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Allotigenic and allotigenic accessory trace element contents in different age soil of glaciolacustrine basins

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The distribution of allotigenic elements (AE) (Li, B, Ga, Sc, Ni, Cr, Co, V, Rb) and allotigenic accessory elements (AAE) (Y, Yb, La, Ti, Zr, Nb) in sandy, sandy loamy or loamy-clayey soil of five glaciolacustrine basins was studied to recognise differences in total contents of these trace elements mainly as a result of the different duration of weathering and composition of parent material. Weathering in the Simnas–Balbieriškis basin of the South Lithuanian phase was the longest, in the Venta, Jūra–Šešupė and Kaunas–Kaišiadorys basins of the Middle Lithuanian phase was shorter, and in the Mūša basin of the North Lithuanian phase the shortest. The difference in the duration of weathering is well reflected in sandy soil; it explains most of the significant differences in the content of trace elements and indicates the tendency of a decrease of most AEs and an increase of most AAEs with soil age, while sandy loamy or loamy-clayey soils do not show any significant dependence on weathering duration; the tendencies of variation of most AEs as soil age increases, are opposite compared to sandy soil, and the variation of the contents of AAEs is less expressed, except an increase of Nb. This is predetermined by a more difficult infiltration through these types of soil. Most of the significant differences in AE contents in sandy loamy or loamy-clayey soil of different basins can be explained by the lithological influence of the prevailing type of surface glaciolacustrine sediments (clay or coarser sediments) and the mineralogical influence of the main minerals of surface glaciolacustrine clay (illite and kaolinite), which depend on the material brought by different glacier lobes.

Key words: allotigenic elements, allotigenic accessory elements, soil, duration of weathering, glaciolacustrine sediments, hydromica, kaolinite

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INTRODUCTION

The variation of background values among soil regions (Kadūnas et al., 1999) indicates that there are territorial geochemical differences of the surface layer of Lithuanian soil. The grain-size composition of soil and its parent material has the most important influence on trace element contents in soil (Baltakis, 1993). But this is not the only factor that influences the chemical composition of soil. There are many such factors defined by V. Dokuchaev (parent material, flora and fauna, climate, relief, and age) and supplemented by Dobrovolskii (surface water, groundwater and anthropogenic activity) (Dobrovolskii, 1989). Therefore, one has to take into account not only the type of parent material (grain-size and mineral composition, origin), but also climate and age factors. Thus, it should be accounted for that trace element contents in the soil can slightly reflect paleoclimate conditions, although they do not help in restoring the history of climate change. The influence of paleoclimate on soil is manifested through the difference in weathering duration, i. e. soil age. This influence on trace element content in Lithuanian soils has been analysed by comparing the soil region of penultimate glaciation located in Ašmena Highlands and Lyda Plateau with other soil regions in the areas of the last glaciation (Kadūnas et al., 1999). The minimum median content of Li, B, Ga, V, Cr, Co, Ni, Cu, Sn, Y, Yb, La, Sc, Rb in sandy loamy and loamy-clayey soil and the maximum median content of P, Mn, Ag, Zr and Nb in all types of mineral soil is characteristic of the former region that can be explained in terms of a more protracted duration of weathering (Kadūnas et al., 1999). A longer duration of weathering results in increased contents of *allothigenic accessory elements* which are related to weathering-resistant heavy minerals (that accumulate during weathering) and decreased contents of *allothigenic elements* (AE) related to less resistant to weathering minerals and finest fractions of soil (these elements are washed out during weathering). Earlier investigations revealed Y, Yb, La, Ti, Zr, Nb to belong to AAEs and Li, B, Ga, Sc, Ni, Cr, Co, V, Rb to AEs (Kadūnas et al., 1999). AAEs have been investigated in different age soil regions of the Ašmena Highlands, Lower Nemunas Plain and Mūša–Nemunėlis Plain (Vareikienė et al., 2008), however, the genesis of the parental material was not taken into account. The goals of the present study were: 1) identification of the relationship of AE and AAE contents with the age of soil of the same grain-size type on the parental material of the same genesis – glaciolacustrine sediments of proglacial basins; 2) interpretation of differences revealed among soils of various basins mainly as a result of unequal duration of weathering or peculiarities of parent rocks.

OBJECTS, METHODS AND DATA SOURCES

Five glaciolacustrine basins of different age were selected for the study: Simnas–Balbieriškis of South Lithuanian (SL) phase, the Venta, Jūra–Šešupė and Kaunas–Kaišiadorys of Middle Lithuanian (ML) phase, and the Mūša of North Lithuanian (NL) phase (Fig. 1). Geochemical data of sandy, sandy loamy and loamy-clayey soil samples collected from these basins for the Geochemical Atlas of Lithuania (Kadūnas et al., 1999) were used for comparative analysis. The above-listed six AAEs and nine AEs were analysed in more detail. The methods of sampling and analysis are described elsewhere (Kadūnas et al., 1999). Using the U-test (Corder, Foreman, 2009), significant (at $p = 0.05$) differences of the total contents of these elements were identified for each type of soil of different basins. The concentration coefficients were calculated for each sample in comparison with the element background values of a respective soil type on

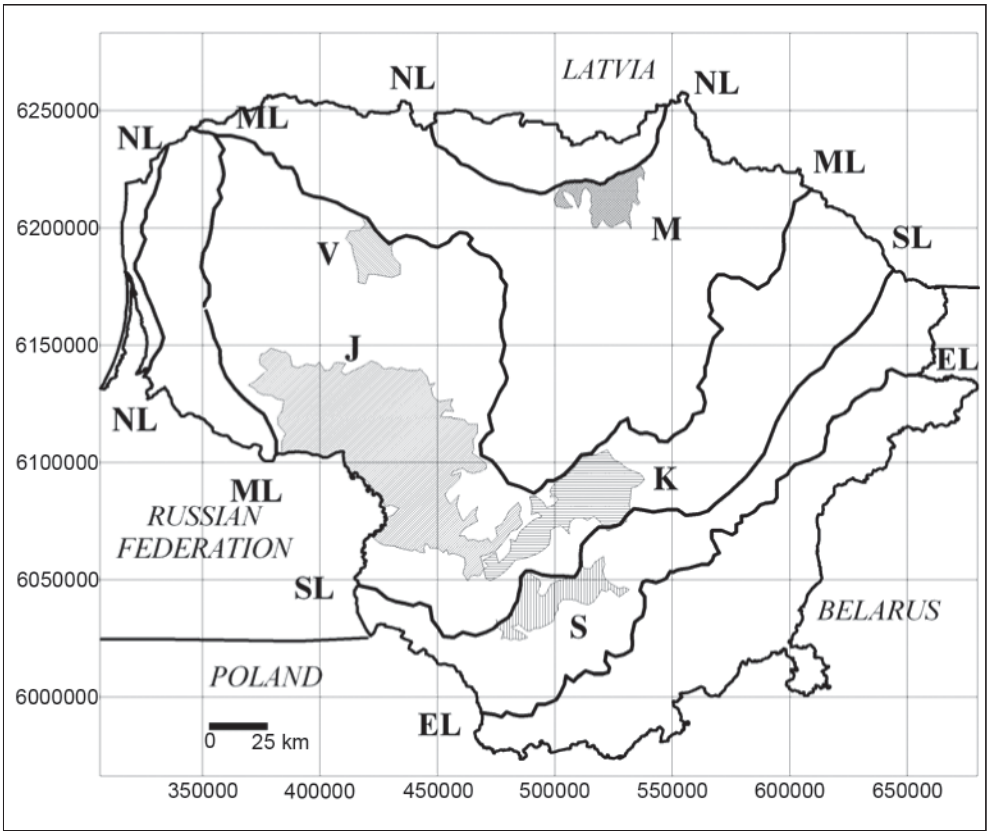

Fig. 1. Glaciolacustrine basins studied:
M – Mūša basin of North Lithuanian phase (NL), S – Simnas–Balbieriškis basin of South Lithuanian phase (SL), Middle Lithuanian phase (ML) basins: V – Venta, J – Jūra–Šešupė, K – Kaunas–Kaišiadorys. EL – East Lithuanian phase. Boundaries of phases after (Gaigalas, 2001)

1 pav. Tirti limnoglacialiniai baseinai:
M – Šiaurės Lietuvos fazės (NL) Mūšos baseinas, S – Pietų Lietuvos fazės (SL) Simno-Balbieriškio baseinas, Vidurio Lietuvos fazės (ML) baseinai: V – Ventos, J – Jūros-Šešupės, K – Kauno-Kaišiadorių. EL – Rytų Lietuvos fazė. Fazių ribos pateiktos pagal (Gaigalas, 2001)

glaciolacustrine sediments (Kadūnas et al., 1999). Then the median values of the concentration coefficients *Kkm* for each soil type of a basin were estimated. The average *AKkm* values in three basins of the ML phase were calculated.

RESULTS

Sandy soil

The *Kkm* values of almost all AEs except Ga in the oldest sandy soil of the Simnas–Balbieriškis basin are lower than in the youngest sandy soil of the Mūša basin (Fig. 2). Five AEs (V, Cr, Ni, Sc ir Rb) are characterised by the relationship *Kkm(SL) < AKkm(ML) < Kkm(NL)* indicating a decrease of AE contents with increasing soil age. Significantly higher contents of some AEs in soil of the NL phase basin in comparison with the SL phase basin or with one of the ML phase basins can be explained by weathering (Table 1). However, the contents of B and V, on the contrary, are significantly lower in the younger soil of the Kaunas–Kaišiadorys basin compared to the older sandy soil of the Simnas–Balbieriškis basin. This relationship cannot be explained by weathering. Unlike AE, the weathering can explain the increase of AAE contents by an increase of soil age. It is supported by the following facts: 1) the *Kkmed* values of Ti, Zr, Nb and La in the oldest sandy soil of the Simnas–Balbieriškis basin are higher than in the youngest sandy soil of the Mūša basin (Fig. 2); 2) three AAEs (Nb, Ti, La) are characterised by the relationship *Kkm(SL) > AKkm(ML) > Kkm(NL)*. A direct relationship of AAEs with soil age is especially distinct for Nb. Some significant differences in AAEs (Nb, Zr, La) between the oldest and the youngest soil or soils of less age differences can be explained by weathering. However, significantly higher contents of Y and Yb in the youngest soil compared to the older soil cannot be explained by the duration of weathering. Significant differences in AE or AAE contents in sandy soil of similar age also need explanation.

Sandy loamy soil

By contrast with sandy soil, there is a direct relationship between most of AE contents and soil age: 1) the *Kkm* values of almost all AEs except Sc, in the oldest sandy loamy soil of the Simnas–Balbieriškis basin are higher than in the youngest sandy loamy soil of the Mūša basin (Fig. 3, *A*), 2) five AEs (V, Cr, Co, Ni and Rb) are characterised by the relationship *Kkm(SL) > AKkm(ML) > Kkm(NL)*. A significantly higher content of Sc in the youngest soil of the Mūša basin compared to the older Kaunas–Kaišiadorys basin is the only significant difference that can be explained by a different duration of weathering. However, significantly higher contents of other AE in oldest soils compared to younger as well as significant

Table 1. **Interpretation of significant geochemical differences among soils of glaciolacustrine basins**
1 lentelė. **Limnoglacialinių baseinų dirvožemių reikšmingų geocheminių skirtumų interpretavimas**

	M	V	J	K	S
			Sandy soil		
M	x	**B, Sc** (w), Yb (a, l)	**Sc, Rb** (w, l), Y (a)	**B, V, Cr, Co, Ni, Sc, Rb** (w, l)	**Co, Ni, Sc, Rb** (w), Yb (a, l)
V	–	x	–	**Ga** (l)	–
J	Nb (w, l)	Nb (l)	x	**B, Ga, V, Cr** (l)	–
K	–	Zr, Nb (l)	–	x	–
S	Nb (w)	Zr, Nb (w)	–	**B, V** (l), La (w)	x
			Sandy-loamy soil		
	M	**V**	**J**	**K**	**S**
M	x	–	–	**Sc** (w, l)	–
V	–	x	**Rb** (l)	–	–
J	–	–	x	**B, V** (l, m)	–
K	–	–	–	x	–
S	**Co** (l, m)	–	**Sc, Rb** (l, m)	**B, V, Co, Sc, Rb** (l, m)	x
			Loamy-clayey soil		
	M	**V**	**J**	**K**	**S**
M	x	**B, Ga** (w), Yb (a, l)	–	–	–
V	–	x	–	–	–
J	**B, V, Cr** (m), Nb (w, l)	**B, Ga, V, Cr** (m)	x	–	–
K	**B** (m), Nb (w, l)	**B**	–	x	–
S	**B, V** (l, m)	**B, Ga, Cr** (l, m), Yb (w)	**Li, Ni** (l, m)	–	x

Explanations. M – Mūša basin of North Lithuanian phase, S – Simnas–Balbieriškis basin of South Lithuanian phase, Middle Lithuanian phase basins: V – Venta, J – Jūra–Šešupė, K – Kaunas–Kaišiadorys. Significant differences are given only for AEs (in bold) and AAEs. The element written in the cell of the table means that its content in the basin, indicated in the row is significantly higher than in the basin indicated in the column. x – cannot be compared. Possible reasons for significant differences: w – weathering duration is different, a – agricultural impact, l – lithological influence of the prevailing type of surface glaciolacustrine sediments, m – mineral composition of glaciolacustrine clays.

Paaiškinimai. M – Šiaurės Lietuvos fazės Mūšos baseinas, S – Pietų Lietuvos fazės Simno-Balbieriškio baseinas, Vidurio Lietuvos fazės baseinai: V – Ventos, J – Jūros-Šešupės, K – Kauno-Kaišiadorių. Pateikti tik AE (jie paryškinti) ir AAE reikšmingi skirtumai. Lentelės ląstelėje įrašytas elementas reiškia, kad jo kiekis eilutėje nurodytame baseine reikšmingai didesnis nei stulpelyje nurodytame baseine. x – nelyginama. Galimos reikšmingų skirtumų priežastys: w – nevienoda dūlėjimo trukmė, a – žemės ūkio poveikis, l – vyraujančio paviršinių limnoglacialinių nuogulų tipo litologinis poveikis, m – limnoglacialinio molio mineralinės sudėties poveikis.

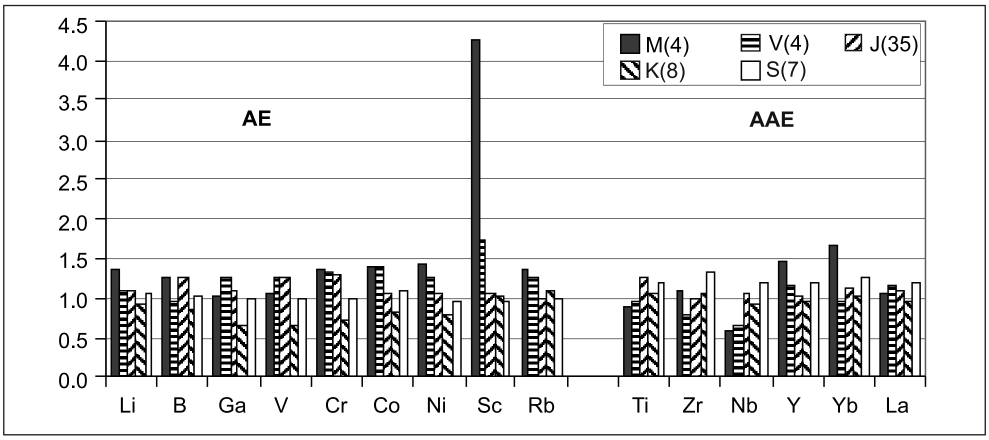

Fig. 2. Median values of concentration coefficients of allothigenic and allothigenic accessory trace elements in sandy soils of different glaciolacustrine basins:
M – Mūša basin of North Lithuanian phase, S – Simnas–Balbieriškis basin of South Lithuanian phase, Middle Lithuanian phase basins: V – Venta, J – Jūra–Šešupė, K – Kaunas–Kaišiadorys. The number of samples is in parentheses. AE – allothigenic elements, AAE – allothigenic accessory elements

2 pav. Alotigeninių ir alotigeninių akcesorinių mikroelementų koncentracijos koeficientų medianos smėlio dirvožemiuose iš įvairių limnoglacialinių baseinų:
M – Šiaurės Lietuvos fazės Mūšos baseinas, S – Pietų Lietuvos fazės Simno-Balbieriškio baseinas, Vidurio Lietuvos fazės baseinai: V – Ventos, J – Jūros-Šešupės, K – Kauno-Kaišiadorių. Skliaustuose nurodytas mėginių skaičius. AE – alotigeniniai elementai, AAE – alotigeniniai akcesoriniai elementai

differences among the ML phase basins cannot be explained by weathering. Though less expressed (no significant differences), the prevailing tendency of AAE variations, as sandy loamy soil is older, is the same as in sandy soil (Fig. 3, *A*): 1) most of AAE (Ti, Nb, Yb, La) have higher *Kkm* values in the oldest sandy loamy soil of the Simnas–Balbieriškis basin compared to the youngest sandy loamy soil of the Mūša basin, 2) two AAEs (Ti and Nb) are characterised by the relationship *Kkm(SL) > AKkm(ML) > Kkm(NL)*. Although Zr and Y have a lower *Kkm* in the oldest sandy loamy soil of the Simnas–Balbieriškis basin as compared to the youngest Mūša basin, this difference is not statistically significant.

Loamy-clayey soil

Like sandy loamy soil, the loamy-clayey soil shows a direct relationship between AE contents and soil age: 1) the *Kkm* values of all AEs in the Simnas–Balbieriškis basin are higher than in the youngest loamy-clayey soil of the Mūša basin (Fig. 3, B), 2) B, V, Cr, Sc are characterised by the relationship *Kkm(SL) > AKkm(ML) > Kkm(NL)*. A significant difference in AE contents, which can be explained by a different duration of weathering, is recognised only for the Mūša and the Venta basins. A direct relationship of AAE content with soil age is not well expressed: 1) only the contents of Ti, Nb in the oldest soil of the Simnas–Balbieriškis basin are higher than in the youngest soil of the Mūša basin; 2) only Nb is characterised by the relationship *Kkm(SL) > AKkm(ML) > Kkm(NL)*. The number of significant differences according to AAE content in loamy-clayey soil of various basins is small (only for Nb and Yb). Almost all of them can be explained by weathering, except a significantly higher content of Yb in the youngest Mūša basin compared to the older Venta basin.

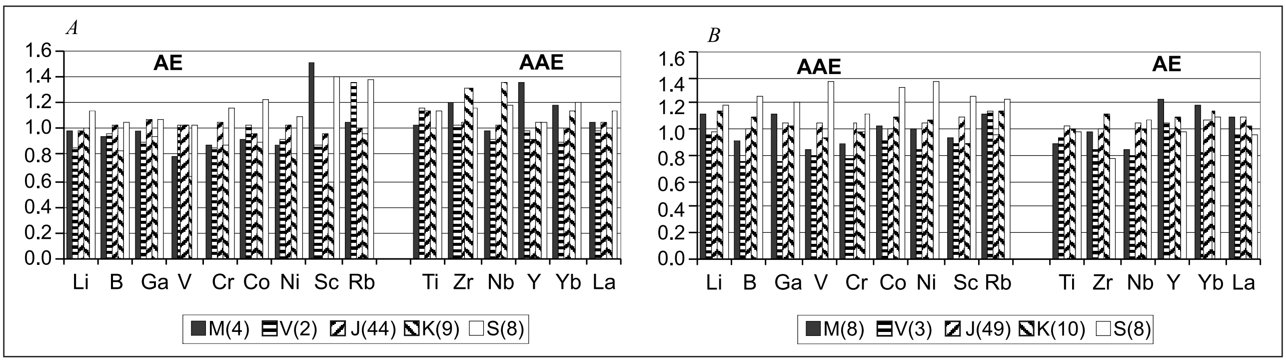

Fig. 3. Median values of concentration coefficients of allothigenic and allothigenic accessory trace elements in sandy loamy (*A*) and loamy clayey (*B*) soil of different glaciolacustrine masins. For explanations, see Fig. 2.

3 pav. Alotigeninių ir alotigeninių akcesorinių mikroelementų koncentracijos koeficientų medianos priesmėlio (*A*) ir priemolio-molio (*B*) dirvožemiuose iš įvairių limnoglacialinių baseinų. Paaiškinimus žr. 2 pav.

DISCUSSION

Most of significant differences of AE in sandy soil of different age (except the significantly higher B and V in the Simnas–Balbieriškis basin compared to the Kaunas–Kaišiadorys basin) can be explained by a different duration of weathering. The relationship of AE content to soil age in sandy loamy or loamy-clayey soils of glaciolacustrine basins is opposite to that of sandy soil and thus cannot be explained by weathering. An increase of AAE content with soil age is most distinct also in sandy soil, but only for some AAEs. In this sense, AAEs are less informative as indicators of weathering duration, except for Nb.

The results of the present study were compared with AAE and AE regularities in sandy loamy and loamy-clayey soil formed on the basal till of various phases of the last glaciation (Kadūnas et al., 1999). To reveal the latter regularities, the median values of the elements were divided by background values. As regards AAEs, they were also less informative indicators of weathering duration than AEs. The expected tendency of the lowest *Kkm* in soil from NL phase areas and the highest *Kkm* in soil from SL phase areas was observed in sandy loamy soil only for Ti, Nb and La (Fig. 4, *A*), while in loamy-clayey soil only for Y and Zr (Fig. 4, *B*). However, a decrease of the contents of AE with the increasing duration of weathering was manifested in sandy loamy or loamy-clayey soil on basal till much more clearly as compared with analogous types of soil on glaciolacustrine sediments. In sandy loamy soil it was distinct for Li, Ga, Rb, Co, Cr, V, in loamy-clayey soil for Li, Ga, Rb, Sc. The Li, Rb, Ga group is most likely related to mica. During weathering of mica, these elements were washed out from soil formed on basal till. However, in sandy loamy or loamy-clayey soil formed on glaciolacustrine sediments this outwash was probably lower. As the relationship with soil age is even opposite than in respective types of soil on basal till, it is necessary to look for other reasons to explain this fact.

Differences among various grain-size types of soil in AE contents with regard to the duration of weathering can be explained by an easier infiltration of water in sandy soil, which results in a faster AE outwash from sandy soil than from sandy loamy or loamy-clayey soil. Therefore, the weathering effect is much more pronounced in sandy than in sandy loamy or loamy-clayey soils. However, this mechanism does not explain the increase of AE contents in sandy loamy and loamy-clayey soil as their age increases. Besides, other mechanisms should be considered to explain significant differences of AE or AAE contents in all types of soil of different basins. There are three possible reasons: 1) inconsistent subdivision of elements into AE and AAE groups, 2) influence of agricultural activities, 3) differences in trace element composition of different glaciolacustrine sediments. The first two reasons explain significant differences in Y and Yb. Sometimes, the prevailing mode of occurrence of these elements is not related to weathering-resistant minerals (Baltakis, 1993); besides, part of them might be agrogenic due to application of phosphorous fertilisers (Vareikienė, 1998), especially near Pasvalys and Joniškėlis. This explains the significantly higher contents of Y and Yb in sandy and loamy-clayey soil of the youngest Mūša basin compared with older basins. The third reason has several explanations: 1) different prevailing lithology in the surface layer of glaciolacustrine basins, which depended on sedimentation conditions in the final stage of development of proglacial lakes; 2) differences in contents of main clay minerals derived from different glacial lobes and deposited in different glaciolacustrine basins.

The different lithology of glaciolacustrine basins depended on sedimentation conditions which were partly deter-

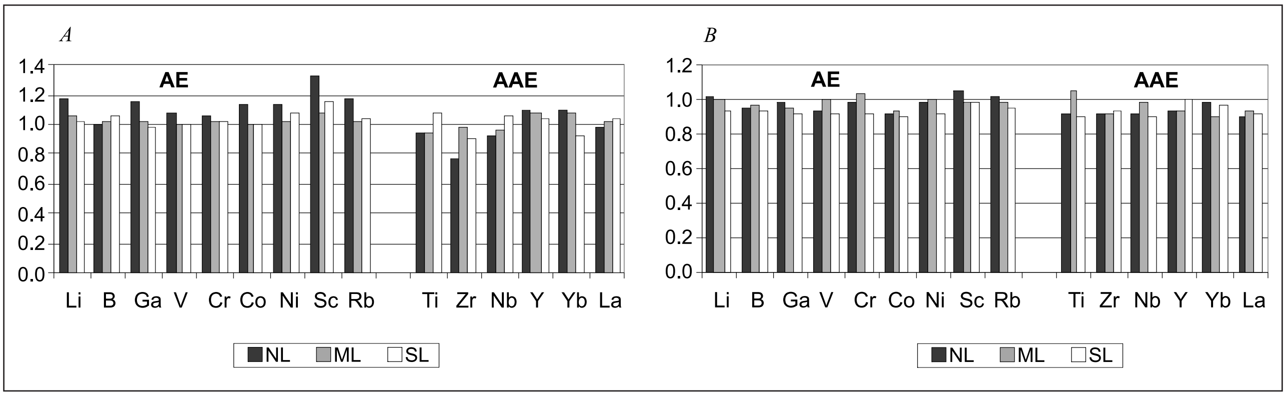

Fig. 4. Median values of concentration coefficients of allothigenic and allothigenic accessory elements in sandy-loamy (*A*) and loamy-clayey (*B*) soil formed on different age basal till.
Soil formed on different age basal till: NL – North Lithuanian phase, ML – Middle Lithuanian phase, SL – South Lithuanian phase. AE – allothigenic elements, AAE – allothigenic accessory elements. For explanations, see Fig. 2.

4 pav. Alotigeninių ir alotigeninių akcesorinių mikroelementų koncentracijos koeficientų medianos priesmėlio (*A*) ir priemolio-molio (*B*) dirvožemiuose, susiformavusiuose ant skirtingo amžiaus dugninės morenos.
Dirvožemiai, susiformavę ant skirtingo amžiaus dugninės morenos: NL – Šiaurės Lietuvos fazės, ML – Vidurio Lietuvos fazės, SL – Pietų Lietuvos fazės. AE – alotigeniniai elementai, AAE – alotigeniniai akcesoriniai elementai. Paaiškinimus žr. 2 pav.

Table 2. **Illite and kaolinite percentage in surface glaciolacustrine clay**
2 lentelė. **Hidrožėrutis ir kaolinitas baseinų paviršiniame limnoglacialiniame molyje**

Intervals of IL	**Number of clay samples in the intervals for each basin**					**Intervals of KAO**	**Number of clay samples in the intervals for each basin**				
	M	**V**	**J**	**K**	**S**		**M**	**V**	**J**	**K**	**S**
85–90%			4	3		5–10%		**6**	1	1	
80–85%		**4**	**22**	3	**9**	10–15%			**18**	**6**	**9**
75–80%		2	9	**5**	4	15–20%		1	11	**6**	4
70–75%	**2**	1	8	**5**		20–25%	**2**		14	3	
65–70%	1		1	1		25–30%	1			1	
N	3	7	44	17	13	N	3	7	44	17	13
WAP	70.8%	79.6%	79.8%	78.1%	81.0%	WA	24.2%	8.9%	16.8%	16.7%	14.0%

Explanation. Table is compiled after data by V. Mikaila, G. Juozapavičius and R. Malskaitis referred in (Kazakauskas, 2000). Basins: M – Mūša, V – Venta, J – Jūra–Šešupė, K – Kaunas–Kaišiadorys, S – Simnas–Balbieriškis. IL – illite, KAO – kaolinite, N – number of clay samples from the basins, WAP – weighted average percentage. Number of clay samples in the modal percentage intervals is in bold. According to the descending WAP of illite, the basins can be arranged in the sequence S > J > V > K > M and according to the ascending WAP of kaolinite in the sequence V < S < K < J < M.

Paaiškinimas. Lentelė sudaryta pagal V. Mikailos, G. Juozapavičiaus ir R. Malskaičio duomenis (Kazakauskas, 2000). Baseinai: M – Mūšos, V – Ventos, J – Jūros-Šešupės, K – Kauno-Kaišiadorių, S – Simno-Balbieriškio. IL – hidrožėrutis, KAO – kaolinitas, N – molio mėginių iš baseinų skaičius, WAP – svertiniai procentiniai vidurkiai. Modaliniuose procentiniuose intervaluose paryškinti molio mėginių skaičiai. Hidrožėručio WAP mažėjimo tvarka baseinus galima išrikiuoti S > J > V > K > M, o kaolinito WAP didėjimo tvarka – V < S < K < J < M.

mined by the climate change. The grain-size composition of glaciolacustrine sediments depended on the annual and seasonal changes of sedimentation, on the character of sediment input into a lake, and on the conditions of the sedimentation environment (Kazakauskas, 2000). The grain-size composition of glaciolacustrine clay varies in different basins as well as in different parts of an individual basin. The sequence of glaciolacustrine varved sediments reflects the sedimentation conditions determined by paleoclimate which has been reconstructed in different glaciolacustrine basins (Kazakauskas, Gaigalas, 2004).

According to the Quaternary geological map of Lithuania (Guobytė, 2002) with generalised areas of the spreading of clay or coarser sediments on the surface of glaciolacustrine basins, the percentage of soil samples in the areas with prevailing clay was estimated. According to this percentage, the basins are arranged as follows: Simnas–Balbieriškis (70%), Venta (67%), Mūša–Nemunėlis (56%), Jūra–Šešupė (45%) and Kaunas–Kaišiadorys (38%). The arrangement of the basins according to coarser sediments is opposite. Supposing that clay is enriched with AEs and has a lower AAE content in comparison with coarser sediments, the higher the percentage of soil samples from areas where glaciolacustrine clay prevails, the higher should be the content of AEs and the lower the content of AAEs in the soil of a basin. As regards AEs, the prevailing lithology of the basins explains all their significant differences in sandy loamy soil, which could not be explained by the various duration of weathering. Most of the significant differences of AE content in sandy soil and some in loamy-clayey soil can be explained by the same reason (Table 1). As concerns AAEs, the lithological reason also explains some of the significant differences in sandy soil and some in loamy-clayey soil.

Significant differences in AE contents in sandy loamy or loamy-clayey soil can also be explained by the varying mineral composition of clay derived from different glacier lobes. Montmorillonite is characterised by the highest sorption capacity compared to other soil clay minerals, followed by illite, while kaolinite has the lowest sorption capacity (Dobrovolskii, 1989). Investigations of clay minerals of the basins by V. Mikaila, G. Juozapavičius and R. Malskaitis have shown that illite prevails, followed by kaolinite, while the content of chlorite is much lower, and montmorillonite is found only in some sites. Therefore, the AE contents are supposed to increase, as the content of illite grows and the content of kaolinite decreases. Studies of these two clay minerals in all basins show a distinct difference in material derived from various glacier lobes. The weighted average percentage of illite in basins located in the east (Kaunas–Kaišiadorys and Mūša) is lower than in those located in the west, while kaolinite, on the contrary, shows a higher concentration in the former two basins (Table 2). Therefore, the clay mineral composition, and consequently AE content in basins of the same phase, can differ more than clay in basins of different phases. Geochemical investigations in other countries have also shown that there might be greater differences depending on location than on age (Lukashev, 1970).

The Mūša basin of the NL phase is characterised by the lowest weighted average percentage (WAP) of illite and the highest WAP of kaolinite (Table 2). This explains significantly lower contents of some AEs in sandy loamy (Co) and loamy-clayey (B, V, Cr) soils of this basin than in the older soils (Table 1). The highest WAP of illite in the Simnas–Balbieriškis basin explains the significantly higher AE content in sandy loamy or loamy-clayey soil of this basin compared to the younger basins. However, the mineralogical interpretation of differences in AE content in sandy loamy or loamy-clayey soils in various ML phase basins (Table 1) is not always possible. The same concerns significant differences between ML and NL phase basins. As a rule, there are several reasons explaining significant differences, but not all of them were taken into account due to lack of data. For example, a significantly higher content of B in the loamy-clayey soil of the Kaunas–Kaišiadorys basin compared with the Venta basin cannot be explained by the above-mentioned reasons.

CONCLUSIONS

Soil of different glaciolacustrine basins differs in AE and AAE content. The different duration of weathering is well reflected in sandy soil, it explains most of significant differences in the content of these elements, most of AEs decreasing in concentration while most of AAEs increasing in the contents with soil age. Differences in weathering duration are masked in sandy loamy and loamy-clayey soil of these basins; the age trend of the content of most AEs, except Sc, is opposite to that of sandy soil, while the trend of AAEs is less manifested, except a distinct decrease of Nb content. The minor impact of weathering is related to a slow infiltration of water in sandy loamy and loamy-clayey soil. Most of the significant differences in AE content in sandy loamy and loamy-clayey soils of different basins can be explained by differences in their lithological composition (clay vs. coarser sediments) and clay mineral composition of glaciolacustrine basins (illite vs. kaolinite), depending on the material derived from different glacier lobes. Most of the significant differences in AE content in soils of various glaciolacustrine basins of the ML phase can be explained by these reasons.

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ALOTIGENINIŲ IR ALOTIGENINIŲ AKCESORINIŲ MIKROELEMENTŲ KIEKIAI SKIRTINGO AMŽIAUS LIMNOGLACIALINIŲ BASEINŲ DIRVOŽEMIUOSE

Santrauka

Nagrinėjami alotigeninių mikroelementų (AM: Li, B, Ga, Sc, Ni, Cr, Co, V, Rb) ir alotigeninių akcesorinių mikroelementų (AAM: Y, Yb, La, Ti, Zr, Nb) bendrųjų kiekių skirtumai penkių limnoglacialinių baseinų smėlio, priesmėlio ir priemolio-molio dirvožemiuose. Tyrimo tikslai – išsiaiškinti, kaip AM ir AAM kiekiai siejasi su dirvožemio amžiumi tos pačios mechaninės sudėties dirvožemiuose ant vienodos genezės dirvodarinių uolienų, t. y. limnoglacialinių prieledyninių baseinų nuogulų, ir interpretuoti nustatytus skirtumus pirmiausiai remiantis dūlėjimo trukmės ir dirvodarinių uolienų skirtumais. Dirvožemiai Simno-Balbieriškio baseine, susiformavusiame Pietų Lietuvos fazės metu, dūlėjo ilgiausiai, Ventos, Jūros-Šešupės ir Kauno-Kaišiadorių baseinuose, susiformavusiuose Vidurio Lietuvos fazės metu, – trumpiau, o Mūšos baseine, susiformavusiame Šiaurės Lietuvos fazės metu, – trumpiausiai. Smėlio dirvožemiuose gerai atsispindi dūlėjimo trukmės įvairovė, kuri paaiškina daugelį reikšmingų skirtumų tarp minėtų elementų kiekių ir rodo daugumos AM kiekių mažėjimo bei daugumos AAM kiekių didėjimo tendencijas. Šių baseinų priesmėlio bei priemolio-molio dirvožemiuose dūlėjimo trukmės skirtumai beveik neatsispindi, daugelio AM kiekių kaitos tendencijos, ilgėjant dirvožemio amžiui, yra priešingos nei smėlio dirvožemiuose, o AAM kiekių – mažiau išreikštos, išskyrus Nb kiekių mažėjimą. Mažesnį dūlėjimo pasekmių atspindį priesmėlio ir priemolio-molio dirvožemiuose lėmė lėtesnė vandens infiltracija pro šiuos dirvožemius, lyginant su smėlio dirvožemiais. Daugelį reikšmingų skirtumų tarp AM kiekių įvairių baseinų priesmėlio bei priemolio-molio dirvožemiuose paaiškina vyraujančių limnoglacialinių nuogulų (molio ar rupesnių nuogulų) litologinis poveikis ir paviršinio limnoglacialinio molio pagrindinių mineralų (hidrožėručio ir kaolinito), priklausančių nuo įvairių ledyno plaštakų atnešamos medžiagos, procentinis kiekis.

Raktažodžiai: alotigeniniai ir alotigeniniai akcesoriniai mikroelementai, dirvožemis, dūlėjimo trukmė, limnoglacialinės nuogulos