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Measurements of ice thicknesses using georadar in alpine caves

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Several caves in high elevated alpine regions host massive ice fillings and underground glaciers. The age of the ice may exceed several hundred or thousand years and the ice bodies possibly have recorded paleoclimatic information. Despite their scientific value, the knowledge on ice caves is relatively sparse, and even the genesis and evolution of the ice fillings is not well understood. The project AUSTRO*ICE*CAVES*2100 is a pilot study funded by the Austrian Academy of Sciences and aims at providing basic information on the formation and composition of underground ice bodies. In the presented study, we focus on the results of ground penetrating radar (GPR) which was used to determine the ice thickness in three ice caves in the Northern Calcareous Alps of Austria (Eisriesenwelt, province of Salzburg; Dachstein- Mammuthoehle and Dachstein-Rieseneishoehle, province of Upper Austria). It could be shown that shielded antennas with relatively high frequencies (500 MHz) are sufficient to penetrate the ice up to 15 m depth. 3D layouts (crossing profiles) were necessary to delineate the strongly curved subsurface in detail and to verify that certain reflections in the radargramm sections originate from the subsurface. In almost all radargramm sections, the lower boundary of the ice body is identified by the onset of strong and sharp reflections. We attribute this to either increased humidity at the ice - rock contact (due to melting) or to a sedimentary layer between ice and rock. Pronounced layering of the ice body itself is clearly seen at some locations, which may results from alternating air content. The maximum thickness is 7.5 m in Eisriesenwelt, 6 m in the Dachstein-Mammuthoehle and 15 m in the Dachstein-Rieseneishoehle. The propagation velocity of the ice bodies (0.165 m/s) is close to the velocity of temperate glaciers. To conclude, GPR with shielded high-frequency antennas proves to be a very effective tool to investigate the extent and internal structure of underground glaciers.

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