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Lithologic Conditions of Inundated Slope Defluction in River Valleys of the Eastern East European Plain.

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ABSTRACT

The field stationary researches carried out within the last 30 years proved ubiquitous development of soil and ground masses sluggish movements on slopes and in the bottoms of river valleys. Speeds of these movements and their distribution are determined by slope vertical and profile. The purpose of this article is to establish dependence of similar movements on various natural factors intensity. Our own field research data confirm that the maximal speed of friable material shift is observed in clays and heavy loams, and minimum speeds of shift are typical for mild loamy structure deposits. For sand intensity of creep fades so that the size of soil peripheral speed shift is within limiting measurement accuracies. The inundated defluction study showed the shifting of top inundated alluvion depth in a lengthwise direction on the valley bottom and change of this shifting direction with depth. Average peripheral speed of upper inundated alluvion shift, according to results of the plates position concerning the profile line and the fixed reference point in the bottom of exploring shaft, changed from 0,3 to 60 mm * year$^{-1.}$ The maximal shift was observed near waterway bed, and minimum – at the rear seam of the bottom. Intensity of longitudinal shift is in direct dependence on biases of longitudinal profile of the river and alluvion mechanical structure. In the upper alluvion part, a loamy facies inundated alluvion, the average size of shift made 47 mm * year^{-1}. In the bottom part the inundated alluvion within river facies the sandy structure speed decreases to 0,2 – 0,3 mm/year. From the depth of 1 m speed fades sharply.

Keywords: creep, defluction, slope, flood plain, inundated alluvion, river valley.

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INTRODUCTION

The sluggish and mass shift of unconsolidated soil and ground masses phenomenon, widely known under the term "creep" (from English creep – to creep, slip) and a defluction (from Germ. defluktion – to leak, to flow down), influences all ground slopes in various degree. However intensity of these movements ranges considerably and depends on lithologic structure of soils, relief features, climatic conditions and other factors. Creep (defluction) is based on the vertical hydrothermal soil movements, which are caused by changes in friable material volume dependent on phase changes of water (cryogenic), changes of soil humidity (hydrogenic), and temperatures (thermogenic). While soil increases in volume its particles move up the normal of a slope surface, and while decreasing they shift down a vertical by means of gravity. Total resultant movement of material is directed downhill [1].

For the first time this phenomenon drew the attention of C. Davison [2], who used the term "creep" for designation of hydrothermal soil and ground masses movements. At the beginning of the XX century P. Gotsinger tried to receive the quantitative data of soil current intensity on slopes of Vienna Wood mountains in Europe. Famous geomorphologists I.P. Gerasimov [3], V. Penk [4], A. Young [5,6,7] laid the theoretical and methodical foundation of this phenomenon detailed studying. D.G. Panov [8] and S.S. Voskresensky [9] offered the term "defluction" to define the phenomenon of soil and cespitose masses sluggish shift downhill. Great contribution to creep (defluction) studying was made by T. Gerlach [10], S. Rudberg [11], S. Schumm [12, 13], B.S. Rusanov [14], A.P. Dedkov and W.A. Duglav [15], E.A. Chasovnikova [16], etc.

Geomorphologists of the Kazan University in 30 years obtained large volume of natural data on defluction stationary studying results. This allowed to reveal the new phenomenon taking place in the river valley bottoms – the floodplains downstream (falling) soil sluggish shift of the river beds we called the inundated defluction [17].

Now the mechanism and conditions of slope and inundated defluction manifestation are quite clear. The purpose of the present article is to establish defluction dependence on various natural factors.

RESEARCH METHODS

In order to study slope and inundated defluction in 1982 - 1985 we placed the network of stationary observation points on slopes and the river valleys bottoms, including 72 exploring shafts. These were put strictly along the profiles which are stretched from the brow to the sole of slopes. Slopes differed from each other by steepness, length, height and exposition. Depending on slope length the profile included from 3 to 6 exploring shafts, at average distance of 20 m between them. The slope steepness changed from 5 ° to 35 °, and their length from 60 m to 130 m.

In the river valley bottoms the profiles were laid across a flood plain perpendicular to the river bed. Width of a flood plain changed from 15 m to 22 m. Exploring shafts were put each 4 – 5 m. Biases of river longitudinal profiles changed from 0,001 ‰ to 0,020 ‰. Slopes and the river valley bottoms were made of clay quarternary age deposits, loamy and sandy mechanical structures. The reference point representing a metal core 0,5 m long with a 1 cm section diameter was upright hammered immovably into the bottom of each exploring shaft of 1,5 - 2,0 m in depth in the wall basis through slope falling. Beside the exploring shaft in alignment with the above described reference point one more similar reference point over which the theodolite aligned on it by means of down settled plumb was established. In this case the telescope sighting vertical axis of theodolite was in strictly vertical plane of these two reference points and fixed in exploring shaft wall in line along which metal plates of 4 - 6 cm^2 were established. Intervals between plates usually made 10 – 15 cm. After the plates were placed their position was noted in the field diary. The exploring shafts were carefully covered with soil, closed with turf and instrumentally attached to the reference points available on scene.

Through particular time periods, usually no less than 3 years, exploring shafts were opened and, whenever possible, more precise deviation measurements were made by means of plastic ruler, starting from the line of vertical plane along which they originally had been put.

On the basis of field data intensity of defluction was defined by various ways [1]:

- The peripheral speed of plate shift in the direction of slope falling (mm * per year^{-1}). According to linear speed data the epure speed was built showing change of speeds with depth.
- The average speed of soil shift in exploring shaft was determined by dividing the area of epure to shift depth.
- The soil volume displaced in unit of time on all depth of slope shift site on extension of particular length. It was defined as work of the epure area on site length by extension.
- On all points of supervision the detailed morphometric and morphological relief characteristic was given, the geological structure was studied and soil lithologic composition was defined.

RESEARCH RESULTS AND DISCUSSION

Creep (slope defluction) is showing at the depth of 1,2 - 1,5 m, which corresponds to the average depth of soil freezing in winter season. The peripheral speed of soil shift depends on mechanical composition of soils, on the steepness and exposition of slopes.

Major factor of slope defluction manifestation is the lithologic structure of soils. Field data confirm that the maximal shift speed of friable material is observed in clays and heavy loams (average of 3,6 mm * year^{-1}), and minimum shift speeds (average of 2,6 mm * year^{-1}) are common for deposits of mild loamy structure. For sand the creep intensity fades so that the size of soil peripheral speed shift is within limiting measurement accuracies.

The lithologic soil composition defines the epure shift speed and its type. By changes of deposit size distribution to the peripheral shift speed it is possible to allocate some epure types:

- The mechanical structure of deposits (light - medium - heavy) down exploring shaft section does not change and remains constant. In this case the distribution velocity completely corresponds to epure in which the maximum shift is observed on surface, and in depth there is a decrease of speeds up to the complete attenuation of shift process on depths of 1,2 - 1,5 m.
- Down a section material coarsening takes place. Epure has the form similar to the first type, but decrease of the peripheral soil shift speeds happens even more sharply. Attenuation of shifts is observed approximately at the same depth.
- On the surface material is rougher than in depth. Epure of an absolutely different type appears when the maximum of soil shift is observed at some depth.
- Inside section there is a frequent alternation of layers differing by mechanical structure, especially by content of sand and clay. In this case epure takes composite pinnacled form.

Data of stationary observation show that the peripheral shift speed and volume of moved material essentially depend on slope expositions to which the phenomenon of snow asymmetry of river valley slopes, ravines and beams is bound in the east of East European Plain. Warm slopes (southern, western and southwest) get warmed well, others are exempted from snow earlier in the spring. Therefore they are drier and steep, but in equal conditions, do not differ greatly from the peripheral shift speeds and volumes of the moved material. On cold slopes (northern, east, northeast) snow stays long, and they are more wet, are substantially subjected to flattening processes, sliding and slope defluction. Therefore intensity of creep on cold slopes considerably increases (tab. 1).

Table 1: The common average values of slope defluction intensity in the east of Russian Plain under conditions of various mechanical soil composition, slope exposition and steepness

Mechanical composition of soils	Slope exposition		Slope ratio		Mean value of intensity
	u. z, u-z	s, v, c-v	<10°	>10°	
Light loam	a) 6,7 b) 2,3	a) 10,8 b) 2,9	a) 7,8 b) 2,1	a) 9,4 b) 2,2	a) 8,8 b) 2,6
Medium loam	a) 10,8 b) 2,4	a) 13,9 b) 3,5	a) 8,4 b) 2,9	a) 9,8 b) 3,2	a) 11,9 b) 2,7
Heavy loam, clay	a) 12,2 b) 2,8	a) 27,8 b) 4,3	a) 13,2 b) 3,1	a) 18,1 b) 4,2	a) 17,37 b) 3,6

Note: a) the moving material volume (cm ^{3}*cm^{-1}*year^{-1}); b) the peripheral shift speed (mm * year^{-1}).

Field data confirms the direct dependence of the peripheral shift speeds on the slope steepness, which is caused by increase in gravitational component of downhill soil shift [18].

The inundated defluction study showed the shifting in top inundated alluvion depth in a lengthwise direction on the valley bottom and change of this shift direction with depth. Average peripheral speed of upper inundated alluvion shift according to results of the plates position concerning the profile line and the fixed reference point in the bottom of exploring shaft changed from 0,3 to 60 mm * year$^{-1.}$ The maximal shift was observed near waterway bed, and minimum – at the rear seam of the bottom. Intensity of longitudinal shift is in direct dependence on biases of longitudinal profile of the river and alluvion mechanical structure. In the upper alluvion part, a loamy facies inundated alluvion, the average size of shift made 47 mm * year^{-1}. In the bottom part the inundated alluvion speed within river facies of sandy structure decreases to 0,2 – 0,3 mm/year. From the depth of 1 m speed fades sharply.

Intensity of longitudinal shift of the high layer inundated alluvion depends on longitudinal profile biases of the river as well. For example, on river Knya (confluent of river Vyatka) in headstream the soil shift speed made 62 mm * year^{-1}, in lower current – 53 mm * year^{-1}. The river bias on this site decreased from 0,01 to 0,005 ‰.

Based on the abovesaid main results of this work are the following:

- The bottoms and slopes of river valleys are subjected to sluggish soil shift and ground masses shift which is caused by hydrothermal changes in them.
- Material shift speed on slopes significantly depends on mechanical composition of soils. Shifts fade in deposits of rough structures like sand and, on the contrary, increase in clay and loamy soils. This factor is decisive and basic in defluction manifestation. Other factors, such as exposition and steepness of slopes, are the controlling factors.
- Manifestation speed of slope and inundated defluction is not identical. Flood plain soil shift happens more intensively, than on valley slopes. The inundated defluction mostly shows more intensively in spring time, especially during the high water period, when the flood plain is filled with thawed snow, and, apparently, weakens in summer and in fall before complete attenuation in winter season. The mechanism of inundated alluvion movement, apparently, is that during a high water inundated soils of loamy structure become highly flexible and under the influence of hydrostatic and flowing pressure the flood waters are displaced downstream even at small biases of river valleys.
- Slope and inundated defluction form a uniform chain of rather sluggish material transfer, which, having displaced from slopes of river valleys in their bottoms, and having formed stream of inundated alluvion shift, moves further. These can explain very weak creep relief-forming value in process.

SUMMARY

On the basis of the performed work it is possible to draw the following conclusions:

- Intensity of defluction increases during the flood period and weakens in summer and in fall before the complete attenuation in winter season.
- Flood plain soil shift happens more intensively, than on valley slopes.
- Direct dependence of the peripheral shift speeds on the slope steepness that is caused by increase in gravitational component of downhill soil shift is revealed [18].

CONCLUSION

The bottoms and slopes of river valleys are subject to sluggish soil shift and ground masses shift which is caused by hydrothermal changes in them. Shift speed of slope material, mainly, depends on distribution soils. Shifts fade in deposits of rough structures like sand and, on the contrary, increase in clay and loamy soils.

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