

Chronology and rate of valley deepening in the Sudetes and Tatra Mountains determined through cosmogenic nuclide burial dating of cave sediments

The Tatras and Sudetes span much of the rugged southern border of Poland. The distinct character of these mountain ranges is the product of the competition between the internal deformation of the Earth's crust and long-term climate sculpting the landscape. The higher elevation Tatra have been subject to repeated advances and retreats of mountain glaciers over at least the past one million years, while in the lower elevation Sudetes the development of mountain glaciers has been geographically restricted and infrequent. Indeed, the heavily glaciated Tatra have the appearance of a miniature version of the Alps. The standard assumption in glaciated mountain ranges is that the pre-glacial river valleys are widened and deepened by each successive glacial episode, however, geologists often cannot decipher how the landscape was modified prior to the last glaciation because so much of the prior glaciation is often destroyed by the most recent glacial event. Meanwhile, with the limited temporal and spatial extent of glaciation, valley incision in the Sudetes is controlled almost exclusively by processes typical of purely fluvial environments. The juxtaposition of these different landscapes have a strong potential for understanding what portion of valley erosion in the Tatra is glacial and which occurred prior to the onset of glacial conditions in the Pleistocene. The key to uniting these landscapes lies beneath them, in the carbonate cave networks preserved in each range. Cave networks develop at or slightly below the water table. As the local water table drops in response to incision of the valley by glaciers or rivers, a new cave system develops at the new position, thus under the right conditions, the sequence of valley incision is preserved in cave levels.

A team of scientists from the University of Wrocław's Institute of Geological Sciences and the University of Silesia's Faculty of Earth Sciences will conduct a two-year study that goes under the Tatra and Sudetes to constrain the timing of valley incision in both ranges. To achieve this, the research team will use cosmogenic nuclides, rare isotopes of the elements aluminium, beryllium and neon produced almost exclusively in the upper two meters of the Earth's surface by interactions with cosmic rays, to tell time and infer erosion rates of the Sudetes and Tatra mountains. Rocks and sediments initially exposed at the surface carry an initial concentration of cosmogenic nuclides related to the local erosion rate are washed into and deposited in caves. Once buried in the caves and shielded from the secondary cosmic ray flux, the decay of the radioactive isotopes of Al and Be can be used as clocks and it is possible to deduce the average rate of erosion in a river valley prior to burial. The cosmogenic nuclide chronometers used here can resolve time between ~ 300 ka to 18 Ma, much more than other geochronology techniques applied to the Tatra and Sudetes to date.

Using the information gleaned from their analysis of valley incision in both ranges, the research team will develop a chronology of valley incision for three valleys in the Tatra and at least two localities in the Sudetes. Using this chronology they will test the commonly held assumption that each glaciation results in valley deepening determine how much pre-glacial river incision occurred in the Tatra and Sudetes. This will allow the team to explore the importance of older, non-glaciation related changes in climate and its influence on valley incision. The contrast in mean elevation between the Sudetes, Tatra and Alps makes an ideal natural experiment in exploring the concept of elevation-dependent thresholds that control glacier development and erosivity.