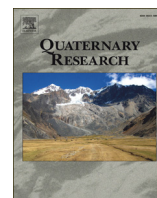




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## Carbon and oxygen stable isotope compositions of late Pleistocene mammal teeth from dolines of Ajoie (Northwestern Switzerland)

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### ABSTRACT

Fossils of megaherbivores from eight late Pleistocene <sup>14</sup>C- and OSL-dated doline infillings of Ajoie (NW Switzerland) were discovered along the Transjuran highway in the Swiss Jura. Carbon and oxygen analyses of enamel were performed on forty-six teeth of large mammals (*Equus germanicus*, *Mammuthus primigenius*, *Coelodonta antiquitatis*, and *Bison priscus*), coming from one doline in Boncourt (~80 ka, marine oxygen isotope stage MIS5a) and seven in Courtedoux (51–27 ka, late MIS3), in order to reconstruct the paleoclimatic and paleoenvironmental conditions of the region. Similar enamel  $\delta^{13}\text{C}$  values for both periods, ranging from  $-14.5$  to  $-9.2\%$ , indicate that the megaherbivores lived in a  $\text{C}_3$  plant-dominated environment. Enamel  $\delta^{18}\text{O}_{\text{PO}_4}$  values range from 10.9 to 16.3‰ with a mean of  $13.5 \pm 1.0\%$  ( $n = 46$ ). Mean air temperatures (MATs) were inferred using species-specific  $\delta^{18}\text{O}_{\text{PO}_4} - \delta^{18}\text{O}_{\text{H}_2\text{O}}$ -calibrations for modern mammals and a present-day precipitation  $\delta^{18}\text{O}_{\text{H}_2\text{O}}$ -MAT relation for Switzerland. Similar average MATs of  $6.6 \pm 3.6^\circ\text{C}$  for the deposits dated to ~80 ka and  $6.5 \pm 3.3^\circ\text{C}$  for those dated to the interval 51–27 ka were estimated. This suggests that these mammals in the Ajoie area lived in mild periods of the late Pleistocene with MATs only about  $2.5^\circ\text{C}$  lower than modern-day temperatures.

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### Introduction

Climate conditions are reflected in the taxonomic composition of the mammal faunas (e.g., Brugal and Croitor, 2007), as well as in the oxygen isotope composition of mammalian bones and teeth (e.g., Koch, 1998). Therefore, Pleistocene mammal assemblages are of special interest for paleoclimatic reconstruction, as Quaternary climates repeatedly shifted from cold to warm temperatures over short periods of time (Zachos et al., 2001). The Middle Pleniglacial (Marine Oxygen Isotope Stage (MIS) 3) usually considered as a mega-interstadial with several warmer and cooler intervals (Van Andel and Davies, 2003), was the warmest part of the Weichselian (~115 to 11.7 ka; MIS5 to MIS2). According to data obtained from Western Europe, the final part of MIS3 corresponds to the Hengelo, Huneborg and Denekamp interstadials ("glacial interstadials" G11 to G15), which roughly preceded the Last Glacial Maximum of the Late Pleniglacial (Johnsen et al., 1997; Markova et al., 2009). These interstadials are typically recorded in the sequence of infillings of the dolines in Ajoie (NW Switzerland), comprising many fossils of large mammals from the so-called Mammoth Steppe fauna

(or the late Pleistocene *Mammuthus*–*Coelodonta* faunal complex; Kahlke, 1999). These fossils yield important information about environmental and climatic conditions of this time interval, even though minor climatic changes such as interstadials did not drastically change the faunal composition. The interval G11 to G15 coincided with the extinction of *Homo neanderthalensis* and the spread of *Homo sapiens* in Europe (Johnson, 2002; Van Andel and Davies, 2003; Mellars, 2004; Manzi, 2011). However, the Mammoth Steppe fauna remained unaltered after the arrival of anatomically modern humans until the beginning of the Last Glacial Maximum, when these megaherbivores vanished (von Koenigswald, 2006).

Eight late Pleistocene doline infillings were excavated along the Transjuran highway in Ajoie, near Porrentruy (Canton Jura, NW Switzerland). Skeletal remains of late Pleistocene mammals were found in fossiliferous layers alongside with gastropods and charcoal. Radiocarbon dating of these mammal bones, gastropod shells (*Arianta arbustorum*), and charcoal, as well as OSL (optically stimulated luminescence) analyses of the embedding sediments were performed to constrain the timing of doline formation (Becker et al., 2013). Two phases of doline infillings with late Pleistocene mammal fossils were detected: a latest Early Glacial filling phase within the doline from Boncourt-Grand Combe (GC) and a late Middle Pleniglacial filling phase within the seven dolines from Courtedoux-Vâ Tche Tchâ (VTA-SY, -V1, -V2,

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