PALEOLAKES IN THE NORTHWEST HELLAS REGION: IMPLICATIONS FOR PALEO-CLIMATE AND REGIONAL GEOLOGIC HISTORY. J. Zhao[1], L. Xiao[1], T. D. Glotch[2]. [1]Planetary Science Institute, China University of Geosciences, Wuhan, 430074, P. R. China (jnzhao@cug.edu.cn), [2]Department of Geosciences, Stony Brook University, Stony Brook, NY 11794

Introduction: Hellas basin is the largest impact basin in the martian southern highlands and acts as a major depositional sink for the highlands. Plenty of fluvial landscapes are distributed around the Hellas basin. In the northwest Hellas region, several paleolakes have been identified in previous studies [1,2]. However, limited by data resolution, their survey may not be comprehensive. In addition, there are no detailed studies on the geologic characteristics of the paleolakes, especially the ages of the paleolakes and the post-lacustrine modification processes. In this study, we conducted a detailed survey of the crater-hosted paleolakes in the northwest Hellas region. This work will help understand the paleo-climate and shed light on the geologic history of the region.

Geologic Background: Our study area (40°-65°E, 15°-35°S; inset in Fig.1) is located around the northwest margin of the Hellas basin. The elevation of this area decreases from ~3000 m in the northwest to about -2000 m in the southeast. A discontinuous scarp extends from the southwest to the northeast and divides the area into two parts (Fig.1): the northwestern "highlands" and southeastern "lowlands". Several geologic units, including Noachian basement rock unit, a Noachian heavily cratered unit, and Noachian to Hesperian volcanic and sedimentary units have been mapped [3,4]. In previous studies, three open-basin lakes and 14 closed-basin lakes have been identified [1, 2].

Data and Methods: We used Context Camera (CTX) images (~6 m/pixel) and Mars Orbiter Laser Altimeter (MOLA) Mission Experiment Gridded Data Records (MEGDRs: 128 pixel/degree) to identify paleolakes and measure the regional topography. High Resolution Imaging Science Experiment (HiRISE) images (~0.25 m/pixel) and digital terrain models (DTMs) generated from CTX and HiRISE stereopairs [5] were used for detailed analyses of geomorphologic features. The Thermal Emission Imaging System (THEMIS) IR mosaics (~100 m/pixel) were used as the regional context. Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) and THEMIS spectral data were used to analyze mineral compositions. We used crater size-frequency distribution measurements [6] to acquire the age of the paleolakes and the time of post-lacustrine modification events.

Results: *Identification and distribution of paleolakes.* A total of 64 paleolakes were identified, including 14 open-basin lakes and 50 closed-basin lakes. Among them, 11 open-basin lakes and 38 closed-basin lakes were newly discovered (e.g. Fig.2). The closed basin lakes were further divided into two types according to the lengths of their inlet valleys [2]: basins with long inlet valleys (>20 km) and basins with short inlet valleys (<20 km). The distribution of the paleolakes shows that all of the open-basin lakes in the study region are located in the northwest highlands or along the highlands/lowlands boundary. In contrast, closed-basin lakes can be found all over the area. However, it should be noted that all of the closed-basin lakes in the southeast lowland have short inlet valleys.

Geomorphology of the paleolakes. Most of the paleolake basins are circular in shape. Their diameters range from 4.5 to 75 km and their surface areas are 65 to 1.7×10^4 km^2. Depositional landforms in the basins are mainly layered deposits and deltas. A total of 11 deltas were observed and most of them are relatively small with the largest one covering an area of ~35 km^2. These deltas could be roughly divided into three types based on their shapes: fan-shanped (e.g. Fig.2a), lobate, and elongated. Layered deposits were found in 16 basins and they usually occurred in erosional windows (e.g. Fig.2). The maximum thickness of exposed layered deposits is up to 600 m.

Post-lacustrine modification of the paleolakes. Several post-lacustrine modification processes occurred in the paleolakes, including cratering and ejecta superposing, aeolian processes, volcanic and glacial activities, etc. Among them, volcanic resurfacing was observed in 31 paleolakes and these units usually have low albedo, high thermal inertia, rough and resistant surfaces with volcanic landforms such as wrinkle ridges and lobate lava flow fronts. Glacial resurfacing occurred in eight paleolakes, all of which are located at higher latitude (south of ~25°S). Typical glacial landforms such as softened terrain, ring-mold craters and viscous flow features are observed in the basins.

Age determination. We obtained the ages of the paleolakes by performing crater counting on the sedimentary units in lake basins. Three areas were studied and their absolute model ages are 3.62 Ga, 3.65 Ga and 3.65 Ga, respectively. We also tried to constrain the time of the resurfacing events. Results from crater size-frequency distribution measurements showed that the volcanic and glacial resurfacing units are around 3.3 Ga and 1.1 Ga, respectively.

Identification of aqueous minerals. We analyzed CRISM data overlapping the paleolakes to search for aqueous minerals. Results (Fig.1) show that Fe/Mg-smectites were identified in 10 paleolakes that are distributed in both the highlands and lowlands. Carbonates are likely present in one paleolake in the highland region. Anhydrous chloride was identified in one paleolake using THEMIS data. It shows dark blue in THEMIS DCS 8-7-5 mosaic and a blue slope in THEMIS spectra.

Discussion: *Implications for the paleo-climate and paleo-environment.* Widely distributed aqueous minerals and paleolakes in northwest Hellas imply a warm and wet climate at least in the Late Noachian. Dating results showed that the paleolakes dried up near the Noachian/Hesperian boundary. The relatively small time span (3.62-3.65 Ga) indicates an abrupt climate change in the study region from Noachian to Hesperian. Mineral analyses showed that the dominant aqueous mineral type in the paleolakes is phyllosilicate whereas evaporites are rare, which could be caused by a short-lived nature of the paleolakes owing to abrupt climate change. Besides, the absence of both the open-basin lakes and the closed-basin lakes with long inlet valleys in the southeast lowland indicates that the duration of lakes in this area could be shorter than in the northwest highlands. A possible explanation is that this area could once be in a subaqueous environment, which supports the hypothesis of the “Hellas ocean”. This is also consistent with the results by Salese et al. (2016) [3].

Geologic history of the northwest Hellas region. First, Hellas basin formed in a large impact event around 4.0 Ga ago [7]. Impact ejecta and materials excavated from depth scattered in the study region. Then lakes formed in the highland and the “Hellas ocean” occupied the Hellas basin and the southeast lowland of the study region. After the sea level decreased, the lowland region exposed and lakes formed. At around 3.7 Ga, climate change resulted in the draining of the lakes. In the Hesperian, volcanic activities resurfaced the paleolake basins. Finally, in the Amazonian, glacial activities modified the paleolakes south of 25 °S.

Conclusion: We identified 64 paleolakes in the northwest Hellas region and studied their geomorphology, post-lacustrine modification, mineralogy and ages. Our results support the existence of the “Hellas ocean” and indicate that an abrupt climate change from warm to cold happend in the study region near the Noachian/Hesperian boundary.

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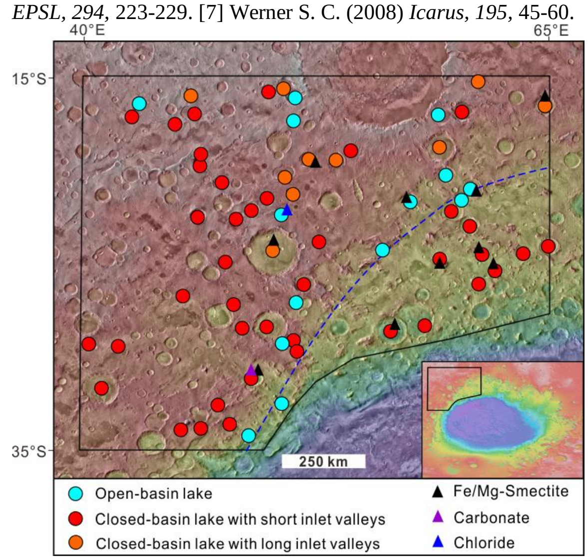

Fig.1 Distribution of different types of paleolakes and aqueous minerals. The dark blue dashed line denotes the approximate boundary of “highlands” and “lowlands”. The background is THEMIS daytime IR map overlaid with MOLA elevation map.

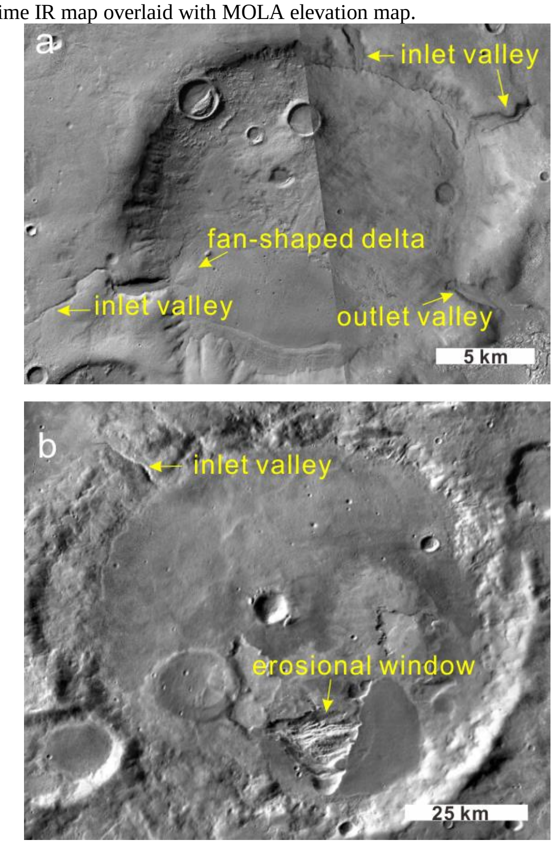

Fig.2 (a) A representative newly identified open-basin lake. Glacial resurfacing has occurred in the basin. CTX images IDs: G19_025701_1467_XI_33S309W; J09_048184_1469_XN_33S309W. (b) A representative newly identified closed-basin lake (THEMIS daytime IR mosaic). Erosional windows can be observed in the basin.