Species composition of Western Siberia waterbodies paleoflora during the Pleistocene

Dmitry Alekseevich Durnikin, Anna Sergeevna Eremina

Altai State University, Lenina Blvd, 61, Barnaul, 656000, Russian Federation

Abstract. The main stages of Western Siberia waterbodies paleoflora development in the Pleistocene were examined. The core of reservoirs flora got formed during the Upper Pliocene – Pleistocene (Early - Middle Neopleistocene). Later on, during the Middle – Late Pleistocene, the depletion of flora core occurred because of the loss of thermophilic species. It can be explained with the geomorphological and climatic changes during these stages. At the same time, since the Eopleistocene, the waterbodies flora was replenished with the elements of halophilic complex.

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Introduction

In order to provide reliable biostratigraphic data, when exploring the continental Tertiary deposits of the majority of the continental deposits (the presence of orthofauna (mammals residues) is very rare there), the methods of paleobotany, particularly paleocarpology, are used. The main object of paleocarpology is diasporidium fossils (seeds, fruits, and other remnants of generative sphere) [1-3].

The most difficult stage of any region flora studying is to restore the historical stages of its development [4-7]. The determination of the main stages of the waterbodies flora development on the certain territory is an important problem of botanical geography as well as the identification of species relicts [8]. The important role for understanding the flora and vegetation history of the Western Siberia goes to the works and books of the founder of the Soviet paleocarpological school P.A. Nikitin, his son V.P. Nikitin, and P.I. Dorofeyev, as well as many other researchers of the Siberian region paleoflora [9].

Methodology

In this article, all the datings of fossil paleoflora are given according to the schemes used by O.M. Adamenko in “Mesozoic and Cenozoic eras of Steppe Altai” [10]. Also the datings done by V.P. Nikitin and mentioned in his book “Paleocarpology and stratigraphy of Paleogene and Neogene of Asiatic Russia” are used when describing the data of Western Siberia.

The main part

In the Pleistocene because of a decrease in waterbodies area and the appearance of wetlands, first of all along floodplains of large and medium-sized rivers, the new flora species start their active developing. For example: *Cicuta virosa*, *Oenanthe aquatica*, *Sium latifolium*, *Hippuris vulgaris*, *Menyanthes trifoliata*, *Comarum palustre, Juncus arcticulatus, J. bufonius, J. filiformis, Carex bohemica, Typha angustifolia, T. latifolia*, *Sagittaria sagittifolia, Scirpus lacustris*. In the Pleistocene epoch of the Quaternary period the development of some representatives of the hydro-hygro halophilic complex in the reservoirs of the south Ob-Irtysh interfluve is observed. In the Holocene only some of these representatives survived and they even exist nowadays. They are: *Najas marina*, *Zannichellia pedunculata*, *Caulinia flexilis*, *Triglochin maritima, Rumex maritimus, Scirpus maritimus.* At this time, the formation of the modern West Siberian waterbodies flora and vegetation was noticed. The water and riparian plants species growing now in the Western Siberia have turned to be modern not only morphologically, but also climatically.

Further the description of the Pleistocene Western Siberia waterbodies paleoflora species composition is presented.

The abbreviations which were used: (m) is widely spread species; the asterisk (*) denotes a species now existing in the world's flora, but not detected for waterbodies flora of the Western Siberia; the bold type is used for the species currently found in Western Siberia.

Azollaceae. *Azolla aspera* Dorof., *A. sibirica* Dorof. (m)., *A. interglacialica* Nikit., *A. nikitinii* Dorof., A. pseudopinnata P. Nikit..

Salviniaceae. *Salvinia glabra* P. Nikit., *S. intermedia* P. Nikit., ***S. natans* (L.) All** (m), *S. sibirica* P. Nikit., *S. tuberculata* P. Nikit..

Isoetaceae. *Isoetes echinospora* Dur.*, *I. lacustris* L.*.

Nymphaeaceae. *Nymphaea alba* L.*, ***N. candida* Presl.,** *Nuphar advena* (Soland.) R.Br., ***N. pumila* (Timm) DC., *N. lutea* (L.) Sm.**

Ceratophyllaceae. ***Ceratophyllum demersum***

L., ***C. submersum*** **L.,** *C. oryzetorum* Kom.*.

Ranunculaceae. ***Caltha palustris*** **L.,** ***Halerpestes salsuginosa*** **(Pall.) Green.,** ***Batrachium aquatilis*** **L.**(m), *Ranunculus sceleratoides* P. Nikit., ***R. flammula*** **L.**(m), ***R. polyphyllus*** **Kit.,** ***R. radicans*** **C. A. Mey.,** ***R. repens*** **L.**(m), ***R. reptans*** **L.,** ***R. sceleratus*** **L.**(m).

Droseraceae. *Aldrovanda vesiculosa* (L.) Monti*.

Typhaceae. ***Typha angustifolia*** **L.,** ***T. latifolia*** **L.**

Najadaceae. ***Najas marina*** **L.,** ***N. major*** **L.,** *Caulinia graminea* (Del.) Tzvel.*, *C. aspera* (C. et E. Reid) Dorof., ***C. minor*** **(All.) Coss. et Germ.**(m), ***C. flexilis*** **Willd,** *C. sukaczevii* Dorof., *C. tenuissima* (A. Br.) Magnus.*, *C. lanceolata* (C. et E. Reid) Dorof.

Potamogetonaceae. *Potamogeton acutifolius* Link.*, *P. asiaticus* A. Benn. (=*P. octandrus* Poir.)*, ***P. alpinus*** **Balb.**(m), *P. coloratus* Hornem.*, ***P. crispus*** **L.,** *P. drucei* Freyer., ***P. filiformis*** **Pers.**(m), ***P. friesii*** **Rupr.,** ***P. heterophyllus*** **Schreb., (=*P. gamineus*** **L.),** *P. malainus* Miq.*, ***P. natans*** **L.**(m), *P. nodosus* Poirr.*, ***P. obtusifolius*** **Mert. et Koch.,** *P. oxyphyllus* Miq.*, ***P. pectinatus*** **L.**(m), ***P. perfoliatus*** **L.**(m), ***P. praelongus*** **Wulf.**(m), ***P. pusillus*** **L.** (m), ***P. trichoides*** **Cham. Et Schlecht.,** ***P. vaginatus*** **Turcz.**(m), ***P. zosterifolius*** **Schum., (=*P. compressus*** **L.).**

Scheuchzeriaceae. ***Scheuchzeria palustris*** **L.**

Butomaceae. ***Butomus umbellatus*** **L.**(m).

Alismataceae. ***Alisma arcuatum*** **Michal. (=*A. gramineum*** **Lej.),** ***A. plantago-aquatica*** **L.,** ***A. lanceolatum*** **Wither.,** ***Sagittaria sagittifolia*** **L.,** ***S. natans*** **Pall.**

Hydrocharitaceae. ***Hydrocharis morsus-ranae*** **L.**(m), ***Stratioites aloides*** **L.** (m).

Araceae. ***Acorus calamus*** **L.,** ***Calla palustris*** **L.**

Polygonaceae. ***Polygonum amphibium*** **L.,** ***P. hydropiper*** **L.,** ***Rumex maritimus*** **L.** (m).

Brassicaceae. ***Roripa palustris*** **Bess.**(m).

Callitrichaceae. *Callitriche stagnalis* Scop.*, ***Elatine alsinastrum*** **L.,** ***E. hydropiper*** **L.**

Cyperaceae. *Scirpus cyperinus* (L.) Kunth.*, ***S. lacustris*** **L.**(m), ***S. maritimus*** **L.,** *S. melanospermus* C. A. Mey.*, *S. michelianus* L. (=*Dichostylis micheliana* (L.) Ness*, *S. mucronatus* L.*, ***S. radicans*** **Schkubr,** *S. supinus* L.*, ***S. tabernaemontani*** **C. C. Gmel.,** *S. triqueter* L.*, ***Carex acuta*** **L.,** ***C. acutiformis*** **Fhrh.,** ***C. aquatilis*** **Wahl.,** ***C. caespitosa*** **L.,** ***C. bohemica*** **Schreb.,** ***C. diandra*** **Schrank.,** ***C. elongata*** **L.,** ***C. heleonastes*** **Ehrh.,** ***C. lasiocarpa*** **Ehrh.,** ***C. leporina*** **L. (=*C. ovalis*** **Good.),** ***C. limos*****a L.,** ***C. atherodes*** **Sprenge,** ***C. pauciflora*** **Lightf.,** ***C. pseudocyperus*** **L.,** ***C. riparia*** **Curt.,** ***C. rostrata*** **Stokes,** *C. rostrata-pliocenica* P. Nikit., ***C. vaginata*** **Tausch.,** ***C. vesicaria*** **L.,** ***C. vulpine*** **L.,** *C. paucifloraeformis* V. Nikit., ***Cyperus fuscus*** **L.,** ***C. glomeratus*** **L.,** *C. longus* L.*, ***Eleocharis acicularis*** **R. et Sch.),** ***E. palustris*** **R. Br.**(m), *E. praemaximowiczii* Dorof., ***E. ovata*** **Roem. et Schult.**(m).

Lemnaceae. ***Lemna trisulca*** **L.,** ***L. minor*** **L.,** *L. gibba* L.*, ***Spirodela polyrriza*** **Schleid.**

Trapaceae. ***Trapa natans*** **L.**

Halorgaceae. *Myriophyllum altaicum* V.P. Nikit., ***M. spicatum*** **L.**(m), ***M. verticillatum*** **L.,** *M. spinulosum* Dorof.

Hippuridaceae. ***Hippuris vulgaris*** **L.**(m).

Apiaceae. ***Cicuta virosa*** **L.,** ***Oenanthe aquatica*** **Poirr.,** ***Sium latifolium*** **L.**

Menyantaceae. ***Menyanthes trifoliata*** **L.**(m), ***Nymphoides peltatum*** **Ktze,** *Naumburgia subthyrsiflora*, P. Nikit., ***N. thyrsiflora*** **(L.) Rchb.**

Sparganiaceae. ***Sparganium affine*** **Schnizl. (=*S. angustifolium*** **Michx.),** ***S. friesii*** **Beurl. (=*S. gramineum*** **Georgi),** ***S. glomeratum*** **Laest.,** ***S. hyperboreum*** **Laest.,** ***S. minimum*** **Wallr.,** ***S. ramosum*** **Huds. (=*S. erectum*** **L.),** ***S. simplex*** **Huds.**

Zannichelliaceae. *Zannichellia major* Boenn.*, ***Z. palustris*** **L.,** ***Z. pedunculata*** **Rchb.**

Juncaceae. ***Juncus arcticulatus*** **L.,** ***J. arcticus*** **Willd.,** ***J. bufonius*** **L.,** ***J. compressus*** **Jacq.,** ***J. filiformis*** **L.,** *J. inflexus* L.*, ***J. gerardii*** **Loisel.**(m).

The leading families of the Western Siberia waterbodies paleoflora are: *Cyperaceae* (38 species), *Potamogetonaceae* (21 species), and *Ranunculaceae* (10 species), which represent 42.8% of total paleoflora. In the Pleistocene *Potamogetonaceae* is represented by 21 species. It is important to mention that the endocarps of numerous pondweeds are good stratigraphic indicators. The abundance and diversity of pondweed fruitlets is typical for the diagonal sands (the Middle Pleistocene Tobolsk horizon various sedimentary rocks as well). Among the Middle Pleistocene pondweeds 15 species exist nowadays in the various regions of the Western Siberia [11], and four species are not found there anymore. They are: *P. acutifolius* Link. (the species is found only in the European part of Russia and the Caucasus), *P. asiaticus* A. Benn. (=*P. octandrus* Poir., (=*P. miduhikimo* Makino) (nowadays it is Far Eastern species which occurs in Primorye), *P. malainus* Miq. (Eastern Siberia, Dauriya, and south Primorye), *P. oxyphyllus* Miq. (the species is found only in the South Primorye of the Russian Federation). There are 10 species of pondweed which are not found anymore in the Pleistocene waterbodies flora: *P. aldanensis* Dorof., *P. besczeulicus* Dorof., *P. decipiens* V. Nikit., *P. erosus* Nikit., *P. jacuticus* Dorof., *P. minimus* Dorof., *P. omoloicus* P. Dorof., *P. tepperi* A. Benn., *P. tertiarius* Dorof., *P. polygonifolius* Pourr. Only *P.*

Tepperi out of these 10 species is detected in the modern flora. It occurs in Australia. The family *Cyperaceae* in the Pleistocene is represented by the following genera: *Carex*, *Scirpus, Cyperus*, and *Eleocharis*. It is necessary to point out that only *Cyperus longus* L. was not observed in the modern Western Siberia flora. It occurs at the European part of Russia and the Caucasus [12]. The top of buttercup family (*Ranunculaceae*) biological diversity was reached in the Middle Pleistocene (10 species). According to V.P. Nikitin [9], the seeds of *Ranunculus aquatilis, R. flammula, R. repens,* and *R. sceleratus* are found in a great number. There are nine modern species out of the general number of the family representatives.

Conclusion

In the Eopleistocene the final formations of the modern Western Siberian waterbodies flora and vegetation were completed. In the Pleistocene epoch of the Quaternary period the development of some representatives of the hydro-hygro halophilic complex in the reservoirs of the Western Siberia was observed. In the Holocene only some of these representatives survived and they even exist nowadays. They are: *Najas marina*, *Zannichellia pedunculata*, *Caulinia flexilis*, *Triglochin maritima, Rumex maritimus, Scirpus maritimus*.

The dry periods of interglacial followed by wetter epochs of the Pleistocene glaciations caused the reduction of reservoirs flora species diversity. Insensibly the thermophilic exotic species of the prior periods have disappeared out of the fossil complexes (genera *Azolla, Brasenia, Aldrovanda*, etc.). The Holocene Western Siberian waterbodies flora got formed out of the Eopleistocene and the Neopleistocene flora elements. It has turned to be close to the modern one. The top of a ranked list of the Pleistocene waterbodies flora is represented by the following families: *Cyperaceae, Potamogetonaceae, Ranunculaceae, Najadaceae, Sparganiaceae, Juncaceae, Azollaceae, Alismataceae, Salviniaceae,* and *Nymphaeaceae*. These 10 leading families represent 69.5% species of waterbodies flora.

Corresponding Author:
Dr. Durnikin Dmitry Alekseevich
Altai State University
Lenina Blvd, 61, Barnaul, 656000, Russia

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