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Rock Lithology Role at Spatial Analysis of Russian Plain Eastern Part Climatic Skewness

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ABSTRACT

To determine the influence of rock lithology of rocks on the river valley slope asymmetry the rocks of the Upper Cretaceous and Paleogene, the Tatar level of Upper Perm and Jurassic-Lower Cretaceous were studied as the most occurring in the eastern part of the Russian Plain. To exclude the influence of slope age on its steepness only small river valley were considered with the Late Pleistocene age in most cases. The geological structure of the territory was determined by medium-and large-scale geological maps, according to literature data and field observations. The sites were chosen to cover the diverse range of rocks which were classified in 5 lithological groups. The study results showed that the steep slopes of the river valleys developed in relatively strong rocks of Kazan and Tatar tiers of Upper Perm, Upper Cretaceous and Paleogene, have approximately equal slope and are markedly superior to the slope steepness composed of sand and clay rocks of the Jurassic, Lower Cretaceous, and especially Neogene-Quaternary. In addition to rock lithology content the slope steepness is also determined by river valley incision depth and their exposure.

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The composition of rocks essentially determines the slope steepness, so we tried to study the angles of small river valley slopes in different lithological conditions and compare the obtained data with asymmetry coefficients. The eastern territory of the Russian Plain is a classical area of Permian sediment development. The Kazan AND Tatar of Upper Permian sediments are most common. Kazan tier sediments are out of the Tatar arch lifted areas, the margins of Tokmovsky and Zhigulevsko-Pugachevsky vaults, the central and southern parts of Vyatka dislocation zone [1-3]. The Kazan tier is represented by the sea and lagoon-marine carbonate, carbonate-sulfate, carbonate-clastic sediments in the west. They are replaced by red coastal continental formations in the east. The red-colored sediments of Tatar tier form huge fields of escapes in the Middle Volga and only to the south the latitudes of Samara gradually sink beneath younger rocks of Mesozoic and Cenozoic groups. The most complete and powerful (up to 600 m) section of Tatar tier is known in northern part of the Vyatka bank. The sediments consist of clays, silts, marls, limestones, dolomites. The triassic formations appear on the day surface in the northern part of the described region in the basins of the Upper Kama, Vyatka, Vetluga. The most significant areas of escapes are located on the left bank slope of the Samara river valley. The deposits are presented by brown-red clay, sandstones, the conglomerates with silica and quartz pebbles. Lithologically they are same with Tatar tier rocks. The Jurassic system sediments are widespread. In the north, their escapes on the day surface refer to Sysola, Maulomy, Velykaya, Letka, Cobra, Upper Kama basins. In the southwestern part of the considered territory the Jurassic sediments appear in the watersheds of Sura, Sviyaga river and on the right bank of the Volga in the Ulyanovsk region, within Zhigulevsky-Pugachevsky vault. Jurassic deposits are composed of clays, sandstones, siltstones, marls. Their power does not exceed 200 m.

The Cretaceous sediments are common in Sysola river basin, the upper flow of Kama and Vyatka, on the right bank of the Volga river, south of Ulyanovsk. They are represented by white chalk, chalk-like marls, silica clays and clay rocks. Their power makes 500 - 600 m.

Paleogene deposits occur mainly along the right bank of the Volga river within the considered area. Their escapes make a discontinuous strip stretching from Ulyanovsk city to Krasnoarmeysk city and they are represented by sands, sandstones, silica clays, thin clays. The Paleogene power makes up to 300 m. Neogene sediments are developed quite widely in the valleys of the river Volga, Kama, Vyatka and its numerous branches. From the bottom up Neogene sediments are presented by river sands with gravel and pebbles, sandy

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loams. To the north they are replaced by lacustrine-alluvial sand and clay formations. At the more northern areas marine clays are developed with subordinate interbedded sands and silts of Akchagyl transgression period. The incision ends with continental sands, loams, sandy loams. The Neogene power reaches 300 m [4-6].

The quaternary sediments are represented in the centre and south by continental extraglacial formations. The north and north-west of the district has moraine and glaciofluvial sediments of the middle Pleistocene age. The sea sediments occur in the south, in the Volga river valley. Eluvial deposits are developed in watersheds, the slopes have deluvial-salt fluxing loams with the streaks of buried soils. The river valleys have up to 10 alluvial formations from Eopleistocene to Holocene inclusive.

According to lithologic characteristics that significantly influence the erosion and, consequently, the appearance of the river valleys, all the rocks, appearing on the day surface were divided into four groups with some degree of conditionality.

1) sand-clay-carbonate group of Tatar Upper Permian and Triassic. The valleys in these rocks have an average asymmetry;
2) sand-silt-clay of the Upper Jurassic, Lower Cretaceous, Neogene and Pleistocene. They have valleys with a weak slope asymmetry;
3) the chalk and marl of the Upper Cretaceous represented by sharply asymmetric slopes;
4) silica clays and Paleogene sandstones forming a rather sharp asymmetry of river valleys.

To eliminate the effects of different lithology on the valley transverse profile of the correction factor was introduced. To calculate the correction coefficient of the the river valley slope asymmetry the Tatar tier rocks were taken as a reference, because they occupy the largest area and the intensity of their slope processes development is an average one. The degree of valley asymmetry was presented by 1. Carboniferous sediments were excluded from analysis due to its limited distribution.

The composition of rocks essentially determines the slope steepness. So we have attempted to study the angles of small river valley slopes in different lithological conditions and to compare the obtained data with asymmetry coefficients. Only small river valleys were considered for analysis to exclude the effect of age on their steepness. In most cases, the analyzed valleys are of late Pleistocene age [7].

To determine the influence of rock lithology on the slope asymmetry of the river valleys the special studies on 14 sites located submeridionally from the basin of Sysola river in the north to the Ilovlya river basin in the south. The geological structure of the territory was determined by medium-and large-scale geological maps, by literature data and field observations. The sites were chosen so that they covered a diverse range of rocks. The following lithological groups were presented:

1. Carbonate one of the Kazan tier from Upper Perm (P2kz);
2. Sandy-clay-carbonate of the Tatar tier from Upper Perm and Lower Triassic (R2t+T1);
3. Sandy clay Jurassic-Cretaceous (J, K1);
4. Chalk , marl of Upper Cretaceous and sandstone - silica clay, Paleogene (K2+P);
5. Sandy-silty-clay of the Neogene and Pleistocene (N-Q).

The results of map processing are compiled in summary table 1.

Table 1: Rock lithology influence on river valley slopes.

Item №	Region	Rock group	Average angle (grades) and number of profiles			Slope height, m
			In general	Cold rhumbs	Warm rhumbs	
1	Sysola river near Syktyvkar city	3	5,9/79	3,2/7	6,1/72	25 – 30
2	Bystritsa river	1	4,5/73	2,3/14	4,6/59	20 – 25
3	Ludyana river	1	10,3/61	7,3/6	10,6/55	40 – 50
4	Middle course of Vyatka river	2	3,0/33	3,6/6	4,0/27	20 – 25
5	Riverhead of Kazanka river	2	8,0/129	5,0/8	8,1/123	30 – 35
6	Sulitsa river	2	10,0/140	9,0/20	10,3/120	40 – 50
7	Riverhead of Ulema river	2	10,0/41	9,9/10	10,8/31	40 – 50
		2	4,9/52	4,0/8	4,7/44	25 – 30
8	Riverheads of Usa river	4	11,1/40	8,3/3	11,4/37	35 – 40
		3	7,0/42	2,5/4	7,4/38	40
9	Riverheads of Tereshky river	3	7,5/57	6,8/26	8,1/31	30 – 40
		4	9,4/43	7,7/17	10,5/26	35
10	Middle course of Tereshky river	3	5,7/73	5,1/43	7,2/30	35 – 40
11	Lower course of Tereshky river	3	8,1/22	7,0/8	8,6/14	35 – 40
		4	11,2/37	10,8/14	11,3/23	35 – 40
12	Riverheads of Kamyshly and Ilovye river	3	5,9/139	4,7/36	6,3/103	45
13	Riverheads of Berdiya river	4	10,9/43	9,7/21	12,0/22	40
14	Volga-Don interfluve	4	8,6/38	8,5/20	8,6/18	30 – 35
		5	3,5/50	2,6/14	3,8/36	20 – 25

Note: The rock group numbers correspond to abovementioned lithological types.

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Table 1 demonstrates that the average angle of the of the river valley steep slopes is in different conditions. The steepest slopes formed in the rocks of the Upper Cretaceous and Paleogene, where the average slope angle for warm rhumbs reaches a maximum value of 12° in the riverheads of Berdiya river. The minimum values for this lithologic group are in the riverheads of Tereshky river and make 7,7°(cold rhumbs). An average angle of steep slopes composed of Kazan sediments makes 7,5°, varying from 2,3° (cold rhumbs basin of Bystritsa river) to 10,6° (warm rhumbs of Ludyany river basin). In Tatar deposits an average slope angle makes 8,5°, varying from 3,6° in the middle course of the Vyatka river to 10° (in the upper course of Ulema river). The fluctuations of steep slope angle in Jurassic-Lower Cretaceous rocks from 2,5° in the riverheads of Usy river to 8,6° in the lower reaches of Tereshky river at an average value of 6,5°. In the Neogene-Quaternary sediments an average tilt angle makes 3,5°. The minimum value angles are typical for cold rhumb slopes.

The studies demonstrated that the steep slopes of river valleys developed in a relatively strong rocks of Kazan and Tatar tiers of Upper Permian, Upper Cretaceous and Paleogene, have approximately equal slopes and are markedly superior to the steepness of the slopes, composed of sand and clay rocks of the Jurassic, Cretaceous, and especially Neogene-Quaternary (table 2).

Table 2: Average tilt angles of slopes, depending on rock composition.

Item №	Lithologic and stratigraphic groups	Number of profiles	Average tilt angle, grades		
			For slopes in general	For steep slope	For entle slope
1	Chalk, marl of the Upper Cretaceous, Paleogene sandstones and silica clays	262	10,2	12,0	7,7
2	Sandy-clay-carbonate of Upper Perm Tatar tier	462	8,5	10,8	4,8
3	Carbonate of Upper Perm Kazan tier	134	7,5	10,8	3,6
4	Sandy clay Jurassic-Lower Cretaceous	505	6,5	8,6	5,0
5	Sandy-silty clay of the Neogene and Pleistocene	50	3,5	3,8	2,6

The rocks of the Upper Cretaceous and Paleogene, Tatar tier, Upper Perm and Jurassic- Lower Cretaceous were taken for analysis, as they are commonly found on the explored region territory. There is no distinct regularity in the change of slope average steepness in the Upper Cretaceous and Paleogene rocks. The Jurassic-Lower Cretaceous rocks and the sediments of the Upper Perm Tatar tier has an average slope decrease from south to north at 1° - 4°, but this regularity is obscured by sharp fluctuations at neighbor areas.

One reason of such sharp fluctuations is the possible influence of incision depth and river valleys. To clarify this factor the river valleys were subdivided by depth incision into two groups: the group with an incision less than 35 m and the group with an incision more than 35 m. The boundary of 35 m. is taken conventionally as an average incision depth of all analyzed valleys. According to all lithologic groups an average angle in the first group is smaller than in the second one [8-10].

It should be noted that 75% cases of explored valleys have the SE, S, SW and W exposition of steep slopes (warm rhumbs). Moreover, the average angle of these steep slope rhumbs makes 7,6° and almost always higher than the average slope of SE, S, SW and W steep slope expositions (cold rhumbs). In some cases (the middle course of Cobra river of Yurya, Tetyushi, Kamishin towns) the high proportion of cold rhumb steep slopes caused by significant role of SW-NE valleys. The slopes of these valleys are exposed respectively to the NW-SE. Such sites are slightly asymmetrical and the exposition of a steeper slope in such cases is difficult to determine, and it is often accidental one.

Thus, the measurements showed that the slope steepness besides lithological composition is determined by river valley incision depth river and slope exposition. The determination of asymmetry degree through steepness of slopes is less revealing than through a special dimensionless coefficient.

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