Pleistocene glaciation on the northern slopes of the Low Tatra Mountains

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A dissertation abstract

In the Western Carpathians, apart from the Tatra Mountains, the Low Tatra Mountains is the only massif with well-preserved landforms of Pleistocene glaciation. However, knowledge of the glacial geomorphology and Pleistocene glaciations of this massif remains significantly limited. The objective of this doctoral dissertation is to analyse the glacial geomorphology and reconstruct the evolution of Pleistocene glaciers on the northern slopes of the highest mountain range within the Low Tatra Mountains - the Mt. Ďumbier group.

The study employs a multi-method approach including the analysis of digital terrain models, field mapping, sedimentological analysis of sediments (clast size and roundness assessment), relative dating of boulders using the Schmidt hammer rebound test, and glaciological techniques for glacier reconstruction and the estimation of equilibrium line altitudes. Specific objectives include the morphometric characterization of glacial cirques, mapping of indicator landforms such as moraines and trimlines associated with the maximum glaciation, reconstruction of glaciers and their equilibrium line altitude (ELA). Additionally, the study aims to identify and characterize the stages of deglaciation following the maximum glaciation.

The results of the research indicate that 29 glacial cirques are located on the northern slope of the Mt. Ďumbier group. Nearly half of them have well-developed walls and relatively flat floors. Most of them are simple cirques, and their cirque floor elevation are located at ~1370–1640 m a.s.l. Their morphometric parameters and degree of development are comparable to the average observed in other Carpathian massifs. However, they are significantly less developed compared to the Tatra cirques.

Both the fresh, well-developed relief of maximum moraines in the Ďumbier massif and the weathering degree of the moraine boulders, similar to that found in the Tatra Mountains as determined by the Schmidt hammer method (R = 34.1±2.3), indicate that they were formed during the Last Glacial Maximum (LGM), which is dated in the neighbouring Tatra Mountains to 26–18 ka. Outside the terminal moraines, no landforms or deposits were identified that could be associated with older glaciations. In the study area, 11 glaciers from the LGM have been reconstructed. The largest ones reached ~4.5–5.5 km in length and all of them together occupied an area of ~32 km^2. Their average thickness was about 41 m, and the total volume of ice was 1.7 km^3, which for comparison, constitutes only 6.8% of the volume of the glaciers in the Tatra Mountains. In the terminal-moraine zones of four glacier systems in the valleys of Zadná voda stream valley, Široka, Bystrá and Ludárova, landforms of meltwater depressions and hummocky moraine are commonly found, indicating that these glaciers were covered by debris. For the 11 LGM glaciers, the estimated average ELA (area-altitude balance ratio 1.6) resulted in ~1430 m a.s.l., which is a comparable value to the northern slopes of the Western Tatra Mountains. This result fits well within the regional trend of increasing ELA from west to east across European massifs. The slightly lower ELA compared to the Western Tatra Mountains (1450 m a.s.l.) can be explained by the effect of enhanced snow accumulation due to drifting from the extensive flat summit surfaces, which are the better preserved there than in the Tatra Mountains.

Late-glacial recessional systems primarily occur in the upper parts of valleys, typically at elevations between 1300–1700 m a.s.l. They indicate the presence of one to two main stages of deglaciation. Only the highest cirques with steep rock walls, which have the greatest potential for glacier development, do these two main stages (I and II) locally separated into three stages of deglaciation (e.g., Ia, Ib, and II). In contrast, in the lower-lying cirques, only one system of landforms (stage I–II) developed, predominantly of rock glaciers. Within the recessional landforms, there is a clear continuum of debris-ice landforms, ranging from moraine deposits of debris-covered glaciers to the frontal moraine and talus rock glaciers. In the first stage of deglaciation (after the LGM phase), the extent of glaciers and debris glaciers ranged from 50% to 1.4% of the glacier extent during the glacial maximum. After the second stage, this was from 14% to 1.4% respectively. Both recessional stages occurred during the Oldest Dryas (18.9–14.6 ka), as evidenced by the comparison of their morpho-stratigraphic position, absolute elevation, and degree of weathering (R: from 39.8±1.3 to 41.0±1.7) with the well-defined sequence of deglacial landforms in the Tatra Mountains. It can be assumed that the final deglaciation of the Low Tatra Mountains occurred during (18.9–14.6 ka) or after the Oldest Dryas in the Bølling–Allerød interphase (14.6–12.9 ka). There are no equivalents of the Younger Dryas glacial landforms (12.9–11.7 ka) known from the neighbouring Tatra Mountains.