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Young Uplift in the Non-Glaciated Parts of the Eastern Alps

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We report the first incision rates derived from burial ages of cave sediments from the eastern margin of the Eastern Alps. At the transition zone between the Alpine orogen and the Pannonian basin, the Mur river passes through the Paleozoic of Graz – a region of karstifiable rocks called the Central Styrian Karst. This river dissects the study area in a north-south trend and has left behind an abundance of caves which can be grouped into several distinct levels according to their elevations above the present fluvial base level. Age estimates of abandoned cave levels are constrained by dating fluvial sediments washed into caves during the waning stages of speleogenesis with the terrestrial cosmogenic nuclide method. These ages and the elevations of the cave levels relative to the current valley bottom are used to infer a history of 4 million years (my) of water table position, influenced by the entrenchment and aggradation of the Mur river. We observe rather low rates of bedrock incision over the last 4 Ma ($\sim$0.1 mm/y on average) with a decrease in this trend to lower rates around 2.5 Ma. However the pre-burial erosion rate estimates from backward modeling of the data show even lower rates, indicating disequilibrium between the incision in the main river and its tributaries and their hinterland. We relate this to the increase of drainage area of the Mur river due to stream piracy of the paleo-Mur-Mürz in Late Miocene to Pliocene times. The decrease in valley lowering is attributed to the rise of the base level related to aggradation of sediments within the valley. We explain this observation by continuous sediment transport through the valley from the upstream section of the Mur river limiting the erosional potential of the river in a transport limited state. Putting these relative rates into a vertical reference frame allows us to attribute most of the inferred incision to surface uplift of the region in the range of 0.1 mm/y over the last 4 Ma.