ISSN 0031-0301, Paleontological Journal, 2006, Vol. 40, Suppl. 5, pp. S595–S603. © Pleiades Publishing, Inc., 2006.

The Use of Fossilized Honey for Paleoecological Reconstruction: A Palynological Study of Archeological Material from Georgia

E. V. Kvavadze

Institute of Paleobiology, Academy of Sciences of Georgia, ul. Potochnaya-Niagvris 4, Tbilisi 8, Georgia 0108

e-mail: eliso@paleobi.acnet.ge

Received February 7, 2006

Abstract—Palynological analysis of the organic contents of ceramic pots from the Kodiani burial mound, which is dated as 27th–25th centuries B.C., revealed that they contained honey. The samples are extremely rich in excellently preserved pollen grains, including numerous pollen grains of insect-pollinated plants. Such characteristics are typical of palynological assemblages from honey. The palynological assemblages from three pot fragments studied are dominated by pollen grains of Rosaceae; however, they differ from one another in the subdominants. The discovery of several kinds of honey testifies to the presence of well-developed beekeeping in the time of the Early Kurgans. Agriculture, with a significant role of wheat, was also developed in the region of Georgia under study. According to the composition of the palynospectra, the ecological conditions that existed during the epoch studied differ significantly from the present day.

DOI: 10.1134/S0031030106110074

Key words: fossil honey, palynological analysis, the Bronze Age, southern Georgia, paleoecology, and beekeeping.

INTRODUCTION

The application of palynological methods within the framework of archeological studies, in particular, in studies of burial mounds and other types of burials, provides direct and reliable information for the reconstruction of both the customs and the type of economic activity of ancient man, as well as the paleolandscapes where he lived (van Zeist, 1967; Groenman-van Waateringe, 1979; Körber-Grohne 1985; Rösch 1999). In Georgia, such studies are quite innovative (Kvavadze et al., 2004a, 2004b).

In this paper we present palynological data obtained from the study of Kodiani burial mound no. 1, which is dated as 27th–25th centuries B.C. The burial mound was excavated in August 2004 during the construction of the Baku–Tbilisi–Ceihan oil pipeline, at the 193 km point of the Georgian portion of the pipeline. This burial mound is situated in the Borzhomi District southwest of Bakuriani, at the interfluvial ridge of the Trialeti Mountain Range, between the villages of Sakire and Tsikhisdzhvari, near the piedmont foot of Kodiani Mountain (Fig. 1). These mountains are the western margin of the Trialeti Mountain Range, formed by Middle Eocene volcanic rocks with andesitic tuff breccias, tuff-sandstones, and others (Maruashvili, 1971). The altitude of the Kodiani burial mound is 2289 m above sea level.

Nowadays, the locality is covered by subalpine meadows with thickets of Caucasian rhododendron and some elements of subalpine stunted forest in valleys (Fig. 2). The climate is cool. According to the data of the nearest meteorological station in Tskhratskaro, which is situated 2410 m above sea level, the average annual temperature is 0.1°C. The January temperature does not exceed –10.9°C, and the mid-July temperature reaches 9.6°C. The annual range of temperature is 24°C. At of 2200–2410 m, about 1200 mm of annual precipitation is recorded (Lominadze and Chirakadze, 1971). The prevailing winds are westerly and southerly. The number of periods without wind is 914 per year (of 1460 observations, Lominadze and Chirakadze, 1971).

The burial mound under study was discovered during construction work in the southern wall of the passage of the pipeline, where the smooth surface of an ancient meadow, including its humus horizon, and the burial chamber, were exposed. The excavations revealed a small burial (2.5 m long and 2 m wide), which was dug into the smooth top surface of a natural hill. The burial chamber is 2 m high and is covered with a log ceiling. The logs and branches vary in size; some are relatively large, up to 15 cm in diameter. In addition to the log ceiling, a stonework circular embankment 19–20 m in diameter and 0.9–1 m high was found.

Large fragments of two earthenware pots with a black shining surface and one wooden pot were found on the floor of the burial pit, in its central region among fallen logs and branches (Fig. 3). A human skull, fragments of a humerus, and a small tetrahedral bipyramidal bronze arrow-head were also found. All of the items were covered with a well-preserved mat. The bone remains have been identified as having belonged to a woman younger than 50 years old (Kvavadze et al., 2004c).

(a)

(b)

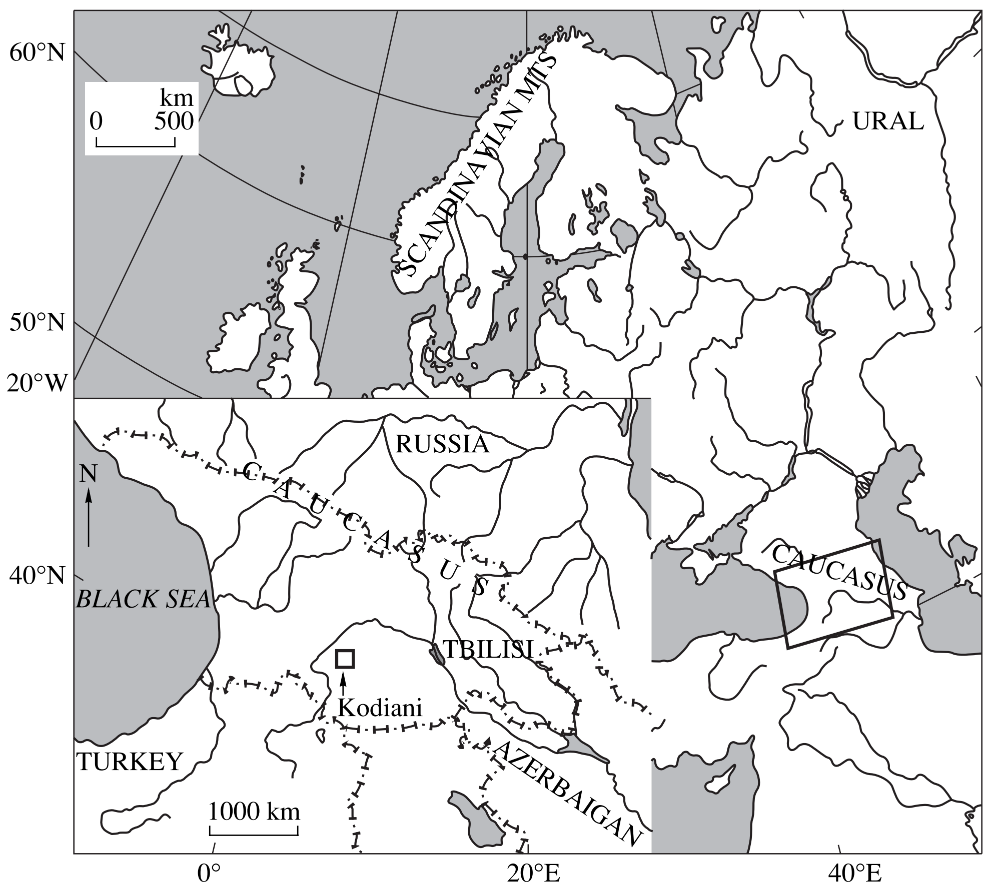

Fig. 1. (a) General appearance of Kodiani Mountain (photograph produced by I.G. Gambashidze); (b) Map of Georgia and the position of the Kodiani burial mound.

Fig. 2. Present-day landscape in the vicinity of the Kodiani burial mound (photograph of I.G. Gambashidze).

The technology and shape of the earthenware pots and arrow-head are identical to artifacts from mounds of the Martkop period (Mindiashvili et al., 2003), and, therefore, the Kodiani burial mound is dated to the time of the Early Kurgans (Fig. 3). Since peglike tools have been found that resemble those of Akhad and Elamel dynasties, this culture is dated to the 27th–25th centuries B.C.

MATERIALS AND METHOD

The burial mound was excavated in August 2004. In total, 18 samples were collected for palynological analysis from different layers of the embankment, the layer of buried soil and from ceramic pots and their fragments. The palynological spectra from the contents of ceramic and wooden pots from the northwestern part of the burial chamber were surprising; in contrast to the buried soil, the concentration of pollen grains and spores was extraordinarily high. Each slide of the buried soil (glass 22 × 22 mm, objective ×20) contained about 450–500 pollen grains, whereas those from the pots showed several hundred thousand pollen grains. In addition, pollen grains from the pots were remarkably well preserved. Palynological practice testifies that such a high abundance of well-preserved pollen is specifically characteristic of both modern and fossil honey (Dickson, 1978; Rösch, 1999, 2002; Asanidze, 2005).

For palynological analysis, 100 g of the organic matter was taken from the bottom of the ceramic pots and their fragments and processed following standard procedure. The organic matter was first treated and boiled with KOH, then centrifuged in cadmium liquid and acetolyzed by the Erdtman method. Samples of modern honey were analyzed without centrifugation in cadmium liquid. Pollen grains were identified and counted in glycerol slides under a Leitz Wertzlar no. 5222929 light microscope. We used modern atlases and our original collections of reference slides of modern pollen. The material is housed at the Davitashvili Institute of Paleobiology of the Academy of Sciences of Georgia.

RESULTS AND DISCUSSION

The palynospectra of organic remains from three pots, buried soil, and from modern honey of the region studied are analyzed.

The taxonomic composition of all samples from the three fossil samples collected from the pots is dominated by members of the Rosaceae: often the field of view is filled completely by their pollen grains. However, the second, third, and fourth most numerous taxa differ (Table 1). For simplicity, the number of pollen grains of Rosaceae is not given from the 30 rows examined (= from the entire slide), but from one-sixth of the total number, i.e., from five rows.

Apart from the Rosaceae, the second most numerous taxon in sample 1, which was collected from the pot with a triangular handle, is linden (*Tilia cordata*) (Fig. 4). Members of the Apiaceae, particularly *Astrancia maxima* Pall, are the second most numerous taxon in sample 2 (obtained from the pot with a broken handle). The spectrum of sample 3 (from the ceramic frag-

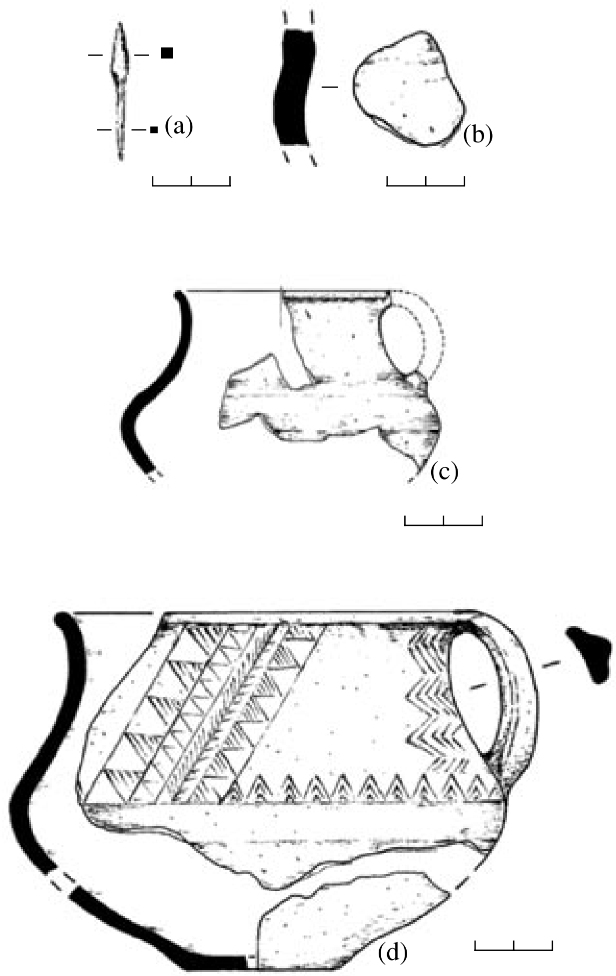

Fig. 3. Archeological material excavated from the Kodiani burial mound: (a) bronze arrow head; (b) remains of earthenware pot from the filling matter of the burial chamber; (c) earthenware pot with a broken handle; (d) ornamented pot with a three-ribbed handle, collected from the bottom of the burial chamber. Scale bar: (a, b) 1 cm; (c, d) 2 cm.

ments of the third pot) includes the Graminae as the second most numerous taxon.

Let us consider each spectrum in more detail. The Rosaceae of all three samples are dominated by pollen grains of the *Filipendula ulmaria* (meadowsweet) type. Nowadays, this large perennial plant grows in wet forests, forest clearings, grassy swamps, banks, and lakesides. Like other Rosaceae, *Filipendula* is a good melliferous plant, with sweet and fragrant nectar. Its flowers have numerous stamens producing a huge number of pollen grains. Therefore, the samples under study contain very numerous pollen grains of meadowsweet. Each field of view enumerates up to 100–150 pollen grains of meadowsweet, and each slide has up to several hundred thousand. Pollen grains of the *Fragaria-type* and *Rosa*-type are also very numerous. Pollen grains of *Rubus* (blackberry), *Pyrus* (wild pear), and *Prunus* (wild plum) are less numerous. There are also many other members of the family Rosaceae, not identifiable to genus.

As already noted, the trees and shrubs of sample 1 are dominated by *Tilia cordata* Mill. The second dominant is *Rubus* (blackberry). Pollen grains of *Castanea, Carpinus caucasica* A. Grossh., *Corylus, Salix*, and *Euonymus* are solitary. Pollen grains of *Abies, Picea*, and *Pinus* are rare. Apart from members of the Rosaceae, herbs include members of the Apiaceae and Liliaceae. Members of the Poaceae, including cultivated plants (cereals), are also present: these are *Triticum*, *Hordeum*, and *Secale*. Pollen grains of the Asteraceae, Polygonaceae, Boraginaceae, and Ranunculaceae were recorded. Of all spore plants, one spore of *Polypodium vulgare* L. and two spores of *Botrychium lunaria* were found.

In general, the palynological spectra from sample 2 resemble the above-described, Rosaceae-dominated, spectrum. However, conifers rather than linden prevail among trees. It is noteworthy that spruce is less frequent than fir. Pollen grains of hazel (*Corylus*), blackberry (*Rubus*), wild plum (*Prunus*), wild pear (*Pyrus*), and dog rose are numerous. Pollen grains of oak, maple, alder, beech, hornbeam, birch, willow, and linden are solitary. Similarly to sample 1, the herbs are rich in the *Filipendula ulmaria* and *Fragaria types*. Pollen grains of the Apiaceae are numerous (particularly *Astrancia maxima*). However, the family Liliaceae does not dominate in sample 2, being represented only by solitary pollen grains. One more difference is the presence of *Rumex, Lotus*, Caryophyllaceae, and *Armeria*. Pollen grains of both wild and cultivated cereals are more frequent. Among cultivated cereals, wheat and barley were identified. Fern spores are much more numerous in this sample.

After the abundant pollen grains of the Rosaceae, which are the first dominant of sample 3, cereals also play an important role, becoming more prominent (second dominant) than the Apiaceae (Fig. 4). Pollen grains of *Avena* join *Triticum*, *Hordeum*, and *Secale* among the cultivated cereals. It is interesting that only this sample contains pollen grains of *Turgenia latifolia* (L.) Hoffm., a weed in cereal crops in the Caucasus and a good melliferous plant. The role of the Polygonaceae increases. Apiaceae, Compositae, Ranunculaceae, *Rumex* are numerous. Pollen grains of *Epilobium, Echinops, Chamaenerion, Valeriana, Cerastium*, and the Liliaceae are solitary. The participation of spore plants is insignificant. The only fern spore found was *Ophioglossum vulgatum* L.

In the group of trees and shrubs, conifers (pine, fir, and spruce) and the Rosaceae (blackberry, mountain ash, and dog rose) prevail. Pollen grains of beech, oak, hornbeam, alder, birch, and linden are solitary.

A comparison between the list of plants of which pollen grains were found in the pots (Table 1) and a list of melliferous plants of the Caucasus (Grossgeim, 1946) reveals that 95% of the taxa in the fossil palyno-

The number of pollen grains and spores in the samples under study

List of plant taxa found during palynological analysis of the Kodiani burial mound	Sample 1, fossil honey	Sample 2, fossil honey	Sample 3, fossil honey	Sample 4, modern honey	Sample 5, buried soil
Abies nordmanniana	1	13	3	–	5
Picea orientalis	1	5	2	–	3
Pinus	3	23	16	1	55
Betula	–	1	1	–	–
Fagus orientalis	–	1	1	–	1
Alnus	–	1	1	–	1
Carpinus caucasica	1	1	2	1	2
Quercus	1	2	1	1	5
Tilia cordata type	39	3	1	1	2
Castanea sativa	1	1	–	–	–
Salix	1	2	–	–	–
Rubus type	13	3	7	–	–
Sorbus type	1	4	6	7	–
Pyrus type	3	4	–	–	–
Prunus type	–	4	–	–	–
Euonymus	1	–	–	–	–
Acer	–	1	–	–	–
Corylus	2	5	–	–	3
Rosa canina type	–	4	–	–	–
Rosa type	4530	5640	8275	3	–
Ephedra procera	–	–	–	–	2
Rhododendron caucasica	–	–	–	15	–
Sum of arboreal members	4598	5718	8316	29	79
Cerealia	4	5	7	–	1
Triticum	2	4	3	–	–
Avena	–	–	2	–	–
Secale cerealia	1	–	2	–	–
Hordeum	1	3	7	–	–
Poaceae, unidentifiable more precisely	7	28	123	2	5
Chenopodiaceae	1	1	–	1	2
Chenopodium album type	–	2	–	–	–
Filipendula ulmaria type	22500	27845	30680	5	–
Rosaceae, unidentifiable more precisely	15060	21820	20540	28	–
Fragaria type	6012	11050	7806	7	–
Apiaceae, unidentifiable more precisely	32	38	20	155	–
Astrancia maxima type	7	17	16	–	–
Heraclaum type	9	5	2	2	–
Turgenia type	–	–	1	–	–
Echinops type	–	–	2	–	–
Aster	4	1	5	1	6
Achilleae type	2	2	2	–	–
Taraxacum type	2	1	1	3	1
Cichorioideae, unidentifiable more precisely	1	1	2	7	14
Cirsium type	1	–	1	1	3

Table. (Contd.)

List of plant taxa found during palynological analysis of the Kodiani burial mound	Sample 1, fossil honey	Sample 2, fossil honey	Sample 3, fossil honey	Sample 4, modern honey	Sample 5, buried soil
Carduus type	1	2	13	21	–
Fagopyrum	1	–	–	–	–
Centaurea cyanus	–	1	–	1	–
Centaurea montana type	–	–	1	1	–
Centaurea, unidentifiable more precisely	4	3	10	68	–
Polygonum, unidentifiable more precisely	2	1	12	1	18
P. viviparum type	1	4	4	–	1
Serratula type	2	–	–	–	–
Jurinea type	3	1	1	1	–
Valeriana	–	–	1	–	–
Chamaeneriin type	–	–	1	–	–
Polygonum bistorta type	–	–	2	2	–
Polygonum alpestre type	–	1	–	–	–
Ranunculus	1	4	4	6	1
Boraginaceae, unidentifiable more precisely	6	4	4	5	2
Helianthemum	5	2	1	15	–
Saxifraga type	–	–	–	–	7
Papaver type	–	–	–	9	–
Malva	–	–	–	1	–
Armeria type	–	1	–	3	–
Caryophyllaceae, unidentifiable more precisely	–	2	–	–	11
Cerastium type	1	–	1	–	–
Colchicum speciosum type	9	2	2	–	–
Liliaceae, unidentifiable more precisely	16	2	2	–	–
Epilobium	–	–	1	1	–
Campanula	–	–	–	2	–
Symphytum	–	–	–	16	–
Knautia arvensis type	–	–	–	35	–
Scabiosa	–	–	–	2	–
Prunella	–	–	–	21	–
Viola	–	–	–	1	–
Rumex	–	6	1	–	–
Primula, unidentifiable more precisely	2	1	1	–	–
Lotus, unidentifiable more precisely	–	6	1	–	–
Unidentifiable pollen grains of herbs	5	12	8	19	12
Polypodiaceae, unidentifiable more precisely	–	17	5	5	210
Polypodium vulgare	1	–	2	–	2
Ophioglossum vulgatum	–	–	1	–	3
Cryptogramma crispa	–	3	1	–	20
Botrychium lunaria	2	1	5	–	30
Lycopodium, unidentifiable more precisely	–	–	–	–	1
Sphagnum	–	–	–	–	2
Total sum of pollen grains of herbs	43708	60905	59307	448	352
Total sum of pollen grains and spores	48306	66623	67623	477	431
Sum of forest elements	48189	66461	67388	90	365

spectra are good melliferous plants. It is clear that the three pots contained honey. This is a very rare case for this epoch, when different pots in burials usually contained different food, which is proved both by our analyses of pot content from many burials and by the data of other scientists (Demkin, 2000; Shishlina et al., 2002). This point allows us to hypothesize that the buried woman was a beekeeper. The quality of the honey was equally high in all pots because the concentration of pollen is very high. The honey of the different pots should have differed in taste. It is known that white honey is particularly fragrant and is currently considered as the best type of honey. Apparently, the people of those ancient times also knew this and kept bees near lime forests. Apparently, these people did keep bees (rather than collecting the honey of wild bees). The existence of beekeeping is supported by the occurrence in the honey of pollen grains of cultivated cereals and weeds growing near human habitation. Even the custom of putting honey in a grave suggests the existence of well-developed beekeeping.

It is agreed that man started beekeeping in Asia Minor and ancient Egypt (Lucas, 1958; Robakidze, 1960; Konigsmann, 1968; Stanek, 1977). This is supported by ancient texts, where honey is mentioned since the time of the VI dynasty (2750–2475 B.C.). As a burial offering, honey was used in Egypt in the epoch of the XVIII dynasty (1580–1350 B.C.). For example, there is an inscription on small pots from the tomb of Tutankhamen, "honey of good quality" (Lucas, 1958, p. 71).

Archeologists (Kuftin, 1948, 1949), historians, and ethnographers (Robakidze, 1960) hypothesized the existence of ancient beekeeping in Georgia. According to Robakidze (1960), written sources directly mention the existence of beekeeping in the private life of Colches in the fourth century B.C. Analogous evidence for tribes related to Georgians are dated to the eighth century B.C. However, indirect evidence of beekeeping has been found in earlier epochs. One such example is the well-developed metallurgy of the Bronze Age in the Caucasus, when pieces of casts were made of wax (Kuftin, 1948; Inanishvili, 2003). Starting from the third millennium, metallurgy was prominent enough to demand a constant source of wax (Robakidze, 1960). Collecting of honey and wax was insufficient to satisfy the requirements of bronze casting. In this context, our new, reliable palynological data ultimately provide new support for the views of ethnographers and archeologists about the existence of ancient beekeeping in Georgia.

Our study of the fossil honey from the Kodiani 1 burial mound discovered pollen grains of plants the ecological preferences of which suggest the existence in the region studied of thermophilic broad-leaved forests, including linden, oak, chestnut, hornbeam, beech, and others. This conclusion is also supported by the abundance of such forest herbs as meadowsweet, strawberry, and other members of the Rosaceae. There are also hazel, blackberry, wild pear, wild plum, and other indicators of thermophilic forests. The presence of conifer pollen in the spectrum may be explained by the visitation from distant mountains and sedimentation on petals of melliferous flowers, since in mountain regions the influx of nonlocal pollen per square centimeter is very high (nearly ten times as high as on plains; Kvavadze, 2001).

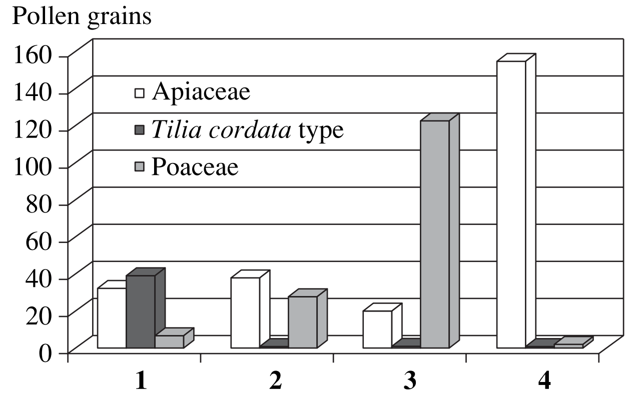

Fig. 4. Diagram of subdominants in the palynological spectra of the samples under study: (**1**, **2**, **3**) the numbers of samples of the fossil honey; (**4**) the number of the sample of the modern honey.

A warmer climate would explain the cultivation of wheat and other cereals in such high mountains.

We decided to support our conclusions with actual palynological data. Modern honey from the nearest village, Tsikhisdzhvari, was studied to check how authentically the palynological spectrum of honey reflects the vegetation of the surrounding landscape (table). Nowadays, there are subalpine meadows there dominated by Apiaceae and with bushes of Caucasian rhododendron. In valleys, elements of subalpine stunted forest of birch, mountain ash, and pine grow.

The modern honey from Tsikhisdzhvari was not of very good quality. It is known that under extreme conditions, especially during cold springs and summers, bees are fed with sugar syrup. This makes the quality of the honey much lower. However, even the palynological spectrum of the pollen grains that the bees were able to collect in good weather includes all the elements of the surrounding vegetation (table). Pollen grains of rhododendron and mountain ash prevail among trees and shrubs, a good reflection of the existing ecosystems. The pollen grains of the Apiaceae, the herb dominant, also reflect the modern situation. We should particularly note that the spectrum of the modern honey contains few pollen grains of the Rosaceae. By contrast, there are numerous pollen grains of the dominant of subalpine meadows *Knautia arvensis* (L.) Coult. Pollen grains of *Centaurea* also dominate. Both *Knautia* and *Centaurea* are good melliferous plants (Rabotnov, 1971).

To decide whether or not the fossil honey was of local origin, and to exclude the possibility of its import from warmer regions of Georgia, we compared the palynological spectra of the fossil honey and the soil that was buried during the funeral. This comparison revealed many common characteristics. The soil spectra also indicate the existence of forest vegetation. Pollen grains of linden and cultivated cereals were also recorded. There are numerous spores of forest ferns: up to 58.3–63.0% of the total of the assemblage (table). The most important find is the presence of *Polypodium vulgare* and *Ophioglossum.* These ferns are characteristic of broad-leaved forests of the middle level of the Caucasian Mountains and at present do not grow in high mountains.

CONCLUSIONS

As a good preservative, fossil honey recorded the most complete list of wild and cultivated plants of the epoch (about 80 taxa in comparison to 35 taxa in the buried soil) and has been shown to be a very promising information source for paleoecological reconstructions, revealing the diversity of ancient ecosystems and the type of human economical activity and diet.

The analysis of the palynospectra of the fossil honey revealed the existence of thermophilic forests in the region of Kodiani Mountain in the 27th–25th centuries B.C. with the participation of linden, chestnut, hornbeam, oak, beech, maple, and others. High-mountain forests of birch, mountain ash, willow, and dark coniferous elements grew at high altitudes of spurs of the Trialeti Mountain Range.

Apart from beekeeping, man had developed agriculture and cultivated mostly wheat. Crops of barley, rye, and oats were not significant. The cultivation of cereal crops is proven not only by the presence of pollen grains of cultivated cereals, but also weeds that are indicators of plowed fields. These are several species of *Polygonum, Turgenia, Centaurea cyanus, Chenopodium album* L., *Carduus, Fagopyrum,* and others. Animal husbandry was indicated by the presence of pollen grains of pasture weeds in the spectra: *Ranunculus, Rumex, Cirsium, Taraxacum, Chenopodium, Cerastium*, and others. Apparently, the density of the human population was relatively high, since the percentage of pollen grains of weeds growing near habitations, along roads, and in ruderal places is high: Cichorioidae-type, *Serratula, Echinops*, and *Heracleum*.

The presence of broad-leaved forests with linden, cultivation of cereal crops, and beekeeping at about 2300 m above sea level strongly suggests a warmer climate than the present climate of the territory. Analogous paleoecological reconstructions were obtained on the basis of the palynological study of the neighboring burial mound Topioli (vicinity of Lake Tabatskuri, the valley of the Ktsiya River), which also belongs to the epoch of Early Kurgans and is situated at 2000 m above sea level. The palynological spectra of Topioli also includes pollen grains of thermophilic broad-leaved trees (linden and hornbeam), numerous spores of forest ferns, and pollen grains of cereal crops. Our conclusion about the climatic optimum in the 27th–25th centuries B.C. is also supported by the study of lake deposits in southern Georgia (Kvavadze and Connor, 2005).

ACKNOWLEDGMENTS

I am grateful to the British Petroleum Company for the financial support of the excavation of the burial mound and laboratory studies, and to the archeologists I.O. Gambashidze, G.M. Mindiashvili, and G.K. Gogochuri (Lordkipanidze Center of Archeological Research, Academy of Sciences of Georgia) for their help during the study.

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