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Eneolithic pile dwellings south of the Alps precisely dated with tree-ring chronologies from the north

Katarina Čufar[a,*], Willy Tegel[b], Maks Merela[a], Bernd Kromer[c], Anton Velušček[d]

[a] University of Ljubljana, Biotechnical Faculty, Department of Wood Science and Technology, Jamnikarjeva 101, SI-1000 Ljubljana, Slovenia
[b] University of Freiburg, Chair of Forest Growth, Freiburg, Tennenbacher Str. 4, D-79106 Freiburg, Germany
[c] Heidelberg Academy of Sciences, Institute of Environmental Physics, Im Neuenheimer Feld 229, D-69120Heidelberg, Germany
[d] Scientific Research Centre of the Slovenian Academy of Sciences and Arts, Institute of Archaeology, Novi trg 2, SI-1000 Ljubljana, Slovenia

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ABSTRACT

We present dendrochronological dating of Eneolithic pile dwellings on Ljubljansko barje, Slovenia, from the 4th millennium BC, partly included on the UNESCO world heritage list in 2011. Samples of oak (*Quercus* sp.) timbers from the posts on which the dwellings were built have been collected over the past 20 years. They have been dendrochronologically cross-dated and (pre) dated by ^{14}C wiggle-matching. We describe the construction of a 442-year chronology BAR-3330 based on 106 cross-dated tree-ring series of wood from six pile-dwelling sites. Comparison of BAR-3330 with reference chronologies of more than 500 km distant areas north of the Alps showed that it can be teleconnected and dated with a combined German Swiss chronology. The time span of BAR-3330 was defined in this way as 3771–3330 BC. We were thus able to date exactly building activities on the pile dwellings Strojanova voda (SV), Hočevarica (HO), Maharski prekop (MP), Črešnja pri Bistri (CR), Spodnje mostišče (SM) and Stare gmajne (SG), in which early copper metallurgy played an important role. This is the first dendrochronological dating of prehistoric pile dwellings south of the Alps using reference chronologies from the north based on teleconnection. It provides an opportunity to continue filling the spatial and temporal gaps in the absolute chronology of the 4th millennium BC in the area south and south east of the Alps.

1. Introduction

Ljubljansko barje, Slovenia, is a location where the remains of numerous prehistoric wetland and lake shore settlements have been preserved. They are among the 937 known archaeological pile-dwelling sites in six countries around the Alpine and sub-alpine regions of Europe, of which 111 were included on the UNESCO world heritage list in 2011 (Fig. 1a) (UNESCO, 2015). Ljubljansko barje is the most extreme southeastern location of these sites (Fig. 1 a and b).

Between 1995 and 2012, archaeological (mainly rescue) excavations were performed on 15 prehistoric wetland settlements on Ljubljansko barje (e.g., Čufar et al., 1997, 2013). In all cases, waterlogged wood was collected for dendrochronological and radiocarbon investigations. Tree ring chronologies of either oak (*Quercus* sp.) or ash (*Fraxinus* sp.) were thus constructed for nearly all excavated sites. As the number of excavated sites and chronologies increased with time, many of them could be relatively cross-dated. This helped to establish the chronology of settlement activities in the 4th and 3rd millennia BC. Furthermore, ^{14}C dating calibrated with the wiggle-matching procedure helped to propose an absolute dating of settlement activities, showing that most of the pile dwellings on Ljubljansko barje were occupied in the period of ca. 3650–2400 BC (Čufar et al., 2010, 2013). This period corresponds to the middle and late Eneolithic in Slovenia (Velušček, 2004, 2014), which agrees with the period between Neolithic and Bronze Age (e.g., Jacomet, 2007).

Previous research helped to suggest precise dating for oak tree-ring chronologies covering the period of ca. 3744 – 3332 ± 10 cal BC (Čufar et al., 2010) but they could not be dated by means of dendrochronology. Lack of dendrochronological dating is generally a problem at prehistoric wetland sites south of the Alps (Čufar and Martinelli, 2004), since there are no multi-millennial reference chronologies in the area (Haneca et al., 2009). Such chronologies have been constructed in areas north of the Alps. However, the Alps seem to represent a boundary for tree-ring signals of oaks growing in the areas on different sides of this mountain ridge (Ważny, 2009).

* Corresponding author. Fax: +386 1 25 72 297.
E-mail addresses: katarina.cufar@bf.uni-lj.si (K. Čufar), tegel@dendro.de (W. Tegel), maks.merela@bf.uni-lj.si (M. Merela), bernd.kromer@iup.uni-heidelberg.de (B. Kromer), anton.veluscek@zrc-sazu.si (A. Velušček).

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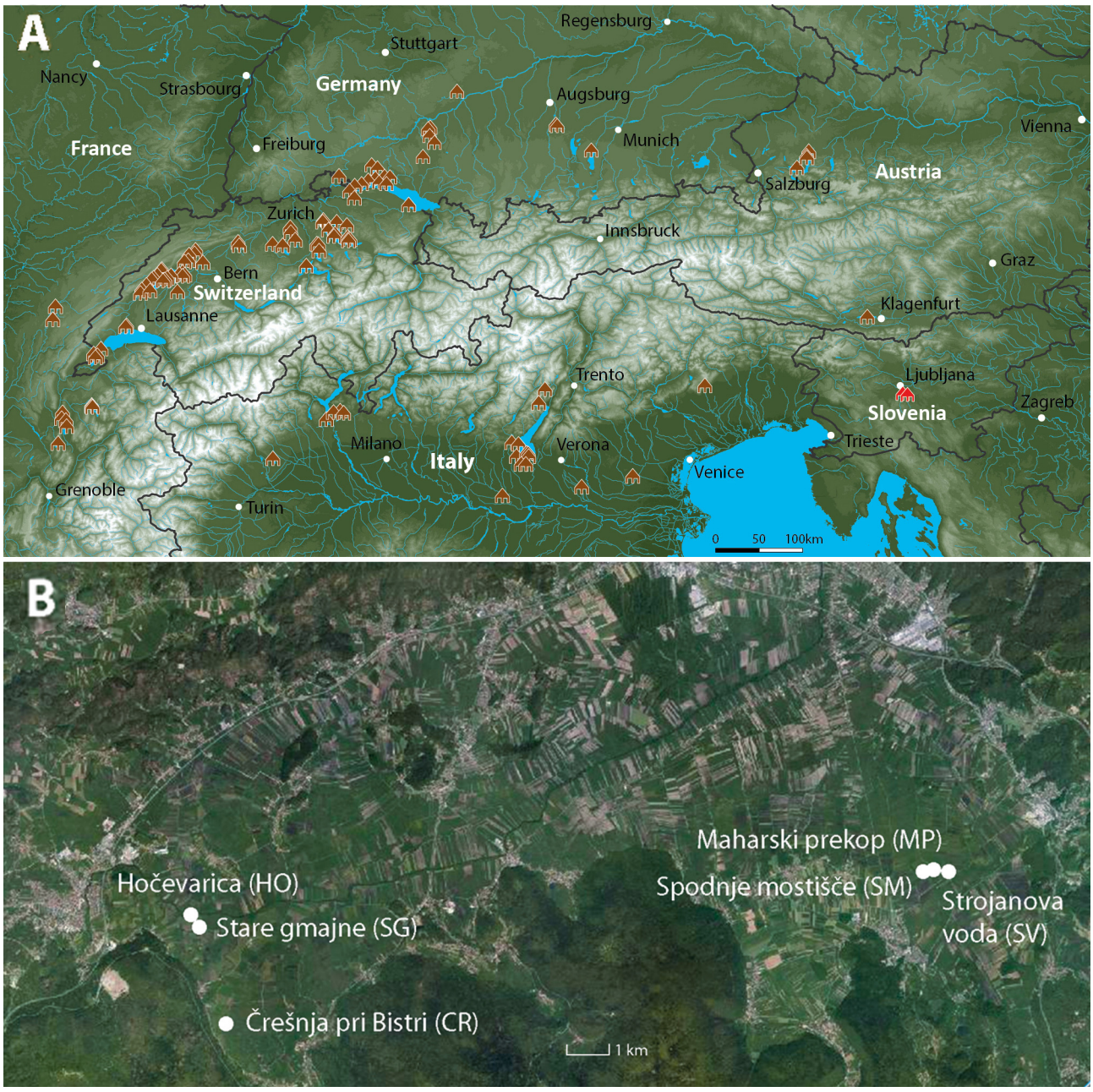

Fig. 1. Maps showing (A) 111 locations of prehistoric pile dwelling sites around the Alps entered on the UNESCO world heritage list in 2011 (after S. Fasel, F. Kilchör and Landesamt für Denkmalpflege Baden-Württemberg) and (B) Ljubljansko barje with locations of six pile dwellings from the 4th millennium BC which were investigated in this study. SM, MP and SV belong to the group of Slovenian sites on the UNESCO list.

Among the multi-millennial reference chronologies constructed in areas north of the Alps, is the southern German-Hohenheim oak chronology, which covers the period between 8480 BC and AD 2009 and is the longest tree-ring chronology in the world (Becker, 1985; Friedrich et al., 2004). Construction of this chronology in the 1980s was crucial for the accurate dating of numerous Alpine wetland and lake shore settlements in Germany, Switzerland and France investigated by several laboratories in co-operation with Bernd Becker (e.g., Becker et al., 1985; Billamboz, 1996, 2006; Hurni and Orcel, 1996; Pétrequin, 1996; Tercier et al., 1996; Pétrequin et al., 1998; Viellet, 2002).

In areas south of the Alps, in Italy and Slovenia, the dating of prehistoric tree-ring series can only be done with help of teleconnection, i.e., by using remote reference chronologies from north of the Alps. However, attempts to do so have failed (Martinelli, 1990; Čufar et al., 2010). On the other hand, investigations of modern oak from Slovenia have shown that teleconnection over the Alps can work if the chronologies are sufficiently long (multi-centennial) and replicated (Čufar et al., 2008).

Continuous excavations on Ljubljansko barje over the past two decades, with a gradually increasing number of tree-ring series (Čufar et al., 2013), has given hope that an adequately long and well replicated chronology could be constructed for the 4th millennium BC. In addition, recent advances in dendrochronology, the increasing number of investigated prehistoric sites all over Europe and the improvement of reference chronologies (Grabner et al., 2007; Pichler et al., 2009; Tegel et al., 2010, 2012; Tegel and Vanmoerkerke, 2011; Kolar et al., 2012), gave hope that teleconnection over the Alps could finally also be successful for prehistoric chronologies.