GEOGRAPHY AND TOURISM, Vol. 4, No. 2 (2016), 53-59, Semi-Annual Journal
eISSN 2449-9706, ISSN 2353-4524, DOI: 10.5281/zenodo.223914

Nikolay N. Nazarov, Irina V. Frolova
Perm State National Research University, Perm, Russia, email: nazarov@psu.ru

Revisiting the time of the last mass straightening bends on the upper Kama

Abstract: The scientists investigating channels and palaeographers still do not have a clear answer to the question when the last mass channel directional change processes started on the upper Kama and its tributaries. Distinct morphometrical parameters of numerous ox-bows, now located along relatively straight channel parts and at the same time absence of imperforation (ageing) signs do not allow to makes unambiguous conclusions about the duration of directional straightening of the river and major restructuring of the floodplain-channel complexes. Finding the answer to this question included: a) the analysis of historical documents and local folklore that mention change in the location (removal) of the Kama channel; b) comparison of the degree of the Kama ox-bows imperforation and peat overgrowing with the standard peat accumulation rates under the conditions of taiga landscapes. According to the results of complex analysis the following suggestion has been made – the beginning of the last mass straightening bends of the upper Kama was in the second half the Subatlantic period.

Keywords: improvement channel processes, channel morphodynamics, a bend, floodplain-channel complexes, an ox-bow, peat, folklore, radiocarbon dating, holocene

1. Introduction

Today study of patterns and features of the river channels morphodynamics in the previous stages of floodplain-channel complexes (FCC) development is the key to solve the problems associated primarily with the rationale of regional patterns of development of coastal areas. Currently active channel processes in many regions of Russia have led to a real risk for settlements and the economic complex. According to all indications, in the last decades at many rivers of the Urals and Western Siberia there is a consistent increase in the velocity of the transversal and (or) longitudinal movement of river bends, which leads to erosion processing (destruction) of the kerb areas of floodplain terraces and indigenous valley slopes which previously seemed relatively safe (Nazarov *et al.*, 2010; Zawadzky *et al.*, 2013). The reconstruction of the channels morphology at different stages of FCC formation and the establishment of time prevalence of certain morphological types of channels can provide the necessary basis for the prediction of such changes in future (Chernov, Harrison, 1981; Chalov, 1996, 2011; Panin *et al*, 2011).

Lack of reliable data about the stages of the development of river systems in holocene for whole regions and river basins, characterized by different directions of channel processes, does not allow to estimate the stability of valley geosystems today. Even in case we advance in the study of periodicity (cycles) of the development of the entire spectrum of erosion processes (Velichko *et al.* 1982; Surmach, 1992; Borzenkova, Budyko Ed., 1992; Maksimov, 1995), the riverbed and its forms (Chalov, Chernov, 1996; Nazarov, Chernov, 1997; Zawadzky *et al.*, 2002; Makhinov, 2006; Kargapolova, 2006; Nazarov *et al.*, 2010) the problem of increasing the reliability of the medium-and long-term forecasts of functioning floodplain – channel complexes (FCC), apparently is still far from being solved. Several possible scenarios of climate development in the coming decades (Meleshko *et al.*, 2008; Kasimov, Kislov, Eds., 2011) determine uncertainty in the trajectory of the FCC,

and, hence, the uncertainty in predicting their future.

The analysis of the research data on the subject reveals that there are sufficiently strong evidence and conclusions on the parameters of the channel processes in the early and middle holocene, however, the development of FCC in its late stage looks uncertain. In many areas of the floodplain along the upper Kama together with oxbow rivers (lakes with quagmire, grassroots arc swamps), which by their parameters – width, radius of curvature and bends step – are significantly different from the modern channel; there are oxbow lakes which are morphometrically and morphologically different from the oxbow rivers. The oxbow lakes are larger in size; many of them are currently connected with the river by canals. With some confidence we can assert the existence of at least two generations of the oxbow lake type on the flood plain on the Kama, distinguishing in the degree of natural degradation (shoaling, the degree of vegetation imperforation and swamping) and water surface level elevations.

2. The aims of study

The questions that the researchers of channel processes of Perm Prikamye have not answered yet are the following: a) what is the time of the beginning and the end of the last scale transformation stage of channel processes direction of the river Kama and its tributaries; b) what are the causes of these changes.

Distinct morphometrical parameters of numerous ox-bows, located nowadays along relatively straight channel parts and at the same time absence of imperforation (ageing) signs do not allow to make unambiguous conclusions about the duration of directional straightening of the river and major restructuring of the floodplain-channel complexes. The results of the previous researches conducted by geologists-surveyors and geomorphologists which only indicate the holocene age of flood plain generations with oxbow lakes do not clarify the issuen. We need to analyze the available data concerning the issue of quick change of the channel processes direction in Perm Prikamye. Such data, in our opinion, are historical records of local folklore, which mention the moving of the Kama bed in the recent past. Besides, the observation data about the speed of ox-bow peating in conditions of taiga landscape and the results of radiocarbon dating of these sediments will help to answer the question about the duration of the transition stage of an oxbow lake to a swamp and then to a "dry" ill-defined floodplain lowering made by peat and floodplain alluvium. Only a comprehensive analysis of all the available data, which includes a variety of data sources can contribute to the establishment of the duration of the functioning stage of oxbow rivers as lakes and thereby contribute to addressing the issue of the time of bends straightening.

3. The facts of the river channel removal in folklore and historical records

A significant part of the data listed below fixes the change of the channel location in space and time, using as a sort of frames the former or today settlements on the banks of the Kama or its tributaries. It is known that the first settlements of Permians ancestors (Komi-Permyaks) in Perm region date back to the 8^{th}-6^{th} centuries B.C. By that time, there were 12 villages and 2 towns on the upper Kama and at least 54 settlements on the middle Kama, both here and in the upper regions of the river, they used to be generally located on the floodplain terraces and higher elevations of the plains (Gening, 1988). According to historians and archaeologists people chose such places by the specifics of economic activities including floodplain agriculture and house cattle breeding, combined with hunting, fishing and gathering. Many descriptions of life of the indigenous and Russian population of Perm the Great and in the later

period (Middle Ages) also mark the peculiarity to put villages on steep high unflooded riverbanks.

Not only practical benefits (a water road, fishing, hunting, etc.), but also the religious foundations and traditions influenced the location of settlements on the banks of rivers. For example, Novgorod Christians, who came to explore new places, put an icon into the river (sometimes even three times) and built a settlement on the place where it reached the bank. According to another data, the northern Slavs, Karelians and Scandinavians (the tribes settling along river and lakes banks) often used first timber trees for fortune-telling. The northern Russian tradition says that timber which was delivered by water to the intended location, suddenly sailed away, leading people to some other place (Russia primordial....).

A selection of the following examples of primitive ("folklore") description of the causes and consequences of the Kama channel straightening includes the data about the settlements in which the memory of their inhabitants contains information about the riverbed displacement and an oxbow formation in its place. In most cases, this information is presented in the form of legends and has no dated. For example, the change of the Kama channel location at Village Bolshie Doldy its dwellers explained by the fact of christening of Perm the Great and the role of Stephen Velikopermskiy in this process. According to one legend, Stephen sailed to the village from the upper Kama on a large stone; a large tree grew on that place, and the cross was put there, which later was transferred to a chapel; in the memory of the event the locals prayed on the banks in honor of the saint (Chagin, 1999). In another legend, recorded in the neighboring to Bolshie Doldy, the attitude of the local (pagan) population to Stefan was the cause for leaving the bed from the settlement. „And this Stephen Permskiy floated on this raft, floated to Doldy Village, and it is all true. Our parents and doldintsy knew this ... He preached all this Christian faith. They began to throw stones into him. And the Kama was then very close, almost on the bank they lived. And so they began to throw and the Kama moved away from them, and they were left without water" – A.A. Zarubina, born in 1939, village Ust-Urolka (Kurochkina, 2011).

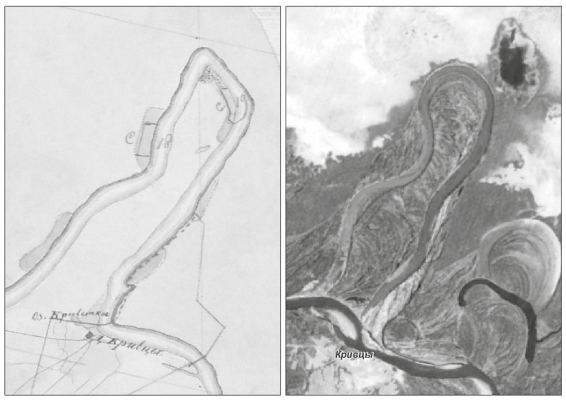
There is another legend popular among the Bolshie Doldy dwellers: "Once an old woman went to the Kama to take some water. While she was drawing water, the icon of Saint Nicholas was washed ashore. The woman pushed the icon away by the shoulder yoke and the Kama followed the icon to the left." The river changed its channel being offended and now on that place there is an oxbow. Thus the dwellers have to hurt their feet going for water (Usolskiy Historical and Architectural Museum....).

I. J. Krivoshchekov (1914) in his description of the former location of Bolshie Doldy, which today is 2.5 km from the Kama channel, says the following: „... In the village there is a burial ground Lazar, near which there are findings of chudskoy artifacts, some of them are in the Yekaterinburg Museum and the dwellers say that there was the chudskoi settlement there before, but it was destroyed by coastal erosion of the Kama „ (p. 219-221).

The church books, extracts from which were published in the 19th-beginning of 20th centuries, say that there was a tortuous (meandering) channel of the Kama on the place of the modern relatively straight channel area between villages Bondyug and Ust-Urolka in the 15th-16th centuries (Nazarov, Cherepanov, 2012). Some settlements, which used to be on the oxbow banks, now are located on oxbow lakes or several hundreds meters away from the channel. According to historical records, „... Pogost Kolchug (in M. Kaisarov's scribe book "Kulchyuk") was one of the most populated in Cherdynsky uyezd (an administrative subdivision in Russia from the 13th century). Located on the banks of the Kama (highlighted by the author), in a short distance from the Kolva, it held a very favorable geographical position ... and served as the dock at the nearest point of the left bank of the Kama (higher than Pyanteg Village)" (Dmitriev, 1889, p. 80-81). At present time Kolchug village is located on the basic bank at the oxbow 2.0 km from the modern channel of the Kama.

The map of Cherdynsky uyezd, dated back to 1780-1790, with the appropriate spatial analysis detail, depicts the Kama channel at Krivtsy village that when comparing the location of individual elements of the channel with the present situation has allowed us to establish the approximate age of Krivtsy oxbow, which at the

end of the XVIII century was a bend in the river – no more than 230 years ago (Fig. 1).



a b

Figure 1. Oxbow straightening at Krivtsy village
A –1780-1790; b – 2010

No less dramatic changes in the position of the river Kama occurred around the same period in the area of Borovsk (Solikamsk district). The oxbow was formed there as a result of the channel straightening (Fig. 2).

The research by V.A. Shmyrov et al analyses a sudden change of a channel processes regime (Shmyrov *et al.*, 1977). According to the study of archaeological digs data made in 1952-1954 on the place of non-existing today Orel-town (16th-17th centuries) (Oborin, 1967), as well as to the descriptions of cases of spring flooding of high floodplain in 1629, 1680, 1736, 1741, 1768 and the subsequent channel break in 1810 to 1.5 km to the west through the high floodplain (the place of its current location) (Shishonko, 1881), the authors inferred about the youth of the modern channel at the village Orel. As an additional argument, the researchers provide the data about the significant width of the low floodplain (300-500 m), in their opinion it also indicates a change in the position of the Kama river bed at the end of the second half of the holocene (the end of the 18th-19th centuries). Later, one of the authors (Spirin, Shmyrov, 1984), pointing to the tectonic nature of the channel regime change of Perm Prikamye rivers provides other data, supported by the results of archaeological research. The remains of Russian first settlements located on the relatively straight adapted channel of the Kama at Isady village (20 km upstream the Vishera river) testify that the left tributary was the main channel in the 14th -15th centuries, which is now a parched oxbow.

Figure 2. Change of a meandering channel to a relatively straight one at Solikamsk

4. Imperforation rates of oxbow lakes

As it has been mentioned above, the duration of the period of open water in oxbows before it starts to transform into swamps can be determined according to the data about the peat age and the rate of its accumulation. From the total available data related to the growth rate of the peat layer in oxbows, we refer to the activity of peat formation in the range of landscapes, similar to the natural conditions of the Perm Prikamye. It has been estimated that the increase of green weight of peat in Western Siberia oxbow formations occurs at a rate of 1-3 mm·year^{-1} (Davydova, Koshevoy, 2001). This is slightly higher than the vertical growth of the peat bog in fixed arrays of middle and northern taiga of the European part of Russia – from 0.35 to 1.13 mm·year^{-1} (Inisheva *et al.*, 2013).

Archeological researches have made a significant contribution to the issue of the age of ancient (peated) oxbows determination. The time of oxbow formation, which first used to be a lake then transformed into a swamp and

finally into an ill-defined in relief lowering at the Northern Dvina floodplain, was set at Marmuginsky peatbog. At 23 m from its edge in the thickness of flaky sand and clay deposits formed by the movement of the river bend, at a depth of 3.2 m the accumulation of ceramics belonging to an early Bronze Age (II century B.C.) was discovered. Since there are 20 clay annual layers between the discovery and the peatbog it was suggested that ceramics came here shortly before the meander cutting. Chains (fishing equipment), which were built in the time of the oxbow existence, i.e. in the era following the Neolithic one, were discovered in the peatbog. Researchers deduced this because of the fact that at the edge of the peatbog, far from the modern channel, the Early Bronze Age and Early Iron Age site was discovered (Burov, 1969).

Another example of the age determination of oxbow sediments is the study of oxbow deposits on the right bank of the Vychegda River near the village of Sedkyrkesch. The present-day river channel intensively eroding the right bank revealed the deposits of the buried ancient oxbow segment of the floodplain. The radiocarbon dating of the lower part of the peat layer at a depth of about 4 m, which exposed the oxbow lake sediments swamps showed age 3160 ± 140^{14}C years ago (GIAS – 3348). At the top of the peat layer there is radiocarbon dating of 630 ± 100^{14}C years ago (GIAS – 3339). The radiocarbon dating and palynological characteristics of the sediments that are listed in this paper indicate that the accumulation of oxbow sediments occurred from early subareal to late subatlantic periods (Buravskaya *et al.*, 2012).

5. Discussion of results and conclusions

Taking into account the power and the rate of oxbow peat accumulation of 1-3 mm·-year^{-1} as the initial data, as well as the results of sporo-pollen and radiocarbon analyses of the „aggregate" of channel forms and (or) of archaeological finds, in the first approximation we can determine the functioning time of already „dry" oxbows, under conditions of still open water surface. The duration of this period is the difference between the dates of burial objects (in our case these are ceramics and chains), caught in the channel in the river or lake conditions and the duration of the peat accumulation stage.

The calculations show that after a bend straightening the approximate duration of the conservation of the oxbow river in a form of a lake can range from 500 to 2000 years. At the end of the open water stage the oxbow reaches a swamp stage and after the filling of the entire volume of a degraded channel form by peat and floodplain alluvium the oxbow becomes a new morphological element of the floodplain.

All the above cartographic and historical documents, showing the instability of the spatial position of the Kama river bed, and the results of calculating the duration of the conservation of the broken river bends as oxbow lakes lead to the conservative assumption about the time of their formation. Apparently, the last mass straightening of bends in some areas of the upper Kama occurs in the second half of the subatlantic period.

Such evolution can be explained by changes in water availability, primarily affecting the provision of channel formation discharge of the upper interval (Chalov, Chernov, 1996; Chalov, 2011). High floods, when a floodplain was flooded, which apparently occurred throughout the Middle Ages until the 19th century determined the straightening of the Kama bends through the spur. Currently there is side erosion advancement in Perm Prikamye due to water availability increase and as a result the increase of the duration of channel formation discharge of upper and middle intervals (Nazarov, Chernov, 1997; Nazarov, Egorkina, 2004; Nazarov, 2009). Almost at all rivers in the region, including the Kama River, we observe an increase in the bends size, i.e. curvature of the channel increases at relatively straight sections of the river (Nazarov, Cherepanov, 2012).

6. Acknowledgements

This work was supported by RFBR grant (№ 16-05-00356)

The article was presented at the International Scientific Conference
„Human Impact on the Fluvial Processes of Eurasian Rivers"
on September 7th-9th, 2016 in Bydgoszcz (Poland).

References

Borzenkova I.I., Budyko M.I. Ed., 1992. Climate change in the Cenozoic era. Gidrometeoizdat, St. Petersburg.

Buravskaya M.N., Golubev Yu.V., Marchenko-Vagapova T.I., 2012. Partition of oxbow deposits in the outcrop of Sedkyrkesch (middle stream of the Vychegda river) based on a comprehensive analysis. Proceedings of Komi scientific center of the RAS Ural Department 2 (10), 84-97.

Burov G.M., 1969. On search of ancient wooden objects and fishing equipment in the oxbow peatlands of lowland rivers. Brief Reports of the Institute of Archaeology, USSR Academy of Sciences 117, 130-134.

Chagin G.N., 1999. History in memory of Russian peasants of the Middle Urals in the middle of 19th – early 20th century. Perm. University Press Perm.

Chalov R.S., 1996. Historical Channel Study: subject, methods of researches and the role of the relief in the study. Geomorphology 4, 13-18.

Chalov R.S., 2011. Channel Study: theory, geography, and practice. V. 2. Morphodynamics of river channels. M. KRASAND.

Chalov R.S., Chernov A.V., 1996. Kama basin zoning on factors and forms of channel processes display in medium and large rivers. Issues of Physical Geography and Geoecology of the Urals. Perm State University. Perm, 10-20.

Chernov A.V., Harrison L.M., 1981. Paleogeographic analysis of the development of channel deformations wide of floodplain rivers in the Holocene (a case study of the upper and middle Ob). Bulletin of Moscow Society of Naturalists, Geology 5 (4), 97-108.

Davydova M.I., Koshevoy V.A., 2001. Yugansky Reserve [electronic resource] URL: http://geo.1september.ru/2001/35/2.htm (access date: 15.01.2014).

Dmitriev A., 1889. The Collection of historical articles and materials mainly about Perm Region, Issue 1. P.F. Kamensky's Typography, Perm.

Gening V.F., 1988. Ethnic history of the Western Urals at the turn of A.D. (Pyanoborskaya epoch of III century BC. II century A.D.). Nauka, Moscow.

Inisheva L.I., Kobak K.I., Turchinovich I.E., 2013. The development of waterlogging process and accumulation rate of carbon in wetland ecosystems in Russia. Geography and natural resources 3, 60-68.

Kargapolova I.N., 2006. Reaction of river channels on conductivity change and anthropogenic influence over the past century: Author's abstract. Geography. Moscow State University Press, Moscow.

Kasimov N.S., Kislov A.V. Eds., 2011. Ecological and geographical consequences of global warming of 21st century on the East European Plain and Western Siberia. MAKS Press, Moscow.

Krivoshchekov I.J., 1914. Geography and Statistics Dictionary of Cherdynsk district of Perm province. Edition of Cherdynsk uezd zemstvo. Electro- Typography „Trud", Perm.

Kurochkina M.V., 2011. Oral history of Kama villages in the system of local and family folklore (a case study of contemporary records). [Electronic resource] URL: http://elar.urfu.ru/bitstream/10995/20291/1/dc3-2011-17.pdf (access date: 15.01.2014)

Makhinov A.N., 2006. Modern relief formation under alluvial accumulations. Dalnauka, Vladivostok.

Maksimov E.V., 1995. Rhythms on Earth and in Space. Izdat Sant Petersburgskowo Universyteta, St. Petersburg.

Nazarov N.N., 2009. Drainage variability and channel processes in Prikamye. 24 Plenary interuniversity coordination meeting on the problem of erosion, fluvial and mouth processes. ASU Press, Barnaul, 155-157.

Nazarov N.N., Chernov A.V., 1997. Features of display and intensity rating of horizontal channel deformations of the rivers of Perm Prikamye. Geomorphology 2, 55-60.

Nazarov N.N., Egorkina S.S., 2004. Rivers of Perm Krai: Horizontal riverbed deformation. PPC „Zvezda", Perm.

Nazarov N.N., Rysin I.I., Petukhov L.N., 2010. The results channel forming processes in the Kama river basin. Bulletin of Udmurt University 1. 83-96.

Nazarov N.N., Cherepanov E.S., 2012. Floodplain-channel complexes of Perm Prikamye. Perm State National Research University, Perm.

Oborin V.A., 1967. Orel-town as the Russian defensive pivot in the Prikamye of 16th-17th centuries. Scholarly Notes of Perm University 10 (3), 23-36.

Panin A.V., Sydorchuk A.Yu., Chernov A.V., 2011. Main stages of the floodplains of lowland rivers of Northern Eurasia. Geomorphology 3, 20-31.

Russia primordial. Choice of a settlement location. [Electronic resource] URL: http://www.rusizn.ru/history018_003.html (access date: 15.01.2014)

Shishonko V.N., 1881. Perm Chronicles. In five periods, V.1. State Printing Zemsky Council, Perm.

Shmyrov V.A., Bolonkin P.F., Spirin L.N., 1977. Late Holocene history of Solikamsk depression on geomorphological and archaeological data. Physical and geographical basis for the development and distribution of productive forces of non-black soil Ural. Perm University Press Perm, 48 – 55.

Spirin L.N., Shmyrov V.A., 1984. Main features of the Holocene tectonics and paleogeography of the Perm Pre-Urals. Physical and geographical foundations for development and distribution of productive forces of non-black soil Urals. Perm University Press, Perm, 107-112.

Surmach G.P., 1992. Relief formation, forest-steppe zone formation, modern erosion and anti-erosion measures. VNIALMI, Volgograd.

Usolskiy Historical and Architectural Museum „The Stroganovs' Houses" [Electronic resource] URL: http://pstroganov.com/?public=5 (access date: 15.12.2013)

Velichko A.A., Bordnikov V.V., Nechaev V.P., 1982. Reconstruction of permafrost zones and stages of development. In: Palaeogeography of Europe for the last hundred thousand years (Atlas-monograph). Nauka, Moscow, 74-81.

Zawadzky A.S., Kargapolova I.N., Chalov R.S., 2002. Stages of free bends development and their hydrological and morphological analysis. Vestnik MGU, Ser. Geography 2, 17-22.

Zawadzky A.S., Ilyasov A.K., Ruleva S.N., Surkov V.V., Turykin L.A., Chalov R.S., 2013. Evolution of Kolpashevo bend of the Ob river and development of dangerous display of channel processes. Geography and natural resources 1, 56-64.