RADIOCARBON DATA AND ANTHROPOCHEMISTRY OF ANCIENT MOSCOW

E. ALEXANDROVSKAYA and A. ALEXANDROVSKIY

Institute of Geography, Russian Academy of Sciences,
Staromonetny 29, 119017 Moscow, Russia
(e-mail: pedology@igras.geonet.ru)

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Abstract: New data on the age of ancient hillforts in the territory of Moscow have been obtained with the use of radiocarbon dating. Hillforts of the Iron Age (D'yakovskaya culture) existed in Moscow area from the 8th century BC to the 7th century AD; settlements of the medieval age appeared in the 11th–12th centuries AD. Urban soils in the central part of Moscow consist of a thick (3–5 m) layer of habitation deposits (the cultural layer). These deposits were accumulated from the 12th to the 20th century. They are rich in organic matter, carbonates, phosphorus, and various microelements. Strong alkalinity and high stoniness are characteristic of the habitation deposits. We studied the accumulation of elements and their compounds within the habitation deposits of Moscow. These data, together with information on the microelemental composition of the bones of ancient residents of Moscow, allowed us to assess the living conditions of people.

1. INTRODUCTION

Archaeological objects of different ages are known within the territory of Moscow, including several hillforts of the Iron Age (D'yakovskaya culture). Some of them are found in the area of Moscow, like D'yakovo, Kremlin, etc. (**Fig. 1**). Radiocarbon dating of charcoal from habitation layers of the D'yakovskaya culture in Moscow Kremlin, under the Archangel Cathedral gave the following dates (from the depth of 1.60, 1.65, and 1.75 m below the modern surface): 2210±40 BP (GrA-13656), 2220±40 BP (GrA-13657), and 2240±40 BP (GrA-13658), respectively. The calibrated (95.4%) age interval is 381-341 (19.1%) and 325-203(76.3%) cal BC (**Fig.2**).

The key hillfort of the D'yakovskaya culture (D'yakovo hillfort in the south-eastern part of Moscow) existed for many centuries. Many radiocarbon dates have been obtained for this hillfort. These dates suggest that the first settlers appeared there in the 8th century BC. This hillfort existed until the 6th–7th century AD (Alexandrovskiy *et al.*, 2004).

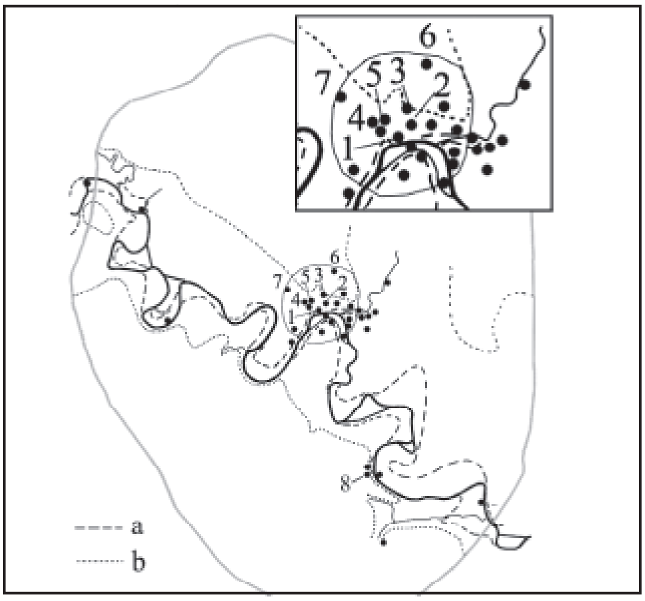

Fig. 1. *Location of sites: 1 – Kremlin, 2 – Red Square, 3 – Trinity church, 4 – Romanov Dvor, 5 – Manezh, 6 – Sretenka, 7 – Tverskoy Boulevard, 8 – D'yakovo hillfort; a – Valley of Moskva River, b – Floodplain.*

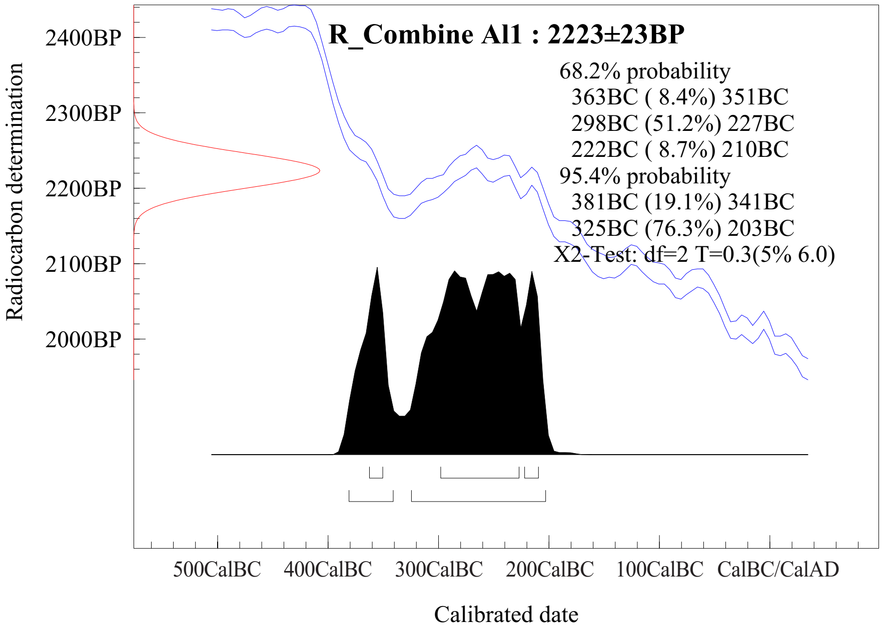

Fig. 2. *Results of calibration of radiocarbon dates according to the Oxford calibration program from habitation deposits of the D'yakovskaya culture in Moscow Kremlin.*

The habitation deposits (cultural layer) and soils of Moscow have a complicated morphology formed under the impact of rapidly changing natural and anthropogenic processes. Initially, the soil cover of Moscow was composed of Podzoluvisols that formed during the Holocene on lithologically diverse sediments. These soils are still preserved in Moscow within forest groves and park zones; on the rest of the territory they are strongly transformed. The main distinction of urban soils from natural ones is due to active accumulation of anthropogenic waste that form a cultural layer (habitation deposits) with specific properties and composition (Blume, 1989; Stroganova and Agarkova, 1992; Burghart, 1994; Dobrovol'skiy, 1997).

Various types of habitation deposits can be distinguished: debris from house construction, municipal waste, excavated bedrock (from digging of foundation pits), industrial waste and pollutants, artificially introduced or created lawn and garden soils, etc. The cultural layer buries the initial soil and is characterised by high alkalinity, stratification, evident traces of different technogenic impacts and a high stone content. It is also contaminated by a wide range of chemical elements, including pollutants (Thornton, 1991), and contains numerous archaeological artifacts (Boytsov *et al.,* 1993). Besides, there are various traces of soil formation within this layer, including poorly developed buried soils. Thus, this layer is simultaneously a soil, sediment, and a cultural layer (Alexandrovskiy *et al.,* 1997).

Chemical elements and their compounds contained in urban soils and habitation deposits, as well as other sources (water, air) of element input into human bodies affect the health of people and their behaviour. It is important that the sources of elements and the intensity of the uptake of different elements by humans have been changing with time. This problem is studied by anthropochemistry, a science about the role of the chemistry of the environment in the life of humans and human civilizations (Alexandrovskaya and Alexandrovskiy, 2003; Alexandrovskaya and Panova, 2003).

The aim of this study was to reconstruct the initial (10–11th centuries AD) rural environment of Moscow, the environment during the early urban stage of Moscow history (12-14th centuries AD), and the environment of the medieval town (15-17th centuries AD) and assess the anthropochemistry of ancient peoples.

2. MATERIALS AND METHODS

The age of the soils and cultural layers of ancient hillforts was determined using both Radiocarbon- and archaeological dating, stratigraphic analysis of the sediments and the degree of development of the soil structures.

Radiocarbon dating was carried out by AMS in Groningen (laboratory code GrA), and conventionaly by LSC method in Moscow (laboratory code GIN and IGAN). For dating, charcoal pieces from cultural layers, and humic acids from soils were used. Calibration of dates was carried out with the OxCal calibration program v.3.10 (Bronk Ramsey, 2005), updated with the recommended IntCal04 dataset (Reimer *et al.*, 2004).

The history of interaction between humans and the environment can be traced in urban soils by means of pedological and paleogeographical methods (Boytsov *et al.,* 1993). The new archaeological-geological-pedological approach is suggested for the study of these unique objects. The use of the methods of geochemistry, especially for bone tissue of ancient peoples, can be also very fruitful for reconstruction of living conditions.

The content of organic matter, carbonates, and phosphorus was determined in buried soils and cultural layer of Moscow by routine methods. Analysis of the microelemental composition of habitation deposits and bone tissue was performed by the X-ray fluorescence method.

Table 1. *Sample composition and ^{14}C dating results from Ilyinka street and the Kazanski cathedral on the Red Square, Moscow.*

No. of sample	Sample description	depth (cm)	Wood species in order of frequency	^{14}C Age (BP)	Lab code	Cal Age (AD) (68.2 % confo intervals)
			Ilyinka site			
Il-13	Cultural layer	290	Pine*, fir-tree*, bark, asp, oak*	640±60	Ki6078	1281-1318, 1344-1392
Il-6	Cultural layer	290	Pine, fir-tree, bark, asp, oak*	660±50	GrA-6089	1277-1312, 1352-1386
Il-1	Cultural layer	300	Pine*, lime-tree*, fir-tree*, apple-tree*	620±35	GrN-22469	1292-1318, 1346-1390
Il-2	Cultural layer	315	Bark*, fir-tree*, pine*, birch*, asp*	810±35	GrN-22470	1213-1262
Il-4	Cultural layer	315	Bark*, fir-tree*, pine*, birch*, asp*	825±95	IGAN1650	1050-1084, 1120-1138, 1158-1271
Il-9	Cultural layer, pit	320	Fir-tree*, birch*	515±30	GrN-22472	1404-1430
IL-14	Cultural layer, pit	320	Fir-tree*, birch*	550±35	Ki-5892	1318-1344, 1392-1418
IL-7	Cultural layer	325	Fir-tree*, pine	875±60	GrA-6282	1044-1094, 1116-1142, 1152-1223
Il-15	Cultural layer	325	Fir-tree*, pine	860±40	Ki-5917	1054-1080, 1122-1136, 1158-1230
Il-8	Plough soil	335	Fir, pine, ash-tree, oak*, lime-tree, asp	920±60	GrA-6291	1034-1162
Il-16	Plough soil, broad-leave	340	Fir, pine, ash-tree*, oak*, lime-tree, asp	935±45	Ki-5895	1028-1058, 1074-1124, 1134-1160
Il-17	Plough soil, coniferous	340	Fir*, pine*, ash-tree, oak, lime-tree, asp	850±35	Ki-5916	1162-1242
Il-10	Plough soil	340	Fir*, pine*,ash-tree*, oak*,lime-tree*,asp*	965±125	IGAN1720	961-1221
Il-11	Plough soil, humic acid	340	-	840±60	IGAN1713	1058-1072, 1126-1134, 1160-1262
Il-3	Plough soil	340	Fir*,pine*,ash-tree*, oak*, lime-tree*,asp*	830±40	GrN-22471	1172-1250
Il-5	Plough soil	340	Fir*,pine*,ash-tree*, oak*, lime-tree*,asp*	1030±95	Ki-5215	890-1048, 1086-1120, 1138-1156
			Kazanski Cathedral			
Kz-1	Dwelling 1, plank 11	285	Pine*	820±30	Gin-7179	1181-1186, 1209-1257
Kz-2	Dwelling 1, plank 12	287	Pine*	820±20	Gin-7181	1215-1250
Kz-4	Dwelling 1, plank 12	287	Pine*	1020±15	GrN-22473	1003-1018
Kz-3	Dwelling 1, log	289	-	830±30	Gin-7183	1175-1239
Kz-6	Dwelling 1, post	295	-	880±160	Gin-7184	1010-1275
Kz-7	Dwelling 1, stove 7	287	Rosaceae*	930±40	Gin-7180	1032-1058, 1074-1124, 1134-1160
Kz-9	Dwelling 1, stove 7	287	Rosaceae*	865±40	Ki-5893	1052-1082, 1120-1136, 1158-1227
Kz-5	Dwelling 1, stove 7	287	Rosaceae*	925±25	GrN-22474	1036-1054, 1078-1124, 1136-1158
Kz-11	"Black layer"	290	Oak*	890±40	Ki-5894	1042-1094,1114-1144, 1152-1177, 1193-1207
Kz-8	Dwelling 1, plank 10	289	Pine*	960±40	Gin-7182	1016-1050, 1084-1120, 1136-1158
Kz-10	Plough soil	295	Oak*, ash-tree, rosaceae	920±60	GrA-6284	1034-1162

** used for ^{14}C dating*

3. RESULTS

Early ^{14}C dates and pottery artifacts from the D'yakovo Hillfort show that the cultural layer began to accumulate at this site before the 5th century BC (Alexandrovskiy *et al.,* 2004). Identical pottery fragments were found at other sites (Tchertov Gorodok and Seletskoe Hillfort), with bones and charcoal dated to 2570±70 BP and 2590±70 BP (GIN - 7569, 4774). The calibrated (95.4%) interval is 834-705(54.6%) and 695-539(40.8%) (**Fig. 3**).

The earliest dates obtained for the medieval layer date back to the 11–12th centuries AD (**Table 1, Fig.4**; Alexandrovskiy *et al.,* 2000).

Under the impact of anthropogenic activity, a thick layer of habitation deposits was accumulated on the surface of natural landforms shaped by glacial, alluvial, and other natural processes. Its thickness in the central part of Moscow reached 2-3 m increasing to 7–10 (up to 20) m in depressions (flat-bottom ravines, river valleys, sinkholes). This layer has the following composition:

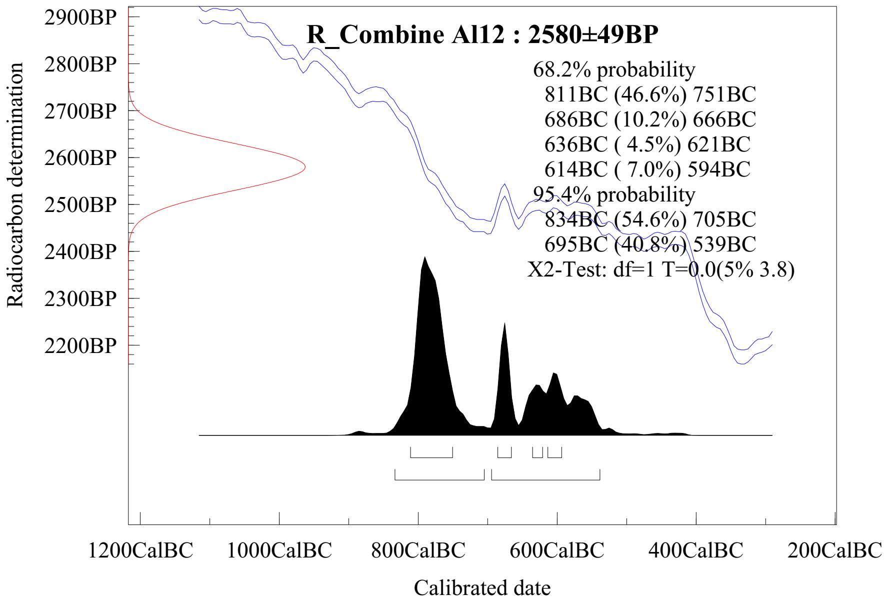

Fig. 3. *Results of the calibration of radiocarbon dates according to the Oxford calibration program from two hillforts of the D'yakovskaya culture near Moscow.*

Table 2. *Analytical data for the cultural layer, surface, and buried soils from Moscow. CL1 – brick-lime cultural layer, CL2 – organic-rich cultural layer, Ap – plaggen horizon and E – eluvial horizon of initial Podzo-luvisols.*

Site	Age, century	Layer or horizon	Depth (cm)	pH	Humus (%)	$CaCO_3$ (%)	$P_{extractable}$ (mg/100g)	Cu (mg/kg)	Pb (mg/kg)	As (mg/kg)
Tverskoy , boulevard 16 (yard)	20	A1	10	7.8	2.3	5.3	240	**108**	**133**	**19**
	19	AB	40	7.4	4.9	3.2	212	**105**	**264**	**31**
	19	CL1	60	7.7	2.4	5.3	1864	**247**	**461**	**53**
	18	CL1	80	7.9	4.1	5.2	12	**1014**	**890**	**58**
	17/18	A1	135	7.5	3.9	2.0	232	**154**	**108**	**23**
		CL1	175	7.5	4.6	4.5	360	**198**	**226**	**30**
	17	CL2	175	7.5	3.1	1.2	384	**137**	**123**	**17**
		CL2	240	7.2	2.6	0.0	418	**299**	43	**17**
	15/16	Ap	255	7.3	1.5	0.0	366	81	15	3
		E	270	7.3	0.2	0.0	110	14	7	4
Romanov Lane, 4 (Moscow University Yard)	20	A1	10		4.7		66.7	**197**	**228**	**8**
	19/20	AB	75		3.2		132.9	**125**	**51**	**12**
	19	CL1	110		5.0		131.6	**183**	**161**	**25**
		A1	170		3.2		240.4	90	24	**17**
	18	CL1	230		1.2		232.8	**1204**	**57**	**11**
	17	CL1	230		1.6		212.0	**1910**	**120**	**25**
	17	CL1/2	290		5.5		226.5	-	-	-
	17	CL1/2	315		2.2		301.7	30	20	6
	16	CL12	325		8.7		411.8	-	-	-
	16	Ap	345		3.1		276.2	72	17	8
	15	A	360		0.4		165.8	9	8	8
Natural soil near Moscow		A1E	0-10	4.7	3.6	0.0	5.0	12	5	2

Bold – high concentration

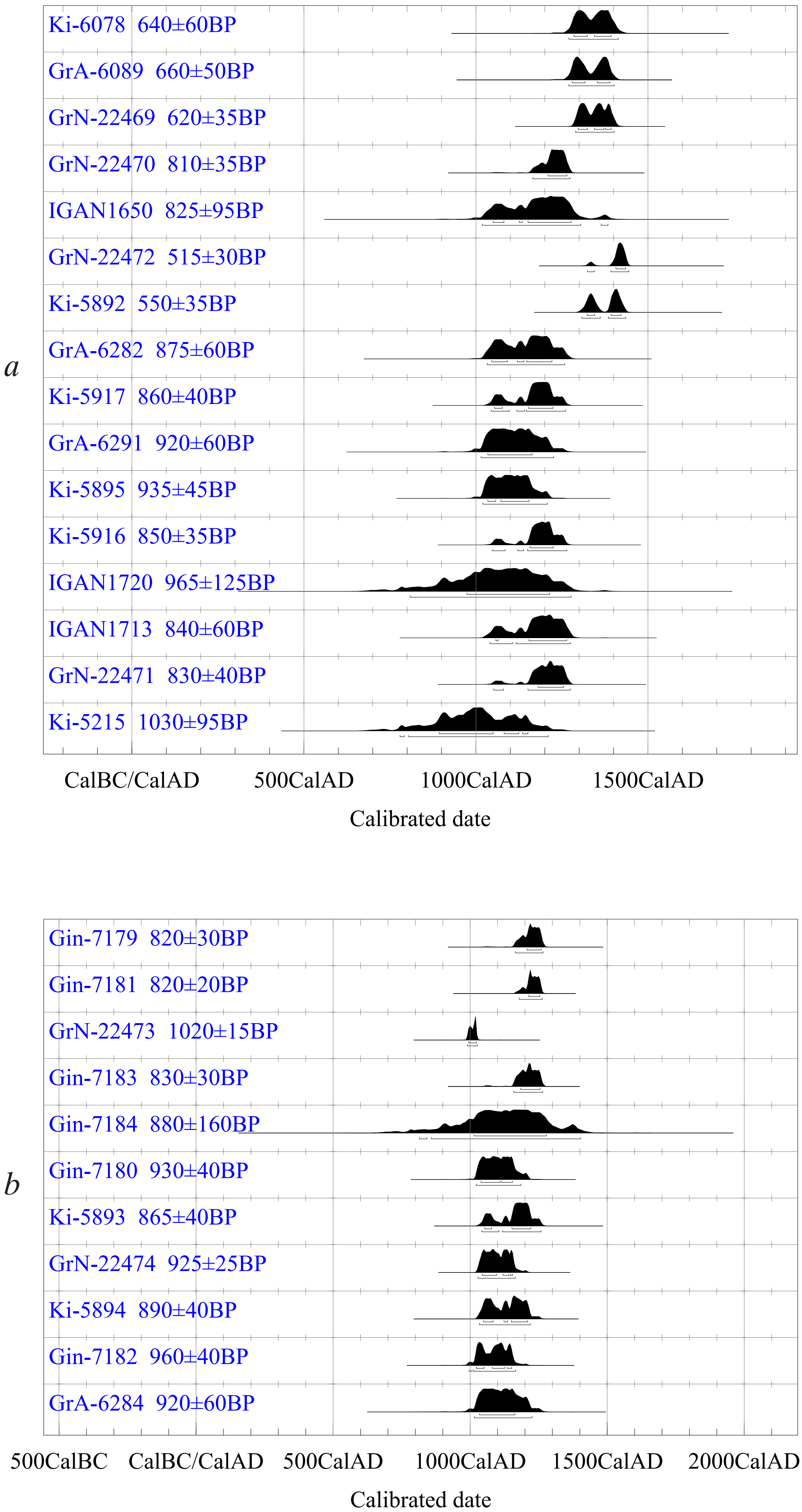

Fig. 4. *Results of the calibration of radiocarbon dates according to the Oxford calibration program: (a) Ilyinka site and (b) Kazanski Cathedral.*

(1) The buried soil beneath is usually a Podzoluvisol with a sandy-loamy texture. The soil has a deep profile with eluvial and illuvial horizons. Its upper part often merges together with the overlying habitation deposit (the boundary between them is indistinct). In many cases, initial soil contains a plough horizon of 7–12 cm thickness, sometimes with erosion features.
(2) Above the surface of the buried natural soil we can often see a humus-rich horizon with interlayers of charcoal and ash (the remains of ancient fires) and inclusions of construction debris. This horizon was formed during the period of wooden construction; it can be named as organic-rich cultural layer. Sometimes, this horizon includes the remains of decomposed wooden chip, rotten manure, and other plant remains.
(3) Above it, a very thick layer with an increased stone content is found. It is enriched in brick debris and lime that were applied during the period of stone construction. This horizon is referred to as a lithogenic horizon and is marked by lower humus content, and alkaline reaction.

The horizons of poorly developed soils are also contained in the thickness of habitation deposits. Most of them consist of humus horizon only, with a gradual transition to the underlying material.

The habitation deposits differ from the zonal Podzoluvisols by a higher content of organic matter, carbonates, and phosphorus. The main sources of carbonates were the limestone and mortar that were being used widely since the 17–18th centuries. Carbonates migrated into lower layers, including the initial Podzoluvisol, and the reaction of these layers changed from acid to alkaline (**Table 2**). The phosphorus content of the cultural layer is many times higher than that in the Podzoluvisols of the surrounding area.

The 11-12th century layers under the Red Square are marked by a relatively low content of metals and other elements. The habitation deposits of the 12-13th centuries under the Red Square contains much organic matter, primarily woody remains. They are relatively enriched in carbonates owing to the input of lime derived from construction limestone. It also has increased Cu and Zn content, because these elements were used for various purposes in that time, and much As, which was used for the depilation in tanning (Giua, 1962; Alexandrovskaya, 1996). In the cultural layers of old towns of Kursk region accumulations of these elements are higher than those in the recent municipal deposits (Kaidanova, 1992).

In the more recent deposits of Moscow the content of calcium oxide and many microelements considerably increases. In the Kremlin (**Table 3**), medieval cultural deposits proved much cleaner than in the nearest town (Ilyinka site; **Table 4**).

The horizons of the 17–19th centuries contain maximum concentration of such elements as lead, copper, and arsenic. Thus, the concentration of arsenic increases up to 74 mg/kg (as compared to the Clarke value of 2 mg/kg). The average concentration of Cu in natural soils of the Moscow region is 3-20 mg kg^{-1}, but in the cultural layer of the 15-16th centuries it reaches 650 mg kg^{-1}. The Clarke value for Pb is 13 mg kg^{-1} (3-5 mg kg^{-1} in soils), but in the cultural deposits of the 19th century it can reach 1320 mg kg^{-1}.

The next stage was a study of the microelement composition of bone tissue recovered from burial grounds of the grand Russian princesses and czarinas of the 15th and 16th centuries in the cemetery of the Ascension Convent of the Kremlin (**Table 5**), and remains of the urban population of different social and age groups (**Tables 6 and 7**).

In the bone tissue of high-born Russian ladies of the 15th, 16th, and early 17th centuries we see an enhanced concentration of lead, mercury, copper, occasionally barium, and other elements that might have been present in the cosmetics used at the time (and they often contained toxic agents; **Table 5**). Sure enough, our contemporaries

Table 3. *Microelements in soils and deposits near the Archangel Cathedral in the Moscow Kremlin (mg/kg).*

Dig, sample, century	Ni	Cu	Zn	Hg	As	Pb
Mean concentration in the earth crust	99	30	76	0.5	2	13
1st trench, north, 15th century layer	8	34	49	1.6	5	14
1st trench, south, 15th century layer, 120 cm deep	31	57	103	1.2	6	24
15th century layer, 150 cm, pit	24	59	99	0.9	5	28
14th century layer, 200 cm, pit	13	26	57	0.7	5	10

Bold – high concentration

Table 4. *Microelements in soils and deposits of the Moscow (mg/kg).*

Dig, sample, century	Ni	Cu	Zn	As	Pb
Mean concentration in the earth crust	99	30	76	2	13
Trinity Cathedral (suburb of medieval Moscow)					
16th century, deposits	9	31	42	8	13
15th century, deposits	11	13	42	7	7
14th - 15th century, deposits/buried soil	11	83	51	9	9
Initial soil	9	15	21	5	2
Ilyinka street (near Kremlin)					
15th – 16th century, deposits	44	**205**	**486**	**16**	**94**

Bold – high concentration

will recoil at the mere mention of substances like white lead, antimony or cinnabar (the chief source of mercury), all of them highly poisonous. But fashionable ladies of the Middle Ages did use them. Drugs and salves were another source of poison. Some medicines contained lead (Goulard water), and salves – mercury and arsenic. Lead-containing remedies, by the way, appeared in Europe in the 10th century, and were in common use from the 15th century onwards. All the objects we have studied show an enhanced concentration of mercury. The big doses of this element are very harmful. The poisonous mercury could come from medical drugs, dyes (from cinnabar that was in much use at the day), from vapours released in the process of gilding; the presence of an open mercury barometer in the Kremlin likewise could have a role to play.

In the bones of monks and townspeople of 14-16th centuries, concentration of microelements is lower (**Table 6**). Also in the remains of children from Kremlin the content of toxic elements is higher than that in town children (**Table 8**).

Table 5. *Microelements in bone tissues of women buried in the Kremlin (mg/100g of bone tissues).*

Objects	Cu	Zn	Mn	Pb	As	Ag	Hg
Mean concentration in bone tissue today	1.8	14	10	1.9	0.1	0.04	0.04
Åvdîciya Dînskaya, 1407	1.1	10.0	10	**20.0**	0.1	0.04	0.03
Grand Princess Maria Borisovna, 1467	10.4	**338**	0.3	**90.3**	0.3	0.04	**1.05**
Grand Princess Sîfia Paleolog, 1503	7.1	27.0	0.4	**58.6**	0.3	0.04	0.05
Grand Princess Yelena Glinskaya 1538	3.8	40.6	0.4	**56.4**	**0.8**	0.04	0.05
Czarina Ànastasia Romanovna. 1560	9.1	24.9	0.3	**160**	**0.8**	**6.6**	**0.13**
Czarina Maria Nagaya, 1608	1.9	24.3	1.2	**19.3**	0.1	0.04	**0.60**

Bold – high concentration

Table 6. *Microelements in bone tissues of men, women, and children buried in the Trinity Cathedral (mg/100g of bone tissues).*

Objects	Cu	Zn	Mn	Pb	As	Ag	Hg
Mean concentration in bone tissue today	1.8	14	10	1.9	0.1	0.04	0.04
			Men				
228 25-35 years old	0.7	18	6.9	**3.4**	**0.4**	0.01	0.04
162 35-45 years old	**4.0**	**60**	**56.0**	**16.4**	0.3	**10.0**	0.03
156 35-45 years old	0.9	**60**	**27.8**	**5.9**	0.1	0.01	0.03
164 35-45 years old	*0.5*	**42**	**28.0**	2.0	0.1	0.01	0.03
203 35-45 years old	*0.2*	21	7.0	2.5	0.1	0.01	0.03
187 45-55 years old	*0.2*	19	*3.5*	*0.2*	0.3	**13.0**	0.04
234 45-55 years old	0.7	27	**24.5**	0.8	0.3	0.01	0.03
227 45-55 years old	*0.5*	21	7.2	**3.8**	0.2	0.01	0.02
153 55 years oldest	*0.6*	24	**34.7**	**5.3**	0.2	0.01	0.03
			Women				
165 20-35 years old	0.9	**48**	**112**	**1.0**	0.1	0.01	0.03
209 25-35 years old	1.1	**70**	14.5	2.3	**0.5**	0.01	0.03
174 25-35 years old	0.9	**64**	**15.7**	**4.0**	0.3	0.01	0.01
155 45-55 years old	*0.3*	**36**	**70**	**10.5**	0.1	0.01	0.03
198 45-55 years old	*0.3*	**53**	**63**	1.0	0.1	0.01	0.03
			Children				
176 12-13 years old	0.5	21	**21.0**	0.5	0.1	0.01	0.02
235 12-13 years old	*0.6*	**62**	**23.9**	0.9	**0.5**	0.01	0.03
210 9-10 years old	*0.6*	**24**	6.4	1.5	**0.9**	0.01	0.03
167 8-9 years old	1.0	**152**	**315**	0.8	0.3	0.01	0.03
218 6-7 years old	1.6	**58**	6.8	1.6	**0.7**	0.01	0.01
249 5-6 years old	1.0	**34**	13.1	0.3	0.1	0.01	0.03
223 1.5 years old	1.2	**58**	**42.0**	**4.0**	**0.9**	0.01	0.01
222 1 infant	0.8	**61**	**21.0**	**4.3**	**1.2**	0.01	0.02

Bold – high concentration, Italic – low concentration

Table 7. *Microelements in bone tissues of men buried in the Kremlin (mg/100g of bone tissues).*

Objects	Cu	Zn	Mn	Pb	As	Hg
Mean concentration in bone tissue today	1.8	14	10	1.9	0.1	0.04
Monk, grave 905	3.6	23.9	18	**8.7**	**3.0**	0.03
Monk, grave 906	**3.9**	**39.8**	14	**32.0**	**5.6**	**0.09**

Bold – high concentration

Table 8. *Microelements in bone tissues of children buried in the Kremlin (mg/100g of bone tissues).*

Objects	Cu	Zn	Mn	Pb	As	Hg
Mean concentration in bone tissue today	1.8	14	10	1.9	0.1	0.04
Grand Princess Mariya, daughter Ivan IV, infant	3.5	**210**	**64**	**42.0**	**0.9**	**0.09**
Princess Anna Belsky, infant	1.8	12	8	**12.0**	**0.4**	0.01
Grand Princess Feodosiya, daughter Yrina Godunova, 2 years old	**27.0**	**500**	6	**14.2**	**0.6**	**0.2**
Grand Princess Pelageya, daughter Alecs. Mich. Romanova, infant	3.0	50	**20**	**18.0**	**0.5**	0.04
Princess Maria Staritsca, 5-7 years old	**3.9**	**44.7**	15	**51.4**	**8.1**	**0.11**
Princess Anastasiya Staritsca infant	**6.8**	**30.5**	3.9	**15.9**	**1.6**	**0.16**
Prince Fyodor Belsky, infant	1.7	23.9	8.4	**34.7**	**1.0**	0.02

Bold – high concentration

4. DISCUSSION

The list of dates from Iron Age hillforts located along the Moskva River valley proves that the interval 8th century BC – 1st century AD corresponds to the period of the most intensive functioning of these sites. Only some of them (D'yakovo Hillfort as well) were still in use up to the 6-7th century AD.

The Medieval stage of Moscow settlement began in the 11th–12th centuries AD. Ancient town appeared in the place of Kremlin in the 12th century. Most of the radiocarbon dates for this period have been from habitation deposits under the Red Square (**Table 1**).

Several stages can be distinguished in the development of soils and cultural layer of Moscow: (1) Natural pedogenesis in a forested landscape; (2) Anthropogenic transformation of the natural soils for arable and/or pastoral farming; (3) Burial of these soils under the cultural layer, their subsequent disturbance by digging and their gradual transformation by diagenetic processes; (4) Accumulation of the cultural layer with dispersed features of soil formation and with development of distinct soil horizons.

Data obtained attest to active accumulation of As, Cu, Pb, and other elements in the habitation deposits from 12-13th centuries with maximum in 17-19th centuries. The increased concentration of As was connected with the use of this element in the tanning and dyeing industries. Copper was used for domestic and horticultural pest control and as a ductile metal. Also, Blue vitriol may have been used to preserve timber for construction purposes. Pb in the 15-20th centuries was used for making household utensils and also for pipes and roof covering. Also, Pb-based paints were widely used from the 15th century.

Such are the results of our studies of the microelement composition of bone tissue belonging to women buried in the Middle Ages within the Moscow Kremlin and of habitation deposits in some parts of its territory. These data enable us to get an idea of the environment of palatial chambers where Russian ladies spent their life; in some cases we can learn the true causes of their death. But here's what we need for the understanding of all the factors impacting people's life: first, a more representative sample of data, and second, research findings on the remains of the urban population of different social and age groups. Relevant studies are underway now.

The data given in **Table 7** may serve by way of illustration. They show a more complex microelement composition of the bone tissue of man buried within the Kremlin and the St. Andronicus monastery compared with corresponding data on women buried in the vaults of the Ascension Cathedral. Since some of the monks must have been involved with icon painting, their organism accumulated toxic substances contained in the paints they were using.

X-ray fluorescence studies of the remains of children belonging to the families of grand princes and czars are of considerable interest too (**Table 8**).

They must have been living in an extremely unfavourable anthropochemical environment, or else have been administered toxic medication. We cannot rule out cases of premeditated poisoning in the course of power struggle at the court of Moscow sovereigns.

5. CONCLUSION

According to calibrated radiocarbon data, the Iron-Age hillforts in the centre of Moscow existed from the 8th century BC to the 6-7th century AD; the Medieval stage of Moscow settlement began in the 11th–12th centuries AD. The habitation deposits accumulated during the Middle Ages have an average thickness of about 3-5 m (up to 15 m in depressions of the initial relief) and are underlain by the Holocene paleosol. The layer of habitation deposits contains numerous traces of pedogenic processes and weakly developed buried soils. The underlying paleosol usually has the features attesting to its cultivation or even a well-developed plaggen horizon.

Continuous accumulation of municipal waste, construction material, paints, and other substances of anthropogenic origin resulted in considerable content of organic substances, carbonates, phosphorus and pollutants within the cultural layer. Their content at the depth of 1–3 m often exceeds that in the surface layer. Excavation works can lead to additional input of previously buried contaminants to the surface and serve as additional sources of pollution of urban environment.

Soils in Kremlin in 14-17th centuries were much cleaner than in the surrounding medieval town, where various industries were located. Nevertheless, concentrations of Pb, Cu, and Hg in the bones of grand Russian princesses and czarinas buried in Kremlin are much higher than those in the bones of women from the surrounding town. This resulted from living conditions of high-born women, which used white lead and other toxic elements as cosmetics and used toxic medications.

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