



Quantification of centennial erosion rates in gypsum outcrops based on anatomical modifications in exposed roots

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The karstic landscape of Triassic gypsum and anhydrite in the northern French Alps is of a discontinuous nature and is found mainly in the internal zone and high mountain areas, where it is made up of original landforms such as karstic domes. To date, despite intense surface weathering and karstic corrosion which generate karstic forms, gullies and result in the transport of considerable loads by mountain torrents after heavy rains data on the meteorological degradation of gypsum outcrops are yet extremely rare.

In the Vanoise Massif (French Alps) erosion rates were obtained with the monitoring of weight and volume losses of calibrated gypsum tablets. Measurements from these sites indicate denudation rates varying between 0.2 and 6 mm yr⁻¹ in the subalpine zone. Erosion is attributed to intense dissolution, seasonal water streams, avalanches and freezethaw cycles weathering. On woody slopes, such continuous denudation processes are sufficient to expose roots while allowing them to keep their tips in the ground. In this study, data from continuous field monitoring of micrometric method and gypsum tablets covering the past 10 years, have, for the first time, been compared with an alternative method based on dendrogeomorphology. A total of 45 exposed roots of *Pinus montana* were sampled in the gypsum badlands and the anatomical variations in annual growth rings due to exposure caused by denudation were analysed. The first year of exposure was determined via the peculiar size reduction of earlywood tracheids. The medium-term erosion rates (0.5-5 mm.yr⁻¹) as observed in the root-ring series match with erosion rates derived from gypsum tablets. The detailed knowledge of anatomical changes in roots is thus demonstrated a powerful tool for geoscientists to quantify minimal rates of soil erosion in areas where measurements of past processes are not readily available.