Pollen in winter precipitation in the south of Western Siberia

N A Kuryatnikova1*, N S Malygina2 and E Yu Mitrofanova2

1Altai State University, Barnaul, 61 Lenina Street, Barnaul, 656049 Russia;
2Institute for Water and Environmental Problems SB RAS, 1 Molodezhnaya Street, 656038, Russia
*Email: ryabchinnatalia@gmail.com

Abstract. The results of a microscopic analysis of 39 samples of (snow) precipitation taken in the steppe zone of the south of Western Siberia during the cold period of 2019/20 are presented. The samples contain pollen grains of woody (Betula sp., Pinus sp.) and herbaceous taxa (Artemisia sp., families Asteraceae, Chenopodiaceae, Poaceae). The herbaceous samples predominate in the spectrum - 51%. To determine the areas of pollen grain arrival, the frequency back trajectories of the air masses are calculated with the HYSPLIT model for the atmospheric boundary layer during 120 hours. Analysis of pressure topography maps, maps of distributions of snow cover, average velocities and wind directions has made it possible to identify the areas of arrival of the pollen grains. The area of arrival of Artemisia sp. is the territory of the Turan Plain.

1. Introduction
Pollen grains have recently been actively used as an additional tool in paleoclimatic and paleoecological reconstructions of environmental conditions [1, 2, 3, 4]. Their good resistance to changes in environmental conditions can explain this use of pollen grains: the pollen has a sporopollenine shell (which contributes to their preservation) and a direct relationship with meteorological parameters, which makes it possible to distinguish seasonal changes in the pollen spectrum [5]. Coming mainly from the biosphere, pollen particles entering the atmosphere are actively involved in the nucleation processes, which contributes to the formation of atmospheric precipitation and affects the changes in meteorological parameters [6, 7]. In addition, the morphological features of pollen grains (large sizes up to 100 microns and the presence of air sacs) allow them to be transported in the atmosphere over considerable distances, which must be taken into account in paleoclimatic and paleoecological reconstructions. However, the study of the transport and deposition of pollen grains with atmospheric precipitation (especially during the cold period), in view of their seasonal distribution, unfortunately has not been given due attention.

2. Method
Samples of solid precipitation (snow) were taken in cylindrical samplers at a key site located in the steppe zone of the Altai territory during the cold period of 2019/20 (from November 2019 to March 2020). For the cold period, the time interval was taken when atmospheric precipitation fell in solid form, i.e. in the form of snow. It should be noted that the date of the sampler installation was chosen according to the forecast of the beginning of the formation of a stable snow cover, which is a limiting factor and limits the secondary rise of pollen grains from the earth's surface. In total, 39 samples of solid precipitation were taken during the observation period. After the end of precipitation, the collected samples were thawed at room temperature in tightly closed plastic containers. 40% formalin
was added to melt the water in order to reduce the development of microflora and stood in a cool dark place for 7-10 days, depending on the volume. The samples were concentrated by decantation. Subsequently, the prepared samples were examined using a light microscope at a magnification of 400 times. During the microscopy, a 0.2 ml Nageotte counting chamber was used. To identify the species, atlases [8, 9, 10, 11], as well as international databases [12, 13] were used.

As a result of the microscopy in the solid precipitation samples taken during the cold period of 2019/20, pollen grains of woody and herbaceous taxa were identified (Figure 1).

![Figure 1. Microphotography of identified pollen grains. (a) Betula sp.; (b) Pinus sp.; (c) Asteraceae.](image)

3. Results and discussion

Herbaceous taxa are represented (Artemisia sp., Families Asteraceae, Chenopodiaceae, Poaceae) and account for 51% of the total seasonal spectrum. The greatest concentration among the herbaceous species falls on representatives of this family. Chenopodiaceae - 26% of the total spectrum, which were identified in the first three months of the cold period (Figure 2 a, b). The lowest frequency of occurrence belongs to pollen of the family, Poaceae - 5% and Artemisia sp. - 5%. Pollen of Artemisia sp. was found only in samples taken in December. Pollen Asteraceae makes up 15% of the total spectrum and was detected in samples taken in the first months of the cold period, November and December.

![Figure 2. Taxonomic diversity in the pollen spectrum. (a) distribution of the taxon by month; b) contribution of the taxon to the total spectrum.](image)
February. All pollen grains interpreted in the samples belong to anemophilic plants, whose pollen has a number of morphological features (the presence of air sacs, smooth exine/surface) (Safatova, 2013), which allows them to be transported over long distances. In this regard, it can be assumed that the identified pollen grains in the samples of the cold period had an advective character. According to an analysis of the maps of the snow cover distribution [14], the sampling area, as well as the adjacent territories (within a radius of 500 km), were covered with a stable snow cover, which is a limiting factor and limits the secondary rise of pollen grains.

To determine the territories from which, possibly, the pollen grains identified in the samples came from, the frequency return trajectories of air masses were calculated by a model HYSPLIT [15]. It should be noted that this graph reflects the number of trajectory passes in each grid cell. The trajectories were calculated for a duration of 120 hours, which is equal to the average duration of the natural synoptic period for the study area, and the height of the calculated trajectories corresponded to the height of the atmospheric boundary layer according to data obtained using ERA5 [16].

Thus, according to the calculated trajectories (Figure 3 a), the pollen grains of Artemisia sp. isolated in the December samples with a probability of more than 30% came from territories of the Turan Plain.
The above analysis of maps of the distribution of snow cover (Figure 3 b) showed that the territories of formation of the air masses were free of snow cover, which facilitated a secondary rise of pollen grains under the influence of ascending air currents and further transport over considerable distances. Additionally, the wind directions were analyzed (Figure 3 c) to obtain the average speed (m/s) and the wind direction at the altitude of 1000 mb [17], which also showed that on the date of precipitation and the days preceding it winds of southwestern directions were predominant. An analysis of baric topography maps showed [18] (Figure 3 d) that ascending air flows were formed over the territories of the Turan Plain, which contributed to a secondary rise of pollen grains from territories free from snow cover.

Thus, the combined use of HYSPLIT frequency trajectories for determining the height of the atmospheric boundary layer during 120 hours using baric topography maps, NCEP/NCAR reanalysis data, maps of the distribution of snow cover and distribution areas of the identified taxa made it possible to reliably determine the areas from which the pollen grains came with precipitation.

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References
[1] Nakazawa F et al 2015 Environ. Earth Sci. 74 (3) 1851-59
[2] Papina T, Blyakharchuk T, Eichler A, Malygina N, Mitrofanova E and Schwikowski M 2013 Climate of the Past 9 (5) 2399-11
[3] Festi D et al 2011 Cryosphere 11 (2) 937-48
[4] Zaky A, Kachima K, Frontalini F, Ibrahim M, Khalifa M, Fukumoto Y, Gad D, Behling H 2020 Quat. Int. 542 109-20
[5] Fang Y, Ma C and Bunting M 2018 J. Geophys. Res.: Atmospheres 123 (19) 10842-56
[6] Despres V, Huffman J and Burrows S 2012 Tellus B 64 15598
[7] Huffman J, Perring A and Savage N 2019 Real-time sensing of bioaerosols: Review and current perspectives Aerosol Sci. Tech. 1-56
[8] Kupriyanova L A and Aleshina L A. 1972 Pollen and Plant Spores of the Flora of the USSR. (Leningrad: Nauka) p 171
[9] Kupriyanova L A and Aleshina L A 1978 Pollen and Spores of Dicotyledonous Plants of the Flora of the European Part of the USSR (Leningrad: Nauka) p 174
[10] Dzjuba O F 2005 Atlas of Pollen Grains (Non-acetolized and Acetolized), Most Common in the Air Basin of Eastern Europe p 70
[11] Karpovich I V, Drebegzina E S, Elovikova E N, Legotkina G I, Zubova E N, Kuzjaev R Z and Hismatullin R G 2015 Pollen Atlas (Ekaterinburg: Ural'skij rabochij) p 318
[12] https://www.paldat.org/search/A
[13] https://pollenatlas.net/homepage
[14] https://www.natice.noaa.gov/index.html
[15] https://www.ready.noaa.gov/HYSPLIT.php.
[16] https://www.ecmwf.int/en/forecasts/datasets/reanalysis-datasets/era5
[17] https://psl.noaa.gov/data/gridded/data.ncep.reanalysis.html
[18] http://www.aari.ru/main.php?lg=0&id=2.