ORTHOPHOTO GLACIER MAP OF THE GROSSVENEDIGER; 1:10'000

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The aerial photograph of a glacier is far more accurate than the normal topographic map. Therefore, a differentially restituted aerial photograph (orthophoto) combined with contour lines is particularly suited as a map basis for glaciological studies. There are, however, various difficulties to be overcome in producing these orthophoto glacier maps. They arise through displacement in the orthophotos of steep slopes due to the great differences in height in alpine regions, which cannot always be compensated by the orthoprojector. They are also caused by the striated appearance of snow and shadow areas, and by cast shadow in the aerial photographs. The Institute of Cartography and Reproduction Technique of the Technical University in Vienna was able to overcome these difficulties in the production of the attached six-colour aerial map of the Grossvenediger at a scale of 1:10'000 (Hohe Tauern, Austria).

The aerial photograph was taken in September 1974 at an average photographic scale of 1:30'000 with a wide-angle lens. The survey flight was timed for 10.45 hrs in order to achieve a minimum of cast shadow in the photographs. On the basis of ground survey control points established in the terrain the orthophotos were produced at the Institute of Applied Geodesy in Frankfurt/Main with an orthoprojector GZ 1 at a scale of 1:10'000. The difference in height of 1520m between the peak of the Grossvenediger and the Untersulzbach valley was only just resolved.

The map was based on a double orthophoto. However, as this showed inaccuracies in the pictures of the area of Kleinvenediger-Viltragenkees the subsequent single orthophoto was used. This had been produced from an aerial photo with a better view of the terrain of the Kleinvenediger. Therefore, care must be taken to ensure that orthophotos are made from both survey pictures of an area. The orthophotos were combined in a montage photograph so that a faultless picture resulted in which even the shadow strips of the firn fields in the orthophoto were removed by retouching. The orthophoto thus prepared was the most important basis for the production of aerial survey maps. It was scanned for offset printing, and the glacier areas were divided into glacier shading (blue/green) and land shading (grey).

A contour outline is, however, also absolutely essential for producing this map. This was done at the Institute of Photogrammetry of the Technical University, Vienna, from the same aerial survey photos, and using the same ground control survey points as had been used in making the orthophotos. Thus the contours exactly match all the details of the vertical aerial photos. This, particularly in alpine regions, can only be achieved with analogous evaluation of the aerial survey photos, using highly advanced stereo evaluation equipment. The contours obtained from the orthophoto production alone are insufficient. For the Untersulzbachkees and the Obersulzbachkees an equidistance of 10m was chosen for the contours, such as is necessary for glaciological studies, and the remaining area was shown in contours spaced at 20m. The contour lines in the glacier regions are drawn in blue, those elsewhere in brown.

For the main glaciers the brown contours of ice-free areas were continued as brown sub-glacial contour lines. Below E. Brückl reports on the construction of these sub-glacial contour lines which allow examination of the depth ratios of the Untersulzbachkees and the Obersulzbachkees. In spite of their schematic progression, the brown sub-glacial contour lines harmonise with the orthophoto structural picture of the glacier surface, which is in turn shown by blue glacier contour lines.

The subsequent cartographic work comprised the production of rock drawing, which was needed to emphasise the ledges of the tapered peak ridges and of moraines, and to show scree slopes etc. Here too, the orthophoto proved to be the best basis for mapping. The aerial survey map of the Grossvenediger was orientated south-south-east in order to avoid the pseudo-plastic impression which would have resulted from orientation to the north. The shadows caused by sunlight in the northern hemisphere result in many cases in a negative impression of the relief, which can only be avoided by south orientation of the maps.

It is thus possible to produce orthophoto glacier maps within a short period of time: checking of ground control points and survey flights at the time of least snow cover in September; production of orthophotographs and evaluation of contours by the end of the year; cartographic work, reproduction and printing of the map during the following six

months so as to have the map ready for glaciological fieldwork in the summer.

The Sub-Glacial Contour Lines for the Orthophoto Map of the Grossvenediger; 1:10'000

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The construction of the contour lines of the sub-glacier topography in the Untersulzbachkees in the firn region (above 2'800m) is based on the results of seismic surveys of ice thickness. These measurements were carried out by the Central Institute of Meteorology and Geodynamics, Vienna, in the course of the International Hydrological Decade, and showed the ice thickness along three cross-sections at altitudes of 3'200m, 3'050m and 2'850m. In order to interpolate the ice thickness between the seismic profiles, the combination of ice thickness and surface incline was applied. Whilst the interpolation value in the previously studied glaciers did not deviate systematically from a constant figure, a relation to the slope angle could be found at the Untersulzbachkees, and this was taken into consideration in the construction of the sub-glacial contour lines. In spur and ridge areas the described method of interpolation cannot be applied, and these areas were ascertained by morphological progression probability.

There were no ice thickness surveys of the terminus of the Untersulzbachkees. Here the ice thickness was calculated by comparing the maps of the various glacier stages. This method is based on the assumption that the ratio of the ice thickness to the surface incline remains constant.

In the now ice-free perimeter (glacier stage 1974) this result could be directly ascertained by comparison with the map of 1934. In higher portions of the tongue this was determined by the sinking ratio of the glacier surface and the relative changes of incline. As this method could only be employed for the ice thickness along the central line of the glacier terminus the sub-glacial contour lines towards the edge of the glacier were interpolated, using morphological considerations.

The accuracy of the contour lines (obtained by comparing maps) is indicated by the agreement of the transverse strain on the glacier bed (calculated from the ratio of ice thickness to surface incline) in the seismically surveyed firn area with that in the terminus region.