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PHOSPHORUS – AN INDICATOR OF THE MAN ACTIVITY IN PLEISTOCENE

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INTRODUCTION

Large amounts of phosphates may be accumulated in the contemporary soil cover as a result of intensive mineral nutrition [Soil Taxonomy 1975; Chojnicki and Czarnowska 1993] as well as following a long lasting soil-forming process, e.g., since the commencement of holocene [Konecka-Betley et al. 1985; Brogowski, Okołowicz 1986]. Overabundant concentrations of the element may also occur at the medieval archaeological objects, where diverse man activity took part as well as, over large area with contemporary activity of man [Marcinek, Wiślański 1959; Konecka-Betley et al. 1969; Brzeziński et al. 1983; Konecka-Betley, Okołowicz 1989; Banaszuk et al. 1996].

In this paper, there are presented results concerning of phosphorus content. The actual concentration of phosphorus, in the late Pleistocene fossil soils (paleosoils), can be seen as an indicator of the man activity. Different fractions of this macroelement bounded with Ca, Fe, Al – either labile or occluded, determine the properties of the environment [Czępińska-Kamińska 1994] while the excessive concentration of the element (much larger than that in the natural sediments) indicate the past presence of a longer or shorter man's activity of a diversified character.

OBJECT AND METHODS

The paleo-pedological study, including the analyses of the phosphorus amount, were conducted in fossil soils and loess – Vistulian sediments, from the area of a late Paleolithic archaeological site Spadzista C2 in Krakow (Table 1) [Konecka-Betley 1987]. Results of an earlier study carried out at the same site (Spadzista B and C1) were published as early as 1974 [Kozłowski] and 1975 [Kozłowski et al]. In those earlier studies, the paleo-pedological analyses were conducted by von Vliet and only trace amounts of phosphorus were found.

In the samples collected at the Spadzista C2 site, analyses were conducted of the content of mineral and organic phosphorus soluble in ammonia and oxalic acid.

TABLE 1. The content of various forms of P_2O_5 in mg/100 g of soil in upper paleolithic site – Cracow, Spadzista Street C_2

Stratigraphic layer	No of sample	P_2O_5 soluble in 0.5 N$(COOH)_2$		4% NH_4OH		Sum P_2O_5 soluble in 0.5N$(COOH)_2$ and 4% NH_4OH		
		mineral(1)	organic(2)	mineral(3)	organic (4)	mineral(5)	organic (6)	Σ(1+2+3+4)
2	1	56.4	4.4	2.6	1.3	59.0	5.7	64.7
3	2	59.3	3.6	2.1	0.2	61.4	3.8	65.2
4	3	65.1	2.3	1.4	0.0	66.5	2.3	68.8
	4	67.3	9.2	0.7	0.5	68.0	9.7	77.7
5	5	70.6	6.3	0.6	1.8	71.2	8.1	79.3
	6	74.6	5.2	1.2	1.7	75.8	6.9	82.7
	7	60.0	5.2	1.5	0.5	61.5	5.7	67.2
6	8	172.0	10.2	3.6	0.3	175.6	10.5	186.1
	9	594.3	108.3	26.9	14.4	621.2	122.7	743.9
	10	60.8	4.0	2.3	1.7	63.1	5.7	68.8
7	11	78.3	2.9	0.6	0.9	78.9	3.8	82.7
	12	73.9	3.7	1.0	0.5	74.9	4.2	79.1
8	–	–	–	–	–	–	–	–
9	13	70.6	5.9	0.7	0.6	71.3	6.5	77.8
	14	68.8	2.2	1.2	0.3	70.0	2.5	72.5
	15	72.5	1.1	1.6	0.3	74.1	1.4	75.5
10	–	–	–	–	–	–	–	–
11	16	45.4	2.9	0.5	0.7	45.9	3.6	49.5
12	17	56.4	2.2	0.6	0.6	57.0	2.8	59.8

TABLE 2. Selected physico-chemical and archaeological properties of stratigraphic layers

No of layers	No of sample	Depth [cm]	pH in KCl	$CaCO_3$ [%]	C	Mn [mg/kg of soil]	Zn	Cu	Archaeological level and ^{14}C age*	Soil and stratigraphic layers
2	1	+2.20	4.89	0.00	0,02	300	107	8		Bt
3	2	+2.00	4.85	0.00	0,04	337	35	5		C
4	3	+1.60	4.98	0.00	0,08	362	20	6		
	4	+1.30	6.97	1.99	0,08	375	20	6		
5	5	+1.00	7.12	4.55	0,04	325	50	18		Inicial soil?
	6	+0.70	7.12	5.13	0,08	350	20	8		
	7	+0.40	7.11	5.03	0,10	412	35	10	I	
6	8	+0.20	7.08	5.65	0.21	525	25	10	II	Brown gley arctic soil
	9	–0.00	7.06	3.92	0.45	425	17	15	III 24 000±180	with periglacial
	10	–0.20	7.12	1.83	0.25	337	55	18	IV	disturbances
7	11	–0.40	7.11	2.51	0.08	250	225	70	V 32 000±2000	Denekamp
	12	–0.50	7.16	3.66	0.04	275	30	32	> 42 100±1400	Hengelo
8	–	–	–	–	–	–	–	–		
9	13	–0.80	7.13	3.45	0.02	300	30	13		
	14	–1.00	7.15	3.35	0.02	375	30	15		
	15	–1.50	6.86	0.21	0.04	312	35	13		
10	–	–	–	–	–	–	–	–		
11	16	–1.90	7.04	2.77	0.13	487	29	11		Weakly developed soil
12	17	–2.40	7.06	3.19	0.05	425	30	32		Oderade, Amersförd

*[Kozłowski, Sobczyk 1987]

The analyses were done following the Gigel method as modified by Brogowski [1966]; 17 samples were collected from 9 layers of different depth. Out of these, three layers were represented by 3 samples (samples number 5, 6, 9) and two layers – by two samples (number 4 and 7) and the remaining layers were represented by single samples. Among the layers identified (number 5, 6 and 7), artifacts were found that allowed for determination of five different cultural horizons [Kozłowski and Sobczyk 1987]. The marking of horizons and samples was done with strict conformance to the earlier studies (carried out in the 1970-es) of the B and C1 Spadzista site. In all the samples collected there were determined: grain-size distribution, reaction, $CaCO_3$ content; besides, preliminary micromorphological study was carried out (its results were published earlier: [Kozłowski, Sobczyk 1987]).

RESULTS

The Spadzista C2 site is situated on Vistulian Eolithic sediments, partly transformed by water and partly – with admixture of sand [Konecka-Betley 1987]. Within this site neither early warta loess nor any other sediments were identified such that could have given the origin to the Eems interglacial soil [Chmielewski et al. 1977]. Considering the actual content of phosphorus readily soluble in oxalic acid and in ammonia in the Spadzista C2 site it was found that the least amounts of this element occur in the oldest horizons number 11 and 12 as well as, in horizons number 2, 3 and 4 situated in the ceiling. The content of mineral and organic phosphorus is relatively small within the limits commonly accepted for contemporary soils originated either from loess or dusty clay (from 49.5 to 68.0 mg/100 g of soil – Table 1). The content of phosphorus it the remaining samples from particular horizons is different. In horizon 9 there are definitely more than 70 mg/100 g of soil of this macroelement (from 72.5 to 77.8 mg). In horizons: 5 and 7 its concentration is even higher, and it reaches its maximum in layer 6: 743.9 mg/100 g of soil. Such high concentrations of phosphorus are connected with the presence of five cultural layers in the horizons under question.

There is a very small content of organic phosphorus soluble in oxalic acid and in ammonia as compared with the content of mineral phosphorus (usually 15...20 times less than mineral phosphorus). On the other hand, much more forms of organic phosphorus soluble in oxalic acid occur in horizon 6; in this layer its content is only 5 times less as compared with the mineral phosphorus: 108.3 mg/100 g of soil. Except of the enormously increased content of phosphorus in horizon 6, and particularly so in samples number 8 and 9, also the content of manganese is increased in this horizon (Table 2) comparing to the samples from the ceiling and the floor of this site. In horizon 7, however, a significantly increased concentrations of zinc (225 mg/kg of soil) and cupper (70 mg/kg of soil) occur in sample 11, as compared with the remaining samples.

DISCUSSION

The fact that increased concentration of phosphorus in archaeological objects is connected with the activity of man has been noticed long ago in the Scandinavia

[Brzeziński et al. 1983]. The studies on this element distribution made it possible to determine the distribution of medieval settlements and cemeteries thanks the observed fact that the significantly increased concentration of phosphorus accompanies such places, as compared with soil cover non-altered by the man of those times.

The research of the concentration of phosphorus in early medieval sites in Poland [Marcinek, Wiślański 1956; Konecka-Betley et al. 1969, Konecka-Betley, Okołowicz 1986] has been initiated since 1960's. It went back even to sites as old as dates 2000 years BP [Kołoząb – unpublished manuscript].

It was very recently that the concentration of both organic and mineral phosphorus was studied in fossil soils originated from Vistulian loess, in a late Paleolithic site Spadzista C2; in this site the activity of man is proved by artifacts [Kozłowski, Sobczyk 1987]. First of all, the distribution and concentration of this macroelement in five separated cultural layers was studied, as compared with the ceiling and the floor of the outcrop.

In the floor – horizons 11 and 12 – traces of a soil forming process are visible as; an increased concentration of carbon. This suggests the occurrence of a interim in loess sedimentation, some degree of stabilization of the surface and the invasion of poor vegetation. A poorly developed fossil soil may be identified here, of the A–C type of structure; it may be dated back to the after-Eems cooling of climate, that is the Odderade or, maybe, Amersförd, interstadial. In the soil no increased concentration of phosphorus was found; only the concentration of Mn and Fe were slightly increased [Konecka-Betley 1987]. This is a hydromorphic soil. The layer 10 was not analyzed. In layer 9, some admixture of sand in loess was found in the layer's ceiling (sample no 13) as well as decarbonization of its floor (sample 15), all these suggest the frost creep of this layer. The varying distribution of phosphorus in the three samples also confirms the displacement, and the amount of this element is somewhat higher as compared with the outcrop floor. Layer 8 was not subject to analyses but it was dated, using solely the ^{14}C method, for 42100 years BP± 1400 (that is: the Hengelo interstadial or, perhaps, the Moershoofd one?).

The cultural layers strictly connected with the activity of man were found in horizons 6 and 7. These horizons cover, first of all, a fossil soil or fossil soils – originated in the Denekamp interstadial – of the profile structure A - Bbr - C with the highest concentrations of P_2O_5 out of the entire site under study. Both horizons are shifted by solifluction for a short distance. Horizon 7 is equivalent with the Bbr horizon of an arctic brown soil, despite the occurrence of some amount of carbonates. This diagnosis is confirmed, first of all, by micromorphological analyses [Konecka-Betley 1987]. It was concluded on their basis that except of the silasepic type plasma characteristic for the processes of lithogenesis, also the lattisepic type plasma is present, typical for the processes of pedogenesis. In sample number 11 from this layer, also significantly high amount of zinc and cupper occur as well as, somewhat increased concentration of phosphorus (about 80 mg/100 g of soil) as compared with the outcrop floor. This last fact may suggest that, despite the Oryniacka culture artifacts, man was only rarely settled down in the area of interest. In layer 6, a distinctly marked phenomenon of solifluction occurs with four separate cultural levels, of age younger than Oryniak. This layer is built of stratified, gleyed loess, containing the highest concentration of carbon and both organic and mineral phosphorus. This layer is the most 'anthropogenized'

one because the concentration of phosphorus exceeds the level of 700 mg/100 g of soil.

The layer number 6 may be interpreted in two ways: either as an arctic brown soils horizon A shifted during periglacial conditions or as an arctic gley soil disturbed by solifluction that originates under the prevailing conditions of a very cool climate. This soil had fast transformed into the fossil soil and was subsequently conserved as a result of younger loess cover brought with wind (layer 5). The discriminated in the soil four cultural levels containing large amounts of artifacts and, also, the highest concentration of phosphorus, may suggest either a long-lasting or frequent living of the contemporary man in the area under question. Those could have been human's groups of hunters (bones of mammoth, cave-bear and polar fox were found [Kozłowski, Sobczyk 1987; Kubiak 1987; Kozłowski 1974; Kozłowski et al. 1975] frequently setting their settlements at the Spadzista site.

In layer 5, initial-stage of soil forming processes are present and the concentration of phosphorus resembles that in the outcrop floor. However, the layers 2 and 3 and, possibly, also 4, represent the bottom genetic horizons Bt and C of a decalcified lessive soil, present at the actual surface. Those layers do not contribute at all to the problem of phosphorus concentration.

CONCLUSIONS

1. High and very high concentrations of phosphorus at the Spadzista C2 site occur, first of all, in the cultural layers.
2. Layer 6 that is the one containing the largest concentration of phosphorus should be considered, following the above presented indices of soils anthropogenization [Konecka-Betley, Okołowicz 1989], as a very heavily deformed by the activity of man.

It seems, also, reasonable, to employ the concentration of some microelements in fossil soils as an indicator of the activity of man. However, because of the very little empirical support for this thesis (few studies were done so far) this statement cannot be treated as a fully justified conclusion.

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FOSFOR JAKO WSKAŹNIK DZIAŁALNOŚCI CZŁOWIEKA W PLEJSTOCENIE

Katedra Gleboznawstwa SGGW w Warszawie

STRESZCZENIE

Badania przeprowadzono w glebach kopalnych i osadach lessowych vistulianu z obszaru górnopaleolitycznego stanowiska archeologicznego Spadzista C2 w Krakowie.

W obrębie tego stanowiska nie stwierdzono występowania lessów starszych. W wydzielonych interstadialnych glebach kopalnych szczególną uwagę zwrócono na zwiększoną zawartość fosforu, traktując go jako wskaźnik bytowania człowieka. Znacznie większa w niektórych poziomach ilość fosforu wskazuje na dłuższą lub krótszą – ale różnorodną – działalność ludzką potwierdzoną także artefaktami. Największe nagromadzenie bowiem fosforu występuje przede wszystkim w warstwach kulturowych. Poziomy o największej zawartości tego składnika można potraktować jako silnie przekształcone antropogenicznie już w późnym plejstocenie.

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