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# An Anatomic Study of Wood Charcoal Discovered from the Archaeological Site of Kelar, Kelardasht in North of Iran

Mahmood Heydarian<sup>1</sup> , Seyed Mehdi Mousavi Kouhpar<sup>2</sup> 

## Abstract

This study aims to present qualitative and quantitative explanations of eight kinds of charcoal discovered from an archeological site at Tepe Kelar in northern Iran. The excavations were carried out in 2006 and 2008. In addition to cultural remains, different kinds of charcoals were discovered hence, their descriptive analysis provided valuable information about culture and ecology of the region during the prehistoric period. To analyze the samples, thin transverses and their radial sections were prepared and analyzed using Electron Microscope, and specifications of the vessels, tissue, wood rays, and other elements of them were measured and recorded. The identification of the woods was initially conducted through the microscopic properties of hardwood and the findings were then compared with the Atlas of woods in North of Iran. The taxonomic identification using the wood anatomy showed that four samples belong to the genus *Fagus Orientalis* Lipsky 1898, one of which belongs to genus *Corylus Avellana* 1753 and the remaining three samples were not recognizable due to their small size. In the third trench, ruins of a metal melting kiln were discovered together with large pieces of charcoals. It is likely that wood species identified in this study were used to melt metals in the Bronze and Iron Ages.

**Keywords:** Anatomy; Tepe Kelar; *Corylus Avellana* 1753; *Fagus Orientalis* Lipsky 1898; Charcoal.

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## Introduction

Years ago biological researchers conducted descriptive and anatomic analyses of different kinds of woods in order to get information regarding the phylogenetic evolution and classification of plants. Paleologists and archeologists went even beyond this limit and studied fossils of plants and woods and charcoals were discovered at archeological sites. "Compared with other parts of the plants, wood fossils have the privilege to keep a longer record of their habitat and keep the historical records like a book" (Toghraei *et al.* 2011). The burned and unburned remains of plants providing other data on an archeological site can show economic aspect and lifestyle of human society in different eras. This data shows that plants have had played

important roles in the life of people not only as food, but also as fuel for household, roof and maybe as the industrial fuel. Descriptive identification of archeological woods among plant fossils provides information on plants, agriculture, weather, environment, timber trade, deforestation in history and prehistory (e.g. Willcox, 1974; Kuniholm, 1997; Newton and Kuniholm, 2001; Asouti and Hather, 2001; Fairbairn *et al.*, 2002; Asouti, 2003a; Riehl and Marinova, 2008).

Charcoal, which is the result of slow decomposition of wood, experiences some physical and chemical changes due to lack of oxygen (Asouti 2006), but it keeps some of its anatomic characteristics over time so that it could potentially be used to identify its family root in ancient time (Prior, 1993). Due to morpho-



Fig. 1. The Location of Tape Kelar and Mazandaran Province in North of Iran

Table 1. The Result of Radiocarbon Test\* from I and II Trenches in Tepe Kelar, Mazandaran, Iran

Row	Lab Number	Trench No	Depth (Cm)	Kind	Results(BP)	Calibrated Date with 95% Probability (BC)
1	OxA-18245	I	4/87	charcoal	30 ± 3662	cal BC 1952
2	OxA -18240	I	5/49	charcoal	30 ± 3785	cal BC 2299
3	OxA -18241	I	6/23	charcoal	30 ± 4169	cal BC 2661
4	OxA -18256	I	6/57	charcoal	32 ± 4116	cal BC 2577
5	OxA -18210	I	8/21	bone	33 ± 4865	cal BC 3632
6	OxA -18211	I	8/21	bone	32 ± 4864	cal BC 3632
7	OxA -18213	I	8/21	bone	33 ± 4872	cal BC 3633
8	OxA -18242	I	8/60	charcoal	31 ± 4956	cal BC 3657
9	OxA -22884	I	9/15	charcoal	29 ± 4931	cal BC 3652
10	OxA -22887	I	9/30	charcoal	28 ± 4959	cal BC 3660
11	OxA -23065	I	9/50	bone	31 ± 5043	cal BC 3766

\*These samples are tested in Research Laboratory for Archaeology and the History of Art, Oxford University, UK. The dates are uncalibrated in radiocarbon years BP (Before Present-AD 1950) using the half-life of 5568 years. Isotopic fractionation has been corrected using the measured  $^{13}\text{C}$  values quoted (to  $\pm 0.3$  per mil relative to VPDB).

logical similarity of wood cells in a group, it is impossible to distinguish some of the samples belonging to the one group (Tennessen *et al.*, 2002). This study aims to analyze eight kinds of charcoals found at the Kelar archeological site in order to find out the kind of wood used by prehistoric residents of the Kelardash region.

### Materials and Method

The materials used in this study were charcoals discovered during the Tepe Kelar excavation (Fig. 1). Tepe Kelar is a prehistoric site located at Kelardasht, a city in the north of Iran (Mousavi Kouhpar 2007, 2008). The site was excavated for stratigraphy in two seasons in 2006 and 2008, during which three trenches (i.e. I and II 2x5 meters and III 10x10 meters) were excavated. The area holds traces of life during the Chalcolithic period until the late Islamic period. The site was formatted in 3766 $\pm$ 30 BC (Chalcolithic period). After this layer, there are layers dated back to the Late Bronze Age 2880 $\pm$ 30

until 2830 $\pm$ 32. The layers related to the Middle Bronze Age were from 2299 $\pm$ 30. Although the results related to the Iron Age were not ready yet, the results would currently be considered as an important advance in archeological studies in the west of Mazandaran province and the north of Iran (Mousavi Kouhpar *et al.*, 2007). The radiocarbon dating was used for age determination of the layers and the results are presented in Table 1.

It should be noted that "the macroscopic structure<sup>1</sup> of the woods is identifiable by naked eye or with a x10 magnifier" (Parsa Pajouh and Schweingruber, 1988). However, the identification of some woods is only possible by testing their thin sections using x40 or x50 microscope (Parsa Pajouh and Schweingruber, 1988; Lashkarbolouki *et al.*, 2009; Ramazani *et al.*, 2013). Microscopic specifications of a tree trunk in transverse<sup>2</sup>,

<sup>1</sup>That is the study of wood according to its appearance or using a magnifier not stronger than x10.

<sup>2</sup> *Transverse Surface* in fact shows the transverse section of wood. This is available in different mag-

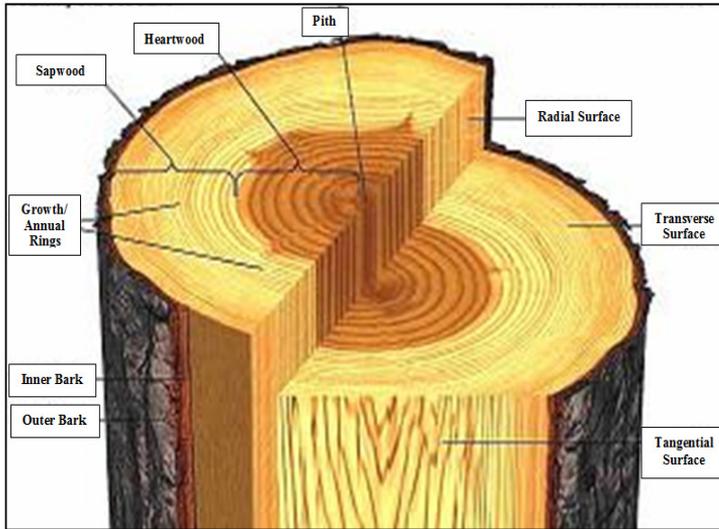


Fig. 2. The Anatomy of a Tree Trunk (Parsa Pajouh and Schweingruber, 1988)

radial<sup>1</sup> and tangential<sup>2</sup> sections are illustrated in Fig. 2. The eight samples of the woods and their charcoals found in the study site were tested in the laboratory of CCHS.<sup>3</sup> The transverse and radial sections

nification and plays an important role in the study of growth ring, spring and summer wood percentage, transformation of spring wood to summer wood, diameter of vessel, presence or lack of axis parenchyma, arrangement of wood elements, the number of wood ray, and so on (Toghraei *et al.*, 2011).

<sup>1</sup> *Radial surface* is a section parallel to wood layers and in the trunks with normal growth usually passes through the pith. This section is important in showing wood ray, pores and vessel opening (Toghraei *et al.*, 2011).

<sup>2</sup> *Tangential surface* is a section parallel to the tree bark and close to the bark. The section is actually attached to it and as we go towards the pit little by little, we get close to the radial section. This section is very important in studying wood ray. Wood rays are rows of cells right angled to the tissue and from the pith, they are spreadable to the bark in a radial direction. In this section, with x40 and x100 magnification the height and the number of wood ray can be studied (Toghraei *et al.*, 2011).

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of the burned woods were exposed to the reflection of a light from an Electron Microscope Scanning with magnification of x40, x100, and x160. Specifications related to the vessels, tissue, wood rays, and other elements were then measured and pictured. The samples were described using microscopic specifications list used for hardwoods (Parsa Pajouh and Schweingruber, 1988; IAWA, 1989). Hardwoods are trees that only have leaves during specific season or seasons and like other plants sprouting leaf during the spring. They keep their leaves until the autumn and then lose them, and during the winter they are completely leafless. This is because they are called summerwoods. These trees have wide leaves and usually stronger and smaller tissue and woods, such as Sycamore, Beech, and Alder.

The timber of hardwoods or summerwoods is generally hard with special density and their tissues have pores, and when cut from the length, open holes can be seen on their surface. The anatomic specifications of the tested charcoals are presented in Table 2.

Table 2. Descriptive Specification of Charcoals Discovered in the Tape Kelar Excavation

Row	Excavator and Lab Number	Descriptive Specification
1	1-4021-413-I-28-8-08	<i>Fagus Orientalis Lipsky</i>
2	4-4067-425-I-3-9-08	<i>Fagus Orientalis Lipsky</i>
3	9-2408-241-II-3-8-08	<i>Corylus Avellana</i>
4	13-1389-147-I-20-8-08	not recognizable due to the small size
5	14-1401-147-I-21-8-08	not recognizable due to the small size
6	15-1406-147-I-21-8-08	not recognizable due to the small size
7	16-3054-311-III-22-8-08	<i>Fagus Orientalis Lipsky</i>
8	18-3022-311-III-26-8-08	<i>Fagus Orientalis Lipsky</i>

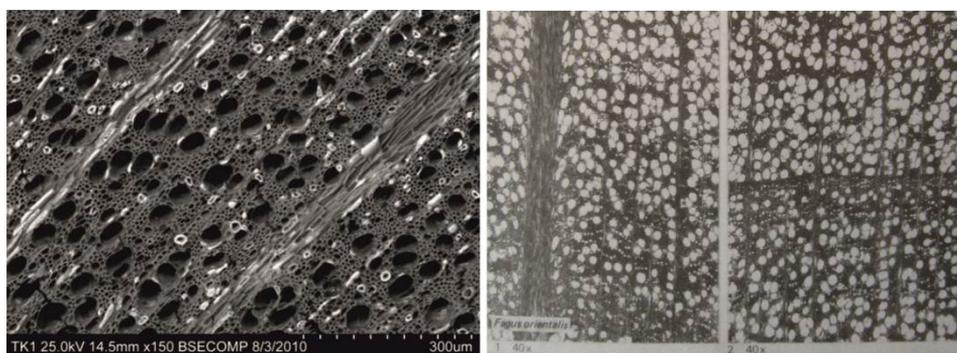


Fig. 3. Details of Transverse Section of *Fagus Orientalis Lipsky* 1898 (right) (Parsa Pajouh and Schweingruber, 1988), The Same Details in Sample I 1-41-4021-413 at Tepe Kelar (left).

## Results and Discussion

Upon the completion of the microscopic test<sup>1</sup> on charcoals of the selected woods, the results were compared with the Atlas of wood representing the north of Iran (Parsa Pajouh and Schweingruber, 1988). Five out of the eight selected woods were identified but the remaining three wood samples could not be identified due to their small size. The results showed that four samples of charcoals found at the Kelar archeological site are from *Fagus Orientalis Lipsky* 1898 and one is from *Corylus Avellana* 1753. With regard to the *Fagus Orientalis Lipsky* 1898 samples their transverse sections (Fig. 3) indicate that their wood is smooth, the

vessels are scattered with false inside wood that sometimes show a half pore and often is called the red heart of *Fagus Orientalis Lipsky* 1898. Vessel holes are single or attached to two by two or four. The wood ray is smooth and their width is different; they might be very wide or very thin; approximately six of them are visible in each millimeter. The fiber tissue is numerous and compressed, the boundaries of annual ring are clear due to the presence of more compressed fibers and seem curved when exposed to a very wide wood ray. The tissues are scattered, bead-like and attached to each other. Their radial section (Fig. 4) shows a single or multiple wood ray cells. Their height is varied from a few cells with four millimeters; they also have thick rim. Their radial section shows vessels with

<sup>1</sup> Thin sections of wood are prepared so that permanent or temporary light would pass and be analyzed by microscope.

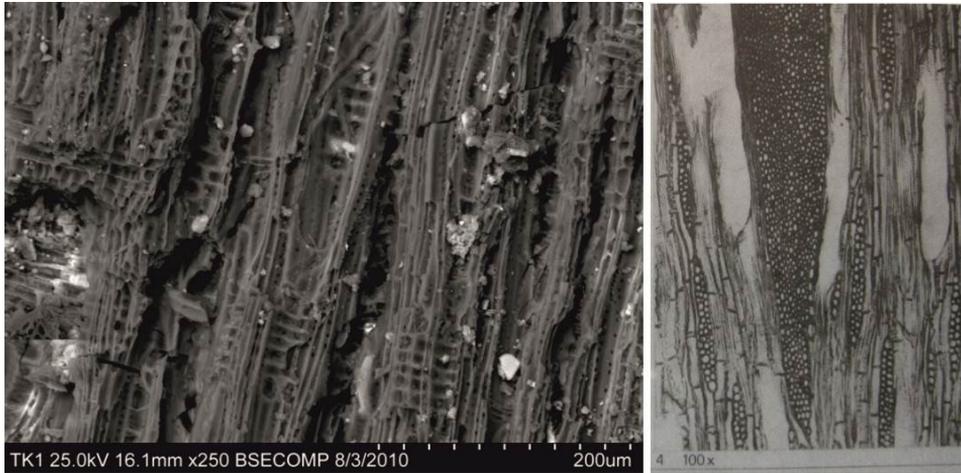


Fig. 4. Details of Radial Section (Pieces of Ladder Like Ppening) of *Fagus Orientalis* Lipsky 1898 (right) (Parsa Pajouh and Schweingruber, 1988), The Same Details in Sample I 1-41-4021-413 at Tepe Kelar (left)

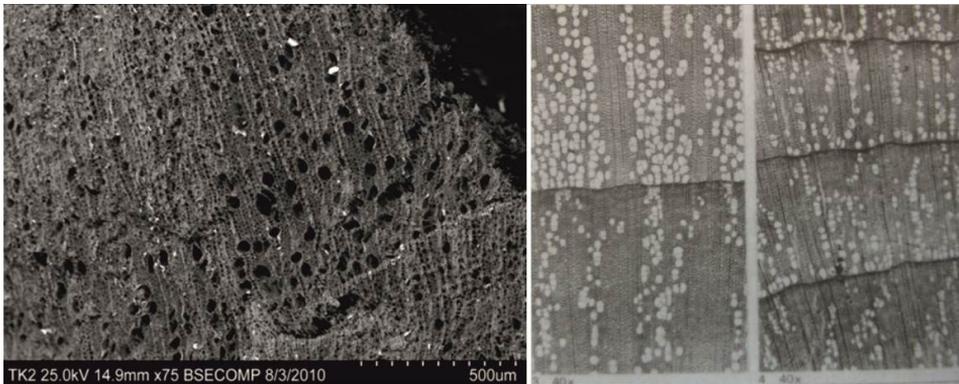


Fig. 5. Details of Transverse Section of *Corylus Avellana* (right) (Parsa Pajouh and Schweingruber, 1988), the Same Details in Samples II 9-2408-241 at Tepe Kelar (left)

single or ladder-like opening and sometimes window-like. The pores between vessels have halo with slit like openings and sometimes seen ladder-like. The openings between ray and vessels are simple but large. The wood ray is smooth and rarely heterogeneous with a row of cubic cells on the side. Its fiber tissue is made of libriform fiber and tracheid fiber is rarely seen there. Its tissue cells are short with tiny pores.

The *Corylus Avellana* sample has the following descriptive speculations. Its transverse section (Fig. 5) shows that the wood is smooth and the vessels are

scattered without inside wood. The vessel openings are small and spring woods are attached so that half of the opening is seen and arranged in the radial direction. The wood ray is very weak but numerous (about 15 to 20 in each millimeter). *Corylus Avellana* has false wood ray. The Parenchyma are scattered in the width of annual ring. The boundary of annual ring is usually clear and often wave-like, so that this state would show when exposed to wood ray. Its radial section (Fig. 6) shows a single and rarely two or three-celled wood rays which are located in a false wood ray. The cells of wood



Fig. 6. Details of Radial Section (Open Ladder) of *Corylus Avellana* (right) (Parsa Pajouh and Schweingruber, 1988), The Same Details in Sample II 9-2408-241 at Tepe Kelar (left)

ray have an oval section and are directed toward the ray axis. The vessels are thin and long and the walls have holes. Its wall is thin and usually ornamented with thin threads. The openings between vessels are big rayed and numerous. The wood ray is unsmooth and numerous cubic cells are seen there and a row of rectangular cell is placed upward on the side. Its fiber tissue consists of libriform fiber with a little tracheid fiber and only a few Parenchyma cells are visible.

### Conclusion

Upon the completion of the microscopic test<sup>1</sup> on the charcoals of the selected woods from Tepe Kelar, five out of eight selected woods could be identified. Four of the selected woods showed a high degree of similarity with *Fagus Orientalis Lipsky 1898* species (Parsa Pajouh and Schweingruber, 1988; Pour Babaei *et al.*, 2006) and one with *Corylus Avellanas 1753* pieces. Due to a limited excavation undertaken in this archeological site, having more samples was not possible and the findings of the research could not be further extended. This is particularly the case on the economic-nutritional im-

portance of these trees.. Since *Fagus Orientalis Lipsky* is known to have many rural usage such as making door, window, pillar, bench, cradle, row, and sandals (Sabeti, 2003), it would be highly likely that this wood had an important role in the life of people at the time; an enough justification why they were found in this site along with other products related to daily human activity. The inhabitants of the region during the 4<sup>th</sup>, 3<sup>rd</sup> and 2<sup>nd</sup> century BC would probably use these woods as fuel and construction material. Due to the kiln discovered in the mass of charcoal found there during the third excavation it would be highly likely that the people would use this wood for melting metals. Yet, in these periods, branches, bamboos and clay would have been used for covering roofs in this region. Since there is still no evidence or trace of wood on the stone bases and pillars found in the excavation, it is difficult to suggest that these people would use wooden materials in the construction of houses. However, strong evidence exists to suggest that the woods, which are studied in this study, would be used only as fuel for household and industry.

According to the tests undertaken on the charcoals and results obtained, this research study can be considered

<sup>1</sup> Thin sections of wood are prepared so that permanent or temporary light would pass and be analyzed by microscope.

as the first milestone for further excavations on the site. In a wider context, the collection of more samples of charcoal and other plant fossils in an extended geographical area in the North of Iran and their comparison with the present day samples may lead to a better understanding of the evolution of forests and habitats. The results of the current study indicates the high quantity use of the *Fagus Orientalis Lipsky* charcoal compared with other woods at that time, and this implies that our first ancestors in this region were aware of the quality of *Fagus*

*Orientalis Lipsky* and that is why they used it excessively. Upon the acceptance of excessive use of this species at the time, it could be concluded that the process of deforestation of *Fagus Orientalis Lipsky* is not restricted to the present time and it would have been a common and continual process in the past, too. Despite using the species as a potential fuel source and other rural usages at that time but it seems that the low number of population in the past did not lead to the disappearance of the woods.

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