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APPROXIMATE VALUES OF MECHANICAL AND CHEMICAL DENUDATION ON THE NORTH-EAST SLOPE OF LESSER CAUCASUS

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ABSTRACT

The research considers questions of chemical and mechanical denudation on the north-east slope of Lesser Caucasus. Thus according to data on tractional, suspended and soluble substances and considering their approximate theoretical relationship we have defined the total amount of substances which were transferred from the specified slope for one year. Considering the catchment area of this slope, we have defined the approximate value of denudation cutoff for 1000 years: ≈ 280 mm/1000 years. This value is compared with a number of data on river basins of Europe. In connection with the defined total amount of alluvial adjournment (2836114) of rivers of investigated territory (in m^3/year) we have defined the chemical denudation of substances transferred by the mountain rivers, and the approximate area of the given slope (≈ 12875$км^2$). Taking into account relationships of substances we have determined values of chemical denudation: 28,6240 m^3/km^2/year and 18,1183 m^3/km^2/year respectively, the average value: 23,37115 m^3/km^2/year. Also, we have compared data on separate rivers.

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INTRODUCTION

Denudation questions are of great importance during the analysis of various geological processes. From this point of view the quantitative aspect of denudation cutoff on the NE slope of Lesser Caucasus attracts attention. In order to determine this parameter various formulas are used. In particular, S.Dzhadson and D.Ritter (Кукал, 1987) have proposed a formula to calculate speed of regional erosion (denudation):

$$D=0,0052L$$

Where D-the speed of erosion (in foots for 1000 years); L- the weight of all material transported by the rivers, belonging to certain basin (in million tons/year).

According to some researchers, particularly S.Trimbla (Кукал, 1987), land erosion performed at a slower speed compared with the values obtained from this or a similar formula.

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Indeed, simple calculations show that computation of this formula gives extremely high values. It should be noted that, as known, in the literature speed of erosion, also speed of denudation process means the speed of cutoff or alignment of a terrestrial surface (Кукал, 1987). After these explanations we will present some tables concerning to the various mechanisms of erosion. For example, Table 55 in the Кукал (1987) shows various mechanisms of erosion in the Alpes: solifluction, river erosion, landslides, avalanches, glacial exaration. Table 56 in the same study shows speed of erosion in the Alpes, defined by different methods according to different authors (with corrections). So, there are different methods: by quantity of suspended material in rivers, the volume of delta of Rion river, the balance of the system-pressure-temperature in metamorphic rocks, difference in absolute age of muscovite and biotite, models of thermal evolution. Besides, there are different mechanisms of erosion on hillsides in Scandinavia (table 57 in Кукал, 1987).

Denudation cutoff

To determine the denudation cutoff we used hydrological data on the rivers of the specified slope of Lesser Caucasus: the average annual runoff of the slope rivers in m^3/sec., and also the average turbidity in g/m^3. Elementary calculations on the basis of Hasanov`s (Həsənov et. al., 1973) studies have allowed us to obtain turbidity values for the rivers of the given slope (Table 1). For approximate definition of the tractional (bottom), suspended and soluble substances for the mountain rivers, we use a corresponding ratio a:b:c = 0,86:6,8:1 (Страхов, 1960). Also it is possible to use other ratios (Xəlifəzadə Ç.M. and Məmmədov İ.Ə., 2003). For this purpose first of all we determine the total volume of suspended deposits of groups of rivers of given slope. The volume of these deposits is approximately equal to 2836.114 m^3/year. According to table 1, we determine the total volume of solid runoff of these rivers, in a m^3/years Table 2.

denudation for specified time and supposed absence of isostasy processes that might take place.

Mechanical denudation

It is necessary to notice that the great researcher-lithologist academician N.M.Strakhov in his research «Basis of the Lithogenesis theory» (Страхов, 1960) recommends to define this parameter in tons per km^2 within a year (t/km^2/year).

In this paper we consider mechanical denudation as a result of an annual solid runoff of rivers of the NE slope of Lesser Caucasus. In this connection first of all we take the total volume of suspended deposits annually taken down by the rivers of the NE slope – 2836114 m^3/year.

Table 1. The average annual runoff, the average annual discharge of suspended sediments and the average turbidity of rivers

№	The rivers	Average annual runoff, m^3/sec.	Average annual discharge of suspended sediments, kg/sec.	Average turbidity, g/м^3
1.	Akstafachay	13,6	4,0	290
2.	Kurakchay	14,5	1,16	73
3.	Terterchay	22,0	7,35	334
4.	Ganjachay	4,0	0,058	75
5.	Tauzchay	0,85	0,24	50
6.	Khachinchay	3,20	0,19	60
7.	Shamkirchay	8,37	2,0	250
8.	Jogaschay	0,90	0,18	200

Table 2. The total volume of solid runoff of rivers

№	The rivers	The total volume of solid runoff , m3/year
1.	Akstafachay	122674
2.	Kurakchay	329235
3.	Terterchay	2285000
4.	Ganjachay	9331
5.	Tauzchay	13219
6.	Khachinchay	5972
7.	Shamkirchay	65085
8.	Jogaschay	5598
Total		2836114

Using the above-stated relations, we obtain the volume of tractional (bottom) deposits of these rivers, and then the volume of soluble substances transferred by the specified rivers. Numerical values of these volumes are respectively: ≈ 359 m^3/year and ≈ 417 m^3/year. In this case the total amount of the tractional (bottom), suspended and soluble substances makes 3612114 m^3 /year. Therefore, taking into account the total drainage area of NE slope of Lesser Caucasus we will have:

$$H = \frac{3612114\, m^3/\,year \times\ 1000\, year}{12875\, km^2} = \frac{3612114\, m^3/\,year \times\ 1000\, year}{12875000000\, m^2} \approx$$

$$\approx 0.280\, m/1000\, year \approx 280\, mm/1000\, year$$

Using a comparative-geological method, we present some data on average speed of erosion (denudation) in mm/1000 of years. In river basin of Isere, Grenoble (France) this parameter is 287 mm/1000 years, and in the equitype basin of Reuss river, Lucerne (Switzerland) is about 300 mm/1000 year and etc. (Страхов, 1960). Using the above-stated calculations, we notice, that approximate denudation cut off on the specified slope of Lesser Caucasus will make about ≈280 m/million years. According to our opinion this value can be respectively stable under certain assumptions, and first of all, at approximately identical quantitative development of

Based on the above-stated ratio, we define total volume of tractional (bottom) silts:

2836114 m^3/year : 7,9 = 359, 00177 m^3/year.

Then the total annual volume of solid products, i.e. products of mechanical denudation:

2836114 m^3/year + ≈359 m^3 /year = 3195114 m^3/year.

Considering density of prevailing river deposits (≈2, 65 t/m^3), we obtain total mass of these sediments:

3195114 m^3/year × 2,65 t/m^3 = 84670521 t/year.

Therefore, taking into account the approximate drainage area of NE slope of Lesser Caucasus (≈12875 km^2), we obtain value of mechanical denudation:

84670521 t/year: 12875 km^2 ≈ 658 t/km^2/year.

Thus, this parameter on the north-east slope of Lesser Caucasus ≈ 658 t/km^2/year. For comparison we notice, that according to N.M.Strakhov (Страхов, 1960), for Terek river the value of mechanical denudation is about 587 t/km^2/year, and based on table 3 of the same research the given parameter for Rion river is about 633 t/km^2, for Tigris and Euphrates 690-1000 t/km^2/year, Huang He (China) 640 t/km^2/year. It is necessary to specify that except the above mentioned concept of «mechanical denudation», there is also a concept about «denudation layer», used by eminent hydrologist and morphometrist M.A. Velikanov (Великанов, 1964).

Chemical denudation

Let's pass now to definition of the approximated values of chemical denudation in study area. From this point of view it is logic continuation of the previous work. First of all, the author relies on relevant materials based on known ratios of river deposits of various types, including dislocated deposits on various river sites on the NE slope of Lesser Caucasus. In this regard, it is necessary to use corresponding ratios of the tractional, suspended and soluble substances transferred by the mountain rivers. In this case we mean the corresponding ratios which are published by various experts: G.V. Lopatin (based on Страхов, 1960; Xəlifəzadə Ç.M. and Məmmədov İ.Ə., 2003). On the basis of these ratios, which are based on averaged data, we can easily define percentage of corresponding types of alluvial deposits. In this case First off all, we are interested in percentage of the soluble substances which are a component of river alluvium, i.e., using the above-stated ratios, we obtain corresponding average values.

As N.M. Strakhov specifies (based on G.V. Lopatin's materials) (p. 40; Страхов, 1960): «… on mountainous sites the ratio varies even more toward prevalence of clastic material – a:b:c=0,86:6,8:1,0 ...».

Besides, there are also materials about distribution of various deposit types in the mountain rivers: a:b:c=1:5:0,5 (Xəlifəzadə Ç.M. and Məmmədov İ.Ə., 2003). Using this ratio, we obtain the general percentage of soluble part of alluvial deposits in relation to their total value (2836114 m^3/year), which is about 8,66 - 11,5 %.

After that let us pass to a following ratio of various deposit types of the mountain rivers: a:b:c=1:5:0,5 (Xəlifəzadə Ç.M. and Məmmədov İ.Ə., 2003). Therefore the general total value of the specified indicators makes 6,5. In this connection the percentage of soluble part of rocks in relation to this value makes 7,6 %.

Thus, we have the data characterizing percentage of soluble deposits in relation to a total mass of alluvium: 11,5 % and 7,6 %. In this regard, the usage of percentage of soluble substances (based on the data analysis of G.V.Lopatin) allows us to compose the following proportion:

2836114 m^3/year - 88,5 %

x - 11,5 %

$$x = \frac{2836114\, m^3/year \times 11{,}5\%}{88{,}5\%} = \frac{32615311}{88{,}5} = 368534{,}58\, m^3/year$$

After that we pass to similar consideration of the following proportion:

2836114 - 92,4 %

x - 7,6 % $x = \frac{2836114\, m^3/year \times 7{,}6\%}{92{,}4\%} = \frac{215\ 5\ 44664}{92{,}4} = 233273{,}44\, m^3/year$

Let's start now definition of two indicators of chemical denudation on the NE slope of Lesser Caucasus, which area is ≈ 12875 км^2.

$$x_1 = \frac{368534{,}58\, m^3/year}{12875\, km^2} = 28{,}6240\, m^3/km^2/year$$

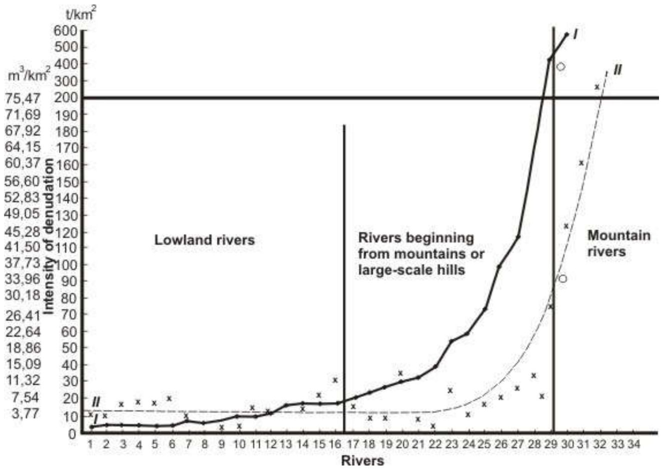
$$x_2 = \frac{233273{,}44\, m^3/year}{12875\, km^2} = 18{,}1183\, m^3/km^2/year$$

Thereupon averaged chemical denudation:

$$28{,}6240\, m^3/km^2/year + 18{,}1183\, m^3/km^2/year = 46{,}7423 : 2 = 23{,}37115\, m^3/km^2/year$$

Comparison of mechanical and chemical denudation

Now let's try to make approximate comparison of chemical denudation with those mechanical denudation, using corresponding curves (p. 20; fig.6, Страхов, 1960).



1-Neva; 2-Yenisei; 3-Luga; 4-Narva; 5-Dnieper; 6-Onega; 7-Ob; 8-Western Dvina; 9-Kolyma; 10-Yana; 11-Mezen; 12-Southern Bug; 13-Northern Dvina; 14-Ural; 15-Don; 16-Volga; 17-Pechora; 18-Indigirka; 19-Amur; 20-Dniester; 21-Kuma; 22-Kalaus; 23-Syr-Darya; 24-Amazon; 25-La Plata; 26-Yukon; 27-Mississippi; 28-Kuban; 29-Kura; 30-Amu-Darya; 31-Terek; 32-Rion; 33-Samur; 34-Sulak. Circles denote rivers of south-east Asia: Indus, Ganges, Brahmaputra, Irrawaddy, Mekong, Yangtze-Chang Jiang and etc.
Note: In the far left column, the author made transfer of some data (t/km^2) in m^3/km^2 at the approximate account of river sediments density (≈2,65 t/m^3).

Figure 1. Relation of mechanical (I) and chemical (II) denudation based on N.M.Strakhov (Страхов, 1960)

In this connection we consider lawful to convert denudation parameters from t/km^2 into m^3/km^2. First of all, it is necessary for possibility of approximate definition of chemical denudation, additionally expressed in m^3/km^2/year, for the purpose of interpolation on a curve of this denudation. After that we easily define obtained concrete values of chemical denudation. In other words, vertical lines which are intersecting a curve of chemical denudation correspond to some points Fig.1 (Страхов, 1960). Thereupon values of chemical denudation approximately correspond to Kuban and Amu-Darya rivers, and based on fig.8 (Страхов, 1960)- approximately to the Kura and Amu-Darya.

Conclusion

The above stated data analysis of denudation cutoff and also mechanical denudation (denudation layer) brings us to some approximate conclusions.

First of all, it is necessary to notice, that the value of denudation cutoff (≈280 mm/1000 years) apparently, testify that according to M.A. Velikanov's data (tab. 14, Horton River, Великанов, 1964), the top zone of the slope near the arch of mountain range is characterized by absence of erosion. It seems that it would be more realistic to talk about weakened form of erosion rather than the absence of erosion. Especially, it also follows from the explanations for given table. Besides, according to this scheme following zone is a zone of active erosion. It is necessary to notice that presence of three basic types of mountain slope is widely known: convex, concave and rectilinear. It is known also, that examples of a convex mountain slope are most common. Considering long development of denudation cutoff, we can reasonably talk about gradual displacement of active erosion zone including also appearance and the further development of tractional load zone. Therefore, it is possible to make a preliminary practical conclusion about the greatest development of gold-bearing placers in this zone of active erosion. It is more justified when the known density of gold-bearing placer particles taken into account. Besides, apparently, it is necessary to consider also possibilities of certain removal of alluvial gold-bearing placers during the high water or flood periods. These are some possible recommendations in connection with established morphometric parameters.

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