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The contribution of ice-deposits to the Martian hydrologic systems in the Hellas basin rim region

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Abstract

In our study we have analyzed 1) the head regions of the Hellas region outflow channels and related structures, and 2) the morphologic and morphometric characteristics of one of the channel systems within the Hellas rim region. We have found that ice-deposits are important as primary sources (both sub- and on-surface) for the different scale systems and they also contribute widely to the later modification of the channels (i.e. lineated valley fill (LVF) and lobate debris aprons (LDA) formations).

1. Introduction

The eastern Hellas rim region has numerous fluvial systems, which were mainly active during the Hesperian period, with a few systems dating to the late Noachian and early Amazonian ([1] and references therein). The major outflow channels Dao, Niger, Harmakhis and Reull Valles are the most prominent fluvial/water-related features in the area. These channels have been proposed to originate from melt water flows triggered by the late-stage effusive volcanism of Tyrrhena Patera [2] or by the volcanic intrusions and the emplacement of Hadriaca Patera [3] or by both (e.g. [4]). There are also a high number of smaller channels and channel networks on the highlands surrounding Hellas Basin [e.g. 1]. Our focus of this part of the study was on a particular extensive channel system and related interconnected paleo-lake craters.

2. Ice deposits in the valles head regions

The morphologic and topographic characteristics of the outflow channels suggest that the systems formed due to water release from subsurface sources. All systems apparently have their sources at different topographic levels below or within the layered suite of regional volcanic deposits [5]. We have found that the deposition of ice-bearing materials at different levels during the growth of the lava plateau in the region explains the key features of the fluvial systems: the subsurface nature of the sources and the relatively young age [5]. The higher topographic position of the ice-bearing deposits corresponds to the younger age of deposition. The possible accumulations of ice were buried by successive lava flows and later were heated by magmatic intrusions causing the melting of the icy deposits. The subsequent melting resulted in the formation the outflow channels and possibly resulted even in larger scale flooding [2, 5-6]. The formation of the outflow channels may have also been multi-phased [7]. The deposition of ice in succession with lava flow covering may have been caused by the accumulation of atmospheric ice in the source areas.

3. Ice deposits in the channel initiation zones

Ice deposits have also influenced the formation of surface channels. In our analysis and mapping of one regional system, the influence of ice both in the initial channel formation and later modification and embayment was shown. In general, the studied system is a shallow and unconfined channel which runs over Hesperia Planum. Based on the cross-cutting relations, this extensive fluvial system formed during the Hesperian – early Amazonian. This system originates from four distinct regions: 1) The north-eastern branch can be traced to a ~9 km circular depression at 35.0°S, 106.4°E indicating subsurface melting as the source for this part. 2) The eastern and south-eastern branches finally vanish from view, leaving the actual source areas unresolved with current data. 3) The southern branch begins at the contact of crater ejecta field on the northern flank of a Noachian mountain. Viscous, lineated flows (interpretated as ice-faciliated) originating from the highlands occur to the south of the ejecta-channel contact (at 37.4°S, 105.2°E). 4) The south-western branch (36.6°S, 104.2°E) starts also from a mountain slope, from within two joined craters with floors covered by lineated viscous fill.

In detailed view of the the channel sources, we note that the S and SW channel branches originate from steep highland areas and are currently superimposed by lineated flow features, the type of which has been interpretated as glacial deposits [8-10]. This terrain also resembles the proposed glacial deposits found in other craters within the same region (see e.g. [10]). Channel branches were likely caused by melt water from these deposits. A major volume of water entered the system from the initiation areas of the channel branches from within southern Hesperia Planum. Their origin remains mostly undefined as the E and SE branches disappear from view before their sources can be identified upstream. The sources may have originally been ground water (or ice) beneath the Hesperian lava, or melt water of snow/ice accumulation on the isolated massif remnants located nearby. The circular depression associated with the NE branch is probably caused by local melting and runoff of subsurface ice deposits and the most probable reason for the heating is the interaction with endogenic processes, indicated e.g. by Ivanov and others [6], and also by Kostama and others [5] for the Hellas outflow channels.

4. Later ice deposits

The large canyons of the outflow channels and also the last ~80 km of the mapped channel system have been superposed by viscous flows and deposits. These deposits are originating mostly from alcove-like depressions on the adjacent slopes. Material shows flow-like movement (induced by the slope of the surface). In addition, the material exhibits 1) compression in places where it is going through narrow straits, 2) extension after the strait, and 3) pits on its surface, indicating sublimation of volatiles. The material forms downslope pointing nested lobes throughout the area, typical of glacial-like flows; LVF (e.g. [10]) and LDA, both of which are found in abundance within the eastern Hellas region [11]. They have been interpreted to be caused by rock glaciers and/or debris covered glaciers (cf. [10]).

5. Conclusions

The ice-deposits are important in many cases as the primary sources (both sub- and on-surface) for the different scale fluvial systems (larger outflow as well as smaller surface channels) and they also contribute widely to the later modification and embayment of the fluvial systems. This is seen for example as LVF and LDA formations on the valley and channel floors.

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