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An Abstract of a Doctoral Dissertation entitled

YOUNGER DRYAS GLACIATION IN THE HIGH TATRA MOUNTAINS

Zlodowacenie Tatr Wysokich w młodszym dryasie

The Younger Dryas (YD; 12.9 – 11.7 ka) cooling was the last resumption of glacial conditions in the Pleistocene, which had an extensive impact on mountain environments across the Europe. Glaciers increased their volumes or readvanced anew in many cirques and valleys, as it had taken place in the High Tatra Mountains. Geomorphological record in forms of moraines and relict rockglaciers can be investigated for further inference on paleoclimatic conditions that led to inception of the glaciation. In this dissertation, the time of activity of the last glaciers in the upper parts of the High Tatra Mts. was examined. Due to relatively high altitude and northernmost location, it is the most favorable area for inception and persistence of a glaciation in the end of the Pleistocene. Research area is located in the eastern parts of the High Tatra Mts., consisting upper parts of four valleys, both on northern and southern side of the massif. In these four valleys, including Veľká Studená, Päť Spišských plies Valley on the southern side as well as Litvorová and Rovienky Valleys located on the northern side, rich assemblage of glacial, and periglacial landforms can be found. On the base of morphostratigraphy, these landforms were attributed to two glacial systems, younger and older. The younger system, located in the upper parts of cirques consists of moraines and relict rockglaciers and records the last stage of glacial activity in these mountains. In previous research, this system was connected to the Early Holocene or even the Little Ice Age (LIA), however with no geochronological proof. This dissertation includes detailed geomorphological mapping combined with cosmogenic exposure dating using isotope ^{10}Be, in order to determine the time of deglaciation connected with the YD. The 47 samples for the ^{10}Be dating was analyzed from both moraines and relict rockglaciers as well as ice-moulded bedrock located both outside and

inside of the younger system. In addition, moraines representing the older system were dated. This dating strategy allowed recognition of the last stages of glacial activity in the High Tatra Mts. in spatial and temporal context as well as recreating glaciation history of these mountains.

Chapter 1 introduces the main objectives and aims of the dissertation in the context of previous research. The chapter also provides an overview of the previous studies, which tackled the problem of glaciation history in the Tatra Mts. as well as the timing question of the final deglaciation of the Tatra Mountains. Chapter 2 introduces into geographical and geological setting as well as modern climate of the study area. In the Chapter 3 selected methodology is described which was chosen to investigate the research objectives. The chapter also briefly introduces into the primary dating results obtained in this study. Chapter 4 provides a detailed geomorphological description with maps of the study sites and brings the chronostratigraphical context from the results of exposure dating. Further, for each of studied valleys a short summary of main findings is provided. A synthesis and general time frame for all investigated valley is inferred in the end of this chapter. Based on the obtained data and the stratigraphy shown in previous chapters, in Chapter 5 the proposed Younger Dryas glacier margins are presented. These glaciers are reconstructed and the Younger Dryas Equilibrium Line Altitude (YD ELA) is estimated. Based on which, further parts of this chapter introduce into paleoclimate reconstructions and possible climatic scenarios. In Chapter 6, a consistent picture for the studied areas is combined with the evolution of valleys through time. This chapter presents the pattern and style of deglaciation in all investigated valleys together. Chapter 7 discusses glacial geomorphology of investigated area and possible interpretations of landforms and results. This chapter brings results into broader context by comparing them with previous studies. In this chapter, selected topo-climatic factors that may explain some of differences in extent of paleoglaciers as well as their marginalization are discussed. Further considerations regarding the YD paleoclimate in a wider geographical region are discussed by comparison with other mountains in the Carpathian Arc and northern Alps. Within Chapter 8, concluding remarks are made together with a summary of the research findings.

The results indicated that the youngest moraines and rockglaciers, located at most around 2300 m a.s.l. were formed during the YD. Two glacial systems were recognized in the High Tatra Mts., which constitute a response to the YD and the Oldest Dryas (OstD), two main climate deteriorations during the Lateglacial.

Morphostratigraphy and time constraints provided by the dating, lead to estimations of the paleo Equilibrium Line Altitude (paleoELA). This contributes to a better understanding of the pattern and style of the Lateglacial glaciations as well as the final deglaciation of the Tatra Mts. During the YD, the ELA was on average at around 2150 m a.s.l., which means 600 m depression in relation to the current positon (ΔELA). This implies that during the YD, glacier-favoring conditions occurred above 2150 m a.s.l. Based on published paleobotanical data for the Tatra Mts., a change of summer temperature in relation to modern conditions (ΔJJA) between -3.5 to -4 ºC can be deduced. Presented glacio-climatic analysis reveal, that during the YD the High Tatra Mts. were colder and possibly wetter than now, with the annual sums of precipitation similar to modern or higher by even 30%. This scenario finds an agreement with general prevailing atmosphere circulation and directions of moisture transport in Europe during the YD cold period. The results of paleoclimatic modelling show, that climate during the YD in the High Tatra Mts. was more humid than it is suggested by paleoclimate scenarios presented in previous studies.

Keywords: ^{10}Be dating, glacial geomorphology, glaciation, Younger Dryas, ELA, paleoclimate, High Tatra Mountain.