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Localized sub-glacial deep karst formation due to water infiltration into glacier crevasses: A case study from Asiago, Italy

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In karstic plateaus, deep karst phenomena (e.g. abysses) are the preferential pathways for surface water to penetrate the Earth's crust. After percolation along diaclases and meanders, the infiltrated water often springs at the foot of the karstic plateau, potentially representing a valuable water resource. Thus, it is crucial to understand the formation and distribution of deep karst phenomena, for instance to predict karstic groundwater flow paths or to preserve water resources from pollution.
The role of glaciers in enhancing the formation of deep karst is not yet clear. On the one hand, chilly water retains more CO_2 which increases its acidity and efficiency in corroding carbonates. On the other hand, glaciers obliterate the soil and vegetation covering the developing karst decreasing the quantity of humic acids dissolved in the surface water. Nevertheless, ice-caps may play a key role in controlling how and where surface water can access the developing karstic system. Due to the presence of a glacier, some sub-glacial areas may not be reached by surface water, which prevents karstification, while other areas may be connected to intra- or sub-glacial flow paths possibly leading to localized kartification in these areas. Here we investigate the relationship between sub-glacial topography and the development of preferred intra-glacier flow paths and how this relationship leads to localized sub-glacial karstification. As a case study site, we use the karstic plateau of Asiago in Northern Italy.
The Asiago plateau (https://goo.gl/maps/bLezx) is mainly composed of Permian to Cretaceous rocks. The northern and southern boundaries of the plateau are marked by two Alpine trusts, which uplifted the plateau during the Alpine orogeny to $\sim$1500 m above the Po flood plain delimiting the plateau to the South. The Asiago plateau extends for $\sim$600 km^2 and contains $\sim$2100 natural caves, including many significantly deep caves such as the deepest cave of Veneto: the 1011 m deep Malga Fossetta abyss.
During the last glaciation only the northern part of the plateau was covered by glaciers, which modeled the landscape and deposited moraines. Although the lithology is the same (Calcari grigi fm.), we show by applying spatial-statistical methods that the northern part is richer in caves, which we propose to be due to intra- and sub-glacial processes. We use a digital elevation model (DEM) of the Asiago plateau and employ a finite-element model to simulate the flow of an ice-cap. Our results demonstrate that the glacier undergoes localized fracturing when overflowing topographic obstacles. The resulting vertical crevasses allow surface water to infiltrate the glacier and eventually reach the rock surface. Thanks to the glacial abrasion, the water can infiltrate rock joints creating shafts and meanders.
We suggest that sub-glacial deep karstification is enhanced nearby glacier crevasses. Our theory is supported by observations in the northern part of the Asiago plateau, where many caves are aligned with topographic highs and exhibit morphologies related to water flow. Our study sheds light on sub-glacial cave formation helping to forecast locations beneath currently retreating glaciers, which might conceal highly karstified areas.