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Key issues for advancing of Paleoenvironmental Reconstructions in Bulgarian High Mountains

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The environment of the high mountains is very sensitive to any kind of impact; therefore they are appropriate case study areas for an investigation of the impact of global changes. The Pleistocene glaciations are the main landform and environment formation factor of the high mountains in Bulgaria. The paleoenvironmental reconstructions in these mountains would be very useful to solve issues related to contemporary impact on these complexes. Rila (2925 m) and Pirin (2914 m) are the highest Bulgarian Mountains which have been glaciated during the Pleistocene. The paleoglacial relief forms and lake sediments in these mountains contain valuable information for the paleoenvironment. Although, there are particular achievements in the investigations so far, there are still unresolved scientific issues. The paper makes a review on the state of the art of the investigation of high mountain landscapes in Bulgaria and outlines four main objectives facing the researchers studying the development of these landscapes during late Pleistocene and Holocene.

Keywords: *Cosmogenic Nuclide dating (10Be), Luminescence dating, Periglacial geomorphology, Radiocarbon dating*

1. Application of Cosmogenic Nuclide dating (10Be) on moraines in parts of Rila and the silicate part of Pirin

During fieldwork of the authors, conducted in 2007, the main catchments in Rila Mountain were checked, and 53 samples for obtaining ^{10}Be exposure age were taken. Part of them have been analysed and the results are ready to publish. Although, most of the mountain was observed during the 2007 campaign, there are still some important parts which are still not sampled (Kuhlemann et al., 2008). One of them is the north-western part of Rila in the area of Otovitsa valley. A complex of glacial forms was observed in this valley more than half a century ago (Ivanov, 1954). There are still no samplings also from some right tributaries of Maritsa river valley and the Blagoevgradska Bistritsa valley, where there are also traces of Pleistocene glaciations (Glovnia, 1958).

It is very important to date moraines in the silicate part of Pirin mountain, where there are no ^{10}Be samples taken so far. There is a stadial moraine above the town of Bansko at about 1000 m a. s. l. which contains big boulders appropriate for ^{10}Be sampling. The potential objects for sampling were marked during a preliminary investigation conducted in 2009. There is a large size boulder which most likely stays unmoved on the surface since the time of its accumulation.

There are possibilities to discover moraines, formed during the last stages of the glaciers retreat, in the upper-stream parts of the rivers Banderitsa and Demianitsa. The middle stream parts of these rivers are too narrow and it is unlikely to find appropriate sampling objects there. Some wide valleys, located to the south-west from the main drainage divide are more perspective for finding good sampling materials. Special attention should be paid on the river Mozgovitsa valley, where a large moraine at about 1650 m has been described. The neighbouring valleys of Begovitsa and Bashlitsa also contain a complex of stadial moraines described by Velchev and Kenderova (1994).
There are also traces of exaration and ablation activity within the valley of Pirinska Bistritsa. A very well preserved terminal moraine made by boulders is located at 1600 m within this valley (Choleev, 1981). The same author considered its formation during the last glaciation. There are large size marginal moraines located upper-stream, which can be observed even in the satellite images. The glacial accumulation forms there are very well preserved due to the slant stream direction inclination and the length of the river. Therefore, this valley should be investigated in details and the moraines should be dated. Thus, it can be used as a main reference site for the Würmian glaciation stages in Pirin Mountain.

2. Detailed investigation of sediment layers at the foot of Rila and Pirin mountains by Luminescence dating and correlation with the older glaciations

There are several authors that investigate the age and number of the Pleistocene glaciations (Цвијић, 1897; Јанкович, 1904; Radev, 1920; Louis, 1930; Annaheim, 1939; etc). Some of them, who consider that the high mountains in Bulgaria have been glaciated more than once, present as an argument traces of glacial erosive activity in form of input tray cirques and trough shoulders (Gerasimov, 1949). But there are no dating analyses conducted in these areas. This is because any subsequent glaciation destroys the previous accumulation forms. The sediments accumulated at the foot of the mountains are the only object that could be used for dating samples. The method of Luminiscence dating is an appropriate tool for the investigation of such sediments. At the foot of both Rila and Pirin mountains there are deep sediment deposits which can be correlated to the glacial and interglacial periods. The left tributaries of the Struma River are deeply cut into these sediments and in some places there are very good sediment profiles which present almost the whole Pleistocene. Such profile can be found near the village of Ploski at the western foot of Pirin Mountain. The sixth horizon is the only one dated so far. The analyses of the Luminescence dating, made 20 years ago, shows an age of 117k (Velchev and Kenderova, 1994). The other ten horizons have never been dated.
We believe that such profiles can be found also at the foot of Rila Mountain. Interesting results could be obtained by drilling of the extensive fluvio-glacial cone of the Iskar River in Samokov Plain, which is located north of the Rila Mountains. Along with this in future studies it is worth to try the application of dating with a modern optical stimulated luminescence (OSL).

3. Investigation of Holocene periglacial geomorphology

Significant progress has been observed in the pollen analysis based investigations during the last two decades. Several high mountains vegetation reconstructions during different stages of the Holocene have been conducted (Bozilova, 1981; Bozilova et al. 2002; Tonkov et al. 2000; 2005; 2006; Tonkov, 2003; Stefanova and Ammann, 2003). Detailed investigations of the periglacial forms were performed by M. Glovnia (1959; 1962; 1968) but their results correspond to the scientific achievements in this field from the mid last century. Although, there are some new investigations focused on the periglacial geomorphology (Velchev, 1999; Gikov and Dimitrov, 2010), the research on postglacial morphology is far from being considered as satisfactory. The rocky glaciers are widely represented in Rila and Pirin and they have relict character in both mountains. Some of the rocky glaciers have been formed as a result of accumulation of firn glaciers. From that point of view they can be valuable source for Holocene paleoreconstructions. Attempts to date the time of their formation and the active phase have never been taken so far. It is necessary to conduct new dating methods and approaches to solve these important paleoenvironmental issues.

4. Application of Radiocarbon dating (^{14}C) on high resolution sediments from glacial lakes in different parts of Pirin and Rila mountains

There are Radiocarbon dating samples applied for pollen vegetation analyses in some lake sediments in Rila and Pirin (Bozilova et al. 2002; Tonkov et al. 2000; Tonkov, 2003). However, the samples are usually taken only from the bottom, middle and upper part of the profile. High resolution dating (sampling from every horizon of the profile) will give the opportunity to detect the stages of development of the high mountain complexes during the Holocene more in details.

Such investigation will help resolving the open question about the formation of embryonic glaciers in the highest-lying cirques of Rila and Pirin during cold spells prior to 8,2 k and 3 k years. An appropriate object for such investigation could be Ledenoto Ezero (Ice Lake), which is the highest lake in Rila situated at 2700 m close to the Mousala peak. There is a shallow negative form close to its southern coast which is surrounded by underwater moraine north of (Gachev et al. 2008). The dating of the lake sediments in this area will help to date the underwater moraine.

Conclusion

A team of Bulgarian geomorphologists formulated six main issues directed to clarify the development of the glacial and periglacial forms in the Bulgarian mountains (Glovnia, 1964). Some of them like pollen analyses of the sediments have been realized. A question still remains for the coordination of the glaciations in Rila and Pirin and the accumulation of loess in the Danube plain.

The application of a set of modern dating methods will allow answering the question about the number and age of the glaciations in Rila and Pirin. The debate on the Rissian or even Wurmian age of some low stream located moraines in the valley of Mozgovitsa (Pirin) and the valley of Razhavitsa (Rila), expressed recently by some researchers, would find its confirmation or dismiss.

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