Chapter 14
Charcoal Remains from Azokh 1 Cave: Preliminary Results

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Abstract We present here the results of the charcoal analyses from Unit II and Unit Vu from Azokh 1 Cave. The results from the anthracological study show a variable record with up to nine taxa, including variability within the identified genera or types. The most abundant taxon is *Prunus,* which represents 80% of the record in Unit II. The charcoal record from Azokh 1 shows a record including *Prunus*, *Acer*, Maloideae and *Quercus* sp. and other trees and shrubs. The taxa recorded were probably abundant in the landscape near the cave reflecting mild and humid environmental conditions. The charcoal is probably the remains of firewood used during the human occupations.

Резюме В данной статье представлены результаты анализа образцов древесного угля из седиментных подразделений *II* и *IV* пещеры *Азох 1*. Использованная методология основана на изучении фрагментов угля с целью генерации данных о формировании растительности в прошлом и ее эволюции во времени. Более того, с помощью данного анализа была получена информация о поведении человека, относящаяся к использованию им лесных ресурсов. Данное исследование основано на анализе 907 фрагментов древесного угля, которые были найдены в результате визуального сбора и влажного просеивания. До проведения идентификации образцы были вручную измельчены для отделения трех анатомических сегментов, которые позволяют описать клеточную структуру дерева. Классификация образцов древесного угля из подразделения *II* выявила разнообразный спектр видов, включающий *Prunus* (слива), *Acer* (клен), *Quercus* sp. *deciduous* (лиственный дуб), Maloideae (яблоня), *Lonicera* (жимолость), *Paliurus/Ziziphus* (терн Христа/ююба), *Celtis/Zelkova* (каркас/зелькова), *Euonymus* (бересклет) и *Ulmaceae* (семейство вязов). Наиболее обильно представлен таксон *Prunus*, который составляет 80% всех находок. *Quercus* sp. *deciduous*, *Acer* и *Maloideae* встречаются с частотой 2–4%, остальные таксоны имеют частоту менее 1%. Подразделение IV содержало меньшее количество остатков древесного угля и включало представителей трех таксонов: *Prunus, Maloideae* и *Quercus* sp. *deciduous*.

Перечень находок древесного угля из Азохской пещеры указывает на специфическое формирование растительного мира с превалированием *Prunus, Acer, Maloideae* и *Quercus* sp. *Deciduous* среди деревьев и кустарников. В ландшафте окрестностей пещеры в изобилии встречались различные таксоны, отражая тем самым особый тип формирования флоры, характеризующийся последовательностью, которая привела к появлению лиственного дубового леса. Этот растительный ландшафт свидетельствует о наличии мягких и влажных условий среды. Использование древесины в качестве топлива указывает на четко выраженную тенденцию в применении наиболее распространенных видов, при котором предпочтение отдано древесине сливовых деревьев.

Keywords Pleistocene • Southern Caucasus • Vegetation • Firewood • *Prunus*

Introduction

Anthracology is an archaeobotanical discipline based on the taxonomic identification of charcoal remains from archeological or natural deposits (see Vernet 1992; Thiébault 2002; Fiorentino and Magri 2008; Damblon and Court-Picon 2008; Badal et al. 2011). The aim of this discipline is the recog-

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nition of past vegetation and its evolution through time, and it includes the study of firewood uses in relation to human behavior. Archeological charcoal from Paleolithic sites is often produced through the use of wood as fuel in domestic hearths; and therefore their anthropic origin has to be considered when interpreting the results. The presence of charcoal from firewood is an artifact conditioned by human choices and can be interpreted as such (Hastorf and Popper 1988; Théry-Parisot 2001; Asouti and Austin 2005; Allué and García-Antón 2006; Théry-Parisot et al. 2009). In addition, the value of charcoal analysis has been shown as a tool for paleoecological reconstruction (Western 1971; Vernet 1973, 1997; Figueiral and Mosbrugger 2000; Willis and Van Andel 2004; Théry-Parisot et al. 2010). This interpretation is based on the ecological characterization of the species and their dependence on ranges of climatic conditions, and it takes into account their diachronic evolution and cultural bias. Both aspects of the discipline depend on a fine and accurate sampling method, and both are being considered in this study.

The Caucasus has an important role in human evolution and dispersal due to its geographic position. Furthermore, concerning past vegetation, it is a key area for the understanding of change through time. Charcoal studies from the Caucasus are little known and the development of new studies concerning archaeobotany is now providing data on different topics concerning environmental change, firewood exploitation, and plant uses. Current and earlier studies in the area are based on pollen and plant macro-remains (seeds, charcoal, leaves) from different periods including the Pleistocene and Holocene archeological and natural deposits (Tumajanov 1971; Lisitsina and Prischepenko 1977; Zelikson and Gubonina 1985; Klopotovskaja von et al. 1989; Shatilova 1990 in Golovanova and Doronichev 2003; Djafarov 1999; Gabunia et al. 2000; Lioubine 2002; Gabrielian and Gasparyan 2003; Allué 2004; Connor et al. 2004; Kvavadze and Connor 2005; Hovsepyan and Willcox 2008; Messager et al. 2008; Díez et al. 2009; Joannin et al. 2010; Ollivier et al. 2010; Ghukasyan et al. 2010; Gabrielyan and Kovar-Eder 2011). During the last decades, the development of diverse interdisciplinary projects in the southern Caucasus has enlarged the archeobotanical assemblages, even if Pleistocene data are still very few (Gabrielian and Gasparyan 2003; Joannin et al. 2010; Ollivier et al. 2010; Ghukasyan et al. 2010; Gabrielyan and Kovar-Eder 2011).

The area under study is a mountainous zone bordering the Iranian, Armenian, and Azerbaijan territories (see Fernández-Jalvo et al. 2016). At present due to the vast intensity of human exploitation, forested areas in the southern Caucasus are scarce (Moreno-Sánchez and Sayadyan 2005). In the area near Azokh, landscape is dominated by *Paliurus spina-christi* due mainly to human disturbances related to wood cutting and livestock.

In this chapter, we are presenting the results from the charcoal analyses from Unit II and Unit Vu from Azokh 1 cave in order to provide new data concerning past vegetation and plant resources. Unit II has been dated by ESR from the top 100 to around 200 ka BP at the base and Unit Vu has been dated by ESR around 200 ka BP (see Appendix dating).

Materials and Methods

This study is based on 886 charcoal fragments from Unit II and 21 from Unit Vu that were recovered during the 2005–2009 field seasons, using hand collection and wet sieving. Hand collection is used particularly for Paleolithic deposits, in which the excavation technique permits the view of the charcoal fragments *in situ* (Allué 2006). For this purpose, each piece of charcoal of about 4–5 mm is extracted, wrapped in aluminum foil, and labeled. This kind of sampling should be accompanied by screening the sediment, and this was the procedure followed here.

For charcoal identification, the remains were fragmented by hand in order to obtain the three wood anatomy sections necessary for the description of the cell structure. Charcoal fragments were observed through a metallographic reflected light microscope with dark and light fields, using ×5, ×20, ×50 magnifications (Olympus BX41). The identification is supported with a reference collection and various wood anatomy atlases (Fahn et al. 1986; Schweingruber 1990; Benkova and Schweingruber 2004; Insidewood 2004; Schweingruber and Landolt 2005) and a charcoal reference collection made from the area.

The identification rank used in charcoal analyses is family, genus, type, and occasionally the species. Charcoal analysis does not always permit a species-level identification due to factors such as small size of the charcoal fragment, the cell structure modifications produced by combustion or postdepositional processes, low anatomical variability among species, or the absence within the fragment of all the characteristics which define a species.

Quantification of charcoal assemblages is usually based on numbers of fragments or the presence/absence of the different taxa. Furthermore, depending on the number of fragments a statistical approach can be made. Usually, a minimum number of fragments is necessary, and data sets of between 250 and 500 fragments per unit are required to obtain the total record (Chabal et al. 1999). However, the variability of a charcoal assemblage depends on firewood management, type and duration of occupations, type of plant formation exploited, sampling, type of structures, etc.

Results

The charcoal record from Unit II shows a wide diversity of taxa (Table 14.1) with *Prunus* (plums), *Acer* (maple), *Quercus* sp. deciduous (deciduous oaks), Maloideae (pomes), *Lonicera* (honeysuckle), *Paliurus/Ziziphus* (Christ's thorn/jujube), *Celtis/Zelkova (Hackberry/Zelkova)*, *Euonymus* (spindle), and Ulmaceae (elm family). The most abundant taxon is *Prunus* which represents 80% of the record. *Quercus* sp. deciduous, *Acer,* and Maloideae show values between 2 and 4% and the rest of the taxa represent less than 1%. Unit Vu has yielded fewer charcoal remains with just three taxa: *Prunus*, Maloideae, and deciduous *Quercus* sp.

Some of the charcoal types include more than one species due to their similar wood anatomy. The genera *Ziziphus* and *Paliurus* share similar wood anatomy characters and they cannot be differentiated (Schweingruber 1990). *Ziziphus* and *Paliurus* grow at present in the area; nevertheless, *Paliurus* has a wider distribution (Grabrielian and Fragmar-Sapir 2008). *Celtis* and *Zelkova* show some singular characteristics that have not been clearly observable in the fragments from Azokh (Fig. 14.1a, b). According to Schweingruber and Landolt (2005), a difference can be noticed on the basis of the presence of crystals in rays in *Celtis* and their absence in *Zelkova*, but we have not been able to see this character in the charcoal fragments from Azokh. The Maloideae subfamily includes several genera such as *Crataegus*, *Sorbus*, *Malus*, *Cydonia*, etc., that share similar wood anatomy. A slight variability can be identified through the presence or absence of helical thickenings, which has been identified in several fragments; this indicates that in fossil record at Azokh there is more than one species of Maloideae present (Fig. 14.1c, d).

Table 14.1 Results from the anthracological analysis from Units II and Unit Vu from Azokh 1 cave

Taxa	II		V-upper
	Num. frags.	%	Num. frags.
Acer	34	3.84	
Carpinus	1	0.11	
Celtis/Zelkova	4	0.45	
Euonymus	2	0.23	
Lonicera	9	1.02	
Maloideae	23	2.60	3
Prunus	709	80.02	15
Quercus sp. decidous	28	3.16	2
Quercus/Castanea	2	0.23	
Paliurus/Ziziphus	3	0.34	
Ulmaceae	4	0.45	
cf. *Acer*	3	0.34	
cf. Maloideae	1	0.11	
cf. *Prunus*	13	1.47	
cf. *Quercus*			1
cf. Ulmaceae	1	0.11	
Undetermined angiosperm	48	5.42	
Undetermined	1	0.11	
Total number of fragments	886		21

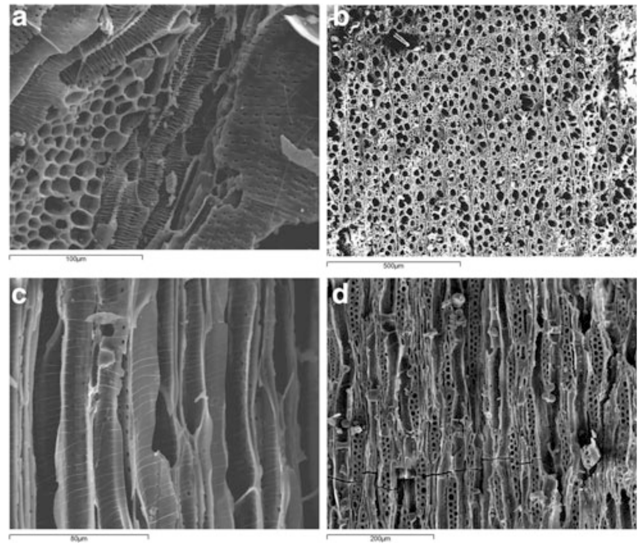

Fig. 14.1 SEM images from Azokh 1 Unit II charcoal fragments. **a** Transversal section of *Celtis/Zelkova* showing heterogeneous and sheath cells in rays. **b** Transversal section of Maloideae. **c** Tangential section of Maloideae showing spiral thickenings. **d** Tangential section of Maloideae showing bi-seriated homogeneous rays

For the genera *Prunus*, *Cerasus,* and *Amygdalus* we use *Prunus sensu lato.* The wood anatomy of *Prunus* species is similar among all the species; but some characters are useful to group them into smaller categories. The most useful characters for European woods from the Mediterranean basin are the ones established by Heinz and Barbaza (1998). The authors described three different *Prunus* types on the basis of the number of cells in the rays. *Prunus* type 1 rays have no more than two cells; *Prunus* type 2 has between three and four cells per ray, and the *Prunus* type 3 has more than five cells. Each type would correspond to different groups, for example type 1 to *Prunus avium/padus* (cherry/European bird cherry), type 2 to *Prunus spinosa/mahaleb* (blackthorn/mahaleb cherry), and type 3 to *Prunus spinosa/amygdalus* (blackthorn/almond tree). Ntinou (2002) also uses three groups according to the species growing at present in Greece. Group I includes *P. armeriaca*, *P. dulcis*, *P. persica,* and *P. webbii*. When the rays were seven or eight seriated and have ring-porous wood they were identified as *Prunus* cf. *amygdalus*. Group II with diffuse-porous wood and two to seven cell rays, with an average of five, includes *P. domestica*, *P. padus*, *P. mahaleb*, *P. spinosa,* and *P. cerasifera*. Group III with semi ring-porous wood to diffuse-porous wood and with up to four ray cells includes *P. avium* and *P. cerasus*. According to Ntinou (2002), *amygdalus* is the only *Prunus* species identified using the ring-porous wood character. Records from other sites in the surrounding areas of Turkey and Armenia often include *amygdalus* on the basis of the same character, whereas the rest of the species are grouped in the *Prunus* genus (Asouti 2003; Emery-Barbier and Thiébault 2005; Hovsepyan and Willcox 2008).

In the Azokh charcoal assemblage, we have grouped the samples according to the characters of Heinz and Barbaza (1998) based on the number of cells in the rays and the presence of ring-porous wood. In Unit II, we have been able to distinguish three different types of *Prunus* according to the former description (Table 14.2, Fig. 14.2). Most of the fragments belong to groups 2 and 3 showing multiseriate rays with more than three series and a semi ring-porous wood. Fragments from type 1 with two seriate rays are less significant, and ring-porous wood has been identified in a few fragments. Therefore, we can conclude that there were several species from this genus preserved in Azokh 1.

Table 14.2 Classification of *Prunus* fragments according to the number of cells in rays and ring porosity

Anatomy character	Types	Num.	%
Number of cells in rays	*Prunus* type 1	87	12.3
	Prunus type 2	197	27.8
	Prunus type 3	214	30.2
	Nonclassified *Prunus*	211	29.8
Ring porosity	Ring-porous *Prunus*	29	
	Ring to semi-ring porous *Prunus*	13	

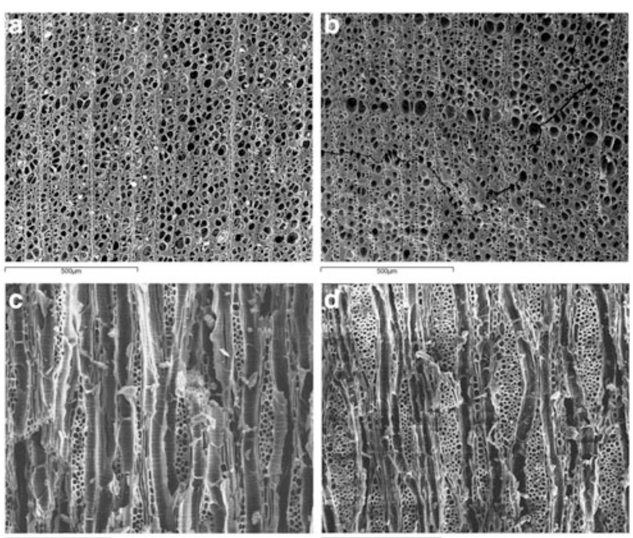

Fig. 14.2 SEM images from Azokh 1 Unit II of *Prunus* charcoal. **a** Transverse section of *Prunus* showing diffuse porosity. **b** Transverse section of *Prunus* showing slightly larger pores in early wood. **c** Tangential section of *Prunus* showing bi to tri-seriated rays. **d** Tangential section of *Prunus* showing multi-seriated rays

Discussion: Vegetal Landscapes and Firewood Uses

Charcoal analysis allows us to describe the vegetation from the local area and the firewood used in the past. For these purposes, we need to take into account the formation process of the assemblage so as to understand the origin of the charcoal assemblage. In relation to this, we are considering various aspects to understand if the charcoal remains are natural or anthropic. First, the location of these remains in the inner part of the cave, far from the entrance, indicates that they could not be naturally deposited. The size of the charcoal fragments is too large for them to have been dispersed from their original hearths suspended in the air. Secondly, the presence of charcoal is continuous in the archeological units and associated with other anthropic remains such as lithics and fauna. These materials, although they present evidence of remobilization, are *in situ* as demonstrated by the taphonomic study (see Marin-Monfort et al. 2016). Furthermore, charcoal and some cultural remains show burning marks, which indicate that there were human activities related to fire. Therefore, even though no spatial pattern indicates an anthopic organization, we consider charcoal as part of the human occupation and not the product of natural fires. In this sense, we suggest that the charcoal assemblage from Azokh is the product of the wood used as firewood by hominins.

The charcoal study shows that there was a high diversity of taxa within genera, especially concerning *Prunus*, for which our anatomical observations show that we can identify several different species. The genus *Prunus* includes at present a diversity of species within several subgenera, such as *Amygdalus*, *Cerasus*, *Laurocerasus,* and *Padus* (RBGE 1998). In the Caucasus area today, there are numerous species and subgenera including *Amygdalus fenziliana*, *A. nairica*, *Armeriaca vulgaris*, *Cerasus avium*, *C. incana*, *C. mahaleb*, *Padus racemosa*, *P. cerasifera* (Gabrielian and Fragman-Sapir 2008). At present in the Azokh area, we can find *A. fenzliana* and *P. cerasifera* the latter also growing in the yards of the village houses. In this discussion, we will use *Prunus sensu latu* when describing our results.

Archeological evidence of plum stones are rather scarce from the Epipaleolithic to the Bronze Age, whereas they increased in Roman times, probably suggesting cultivation (Zohary and Hopf 2000; Martinoli and Jacomet 2004).

Cherry stones (*P. spinosa*, *P. avium*) also appear in deposits from the Mesolithic to Neolithic. *Prunus* wood charcoal is more abundant and is present during the Middle to Upper Pleistocene in several European sequences. Its spread in anthracological records from the Mediterranean basin is clearly marked at the Late Glacial (Heinz 1990; Ntinou 2002; Allué et al. 2007), and it is related to pioneering formations that would led to the development of broad-leaved forests. In the eastern Mediterranean area, *Prunus* and *Amygdalus* are present in several Epipaleolithic and Neolithic sites showing a steppe like formation together with *Pistacia* and *Juniperus* (Asouti 2003; Emery-Barbier and Thiébault 2005). At present in the Caucasus, the different *Prunus* species grow in several plant communities. According to Gabrielian and Fragman-Sapir (2008), these species grow in different types of vegetal communities, such as deciduous forests (*Cerasus avium*), open forests (*Amygdalus fenzliana*, *Prunus cerasus*, *Cerasus mahaleb*, *Cerasus incana*), armeno-iranian phrygana (*Amygdalus fenzliana*, *Cerasus incana*), Shibliak (*Amygdalus anirica*, *A. fenzliana*, *Prunus cerasus*, *Cerasus incana*), and therefore their presence in Azokh Cave could be representing one of this communities. Taking into account the rest of the taxa from the assemblage, we would suggest an open forest being the most likely plant community.

In archeological records, charcoal from *Prunus* can be abundant, whereas *Prunus* pollen is mostly absent from palynological records due to the entomophilous character of its pollen. The same occurs for most of the significant taxa in the charcoal record from Unit II, which are generally absent in pollen records (Connor et al. 2004; Van Zeist and Bottema 2009; Joannin et al. 2010). *Prunus*, and Maloideae pollen dispersal is entomophilous and *Acer* has a low pollen production, and therefore they are usually very poorly represented or totally absent in pollen records. Other genera such as *Euonymus* or *Lonicera* are rarely identified from palynological assemblages, but they are present in charcoal record. In contrast, firewood gathering is likely to target the closest environment to the cave, and preference of the wood that is most abundant and available could cause a high significance of those taxa. The absence of these taxa in most of the pollen records might hide some local plants and their characterization.

New data from travertine deposits with leaf imprints from Pleistocene deposits in the Lesser Caucasus have yielded evidence of specific taxa, providing new light on paleoflora (Ollivier et al. 2010). This study shows the presence of a high diversity of taxa including *Prunus*, *Cerasus avium*, from the *Prunus* genus; *Crataegus*, *Malus*, *Pyrus,* and *Sorbus* from the Maloideae group and a high diversity of species from the *Acer* genus (Ollivier et al. 2010). This would confirm the importance and variability of these taxa during the early stages of the Pleistocene, giving more importance to woody plants. However, pollen data from the same sequence suggest the importance of steppe environments and suggesting in turn a cold climate (Joannin et al. 2010).

The charcoal assemblage at Azokh shows a plant record characterized by trees and shrubs growing probably in an open or semi-open environment. The presence of low values of *Quercus* and *Carpinus* and high values of other mesophilous smaller trees could indicate early stages in the spread of a forest. This vegetation type has no equivalent in the area at present, and it indicates broad-leaved forest of secondary or understory trees and shrubs. This plant community could be a pioneer succession, which based on the *Prunus* types would seem to indicate more or less humid environmental conditions. In this sense, we suggest that a climatic model signifying a recovery of the oak forest formation could be valid for Azokh's record. However, the lack of a continuous anthracological sequence does not let us have an overview of its evolution.

The former paleobotanical studies from this site, based on palynology, show the evolution and transformation of vegetal formation from earlier Pleistocene phases. The pollen record (Zelikson and Gubonina 1985; Djafarov 1999) shows different phases; corresponding to the preacheulian and acheulian layers (Zelikson and Gubonina 1985). Unit II postdates these phases and the pollen spectra show layers with an arboreal pollen spectra dominated by taxa such as *Alnus*, *Fraxinus*, *Betula*, *Ostrya*, *Carpinus,* and *Quercus,* which show fluctuations on their values. According to these authors the vegetation corresponds mainly to a forest environment that changed according to variations in humidity and aridity from low mountain forests to high altitude forests or subalpine. Nevertheless, these data should be taken carefully into account and maintained on hold until new data are available (see Scott et al. 2016).

In summary, the charcoal record from Azokh cave shows a plant community with *Prunus*, *Acer*, Maloideae among other trees and shrubs. The different taxa recorded were probably abundant in the landscape close to the cave and characterized by the dominance of plum trees together with other mesophilous taxa that were exploited for firewood. In contrast, palynological sequences from the nearest area show different forest formation dominated mainly by broad-leaved or coniferous trees according to different forest successions or more open a steppe like landscapes (Bennet et al. 1991; Denk et al. 2001; Willis and Van Andel 2004; Roucoux et al. 2008; Djamali et al. 2008; Joannin et al. 2010). These differences are probably due to the different scales in the approach of the different disciplines. In addition, evidence from the vertebrate fauna shows the presence of both broad-leaved forest and steppe environments, but the evidence for the latter is derived from small mammals, amphibians, and reptiles that have been shown to be predator accumulations derived from species of owls that preferentially hunt over open areas (Andrews et al. 2016). Since the hunting ranges of these predators span several kilometers, it has been suggested that the steppe vegetation from which their prey came could have been some distance from the cave, while the large mammals, which indicate woodland vegetation, came from environments closer to the cave. Thus, the importance of using different approaches would provide a wider range of data in order to understand specific aspects on plant formation and plant uses among early populations. With this study, on the basis of charcoal analyses, we have obtained data based on human choices, the local vegetation, woody species, whereas pollen reflects the natural environment, regional vegetation, herbaceous and wood species, and high pollinating species. It is in fact the use of a multidisciplinary approach that will lead us to a larger comprehension of the vegetal cover.

The plant formation described above was, in short, the source for vegetal raw materials gathered by hunter-gatherers, which is characterizing their subsistence strategies. Food, tool manufacturing and firewood were probably the main objectives for wood gathering. However, we consider that these charcoal specimens were the product of combustion activities during occupation of the site; therefore they are basically related to the exploitation of firewood.

Hunter-gatherers based their exploitation for fuel on different facts such as availability and abundance of the wood in the environment, functionality and duration of the occupation, energy expenses, type of firewood (tree, shrubs, branches, trunks), and supply and type of socioeconomic organization (Théry-Parisot 2001; Allué and Garcia-Antón 2006). Despite this range of options, it is usually suggested that random wood gathering was the most common strategy (Shackelton and Prins 1992; Asouti 2003). There is an ecological conditioning which implies the use of the available species, but there is a preference for the closest trees available and those that produce the greatest amount of dead wood. The needs for fuel in short term occupations do not presuppose in any case the cutting of trees but the gathering of dead branches from the trees or from the ground. Furthermore, the strategy for firewood gathering among hunter-gatherers would not suppose intensive exploitation causing damage to a plant formation. The notable difference between *Prunus* (80%) and the rest of the taxa, suggest that there probably was a preference in wood gathering. This could be related first of the abundance in the environment described earlier in this text, and it also corresponds to the collection of the most available wood according to dead wood production.

Conclusions

1. The charcoal record from Azokh cave shows a plant community with *Prunus*, *Acer*, Maloideae among other trees and shrubs.
2. The different taxa recorded were probably abundant in the landscape close to the cave and characterized by the dominance of plum trees (80% of the sample) together with other mesophilous taxa that were exploited for firewood.
3. From the study of charcoal from Unit II and Unit Vu in Azokh 1 cave, we have contributed to the understanding of local vegetal type. The record shows highly variable spectra suggesting an open or semi-open landscape formed mainly by woody trees and shrubs.
4. The vegetal formation, dominated by pioneer species, would develop toward broad-leaved forests.
5. It is also proposed that firewood gathering based on collecting the most abundant and available species from the nearby area contributed to the plant assemblage.
6. The sequences considering earlier periods from the Lower and Middle Pleistocene from the Caucasus are very few and new contributions are essential for the comprehension of past environments and human interactions.

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