The dendroarchaeology – review of dating the patrimony items across the globe

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Abstract

The dendroarchaeology dating has signified the most accurate method of positioning on a temporal scale a wood item, based upon the analysis of the year growth rings of the trees. Many halidoms of high importance specific to the history study and of the national culture haven’t had attestation proofs regarding their origins time. As already known, Saint Stefan the Great (signification of the Romanian title “Stefan cel Mare si Sfant”) built monasteries, but no one can accurately attest their number, considering that some of them have been restored, while others have been assigned to him, without proving. The materials used in order to build monasteries and churches had been represented by wood and stone, by far. Even for the stone buildings, there are items of really high cultural value, meaning: wood painted icons, iconostasis, sculptures etc., or some other times, the stone walls have been constructed by surrounding a wood skeleton. The dendroarchaeology can offer us many precise answers as regards the edification year or the provenience of the used materials etc. This current study illustrates some of the dendroarchaeology accomplishments in the world, as well as the fragile dating attempts on some Romanian items. Their acquaintance will be quite significant for the archeologists, the restaurateurs and for the owners of some assets, as well.

Key words
dendrochronology, dating, ring width, pattern, oak

The dendroarchaeology can be defined as the science of using the radial growth rings on scaling in time and space a wood item coming from an archaeological site or an artifact. This emphasizes a scientific method on accurately determining in time the period when a tree was cut, transported, processed and used. Since the prehistoric times, the wood and the stone have been the most used materials on building house holdings, or on their endowments, by using the necessary items for the human beings lives. As concerns Romania, an especial significance for the national culture and history has been given by the monasteries, as for instance, the very well-known monasteries of Bukovina. Although the halidoms have existed since the very beginning of the Romanian people (for instance, the Saint Andrew cave, near Ion Corvin place), many of them were destroyed, especially during Maria Teresa empress’s persecution of the Austrian - Hungary Empire. She fought against the orthodoxies, by destroying most of the orthodox wood monasteries in Ardeal, in the second half of the XVIIIth century.

Time localization of the wood items can be carried out by maximum accuracy, by using the dendrochronological dating technique. Studying the year ring has reflected much information regarding the conditions on its framing. Not all of the wood species can be successfully dated, but it is essentially that these should prove various and much differentiated growths for each year in part, where the reference dendrochronological series should be defined for those series with coverage as higher as possible. Since most of the buildings intended to be long lasting were built of oak (Quercus robur L.) and holm-oak (Quercus petraea (Matt.) Liebl.), and due to the wood characteristics of long time resistance, most of them could be dated. One cannot exclusively date all the proofs, since the wood items should prove a minimum number of fifty growth rings per year. The wood should come from regions where limited factors existed, so that the year growth would be able to prove a specific pattern. Last but not least, an adequate number of individual samples should be taken into account, since one would be able to eliminate, as much as possible, the individual character of a single individual. The dendrochronological series that are about to be dated should be homogeneous, as well.

The progress of dendroarchaeology seen as dating tool

Duhamel and Buffon French scientists discovered in 1737 that each twenty-nine growth ring,
starting from the bark towards the marrow, has a different shape as comparing to the others. Future investigations have confirmed that 1709 was an event year. The crossdating underlying on the relative width of the growth ring per year was really established by A.C. Twining in Connecticut (1827), by the mathematician Charles Babbage in England (1838), Jacob Kuechler in Texas (1859), and then, by Douglas (1904). The last one has been seen as the parent of dendroarchaeology, and from the association with the American anthropologist Clark Wissler, many prehistoric discoveries have resulted in the old settlements of the American Indians, where the Aztec or Pueblo Bonito ruins could be noticed, thus defining the new procedure, as “the buildings chronology”. The special interest shown for the accurate placing on the temporal scale of the archaeological wood pieces has made possible the creation of the first dating method, subsequently named “the Douglas method” (Fritts, 1976).

The further research has made progresses in a spectacular way, depending upon the level of prosperity of each state, where many of such research were of national interest, thus examining the culture and habits of the predecessors, and even the demand on pre-state periods of the national territories. Many states have considered such research as national pride reasons (Germany, England or France).

Currently, as regards the Europe region, many detailed studies have been developed, concerning the oak wood found in various archaeological sites, which involved the analysis of the periods necessary to build the holdings, as well as the wood type under use (species of long life hard wood or species of soft wood and low lifetime). The interest hasn’t been ended to only analyzing the big dimensions or valuable items, but the wood used was also investigated, as regards the tools specific to the prehistoric period (Baillie & Brown, 2002). The most important accomplishments have firstly consisted in creating the dendrochronological series, with long time coverage. From this part, the following can be enumerated: the longest chain represented by “the South German Hohenheim oak chronology”, this being carried out in time until the year 8489 B.C. (Friedrich et al. 2004). Other dendrochronological chain with long life time (meaning 7272 years) is represented by means of “Belfast oak chronology”. The highest part of them can be found within the international basis of the growth rings (ITRDB; http://www.ncdc.noaa.gov/paleo/treering.html).

These dendrochronological series have been used in more ways, and respectively for establishing the climate, especially in the less normal periods by which Terra passed through, such as the small glacial epoch. These have also been used for the dendro - ecological analysis, and especially the most important use could be used in dendroarchaeology, being used as reference series for dating. Starting with 1984, when the first long chain on oak was created, the dating of pillars on Central Europe lakes has been started, places when the pile buildings in Neolithic were firstly built (Billamboz, 1995). Therefore, between Constance and Geneva lakes, one could notice many episodes where no anthropic activity existed, especially between the Neolithic and the Bronze epoch. These demographic declensions that cover periods from few decades up to few centuries have been interpreted by the view on recovering the ecosystem on its initial shape of natural forest.

The study of pillars existing in lakes during the Neolithic age, which were exposed to the erosion, has been carried out in detail by Arnold (1986) and Billamboz (1995), when these have grouped various characteristics of the pillars in the so-called “dendro - types”. Schweingruber spoke in 1996 about dating the pile buildings near Zurich Lake, where almost twenty villages, with maximum 100 inhabitants, were established during the Neolithic age. Nowadays, over one million people live in Zurich and surroundings, making an idea over the modifications brought to Terra, by the anthropic factor in almost 4000 years. By dating various wood items or buildings, one was able to make significant observations for people, thus proving the significance of such field.

Until the 19th century, and before the industrial revolution, the wood signified the main material used in the building process. Regional differences as regards the shape and quality of the wood, as well as the independent reasons, such as the economic rationalities, have involved Europe within a complex process of trading the wood. As any economic process, changes were based upon supply and demand, where the offer was almost every time different from one type of wood to another, from the wood used on mines, buildings or boats, up to the wood used on sculptures or other art elements. From the proofs discovered near the Mediterranean Sea, one could notice that the trade with wood has existed more than four millenniums within this region (Kuniholm, 2001).

The best explanation for the results achieved from the dendrochronological studies, as regards the phenomena of cutting many areas of the woods, phenomena known during the people’s history, can be given by means of the fluctuations on the wood market (Baillie & Brown, 2002). Taking into account such observations, one were able to study the interest of the human beings dedicated on certain species of wood, within a certain period and in accordance to the demand variations, thus noticing that the oak wood has always signified a raw material being in permanent demand, where the volume under transaction was the only one diversifed (Schweingruber, 1996).
The involvement of Universities within the dating process

Within the South – East part of America, research carried out within a laboratory in Tucson (Laboratory of Tree-Ring Research – LTRR), which owns the longest tradition within the dendroarchaeological study from the world, has proven many studies concerning the dating of pre - historical constructions, belonging to the old aboriginal civilizations in Navajo, Ute, Hopi, Zuni and Puebloan (Nash, 2002, Towner, 2002). Here, the human behavior was studied for the first time, upon basis of the radial growth rings (Dean, 1996). In the same time, the first climatic realignments were tested, by which the stages of dryness have been emphasized, facts that determined major social changes (Stahle et al. 2009). Such simple correlations are able to determine an analysis of the history’s progress relative to people’s needs. Concerning the above mentioned issues, a relatively recent study (Büntgen & Tegel, 2011) has tried such reestablishment, basing on the radial growth rings of the climatic abnormalities during the medieval age, also known under the name of the small glacial epoch. On the strength of the results achieved, one might notice that the rainy climate has favored the development of the mice population, which represented the main agents of the pestilence extension.

The dendroarchaeology laboratory of the Cornell University has the virtue of classifying, within the temporal scale, the most historical houses of New York and North of America. The research work was dedicated on dating the very old wood, derived from excavation, lakes and roads, with the view on improving the already existing reference series and on extending as longer as possible in time, and up to present, thus reaching the late period of time of the Pleistocene (Griggs, 2006).

The Department of Geographical Sciences within the Arkansas University has carried out essential progresses on investigating the past climate and its effect over the human culture of America and Mexico (Cleaveland, et al., 2003, Therrell, 2005). Investigations of the national architecture were carried out on large scale in countries, such as Canada – Vancouver or British Columbia, where elements during the centuries XVIth and XXth have been dated. Acadian buildings were investigated by Leighton and Laroque in Canada (Smith, et al., 2005).

In accordance to the European Catalogue and to the Tree-Ring Research Association, there are more than fifty dendroarchaeology laboratories in Europe, all of them being involved within dating the historical objects. Oak wood sculptures in the North of Europe have been successfully dated, as well as the statuettes of the Lübeck Cathedral (Eckstein, 2007). The medieval books that have oak or beech covers have also been dated (Lavier, 2005). An especial signal was dedicated to the musical instruments (Burckle & Grissino-Mayer, 2003; Grissino-Mayer, 2004). In order to date and separate the originals as comparing to the fakes, attention was given to the dendro - provenience of trees, fact that resulted in the possibility on specifying the preferred areas on each producer, as the situation of the musical instruments (Haneca et al., 2007).

The dendrochronology gave efficient results in analyzing the wood proofs derived during the Roman period, in the West and Center of Europe (Haneca et al, 2005b, Nicolussi et al, 2005, ), although weaker results were achieved in Italy and in the Mediterranean region, where no reference series were noticed. Dating the archaeological sites in the East of Mediterranean region has been an essential step on extending the dendroarchaeology research in these areas (Hughes et al, 2001, Kuniholm, 2001, Manning et al., 2001).

As regards Germany, the Laboratory of Hamburg University illustrated the dating of Lübeck medieval city, and within the achieved series, certain observations were carried out concerning the woods growth from the past, the wood transportation from one region to another, the economic relationships based on wood as commercial item, as well as the wood cutting season. From all these observations, new knowledge over the properties and quality of wood has been developed (Haneca et al., 2005). Although the University of Hohenheim created the longest chronology from the history, it has tried to form new regional chronologies, so as to use them in different ways, including the study of the historical buildings (Friedrich et al, 2004). The laboratories of Berlin, Frankfurt, Göttingen, Hohenheim and Köln, as well as those of Germany, have issued regularly studies over the dating activity related to the historical artifacts, not only in Germany, but in the rest of the world (for instance, Heussner, Westphal, Leuschner, Tegel, Billamboz and Schmidt), as well. The iron epoch has been much studied in Europe, from where significant results were achieved by Grabner et al., 2007, and thus helping on understanding better that period of time.

An analysis over the wood provenience

An essential theme adopted by the dendroarchaeology consists in the wood’s origin, and respectively in its provenience. Underlying on such analysis, one might take into account the trade relationships between states, the techniques used on cutting and transportation of items, as well as the techniques used on high dimensions buildings or art objects. Such theme has occurred when one tried to date some oak artifacts that were found in England (Baillie, 1995), and of some pictures in Holland, North of Germany or Denmark (Eckstein et al., 1986). The dating attempts over items with local series have failed, thus putting into discussion the wood’s origin issue. The answer came one year later (Haneca et al., 2005, Haneca et al. 2009), when documents were found as
regards the transportation of wood from the Danzig harbor, since the tenth century; subsequently, the series of Poland were able to accurately date the items that were impossible to be dated in the past. The documents found have also proven that most of the state oak woods disappeared and were replaced in the agriculture, and the wood transported from the Danzig harbor was brought from Prussia.

As concerns France, different research was carried out relative to the wood derived from the Roman buildings, as well as for the wood derived from the old Egyptian collections (Haneca et al., 2005b). The dendroarchaeology research was also carried out for the regions of low potential, as for instance, Belgium (Haneca et al., 2005c). By using comparative studies focused within the Alps region, one could determine the significance of the woods in the Roman period, as well as the quantity of the knowledge gathered in the field of processing and transportation of wood, on long distances (Tegel et al., 2010). France has also proven a long tradition in dendroarchaeology, meaning a high potential in the national architecture relative to the North part of the country, taking into account that the South part has known a higher development of the stone architecture.

The boats of the antique ages were often discovered as result of the archaeological diggings that represented the study item of the dendrochronology. Although many of them were emphasized in the publications on this theme of research (Haneca et al. 2009), there were many boats that couldn’t be dated. The reason consisted in the non - correspondence of the series resulted from measuring the yearly growth rings of trees used for building such boats, by comparing with the already existing master series of nowadays. The answer to such non - correspondences came most of the time after more dendrochronological series on regional feature were created. In the same way, one might talk about the fact that huge wood quantities have been transported since the Roman age of Dacia, when most of the valuable wood exploitation was carried out in bad conditions, as the situation of the Cerna Valley rocks. Mentions regarding the wood trade were found in the documents of those times, in the North of the country, meaning in Satu Mare, where it is mentioned that significant quantities of oak wood were cut and transported in Venice or Italy, and the trunks were used as supporting pillars.

Outstanding accomplishments of dendroarchaeology within world’s culture knowledge

The archaeological sites of England have been also well known, since creating new reference dendrochronology series as the second in the length of time has been established, by which many prehistoric settlements were dated; these underlie the interpretation of the climatic modifications from the past (Baillie, 1995, Baillie &Brown, 2002, Boswijk & Whitehouse, 2002). An especial work has been carried out in England, so as to date the ecclesiastic items of the cathedrals architecture, of the medieval cities (Crone, 200), of castles, of houses or of the autochthonous architecture. These studies have emphasized the extremely particular conditions from the past, by the study of the radial growth rings (Leuschner et al., 2002).

Within the Alps South, in Italy, Slovenia and Austria respectively, dating of very old sites haven’t been possible until nowadays, since no long reference chronologies existed, and moreover, dating with the series of Alps North failed. The dendrochronology and cultural patrimony importance has been strongly influenced by the studies carried out in Italy, relative to the wood derived from the historical buildings of Venice (Pignatelli, 1996), church St. Nicholas in Turmima – Sicilia, as well as other buildings from the Center or South of Italy (Romagnoli et al., 2004). The high number of studies derived from different parts of the world has determined taking into account the alburnum wood, for both the number of rings, and their width estimation points of view, as well (Romagnoli et al., 2004).

Within the laboratory of Verona, Italy, many buildings from Venice, situated the North of Italy, were dated. As regards the laboratory of Viterbo, wood buildings from the Center and South of Italy were dated (Romagnoli et al., 2004). In Slovenia, progresses were made, as regards the efforts of the Ljubljana laboratory (Čufar et al., 2008a, Čufar et al., 2008b, Levanič et al., 2001). Hungary made efforts on creating series of 405 years (Grynaeus, 2000).

The dendroarchaeology has been well developed in Poland (Wazny, 2002), where most representatives were also the following: Estonia (Läänelaid & Eckstein, 2003) and Latvia (Zunde, 1998). An especial attention was given to the art items, and due to their high value a very accurate dating was imposed, as well as creating of the non-destructive analysis methods. Amongst the most representative items created, the paintings from the XVIth century, Henri Bles of Belgium can be emphasized (Fraiture, 2002). Two paintings with a name of the German artist Hans van Essen of the Estonian Art Museum in Tallinn were made of Baltic wood (Läänelaid & Nurkse, 2006), and received the dendrochronology analysis, in order to help the art historians to identify the relationship between them. Investigations about the archaeological wood were drawn in Norway (Thun, 2005).

The lack of some growth series that can be used as reference has been quite significant, even if some artifacts of Egypt, belonging to the old Egyptian empire, as well as the Egyptian and Palestinian cultures that were important to the civilization, could not be dated. The possibility on creating such chronologies has been limited, since the woods of these regions, that
offered the wood used on making artifacts, have disappeared long time ago. In this way, if the wood used on artifacts can represent the basis of such chronologies, these might remain only floating, since they cannot be related to the present, by means of the living trees. Even in such conditions, the investigation of the old vegetation has shown significant interest (Liphschitz & Biger, 2001).

Within Asia, Japan represents the state that has proven the highest accomplishments, and remarkable was the successful attempt on dating the Horyuji temple of Nara in 594 A.C., by building the oldest wood construction from the world, which exists nowadays, also. Non-destructive methods have been used on large scale in Japan, as the X rays or the tomograph, in order to date the wood boats (Okochi et al., 2007). At that time, in the North part of Asia, meaning in Mongolia, dating of the oldest monasteries and cemeteries in the region has been carried out as a result of the intense research working (Nachin and Serjbaatar). An obvious progress has been made by the South Korea. Settlements from the XVth century were discovered in Russia and in the above mention region of Asia (Gurskaya, 2005).

Most of the items emphasized in this research paper have been preserved in conditions of low humidity, though there are some artifacts preserved in conditions of humidity, as the canoes, boats or ships, found in all the parts of the world, and dated during all the human civilization periods. The research of such constructions has involved the dendroarchaeology help, since by means of specific studies resulted the possibility of determining the provenience site, and their forming data, as well (Daalen & Beek, 2004).

The first research study in Romania carried out within the archaeology field can be related to the wood monasteries dating in Maramures, as well as to the dating attempts over the Putna monastery (Baboș & Eggertsson, 2002). The archaeology research have been especially carried out in Transylvania, and isolated in Maramures by Iștván Botăr, where the most known were developed in cooperation with Grynaeus András (2007, 2008). The first dendroarchaeology series of Romania were issued in accordance to the ITRDB requirements, which were hardly accomplished after 1990 (Tissecuc, 1991, Tissecuc, 2001, Borlea, 1999, Popa, 2002, Nechita & Popa, 2011, Nechita & Popa, 2012). One might notice that the dendroarchaeology research carried out by Babos and Eggertsson in 2002, when series of 588 years on oak were created.

Conclusions

Estimating the absolute age has been always essential in dating, where setting the boundaries, specific to the first growth ring near the pith, and of the last one near the bark, has also been important in its determination (Baillie, 1995). Estimating the period during which the tree was cut has been also significant, depending on the anatomic features of the first growth ring, meaning in the early spring, summer or during October of the last year and April of the current year, respectively. The young rings emphasize certain features specific to the wood, by which the sap circulates, usually no more than twenty growth rings yearly, although the variability has been quite high, even within the same collectivity (Eckstein, 1984).

The dendrochronology signifies the most accurate dating instrument, where many papers have reflected the accomplishments reached in this field. The trees that grew in temperate or arid regions of the world include in the internal structure of the wood some information, relative to the climatic conditions of each calendar year of growth. The trees grown in similar conditions have answered more often in a corresponding way, as regards the actions of the external factors, by a diminution of the yearly ring width, when they are non-favorable or the reverse situation. A truly particular interest was shown for the Baltic interest, which has a completely special pattern. One should also mention that many chronologies were created for all species of trees, not only for the oak, which was the most profoundly in this research study; these chronologies were also created for species, as spruce or fir. The study under discussion emphasizes the choice on analyzing preponderantly the oak, since most of the items or buildings dedicated on lasting in time in Romania have been built from trees of such species.

Using the non-destructive methods has allowed the analysis of more delicate items of priceless cultural and patrimony value. Dating the books covers or icons has offered us an image over the huge potential that dendroarchaeology has in Romania. The way the social progress was performed in time has also been essential from the religion point of view, by analyzing the wood provenience or its changes and transportation, relative to the church buildings or items. Knowing the accomplishments emphasized in this review has been essential for both the theologians managing such items that can be dated, as well as for those interested on achieving an authentication certificate, specific to the items of uncertain time or space provenience.

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