INTRODUCTION

According to Maglio (1973) the emergence of elephants from Miocene gomphotheres reflects an adaptive shift in their method of chewing, which helped to process a newly available food source, grass. Since the latter is more abrasive than leaves, it provided a selective force on the evolution of tooth crown height. Although this assumption is widely accepted, it is not yet properly confirmed and only few studies dealt with the allies and habits of the successively species so far (e.g. Palombo & Duniec 2003, Gásparik et al. 2005 or Rivals et al. 2012). The present study is based on samples taken from molar teeth of Mammothus meridianalis, M. trogontherii, M. primigenius, and Elephas antiquus from Hungary and Mammutthus rumanus (including the holotype and proposed neotype) from Romania.

ISOTOPIC COMPOSITION

The oxygen isotopic composition of phosphate in enamel of homoeothermic obligate drinkers is directly related to the δ18O of water body, which is related to the δ18O of ingested water. The latter can be linked to the isotopic composition of the local meteoric water, which shows significant correlation with mean annual temperature (MAT). The carbon isotopic composition of molars of herbivorous mammals reflects the photosynthetic pathway of the consumed plants (with a 14.1‰ offset according to widely accepted, it is not yet properly confirmed and only few studies dealt with the carbon isotopic composition of molar enamel can be interpreted as an archive of dietary and climatic information. In addition, since the phosphate and carbonate are cogenetic oxygen-requiring phases in isotopic equilibrium with the same reservoir (body water) at the same expected equilibrium line, the isotopic ratio of carbonate (δ13C) is explicable by drier climate and more open vegetation. The δ13C values range from -13.2‰ to -7.4‰ (V-PDB), which suggest a C3 diet. The average and derived from modern mammals, however with an average of 2‰ higher intercept.

Samples were pre-treated following the method of Koch et al. (1997) and the isotopic compositions were measured by the method of Vennemann et al. (2002) and Spötl & Vennemann (2003). The oxygen isotopic composition of the carbonate and phosphate from enamel show strong linear correlation (r=0.75) and indentation paralell to the standard equilibrium line derived from modern mammals, however with an average of 2‰ higher intercept.

MICROWEAR SCAR ANALYSIS

As an independent dietary proxy, the microwear pattern of enamel was examined, which is attributed to the interaction during mastication between tooth and abrasives. The microwear pattern is represented by more circular wear features (pits) and fewer elongated ones (scratches), whereas the opposite is true for grazers. The analysis was carried out using Microware 4.0 software on SEM micrographs made from the surface of high-resolution epoxy casts. Although the magnification used here (3000x) differs from the 35x magnification used in regular light-microscopic studies, the field of view (0.4x0.3 mm) and the total number of observed scars (usually 20-40 on each image) were approximately the same, therefore we used the light microscopic data of Solounias & Semperebon (2002) and Rivals et al. (2012) for comparison. Palombo et al. (2005) or Tődi et al. (2007) reached similar conclusions regarding the comparability of these methods.

According to our microwear data, M. rumanus and M. meridiionalis were browsers, whereas M. trogontherii and M. primigenius were mixed feeders or more likely grazers. Variation of wear features within a single molar is less than 30% (or usually less than 10% in the case of grazers).

Each isotopic sample in the present study is a bulk of three or more subsamples over the whole height of a single plate, in order to represent the whole period of tooth formation. The δ18O values range from -10.5‰ to -14.4‰ (V-SMOW), which show significant correlation with mean annual temperature (MAT). The data are in good agreement with other climatic proxies from the same period (e.g. Kovács et al. 2013 or Szabó et al. 2014).

PALAEOTEMPERATURE ESTIMATES

The oldest known open steps vegetation of Hungary (δ18O 4.0‰) was fitted with reduced major axis method to the present-day precipitation and surface air temperature data of four Hungarian open steppe sites (Veszprém, Visonta, Üröm-hegy, Visonta). The relationship was approximately the same, therefore we used the light microscopic data of Solounias & Semperebon (2002) and Rivals et al. (2012) for comparison. Palombo et al. (2005) or Tődi et al. (2007) reached similar conclusions regarding the comparability of these methods.

The height of each blue rectangle represents the standard deviation of the measurements, whereas the width represents stratigraphic uncertainty.