

Multi-millennial tree-ring chronologies for dating purposes in Italy

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Abstract –A total of 909 samples of subfossil wood were collected in 38 high elevation sites of the Italian Alps. 517 of them were dated to the calendar year through dendrochronology, allowing the construction of 8 mean chronologies, which all together cover a period of around 11500 years. Such long tree-ring chronologies demonstrate to be a powerful tool for dating of archaeological woods in Italy and abroad.

I. INTRODUCTION

Wood found in environments such as peat bogs, rivers and lakes in high elevation sites could result in up to thousands of years of age. To distinguish them from recent timber and from properly fossilized woods, they are commonly called “sub-fossils” [1].

Sub-fossil woods are a very valuable resource for constructing long dendrochronological series [2]. These chronologies are one of the most efficient tools in the reconstruction of the past climate, in the investigations concerning the hydrological and environmental dynamics and in the dating of archaeological wooden artefacts [3].

In peninsular Italy, suitable preservation environments are hard to find and long tree-ring chronologies are inexistent. We present here the results of a study conducted on subfossil wood in western Trentino. They represent the longest tree-ring chronologies ever constructed in Italy.

II. MATERIAL AND METHODS

909 samples were collected from 38 sites, in an area of approximately 2500 km², at a height between 1250 and 2480 m above sea level (asl), with an average height of 1876 m asl. Most of the examined environments are peat bogs (> 70%), but also torrents and lakes have been taken into account.

Many of the sites are in areas of natural interest (Adamello-Brenta Natural Park) and consequently the use of mechanical means to extract logs from the ground has not been possible (Fig. 1). Thus, the excavation was done by hand and once a log section was extracted, the excavation area was restored to, as close to possible, as it was found. Wood species identification was conducted through microscopic analysis of the anatomical

characteristics.

The trunk sections were cut into the appropriate dimensions and then stored in the refrigerator cell to stop the decay process on still wet wood. The growth rings were measured with the precision of mm/100.



Fig. 1. Typical sampling operations.

Samples with good correlation values were averaged to obtain floating chronologies. The radiocarbon dating of ‘milestone’ samples, selected on the basis of length and statistical reliability, allowed to place the averaged floating chronologies on the absolute chronological scale.

The comparison with the Eastern Alpine Conifer Chronology (EACC) [2] allowed the dating of mean chronologies and many individual series to the calendar year.

III. RESULTS

517 samples on 909 showed good reciprocal correlations. This allowed the construction of 8 mean chronologies made from a mix of species: Spruce, Larch and Stone pine. 7 of them were dated annually by comparison with the EACC and ranged from 8097 BC to 2009 AD, including the year 0. An average chronology remains fluctuating and dated with radiocarbon between 9280 and 9200 BC (confidence interval 95.4%). The total extension of the mean series covers, with gaps, a time

span of about 11500 years (Tab. 1).

Table 1. Descriptive statistics of the mean chronologies.

| Dating method | Samples n. | Length years | Start year | End year |
|-----------------|------------|--------------|-----------------------|----------|
| Dendrochr. | 315 | 2989 | 984BC | 2005AD |
| | 16 | 370 | 1362BC | 993BC |
| | 115 | 3219 | 4961BC | 1743BC |
| | 44 | 1190 | 6264BC | 5075BC |
| | 3 | 305 | 6611BC | 6307BC |
| | 16 | 345 | 7041BC | 6697BC |
| | 4 | 779 | 8095BC | 7317BC |
| ¹⁴ C | 4 | 349 | 9280BC-9200BC (95.4%) | |

The Spruce mean chronology, which cover 2943 years, from 943 BC to 2009 AD, is probably the longest continuous series for the species in the world.

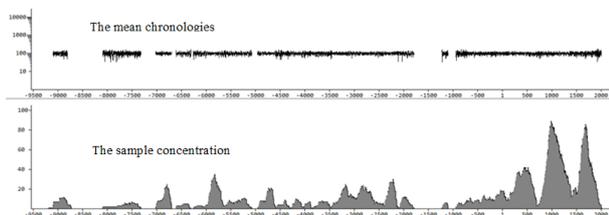


Fig. 2. The mean chronologies and their sample concentration.

IV. DISCUSSION

Long, well replicated and reliable reference chronologies are the fundamental prerequisite of the dendrochronological dating.

The method of dendrochronological dating is based on the laws that regulate the formation of growth rings. In temperate climates, the seasons determine periods of intense growth in trees alternated with periods of reduced growth, which often end with the vegetative stasis. This rotation causes the formation of rings in trees, each of which consists of two slightly different wood tissues: the earlywood, which is formed in the most favorable season to growth (in spring and the summer), and latewood, which is generated before the winter stasis. The alternation of the two tissues allows us to distinguish a ring from the other: usually the light side of the ring is the earlywood, while the latewood is dark.

The width of each ring is a function of environmental conditions, and climate in particular, where the plant lived. If these conditions act on a rather large region, the growing patterns of many plants are synchronized [3].

The dating of an artefact is made by measuring the width of a sufficiently large number of consecutive tree-rings, thus developing a "tree-ring series" which is then compared with long reference series, called master

chronologies, useful for the same species and the same geographical area.

By comparing different tree-ring series (cross-dating), feasible both visually and through statistical tests, the chronologies are cross-matched, i.e. that of the artefact in question is located in an area of the reference where the similarities in terms of growth ring are more evident. Once the cross-matching is made, we are able to determine the year of the last tree-ring measured on the artefact, which does not necessarily coincide with the year in which the artefact itself was made.

This implies that the use of proper reference chronologies is crucial for the obtaining of the right dates. They must be as longer as possible and reliable, and they represent the basis of comparison for the dating of the series measured on individual wooden objects. In general, the greater the agreement between the series, the smaller the distance between the sites where the plants are grown. Thus, it would be useful to compare the series of an artifact to be dated with reference chronologies built in the same area.

Now, for Central-Northern Europe, long tree-ring chronologies have been produced during the last 50 years: Irish oaks chronology spans over 5,000 years [4], while the German oak and pine now surpass 12,000 years [5]. In Italy, however, multi-millennial tree-ring chronologies are still lacking or limited to small portions of floating series.

This research demonstrates that also in Italy it's possible to establish multi-millennial continuous dendrochronological series, with many important consequences in those research fields that deal with history and past reconstructions, such as ecology or climate fluctuations.

For instance, in the field of ecology and hydrology, the distribution of samples demonstrates that environments as peat bogs, have gathered logs for very long times. Phases with high samples concentration are interspersed with periods of few or lack of trunks (Fig. 2). This alternation may be related to hydrological fluctuation of high-altitude environments and may be considered as a proxy to reconstruct hydrological dynamics of the past.

However, the principal application of multi-millennial tree-ring series is in the dating field. In fact, the mean series have already proved to be a powerful tool for dating. The comparison with the long Italian reference chronologies has allowed the dating of many important artifacts and monuments in the Alps, in the rest of Italy such as in the case of the Baptistery of San Giovanni [6] and the Campanile di Giotto in Florence [7], but even abroad, with the dating the roof of the Basilica of the Nativity in Bethlehem [8].

V. CONCLUSIONS

The choice of the correct reference chronology is a crucial moment for the success of dating. Ideally, the

reference chronologies should be long enough, referring to the same species and geographical area of the wood to be dated and sufficiently replicated, which consist of a large number of samples, such as to ensure a wide applicability. The multi-millennial chronologies presented in these pages are going to fill up a gap that has become anachronistic for the dating of cultural heritage in Italy.

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