). Craters <2–4 km in diameter, including most secondaries, are preserved from the Hesperian but not the Noachian Periods [11], so preserved secondaries indicate a Hesperian or younger age of a crater. Statistically robust crater counts are also possible on smaller surfaces for the Hesperian [5]. The relative youth of the large craters in Table 1 allows more accurate stratigraphic analysis than is possible for Noachian craters. We noted age constraints and major stratigraphic observations for each of these six sites.

Table 1. Post-Noachian craters with *D*>150 km.

Crater	Location	Diameter (km)	Epoch
Galle	50.6ºS, 30.9ºW	223	eA
Lyot	50.5ºN, 29.3ºE	220	lH–eA
Lowell	52.0ºS, 81.4ºW	199	H–eA
Gale	5.4ºS, 137.8ºE	154	H
Bakhuysen	23.0ºS, 15.8ºW	153	eH
Holden	26.0ºS, 34.0ºW	153	H

Results:

Galle crater. This crater has experienced little fluvial erosion. A count of craters superimposed on Galle crater and its ejecta returns an Early Amazonian age, consistent with recent mapping [12].

Lyot crater. Lyot crater has sparse but lengthy interior valleys or gullies [13], as well as a northward-draining, parallel valley network that heads at the northern margin of the continuous ejecta [14]. However, significant fluvial erosion of the crater or its ejecta is not observed [15]. Published age estimates vary from Late Hesperian [16] to Early Amazonian [17].

Lowell crater. Interior dissection is relatively sparse and shallow, but some lengthy valleys are evident. Published ages range from roughly the Noachian/Hesperian boundary [16,18] to the Late Hesperian–Early Amazonian [19] (the crater crosscuts Hesperian normal faults).

Gale crater. The Curiosity rover's landing site has moderate rim dissection and an entrance breach that was supplied by a valley network from the southwest. A fan at the end of that entrance breach appears confined west of the thick interior layered deposit (Aeolis Mons). The lower part of Aeolis Mons is also dissected, so adequate time was available for that stratigraphy to accumulate before the erosion occurred. One study dated Gale to around the Noachian/Hesperian transition [20], and it crosscuts the dichotomy boundary scarp, which is Early Hesperian [21,22]. Hanging fluvial valleys west of Gale were incised before the boundary scarp formed and reactivated thereafter, suggesting a post-Noachian hiatus in fluvial activity [23]. Gale crater may have formed during this dry interval.

Bakhuysen crater. This crater has more substantial rim dissection than Gale crater and more prominent alluvial deposits [24] (Fig. 1). A count of superimposed craters >5 km in diameter gives an Early Hesperian age.

Holden crater. The western rim of Holden crater is extensively dissected and sourced a large alluvial fan complex [5,24]. Inside the crater, light-toned stratigraphy is overlain by flood deposits from the Uzboi Vallis entrance breach and younger alluvial fan deposits [25]. Uzboi Vallis received drainage from Nirgal Vallis, which heads 600 km from Holden crater. This complex series of events is unlikely to have occurred in the short time that significant heat from the impact was available. Multiple craters that post-date Holden crater or its ejecta are substantially degraded or contain light-toned stratigraphy, so the craters (which represent geologically infrequent events) formed between the Holden impact and the end of degradation. These observations show that Holden crater degradation was not short-lived. Previous crater counts have constrained Holden crater to the mid-Hesperian [6,25].

Summary of results. The three largest craters in this set appear to be the youngest. They are all located at >50º latitude and have little fluvial erosion of the rim and ejecta. The three smaller craters, all of which are located at <30º latitude, have dissected walls and prominent alluvial fans. Of these three, Holden crater has the most rim erosion, an intermediate amount is observed at Bakhuysen, and Gale has the least. In Holden and Gale craters, infrequent or long-lived geologic events are interspersed between the impacts and the end of crater degradation.

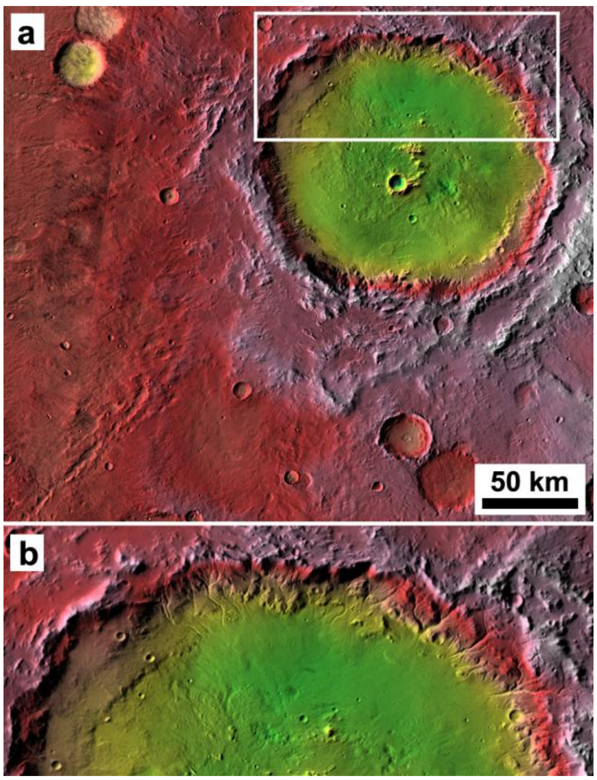

Fig. 1. (a) Hesperian Bakhuysen crater, with rugged rim and secondary crater chains to southwest. (b) Dissected northern rim of the crater (inset box in (a)).

Discussion: The diverse states of degradation for these six large, young craters and the lack of a relationship between crater degradation and size suggests that if larger impacts were capable of generating erosive microclimates, then that capacity had declined severely by sometime in the Early Amazonian Epoch. Larger impacts did not generate substantial crater degradation under Amazonian conditions, so the change in crater degradation with time requires atmospheric evolution independent of the impact process.

During the Hesperian Period, the largest impacts appear to have substantially predated erosion of the crater rims. At Holden crater, multiple geologically rare events (superimposed craters and external flooding from a distant source) occurred between the Holden impact and the end of fan deposition. At Gale crater, adequate time was available to form the lower part of Aeolis Mons before its fluvial dissection.

Collectively, the observations reported here suggest that the largest Hesperian and Amazonian impacts did not create highly erosive microclimates. An atmospheric water cycle may have been intermittently active during the Hesperian Period, but dissection of craters was less than around the Noachian/Hesperian boundary and appears to have been more significant around ~20–30ºS than at higher or lower southern latitudes.

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