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Cover photographs:

Front cover: Switzerland, 2021. Deep beneath the Gornergletscher, in Switzerland, where ice meets rock, an engineer from the team **Flyability** tests a drone modified for surveying glacier caves. This drone can fly along passages inside glacier caves that humans cannot explore – because they are too narrow, too fragile, or pose too many risks. A cage protects the drone from collisions, while a laser scanner creates 3D maps that – over years – might help in calculating changes to the ice mass underground and in detecting danger zones. [Photo by **Robbie Shone**.]

The back cover collage comprises eight images captured in Austrian and Italian ice caves by Robbie Shone. As well as presenting scenes of astonishing colours and beauty, ice caves provide accessible sites for collecting measurements and samples used in a wide variety of scientific investigations, including many facets of palaeoclimatology (and related topics) together with contemporary changes related to ongoing climatic warming.

Image a Beautiful blue ice within one of the photographer’s favourite ice-cave locations, “The Castle” formation in Eisriesenwelt cave near Salzburg. Documenting these and similar formations is important, because they are under threat from warming climates. **Austria 2021.**

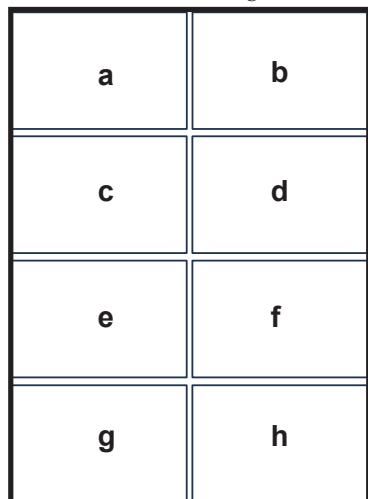


Image b The many layers of ancient ice within this giant plug, suspended above the floor and wedged between the rock walls of Buso della Neve del Zingarella, provide a time record. It is essential that these deposits are sampled and studied before the ice disappears for ever by melting and/or crashing to the floor. **Italy 2021.** Christoph Spötl and Gabriella Koltai (University of Innsbruck) examining layers in a thick bed of ice in

Image c Eisriesenwelt Eishöhle (**Austria, 2020**) to understand permafrost evolution over time. Layered beds of ice up to several centuries old contain climate-record data that remain largely under-studied.

Image d Palaeoclimatologist Tanguy Racine (upper) and his colleague Cecilia Kan use an ‘ice screw’ to extract an ice sample on the 21m ice wall in Eisgruben (**Austria 2021**). Ice has accumulated here for most of the past 2,000 years and ice near the bottom of this 100m-deep cave might be 5,300 years old.

Image e Ice cones in the Schneevulkanhalle of Schwarzmooskogel Eishöhle (**Austria 2021**). In 2013 the cones were up to 20m tall. Now scientists are racing to decipher climate history details stored within the remaining ice before it melts. The yellow glow might relate to light falling on soil-derived impurities within one ice cone.

Image f A team of explorers (La Venta @laventaexploringteam) are mapping and monitoring a cave in the Italian Dolomites using 3D LiDAR technology. Here the change in melt within an ice plug blocking a giant chasm on a high mountain top is being recorded, to assess the effects of climate change. **Italy 2015.**

Image g In Hochschneid cave, east of Salzburg, Tanguy Racine collects twigs and pine needles from ice for C-14 dating, which can show how ice has waxed and waned during millennia of climate change. **Austria 2021.**

Image h For reasons unknown, the volume of ice inside Eiskogelhöhle (**Austria 2021**) has barely changed since being photographed in 2013. Possibly, due to its high elevation, cold winds blow all year round and never become warm enough to melt the ice. In contrast, ice in Schwarzmooskogel (Image e), 500m lower, is melting rapidly.

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