Holocene climate and landscape history of the Pirin Mountains (Southwest Bulgaria)

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Abstract

The development of climate and landscape in the Pirin Mountains in a cultural and historical context was analysed and reconstructed, using a combination of different methods. Periods of prosperity and periods of crisis, which are linked to the climate, were detected for the Balkans and can be shown for Southwest Bulgaria as well. Particularly during the Bronze Age, Iron Age, Roman Age, the "Golden Bulgarian Age" and Little Ice Age, the phases of climatic stagnation and transition correlate with stability (soil formation), activity (erosion), and the dynamic of settlement (expansion vs. abandonment). Determination of age, based on carbon-14, supports these findings.

Keywords: Balkans, climate, cultural history, geoarchive, Holocene, radiocarbon

1 Introduction

The anthropogenic change of natural and cultural landscape increasingly affects ecosystems throughout the world on a regional and global scale. The resulting ecological and economic developments need to be recorded and, if possible, sustainably assessed. Therefore a comprehensive understanding of the structure, function and dynamic nature of these ecosystems is essential. In historic and prehistoric times of low population density, periods of warm climate have always been advantageous for the population, particularly in mountainous regions such as Southeastern Europe (Blümel 2002). High mountain regions situated at the transition between temperate and mediterranean climate are considered as eminently sensitive to current global changes. Slight temperature variations shift cultivation limits and affect runoff regimes as well as slope stability. The mountains such as Pirin, Rila and Rhodopes are of extraordinary importance for adjacent semihumid landscapes such as in North Greece (Grunewald et al. 2007). On the other hand, climatic crisis situations can stimulate adaptation strategies and technological innovations, as ancient mass migrations and current efforts to reduce CO_2 emission demonstrate.

Today, research on long-term human-environment relationships of the past is of increasing interest. There are efforts to reconstruct prehistoric environmental conditions and their spatiotemporal variability. This information is important, particularly with regard to the expected warming by about 2–4°C by the end of the 21st century (IPCC 2007).

Our working group carried out investigations in Southeastern Europe for several years (Grunewald & Stoilov 1998, Grunewald et al. 1999, 2007). The centre of interest is the northern Pirin and its flanking basins and valleys (figure 1). Due to the

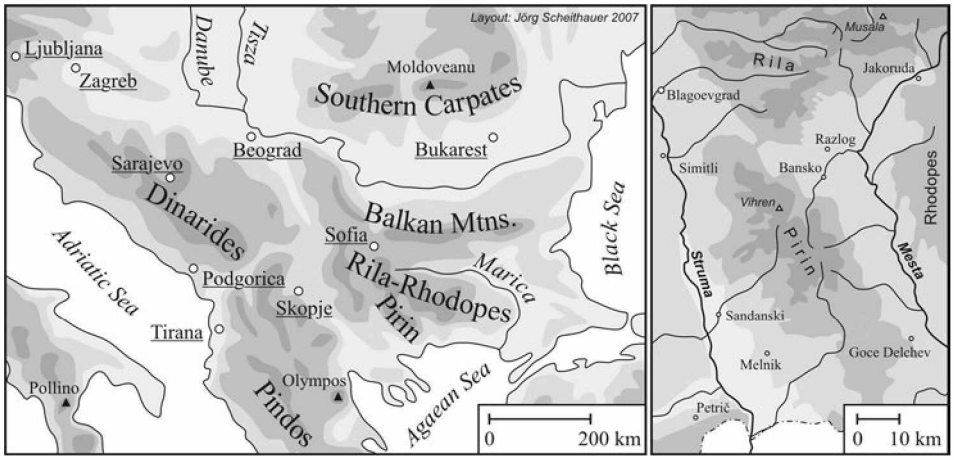

Figure 1: Southeastern Europe (left), Pirin Mountains and flanking basins and valleys (right).

biodiversity, this area can be regarded as an important refugium. The study area of the Pirin Mountains is situated in Southwest Bulgaria between the rivers Struma and Mesta. The Pirin is a horst-blocked highland morphostructure with ridges above 2,500 m a.s.l. and terraced slopes from deep faults. The last glaciation left a typical alpine relief with steep ridges, glacial valleys and 35 cirques, most contain alpine lakes. The main rocks are marbles, gneisses and granites. Karst formations are developed in the marbles. Peak Vihren is the highest point (2,914 m a.s.l.).

Forests in the Pirin Mountains are mostly coniferous. The timber line varies between 2,000 and 2,300 m a.s.l. In the subalpine zone, there are thickets of Dwarf Mountain Pine (*Pinus mugo*) and Juniper (*Juniperus sibirica*). The flora of the Pirin (about 1,300 species from the Central European, alpine, Balkan and the sub-mediterranean area, Anonymous 2003) comprising of many rare species is of great interest and beauty.

The development of climate and landscape during the last 500 years is currently analysed and reconstructed in high resolution for the Pirin Mountains, as part of an international and interdisciplinary project funded by German Research Community DFG (Grant ID: GR 1432/11-1). Besides available climate data, other work methods are applied: dendroecological research on Bosnian Pines (*Pinus heldreichii*), radiocarbon dating of soil material of different altitudinal zones (e.g. moraines and timber line ecotone) and firn ice stratigraphy of a glacieret (figure 2). In addition, literature was reviewed to evaluate the recent development in context of the whole Holocene, the regional cultural history and other European high mountains, in particular the Alps. The article outlines Holocene climate and landscape development in the Pirin Mountains and its surrounding areas.

Figure 2: Investigated geoarchives in the Pirin Mountains (from upper left: moraine and glacieret, subalpine colluvial soil, cirque lake, Bosnian Pine).

2 Climate and landscape history

The geological structure of mountains, basins and valleys in Southwest Bulgaria is very old (Batakliev 1972, Grunewald et al. 1999) and was frequently distorted by transgressions and regressions as well as by glacial and interglacial episodes during Tertiary and Pleistocene. At the climax of last glacial maximum (Wuermian glaciation) the snow limit was located between 2,000 and 2,300 m a.s.l. and impressive valley glaciers characterised high mountains (Louis 1930). Cirques and cirque lakes, U-shaped valleys and moraines are evidence of these glacial activities. Due to increasing warming, glaciers melted and shaped characteristical landscapes such as glacial-fluvial talus fans at the bottom of the mountains and sediments along the runoff paths.

The amount and extent of the material indicates tremendous forces and the dimension of deglaciation processes. Despite the beginning warming, conditions in the mountainous regions were still inhospitable. Tundra vegetation was predominating as well as cold snaps and geomorphologic instability. Late-glacial hunting cultures appeared not before the Younger Dryas (11,000–10,200 BP) and adapted to the new environmental conditions. A global warm period followed the late-glacial cold snap almost immediately. Approximately in 10,200 BP the last cold stage was definitely over and the so-called postglacial climatical optimum followed (Blümel 2002).

A rather long and stable period during Boreal and Atlantic marked the beginning of essential cultural-historical developments. Temperatures were 2°C warmer than today (Blümel 2002). Forests spread out and psychrophilic species were displaced as glacial relics into higher mountain regions. The Bosnian Pine (*Pinus heldreichii*) and Macedonian Pine (*Pinus peuce*) are the most common examples in the Pirin Mountains. It can be assumed that relics of glaciers in this region had been completely melted during Atlantic. The timber line shifted upwards and the development of vegetation and soil reached up to the cirques.

Humans became sedentary in basins and valleys. Southwest Bulgaria is situated near the Fertile Crescent (Palestine, Lebanon, Syria, Mesopotamia, Turkey, Persia), where the Neolithic Revolution took place in approximately 7,000 BC. A culture of nomadic hunter-gatherers turned into a society of agriculture and animal breeding. This way of living also spread to ecologically favoured regions in Southeastern Europe due to immigration or expansive diffusion. The climate in Atlantic was mild with warm summers and reliable atmospheric conditions and hence, was a main factor for high agricultural output and the assertion of neolithic cultures in Europe.

Stefanova & Ammann (2003) as well as Stefanova et al. (2006) reconstructed forest vegetation of the Northern Pirin using pollen analysis. The development of vegetation mirrors postglacial climate trends very well. According to this, deciduous forests (*Quercus, Ulmus, Tilia, Betula*) spread out into sites of middle and lower altitude between 10,200 and 8,500 BP and even reach higher altitudes between 8,500 and 6,500 BP (up to 800 m above today's upper limit for deciduous trees). After 6,500 BP, the deciduous forest was replaced by conifers (*Pinus peuce, Pinus sylvestris, Pinus mugo, Abies alba*) in middle and higher altitudes. From 6,500 to 3,000 BP, the timber line in Northern Pirin was at 2,200 m a.s.l., formed by *Pinus peuce* (Stefanova and Ammann 2003).

Climate in Europe deteriorated again in the Bronze Age (3,000–2,600 BP) as studies on the death of the "glacier body Ötzi" 3,000 years ago revealed. The annual mean temperature was between 1 and 2°C lower than today. Consequently it can be assumed that cultural-historical development stagnated in many parts of Europe (Blümel 2002). The following cold period is considered as a period of change and transition for Southeastern Europe. Thracian tribes probably evolved their culture. They cultivated wine as an indicator for a favourable climate. There is also evidence for the formation of settlements (Belov 2005).

A cyclical up-and-down of temperature levels with an interval of several hundred years without extreme amplitudes characterised the further trend of climate development. The favourable climate can at least partly explain the spread of the Roman Empire. Mean temperatures in Europe during the Older Sub-Atlantic were 1–1.5°C warmer than today. Therefore, various mountain passes remained accessible in winter (e.g. the Imperator Trajan's Balkans passage over the Trojan-Pass, Härtel & Schönfeld 1998). The antique cultural landscape of Southwest Bulgaria with Thracian, Greek, Macedonian and Roman influences, strived for its climax. Foundations of towns are evidence of efficient agriculture and trade. Numerous antique sites in Southwest Bulgaria show this development.

Between the 4th and 6th century the climate became colder and more unsettled again in many parts of Europe. In the mountains, glaciers expanded and timber lines shifted downwards (Veit 2002). Displacement of people and migration were intimately connected with climate. Germanics, Sarmatians, Goths, Eurasian Avars and other tribes crossed the territory of present Bulgaria. They destroyed the ancient cultures and therefore brought the antiquity to an end. Particularly, Slavs and so-called Old Bulgarians became sedentary. They held their ground in the forests and swamplands (Grunewald & Stoilov 1998). In this period the ethnogenesis of the Aromanians occurred (Kahl 1999). They practised transhumance between the Mediterranean Sea in winter and high mountain pastures in summer (e.g. Pirin). This indicates relatively favourable climate conditions in the Balkans region. Soil samples of a "1850-moraine" from an altitude of 2,400 m a.s.l. show accumulations of humus and initial soil development and therefore morphological stability for 332–611 AD (AMS lab codes Erl-8744 and Erl-8746).

The "First Bulgarian Empire" was founded in 681 and showed feudalistic features with farmers and aristocratic Boyars (Paskalevski 2006). By the 8th century, the "expansion of a pre-industrial cultural landscape" with forests, meadows, farming land, settlements, roads, and mining was completed. Soils in the basin of Razlog, covered with colluvial soils, were dated by ^{14}C method to this time (648–774 AD, AMS lab code Erl-8747). These soils show increased, anthropogenic stimulated morphodynamics. In addition, several ^{14}C-dated charcoal findings from subalpine soils in the Pirin indicate a long-term utilisation (534–654 and 659–994 AD, AMS lab codes Erl-8734 until Erl-8742). This trend could only take place under stable warm climatic conditions (figure 3).

In the early Middle Ages, the temperatures increased in Europe. This led to a cultural boom that Bulgaria had already experienced a few centuries before. Between 1187 and 1396, regional rulers were able to establish the "Second Bulgarian Empire" and again became a determining power in the Balkans. Once more, soil formation in high cirques indicates a favourable climate (1147–1273 AD, AMS lab codes Erl-8743 and Erl-8745).

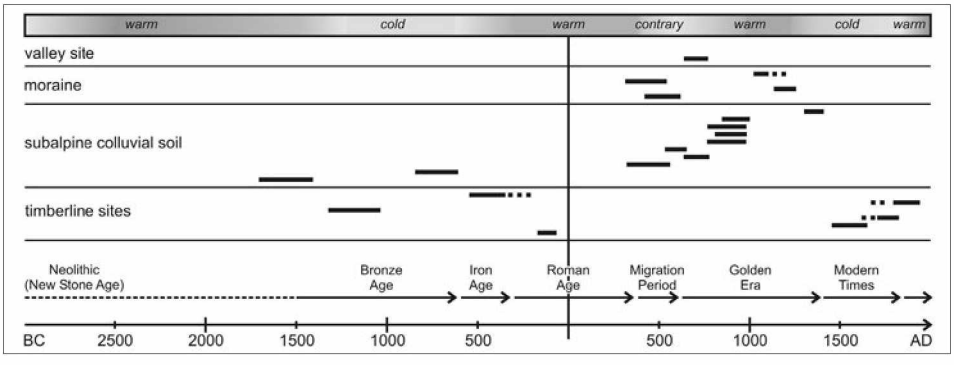

Figure 3: Cultural stages, climate history and analysed radiocarbon age of geoarchives in the Pirin Mountains (black lines: ^{14}C age range BC or AD).

With the beginning of the 14th century, Europe's climate became cold and unsettled. Glacier expansions and timber line depressions are reported for the Alps (Veit 2002). In this regard, there are also several indications for Bulgaria (Grunewald & Scheithauer 2007). The climatic conditions assumingly have weakened the Bulgarian and Byzantine authorities and enabled the invasion of the Ottoman army. It was a time of strong demographic change: Turks and other nationalities influenced Bulgaria and plague and other epidemics reduced the population. Migrations from rural to urban areas or to mountain regions took place (Hadzinikolov et al. 1980).

The Ottoman Empire had fallen to pieces in the 17th/18th century. Changes of possession followed and several reforms were enacted (Hadzinikolov et al. 1980). At the same time, there was a boom of Aromanians in the Pirin (Kahl 1999). An increased occurrence of charcoal in the tree and timber line zone indicates anthropogenic activities between 1644 and 1950 AD (AMS lab codes Erl-10445 and Erl-10447, figure 3). However, during that time, numerous houses were built in Bansko with Bosnian Pine from the upper mountain regions as construction material. Whole Europe finally experienced a warmer period since the mid-19th century. End moraines mark the "peak levels of the Little Ice Age at 1850" and therefore the beginning of the younger climate fluctuation in many high mountains (Blümel 2002, Veit 2002). The period of "Bulgaria's National Renaissance" had come (Weithmann 2000).

Dendroecological and glaciological results also reflect the modern climate development in the Pirin. The series of tree ring width of the Bosnian Pine correlate with individual climate parameters and indicate colder climate conditions at the timber line ecotone between the 15th and mid-19th century (Grunewald & Scheithauer 2008a). Afterwards, the growth of conifers increased again. Several events are archived in more than 700 years old series such as the Maunder Minimum of sun spots activity in 1672–1704 and volcanic eruptions. Furthermore, the shifting and compression of soils during the 4th–6th and 12th/13th century and their formation into a moraine relate to the expansion of the Vihren glacier during the "Little Ice Age" (Grunewald & Scheithauer 2008b). A glacier drilling extracted organic matter from lower firn ice layers in 2006. This material originated from the period 1810–1924 AD (AMS lab code Erl-10448).

Since the 1990s, a man-made greenhouse effect has become more apparent, which includes a fast temperature increase and climate change due to combustion of fossil fuels (CO_2-emission), deforestation, industrialisation, population growth, etc. The statistic analysis of local climate measurement series (Bansko, Musala) showed an annual temperature increase, a longer vegetative period, as well as a locally dryer spring and autumn. Climatic-phenological threshold values also show significant changes.

3 Conclusion

Climatic improvements and social impulses in Europe were mainly observed for the Atlantic, Sub-Atlantic and Younger Modern History. This can be also shown for Southeastern Europe and the Pirin. Optimal conditions for vegetation and soil development existed during the Sub-Atlantic and the Early Middle Ages, which nowadays lie significantly above the timber line. There is an obvious synchronicity with times when social development flourished (during the first and second Bulgarian state). Climatic pessima occurred during the Subboreal and the "Little Ice Age". During that time, the cultural-historical development in Bulgaria was at a standstill. Temperature variations during the Postglacial were, however, within a small range of ±2°C. Figure 3 provides a preliminary synthesis regarding the correlations between climate and cultural history during the Holocene, as indicated by own findings and data.

A secured reconstruction of climate and landscape development requires geoarchives with a high temporal resolution. First investigations on Bosnian Pines of timber line ecotone in the northern Pirin Mountains show that the annual environmental conditions are reliably stored in century-old tree ring series. In this regard, recent measurement series of other parameters are also analysed. Strong evidence can be expected from the so-called climate proxies, late wood density and stable isotopes $\delta^{13}C$ and $\delta^{18}O$ (Schweingruber 1993, Esper et al. 2004, Treydte et al. 2004). To what extent glacier drillings, partly more than 10 metres deep, allow a stratigraphic and therefore a landscape-historical analysis of environmental information (ions such as calcium, nitrate and sulfate, $\delta^{18}O$) archived in firn ice is currently examined.

The political-cultural history of Southeastern Europe is determined by its location between Central Europe and the Orient. The climatic development is determined by the transition from temperate to mediterranean conditions. At a small scale, this characterisation is modified by the inner differentiation and diversity of landscapes. Stronger cultural changes and contrasts can be observed in Bulgaria due to the latest social change, the trends of media reports, as well as an increasing mobilisation, communication, technology, education, and infra-structure. The understanding of the cultural-historical dynamics and regional climate prognoses for the 21st century helps to sustainably shape this trend.

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