EPSC Abstracts
Vol. 11, EPSC2017-418-1, 2017
European Planetary Science Congress 2017

Paleolakes of Northeastern Hellas Basin

N. H. Glines (1,2), H. I. Hargitai (2,3), and V. C. Gulick (1,2)
(1) NASA Ames Research Center, Moffett Field, CA, USA, (2) SETI Institute, Mountain View, CA, USA. (MS 239-20, NASA Ames, Moffett Field, CA, 94035, USA / natalie.glines@nasa.gov / virginia.c.gulick@nasa.gov) (3) Eötvös Loránd University, Budapest, Hungary, (1088 Budapest Muzeum krt 6-8 / hhargitai@gmail.com)

Abstract

We have identified 34 potential paleolakes in the Navua-Hadriacus-Ausonia region of northeastern Hellas, based on our previous mapping [1]. The presence of inflow and outflow channels, terracing, and sedimentary deposits such as delta-like landforms provide evidence for the formation of paleolakes. Although most recently resurfaced during the Amazonian, many paleolakes in this region formed during the Hesperian when Hadriaca Patera was active. Our study reveals a multi-source, episodic, lacustrine history for this region.

1. Introduction

Drainage systems of the Navua-Hadriacus-Ausonia region include outflow channels, valley networks, shallow valleys and channels, and wall valleys [1]. Water flowing in these drainages would have ponded in depressions produced by impact or other processes. Depressions with inlet and/or outlet channels or deposits are considered candidate paleolakes.

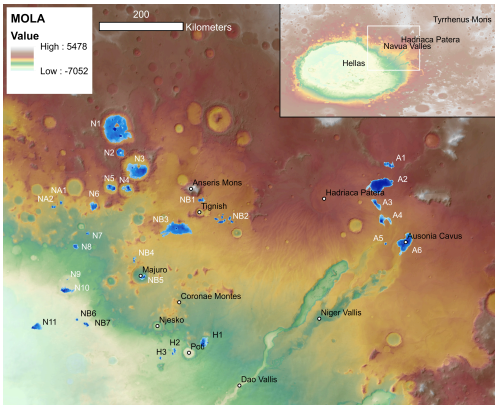

Figure 1: 34 Paleolakes identified, associated with the Navua Valles and surrounding channel systems of NE Hellas.

2. Paleolake Identification

Using a CTX mosaic and our previous drainage mapping [1], we have identified 34 individual paleolakes (Figure 1). Only one paleolake (N10; Figure 2) has been previously identified in any basin database. This lake is referred to as a "Hellas Group" lake by Cabrol and Grin [2], and more specifically as an open basin lake and deltaic deposit (Lake No. 128) by Fassett and Head [3] and Goudge et al., [4].

3. Paleolake Measurements

We delineated lake perimeters and water surface elevations in ArcGIS based on inlet/outlet or terrace elevations from MOLA. We used these elevations to determine water volumes with the 3D Analyst Surface Volume tool. 3 of the 34 lakes have two lake levels measured, and so the sum of all 34 lake volumes has a minimum and maximum, included in Table 1.

Table 1: Sum of 34 Paleolake Measurements

	Lake Area [km^2]	Lake Volume [km^3]	Lake Surface Elevation [m]	Water Depth [m]
MIN	~12,400	1,427	-1,055	9
MAX	~14,000	2,538	-6,345	1014

4. Paleolake Deposits and Floors

Approximately 60% of the basins in this region exhibit some form of terminal deposit. Most deposits are heavily eroded, revealing multiple layers (Fig. 2). About a third of these basins have light-toned deposits on their floor or margin. Patterned ground morphology is evident in several basins and may indicate the presence of periglacial processes. Knobby terrain is located within high elevation segments of the Navua Valles [5], and may be associated with channel activity, although it likely postdates the early major channel formation.

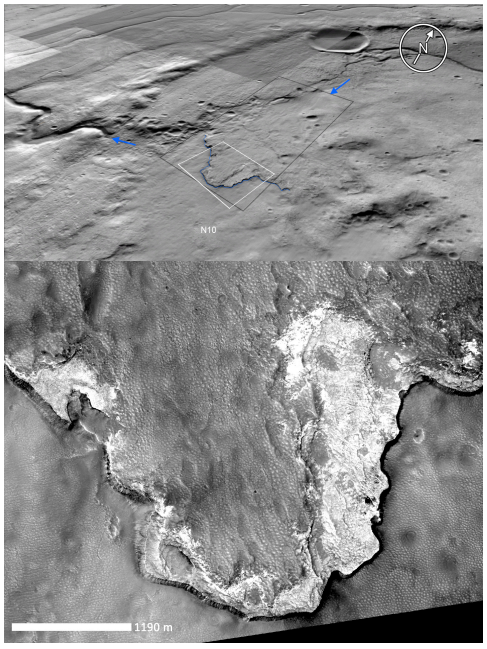

Figure 2: (above) CTX/MOLA perspective view of paleolake N10, deposit, and outlet, with flow direction (blue arrows), HiRISE footprint (black) and inset below (white). (below) HiRISE image ESP_040601_1460 of the eroded deposit margin, blanketed by a patterned material.

5. Timescales

Paleolake surface ages range from 0.5 to 3.75 Ga. Lakes near the floor of Hellas are younger than those in the highlands, consistent with Hellas' volcanic resurfacing at the Hesperian-Amazonian boundary (3.35 Ga). Lakes 3.54 Ga are consistent with the formation of Hadriaca Patera, and with the associated hydrothermal activity. The most common ages, ~3.54 and ~1.00 Ga, occur in all regions. While the oldest lakes are dated to the age of Martian valley networks, the youngest, Amazonian, ages indicate either transient flow, or a combination of periglacial reworking, aeolian modification, or blanketing processes postdating lacustrine episodes.

6. Astrobiological Significance

The Navua-Hadriaca-Ausonia region has a high density of paleolakes fed by channels active over a significant period. This has implications for our understanding of both global climate history and future paleolake identification elsewhere on Mars. It is unlikely that this highland region is unique in its high density of paleolakes, so studies elsewhere using CTX-resolution channel mapping (e.g. [1]) may uncover similar quantities of paleolakes. While liquid water paleolakes with deltaic deposits would be prime targets for astrobiological study (e.g. lake N10), lakes most proximal to hydrothermal centers have high potential for both sustaining and preserving life (e.g. lake A2) [6] even if they were frozen at the surface.

7. Summary and Conclusions

We have identified and measured 34 potential paleolakes within the Navua-Hadriacus-Ausonia region of NE Hellas Basin, Mars. These lakes were fed by channels active episodically throughout Mars' history, likely sourced from both local ground water and precipitation on upslope crater rims and mountain peaks.

Up to ~2,500 km^3 of water or ice would have filled these 34 paleolakes. While the state of the paleolakes as primarily ice or liquid water remains debatable (although our data suggests liquid), the potential volume of water, and potential duration of sustained presence of water on the surface, are significant, with implications for past climate and astrobiological value [6]. Evidence for hydrothermal activity from the local volcanic zone may be preserved in deposit layers throughout the drainage systems [6]. While we promote the region as a target of prime astrobiological investigation [6], we also propose an increased potential for paleolake identification throughout the highlands, following similar detailed CTX-resolution channel and deposit mapping.

Acknowledgements

Support was provided to H. Hargitai by the NASA Postdoctoral Program (NPP), and to V. Gulick and N. Glines by SETI Institute's NAI grant NNX15BB01A, and MRO HiRISE Co-I funds to Gulick.

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