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Temporal and spatial variability of bedrock, debris and glaciers in the Austrian Alps since the Alpine Last Glacial Maximum and its relevance for ecological research

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Abstract

The distribution of bedrock and debris offers special habitats for animals and plants. A conceptual model explains the interaction of bedrock, debris and glaciers. We estimate the distribution of these areas at two different scales (Austrian Alps, Schober Mountains) focussing on their temporal variability since the Alpine Last Glacial Maximum. Based on these considerations the spatial extent of the surface types in the Schober Mountains is reconstructed for four stages since then.

Keywords

Bedrock, debris, glaciers, Last Glacial Maximum, spatial and temporal variability

Introduction

Areas with rocks and debris offer habitats for animals and plants which are adapted to bare surfaces, shady spaces between boulders and rock clefts. The characteristics of these environments stay relatively constant even if the macroclimatic conditions change, i.e. it does not matter much if the climate becomes slightly warmer or colder. Thus some species of rocky and bouldery environments have survived the coldest periods of the Pleistocene and are also able to find refugial habitats in a warming climate as long as bedrock and debris are available to a sufficient extent.

The spatial distribution of bedrock, debris and glaciers in the Alps depends on different factors such as climate (change), elevation, topography, lithology, tectonical setting and vegetation. The term 'debris' includes different types of loose material: autochthonous debris originates from weathering processes, allochthonous debris includes scree (transported by gravity), gravel (transported by water) and morainic sediments or till (transported by glaciers). In this study we attempt to quantitatively estimate the extent of the three surface types bedrock, debris and glaciers at two spatial scales: (i) entire Austrian Alps and (ii) a selected mountain group with sufficient available information. The glaciation of the Alpine Last Glacial Maximum (AlpLGM), approx. 25,000-20,000 years BP, is taken as a starting point.

Status of research

Entire Austrian Alps*:* VAN HUSEN's map (1987) of the AlpLGM glaciation is an excellent basis although it does not provide bedrock and debris information. Despite a good knowledge of the glacial history (e.g. IVY-OCHS et al. 2009) no macro-scale reconstructions of glaciers during the Lateglacial have been published. During the Holocene the extent of glaciers frequently alternated between maxima similar to the one around 1850 ('Little Ice Age Maximum', LIAM) and minima smaller than today's glaciers. To estimate the range of Holocene glacier fluctuations information on both LIAM and current glacier extents (FISCHER et al. 2015) is available.

Schober Mountains (Central Alps, Hohe Tauern Range, Fig.2): Results of investigating the history of glacial and periglacial processes have been provided e.g. by LIEB 1988, BUCHENAUER 1990, KELLERER-PIRKLBAUER 2008 and REITNER et al. 2016. This allows us a first attempt to reconstruct four stages of glaciation as well as areas of bedrock and debris with a GIS-based approach.

Conceptual model of the interactions between bedrock, debris and glaciers

In order to describe the interactions between bedrock, debris and glaciers a deductive model of the processes involved has been developed. It shows in keywords how each surface type influences the two other ones resulting in six interaction processes depicted in Fig. 1.

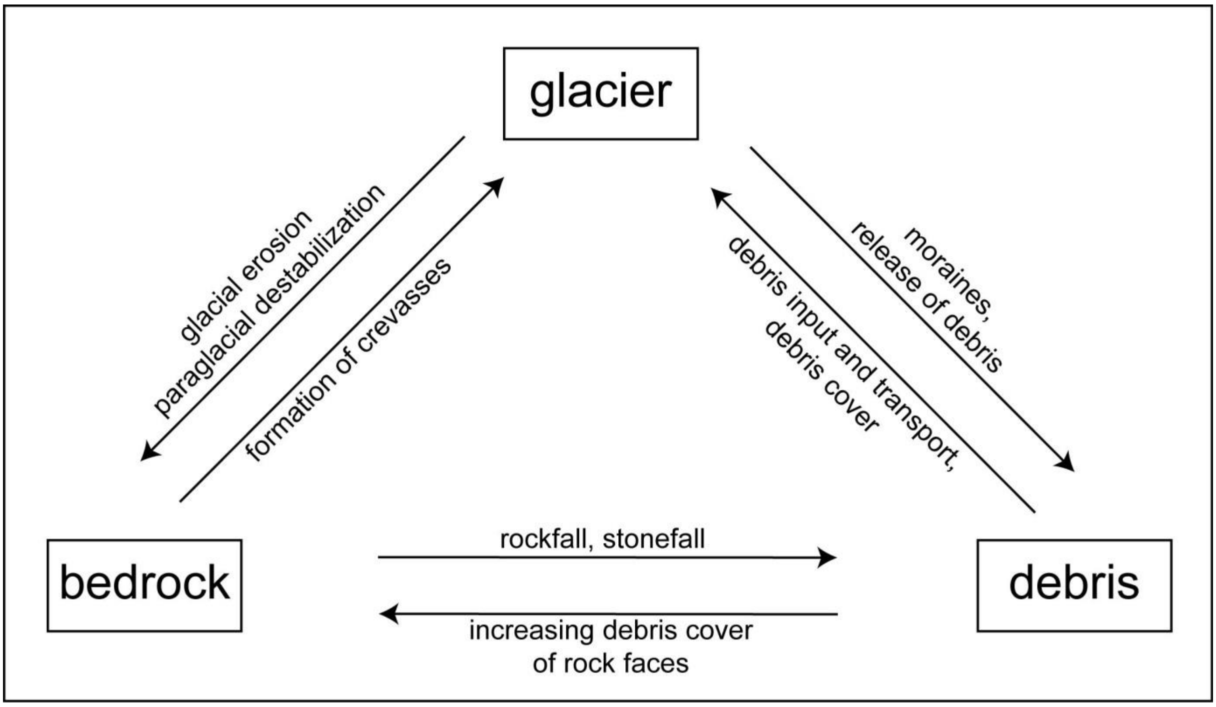

Figure 1: Processes connected to the interactions of bedrock, debris and glaciers in high mountain environments

Spatial variability of bedrock, debris and glaciers at two spatial scales

The Austrian Alps

In Austria the Alps cover ca. 55,000 km² (65 % of the entire territory, BORSDORF 2005). According to VAN HUSEN (1987) the AlpLGM glaciation in Austria covered ca. 40,000 km² leaving ca. 15,000 km² (27 % of the Austrian Alps) ice-free. It is assumed that these ice-free areas were nearly entirely bedrock and debris because vegetation during the AlpLGM was very sparse even in the lowlands. However, near the highest summits in the centre of the interconnected valley-glacier system small areas at crests and summits, wind-exposed plateaus or slopes and nunataks remained ice-free offering limited space for animal and plant life.

The Holocene maxima, which were similar to the LIAM, produced glaciations which amounted to ca. 940 km² (FISCHER et al. 2015), i.e. 1.8 % of the Austrian Alps. No reliable data for bedrock and debris is available. According to the most recent glacier inventory of the Austrian Alps (FISCHER et al. 2015) the glaciers in 2012 covered 415 km² (0.8 % of the Austrian Alps). The reduction of the glaciated area since the LIAM predominantly revealed bedrock and debris areas obviously more rapidly than the vegetation cover increased.

The Schober Mountains

The Schober Mountains cover ca. 390 km², in the following text the percentage of the glaciated area is given. Fig. 2 depicts one example of the four reconstructed stages.

- AlpLGM: To reconstruct the glaciation VAN HUSEN's map (1987) was improved by a detailed analysis of crests and debris slopes using a DEM. The investigated area was covered by ice (Alpine valley glacier system, hanging glaciers on crests) to 94.6 %.
- Younger Dryas maximum (according to REITNER et al. 2016): To reconstruct this Lateglacial stage the monographs mentioned in the status of research-section were used. Uncertainties arise from the lack of evidence in some cirques which were reconstructed in analogy to neighbouring ones. Glaciers covered 20.6 % of the entire area exceeded by bedrock (21.2 %), the released debris (18.1 %) was widely moved by creeping permafrost. Lacking better data we used the 2000 m contour line as upper limit of vegetation cover (Fig. 2).
- Holocene maxima: The extent of glaciers (2.8 %) can be reconstructed exactly because of the existence of pronounced LIAM moraines. The extent of debris and bedrock was estimated using among others the digital version of the geological map 1:50.000 (LINNER et al. 2013).
- Current glaciation: It is restricted (0.3 %) to small areas beneath the highest peaks. The recent reduction of the glacier areas has primarily created further debris areas.

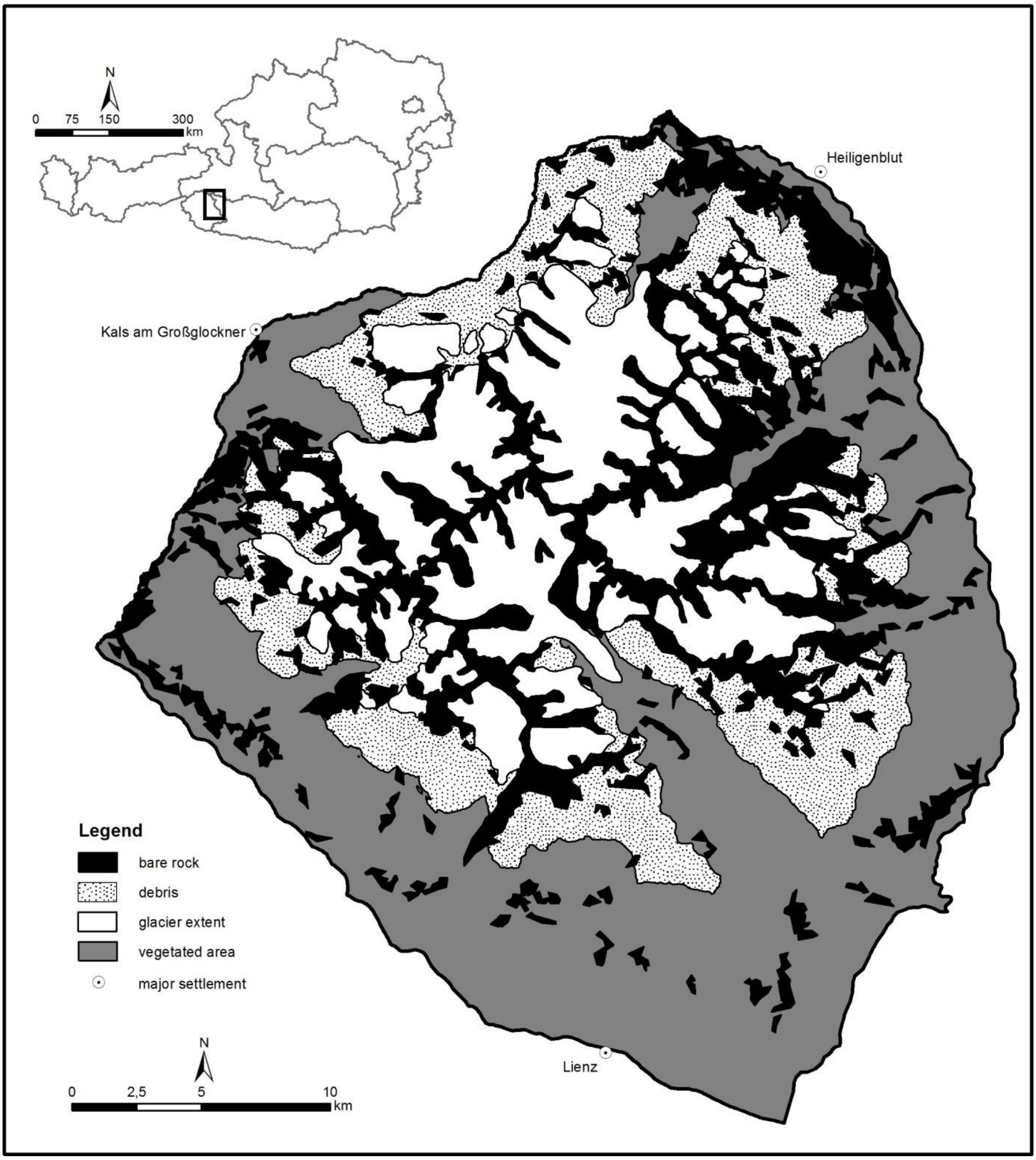

Figure 2: Distribution of bedrock, debris and glaciers in the Schober mountains during the Younger Dryas cooling event (Egesen stadial) around 12.000 years ago

Discussion

The processes which lead to the temporal and spatial variability of the distribution of bedrock, debris and glaciers were identified. However, there are uncertainties in quantifying the extent of these surface types. The best estimation at both spatial scales can be made for the glaciations which are reconstructed using geomorphological evidence. The extent of glaciers appears as the main factor of the distribution of the other two surfaces types.

The retreat of glaciation releases high quantities of debris which under periglacial conditions spread over large areas (transport of allochthonous debris by creeping permafrost) during the Lateglacial and Holocene period. However, the estimation of debris areas is quite uncertain because e.g. it is not clear how to deal with debris which is (slowly) covered by vegetation. In the Holocene the debris extent outside the glacier forefields was assumed to be constant. This follows the considerations that (i) Lateglacial debris areas (especially Egesen sediments are dominated by coarse boulders) were occupied by vegetation only to a limited extent until today and (ii) periglacial processes producing debris lasted over the entire Holocene resulting e.g. in the formation of rock glaciers.

Conclusion

Although a lot of questions regarding spatial extents of bedrock, debris and glaciers remain open – more on the Austrian Alps' scale – a first estimation could be given by our approach. The results show that there is an inverse relation of glaciers on the one and bedrock and debris on the other hand. The extent of debris increases with deglaciation. Plants and animals adapted to rock and debris environments thus found habitats during the entire investigated time period. Future research will have to focus on a more accurate delimitation of the distribution of autochthonous and allochthonuous debris.

References

BORSDORF, A. (ed.) 2005. Das neue Bild Österreichs. Strukturen und Entwicklungen im Alpenraum und in den Vorländern. Österr. Akademie der Wissenschaften, Wien.

BUCHENAUER, H. W. 1990). Gletscher- und Blockgletschergeschichte der westlichen Schobergruppe (Osttirol). Marburger Geographische Schriften 117.

FISCHER, A., SEISER, B., STOCKER WALDHUBER, M., MITTERER, C. & ABERMANN, J. 2015. Tracing glacier changes in Austria from the Little Ice Age to the present using a lidar-based high-resolution glacier inventory in Austria. The Cryosphere, 9, 753–766.

IVY-OCHS, S., KERSCHNER, H., MAISCH, M., CHRISTL, M., KUBIK, P. W. & SCHLÜCHTER C. 2009. Latest Pleistocene and Holocene glacier variations in the European Alps. Quaternary Science Reviews 28 (2009), 2137-2149.

KELLERER-PIRKLBAUER, A. 2008. The Schmidt-hammer as a relative age dating tool for rock glacier surfaces: examples from Northern and Central Europe. 9th International Conference on Permafrost (NICOP), University of Alaska, Fairbanks, USA, 2008, Proceedings, 913-918.

LIEB, G. K. 1988: Die Gletscher und Blockgletscher im Kärntner Teil der Schobergruppe und ihre Entwicklung seit dem Spätglazial. Unpubl. PhD thesis, University of Graz.

LINNER, M., REITNER, J.M. & PAVLIK W. (2013): Geologische Karte der Republik Österreich 1:50,000. Sheet 179 Lienz. Geol. Bundesanstalt, Wien.

REITNER, J. M., IVY-OCHS, S., DRESCHER-SCHNEIDER, R., HAJDAS, I. & LINNER, M. 2016. Reconsidering the current stratigraphy of the Alpine Lateglacial: Implications of the sedimentary and morphological record of the Lienz area (Tyrol/Austria). Quaternary Science Journal 65/2 (2016), 113-144.

VAN HUSEN, D. 1987. Die Ostalpen in den Eiszeiten. Geol. Bundesanstalt, Wien (with map 1:500,000).

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