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VITOSHA MOUNTAIN (SW BULGARIA) DURING THE LITTLE ICE AGE IN THE CONTEXT OF PAST CLIMATE CHANGES IN THE BALKANS

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ABSTRACT

This study aims to present and analyse several descriptions of snow cover conditions on Vitosha Mountain over the last five centuries. It uses the written historical sources and diachronic method. They are discussed in the context of available climate and environmental data for Bulgaria and the adjacent areas of the Balkans during the Little Ice Age (LIA). It can be concluded from the presented descriptions of Vitosha during the LIA that probably in the 17th and early 18th centuries Vitosha had significantly longer snow retention with the presence of permanent or semi-permanent snow patches, a situation that is significantly different from the present environmental conditions. The analysis of the climatic conditions during the LIA in other regions of Bulgaria, as well as in neighboring countries in the Balkans, shows that during this period, especially in the southern parts of the Balkan Peninsula, there was a significant climate cooling. Future studies of the (high resolution) natural archives in Bulgaria are needed to provide more information about the nature of climatic and environmental changes during the LIA.

Keywords: *Vitosha, Little Ice Age, perennial snow, climatic changes*

INTRODUCTION

The global climate changes during the Little Ice Age (LIA) from around 1400 to around 1800 AD and their impact in Europe are relatively well studied and documented. This has been helped by the large amount of information available, including natural archives and man-made archives which allow climatic interpretation. In contrast to many countries in Europe, where a great number of written sources exist, which have been of interest to scientist for decades (Le Roy Ladurie, 1971; Lamb, 2001) and became the basis for the development of historical climatology (Brazdil et al., 2005). Such information is scarcer about the Western Balkans (Mrgic, 2018) and even scarcer for Eastern Balkans including Bulgaria. A variety of historical factors affecting the territory of Bulgaria during this period (Bulgaria was part of the Ottoman Empire for an extended period of time) account for the lack of regular written evidence and chronicles. Still such information does exist, but it is very unsystematic, most often in the form of short marginal notes added to religious books (Nachev, Fermandjiev, 1984), which makes it unsuitable for climate analysis. All these factors considerably reduce the pos-

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sibility of studyng the nature of the climate during the LIA in Bulgaria and its impact on society through the first-order and second-order impacts (Ljungqvist et al., 2021), such as the possibility that climate cooling contributed to more the active deforestation during this period, or led to poorer harvests and higher food prices. Another category of sources that can be used for scientific analysis are the travel notes of foreign authors passing through Bulgarian lands. Such travelogues have been used as weather and climate sources for the mid-17th century in Romania (Teodoreanu, 2014). Despite their uneven and episodic nature, the main route that most often crossed the Bulgarian lands was the road from Belgrade to Istanbul, and one of the higher mountains located near this route is Vitosha. It is some of these descriptions of Vitosha Mountain during the considered period that provide an opportunity to shed a little more light on the character of the snow cover during the LIA, and its possible relation to climate changes.

The purpose of this article is to present and analyse the descriptions of snow cover conditions on Vitosha Mountain during the last five centuries, as well as to discuss them in the context of the past climate and environmental data for Bulgaria and the adjacent areas of the Balkans during the LIA.

MATERIALS AND METHODS

The present study uses the written sources and travel notes of various foreign authors who passed through or explored the Bulgarian lands. A large part of them were published in the book series "Foreign Travelogues about the Balkans" (in seven volumes), and in other separate publications. All these sources for Vitosha Mountain have been critically analyzed (Brazdil et al., 2005). The main method used is the diachronic method. These descriptions are compared with climate reconstructions from natural archives for Bulgaria, as well as with other LIA climate reconstructions (from natural and man-made archives) for the Balkans and the Carpathian region, and other European regions with rich climate data and climate studies.

STUDY AREA

The Vitosha Mountain is located in Southwest Bulgaria, in close proximity to the country's capital city of Sofia (figure 1). It covers an area of 27,485 ha. The average altitude is about 1400 m a.s.l., and the highest peak is Cherni Vrah ("Black Peak") – 2290 m. The mountain was declared the first national park in Bulgaria and the Balkan Peninsula in 1934. It includes two reserves: "Bistrishko Branishte" (total area of 1061 ha) is a forest reserve with mainly spruce forests; "Torfeno Branishte" (total area of 784 ha) is a peat-bog reserve located in the sub-alpine mountain belt.

The average annual temperature of Cherni Vrah is 0.30 °C, and the annual precipitation is 1175 mm. From the data collected by the meteorological stations of Vitosha, it can be seen that snow cover on Cherni Vrah melts completely at the end of May (average) and at the beginning of July (at the latest). In the altitude between 1300 and 1800 m the number of days with snow cover is between 150 and 170 days and in the highest parts about 200 days. The absolute maximum height of the snow cover is reported for Aleko Hut (1810 m) in April – 360 cm (Vekilska, 1967).

During summers, a seasonal snow patch is found on Vitosha between the two peaks Malak Rezen (2175 m) and Golyam Rezen (2276 m). The snow there lasts until July (figure 2). Sometimes it lasts until the new snow falls, which, according to some observations, happens rarely, once in 15–20 years (Deliradev, 1926: 114).

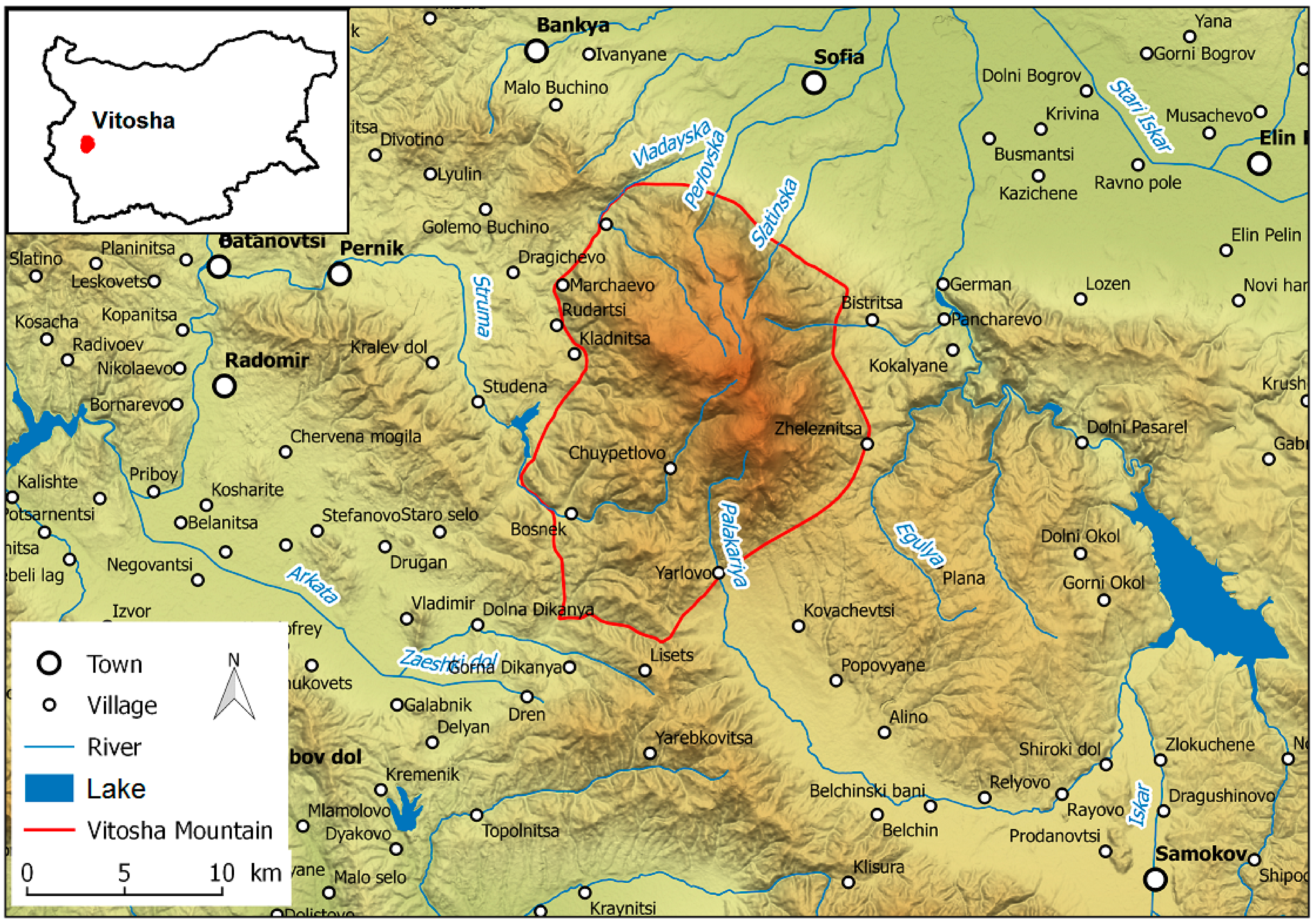

Figure 1. Map of the study area and its vicinity

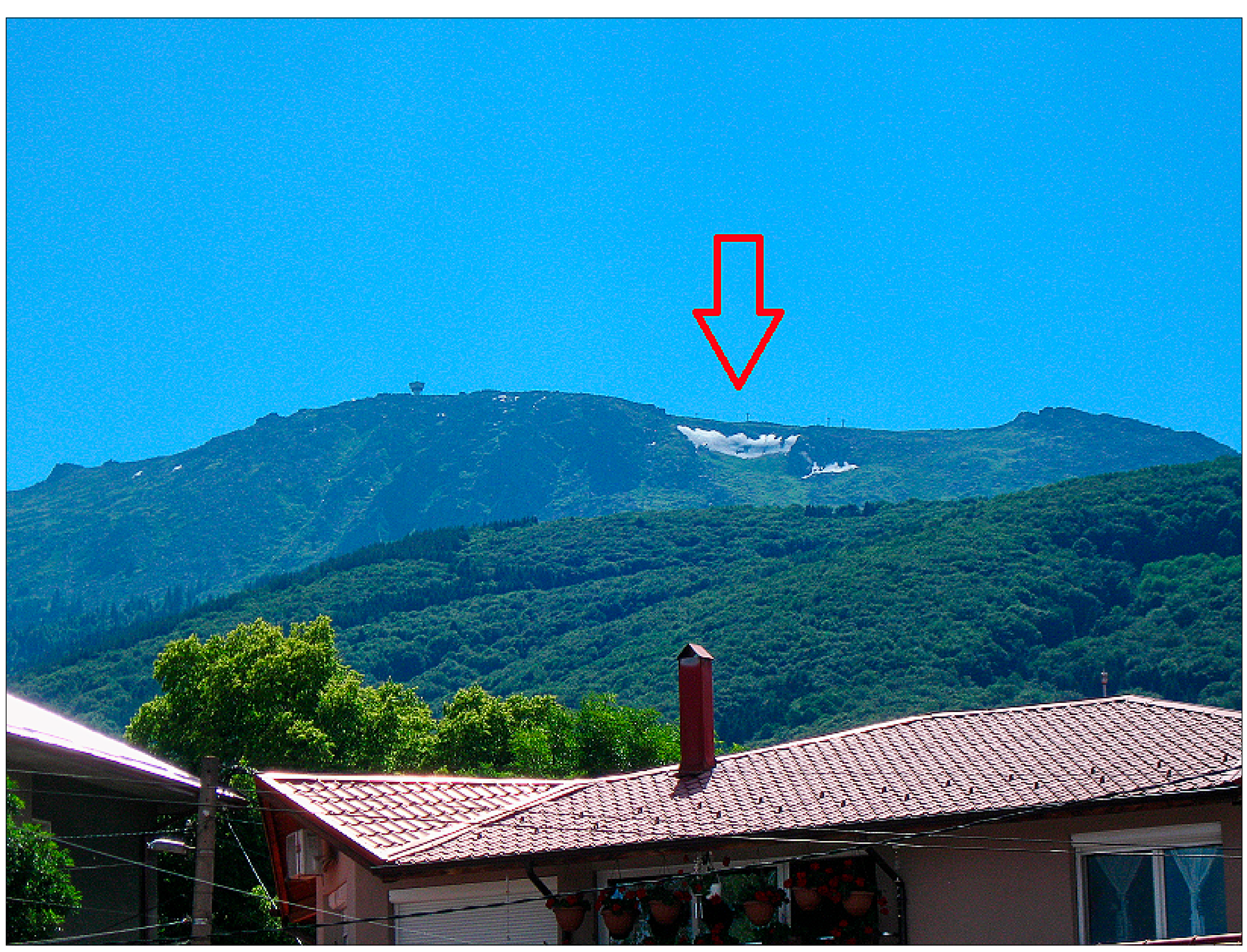

Figure 2. Vitosha Mountain and its largest seasonal snow patch (red arrow), view from Bistritsa village
(Photo: J. Tzvetkov, 19 June 2022)

RESULTS

The first written account of unusual environmental and climatic phenomena in Vitosha can be found in the reports of the ambassador of the Holy Roman Empire, Karl Rym, who passed through Sofia on 17 May 1571. He wrote that south of the city of Sofia was Vitosha Mountain, on the top of which there was a lake, on which the water was very cold and even in summer one could not keep his hand in the water. The high part of the mountain was covered with snow permanently (all year round). Iron was mined at the foot of the mountain and transported to Constantinople (Matkovic, 1892). The information about iron mining is accurate, and the presence of snow on Vitosha in early May is common. The claim that the snow lasted year-round was probably drawn from other people's accounts rather than the result of personal observation. Furthermore, we could suggest the possibility that the expression "year-round covered with snow" may be an allegory for a "high mountain".

We find a note about Vitosha Mountain in Lefevre's reports. They were compiled in 1611, in the form of travel notes, along the route of the French ambassador from Dubrovnik (Ragusa) to Constantinople. At the end of August, passing through Sofia, he mentioned that this region had a cold winter and reported information that near Sofia was located the Vitosha Mountain, "in which it is constantly cold and the snow has not melted there for more than twenty years" (Tzvetkova, 1975). The fact that Lefevre did not visit Vitosha personally, but relayed information that he heard from other people, seriously undermines the credibility of this information. However, it is worth noting that such information would not have been communicated and noted down if it did not represent an unusual phenomenon, and that is the second such account after the one provided by Karl Rym.

In 1616, on his way to Constantinople, Adam Wenner von Crailszheim passed through Sofia on 19 July and described that near Sofia there was a high mountain still covered with a lot of snow. He also mentioned that, lured by the proximity of the mountain, two people of his retinue tried to reach it but failed and by the nightfall were forced to return (Yonov, 1986). Although the mountain was not explicitly mentioned, it was most likely Vitosha. The presence of a snow patch in July in Vitosha is common, but the presence of "a lot of snow" in the second half of July is unusual.

In the summer of 1634, the Englishman Henry Blount, passing through Sofia, wrote that three miles south of the city there was a "high and steep mountain covered with snow all year round" (Todorova, 1987). Here we find the same repeated formulation, which gives no more information than is already available.

The first description of an ascent of Vitosha was given by Evliya Çelebi in 1652. He claims that he spent about forty days on Vitosha in the company of nearly seventy people. He described that there were hundreds of thousands of sheep grazing in the highest parts of the mountain during summertime. Colorful fish were caught in the lakes weighing 6 to 7 oki (1 oka is equal to 1.2 kilograms). Evliya Çelebi mentions that they cooled the sour cherry *hoshaf* (a kind of compote) with pieces of ice (Gadjalov, 1909). This account contains a number of exaggerations (for example, of the number of livestock) and inaccurate information (about the presence of lakes and fish with such enormous size living in the lakes). Mixing up of information about Vitosha and Rila Mountain has been suggested by some modern authors as a possible explanation for that (Ishirkov, 1912).

In 1665, Ricot, a secretary of the English ambassador in Constantinople, passed through Sofia at the beginning of May and described the city as located in a plain surrounded by mountains, the highest of which was covered with snow even in the hottest summer weather (Kesyakov, 1891). Here, again, the information that the snow remained year-round was probably drawn from other people's accounts rather than the result of personal observation, since the presence of a significant snow cover on Vitosha in May is common.

One of the most interesting accounts of Vitosha can be found in the descriptions given by Gerard Cornelius von den Driesch and an anonymous author, who were part of an ambassadorial mission to Constantinople in 1718. The two authors' descriptions of Vitosha (at the end of June) are similar, but slightly more detailed are those by Driesch (Yonov, 1986). He wrote that during the ascent of the mountain he observed great differences in climate, and that the marshes were found in the higher parts of the mountain. The local people used the mountain pastures for the numerous sheep and horses, while iron ore was extracted from the mines in the mountains. He described one of the most notable features of Vitosha, its stone rivers (figure 3), as accu-

Figure 3. Stone river (1750 m a.s.l.) in the "Bistrishko Branishte" reserve, Vitosha Mountain; A and B are taken at the same spot
(Photo: J. Tzvetkov)

mulations of stones which gave the impression that they were not made by nature but by human hand. These descriptions leave no doubt that the author visited and climbed the mountain personally, and accurately described its environment. In his account which is of the greatest interest he wrote that "between the rocks lies a deep snow, which has been so compacted and frozen by the winter frosts that even in the greatest summer heat in the days of Sirius it never melts completely" (Yonov, 1986). This account confirms that, in this period, snow remained year-round in the highest parts of Vitosha.

In 1786, the French traveler Sauveur Lusignan reported that not far from Sofia is located the Vitosha Mountain, "on the top of which there is a plain, where a large number of fragrant flowers grow". He also wrote of a gold mine that was not in operation and that local people often found precious stones in the mountain (Shishmanov, 1891). This description makes it possible to assume that the author climbed the mountain and wrote from personal observation, but it does not contain information about year-round snow retention.

The next detailed descriptions of Vitosha were provided by French geologist Ami Boue as a result of his trips and studies of the Balkans in 1836 – 1838. He climbed Vitosha and wrote that during the ascent he went along paths through oak, beech and conifer forests. The mountain top was rocky and treeless, and its southern slopes were deforested too (Tzvetkova, 1981). Neither his description nor any other later descriptions by other authors contain any information about year-round retention of snow on Vitosha.

DISCUSSION

Information about perennial snow cover on Vitosha generally relates to the 17th century and the beginning of the 18th century AD, which is often considered the culmination of LIA or the Late Maunder Minimum (Luterbacher, 2001). Some recent climate reconstructions for the Northern Hemisphere show even lower LIA temperatures for the 17th century as well (Christiansen, Ljungqvist, 2011, 2012; Xing et al., 2016), with the latest reconstruction indicating the three coldest decades respectively in the 1580s (-0.63 °C), 1600s (-0.66 °C) and 1640s (-0.68 °C) respectively, as compared to the period 1961 – 1990 AD (Xing et al., 2016). These climate changes for the Northern Hemisphere had a different local spatial and temporal manifestation. Keeping in mind that in Southeast Europe a number of climate changes show a different and even opposite trend compared to Western and Northern Europe (Luterbacher et al., 2004; Xoplaki et al., 2005; Brazdil et al., 2022; Trouet et al., 2012; Klesse et al., 2015), climate changes in Bulgaria and the neighboring countries in the Balkans are the most indicative.

As already mentioned, the written sources from Bulgaria are very scarce and unsystematic, but we learn form a marginal note made in a religious book from the village of Kovachevtsi (located southwest of Vitosha; see figure 1) that in 1696 there was a "good winter, such as there has not been for a long time" (Nachev, Fermandjiev, 1984). We can only speculate as to whether this fragmentary piece of evidence suggests a milder winter in colder long-term conditions or vice versa. For Central Europe, the winter of 1695 is known to nave been one of the coldest ones, and it was preceded by several cold winters as well (Lindgren, Neumann, 1981; Pfister, 1992; Luterbacher, 2001; Dobrovolny et al., 2010b).

More information on climate change during the LIA can be obtained from natural archives. The extreme climatic events from natural archives in Vitosha have been studied from tree-rings, but only for the last century (Panayotov et al., 2013). Palynological analyses cover the last 6,000 years or so, but are of low resolution and there are very few absolute dates (Filipovitch, 1988). In Bulgaria, more detailed, high-resolution data from natural archives are available for the Pirin Mountain (SW Bulgaria; the highest peak is Vihren – 2914 m). Tree-ring studies covering the last 600 years indicate the presence of a stress growth period of long duration in the late 16th century and throughout most of the 17th century AD (Panayotov et al., 2010; Zafirov et al., 2020). Dendroclimatological studies of *Pinus heldreichii* from Pirin show the lowest temperatures for June–August for the period 1600–1750 AD reconstructed for Bansko (Grunewald, Scheithauer, 2010, 2011). Also set in this context are the recent studies of the so-called microglaciers in Pirin. The Snezhnika microglacier in Pirin is considered the southernmost microglacier in Europe (Grunewald, Scheithauer, 2010; Hughes, 2012, 2014). Several studies assume that the Snezhnika microglacier in the Great Kazan cirque and the microglacier in the Banski Sukhodol cirque in Pirin were both formed during the LIA (Gachev et al., 2009; Gachev, 2017), or were at least reshaped and advanced during the LIA (Grunewald, Scheithauer, 2011). Some authors assume that the climate in the high parts of the Bulgarian mountains during the LIA was not only colder and more humid (Gachev, 2009, 2011), but that the extent of the microglaciers was about twice as large as the modern area (Gachev, 2020). Similar assumptions have been made about several other microglaciers in the Balkans, which are also considered to have been larger in area during the LIA (Hughes, 2010, 2014; Gachev et al., 2016; Gachev, 2017). Based on climate reconstructions (Klesse et al., 2015), a larger area of snow/glacier masses is also suggested for Mount Olympus (Greece) during the LIA (Styllas et al., 2016). Furthermore, some authors suggest that both glacier and snow masses at lower altitudes throughout the Mediterranean were significantly larger during the LIA (Hughes, 2018).

In Romania and Eastern Europe, written sources do testify to cold winter conditions during the LIA and to a number of extreme winters, but during the second half of the 17th century and the beginning of the 18th century AD (Bădăluță et al., 2019). In the Czech Republic, extremely cold winters and summers were recorded in the second half of the 16th century and the beginning of the 17th century, as well as the end of the 17th century AD (Dobrovolny et al., 2010a). In general, in the Czech Republic, a significant cooling of the climate was observed at the end of the 16th century (especially winter and summer), while in the 17th century the climate was not characterized by a significant cooling, except for a short period at the very end of the 17th century, mostly during winter and spring (Brazdil et al., 2022). Dendroclimatic studies in the Carpathians show that summer temperatures were above or close to normal for the 17th century, with a short-term cooling at the end of the 17th century, while a more prolonged decrease in summer temperatures was recorded in the second half of the 18th century (Popa, Kern, 2009; Kern et al., 2016). Similar are the results of studies in the Tatras (Poland and Slovakia), which also show higher temperatures for the second half of the 17th and the beginning of the 18th century in contrast to the Alps (Büntgen et al., 2007). Spring–summer temperatures (May–June) in the Tatras were lower for the mid-17th century and higher for the beginning and end of the 17th century, and were the lowest during the first half of the 19th century (Büntgen et al., 2013). For the Alps, the greatest and most prolonged summer cooling was during the entire 17th century, combined with a great advance of glaciers that continued into the 19th century AD (Büntgen et al., 2006; Corona et al., 2010). Ice core studies from a cave in Northwest Romania show cooling in autumn and early winter during the LIA and especially in the late 17th and early 18th centuries (Perşoiu et al., 2017).

A high-resolution palynological study in Serbia (Sava Region) show a decline in forest vegetation during the 17th century and an expanse of open landscapes and grasslands, followed by a recovery in the 18th century, which is interpreted as the result of climatic changes during the LIA and the cooling and drying of the Balkans associated with it (Kulkarni et al., 2018). However, it could also be related to anthropogenic impact and particularly to felling of woody vegetation during the harsh cold conditions, or it could be a combination of both factors. Dendroclimatological studies from Albania show that early summer temperatures were lower for the first half of the 17th century and higher for the second half of the 17th century (Levanič et al., 2015).

In the Southern Balkans (Greece), according to written sources, in 1675–1715 (Late Maunder Minimum) cold and more humid winters were frequent. Several very cold winters were recorded at the very beginning of the 18th century. The winter of 1699/1700 was particularly cold, with snow persisting as late as the summer of 1700 on the mountains of Crete (Xoplaki et al., 2001; Grove, Conterio, 1995). Dendroclimatological studies in the Pindus Range (North Greece) show three major 30-year summer cooling periods: 997–1016 AD (-1.63°C), 1444–1473 AD (-1.10°C), 1647–1703 AD (-1.06 °C) (Esper et al., 2020). In Mount Olympus, studies show a continuous trend of decreasing of summer temperatures throughout the 17th century continuing into the 18th century, with the decade 1811–1820 being the coolest (-1.22°C) (Klesse et al., 2015).

Speleothem reconstructions from Southwestern Turkey show a significant cooling during the LIA and especially during the 16th–18th century period (Göktürk, 2011). This is in concordance with written sources which indicate that after a long warmer period between the 14th–16th centuries, the Bosphorus froze twice in the 17th century AD (1621 and 1669) (Yavuz et al., 2007).

CONCLUSION

It can be concluded from the presented descriptions of Vitosha Mountain during the LIA that probably in the 17th and early 18th centuries Vitosha had significantly longer snow retention with the presence of permanent or semi-permanent snow patches, a situation significantly different from the present environmental conditions. Although some of the descriptions of these conditions during the LIA are not reliable enough, as they were not given first-hand, one of them was given directly on the spot when climbing the mountain and cannot be dismissed as unreliable. The analysis of the climatic conditions during the LIA in other regions of Bulgaria, as well as in neighboring countries in the Balkans, shows that during this period, especially in the southern parts of the Balkan Peninsula, a significant climate cooling appeared, as well as environmental conditions with longer retention of snow and ice in the mountain areas. It can be assumed that in the mountain areas during LIA nivation processes were more intensive. Due to the specific limitations and unsystematic nature of the man-made archives in Bulgaria, future studies should focus on natural archives and especially on high resolution proxies. They could provide more information on climatic changes during the LIA, as well as on the nature of glacial and snow (perennial or semi-permanent patches) mass balance and its climate control during the LIA.

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