PSEUDOKARSTIC SUBSIDENCES INDUCED BY SUBSURFACE MELTING OF TEPHRA-COVERED FIRN – ANALOGUES FOR MARTIAN SUBSIDENCES IN THE DYNGJUFJÖLL MASSIF , ICELAND. P. Gadányi[1], A. Gucsik[1,2], Sz. Bérczi[3] [1]University of West Hungary, Department of Physical Geography, Károli G. tér 4, H-9700 Szombathely, Hungary, e-mail: gpeter@ttmk.nyme.hu; [2]Max Planck Institute for Chemistry, Department of Geochemistry, D-55020 Mainz, Germany; [3]Eötvös University, Faculty of Science, Institute of Physics, Dept. Material Physics, H-1117 Budapest, Pázmány P. s. 1/a, Hungary,

Introduction: Pseudokarstic features and forms look like very similar to the karstic ones, but they are not the result of the dissolution but quite different forming processes.

As ice or firn melt by flowing water is analogous to dissolution of soluble rocks (eg. limestone), forming caverns and conduits [1]. If the cavernous firn/ice is covered (eg. with tephra) the occasional collapses of the cavern vaults continue in the covering above it, forming sinkholes and subsidences, similarly like at the covered-karstic terrains. For these pseudokarstic subsidences several nice examples can be found in the Dyngjufjöll massif, Iceland, where the winter snow (which is firn now) was covered with 1-1.5 m thick acid tephra dispersed by the phreatoplinian eruption of the Askja volcano in March 29, 1875.

The purpose of this study is to provide an analogue study area from the one of the well-known volcanic areas of Iceland for the comparison with the Martian ice fields and their morphological features.

The 1875 phreatoplinian eruption of the Askja volcano in the Dyngjufjöll massif: The Dyngjufjöll massif is constituted by pleistocene volcanic rocks. In the middle of the mountain situated the Askja volcano, which has a triple caldera structure [2]. The main one is a glen-coe type caldera with a smaller one in it, which was developed by a collapse as a result of the very explosive phreatoplinian eruption in March 29, 1875. This caldera was subsequently filled with groundwater forming Iceland's deepest (220 m) lake, the Öskjuvatn [2] (Fig. 1). The phreatoplinian eruption expelled 2 km^3 of rhyolitic pumice in less then 12 hours [3].

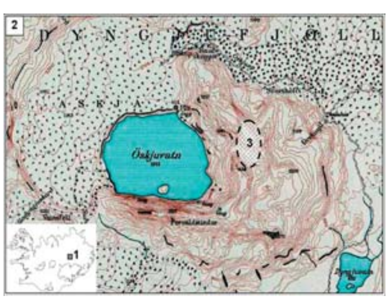

Figure 1. 1: The location of the Dyngjufjöll massif. 2: the map of the Dyngjufjöll with the Askja caldera-complex and Öskjuvatn (map of Lanmælingar Íslands). 3: the examined area.

The phreatoplinian deposits covered the 1874/75 winter snow: Because of the rapid deposition of the phreatoplinian pumice layers, the snow was not molten simultaneously. However, hot water streams from the contact zone between the pumice and snow as well as the gravitational force of the tephra mass itself led to the rapid firn occurrence. It is important to note that the pumice occurring in relatively short distance contains welded pyroclastic particles, which indicate that the phreatoplinian eruption was producing a significant amount of this material.

Pseudokarstic subsidences induced by the melting of the tephra-covered firn: The examined area of the pseudokarstic subsidences is showed in the Figure 1. These forms evolve as a result of the subsurface melting of tephra-covered firn. The firn covered by pumice-tephra layers could be molten in the following ways. At the high elevation, the tephra layers became relatively thin due to the alluvial (streams) or pluvial (rainfalls) erosions and melting of snow as well as mass movement. In this case, the fully exposed or weakly covered firn could be molten by the sunlight during the summer seasons (Fig. 2). The water is streaming down at the boundary of the firn and previous snow layers continuing its path as a ground water in the firn covered by thick tephra layers (Fig. 2). These subsurface streams (with relatively high temperature) produce parallel firn-tunnels in the tephra-covered firn to the slope directions. Because of the drop out process, the roof of these firn-tunnels became thin, which leads to the sink of the tephra layers and roof-breakdown, locally (Fig. 2).

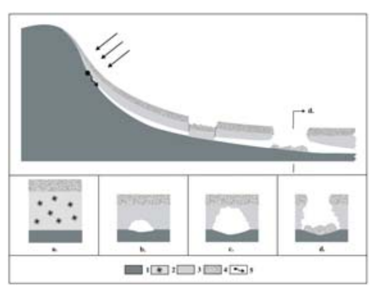

Figure 2. Schematic longitudinal section and cross sections of the pseudokarstic features in the examined area. Legend: 1. the surface, which was covered by the 1874/75 winter snow. 2: the 1874/75 winter snow 3. firn 4: pumice-tephra covering 5. subsurface snow-meltwater streams.

The upper part of the steep slopes shows gorges and gullies, which were also formed by the collapsing firn-tunnels (Fig. 3). In the selected area, the formation of subsidences (locally) due to the lack of the mass should be divided into two groups: (1) Subsidence of the pumice-tephra is evolved by the collapse of the firn-cavern beneath (Figs. 2,4). Subsidences show elongated and circular shapes. In some cases, the covered firn is exposed, but the firn-tunnel remains covered (Fig. 2). (2) Collapsed pits with pumice-tephra blanket contains scallops (formed by drop out processes induced by melting) on the wall of the firn-cavern under the pumice-tephra cover (Figs. 2,4-6).

Figure 3. They are nice examples for the gullies, which are developed by the combination of surface and subsurface flows (as the collapse of the firn-tunnel roofs continue to the surface covering).

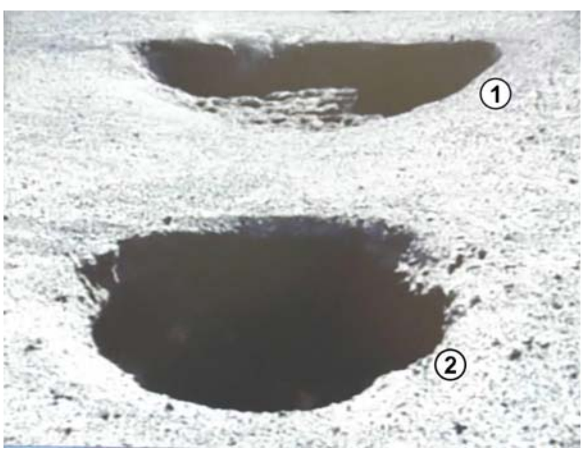

Figure 4. Subsidence (1) of the pumice-tephra covering, andcollapse pit (2), evolved by the collapse of the firn-cavern beneath. Note the hummocky tephra debris on the subsidence's bottom.

Figure 5. Collapsed pit (see sections "d" in Fig. 2.) 1: pumice-tephra covering 2: firn

Figure 6. Scallops on the wall of the firn-cavern under the pumice-tephra cover, revealed by a collapse of the pit on the Fig. 5.

According to Holt et al. [4] Mars Reconnaissance Orbiter (MRO) has identified Martian glaciers (in the Hellas Basin) of water ice under blankets of rocky debris at much lower latitudes than any ice previously identified on Mars. It is important to note that the buried glaciers make sense as preserved fragments from an ice age millions of years ago. On Earth, such buried glacial ice in Antarctica, Iceland or Greenland preserves the record of traces of ancient organisms and past climate history.

Consequently, the subsidences from the selected area from Iceland can aid to understand more about the above-mentioned newly discovered ice shields and their morphological features and climatic environments.

References [1] Smart C. (2004): *Glacier caves and glacier pseudokarst.* In: Gunn J. (ed.): Encyclopedia of Caves and Karst Science, 385-390. [2] Guðmundsson A. T. (1996): *Volcanoes in Iceland.* 71-75. [3] Scarth A. Tanguy J-C. (2001): *Volcanoes of Europe.* 172-174. [4] Holt et al. (2008) *Science* 332: 1235-1238.