

CHANGES IN THE COURSE OF THE KRASNA RIVER IN THE ESTUARY SECTION (POLISH UPLANDS)

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ABSTRACT

The aim of the study was identify the riverbed changes of the Krasna river in its whole length during last centuries based on archival cartographic materials. Additionally in the estuary section, about 2 km long, which was noticed the largest riverbed changes visible on the maps, verified cartographic changes are done geomorphological and geological mapping of the Quaternary sediments. Krasna river is located in the northern part of the Świętokrzyskie voivodship in the Polish Uplands area. It is left tributary of the Czarna Konecka, with a 28 km length. The basin area have about 121 km². It was located in the Old Polish Industrial District. Krasna river was one of the most industrialized rivers of Old Polish Industrial District in 19th c., the waters of the lower section of Krasna river were driven the forges and water mills. The activity of the forges and water mills contributed to changes in the course of the Krasna riverbed, visible on cartographic materials as well as in sediments. In the early 30th year in 20th c., old forges were transformed into water mills. In later years, the mill buildings were transformed into sawmills existing until the middle of the 20th c. On the flood plain, remnants of the iron metallurgy have survived in such forms as shafts and channels as well as in sediments as slags or bricks. With the fall of industrial activity, the renaturalization processes was started in the Krasna river valley and the riverbed itself. This led to the restoration of a natural environment before human changes impact and river come back to its natural course.

Keywords: geomorphology, cartography, Krasna river, Old Polish Industrial District, channel changes

LOCATION

The studied area is located in the northern part of the Świętokrzyskie Voivodeship (Fig.1). The northern part of the Krasna catchment with the estuary of the river is located within the borders of the Opoczno Hills, which are part of the Przedbórz Upland, whereas the southern part lies on the Suchedniów Plateau, which is part of the Kielce Upland [1]. The river is a left-bank tributary of the Czarna Konecka river and is 28.4 km long.

There have been many anthropogenic changes related to industrial activity in Krasna river in last centuries. The water of the lower section of Krasna river was powering water wheels of industrial machines from Krasna to Stara Wieś [2]. Nowadays, the industry in this section does not exist anymore. In contrast, the upper section has remained largely unchanged in last centuries, as it is a very large swampy area, which now, due to the large and unique natural values, has been protected under the Natura 2000 program [3].

AIM OF STUDY AND METHODS

The aim of the study was to recognize changes in the river's course in the estuary section of Krasna river. This section is about 2 km long and there the largest changes were found on the maps.

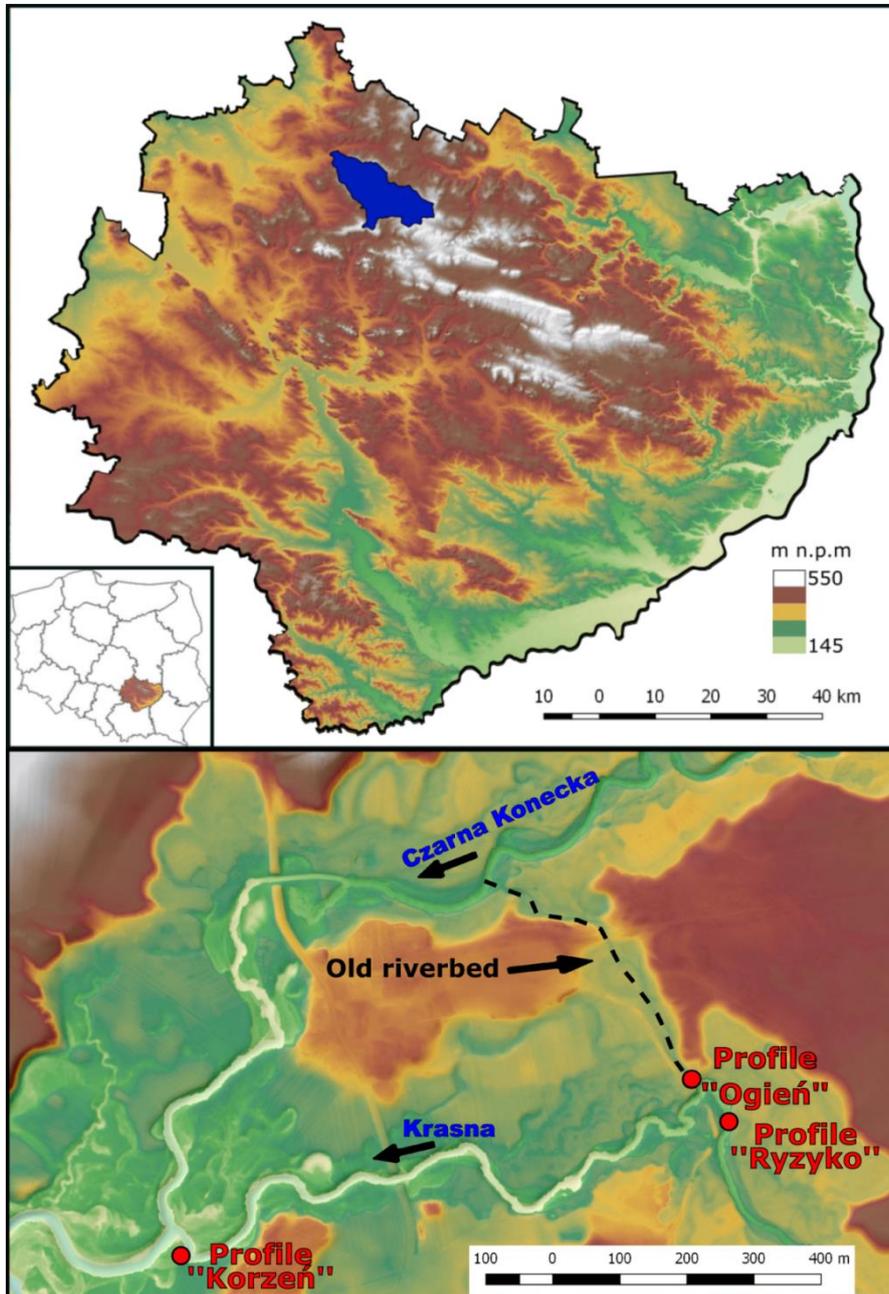


Figure 1. Location of Krasna river drainage basin (blue colour) and digital elevation model (DEM) of lower section of the Krasna river with location of study sites

Cartographic data was verified by geomorphological and geological mapping of the Quaternary sediments. Three sites were subject of a detailed analysis. The following materials were used in the cartographic analysis of changes in the course of the Krasna's riverbed:

- 1) Mappa Szczegulna Woiewodztwa Sandomierskiego Zrządona Z Innych Wielu Mapp Mieyscowych Tak Dawniej Jak I Swiezo Odrysowanych Tudziesz Goscincowych I Niewątpliwych Wiadomosci, Wszystko Według Reguł Graficznych i Obserwacyi Astronomicznych by Karol Perthées from 1791; scale 1:225 000,
- 2) Karta Dawnej Polski arkusz XXVI Radom Wojciecha Chrzanowskiego from 1859; scale 1:300 000,
- 3) Generalkarte von Mitteleuropa arkusz Kielce from 1913; scale 1:200 000,
- 4) Karte des Westlichen Russlands sheet Końskie from 1915; scale 1:100 000,
- 5) Karte des Deutschen Reiches sheet Kielce from 1940; scale 1:100 000,
- 6) Allied map signed by AMS (Army Map Service) series „Poland M651” sheet Kielce from 1944; scale 1:100 000,
- 7) Topographic map developed by Centralny Ośrodek Dokumentacji Geodezji i Katografii (geoportal.gov.pl) from 1994; scale 1:10 000,
- 8) Orthophotomap (geoportal.gov.pl) from 2015; scale 1:10 000.

The analysis of changes was carried out using a retrospective method, i.e. by examining the area from the present state and then gradually moving back to more distant times. The orthophotomap from 2015, available on the geoportal.gov.pl website, was adopted as the basis for the unification of the location. Historical materials were marked by errors such as distance between objects. These maps have been georeferenced, that is giving a raster or vector file a specific coordinate system. Thanks to unambiguous reference points such as churches, road crossings and bridges on the old map and an orthophoto, the former course of the Krasna River was located on a modern foundation. The obtained map (with the river bed changes) is less accurate than the source one, however, it gives the opportunity to compare. The effect of this work is a generalized map with transformations of the river bed allowing to track the changes in the Krasna's course in the last 200 years. As part of geomorphological and geological mapping, several profiles were made and sampled in the estuary section of the valley. Granulometric analysis of sediments using the sieve method was carried out in the Science Laboratories of the Institute of Geography of the Jan Kochanowski University in Kielce, and the graining presented graphically in the Granulom program.

RESULTS

The most important change in the cartographic view was the estuary section of Krasna river (Fig. 2). Krasna river on the oldest map from 1791, just before the estuary to the Czarna Konecka river, rapidly turned west and there was a water reservoir with a mill (Fig. 2A). Another map from 1859, shows a very distinct change of course, because Krasna river did not flow to the west, but to the north and was upstream of Wąsosz and not downstream, as on the previous map. Two water reservoirs were located on the Krasna river - just upstream of the estuary and directly downstream, already on Czarna Konecka river (Fig. 2B). On the map from 1913, the river had only the "western" estuary, and the river rapidly changed its course towards the west downstream of a small water reservoir located on the bend of the river (Fig. 2C).

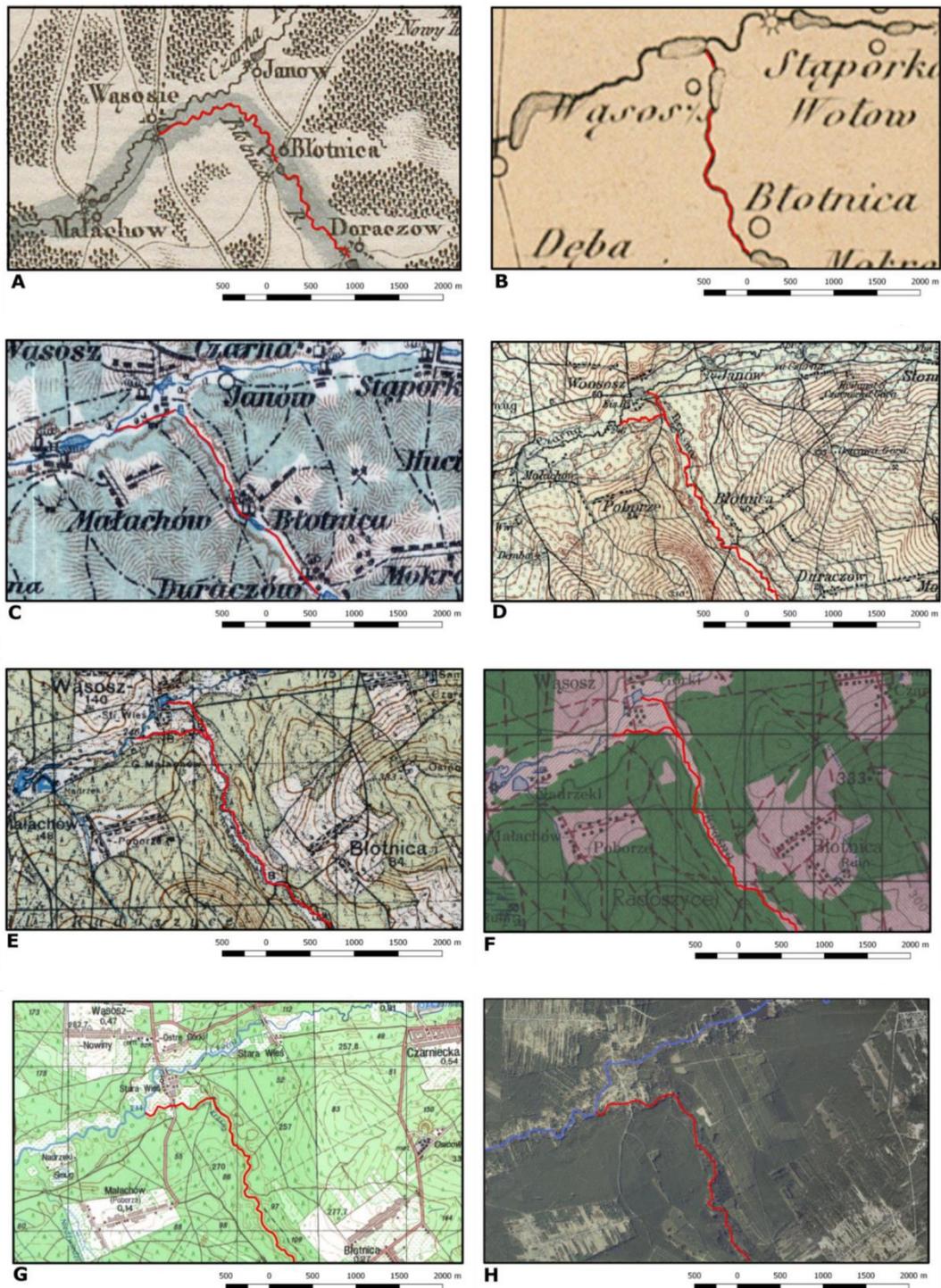


Figure 2. The estuary section of the Krasna river on maps: A - from 1791, B – from 1858, C – from 1913, D – from 1915, E – from 1940, F – from 1944, G – from 1994, H – from 2015

Two years later, Krasna river forked out and came to Czarna Konecka river in two places, downstream and upstream of Wasosz (Fig. 2D). This arrangement lasted until 1944 (Fig. 2E, F). From the late 20th c. to the present times in the estuary section of Krasna river there were no water reservoirs or mills, and its course was similar to that from the late 18th c. – upstream of the estuary Krasna river turned west and came only by one riverbed to the Czarna Konecka river downstream of Wasosz (Fig. 2G, H) [4].

The changes visible on the maps have been verified in the field (Fig. 1).

The “Rzyzko” site is located on the edge of the Pleistocene terrace cut by the river, not far upstream of the fork of the course visible on the old maps (Fig. 1). The profile reveals sand-gravel alluvium, cross bedded in which the podzolic soil has developed in the top [5]. The alluvium can be separated into two members: lower – gravels and sands (I) and upper - sands (II). In the upper, aggradational member there are alternating thicker and finer sands, which indicates that they were accumulated by braided river.

The “Korzeń” site is located just near the estuary of Krasna river to Czarna Konecka river (Fig. 1). In the outcrop, two cut and fill of alluvium are visible in one morphological level [5]. Older, on the left side, are built by cross-bedded, medium and coarse sands, which can be interpreted as channel alluvium of the braided river, building a Pleistocene terrace at the confluence of Krasna river and Czarna Konecka river. The younger cut and fill is connected with the oxbow lake [6], undercutting the Pleistocene terrace, which was completely filled with variously sedimentary facies - fine and medium sands with layers of coarse sands and silty sands, which probably corresponds to the variable sedimentation conditions referring to the size of the flood. On the right side of the exposure, there are also visible point bar sediments (coarse and medium sands) with inclined bedding, which indicates the lateral migration of the riverbed before its cut off [5]. In the sediments of this younger cut and fill artifacts related to human activity have been found - slags, brick fragments and burned sandstones, which indicates that it is the Subatlantic deposits from the period of operation of riverside forges.

The “Ogień” site is located at the entrance to the former Krasna’s river bed running north. It was filled from the mid-twentieth century (Fig. 1) in several phases (Fig. 3). Then, sediments of various grain sizes were deposited. At the bottom of the profile there are fine sands ($M_z = \text{approx. } 4.2 \text{ phi}$, $\delta = \text{approx. } 1.5$). Above, in the first phase of filling, cross-bedding sands were accumulated, which initially narrowed the cross-section of the oxbow lake/canal, and later "plugged in" (neck) the inlet to it. In the upper half of the profile there are numerous slags and large boulders, probably parts of the old channel reinforcements that line the sill gutter, on the right side transformed by man (vertical trace of the dig?). The gutter was filled with medium and fine sands.

DISCUSSIONS

The changes in the Krasna’s course, identified during the analysis of cartographic sources, were related to the development of the Old-Polish Industrial District. The largest of them were marked in the estuary section in which they were verified in the field. Relief and sediments in the outcrops correspond to the changes visible in the cartographic view, but detailed field studies allowed for the extension and deepening of the conclusion drawn from the analysis of old maps.

Podzolic soil in the “Rzyzko” profile shows that the surface of the terrace was not disturbed by man and is preserved in the natural state, so anthropogenic changes in the place of the fork of the course (on the "bend") were limited only to the flood plain and did not "enter" the terrace.

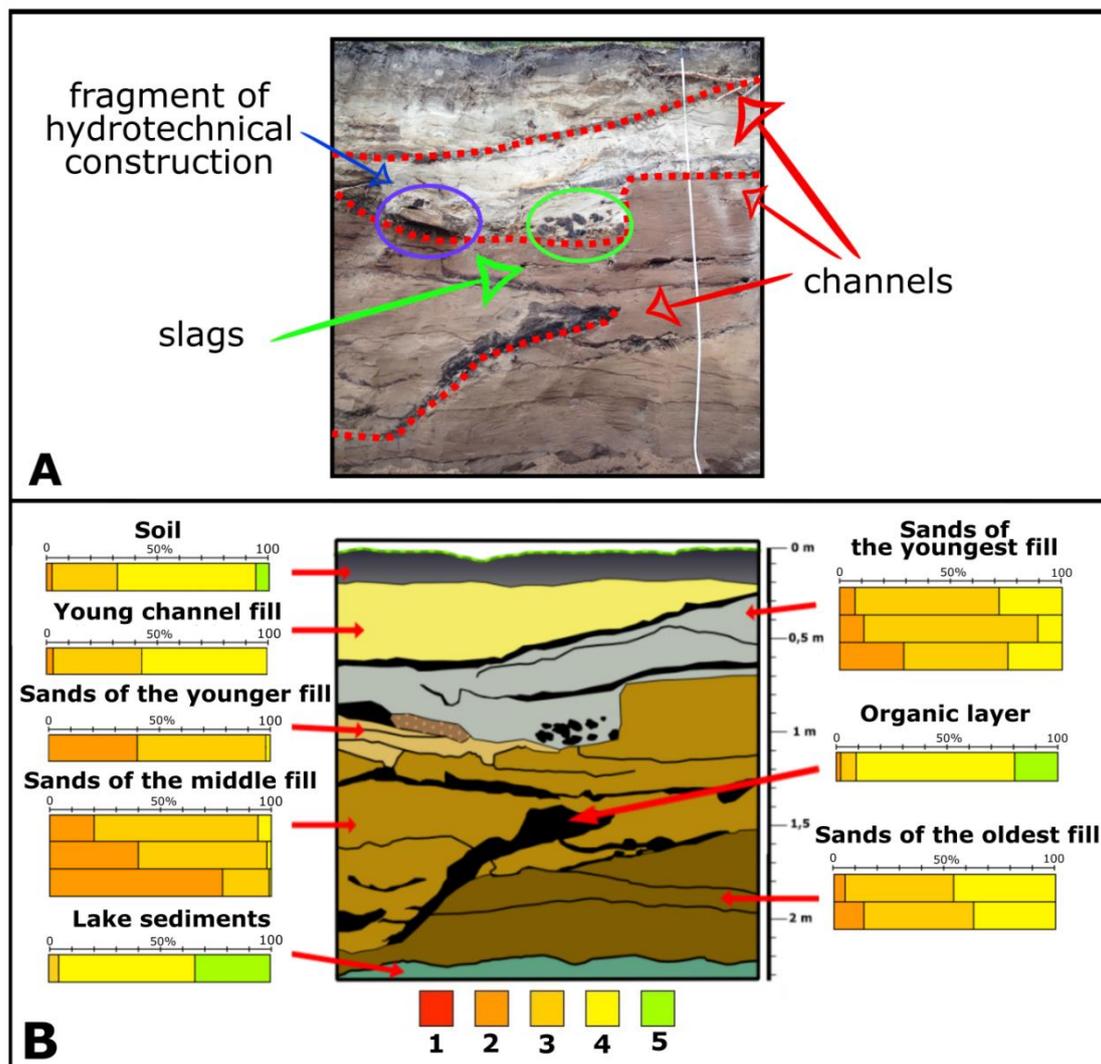


Figure 3. Ogień profile. A – artifacts, B – Fractions: 1-gravel, 2-coarse sand, 3-medium sand, 4- fine sand, 5-silt and clay

The western course of Krasna river downstream of the bend seems to be a natural course of the river, as indicated by two cut and fill of alluvium (the Pleistocene and Subatlantic with metallurgical artifacts) found at the “Korzeń” site. At the same time, between contemporary Krasna river and a fragment of the high terrace (7.5-7.0 meters above river level) and dune complex [7], where Wąsosz village are located, there is a relatively wide zone of the flood plain with well preserved in the relief oxbow lakes visible on the DEM (Fig. 1). This zone from the east is limited by a clear embankment, probably a bank of pond visible here in the map from 1859 (Fig. 2B). This pond stretched from the causeway to the edge of the terraces in the east and had an elongated shape with an N-S axis. The inlet to this pond was located at the “Ogień” site, whereas the outflow from it was artificially dug by narrowing in the high terrace. This analysis compels us to change the geomorphological map in this area [7] [8], because this fragment of the terrace was marked on it as natural, the Holocene. The construction of the pond, the outflow dug and, preserved in fragments, the embankments blocking the Krasna’s flow westward (Fig. 1) were connected with the operation of a water forge in Wąsosz from 1492 (the first mention), that was destroyed in the Swedish Deluge, and rebuilt as a blacksmith workshop in 1662-74, and later in the 19th c., operating as an axe workshop. In 1850, a second

blacksmith workshop was created in the village. The development of industry caused a considerable growth of Wąsosz and nearly doubling the number of inhabitants in the years 1827-1880, so that in 1907 the village had 523 inhabitants. There was also a rolling mill in the village [2]. In the following years a gradual collapse of the industry followed, which was reflected in the map from 1913, where only a small pond located on the Krasna's "bend" is visible, which indicates the advanced process of silting this reservoir. Probably, the fine-grained layer (clay-coated fine sands) of lake sediments occurring in the lowest part of the "Ogień" site is the trace of this reservoir. The confinement and the creation of a sandy inlet trough to the channel formerly supplying the pond took place in 1915-1944 (Fig. 3D-F), which referred to the collapse of the plow iron blacksmith and turpentine workshop in 1936 or 1937, and later to the demolition of buildings and liquidation (in 1943) of the ghetto created here [2]. After the war, Krasna river returned to its natural westward course (Fig. 3G-H).

CONCLUSIONS

The results of study in the Krasna river valley indicate the huge research potential of the cartographic-geomorphological method, currently used to a minimal extent [4][9][10][11]. The analysis of the course of the Krasna riverbed and closer recognition of the estuary section allowed the determination of the river course from the 18th century to the present day. Field verification of cartographic data enabled capturing and proper interpretation of the record contained in the morphology and geological profiles of the flood plain. This allowed to specify and improve the origin of forms marked on the geomorphological map. Applying the Doctrine of Uniformity (Uniformitarianism) enabled a reference of the results to older periods which lack a cartographic view.

In the analyzed last centuries, the main reason for the changes in the course of the Krasna riverbed was water driven forges and mills set up along the river. A large number of these factories developing in the Old-Polish Industrial Region was conditioned by favorable natural circumstances, such as shallow deposits of iron ore, the possibility of using water energy to power industrial machines and forest areas supplying charcoal used in metallurgy. These plants were accompanied by extensive hydrotechnical infrastructure (ponds, canals, windmills, etc.). In the last decades, after the fall of industrial activity based on hydropower, renaturalization processes began within the valley and in the Krasna riverbed, and the river in the estuary section returned to its natural, the Holocene meander belt.

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