A New Effective Method to Assess of Fossil Spore-Pollen Spectra and Past Environment

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With the purpose of assessing fossil spore-pollen spectra (SPS) the author has introduced an absolutely new criterion – **Similarity Index (SI).** This is the criterion, which allows to express an objective connection, which exists between fossil SPS components and corresponding components of modern surface samples. The Similarity Index can be calculated for any taxon of fossil SPS, but provided that the research of sediment samples, surface samples and modern vegetation is carried out in conjugation. This index is calculated with the formula: **X/Y = SI,** where:
X is the percentage content of pollen and spore of any taxon in the composition of a fossil SPS sample;
Y is the percentage content of the same taxon in the composition of a recent SPS sample;
SI is Similarity Index.
With the use of the above formula the Similarity Index can be calculated for any of the components of fossil SPS (Table 1). The table 1 gives an evident illustration of the calculation method.
Tab. 1. Similarity Indices calculated for tree pollen, including long distance blown pollen (*Picea abies, Pinus sibirica, P. sylvestris*) (Ukraintseva 2005, in print).

	Pollen								
Sample, No.	Trees			*Larix dahurica* s.l.			Long distance blown pollen		
	Number	%	**SI**	Number	%	**SI**	Number	%	**SI**
1,surface sample	78	18,6	**1**	53	12,6	**1**	25	5,9	**1**
2, peat	91	16,0	**0, 86**	68	12,0	**0, 95**	23	4,0	**0, 67**
3, peat	63	20,0	**1, 07**	42	13,4	**1, 06**	21	6,6	**1, 1**
4, peat	60	13,4	**0, 72**	50	11,2	**0, 88**	10	2,2	**0, 37**
5, peat	18	4,6	**0, 25**	14	3,6	**0, 28**	4	1,0	**0, 17**
6, peat	14	4,3	**0, 23**	12	3,7	**0, 29**	2	0,6	**0, 10**
7, peat	29	5,9	**0, 32**	28	5,7	**0, 45**	1	0,2	**0, 03**
8, peat	20	4,2	**0, 22**	19	4,0	**0, 32**	1	0,2	**0, 03**
9, loamy sand	31	5,9	**0, 31**	17	3,3	**0, 26**	14	2,6	**0, 44**

Since the SPS composition of modern surface samples is a model, the content in percentages of any of the SPS components of modern surface samples is equal to 1. In other words the Similarity Index of any of the SPS components of modern surface samples is a constant value and equal 1 (see Table 1). In the numerical form it is a decimal fraction, expressed in the following way: **SI is ≥ 0;** graphically it is a point with the coordinate axes. On the basis of the data obtained from calculations with the use of the above formula the Similarity Index Graphs are built. The introduced index allows to make an assessment of fossil SPS on the level of zones and on the phytocoenotic levels. The use of the Similarity Index helps to reconstruct paleogeographic phenomena and events in time and in space with more confidence, and, consequently, to make a better correlation of sediment sequences, containing fossil SPS.

The new offered method of fossil SPS assessment has been practically used with the data obtained as a result of investigation of a series of samples taken from deposits of a specific geological section. The location of the section is the northern part of the Anabar Upland, the left bank of the Fomich River, the 2nd upper flood-land terrace (71 ^{0} 42' N, 108 ^{0} 03' E). The formation of this terrace was taking place throughout the entire Holocene. 10500 +/- 140 year BP a peatbog started forming here; 500 ± 60 year ago the process of peat accumulation stopped, and the peatbog got covered with a sand stratum. Surface sample was taken in the dwarf shrub- sedge- mixed moss larch forest, which is typical of the research area. The tree level in this forest is formed by larch *Larix dahurica* ssp. *cajanderi* - d (cop 3), the height of which reaches 7 to 10 m, the trunk diameter is 10 to 20 cm and the trees` closeness is 0,3–0,6 . The shrub level is formed by brush alder *Duschekia (Alnaster) fruticosa* (cd, cop1, 15%), small birch *Betula exilis* (cd, cop 2, 10-20 %), and ledum *Ledum palustre* (cd, cop 2, 10-20%). The complete landscape and geobotanical description of the research area, as well as the results of the spore-pollen and radiocarbon analyses of the studied samples are given in the work by V.V.Ukraintseva and I.N.Pospelov (in print).

With the use of the above-mentioned formula the Similarity Index for taxa of the zonal level have been calculated, namely for the following groups: 1) trees, 2) shrubs and small shrubs 3) herbs and dwarf shrubs 4) spore plants (Table 2) and taxa of the phytoceonotic level (Table 3).

Tab. 2. Similarity Indices (SI), calculated for the taxa of zonal level contained in the fossil spore-pollen spectra of deposits of the second upper –flood-land terrace of the Fomich river , the north of the Anabar Upland, Russia.

Sample, no.	Depth (cm), lithology	^{14}C dates (BP)	Pollen of trees	Pollen of shrubs and small shrubs	Pollen of herbs	Spores of mosses
			% / SI			
1	0-1, surface sample	1953 – 2004 AD	12, 6 / 1	21, 0 / 1	31,5/ 1	28,9 / 1
2	3-12, peat	500 ± 60	12,0 / 0,95	7,1 / 0,34	19,4 / 0,61	57,5 / 1, 99
3	12-30, peat	3660 ± 60	13,4 / 1,12	27,7 / 1,31	11,0 / 0,35	41, 3 / 1, 42
4	45-55, peat	5720 ± 60	11, 2 / 0, 90	18, 8 / 0, 90	5,0 / 0, 16	64,7 / 2, 24
5	95-105, peat	7040 ± 60	3, 6 / 0, 28	17,5 / 0, 83	12,9 / 0,41	65,0 / 2, 25
6	145-155, peat	7530 ± 70	3, 7 / 0,29	11,1 / 0,52	11,1 / 0,35	73,5 / 2, 54
7	195-205, peat	8150 ± 60	5, 7 / 0,45	16, 8 / 0, 80	14, 5/ 0,46	62,6 / 2, 16
8	255-265, peat	10500 ± 140	4,0 / 0,31	16,8 / 0, 80	10,5 / 0,33	68,5 / 2, 37
9	300-310, loamy sand		3, 3 / 0, 26	32,5 / 1, 55	14,6/ 0,46	47,1/ 1, 63

Tab. 3. Similarity Indices (SI), calculated for the leading taxa of a species, genus and a family rank contained in the fossil spore-pollen spectra of deposits of the second upper –flood-land terrace of the Fomich river , the north of the Anabar Upland, Russia.

Sample	**^{14}C data**	***Larix dahurica*** s.l. (on the zonal level)		***Larix dahurica*** s.l. (on the phytocoenotic level)		***Duschekia fruticosa***		***Betula nana*** s.l.		**Cyperaceae**		**Poaceae**		**Musci**		**Sphagnum**	
		%	**SI**	%	**SI**	%	**SI**	%	**SI**	%	**SI**	%	SI	%	**SI**	%	**Is**
1	1953 – 2003 A.D..	12,6	**1**	32	**1**	24,1	**1**	21,7	**1**	25	**1**	2,2	**1**	68	**1**	20,8	**1**
2	500 +/- 60 BP	12	**0,95**	52	**1,6**	8,4	**0,35**	17,5	**0,8**	84,8	**3,4**	1,8	**0,81**	21,5	**0,31**	76,4	**3,67**
3	3660 +/ - 60 BP.	13,4	**1,1**	28	**0,9**	20	**0,82**	24,7	**1,14**	35	**0**			44,6	**0,65**	48,4	**3,32**
4	5720 + 60 BP	11,2	**0,9**	35,2	**1,1**	43,1	**1,79**	12,6	**0,58**	22	**0**			99,4	**1,46**		
5	7040 + 60 BP	3,6	**0,28**	16,3	**0,5**	54,5	**2,26**	23,2	**1,06**	30	**1,4**	10	**4,54**	93	**1,36**	0,4	**0,02**
6	7530 + /- 70 BP	3,7	**0,29**	24	**0,75**	30	**1,24**	32	**1,47**	36	**0**			94	**1,38**	0,8	**0,04**
7	8150 + 60 BP	5,7	**0,45**	24,1	**0,75**	35,7	**1,48**	33	**1,52**	74,7	**3**	4,2	**1,9**	95	**1,39**	1	**0,05**
8	10500 +/ -140 BP	4	**0,31**	19	**0,59**	48	**1,99**	20	**0,92**	84	**3,36**	8	**3,63**	95,6	**1,4**	0,3	**0,01**
9		3,3	**0,26**	8,5	**0,26**	34	**1,41**	41,5	**1,9**	37,4	**1,5**	6,7	**3,04**	89,5	**1,32**	2,4	**0,11**

The graphs of the Similarity Index were built on the basis of the data given in tables 2 and 3 (Figure1).

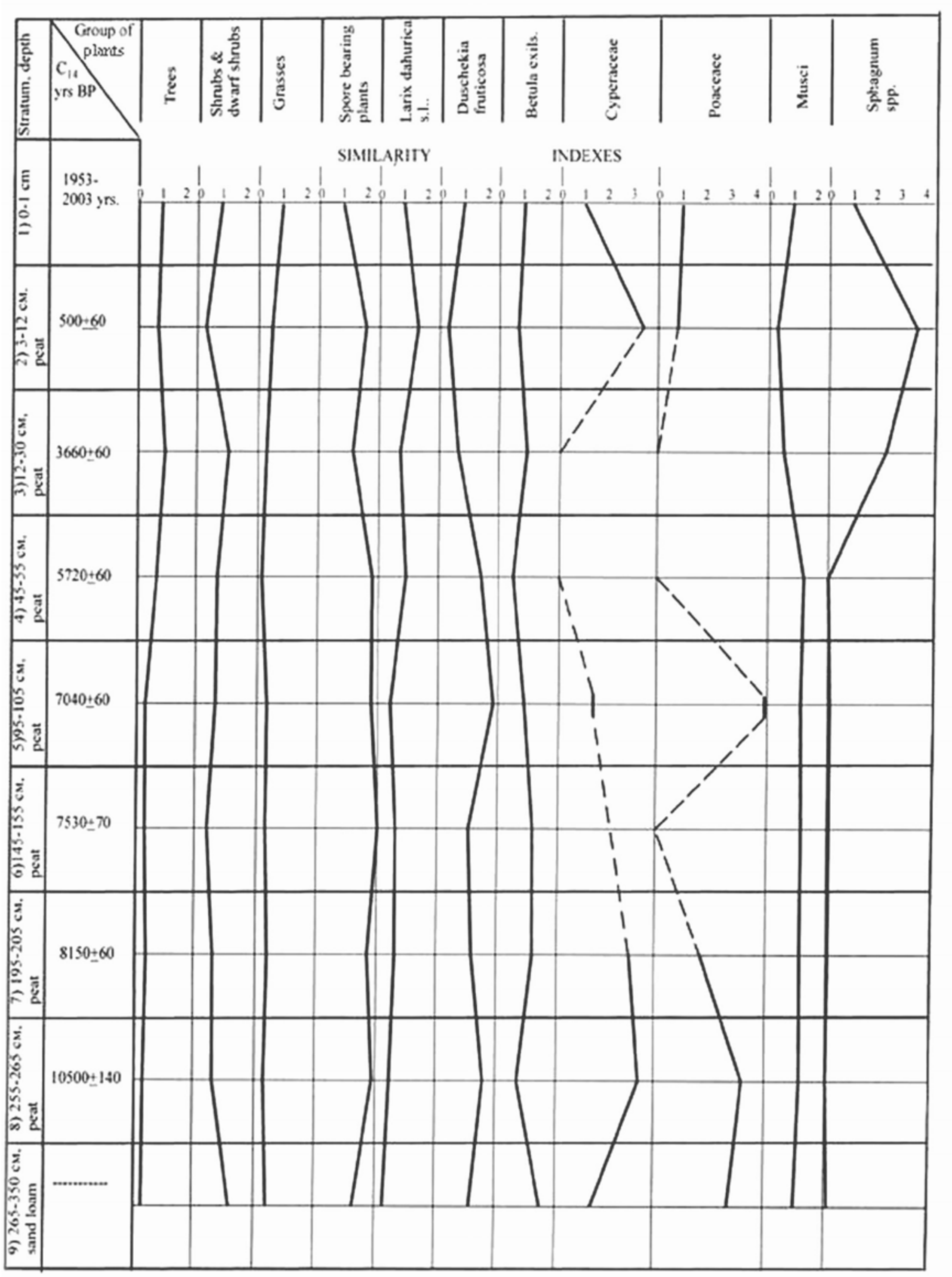

Fig. 1**.** Similarity Indices' graphs for the group of the general composition pollen (trees, shrubs and small shrubs, herbs, spore plants) and for the differentiating taxa (Larix dahurica s.l., Duschekia fruticosa, Betula exilis, Cyperaceae, Poaceae, Musci, Sphagnum spp.).

By the character of changes in the Similarity Indices for the components of the general SPS composition (zonal level) and differentiating taxa (phytoceonotic level) in the lower part of the Fomich River basin one can clearly trace two types of phytochrones – Tundra (I_{1-4}) and Forest (II_{1-4}) (Table 4). Under the term phytochrone one understands the time (period) of existence of a certain reconstructed kind of vegetation. The names of the phytochrones were derived from the names of dominant and co-dominant taxa of spieces`, genus`s and family`s rank.

The data given in Table 4 and in Figure 1 reflect the character of changes in vegetation and climate in the lower Fomich River in the northern part of the Anabar Upland during the Holocene. These changes manifest themselves though the Similarity Indices of the vegetation`s zonal elements, dominant and co-dominant taxa, and are shown in the Similarity Indices graphs.

Tab. 4. Phytochrones established for the lower part of the Fomich river basin , the northern part of the Anabar Upland, Russia.

Sample	**Lithology**	^{14}C **dates (BP)**	**Pollen, spores**				**Phytochrone**	
			Trees	**Shrubs and small shrubs**	**Herbs and dwarf shrubs**	**Spores of mosses**	Name	Index
			Similarity Index					
1	Surface sample	1953–2003 AD	**1**	**1**	**1**	**1**	*Larix dahurica*	**II** $_4$
2	Peat	500 ± 60	**0, 95**	**0, 34**	**0, 61**	**1, 99**	*Larix dahurica*	**II** $_3$
3	Peat	3660 ± 60	**1, 10**	**1, 31**	**0, 35**	**1, 42**	*Larix dahurica*	**II** $_2$
4	Peat	5720 ± 60	**0, 90**	**0, 90**	**0, 16**	**2, 24**	*Larix dahurica*	**II** $_1$
5	Peat	7040 ±60	**O, 28**	**0, 83**	**0, 41**	**2, 25**	*Duschekia fruticosa*	**I** $_4$
6	Peat	7530 ±70	**0, 29**	**0, 52**	**0, 35**	**2, 54**	*Duschekia fruticosa*	**I** $_4$
7	Peat	8150 ±60	**0, 45**	**0, 80**	**0, 46**	**2, 16**	*Duschekia fruticosa, Betula exilis, Larix dahurica*	**I** $_3$
8	Peat	10500±140	**0, 31**	**0, 80**	**0, 33**	**2, 37**	*Duschekia fruticosa, Betula exilis*	**I** $_2$
9	Loamy sand		**0, 26**	**1, 55**	**0, 46**	**1, 63**	*Betula exilis, Duschekia fruticosa*	**I** $_1$

Conclusions

1. The Similarity Index, introduced by me first for the assessment of spore-pollen spectra, is a quantitative characteristic. This characteristic allows assessing the composition of fossil SPS in comparison with the SPS composition of modern surface samples – a model, reflecting the character of modern vegetation of this or that research area.

2. The Similarity Index can only be obtained if the investigation of fossil SPS, the spectra of modern surface samples and modern vegetation is carried out in conjugation.

3. The introduced Index allows making a reliable correlation of fossil SPS on the level of zones and on the phytoceonotic levels.

4. The Similarity Indices graphs give, in my opinion, more information than traditional spore-pollen diagrams, since the Similarity Indices reflect an objective connection, existing between fossil SPS and modern surface samples` spectra. These graphs are more visual and compact in comparison with traditional spore-pollen diagrams, which enables us to make a correlation of palaeogeographic phenomena and events in time and space with more confidence, and, consequently, to make a correlation of sequences of deposits of the same age.

5. Using this new method for assessing fossil SPS we find an opportunity of fulfilling a valuable recommendation of N. M. Strakhov "When analyzing palaeogeographic phenomena and events one should go from the present to the ancient time, since under such method we move from the known towards the unknown and can easier understand specific climatic conditions of the former times" (Strakhov, 1969: 164). As regards the assessment of climates of the past and building up forecasts of climatic changes, the use of the Similarity Index method can make a real contribution in the solution of this one of the most important problems.

6. The said data give an indubitable evidence of the fact that the method I have applied works reliably.

7. This method seems to be applicable for the diatom analysis, for the phoraminifer analysis and in the study of other groups of organisms of organic origin.

References

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