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PATTERNS OF SOIL FORMATION AND DISTRIBUTION IN ARID MOUNTAINS OF THE PAMIR

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Abstract

Some new scientific concepts about the genesis of soils in arid mountains of dry subtropical zone of Pamir were established. It was revealed that the main soil-forming processes, under influence of which developed all the soils of the Pamir are humus accumulation, argilization and leaching under the leadership of the humus-accumulative process. It was showed the leading role of humidity and duration of the biologically active period in the formation of plant landscapes and soil types in all vertical zones as well as the important role of thermal regime in the soil formation of cold and very cold thermal zones that differ by fulvate composition of humus and reddish color profile.

Key words*: arid, distribution soil, mountains, Pamir, humus.*

INTRODUCTION

General schemes of the distribution of soils and vegetation as dependent on the spresding of the sum of active temperatures and the degree of the climatic moistening (the Ivanov-Vysotskii humidity factor) in the Pamir Mountains are suggested. It is shown that the development of particular types of soils and vegetation communities in all vertical thermal belts, except for the cold belt, is mainly controlled by the humidity factor (Kann, 1965; Kuteminski & Leontieva, 1966).

MATERIALS AND METHODS

About 1000 soils' profiles were made across vertical topographical profiles on mountains' slopes of North and South exposition in the lower, middle and upper part of the main river basins of West Pamir.

The analysis (more than 100000) were made according to the accredited classic methodology. Generalization and statistical processing of the high quantitative mass of analytical material let us receive the information about the compound and proprieties of West Pamir soils and draw out the main legitimates of their formation (Cherbari, 2001).

RESULTS AND DISCUSSIONS

The modified idea of Sokolov I.A. (1978) and Fridland V.M. (1979) about the possibility of soil classification using several components: ecological-geographic, regime and profile components of soil classification (Table 1).

Table 1. The components of classification

Ecological-geographic	Regime	Profile genesis
1. Mountain chain 2. Type of vegetation	Facies soils subtypes by sum of tempe-ratures >10°C	1. Types of soils 2. Subtypes of soils

Pamir's' mountain system is unique for investigation of objective laws of soils geographical placing depending on thermal and humid conditions.

Here, on relatively compact mountain territory which is situated in latitude dry subtropical belt, all vertical thermal belts are present: from subtropical to very cold.

Within the most belts conditions of humidity, for the reason of phenomenon of rain shadow, change from extra arid (80-100 mm precipitation per year) to arid humid (1000-1500 mm/year). Rain and snow fall in winter and spring periods; summer is very dry.

The hydrothermal parameters of every subtype of soils have been got by the method of comparison of soil maps, year precipitation and sum of the active (more than 10°C) temperatures. Constructing coordinate graph where value of coefficient humidity according to formula Ivanov-Visotsky is put on axis of abscises, and sum of the active temperatures is put on axis of ordinate, and putting on graph the hydrothermal characteristic of every subtype of soil, we have got a system of closed areal (fields) which describes hydrothermal conditions of existence of every soil.

The system of hydrous rows (sectors of humidity) determines spectrum of subtypes of soils depending on humidity within the one thermal belt, but the system of thermal rows (vertical thermal belts), within the one hydrous row, determines spectrum of soils subtypes depending on thermal regime of territory.

The general scheme of distribution of zonal soils subtypes on territory of Pamir-Alay depending on hydrous and thermal conditions is presented in the Table 2.

Table 2. Vertical and horizontal arrangement of soil systems in arid mountains of the Pamir depending on the thermal and humid conditions

<table>
<tr><td rowspan="2">Altitude climatic (thermal) belts (t°>10°C)</td><td colspan="8">Coefficient humidity</td></tr>
<tr><td>>0.1</td><td>>0.1-0.2</td><td>0.2-0.3</td><td>0.3-0.5</td><td>0.5-1.0</td><td colspan="3">1.0-1.5>1.5</td></tr>
<tr><td></td><td colspan="8">Soils (Humus, % in horizon Ah)</td></tr>
<tr><td>Very cold (t°>10°C)</td><td colspan="2">No</td><td colspan="3">Reddish light brown cryodesertic or Cryo Regosol (1-2%)</td><td colspan="3">Snow belt</td></tr>
<tr><td rowspan="2">Cold (0-900°C)</td><td colspan="2" rowspan="2">Grey pale desert or Yerma regosols (<1%)</td><td colspan="3">Reddish brown semidesertic</td><td colspan="3" rowspan="2">Reddish dark brown steppe (5-10%)</td></tr>
<tr><td>Light (1-2%)</td><td>Typical (2-3%)</td><td>Dark (3-5%)</td></tr>
<tr><td rowspan="2">Cold temperate or moderately cold (900-2000°C)</td><td rowspan="2">Idem</td><td colspan="3">Brown semidesertic</td><td rowspan="2">Dark brown steppe (5-10%)</td><td colspan="3" rowspan="2">Dark brown and Black brown under xerophilous sparse forest or Phaeozems (7-15%)</td></tr>
<tr><td>Light (1-2%)</td><td>Typical (2-3%)</td><td>Dark (3-5%)</td></tr>
<tr><td>Warm temperate or moderately warm (2000-3100°C)</td><td>Idem</td><td>Idem</td><td>Idem</td><td>Idem</td><td>Idem</td><td colspan="3">Dark brown and Black brown under xerophilous sparse forest or Phaeozems (6-12%)</td></tr>
<tr><td>Very warm (3100-3800°C)</td><td>Idem</td><td>Idem</td><td>Idem</td><td>Idem</td><td colspan="2">Brown under xerophilous sparse forest or cambisol xeroforest (5-10%)</td><td>No</td></tr>
<tr><td rowspan="2">Subtropical (3800-4900°C)</td><td rowspan="2">Grey pale or grey brown desertic (<1%)</td><td colspan="3">Serozems or Grey semidesertic</td><td rowspan="2">Kastanozems (2.5-5%)</td><td>Idem</td><td>No</td></tr>
<tr><td>Light (1-2%)</td><td>Typical (2-3%)</td><td>Dark (3-5%)</td><td colspan="2"></td></tr>
<tr><td>Subtropical hot (>4900°C)</td><td>Idem</td><td>Idem</td><td>Idem</td><td colspan="5">No</td></tr>
</table>

A comprehensive study of the composition and properties of soils was carried out on two soil catena. The first soil catena is located in the arid part of the Western Pamir on the Shugnan Ridge in the basin of the river Regista near Khorog, in the altitude range from 2000 to 4500 m. The second soil catena is located on the Darvaz Ridge in the arid-humid part of the Western Pamir, elevations from 1300 m near the village Kalaikhum to 3600 m in the Khaburabad Pass region.

The fractional composition of iron is determined in the soils of the river Vanch area developing in conditions of humidification from extra-arid (precipitation for the year consist 200-230 mm, Humidity coefficient (HC) = 0.11) to arid-humid (precipitation per year 1000-1500 mm, HC = 2.5).

The study of the key issues of the genesis and geographical location of the soil was carried out by comparing the average indicators of the composition and properties of different soil subtypes of shadow slopes, since on these slopes the vertical zone is more contrasting than on the sun slopes.

The influence of slope exposure on the genetic features of the soil is revealed by comparing the average composition and soil properties of the northern and southern slopes of the three vertical belts of the Darvaz Ridge (arid and arid-humid moistening).

Change of thermal conditions with altitude is the main factor of vertical zonality of soils. Vertical thermal belts are uninterrupted, but their upper boundaries are so much the higher than climate becomes more arid.

Within thermal belts humidity is the main factor of forming of different soil systems. Soils of shadow and sun slopes form independent, attended vertical rows of soils.

In the result, the list content of the soils focuses on description of laws of formation and spatial distribution of soils across this mountainous region, as well as problems of their classification and diagnosis.

Some new scientific positions about the genesis of soils in arid mountains of dry subtropical zone are established. It was revealed that the main soil-forming processes, under influence of which develop of all the soils of the Pamir are humus accumulation, glayization and leaching under the leadership of the humus-accumulative process.

It is showed the leading role of moisture and duration of the biologically active period in the formation of plant landscapes and soil types in all vertical zones as well as the important role of thermal regime in the soil formation of cold and very cold thermal zones that differ by fulvate composition of humus and red color of soils.

It was established a weak effect of the parent rock on genetic features of full formatted soils of any vertical zone in arid and sub-arid climate (the limiting factor - moisture) and its growing influence in the arid-humid conditions and moderate temperature regime.

Substantiated the differences in the structures of vertical belts of soils in different parts of the region associated with increasing aridity from east to west and from south to north; the schemes of soil-geographical zoning are given. In addition, to better understand the patterns of spatial distribution of automorphic soils attached to the Pamir´s ridge, the structure of vertical belts of soils in South-Western, Central and Northern zone of Tajikistan.

The main genetic features of the arid soils of the Western Pamir are determined by a system of humus status. The direction and type of humus formation in soils depends on the amount of plant litter entering them and the hydrothermal conditions of its mineralization and humification. The lack of moisture limits biological processes in all mountains belts, low temperatures limit the productivity of vegetation, the activity of microorganisms and humus formation only in cold belts. The peculiarity of the process of humus formation in arid soils is the wide ratio of reserves of underground and above-ground mass of vegetation (60-100 cm) and the narrow ratio of reserves of humus and underground plant mass.

In the vertical soil-climatic zones, except for the cold ones, the following pattern is observed: the factors leading to an increase in the amount of humus in the soils, which determine its higher quality. In cold zones, soils have a homogeneous composition of humus (fulvate type), regardless of its total amount, since the formation of complex humic acids is limited by the lack of heat.

The humus reserves in the soils of the Western Pamir in the 0–100 cm layer vary from very low (less than 50 t/ha) in the soils of the extra-arid deserts (the amount of precipitation is 50-80 mm) to high (500-600 t/ha) in arid-humid soils of the high-grass meadow steppes of the moderately cold belt (the amount of precipitation is 1000-1500 mm).

The humus type of the soils of the Western Pamir is different: *fulvate, saturated with bases, enriched with nitrogen* - in the gray-pale desertic; *fulvate, slightly unsaturated iwith bases, medium-enriched with nitrogen* - in the reddish-brown soils of the cold and very cold belts; *humate-fulvatny, saturated with bases, medium-enriched with nitrogen* - in brown semi-desertic and gray-brown; *fulvate-humate saturated or slightly unsaturated with bases, medium-enriched with nitrogen* - in brown typical, brown steppe, dark brown xerophilous light forest and meadow-steppe; *humid, saturated with bases* - in black-brown xerophilic woodlands and black-brown meadow-steppe soils (Figures 1 and 2).

In all soils, except extra-arid ones, brown humic acids predominate in the humus composition, which indicates the widespread distribution of brown soil formation in the mountains in various forms of its manifestation.

A feature of all the soils of the region is the relatively low amount of absorbed bases, which varies from 4-5 mg-eq. in extra-arid gray-pale

desertic sandy-loamy to 15-25 mg-eq. in arid-humid dark brown and black-brown xerophilous light forests and meadow-steppe heavy loamy, which is associated with a low content of silty in the soils and, therefore, colloidal fractions.

The composition of absorbed bases is dominated by calcium and magnesium cations, and only in arid-humid soils of the temperate zones and in soils of the cold belt, a small amount of absorbed hydrogen appears (0.1-1 mg-eq.). Not only chemical, but also their physical properties of soils are associated with the genesis.

Fully developed soil slopes can be in equilibrium with the factors-soil formers only having certain physical properties that determine their stability in relation to the slope processes in specific hydrothermal conditions.

A significant impact on soil formation in the mountains of the Western Pamir has an exposure of the slopes. The soils of the shadow and solar slopes of the same altitude level differ among themselves at the level of the facies subtypes and form independent, interconnected rows of vertical zones.

The horology of the zonal types and subtypes of the soils of a region is determined by the hydrothermal conditions of their development. With the belt distribution of temperature regimes over the vertical profile of the mountains and the presence of a wide range of degrees of moisture within each thermal belt, the zonal fully developed soils of the Western Pamir are bio-axial organic-mineral systems, the level of organization of which is determined by the amount of heat and moisture entering in them. Each zonal soil type and subtype corresponds to a strictly defined of hydrothermal area.

The moisture of winter precipitation has an important role in soil formation in the Western Pamir: during the snowmelt in the soil profile it creates increased moisture and temporary leaching; contributes to the process of leaching of soil from easily soluble salts and carbonates; causes the manifestation of the process of iron-siallitisation; leads to the emergence in different soils of a hydrothermal regime similar in general during the period of biological activity, which determines the uniformity of their humus composition.

Strengthening the anthropogenic and technological impact on the soil cover of the Western Pamir leads to disruption of the established biosphere equilibrium and negative consequences.

Figure 1. Reddisch light brown cryodesertic or Cryo Regosol

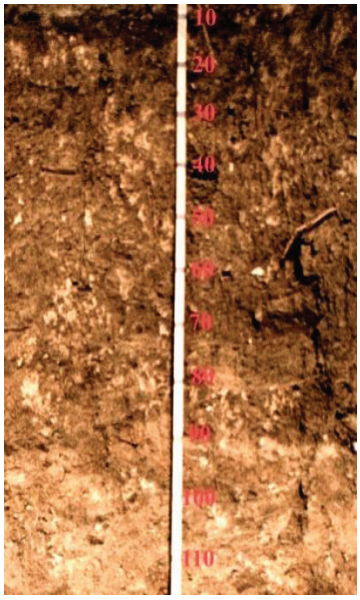

Figure 2. Reddisch dark brown steppe

Soil protection in the region should be considered as a single system of measures aimed at the protection, qualitative

improvement and rational use of its land resources.

CONCLUSIONS

The main physico-geographical peculiarity of the Western Pamir is not only the combination of high-altitude and aridity, but also in the fact that in the general aridity of climate all vertical thermal belts are distinguished - from the subtropical to the very cold, and within most belts there is a very wide the range of humidification levels ranges from extra arid (80-100 mm of precipitation per year, hidrotermic coefficient less than 0.1) to arid-humid (800-1500 mm of precipitation per year, hidrotermic coefficient - 1-3). Such a variety of hydrothermal regimes in a limited area is unique and does not occur in any mountain system of the World.

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