River Valley Direction and Offset of Volga-Kama Interfluve During Neogene-Quaternary

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**ABSTRACT**

This paper presents the data of the Neogene river valleys of the Volga-Kama interfluve reconstruction location. The estimation of the valley offset value and direction in the Neogene-Quaternary period is provided. The main factors influencing the displacement value are considered.

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**INTRODUCTION**

The data of ancient river deposits within the Volga-Kama interfluve are known for over 150 years. The systematic study of Neogene river valleys began in the 30th-40th of the XXth century. The most significant works that presented the first info of Neogene valley network configuration, the age of the corresponding constituent valley sediments and morphology were the studies conducted by Kirsanov N.V. [1], Kashtanov S.G. [2], GoretskY G.I. [3]. Then the data of Neogene valleys were expanded by the works of Obedientova G.V. [4], Dedkov A.P. [5], Sidnev A.V. [6], Butakov G.P. [7]. One of the recent renovations of Neogene valley location was performed in 1997 under the leadership of Maramchin S.A. and Ulanov E.I. during the preparation of "Consolidated geological map of the Republic of Tatarstan deposits at the scale of 1:200 000" [8]. However, these data are largely contradicted with previous studies. The questions about Neogene valley age, position, the confluence of the largest rivers Volga and Kama were under discussion. The issues about values, direction and setoff factors inherited by modern valleys relating to Neogene remained unresolved.

**Material and methods of investigation:**

The article is based on the analysis of 1465 wells which revealed the Neogene sediments in Volga and Kama interfluves within the territory of the Republic of Tatarstan. The program «MapInfo» developed the map of actual material that contains information about the power and absolute mark of Neogene sediment bottom. Then this map was aligned with the "Consolidated geological map of the Republic of Tatarstan deposits at the scale of 1:200 000" [8]. This combination allowed us to specify the boundaries of Neogene sediments on the basis of ancient material, which appeared after the map publication. The material processing was performed by «Surfer 8.0» program according to «Krigging» procedure. This procedure allowed the creation of digital models for Neogene sediment and erosion surface (buried under Neogene sediments) capacity allocation. The maps of Neogene erosion surface were developed, the reconstruction and provision of Neogene paleo valleys and paleo riverbeds were performed according to «MapInfo 6.0» program modeling data. The map analysis of Neogene and modern valley location made it possible to estimate the direction and value of its offset during the Neogene-Quaternary period.

**Neogene valley location:**

The buried Neogene river valleys of the studied area are widespread (Figure 1). The development of Neogene river network within this territory occurred during the Neogene at the verge of Miocene-Pliocene period. The main rivers were Paleo-Kama and Paleo-Volga. And the largest river was Paleo-Kama [9]. At the same time the valleys of almost all currently existing large and medium-sized rivers were founded.
Paleo-Volga valley may be traced within the studied area to the left of the modern Volga channel. Prior to the confluence with Paleo-Kama Paleo-Volga took a series of tributaries: Paleo-Sviyaga, Paleo-Kazanka, Paleo-Mesha. The Paleo-Kama valley is being traced from the modern mouth of the Belaya river along the left bank of the Kama river. Near Nizhnekamsk city Paleo-Kama crosses twice the modern riverbed and is traced to the right of the modern riverbed within Yelabuga-Nizhnekamsk city regions. To the southwest of Nizhnekamsk city Paleo-Kama is divided into two branches. The main Kama water course is mapped towards the Bol. Tolkish - M. Tolkish villages where the merge with the Paleo-Volga took place.

The largest rivers flowing into the Paleo-Kama prior to the confluence with Paleo-Volga were Paleo-Ik, Paleo-Zai and Paleo-Vyatka. The significant tributaries were Paleo-Menzel, Paleo-Chelna, Paleo Kichuy which flew into Paleo-Kama valley from the south, and Paleo-Iz and Paleo-Toima from the north. Almost all paleo valleys of left tributaries, as well as Paleo-Vyatka valley is mapped along the left bank of modern rivers. After the confluence into Paleo-Volga the left bank of Paleo-Kama is mapped major tributary valleys of Paleo-M.Cheremshana, Paleo-B.Cheremshana, Paleo-Sulchy and Paleo-Kondurchy. Paleo-Karmalka flowed into Paleo-Volga-Kama on the right.

The direction and offset value of the river valleys during the Neogene-Quaternary period. Modern river valleys are confined to Neogene valley network. According to the plan the modern river incision (channel) is located either to the left or to the right of the Neogene paleo riverbed or coincides with its position. Table 1 shows the data for some rivers along the modern incision offset direction in relation to Neogene one. The table shows that during the Quaternary the right-hand offset was predominant one. Most paleo valleys are located to the left of the modern valleys and on the rivers which have a meridional direction which is more pronounced.

The largest riverbed offset during the Quaternary is characteristic for Volga river. At that there is only right-hand offset all over the study area. Within the region of Rybnaya Sloboda s. of Chistopol city the deviation of modern paleo riverbed is about 100 km. An average offset makes 30-50 km. The value of modern valley offset in relation to paleo valleys was estimated by paleo riverbed and modern riverbed offset. The offset values of major tributaries of the river Volga and Kama do not exceed 8.0-10.0 km regularly. The lower reach of Sheshma river which recorded the maximum value of 35.0 km makes an exception. For p . The maximum amount of setoff makes 13.5 km for Sviyaga river within the territory of the Tatarstan Republic, 8.5 km for Vyatka river, 8.0 km for Ik river and 7.0 km for Zaia river. For smaller rivers these values do not exceed 3.0-5.0 km. For example the maximum value for Kichuy and Lesnoy Zai makes 4.5 km. The right-hand offset is typical for all these rivers. At that the offset values in the upper reach of river valleys have a minimum value. It should be borne in mind that the real upper reaches of these paleo rivers were destroyed during the subsequent relief development. Therefore the offset values could be closer to zero values. Thus, the offset value depends on the watercourse size. The influence of the Coriolis force is higher, the higher high-water watercourse [10]. However, this trend is broken at the increase of other factors importance, primarily lithologic-tectonic and hydrological ones. As we mentioned above, the Volga river valley offset within the RT makes about 50 km on the average. However within the area of Verhny Uslon settlement where Volga envelopes Verkhneuslonsky brachyanticline the core of which is composed of Permian limestones and dolomites resistant to erosion the
offset value does not exceed 8-10 km. The value of Kama incision offset for the Quaternary period is comparable to Volga offset of the Kazan area. At that Kama was and remains more abounding river than Volga. The Kama maximum offset value does not exceed 10-12 km, and in some areas the modern Kama channel passes over paleo riverbed. The rate of Volga and Kama offset during the Quaternary (1.8 million years) have the same difference. An average offset of Volga river made 0.02-0.06 m/year, the rate of Kama offset is much lower and makes less than 0.006 m/year. There is no directional offset in Kama. Such a feature of Kama river is explained by several factors. Within RT Kama flows in interdome decrease of North and South-Tatar arches and is largely predetermined by the position of the Kama-Kinel system of faults. From the hydrographic point of view the modern Kama as Paleo-Kama, forms significant meanders, resulting to left hand offset of modern incision in some areas.

Table 1: The direction and value of modern incision (riverbed) offset relative to paleo riverbed.

<table>
<thead>
<tr>
<th>River</th>
<th>Paleo-valley total length km</th>
<th>Offset from paleo riverbed to the right km</th>
<th>Offset from paleo riverbed to the left km</th>
<th>Paleo riverbed length without offset (under modern riverbed)</th>
<th>Paleo riverbed length which does not have any modern riverbed correspondence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volga prior to confluence with Kama</td>
<td>186</td>
<td>186</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Paleo Volga after the confluence with Kama</td>
<td>264</td>
<td>264</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Kama</td>
<td>312</td>
<td>247</td>
<td>79</td>
<td>40</td>
<td>13</td>
</tr>
<tr>
<td>Sviyaga</td>
<td>158</td>
<td>141</td>
<td>89</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sheshma</td>
<td>109</td>
<td>107</td>
<td>98</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Zai</td>
<td>121</td>
<td>121</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ik</td>
<td>213</td>
<td>196</td>
<td>92</td>
<td>17</td>
<td>8</td>
</tr>
<tr>
<td>Paleo-Sulcha</td>
<td>81</td>
<td>32</td>
<td>40</td>
<td>49</td>
<td>60</td>
</tr>
<tr>
<td>Paleo-Bol. Cheremshan</td>
<td>71</td>
<td>26</td>
<td>37</td>
<td>45</td>
<td>63</td>
</tr>
<tr>
<td>Paleo-Vyatka</td>
<td>55</td>
<td>50</td>
<td>91</td>
<td>5</td>
<td>9</td>
</tr>
</tbody>
</table>

For some left-side tributaries of Kama the right and left-hand offset is natural. For example, B. Cheremshan river is offset from paleo incision by 10 km on the right by and by 12.5 km on the left. Such offset features are associated with the displacement of modern tectonic shifts of different directions. Lithological factor in such significant offsets is equally important. Almost all quaternary valleys were founded in loose Neogene sediments which influenced at its significant lateral offsets.

During the studies the left-hand shift was revealed in the riverbed part of some left tributaries of Ica, Zaya, Sheshma. The left hand offset of riverbed parts for these small tributaries is related to the hydrodynamic effect of the main river channel causing a spurious effect of Coriolis force [11].

The role of lithological factor in the offset value may be estimated according to the river offset data crossing various lithological complexes.

The most interesting in this respect are the Volga and Sviyaga valleys. The development of Neogene and modern Volga valley within the study area occurred during dolomitic lime and lime-plaster complex of Perm. Below Tetyushi town it enters the strip of easily eroded Jurassic-Cretaceous clay sediments. A significant offset of Volga up to 70-90 km is characteristic for all this area (Fig. 2).

![Fig. 2: Displacement of Volga on the examined area.](image)
The similar picture is observed within the area of Sviyaga river valley. In the middle reaches the river cuts into the carbonate-clay Jurassic-Cretaceous complex, the maximum offset of modern riverbed in relation to paleo riverbed within the segment of 13.5 km, in the lower reaches it cuts into the limestone dolomitic Perm complex, the offset of which is no more than 6.5 km.

Conclusions:
The predominant offset of modern valleys in relation to Neogene ones on the Volga-Kama rivers is the right-hand shift, related to the impact of the Coriolis force on the watercourse. The value of this shift depends primarily on the watercourse size. The offset values of large rivers makes 15-50 km, up to 15 km for medium rivers on the average. These values do not exceed 3.0-5.0 km for small rivers.

However, this trend is disrupted by lithologic and tectonic factor importance increase. The left-side valley offset is related to this factor as well as the variations of its offset values.

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