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Radiocarbon ages of soil charcoals from the southern Alps, Ticino, Switzerland

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Abstract

Radiocarbon dating of macroscopic charcoal is a useful tool for paleoclimatic and paleoecologic reconstructions. Here we present results of ^{14}C dating of charcoals found in charcoal-rich soils of Ticino and the Misox Valley (southern Switzerland) which indicate that the Late Glacial and early Holocene fires coincided with warm phases in the North Atlantic region and low lake levels in the Central Europe. Late Holocene charcoals found in these soils document an earlier than believed presence of sweet chestnut (*Castanea sativa* Mill.) in southern Switzerland. Sweet chestnut trees play a key role in Mediterranean woodlands, and for longer than two millennia have been used as a food source. Based on palynological evidence it is commonly believed that in southern Switzerland *C. sativa* was first introduced 2000 years ago by the Romans, who cultivated it for wood and fruit production. Our results indicate that this tree species was present on the southern slopes of the Alps ~1500 years earlier than previously assumed, and therefore was likely introduced independently from cultivation by the Romans.

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1. Introduction

The genus *Castanea* has been present in the northern hemisphere for the last 80 Ma with the maximum of its extension during the tertiary when the mild, moist climate favoured its growth and expansion. Cooling that occurred sometime between 5 and 1.8 Ma and the following Quaternary glaciations led to the extinction of chestnut at high latitudes and finally to its retreat to the glacial refuges in southern and central Italy, and the Balkans [1]. Spatial distribution of the locations, into which chestnut retreated during the last glacial maximum (LGM), has been exclusively based on pollen reconstructions and correlation with ^{14}C dated records. Krebs et al. [2] summarized the data on distribution of *Castanea sativa* in Europe and North Africa showing more frequent glacial refuge areas and possibly earlier post-glacial presence of chestnut in some of the regions. Despite being an extremely powerful tool for paleo-reconstructions, pollen analyses have limitations, which in the case of *C. sativa* appear to add to the controversy. Drawing maps of the past vegetation distribution is inconclusive if the pollen of a specific taxon are not frequent or not present at all. In addition, pollen of *C. sativa* is difficult to identify precisely because it is morphologically

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very similar to other pollen of *Lotus, Hypericum, Sedum* [3,4]. Macrofossils can be helpful in resolving problems with pollen strata, especially where fragments of charcoal are present. Wood-anatomical analyses of macroscopic charcoal fragments (>2 mm) provide additional information about the presence of trees in the region. Moreover, well characterised charcoal macro remains can be used as a material for radiocarbon dating. In many cases dating of single pieces of macroscopic charcoals, which weigh as little as a few milligrams, is possible using the AMS technique. Such analyses had been successfully applied in archaeology and, more recently, have been used in studies of paleo fires as well as environmental reconstructions (for a review see [5]).

Recently, Willis and van Andel [6] published a compilation of radiocarbon ages (^{14}C ages between 16 and 40 ka BP) of full-glacial age charcoal macrofossils found in 40 archaeological locations of central and eastern Europe. This collection of 151 radiocarbon ages, which was obtained on identified charcoals of various tree species, calls into question the previous picture of steppe-tundra vegetation covering land between the Alps and the Scandinavian Ice Sheet.

Based on the pollen data of the Alpine regions it is believed that *C. sativa* was reintroduced into this region by humans but the arrival path and timing remain controversial. Most previous pollen studies concluded that the Romans introduced *C. sativa* [1,7–9]. However, we believe that an earlier post-glacial expansion of the chestnut tree may have been obscured in pollen spectra. The direct ^{14}C dating of charcoal found in soil and sediments has a great potential for resolving the paleoecology of *C. sativa* in the southern Alps region.

1.1. Study site

Charcoal macrofossils were collected from three soil profiles sampled at two locations near Pura (Ticino) and Roveredo, in the Misox valley (Grisons), in southern Switzerland. The climate is temperate with a mean annual temperature of 12 °C (January, 1 °C; July, 22 °C) and a mean annual precipitation of 1800 mm, which is characteristic of the southern Alpine region. Forest fires are common during dry winters with mean monthly precipitation of 60 mm or less. Heavy rains occur during the rest of the year with a maximum monthly precipitation of 200 mm during the summer. The deciduous forest at the lower elevations (below 1000 m above sea level) is dominated by chestnut (*C. sativa* Mill.) accompanied by oak (*Quercus petraea*, *Q. pubescens*), birch (*Betula pendula*), beech (*Fagus sylvatica*) and to lesser extend elm (*Alnus glutinosa*), ash (*Fraxinus excelsior*), and linden (*Tilia cordata*). Between 1000 and 1400 m the beech (*F. sylvatica*) tree dominates and coniferous forest, whereas Norway spruce (*Picea abies*) and silver fir (*Abies alba*) prevails at elevations higher than 1400 m.

1.2. Soil profiles

Two soil profiles at Roveredo were sampled: Pian d'Arf at 515 m (46°22′51″N, 9°13′25″E) and Prebonella at 1000 m (46°22′50″N, 9°13′57″E). The profile sampled at Pura, is located west from Locarno at 650 m (Pura, 45°98′50″N, 8°86′24″E). These three profiles were studied by Blaser et al. [10] who classified them as cryptopodzolic soils. They contain a thick blackish-brown mineral horizon of exceptionally stable soil organic matter. Soils at the sites dominated by chestnut forest in southern Switzerland usually have extremely high soil organic matter (SOM) stocks (the highest found in Switzerland) of approximately 177 tC ha^{-1} [4]. This feature is explained as the result of a unique combination of mild/wet climate, Fe–/Al– rich acidic bedrock (gneiss) and the presence of high amounts of phenols and tannins in the litter layer, which is characteristic for the chestnut forest [10]. A high content of black carbon (BC), which is formed by incomplete combustion, was also found in our profiles [11] but not in control profiles with low C content, which implies that this form of carbon might have contributed significantly to the high SOM.

1.3. Charcoals

Six charcoal-rich soil profiles were sampled to reconstruct fire frequencies and the impact of burning on the vegetation in Ticino and Misox Valley, Switzerland [11]. Charcoal was extracted from each soil horizon by floating/washing technique then dried and weighted to estimate charcoal content. More than 500 pieces of charcoal (pieces larger than 2 mm) were analysed under the microscope using wood identification techniques in order to determine the botanical species or genus of charred wood [12].

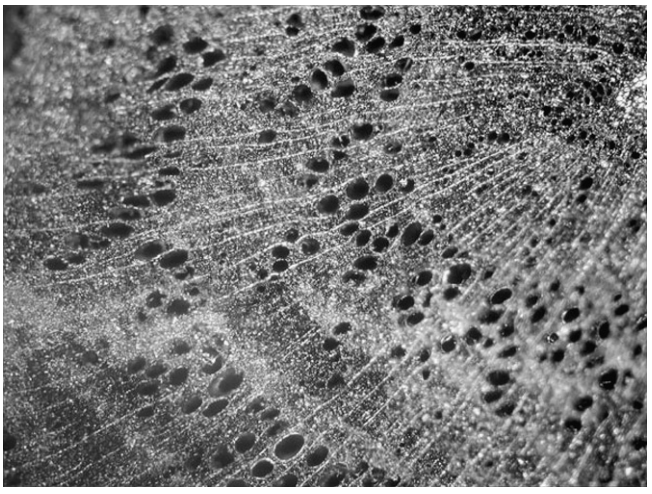

Fig. 1. Microphotograph (50×) of the oldest chestnut charcoal piece found in Swiss soils (ETH-28464, 1640–1420 BC). The wood-anatomical structure is ring-porous, with pores in radial dendritic groups, and homogeneous uniseriate rays, which is characteristic for charcoal derived from the burning of a chestnut tree (*Castanea sativa* Mill.).