



Evaluating competition and conflict among western Ukraine Neolithic farmers with stable isotope analyses of human teeth

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1. Introduction

Stable carbon, oxygen and radiogenic strontium isotope analyses of human teeth of three individuals from Vertebea Cave (Fig. 1) in Ukraine are used to examine the issues of population migration and violence through the lens of dietary resources. Excavations from 2008 and 2012 have produced a minimum of 36 individuals associated with the Tripolie culture group. Of these 36, 12 are represented by mostly complete crania. Eleven of the 12 present cranial fractures, a few of which display multiple fractures. Two hypotheses have been proposed to explain the dramatic increase in interpersonal violence at this time (Korvin-Piotrovskiy, 2012). Either 1) competing immigrants moving into the area caused conflict (Kruts, 2012; Korvin-Piotrovskiy, 2012), or 2) local populations began warring over scarce agricultural resources (Chapman, 2017; Korvin-Piotrovskiy, 2012; Zbenovich, 1996). We evaluate these hypotheses through a pilot study of carbon, oxygen and strontium isotope data of tooth enamel from three individuals in order to identify possible immigrants.

1.1. Archaeological background

The Tripolie is an Eneolithic archaeological culture that dates to 4800–2900 cal. BC in the region that now corresponds to the modern nations of Ukraine, Moldova and Romania (Fig. 1) (Zbenovich, 1996; Rassamakin, 2012). The Tripolie culture in Romania is named Cucuteni (Lillie, 2008). Tripolie-Cucuteni and Cucuteni-Tripolie are names commonly used to recognize this unity (e.g. Zvelebil and Dolukhanov, 1991). However, some researchers propose that Tripolie were not a “unified cultural group” (Diachendo and Harper, 2016, pp. 82) but were made up of heterogeneous ethnic groups with social differentiation (Manzura, 2005, pp. 334). Tripolie distribution reached from the Carpathian Piedmont in the west, the Dneiper River in the east, south to the Black Sea and north to Kiev (Videiko, 2004). In Ukraine, the Czech Republic and Slovakia the Eneolithic is defined as beginning with the onset of copper metallurgy and ends with the start of the Bronze Age (Milisauskas, 2011). The Tripolie population density in the Dneister

area is estimated at 12 individuals per square kilometer, making it one of the most densely settled areas in Europe (Korvin-Piotrovskiy, 2012). The Tripolie-Cucuteni culture area was contemporary with several adjacent Eneolithic cultures, including the Baden and Globular Amphorae cultures (Fowler et al., 2015).

Detailed relative and absolute chronologies divide the Tripolie culture into five phases and subphases, including Tripolie A (4900–4300 cal. BC), Tripolie BI (4300–4100 cal. BC), Tripolie BII (4100–3600 cal. BC), Tripolie CI (3600–3200 cal. BC) and Tripolie CII (3400–2750 cal. BC) (Nikitin et al., 2010; Videiko, 2004). Each is associated with distinct pottery manufacture techniques and decoration (Ryzhov, 2012).

Tripolie subsistence was based on agriculture, pastoralism and hunting and foraging of wild resources. Evidence from the paleobotanical remains at Tripolie sites suggests cultivation of domestics such as hulled wheat types of emmer, einkorn and spelt, hulled and non-hulled barley, peas, bitter vetch and lentils (Pashkevych, 2008). Frequent recovery of hulled wheat shows that these crops were important components of their diet (Zbenovich, 1996). Cereals may have been eaten in the form of porridges, as indicated by the presence of crushed hulled wheat grains inside a pot at the Maydanetske site, Ukraine (Pashkevych, 2008). Wild grapes, cornelian cherries, plums and pears were found included in the foraged botanical remains (Pashkevych, 2004). Hunting and fishing continued to be part of the subsistence strategy demonstrated by presence of roe deer and red deer, wild pigs, aurochs and catfish (Korvin-Piotrovskiy, 2012). According to zooarchaeological finds, the Tripolie also practiced pastoralism of cattle, pigs, sheep and goats (Markova, 2008; Zhuralev, 2008). Cattle are most often dominant in the archaeological record. However, frequencies of domestic species vary from site to site (Ledogar, 2017; Korvin-Piotrovskiy, 2012).

The decline of the Tripolie culture during the CII period (3400–2750 cal BC) was marked by an increase in violent conflict. Increased violence is indicated by the establishment of fortifications at Zhvanets-Schovb, Costesti and Kazarovichy (Markevich, 1981; Korvin-Piotrovskiy, 2012). These settlements were fortified with ditches

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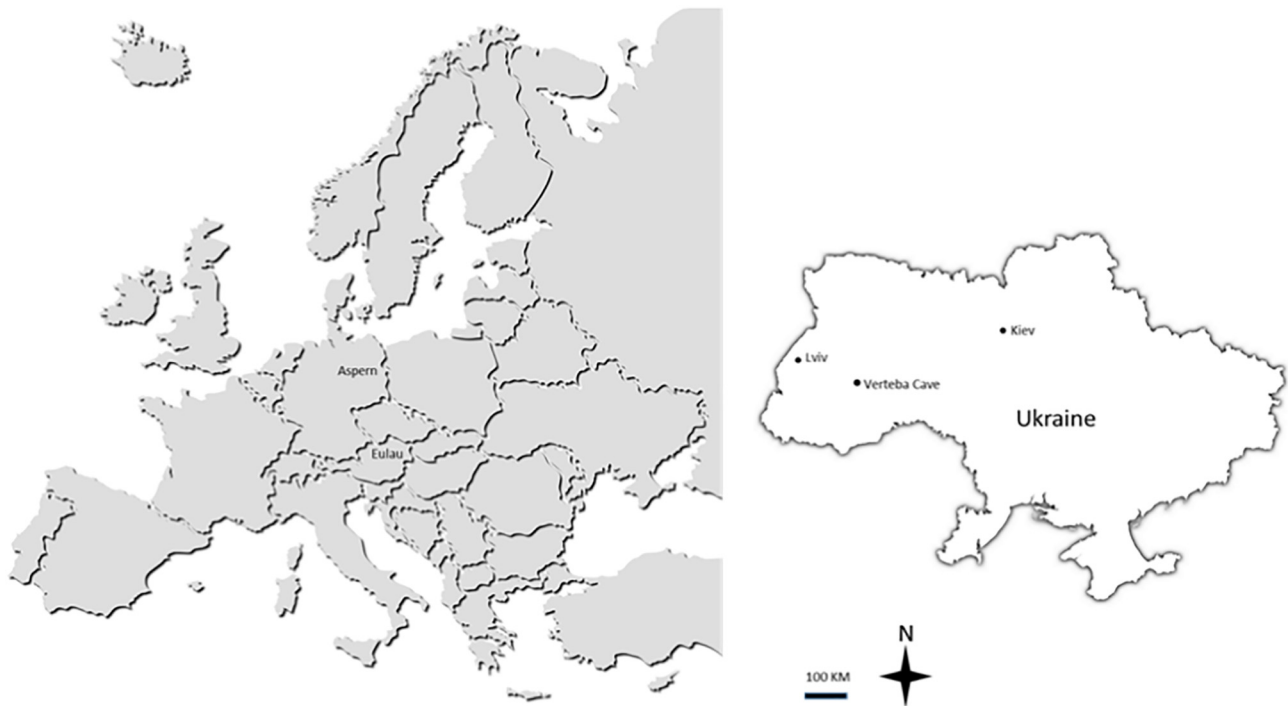


Fig. 1. Location of Verteba Cave and Other Sites Mentioned in Europe. (Verteba cave is 48.7785° N, 25.8839° E).

(Chapman and Gaydarske, 2015) and mounds that were rebuilt multiple times and reinforced with stones. Traumatic injuries on skeletons from Verteba Cave also attest to increasing conflict (Madden et al., 2018).

1.2. Verteba cave and human remains

Verteba Cave is a Tripolie culture mortuary site in Ukraine (Fig. 1), located near the village of Bilche Zolote, Ternopil Oblast, Ukraine, in the steppe forest ecozone. The limestone cave is 8555 m long (Nikitin et al., 2010) and is associated with Tripolie material culture. Analysis of pottery has been used to place the cave in the BII, CI and CII periods of the Tripolie relative chronology, covering 4100–2750 cal. BC (Nikitin et al., 2010; Videiko, 2004). Direct dates of human remains from site 7 affirm this location within the cave dates between 7955 and 3522 cal BC (Ledogar, 2017; Ledogar et al., 2018; Lillie et al., 2017). This is one site of many within the cave, but the only site to be discussed in this work. There are two areas in site 7, Area 1 excavated in 2008 contained the remains of 13 individuals, including subadults, adults, and both sexes. Area 1 held 10 complete crania, more than any site within the cave. Area 1 is a small tunnel. Six complete crania located here were found near the cave walls, including one cache of 4 complete and 1 partial crania. At the close of excavation in 2008 one tooth was taken from 3 Area 1 crania that displayed perimortem trauma. These 3 crania have been radiocarbon dated by Lillie et al. (2017) using 1.5 in. triangular sections of bone from the occipital portion of the skull, these have dates ranging from 3911 to 3522 cal BC. Area 2 was added to the excavation in 2012 and is connected to Area 1 by a small passageway that was blocked in antiquity by standing stones. Three more complete crania were discovered in Area 1, and an additional complete cranium was recovered in the passageway between Area 1 and 2 during 2012 excavations. Area 2 held the only post-cranial bones in articulation at site 7. Nine of the 11 crania with trauma were found in Area 1 with the remaining 2 crania in Area 2. The separation of most of the crania (including most of those with trauma) and articulated post-crania suggests ritual activity. Radiocarbon dates were run on a hand phalange (3930–3877 cal BC) and a zygotomic from Area 2 (7955–7705 cal BC)

(Ledogar, 2017; Ledogar et al., 2018) displaying temporal overlap with Area 1 in the higher levels.

All human remains excavated from Verteba Cave were interred as secondary burials (Madden et al., 2018) and intermixed with pottery, stone and bone tools, faunal remains and ceramic figurines. Excavation in 2012 added 23 individuals for a total minimum number of 36 individuals. These 36 individuals represent males, females, juveniles, as well as adults old and young. Prior to the finds at Verteba Cave few remains have been found associated with the Tripolie culture in the west, mostly individual inhumations beneath house floors (Ledogar et al., 2018). Multiple inhumations at this location, not associated with particular above ground settlements show this to be a unique site.

Taphonomy of the remains includes carnivore tooth marks and whitening due to weathering from exposure outside the cave as the primary stage of the burial ritual (Madden et al., 2018). Two skulls with evidence of perimortem depression fractures also have cutmarks that may indicate dismemberment or excarnation (Lillie et al., 2015; Kadrow and Pokutta, 2016), however most of the remains were completely disarticulated. Four left arms, two hands, and one vertebral column belonging to different individuals were found mostly articulated. Evidence of violence is pervasive (Fig. 2), with a frequency of cranial trauma at 57% including all complete and partial crania (Madden et al., 2018).

2. Diet and residential history reconstruction with stable isotopes

Strontium isotope ($^{87}\text{Sr}/^{86}\text{Sr}$) analysis has been used extensively within archaeology to examine mobility of both humans and other animals (Balasse et al., 2002; Bentley et al., 2004; Ezzo et al., 1997; Grupe et al., 1997; Hodell et al., 2004; Hoppe et al., 1999; Price et al., 1994a; Price et al., 1994b; Price et al., 2000; Sillen et al., 1998; van der Merwe et al., 2000). Tooth enamel does not turn over once formed so isotopic signatures recovered from tooth enamel will reflect the dietary signature during the time of tooth mineralization (Longinelli, 1984; Luz et al., 1984). Analysis of strontium isotope ratio variation among teeth formed at different developmental ages can provide an important source of information on animal and human movements through a

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