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Influence of glaciation on surface and near surface karst morphology - new field evidence from the Hochschwab Massif (Austria)

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Karst scientists still debate on the influence of glacial activity on cave development. Whereas some authors find a direct relationship between cave development and glaciation as high precipitation and concentrated runoff compensate the very low aggressiveness of the melt water, others state that the role of glaciers for the genesis of new caves is negligible. A case study from the Hochschwab - located in the Austrian province of Styria - provides new input to the discussion. Like several other major karst massifs in the Northern Calcareous Alps (NCA), the Hochschwab is characterised by a more than 1 km thick sequence of karstified Triassic carbonates. In Pleistocene cold periods, parts of the high alpine karst plateau were affected by extensive glaciation and for some glacial periods, it has been part of the alpine ice stream network. The Hochschwab provides freshwater for the city of Vienna and detailed (1:5000) karst-morphological field mapping comprising 59 km^2 of its plateau has been conducted. The resulting karst GIS includes 12700 features, among them 7200 dolines and 1200 caves. Spatial statistics in combination with other datasets, like lithologic maps, reveal that glacial erosion is the major factor controlling karst feature distribution. Areas with a high amount of glacial erosion such as cirques are characterised by a very high density of vadose shafts and small dolines. In contrary elevated palaeo landscapes that overtopped the massive ice like Nunataker host mainly large depressions and relatively few shafts. Observations from caves are used to explain the processes that lead to these differentiations: Vadose shafts often exhibit uncorroded speleothems at their

entrances, which shows that they were not enlarged during or after the Würmian cold stage. That rules out significant shaft development during Pleistocene cold periods. In few cases, where debris does not prevent access, major shaft systems can be traced down below huge dolines. Below palaeo landscapes, vadose dome pits can be entered via old phreatic galleries. They reach upward until close to the topographic surface (i.e. into the epikarst) but do not show any surface expression like dolines or karren fields. The observations are combined in a simplified model for the polycyclic influence of glaciation on surface and near surface karst development: In the pre-Quaternary and in Pleistocene warm periods, water from huge dolines and their catchments feed and enlarge vadose shafts. Dome pits develop at the base of the epikarst but do not necessarily form any surface expression. Glacial erosion erased the dolines and truncated inactive vadose canyon shafts or dome pits, which leads to a high density of vertical cave entrances. Only few of these inactive caves get hydrologically reactivated at some depth by active caves that intersect with them accidentally. Vadose shafts are not significantly enlarged below glaciers by melt waters at least for the alpine settings described above. Observations from other massifs within the NCA like Dachstein and Totes Gebirge confirm the presented model. The results are important for practical aspects of karst science like vulnerability assessment as it helps to interpret the influence of surface karst morphology on infiltration conditions and near surface hydrology.