DATING OF OAK TIMBERS FROM ANADOLU HİSARI (ANATOLIAN FORTRESS), İSTANBUL-TÜRKİYE

ANADOLU HİSARI'NDAN ALINAN MEŞE ÖRNEKLERİNİN TARİHLENDİRİLMESİ, İSTANBUL-TÜRKİYE

Makale Bilgisi | **Article Info**

Başvuru: 8 Temmuz 2023 | Received: July 8, 2023
Hakem Değerlendirmesi: 19 Temmuz 2023 | Peer Review: July 19, 2023
Kabul: 3 Nisan 2024 | Accepted: April 3, 2024

DOI : 10.22520/tubaked.1324004

Ünal AKKEMİK* - Yasemin ÖZARSLAN - Tomasz WAŻNY*****

ABSTRACT

Anadolu Hisarı, or the Anatolian Fortress, is a prominent historic building located on the Anatolian side of the Bosphorus, Istanbul, right across the well-known Rumeli Hisarı (the Rumeli Fortress). The fortress is known to have been built during the reign of the Ottoman Sultan, Yıldırım Bayezid, in 1395. In 2022 during the restoration of the fortress we collected a group of stem discs from 6 timbers stored in its garden for dendrochronological dating. The timbers were dated to 1395 after standard dendrochronological methods were applied. This result is consistent with the completion dates of the construction, 1395/1396, mentioned in historical records. The part of the walls from which the sampled timbers had been removed are from the original construction and were replaced during the recent restoration work. Our study shows that identifying the exact context of architectural wood removed during the restoration of such historical buildings in Istanbul can help identify their original parts and the time of restoration activities that may have taken place in the past.

Keywords: Tree Ring, Cultural Heritage, Restoration, Ottoman Fortress, Wood Use

* Prof. Dr., İstanbul Üniversitesi-Cerrahpaşa, Orman Fakültesi, Orman Mühendisliği Bölümü, Orman Botaniği Anabilim Dalı, İstanbul.
e-posta: uakkemik@iuc.edu.tr, ORCID: 0000-0003-2099-5589

** Bir kuruma bağlı değildir.
e-posta: yozarslan@gmail.com, ORCID: 0000-0003-3767-4220

*** Nicolaus Copernicus University, Faculty of Fine Arts, Centre for Research and Conservation of Cultural Heritage Toru'n, Poland.
e-posta: twazny@umk.pl, ORCID: 0000-0001-6641-0131

ÖZET

Anadolu Hisarı, İstanbul Boğazı'nın Anadolu yakasında, ünlü Rumeli Hisarı'nın karşısında yer alan önemli bir tarihi yapıdır. Hisarın, Osmanlı Padişahı Yıldırım Bayezid döneminde, 1395 yılında inşa edildiği bilinmektedir. 2022 yılında yapılan restorasyonu sırasında, Hisarın bahçesine depolanan meşe hatıllarının 6 tanesinden dendrokronolojik tarihleme için disk şeklinde gövde kesitleri alınmıştır. Standart dendrokronoloji yöntemleri uygulandıktan sonra ahşaplar 1395 yılına tarihlendirilmiştir. Bu sonuç, tarihi kayıtlarda geçen inşaatın tamamlanma tarihi olan 1395/1396 ile tutarlıdır. Tarihlendirme sonucuna göre, Hisardan alınan örneklerin orijinal yerlerinin yapının ilk dönemine ait olduğu ve bu restorasyonla ilk defa değiştirildiği sonucuna ulaşılmıştır. Çalışmamız, İstanbul'daki bu tür tarihi binaların restorasyonu sırasında kaldırılan mimari ahşabın tam bağlamının belirlenmesinin, bunların orijinal parçalarının ve geçmişte gerçekleşmiş olabilecek restorasyon faaliyetlerinin zamanının belirlenmesine yardımcı olabileceğini göstermiştir.

Anahtar Kelimeler: Yıllık Halka, Kültürel Miras, Restorasyon, Osmanlı Hisarı, Ahşap Kullanımı.

INTRODUCTION

Istanbul with its 8500 years of known history (Kızıltan, 2010) is one of the most understudied historical megacities of the world, which served as a capital for more than a millennium during the Roman, Byzantine and Ottoman periods. Exposed to a rapid population increase and urban expansion since the mid- 20th century, the city has witnessed an increasing number of archaeological research projects and dendrochronological investigations for securing the protection of its historical and cultural heritage and its transfer to future generations.

Dendrochronology, defined as the science of determining age based on tree rings (Fritts, 1976; Schweingruber, 1988; Akkemik, 2004), is a very powerful science discipline to find the exact date or term of wooden objects. Among them dating studies focusing on Roman and Byzantine period harbors and structures of the city (Pearson et al., 2012; Kuniholm et al., 2014, 2015; Yalçın et al., 2019) and Ottoman-period buildings (Akkemik & Köse, 2004; Akkemik et al., 2019) have contributed in many ways to our understanding of its history and urban development.

Numerous historical buildings and artefacts made of wood exist in today's Istanbul that have been restored many times in the past and will continue to be restored in the future. By using dendrochronology methods, determining construction dates, material used and repair periods of such historical are of great importance for understanding not only the historical but also social and economic development of Istanbul. Greater accumulation of results can provide more far-reaching conclusions regarding, among others, periods of increased construction activity or dominating factors causing its decline (Ljungqvist et al. 2022).

Anadolu Hisarı is one such architectural monuments of great historical importance for understanding the Ottoman past of the city and its urban development. Historical records tell us that this fortress was built in 1395 at the mouth of the Göksu stream, a waterway flowing into the Bosphorus, during the reign of the Sultan Yıldırım Bayezid, an Ottoman ruler who played a major role in the Ottoman expansion into the Byzantine capital of the time (Savvides, 1997; Kuban, 2007). Savvides (1997) stated, based on R. Anhegger (1975), "*Anadolu Hisarı, which was constructed in 1395/1396 on the Anatolian shore of the Bosphorus' narrowest pass, opposite Constantinople, was initially called by the Ottomans 'Güzeldje hisar', that is 'handsome castle'*".

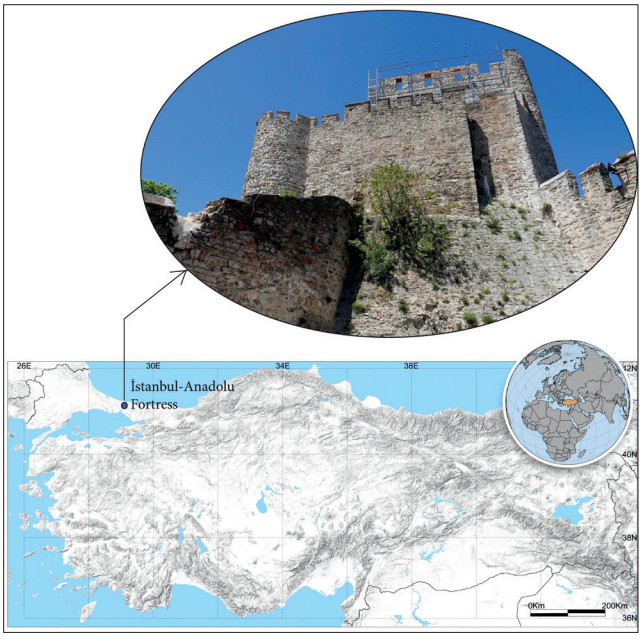
Anadolu Hisarı preserved its architectural integrity until the first half of the 19th century. Until 1825, all the towers of the citadel had cones on top and the surrounding area was empty. Only in the courtyard were the houses where the guards lived. Starting from the 1830s, Anadolu Hisarı was abandoned, and the thin shore between the walls of the fortress and the Göksu stream and the sea was further filled and wooden houses were built there. Later, a very wrong thing was done; the two gates of the fortress opening to the outside were demolished and widened, and the road passing through the courtyard between these two gaps was turned into the main coastal street of the Anatolian side. In 1928, some parts of the fortress were repaired (Anonymous, 1991).

The aim of this study is to identify and date a group of timbers removed during the recent restoration and stored in the garden of Anadolu Hisarı using standard dendrochronology methods. With this dating, it was expected to be found that these timbers are belonging to the construction year of the fortress or one of the repairs during the last 6 centuries.

MATERIAL AND METHODS

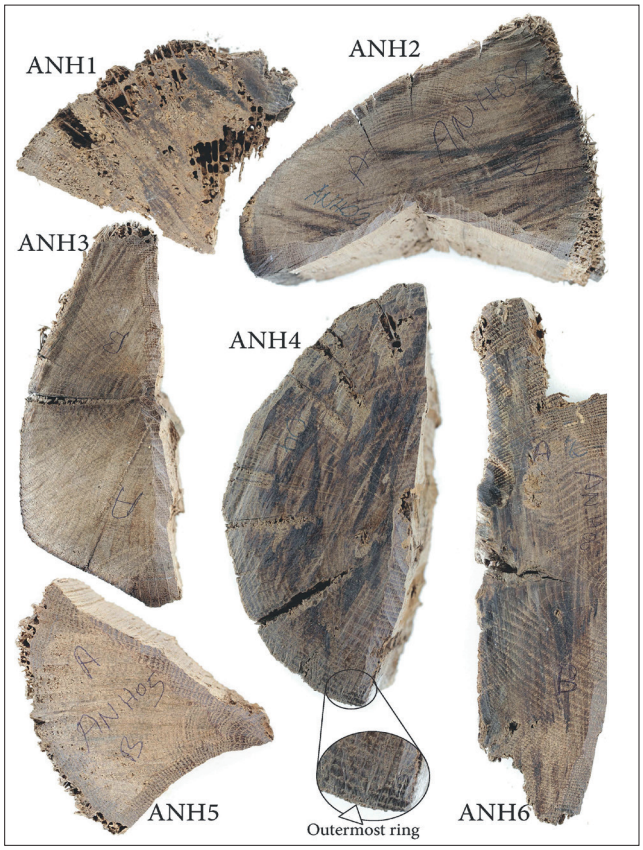
A total of 6 stem discs were cut from the beams using a chainsaw from Anadolu Hisarı (Fig. 1; Fig. 2). The samples were then given a three-letter code, **ANH**, representing ANadolu Hisarı. After they were brought to the Laboratory for Wood Anatomy and Tree Ring Research, Department of Forestry, Faculty of Forestry, Istanbul University-Cerrahpaşa, they were prepared for dendrochronology analysis using standard methods. Before measuring, the transverse surface of the samples was sanded with the use of a belt sander and a series of progressively finer abrasive grits papers to have tree rings and xylem cells clearly visible under microscopic magnification (Fig. 2).

Figure 1. The location of Anadolu Hisarı. The wood beams taken for dating were used through the walls of the construction. / *Anadolu Hisarı'nın konumu. Tarihleme için örnek alınan ahşaplar Hisar duvarında kullanılmış olan hatıllardır.*



DOI: 10.22520/tubaked.1324004

Figure 2. The examined 6 oak beams from Anadolu Hisarı. Only one sample, ANH4, has the outermost ring. The outer parts of the other samples were decomposed. / *Anadolu Hisarı'ndan alınarak incelenen 6 hatıl örneği. Sadece ANH4 adlı hatıl örneğinin en dış halkası bulunmaktadır. Diğer örneklerin dış halkaları bozulmuştur.*



All samples were identified as white oak group of the genus oak (*Quercus* L.) under magnification. Thanks to having strong and durably woods, oak timbers were widely used throughout the history (e.g. Kuniholm, 2000; Akkemik & Güzel, 2004; Akkemik & Kocabaş, 2014; Akkemik et al., 2019), and this kind of wood was used in Anadolu Hisarı, as well.

For measuring, tree rings were marked into 10-year sections and measurements were made on the Time Series Analysis and Presentation (TSAP; Rinn, 2011) and LINTAB (Rinntech®, Germany) measuring systems at a resolution of 0.01 mm. Measurements were made in at least two radii of each sample and an average individual chronology was obtained for each sample. The individual chronologies and the developed mean chronology for Anadolu Hisarı were then cross-dated and synchronized with the oak chronologies built by Peter I. Kuniholm and Tomasz Ważny. From them only the chronology, TYMT061s, produced statistically significant results. Therefore, this chronology was preferred as the reference chronology for dating the mean chronology for Anadolu Hisarı.

To see whether our dating is statistically significant, GLK (Gleichläufigkeit value; percentage of parallel variation between chronologies dated with the reference chronology), TV (standard t-correlation value), TVBP (bandwidth = 5 and logarithm to base e with moving average after trend decrease t-value (Baillie & Pilcher , 1973), max=100), TVH (Wuchswert (Hollstein, 1980), max=100), t-value after trend exit, and CDI (Cross-Dating Index - Date index, which combines GLK and t-values (max=1.000) were automatically calculated by TSAP software.

RESULTS

Total 6 samples, which were used in the dating analysis (Fig. 2), were identified as oak wood, and an individual chronology was built for each (Fig. 3). Each chronology has different numbers of tree rings with varying lengths. Among them the longest individual chronology belongs to the sample ANH3 with 84 years while the shortest one is the sample ANH4 with 32 years. The shortest chronology (ANH4) was also included in the mean chronology alongside the other samples since it has a very high and significant correlations with the other samples and also has the outermost ring preserved. As result, a 102-year long mean chronology for 6 samples was built (Fig. 2 and 3).

During our dating analysis in the TSAP software, the highest and most statistically significant results were obtained between the 6 individual chronologies, the mean chronology (ANH) of the 6 samples and the reference chronology (TYMT061s) built by Peter I. Kuniholm & Tomasz Ważny (Table 1). According to dating results, the individual chronologies were dated to AD1359 to AD1395 with very high statistically significant results (Table 1; Fig. 4). As result, the mean chronology (ANH) covered the years of 1293-1395, and gave the construction date of Anadolu Hisarı as AD1395 (Table 1; Fig 4 and 5).

Figure 3. The individual chronologies from the 6 beam samples and their mean chronology (ANH). / *Alınan 6 hatıl örneğinin bireysel kronolojileri ve bunlardan elde edilen ortalama kronoloji (ANH).*

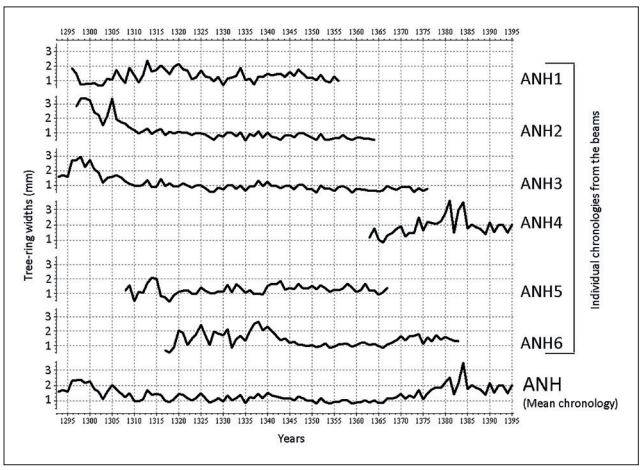
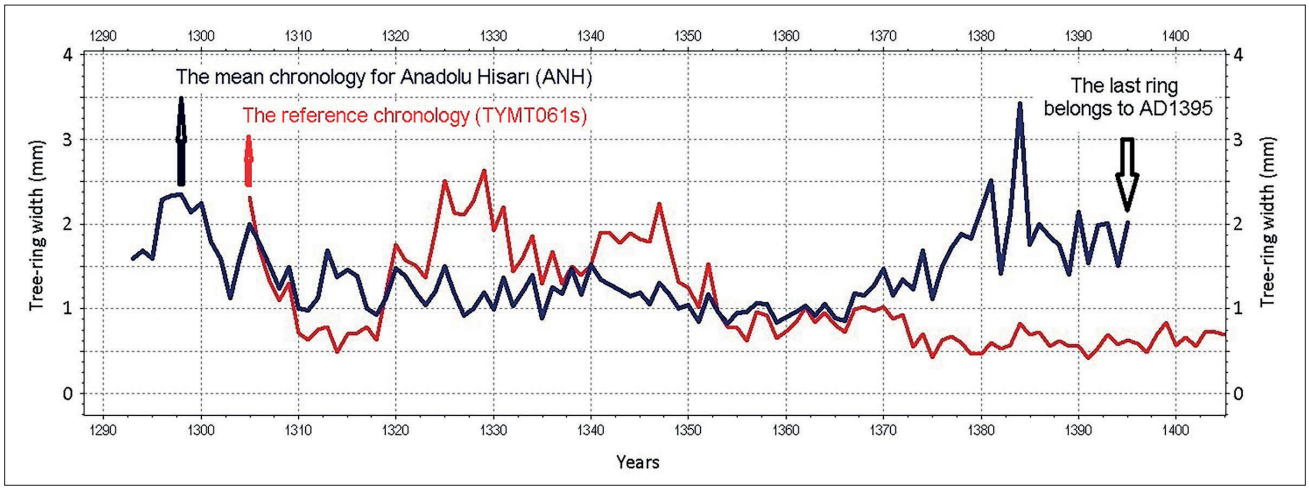


Table 1. Statistical results of cross-dating between the reference chronology (TYMT061s) built by Peter I. Kuniholm & Tomasz Ważny against the individual chronologies for oak samples from Anadolu Hisarı and their mean chronology (ANH). *) indicates a confidence level at 95%, and ***) indicates at 99.9%. / *Peter I. Kuniholm & Tomasz Ważny tarafından oluşturulan referans kronolojisi (TYMT061s) ile Anadolu Hisarı'ndaki meşe örneklerinin bireysel kronolojilere ve bunların ortalama kronolojisi (ANH) arasındaki çapraz tarihlemenin istatistiksel sonuçları. *) %95'lik ve ***) %99,9'luk güven düzeyini gösterir.*

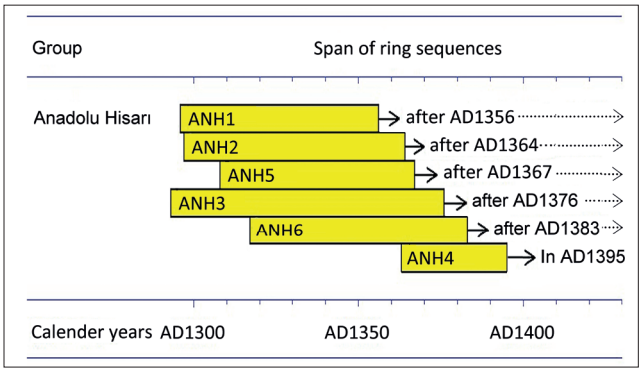
Reference chronology	Floating chronology	Overlap	GL (%)	TV	TVBP	TVH	CDI	First year	Last year	Last ring/ Sapwood
TYMT061s	ANH1	52	78***	0.3	5.5***	5.5***	41	1296	1356	No sapwood
TYMT061s	ANH2	60	73***	1.5	5.6***	4.7***	36	1297	1364	No sapwood
TYMT061s	ANH3	72	75***	1.9	5.3***	4.7***	36	1293	1376	No sapwood
TYMT061s	ANH4	33	84***	1.3	3.5*	4.1***	32	1363	1395	Last ring possible
TYMT061s	ANH5	59	68***	1.0	4.0***	4.5***	29	1308	1367	No sapwood
TYMT061s	ANH6	67	75***	3.8	5.8***	4.8***	40	1317	1383	Unclear sapwood
TYMT061s	**ANH**	**102**	**86*****	**2.1**	**9.1*****	**9.3*****	**76**	**1293**	**1395**	Last ring possible

Figure 4. Dating of the mean chronology (ANH, blue one) from Anadolu Hisarı (average of the individual chronologies) to AD1395 based on the reference chronology (TYMT061s, red one) built by Peter I. Kuniholm & Tomasz Ważny. / *Anadolu Hisarı'ndan elde edilen (bireysel kronolojilerin ortalaması olan) ana kronolojinin (ANH, mavi olan), Peter I. Kuniholm & Tomasz Ważny tarafından oluşturulan referans kronoloji (TYMT061s, kırmızı olan) ile MS1395 yılına tarihlendirilmesi.*



In the sample ANH4, due to having the outermost ring we can give its exact year as AD1395. In the others, samples have not outermost ring, and therefore, the dates given in the figure (Fig. 5) indicate that the timbers were cut after the given dates. For example, in ANH1, the timber was cut after AD1356. Due to lacking the outermost rings in the timbers except ANH6, and different amounts of decomposition and trimming, they were dated to different years between AD1356 to AD1383. However, we can conclude that all these timbers were cut just before the construction year of the fortress (Fig. 5).

Figure 5. Dating results of samples from Anadolu Hisarı. The yellow bars cover the time span of the samples. All 6 timbers may be cut just before the construction year of the fortress. / *Anadolu Hisarı'ından alınan örneklerin tarihlendirmesi. Sarı renkli yatay çubuklar örneklerin kapladığı zaman aralığını göstermektedir. Son yıllarındaki yıllık halkaları bozulmuş olan örnekler de Hisarın yapım yılında kesilmiş olabilir.*



DOI: 10.22520/tubaked.1324004

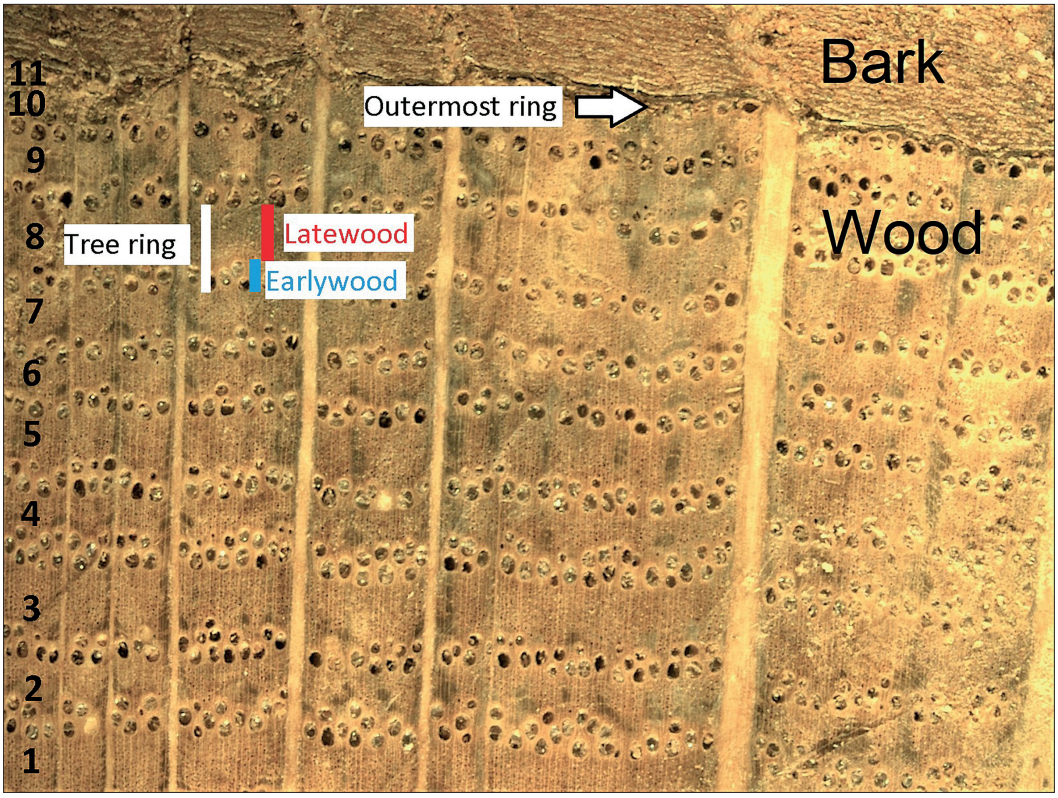
DISCUSSION AND CONCLUSION

Our dendrochronological analysis confirms that the oak timbers analyzed in this study can be securely dated back to the original construction period of Anadolu Hisarı. Our analysis shows that the felling year of Sample ANH4, in which the outermost rings are preserved, was AD1395, which may represent the construction year of the fortress itself. This is also consistent with the completion dates of AD1395/1396 mentioned in historical records (Savvides, 1997; Kuban, 2007).

The reason why the outermost rings in 5 samples do not exist is probably because they were trimmed while the outermost parts of the timbers they belong to were being processed at the time of preparation for construction or decomposition. However, we can suggest that the last year of the timbers may have been the year of AD1395 or just earlier. In some of the samples sapwood rings must have disappeared most probably because they are softer and more susceptible to insect infestation and fungal decay than the more resistant heartwood. Deciduous oaks have usually easily distinguishable sapwood by its brighter color and free conducting water earlywood vessels, and not plugged by tyloses growing into lumen of vessels of heartwood (Rybnicek et al., 2006). However, in the arid areas of Aegean sapwood can be indistinguishable, and it merges completely with heartwood (Fig. 6). Therefore, we do not observe a clear sapwood on the sample ANH4, which dates to the construction year of the fortress.

In this study wood samples were collected and examined from oak timbers removed from the original walls of Anadolu Hisarı and stored in its garden during the recent restoration work. Our study shows that despite insufficient recording of findspots and contextual information, scientific examination and analysis of wood remains found in archaeological excavations and historical buildings, identification of their species (Akkemik & Kocabaş, 2013, 2014) and dendrochronological dating (e.g. Pearson et al., 2012; Akkemik et al., 2019, Christopoulou et al., 2021) can provide valuable information about material preferences, wood technologies and processing techniques of the time period in which they were in use (Akkemik, 2015).

Figure 6. The outermost (youngest) ring and bark of an oak from Zonguldak region, northern Türkiye. None of the rings shows sapwood features. In ANH4, we observed this feature. Arrow indicates the outermost ring, which have only earlywood part. Total 11 rings may be seen in the photo. "Tree ring" shows whole ring, red column indicates the latewood part of the tree ring, and blue column indicates the earlywood part. / *Türkiye›nin kuzeyinde bulunan Zonguldak çevresindeki meşe ağacının en dıştaki (en genç) halkası ve kabuğu. Halkaların hiçbiri diri odun özelliği göstermemektedir. ANH4'te bu özellik gözlemlenmiştir. Ok, yalnızca ilkbahar odunu kısmına sahip olan en dıştaki halkayı göstermektedir. Fotoğrafta toplam 11 adet yıllık halka görülmektedir. "Yıllık halka" ağaç halkasının tamamını, dikey kırmızı çizgi ağaç halkasının yaz odunu kısmını, dikey mavi çizgi ise ilkbahar odunu kısmını göstermektedir.*



It is necessary to identify and record the architectural context and findspot of wood materials in monuments of architecture to reveal whether they belong to the original construction period or have undergone any restoration during their lifespans. The dating results we have achieved by this study suggest that all the analyzed oak timbers belong to the original construction period of Anadolu Hisarı and the parts of the walls where these timbers were originally used have not undergone any restoration until recently.

Acknowledgments

We would like to thank Yeşim Kalkan Güngör (Architect) and Istanbul Metropolitan Municipality Cultural Heritage Department for their support in providing the materials. Part of this study was founded by the National Science Center, Poland, project nr 2016/22/A/HS3/00285.

REFERENCE

Akkemik, Ü. (2004). *Dendrochronology,* İlkeleri-Biyolojik-*Temelleri-Yöntemleri-Uygulama-Alanları,* İstanbul Üniversitesi Yayınları No: 4484/479.

Akkemik, Ü., & Güzel, S. (2004). Kastamonu civarındaki bazı ahşap yapıların dendrokronolojik yöntemlerle tarihlendirilmesi. *Anadolu* Üniversitesi *Bilim ve Teknoloji Dergisi, 5*(1), 65–71.

Akkemik, Ü., & Kocabaş, U. (2013). Woods of the old galleys of Yenikapı, Istanbul. *Mediterranean Archaeology & Archaeometry, 13*(2), 31–41.

Akkemik, Ü., & Kocabaş, U. (2014). Woods of Byzantine trade ships of Yenikapı (Istanbul) and changes in wood use from 6th to 11th century. *Mediterranean Archaeology & Archaeometry, 14*(2), 301–311.

Akkemik, Ü., Köse, N., Ważny, T., Kızıltan, Z., & Öncü, Ö.E. (2019). Dating and dendroprovenancing of the timbers used in Yenikapı historical jetty (İstanbul, Türkiye). *Dendrochronologia* 57, 125628.

Akkemik, Ü., & Dağdeviren, N. (2004). Using Dendrochronological Methods to Date the Wooden Materials Used in Balkapanı Han. İ*stanbul* Üniversitesi *Orman Fakültesi Dergisi, 54*(1), s. 45-53.

Anonymous (1991). İslam Ansiklopedisi. Volume 3: 147-149.

Baillie, M. G. L., & Pilcher, J. R. (1973). A simple cross-dating program for tree-ring research. *Tree-Ring Bulletin,* 33, 7–14.

Christopoulou, A., Ważny, T., Moody, J., Tzigounaki, A., Giapitsoglou, K., Fraidhaki, A., & Fiolitaki, A. (2021). Dendrochronology of a scrapheap, or how the history of preveli monastery was reconstructed. *International Journal of Architectural Heritage*, 15 (10), 1424–1438. https://doi.org/10.1080/15583058.2019.1685023.

Fritts, H.C. (1976). *Tree rings and Climate.* Academic Press, New York, San Francisco

Hollstein, E. (1980). *Mitteleuropäische Eichenchronologie: Trierer dendrochronologis-che Forschungen zur Archäologie und Kunstgeschichte*. P. von Zabern, Mainz.

Kızıltan, Z. (2010). Excavations at Yenikapı, Sirkeci and Üsküdar within Marmaray and Metro project. In U. Kocabaş (Ed.), *Proceedings of the 1st Symposium on Marmaray-Metro Salvage Excavations*, 5th– 6th May 2008 (pp. 1–17). İstanbul: Directorate of Istanbul Archaeological Museums.

Kuban, D. (2007). *Osmanlı Mimarisi*. YEM Yayınları, No:134, İstanbul.

Kunihom, P.I. (2000). Dendrochronological1y dated ottoman monuments, A Historical Archaeology of the Ottoman Empire: Breaking New Ground. In U. Baram, & L. Carrol (Eds). Kluwer Academic Plenum Publishers.

Kuniholm, P. I., Pearson, C. L., & Ważny, T. J. (2014). Yenikapı ve diğer Marmaray proje alanlarında dendrokronoloji araştırmaları. In Ş. Balta, & Ş. Altun (Eds.), *Hayalden Gerçeğe Bir İstanbul* Öyküsü-*Marmaray* (pp.154–159). Gama Holding.

Kuniholm, P. I., Pearson, C. L., Ważny, T.J., & Griggs, C. B. (2015). Of harbors and trees: The Marmaray contribution to a 2367-year Oak-Tree-Ring Chronology from 97 Sites for the Aegean, East Mediterranean, and Black Seas. In P. Magdalino, & N. Ergin (Eds.), *Istanbul and Water* (47, pp. 47–90). Peeters Press.

Ljungqvist, F.C., Seim, A., Tegel, W., Krusic, P.J., Baittinger, C., Belingard, C., Bernabei, M., Bonde, N., Borghaerts, P., Couturier, Y., Crone, A., van Daalen, S., Daly, A., Doeve, P., Domínguez-Delmas, M., Edouard, J.-L., Frank, T., Ginzler, C., Grabner, M., …Büntgen, U. (2022). Regional patterns of late medieval and early Modern European building activity revealed by felling dates. *Frontier in Ecology and Evolution*, 9. https://doi.org/10.3389/fevo.2021.825751.

Savvides, A.G.C. (1997). Constantinople in a vice: Some notes on Anadolu Hisar (1395/1396) and Rumeli Hisar (1452). *Acta Patristica et Byzantina*, 8, 144-149.

Schweingruber, F.H. (1988). *Tree Rings, Basics and Applications of Dendrochronology.* Kluwer Academic Publishers, Dordrecht/ Boston/ London.

Pearson, C. L., Griggs, C. B., Kuniholm, P. I., Brewer, P. W., Ważny, T., & Canady, L. (2012). Dendroarchaeology of the Mid-First Millennium AD in Constantinople. *Journal of Archaeological Science*, 39, 3402–3414.

Rybníček, M., Vavrčík, H., & Hubený R. (2006). Determination of the number of sapwood annual rings in oak in the region of southern Moravia. *Journal of Forest Science*, 52, 2006 (3), 141–146.

Yalçın, N.M., Sezerer-Bulut, M., Pearson, C., Kuniholm, P.I., Algan, O., & Ważny, T. (2019). Establishing a high-resolution stratigraphy in the Holocene marine sequence of the ancient Theodosian harbor of Istanbul with the help of dendrochronology. *Geoarchaeology*, 34:360–374. https://doi.org/10.1002/gea.21729