Seasonal Ice Caves of Georgia

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Abstract

This article examines the seasonal ice caves of Georgia, unique physical and geographical formations in which ice forms during summer and melts in winter. Similar phenomena, known as seasonal ice caves, occur in many countries worldwide and are characterised by ice accumulation during warm periods and comparatively higher internal temperatures during cold winters. This unusual behaviour has not yet been fully explained scientifically and is therefore often described by local populations as “mystical”. The study presents case analyses of the Khorkhebi, Khiza, and Khikhadziri seasonal ice caves. The aim of the article is to raise awareness of the existence of seasonal ice caves among both the scientific community and the general public and to provide a foundation for potential future research collaboration.

Keywords: Natural freezers, seasonal ice caves, mystical caves

Introduction

Seasonal ice caves occur in various regions of Georgia and differ in both origin and morphological characteristics. Existing scientific research on seasonal ice caves (natural freezers) within the territory of Georgia is predominantly descriptive in nature (Kipiani, 1976; Kiknadze, 1963; Rakviashvili, 1965; Tsikarishvili et al., 2010; Ukleba, 1960; Pirpilashvili, 1960). Such caves were documented in Georgia as early as the 18th century. In Description of the Kingdom of Georgia (1745), Vakhushti Bagrationi discusses aspects of the practical use of seasonal ice caves. In particular, during hot summer periods, ice was cut into blocks and transported to the royal palace for various purposes, including the storage of food supplies for the army.

Figure 1. Coudersport Ice Mine

Despite their long-standing historical and scientific significance, the existence of these natural phenomena remains largely unknown to the general public. Most of the seasonal ice caves visited during the present study were found to be collapsed, filled with debris, and difficult to access. This highlights the urgent need for their systematic registration and documentation in order to preserve these natural features for future generations.

A similar seasonal ice cave was discovered in Pennsylvania in 1894. The cave is approximately 121 m deep, 2 m wide, and 3 m long. The ice that forms on its walls, often in the form of icicles, is generally clear and sparkling (Patowary, 2016). Initially, this cave-freezer was used for food storage; since 1900, it has been transformed into a tourist attraction and continues to be used for this purpose today (Fig. 1).

Methods and Materials

In 1987, Tavartkiladze and Kuznetsov developed a mathematical model of the physical process responsible for ice formation in seasonal ice caves, based on the spatial orientation of cave openings in relation to solar radiation (Tavartkiladze, 1987). However, these theoretical calculations were not supported by field observations. To validate the model empirically, continuous meteorological observations were required, which proved difficult at the time due to the absence of automatic weather stations.

Many years later, at the initiative of Professor Tavartkiladze, a group of scientists from the Institute of Geography (the authors of the present paper) conducted field investigations in three seasonal ice caves located in different physical–geographical and climatic conditions: the Khorkhebi, Khiza, and Khikhadziri freezers (Fig. 2). These field visits were carried out between 2009 and 2012 and enabled direct observation of the processes involved in ice formation (Fig. 3).

Figure 3. Khorkhebi natural seasonal ice caves

Results

The results of the initial visual observations indicated that ice formation occurs under varying physical–geographical and geomorphological conditions and develops as a result of the combined influence of climatic factors.

Despite their scientific importance, the existence of these natural phenomena remains largely unknown. Most of the seasonal ice caves examined during fieldwork were found to be collapsed, filled with debris, and difficult to access. This underscores the urgent need for their systematic registration and documentation to ensure their preservation for future generations.

All seasonal ice caves examined are developed within Upper Pliocene dolerite lavas and were formed as a result of tectonic or gravitational processes (Fig. 4).

A particularly notable seasonal ice cave is located in Tetritskaro Municipality, within the Ktsia–Khrami valley, approximately 2.5–3 km from the village of Kldeisi. The cave entrance is situated on the southern slope of the Bedeni Plateau. It is formed within Upper Pliocene dolerite lavas, among large lava blocks with volumes of 30–40 m³, created by tectonic or gravitational processes. Numerous narrow openings occur in this area. One of them—a relatively narrow (0.5–1 m wide) and low passage approximately 10–12 m long—leads to a small chamber 2–2.5 m high. Beyond this chamber, a narrow opening connects to a confined space of 3–4 m², where thick ice layers (0.4–0.5 m) are formed.

Narrow passages between the boulders facilitate the accumulation of cold winter air masses. In summer, water vapour condenses as warm external air mixes with cold air retained between the rock openings, resulting in the formation of crystal-clear ice blocks on the cave floor and ice crystals on the walls due to low temperatures.

During the expedition conducted on 5 August 2009, the air temperature at the cave entrance was 17.4 °C. At a distance of 7 m from the entrance, the temperature decreased to 7.2 °C, while in the ice-formation zone it reached 1.0 °C. In summer, ice is also present in other cavities between the boulders. Condensation and meltwater drain approximately 0.5 km from the cave, forming a spring locally referred to as a “glacial spring”, with a water temperature of 6.0 °C.

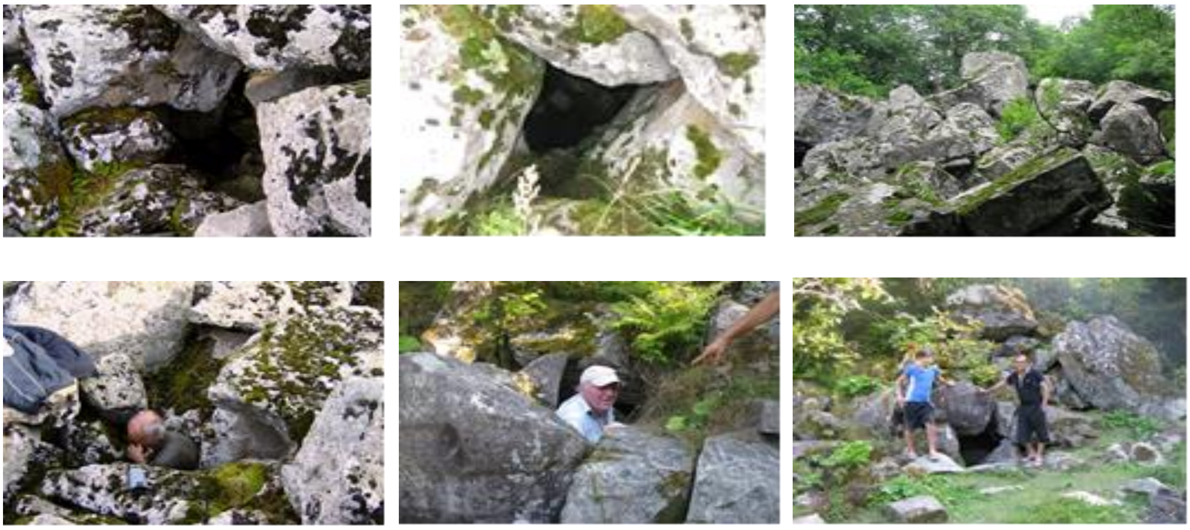

Figure 4. Entrances to the seasonal ice caves

Discussions

According to some researchers, heavy cold air masses accumulate in the depths of the cave in the winter, which freeze the latter when they touch the raised ground water level in the summer and form ice blocks. However, it is not clear how the correlation between ice strength and atmospheric air temperatures can be explained.

Our opinion is that narrow passages between boulders help to accumulate layers of cold winter air. In addition, by mixing warm air from outside and cold air trapped between the holes, water vapor condenses, creating ice boulders on the bottom of the freezer and ice crystals on the walls due to low temperatures.

Conclusion

It is assumed that the conditions for ice formation in seasonal ice caves depend on the topography and climatic characteristics of the area. Disruption of any of these components alters the natural rhythm of ice formation and its contributing factors, which can lead to the loss of this rare natural phenomenon and the potential destruction of the monument itself.

A scientific explanation of the processes occurring in seasonal ice caves and the development of a theoretical framework could, in the future, support the creation of energy-efficient refrigeration infrastructure. The practical implementation of the research results opens broad prospects for the development of energy-saving cold storage facilities, which can bring both public and social benefits.

Moreover, technological advancements in this field do not require above-ground construction or major alterations to the natural landscape. This approach can have a positive impact on both the environment and household economies.

Research in this field carries significant scientific and economic value; therefore, it is essential to promote and support further investigations in this area.

Competing interests

The authors declare that they have no competing interests.

Authors' contribution

T.K. and K.Ts. took the lead in writing the manuscript. N.B. was responsible for editing the manuscript V.G. collected the historical materials. All authors participated in the field trip, provided critical feedback, and contributed to the research, analysis, and preparation of the manuscript.

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