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PALAEOHYDROLOGY OF THE EUROPEAN TAIGA

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Palaeohydrology of the taiga zone of the European Russia practically is not studied. There were only a few attempts of reconstruction of the development of the largest rivers in the European taiga zone - for Northern Dvina, Mezen', and Pechora Rivers, and there were no palaeohydrological evaluations. At the same time this territory contains extensive information on hydrologic events of the past. Paleochannels (often incised) are widely spread in the bottoms of river valleys in the region. Their widths and meander lengths are much larger than those in the recent river valleys. Fragments of paleochannels of smaller sizes than those of the modern rivers also often occur. These morphological features evidence a significant variability of humidity and water yield at this territory in the past.

Research area. Vychegda River basin.

Vychegda River is the right tributary of the Northern Dvina River. Its length is 1130 km and the basin area is 121,000 km^2. The river flow begins within Timan Ridge at the altitudes 200 - 300 m above sea level. The main part of the basin is a dissected plain with mean altitudes 140 - 160 m. The precipitation is 700 mm per annum, of them 350 mm is falling out during the winter-spring period. January is the coldest month of the year (mean air temperature in Kotlas is -14 °C), and July is the warmest one (17.2 °C). The mean annual air temperature is 1.2 °C. Mean annual water discharge at the Vychegda mouth is 1160 m^3/s with the mean maximum value of 7500 m^3/s. The basin is densely forested (up to 98%), and its north -eastern part is swamped.

Fluvial morphology of the lower Vychegda

Morphology of lower Vychegda valley was investigated at the near-mouth section about 120 km long. Valley bottom width increases here from 8 - 10 up to 35 - 50 km. The valley of Vychegda joins that of Northern Dvina. Several terraces and a floodplain with complicated morphology are distinguished in the area.

The second terrace has a relative height of 12-14 m above the river low water level and the total width of 2 - 4 km. There are several steps of different age on the surface of the terrace. The primary fluvial forms are quite clearly seen on the surface of these steps: there are paleochannels, middle and alternating bars, and former floodplain with levees and chutes. The curved bluff of the third terrace forms the right margin of the oldest paleochannel A on the highest step of the second terrace. The paleochannel is completely filled with very fine deposits and peat. Their surface is now 6-7 m above the level of flooding. Its width, though can not be accurately measured, can be estimated as about 1200 m. The age of peat filling is 10500 -10900 years. A well preserved meandering paleochannel B with islands and alternating bars inside is found on the lowermost step of the second terrace. Its mean width is 1300 m (1.5 km in broader sections). Wavelength of the main meander is about 12-14 km. Plant remnants in the top layers of alluvial sands related to the initial phase of paleochannel filling, have an age of 8400-8700 years. Paleochannel B was filled with very fine silty sand, sandy loam and peat, but the deposition was not sufficient to cover completely the primary fluvial relief.

The first terrace is about 2-4 km wide and has a relative height above low flow level of 9-10 m. Several systems of meandering paleochannels C with floodplain natural levees and chutes are well preserved on its surface. Their mean widths are about 600 m; meander wavelengths are about 7 km. The palaeochannels are filled with very fine silty sand, loam and peat. Plant remnants in the top layers of alluvial fine sand have a radiocarbon age 8120±50 years BP (KI-6404).

The floodplain of the lower Vychegda River is 5-7 m high above the low water level. Its total width is about 8 km. The floodplain can be subdivided into four main steps of different age. Well preserved remnants of meandering paleochannels D with natural levees, chutes and oxbows exist on two higher steps. The paleochannel is 800 m wide, meander wavelength is 9 km, and the bankfull depth on the riffles is 6-8 m. The paleochannel is filled by sandy loam 1.0-2.0 m thick at the point bars and by sandy loam and silty fine sand up to 9 m thick at the former pools. Peat in the depressions between adjacent natural levees on the floodplain has an age of 4000-4700 years.

The modern meandering-braided channel of the Vychegda River forms two lowermost steps of the floodplain. The river has sinuous pattern with numerous braids within the main channel. The total width of the river is about 1100 m at the crosses, meander wavelength is about 12 km. Bankfull depth is about 7 m at the riffles and up to 12-14 m at the pools. Channel alluvium is composed of fine and medium sand with the lenses of fine gravel. Floodplain is composed of fine and very fine sand with loam cover 0.5-1.0 m thick. Peat in the depressions between adjacent natural levees on the floodplain has an age 1700-2600 years.

Discussion and conclusion

Empirical hydro-morphological formula, which describes a well known relationship between the mean annual discharge and channel width, was used here for paleohydrological analysis. A measure of the discharge variability within a year was used as third variable to reduce the scatter. The map of this measure for European taiga zone makes it possible to use the method of paleogeographical analogue.

Morphology of paleochannels on the low terraces and the floodplain of the lower Vychegda River considerable changes through time during the Late Glacial – Holocene. Paleochannels were larger, than the modern ones in the Late Glacial – early Boreal. They were significantly smaller than the modern ones during late Boreal – Atlantic, and increased again since Subboreal till present. Mean maximum discharge of Pra-Vychegda changed in the same way. It reached its maximum during the Late Glacial, was greater than the modern one at the beginning of Boreal. It was two times less than the present-day one during late Boreal – early Atlantic, and since the end of Atlantic increased up to its modern values.

The Late Glacial period was characterised by very high differentiation of the flow. The precipitation during a long winter – spring period (mainly in the form of snow) was not less, than in the present-day tundra. Due to a low permeability of the ground in the permafrost zone the snow thaw during the spring led to sharp high floods on the rivers and to formation of large wide river channels. The annual flow was less, than the modern one. The deficit of humidity was related entirely to a summer – autumn season. At the Vychegda River basin the summer precipitation was nearly two times lower, than the recent one. Large periglacial river channels were nearly dry during all the summer due to a low precipitation and negligible ground water flow. The same situation is common in modern periglacial landscapes, for example, on the Yamal Peninsula, in the arctic West Siberia.

Large paleochannel of the early Boreal age was formed by much more uniform flow. The degradation of permafrost led to a decrease of the runoff rate and an increase of summer – autumn ground water input. In the conditions of only seasonal ground freezing the runoff coefficients were close to the recent ones. Estimates of the mean annual precipitation depth for the period are rather high (860 mm). Precipitation of the winter-spring season was doubled compare to the previous period (415 mm), that of the summer - autumn one increased even more - up to 445 mm. A large difference in precipitation regime between the Late Glacial and early Boreal time was derived from the reconstructed different flow distribution within a year for these two periods. Sizes of paleochannels corresponding to these time intervals are very similar.

The late Boreal and Atlantic were relatively less humid. Minimum of precipitation was calculated for the late Boreal and minimum of flow depth – for the middle Atlantic. This temporal shift can be explained by changes in flow variability. The main calculated minimum of humidity is related to the smallest paleochannels formed at that time. In Subboreal and Subatlantic the flow depth and precipitation had a general trend to increase. This trend was also calculated mainly from an increase of channel size, the local maximum and minimum on the curve being related to changes in flow variability.

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