ANNALS OF AGRARIAN SCIENCE, vol. 13, no. 4, 2015
ИЗВЕСТИЯ АГРАРНОЙ НАУКИ, Том 13, Ном. 4, 2015

SOILS OF GEORGIA AND PROBLEMS OF THEIR USE

T.F. Urushadze*, Winfried E.H. Blum, J. Sh. Machavariani***,**
T.O. Kvrivishvili*, R. D. Pirtskhalava***
****Agricultural University of Georgia, Mikheil Sabashvili Institute of Soil Science, Agrochemistry and Reclamation***
240, David Aghmashenebeli Ave., Tbilisi, 0131, Georgia; t_urushadze@yahoo.com; t.kvrivishvili@agruni.edu.ge
*****University of Natural Resources and Life Sciences (BOKU), Vienna***
82, Peter-Jordan Str., Vienna, 1190, Austria; winfried.blum@boku.ac.at
******Georgian Technical University, Research Centre of Production Forces and Natural Resources***
69, M. Kostava Str., Tbilisi, 0179, Georgia; zlomsadze@mail.ru; rusikopirtskhala@yahoo.com
Received: 15.10.15; accepted: 22.11.15

The paper deals with the main features of main soils of Georgia (Red, Yellow, Bog, Yellow Podzolic, Yellow Podzolic Gley, Yellow Brown Forest, Brown Forest, Brown Forest Black, Raw Carbonate, Grey Cinnamonic, Meadow Grey Cinnamonic, Cinnamonic, Meadow Cinnamonic, Black, Chernozems, Mountain Forest Meadow, Mountain Meadow, Mountain Meadow Cherrnozems, Saline, Alluvial), their distribution, areas, history of investigation, ecology – parent rocks, relief, climate, vegetation –, morphology, basic genetic signs – pH, Humus, Nitrogen, exchange cations, texture, bulk chemical composition, different iron forms, classification, the use and improvement approaches. The work generalizes the approaches of many years' research and practice and devises the ways of their optimal use.

Georgia is a mountainous country in the Caucasus, neighboring Russia, Azerbaijan, Armenia and Turkey. Georgia is characterized by a great variety of soil types on its small territory, which includes nearly all soils of the world [1-19]. This can be explained by the enormous variety of soil forming factors within short distances. Therefore, Professor V.V. Dokuchaev, one of the founders of modern soil science in the end of the 19th century, called Georgia an "Open-Air Museum of Soils".

The spectrum of soil types in Georgia reaches from bog soils in the lowlands of the humid subtropics of West Georgia to meadow-grey-cinnamonic and salty soils in the dry subtropics of East Georgia. Foothill-, mountain-forest- and mountain-meadow regions show very different soil types. A great variety of rocks, a specific relief with contrasting climatic conditions and great differences in biodiversity and other soil forming factors determine the enormous variety of soils in Georgia and its specific geographical distribution.

The characteristics of georgian landscapes and soils show the greatest diversity. According to the different local conditions of soil formation, within each soil type a number of subtypes, families and forms with specific characteristics can be distinguished.

The soils of Georgia have been investigated by many scientists. As a result basic principles of soil formation could be defined in modern soil science.

Many soil types were discovered and described on the territory of Georgia, as a result of a complex pattern of bioclimatic, lithological and geomorphologic conditions.

Some of the world soils were first described in Georgia and were later discovered in other countries, too, among them Cinnamonic (Cambisols Chromic) by Professor S. Zakharov in 1904, Meadow-Cinnamonic (Cambisols Chromic) by Professor V. Fridland in 1956,Yellow-Brown Forest (Acrisols Haplic) by Professor T. Urushadze in 1967.

During the Soviet time Georgia was the only republic, where subtropical soil landscapes, suitable for subtropical crops, were widespread, accounting for an increased interest of soil scientists in these soils. Almost all leading soil scientists contributed with special studies, starting with the Report of the Dokuchaev Transcaucasia Statistical Committee in 1899.

One fundamental law of soil geography – the law of vertical distribution of soils - was postulated by Professor V. Dokuchaev on the example of the Caucasus, in particular on the example of Georgian soils.

In 2009 the Soil Map of Georgia was published at a scale 1:500 000. For the first time in the post-Soviet time the national soil classification was correlated to the modern international soil classification (WRB). The map was established by more than 50 scientists and practitioners under the leadership of Professor T. Urushadze. Seven leading authors of the map were awarded with the State

Prize of Georgia.
In 2002-2006 the realization of a land cadastre and land register project co-financed by the German KFW was of great significance. In the framework of this project large groups of soil scientists were trained under field conditions in national and international soil classification (WRB). A working version of the "World Reference Base for Soil Resources" was translated into Georgian and published in 2005. A textbook on field investigation of soils was published in 2006.
Through the influence of human land use activities in many areas, the conditions of soil formation have been changed. In some regions of Georgia the cultivation of soil under irrigation has a history of many centuries, while in other regions soils were cultivated only during some decades.
The timescale of soil formation is most important especially when changes of soil forming conditions occur. Therefore, soil can also be considered as a "mirror of landscape", which reflects the conditions of soil formation. However, soil types do not always indicate the actual soil forming parameters, because they were formed under quite different conditions. Therefore they also indicate previous stages of soil development, thus revealing earlier stages of development. As a result, soil is not only a "mirror of landscape", which reflects the contemporary conditions of the environment, but also a "memory of landscape" through the conservation of paleo-geographic, relict properties. However, soil properties formed under previous conditions do not disappear completely, but are inherited and preserved for a certain period of time.
The soils of Georgia were formed in the Quaternary period, some of them during the Pleistocene and others in the Holocene. Some soils of vertical zonality in the foothill areas are: Ferralic Nitisols, Haplic Acrisols, Albic Luvisols (Humid Subtropics), Vertisols, Chromic Cambisols (dry Subtropics). Soils of the middle belts of the mountains are: Eutric Cambisols, Chernozems and High Mountains Leptosols, which show that the soil types and their properties sometimes do not reflect adequately the actual physical-geographic conditions. This refers especially to soils, which occur around 1000-1200 m a.s.l. Their age is much older than Holocene. Soils above 1200 m of altitude clearly reveal ecological (physical-geographic) conditions in their properties and are therefore a mirror of landscapes.
It is known, that during the history of the Earth continuous changes of the soil cover occurred by burying of old soils and formation of new ones, partly on young sediments or on the remnants of old soils. In the assessment of the actual soil cover it is necessary to distinguish different parameters: age of the soil cover, soil types, soil horizons and others.
Alongside other natural conditions which determine the layout of agricultural crops, increased productivity measures, soil plays a special role. Land as a natural resource is an important element in the biosphere.
Soil diversity and spatial differentiation regularities is determined by the extremely irregular surface, geological structure, hydro-climatic conditions, vegetation and other natural factors, the combination of which form soil types. On the relatively small area, Georgia has soil analogues of the world's different landscapes.
Red soils (Ferralic Nitisols, Haplic Nitisols) are characterize by red colors, clayization and usually by great soil depths. The soil profile shaws the following horizons: A-AB-B-BC-C. The total area of red soils is about 1% of the land surface (130 400 ha). These soil occur in the south-western part of the humid subtropical zone (Adjara, Guria). They are also met in Samegrelo and Abkhazia [20-24].
The ferrallization passes several stages. On the first stage of weathering during intensive hydrolysis of the primary minerals and release of bases and free silica, the formation of montmorillonite takes place. At the next stage of weathering, when the soil thickness increase and bases are lost, the soils become more acid.
The natural vegetation consist of a mixed subtropical forest, where we meet chestnut, oak, beech, hornbeam and others. This forest is described as an evergreen type of forest. Nowadays, a great part of this area is deforested and occupied by subtropical agriculture and tea plantations.
Yellow soils (Ferric Luvisols) are characterized by yellow colors, clayization and usually by deep profiles. The soils show the following horizons: A0-A-AB-B-BC-C [25].
In Georgia the total area of yellow soils covers 4,5% (317.600ha). These soils are widely distributed in the humid subtropical zone of West Georgia in the mountainous hilly belt. The distribution and properties of yellow soils are determined by the influence of the parent rocks.
Natural vegetation consists of mixed subtropical forests (oaks, zelkova, chestnut, pterocarya, lime tree, maple and others). Nowadays, large parts of this area are deforested and used for agricultural production.
Red and yellow soils play significant role in agriculture. They are used under subtropical plants as well as tea plantations. These soils are suffering from the lack of nutritional elements (nitrogen, phosphorus, potassium, calcium, magnesium) and require their constant application in the soil. Due to unfavorable terrain anti-erosion measures are necessary.
Bog and marshy organic soils (Dystric Gleysols, Eutric Gleysols, Histosols) are mainly found in the Kolkheti lowland (220.000ha). The latter represents a triangle between Kobuleti, Ochamchire and Samtredia. Bog soils are sporadically met in East and South Georgia.
Bog soils involve silt-bog (130.400 ha or 1,9% of the country) and organic (peat) bog soils (70.600ha,1% of the territory) [26-28].
The interpretations of the bog formation in the Kolkheti lowland differ greatly. According to A. Motserelia [ ], the formation of bog is connected with precipitation and superficial water from the rivers beds. According to G. Kostava [ ], bog processes are connected with ground

water and soil-ground water.
Due to negative physical properties, bog soils are less useful for agricultural purposes. They can be used after drainage reclamation, which will contribute to the development of animal husbandry. Part of it may be used for agricultural crops (corn, tea, laurel, etc.).
Among hydromorphic soils are peat, silt and raw-carbonate soils, the improvement of which involves complex and long-lasting reclamation measures.
Yellow podzolic soils (Stagnic Acrisols, Ferric Acrisols) are characterized by sharply differentiated profiles with the following sequence of horizons: A-A1A2-A2(g)-B1-B2-BC-C. [29-31]. The main diagnostic features of the soil are a well expressed eluvial horizon, which is poor in silt and sesquioxides, and a yellow-brown illuvial horizon.
In Georgia the total area of yellow podzolic soils is 2% (137.600ha). These soils are distributed in the humid subtropical zone of West Georgia from 30 to 200m a.s.l., mainly on small peripheral slopes of the north-eastern part of the Kolkheti lowland, on old river terraces.
Yellow podzolic soils are distinguished from real podzols by their soil forming conditions (subtropical climate, parent rocks rich in iron). As a result, in these soils a “real” podzolization or weathering of primary and secondary minerals and its translocation in the profile does not take place. The profile of a yellow podzolic soil is the result of so called “pseudopodzolic” processes, the leaching of thin particles, mainly clay and surface gleyization. The process of “lessivage” determines the formation of soil layers with impeded drainage.
On peripheral part of Kolkheti lowland, yellow podzolic (subtropical podzolic) soils occupy significantly large areas and are characterized by low natural fertility, unfavourable physical properties, which include the existence of a large number of dense orstein layer, which is strongly linked and due to poor water permeability soil surface is often bogged. This orstein layer cemented in the soil profile limits the biological productivity of the soil.
Yellow-podzolic gley soils are characterized by sharply differentiated profiles with the following sequence: A-A1A2-B1-B2-BC-CDg-G orA1A2-A2-A2B-BCg. The conditions of the formation of yellow-podzolic gley soils are closely related to those of the yellow-podzolic soils, but are different regarding the soil moisture regime. The total area of yellow-podzolic gley soils is of 0,7% (14.200ha) of the territory of the country. Yellow-podzolic gley soils border on one side, with yellow and raw humus calcareous soils and on the other side with yellow-podzolic and bog soils.
The yellow-podzolic gley soils formed on the old terraces show well-differentiated genetic horizons with a weak humus horizon. Gleyization is already observed at the surface and gradually increases with depth. The ortstein horizonis well-expressed. Yellow-podzolic gley soils are distributed in the same area as yellow-podzolic soils, but they occupy lower parts of the relief.
Their cultivation is rather difficult. It is impossible to grow perennial crops without reclamation measures. They are used under corn and other annual crops. To improve the physical properties of this soil priority is given to deep processing (plantage ploughing), aiming at deepening and loosening ortstein layer.
Yellow brown forest soils ((Stagnik Luvisols, Mollic Luvisols, Humic Luvisols, Ferric Luvisols) are characterized by a well expressed humus and a yellowish brown illuvial horizon. The soil profile usually has the following horizons: A-AB-B1-B2-C1-C2orA-B1-B2-C1-C2orA-AB-B-B1B2-BC.The main diagnostic indexes are well expressed by humus and a yellowish brown B horizon with allitic weathering and high iron oxide content [32-34].
In Georgia the total area of yellow brown forest soils amounts to 1,5% (106.000ha).The yellow brown soils are distributed in West Georgia between the yellow, red and brown forest soils of the subtropical belt (in altitudes from 400-500m to 800-1.000m).
The formation of the yellow brown forest soil combines the formation of a brown forest soil and a yellow soil. As a result, they have much in common. Finally, this combination of processes leads to new properties.
Brown forest soils (Humic Cambisols, Ferric Cambisols, Eutric Cambisols, Dystric Cambisols) are characterized by a weakly differenciated profile, although sometimes as a result of clay formation in the middle part of the profile a textural differentiation is visible. Consequently,a surface gleyization may occur. The soil profile has the following horizons: A0 - A - Bm - C. The main diagnostic feature is the metamorphic clay in the Bm horizon [35-37].
In Georgia brown forest soils are widely distributed. The total area amounts to 1.329.000 ha, which is 18,1% of the total territory.
Brown forest soils occur in East and West Georgia, as well as in South Georgia. In West Georgia they are found between 800m (900m)up to 1.800m (2.000m), inEast Georgia within 900m (1.000m) up to 1.900m (2.000m).
In West Georgia brown forest soils border with yellow brown forest and mountain forest meadow soils, in East Georgia with cinnamonic and mountain forest meadow soils.
Brown forest soils develop the following basic processes: 1) humus formation and humus accumulation, which determine the formation of a dark brown humus horizon beneath the litter layer; 2) siallitic clay formation in the entire profile with insignificant transfer of weathering products and formation of a clay dominated horizon under the humus horizon. In the middle and lower parts of the forest due to favourable physical and chemical properties, brown soil is used for maize and perennial plants, hayfields and pastures.
Brown forest black soils (Haplic Chernosems) are characterized by a thick humus horizon with a humid water regime. The soil profile usually has the following horizons:

A0-A11-A111-A1111-BC2 or A0-A11-A111-AC. The diagnostic features are a black brown (dark brown) color, large blocky structure (crumby-sandy in horizon A11), comparatively friable structure with the absence of carbonates. The brown forest black soils are distributed in the forest belt of the Small Caucasus from 1.100 to 1.600m. These soils border with brown forest soils.

The genesis of these soils is directly connected with the chemistry of the parent rocks (andesite-basalt), particularly with the high content of calcium. Therefore, the natural vegetation (Quercus macranthera F.et M. and abundant grasses) is also rich in calcium. The intensive influence of the vegetation in biological turnover processes is the reason for the organo-mineral composition of the soil and of the deep humus horizons. The humid moisture regime excludes carbonate accumulation and supports the formation of these soils.

Raw carbonate soils (Rendzic Leptosols) are characterized by weakly differentiated profiles. The soil profiles usually have the following horizons: A0-A-AB-BC. They are mainly formed in the forest zone on carbonate rocks (e.g. limestone, marble, dolomite and chalky clay) and are characterized by a leaching or periodically leaching moisture regime. The soil has a well expressed humus horizon with a high exchange capacity.

The total area of raw carbonate soils composes 4,5% (317.200ha) of the total area of the country.

These soils are broadly distributed in West Georgia: Abkhazia, Samegrelo, Racha-Lechkhumi and Zemo Imereti, also in East Georgia: Mtiuleti, Samachablo, Kakheti and Kartli, mostly in areas with limestone and chalky clays. Apart from the mountain forest belt, raw carbonate soils are distributed in the humid and the dry subtropical zone of the high mountains.

The parent rocks of the raw carbonate soils (limestone and chalky clay) contain the main oxides (SiO2, AL2O3, Fe2O3) in insignificant quantities. Lithophyllic plants like lichens, mosses and others growing on these rocks contain twice as much silica, seven times more AL203 and five times more Fe203 than the rock itself. As a result of this biological accumulation of elements by the vegetation, the fine earth becomes rich in the main oxides mainly through calciphyllic trees and grasses.This soils is used for a vineyard, fruit trees, tobacco, bay leaf, citrus and other valuable crops. The high-yielding varieties of wine and champagne grapes grow particularly well .Carbonate content and skeletal structure of this soil provide high-quality yield of vineyards and citrus products. This soil is widely used under field crops as well.

The grey cinnamonic soils (Calcic Kastanozems, Vertic Kastanozems) are characterized by less differentiated profiles which show the following horizons: ACa-BmCa-BCam-BCCa. The main diagnostic features are low content of humus and carbonates, in the middle part of the profile a well expressed clayization and presence of carbonates near the surface [38].

In Georgia the total area of grey cinnamonic soils is 5,8% (402.000ha). These soils are distributed in the south-east ofMarneuli, Gardabani, Sagarejo and other districts. It borders with cinnamonic, black and meadow grey cinnamonic soils.

The properties of the grey cinnamonic soils are related to the bioclimatic conditions. The water regime of this soil is non eluatial. The soil forming process fits into the conditions of an intensive deficit of moisture for quite a long time. They are used for agricultural crops - wheat, barley, corn, sunflower, vegetables as well as technical crops. Relatively small area is occupied by perennial crops.

Meadow Grey Cinnamonic Soils (Haplic Kastanozems, Gleyic Kastanozems, Vertic Kastanozems) are characterized by a non differentiated profile, and in comparison to grey cinnamonic soils with a deeper profile, with gley signs in the entire profile and with an intensive clayization. The soil profile usually has the following horizons: ACa(g) -BtCa(g)-BCat(g) -BCCag-Cg.

In Georgia the total area of meadow grey cinnamonic soils is 3,3% (228.800 ha). The meadow grey cinnamonic soil is formed from grey cinnamonic soils in condition of increased moisture. Soils are mainly distributed in the Marneuli and Gardabani districts, in the Kaspi district on a comparatively small area and in the Alazani valley (right side of Alazani, South-East part) on quite a large area.

The meadow grey cinnamonic soils are formed under the conditions of specific types of water regime. The hydrological conditions play a special role in the formation of these soils.

The meadow type of soil formation is supported, first of all, by the influence of the underground water. A significant role is also attributed to anthropogenic factors.

As a result of irrigation, surplus water in the underground moves in a lateral direction, thus forming ground water, which influences the soil formation process. These soils are characterized by high fertility and due to its farming features is one of the best soils for vine and fruit crops. In addition, these soils are used under wheat, corn, sugar beet, legumes and vegetables.

Cinnamonic Soils (Chromic Cambisols, Calcaric Cambisols, Humic Cambisols, Eutric Cambisol) are characterized by a clear differentiation in colors, a negative water balance and a distinct clayization process. The soil profile usually has the following horizons: A-B(Ca)-BC(BCCa)-CCa. The main diagnostic characteristics are a horizon with clay formation and calcium-carbonates throughout the profile [39-42].

In Georgia the total area of cinnamonic soils is 4,8% (311.600 ha). They are distributed in East Georgia in the subtropical forest steppe mainly between 500m (700m) and 900m(1.3000m) a.s.l. At its lower borders there are meadow cinnamonic, grey cinnamonic and black (plain) chernozems, at the upper border brown forest soils.

The water and temperature regimes are determined by the peculiar bioclimatic rhythm of the Mediterranean region, with hot and dry summers, intensive spring and weakly expressed autumn vegetation (due to precipitation) with short and cold winter periods. These characteristics determine the ”two phase” soil formation process.

During the humid and warm spring and autumn, the biological and chemical processes are very intense, salts and carbonates are leached down the soil profile. Intensive humus formation and weathering take place with an accumulation of clays and iron hydroxides. In summer, when the cinnamonic soils are nearly without moisture, the condensation of the humus and polymerization process take place. The general movement of soil solutions is upwards.

Meadow Cinnamonic Soils (Chromic Cambisols, Calcaric Cambisols, Gleyic Cambisols, Eutric Cambisols) are characterized by a weakly expressed differentiation of the profile, which is deeper than in cinnamonic soils, in the entire profile or in its lower parts with signs of gleyization, with weakly expressed carbonate-illuvial horizons. The soil profile has the following horizons: A-AB-B-BC-C or A11-A111-B1-B2-BC.

In Georgia the total area of meadow cinnamonic soil is 1,9% (130.400 ha). They are formed in the depressions of the areas of cinnamonic soils, which are influenced by increased ground, surface and mixed waters. They are found in the lower and the upper Kartli, Kakheti (right bank of the river Alazani) and Meskheti.

The genesis of the meadow cinnamonic soils is connected with the evolution of the vegetation cover and the anthropogenic influence. The cutting of the forest vegetation increased the level of the ground water that in turn facilitated the meadowing process. The dark colors of the profile, a deep humification, a weakly expressed neoformation of carbonates and the absence of a carbonate illuvial horizon are typical for the meadowing process.

Black Soils (Haplic Vertisols) (so called plain chernozems) are characterized by a clearly expresseddifferentiation, mighty humus horizons, high compactness and clayey texture. The soil profile usually has the following horizons: A-B(Ca)-BC(BCCa)-CCa.The main diagnostic characters are resin black color in the upper part of the profile (usually with luster shine), carbonatization and clayization in the middle part [43-46].

In Georgia the total area of black soils is 3,9% (266.800 ha). These soils are distributed in the hill-plain zone between mountains, in the outer and inner Kakheti, in the lower and particularly in the Middle Kartli regions.

The formation of the black soils is connected with the evolution of alluvial plains, lakes and other forms of depression in the late tertiary period, when large areas fell dry and the level of ground water became much lower. As a result the forest steppe vegetation became dominant. However, the formation of the black soils in the lake depression (Shiraki) was quite different. At the beginning of the quaternary period, as a result of the melting of glaciers the depressions were flooded and the water free areas were occupied by moist meadows.With this, the forest steppe vegetation became dominant. In the Outward Kakheti region in less arid conditions black soils developed, but in the most arid areas the grey-cinnamonic soils. The main characteristics of the black soils (strong clayization, little humification and high CEC) were caused by the influence of a subtropical climate.

Chernozems (Voronic Chernozems, Calcic Chernozems) (so called mountain chernozems) are characterizedbya thick humus horizon. The soil profile usually has the following horizons: A11-A111-AB-BC.In Georgia the total area of chernozems is 1,4% (99.200 ha). These soils are distributed in the southernmo untainousregionsbetween1.200-1.900 m a.s.l. [47].

The formation of chernozems is connected with the formation of secondary meadows after the disappearance of subalpine forests and the formation of lakes.

Soils are characterized by high fertility and due to climatic conditions (long and harsh winters, short vegetation period), the main crops are spring crops wheat and barley as well as corn. A very large share belongs to potatoes, food crops and sown grasses. They are widely used for hay and grazing.

Mountain-Forest-Meadow Soils (Haplic Umbrisols) are characterized by a non differentiated profile, intensive and deep humification, small to average depth and strong leaching. The soil profile usually has the following structure: A0-At-B-BC orA0-AB-BC orA0-A-AB-CD. The total area of these soils distribution is 492.000 ha, which are 7,2% of the territory.

Mountain forest meadow soils are broadly distributed in the subalpine zone of the Caucasian and Transcaucasian southern mountains from 1.800 (2.000)m to 2.000 (2.200)m a.s.l..

Mountain forest meadow soils border with mountain meadow and brown forest soils [48-51].

The mountain forest meadow soils are formed under rather extreme climatic conditions. As a result the soil forming process is slow. The soils are not well developed, skeleton with clay minerals that are close to the unweathered rock. In this case the influence of the rock on soil properties should be significant, but in reality it is not, because the soils are mainly formed on transported rock weathering materials. The increased content of rock fragments makes the podzolic process less expressive. Generally the mountain forest meadow soils are young soils.

Mountain-Meadow Soils (Hyperdistric Umbrisols) are characterized by non differentiated profiles. The soil profile usually has the following horizons: At-A-B-BC. The main diagnostical signs are a well-expressed humus horizon over a small weathering horizon.

In Georgia mountain meadow soils are absolutely dominant. Their total area is 1.758.200 ha, which is 25,1% of the territory.

Mountain meadow soils are widely distributed in subalpine and alpine zones of the Caucasus and the Transcaucasia southern mountains, at 1.800 (2.000)m to 3.200 (3.500)m a.s.l.. The hypsometric limits of their distribution change according to the distance between the mountains and the sea, the physico-geographic conditions of specific mountain massifs and the farming influence of man. In the Great Caucasus the hypsometic distribution amplitude of this soil is over 1.300m, and more than in the Transcaucasian southern mountains.

The main soil forming process is humus formation, sod formation and also structure formation. The main process is leaching. During humus siallitization an intensive humus formation and humus accumulation is visible. The clay formation is without noticeable signs of illuviation. Sod processes are also characterized by intensive humus formation and humus accumulation under the influence of a dense grass vegetation. In mountain peat soils the formation of peat and gley are dominant.

In this area cultivation of agricultural crops is practically impossible. Here high mountain meadows, alpine and subalpine vegetation characteristic for them, the best summer pastures and hayfields , enables the development of animal husbandry. In the lower zone barley, rye and potatoes are sown. Beekeeping is widespread in some places. These soils are favourable for berries: raspberry, currant etc.

Mountain Meadow Chernozems (Phaeozems) are characterized by an undifferentiated profile and a mighty humus horizon. The soil profile usually has the following horizons: A11-A111-BC or A11-A111-B-BC. Its main diagnostic signs are well expressed by mighty humus horizons. In Georgia these soils occupy 109.600 ha, which is 1,6% of the territory.

Mountain meadow chernozems are distributed in South Georgia in subalpine and alpine zones above 1.800 (2.000) m of altitude. This soil borders with nival primitive, subalpine and alpine belt mountain meadow and subalpine belt mountain meadow forest soils.

The mountain meadow chernozem is formed on basic rocks, which mainly define the formation of the humate humus and the increased content of the II fraction of humic acids which are connected with calcium.

This determines not only the dark color of the profile, but also the compact grain structure. The petrographic content of the rocks influences not only the accumulation of humus and some other properties, but also the type of the vegetation cover. All these characteristics resemble to chernozems without free carbonates.

Andosols (Andosols) are characterized by a dark color of the upper horizon, a loamy texture, friable construction and a fine pie-like or lump structure [52].

Andosols are characterized by the following horizons: A1/-A1//-BC1-BC2orA1/-A1//-B1-B2-BCor A-B-BC1-BC2 or A-AB-B1-B2-BC or A1/-A1//-C-CD.They are mainly characterized by a dark or very dark cinnamonic (10 YR 2,5/1,5; 10 YR 2,5/2)color of the humus horizon, well expressed grain-lump or thin-grain structure, a friable constuction and a loamy texture.

Andosols represent one of the soil groups of the World Reference Base for Soil Resources (WRB). In the world their total area makes 110 mln ha. The name is of Japanese origin: “An” means black and “Do” means soil.

Andosols are formed mountainous areas within a broad range of thermic conditions, under different vegetation. The fast weathering of a porus substratum supports the accumulation of stable organo-mineral junctions and the formation of non crystalline minerals, especially allophane and imogolite.

Saline Soils (Vertic Solonchaks, Mollic Solonetz) unite solonchaks and solonetzes. Solonchaks contain soluble salts until the surface, solonetzes only at different depths of the low horizons.

The total area of the saline soils is 1,6% (112.600 ha). These soils are widely distributed on the plains of East Georgia: the Alazani, Eldari, Taribana-Natbeuli, Lakbe, Shavmindvris accumulative valleys, and on the inclined valleys and slopes of erosive watersheds of the Chabandari and Donguz-dara desert. Moreover, they are met in KvemoKartli (Gardabani, Marneuli, Samgori and Krtsanisi valley) and fragmentarily in Shua Kartli.

Solonetzes are divided into: 1) meadow-steppe, 2) steppe, 3) half desert. According to salinization we distinguish: 1) soda, 2) mixed (soda-sulphate-chloride), 3) chloride solonetzes. According to absorbed sodium: 1) very little absorbed sodium up to 10%, 2) little 10-25%, 3) average 25-40%, 4) strong solonetzes >40%.

Saline soils are Solonetzes, due to the presence of a natric horizon or Solonchak due to the presence of a salic horizon. This soils are characterized by low qualities and are useless for agricultural purposes without major reclamation measures, and used only for grazing. To improve soil physical and chemical properties, it is necessary to wash down the easily soluble salts on the background of drainage, deep ploughing, casting and application of organic-mineral fertilizers. After the above measures have been taken, they become suitable for halophytic and average resistant crops (onions, melons, wheat).

Alluvial Soils (Gleyic Fluvisols, Eutric Fluvisols, Dystric Fluvisols) are characterized by regular flooding and the sedimentation of new alluvial layers.This soil is characterized by various hydrological regimes, constructions and properties. Its properties are mainly determined by the nature of the basin, where these soils are developed. The soil profile usually has the following structure: A-BC-C-CD.

In Georgia the total area of alluvial soil is 351.400 ha (5,0%). They are formed on the whole territory of Georgia in different zones.

Alluvial soils are formed as a result of two main processes: zonal soil forming and alluvial plains. Far from river beds zonal processes are strengthened, but near to it, on the contrary, they are weakened [53, 54].

Alluvial soils are widespread in different regions of Georgia and are formed pluvial river sediments with different properties with. These soils are diverse regarding mechanical composition, thickness, skeletal, carbonates, moisture, fertility and other indicators . It occupies 5% of the total area (351400 ha) .

Calcareous alluvial soils are wide spread on the lower terraces of the rivers in the West Georgia, where the intermittent form of calcareous soils are also found. Alluvial soil is used mainly for maize and vegetables. In addition, it will grow tobacco, tea, oils, citrus and other crops. Part of this soil is rather humid with low natural fertility and requires reclamation measures.

Thus, the issue of land resource use in Georgia is quite urgent and requires complex approach to be resolved.

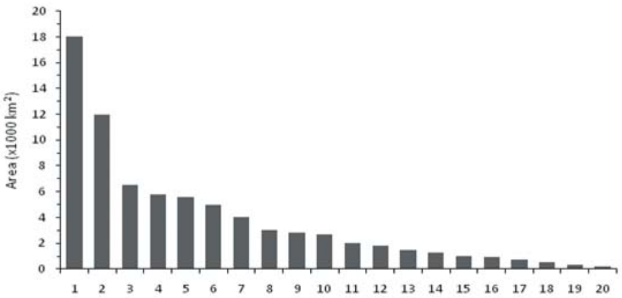

Fig.1. *Areas occupied by soils of Georgia**

1 - Brown forest (Cambisols, humic, ferric, eutric, dystric); 2 – Mountain meadow (Umbrisols hyperdystric); 3 - Cinnamonic (Cambisols chromic, calcaric, humic, eutric); 4 - Alluvial (Fluvisols gleyic, eutric, dystric); 5 – Raw carbonate (Leptosols rendzic); 6 – Yellow brown forest (Luvisols stagnic, humic, ferric); 7 – Meadow cinnamonic (Cambisols chromic, calcaric, gleyic, omllic eutric); 8 - Yellow (Luvisols ferric); 9 - Black (Vertisols haplic); 10 – Yellow podzolic (Acrisols stagnic, efrric); 11 - Chernozems (Chernozems voronic, calcik); 12 - Red (Nitisols ferralic, haplic); 13 - Bog (Gleysols, dystric, eutric Histosols); 14 – Grey cinnamonic (Kastanozems calcic, vertic); 15 – Mountain forest meadow (Ubrisols haplic); 16 – Mountain meadow chernozems (Phaeozems); 17 – Yellow podzolic gley (Acrisols stagnic, ferric, gleyic); 18 – Meadow grey cinnamonic (Kastanozems, haplic, gleyic, vertic); 19 - Saline (Solonchaks vertic, Solonetzes mollic); 20 - Brown forest black (Chernozems, haplic).

**The areas of andosols are not yet defined.*

The soils of Georgia are characterized by different levels of fertility and correspondingly require different measures for improvement [55,56].

Based on this the following sequence could be established for increasing nutrient demand: mountain-meadow, chernozems > brown forest, alluvial > raw-carbonate, red soils, yellow soils, saline >cinnamonic, meadow cinnamonic, grey cinnamonic, meadow grey cinnamonic > black > yellow-podzolic.

Regarding the plant available forms of nitrogen, absorbed phosphorus and exchangeable potassium) the sequence is: mountain-meadow >meadow cinnamonic >cinnamonic, grey cinnamonic >red soils >black, raw carbonate, brown forest, alluvial >yellow-podzolic, chernozems, saline soils. By correlating both sequences, the following overall sequence for the fertility of the main soils of Georgia was found in decreasing order: mountain meadow >meadow cinnamonic >brown forest, red soils, chernozems, black, cinnamonic, grey cinnamonic >raw carbonate >saline >alluvial >yellow podzolic.

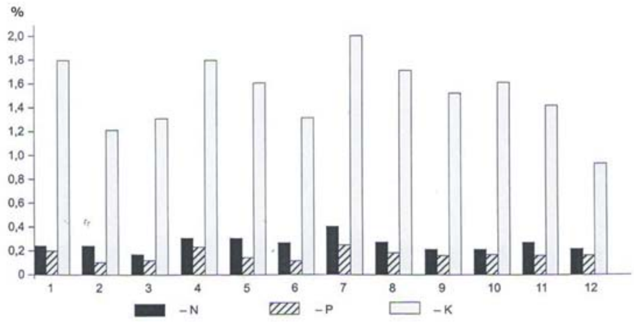

Fig. 2. *Total content of nutrients in the main soils (0-20cm) of Georgia in %.*

1- Red (Nitisols Ferralic, Haplic); 2- Yellow (Luvisols Ferric); 3- Yellow Podzolic (Acrisols Stagnic, Ferric; 4- Yellow brown forest (Luvisols stagnic, Mollic, Humic, Ferric); 5- Raw-carbonate (Leptosols Rendzic); 6- Black (Vertisols Haplic); 7- Chernozems (Chernozems Voronic, Calcic); 8- Cinnamonic (Cambisols Chromic, Calcaric, Humic, Eutric); 9- Meadow cinnamonic (Cambisols Chromic, Calcaric, Humic Eutric); 10- Grey cinnamonic (Kastanozems Calcic, Vertic); 11- Meadow grey cinnamonic (Kastanozems Haplic, Gleyic, Vertic); 12- Alluvial (Fluvisols Gleyic, Eutric, Dystric).

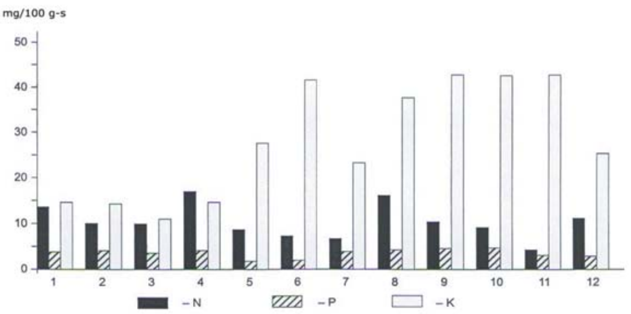

Fig. 3. *Total content of plant available nutrients (in mg/100g) in the main soils (0-20cm) of Georgia*

1- Red (Nitisols Ferralic, Haplic); 2- Yellow (Luvisols Ferric); 3- Yellow Podzolic (Acrisols Stagnic, Ferric; 4- Yellow brown forest (Luvisols stagnic, Mollic, Ferric); 5- Raw-carbonate (Leptosols Rendzic); 6- Black (Vertisols Haplic); 7- Chernozems (Chernozems Voronic, Calcic); 8- Cinnamonic (Cambisols Chromic, Calcaric, umic, Eutric);

9- Meadow cinnamonic (Cambisols Chromic, Calcaric, Humic, Eutric); 10- Grey cinnamonic (Kastanozems Calcic, Vertic); 11- Meadow grey cinnamonic (Kastanozems Haplic, Gleyic, Vertic); 12- Alluvial (Fluvisols Gleyic, Eutric, Dystric).

The soils of Georgia are under threat, especially by intensive soil erosion and contamination with heavy metals and radionuclides [57-67].

Erosion processes are a main factor of soil degradation.

Water erosion affects the whole territory of the country, including West, East and South Georgia.

In Georgia, only16,4% of the arable land are weakly eroded, 11,0% moderately and 3,1% are strongly eroded. All together30,5% of the arable land are eroded, i.e. every third hectar is eroded at a different degree. As a result the loss of harvests is between 30-40%.

Wind erosion is only observed in East and South Georgia,Shida and KvemoKartli and Shiraki.

Wind erosion in Georgia does not occur annually but once in 5-10 years. Strongwind erosion is more frequent in Gare Kakheti and especially in the Shiraki plain.

Processes of wind erosion occur on102.500 ha of arable land of eastern Georgia, which is 21,1% of the total territory.

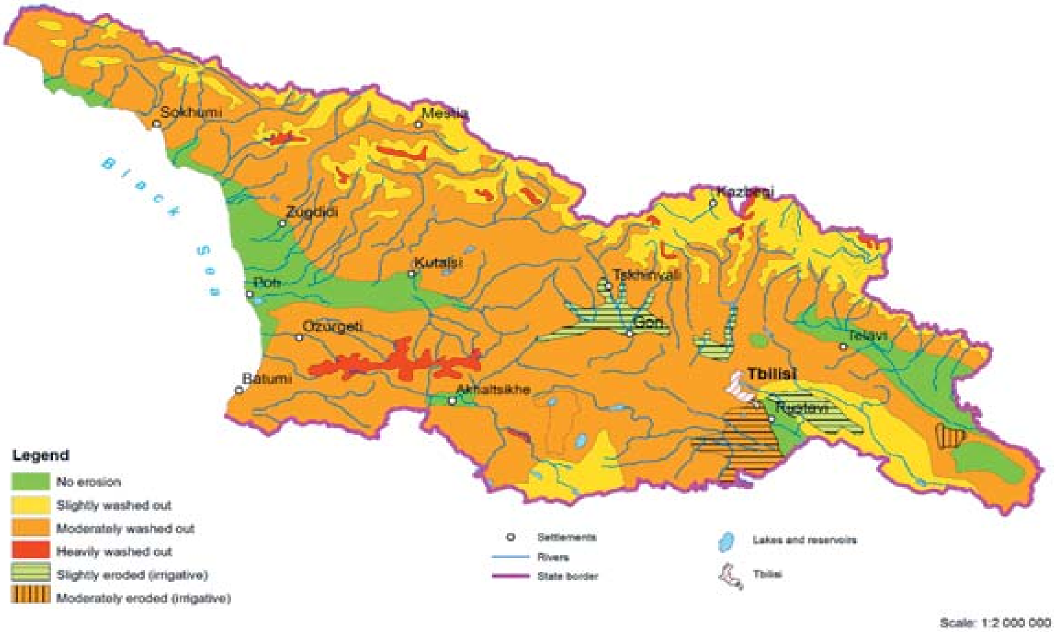

Fig. 4. *Water erosion in Georgia*

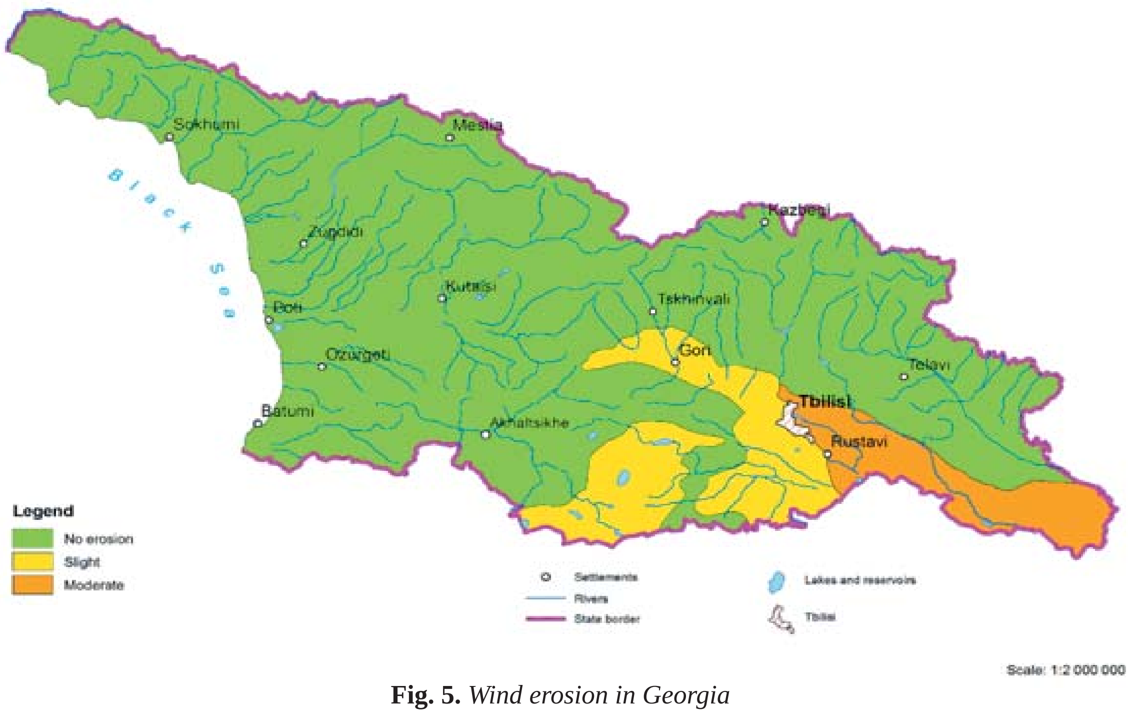

Fig. 5. *Wind erosion in Georgia*

One of the main source for the input of heavy metals are contaminated rivers: one extreme example is the Mashavera valley in south-eastern Georgia.

Kastanozems have a high fertility; on these soils it is possible to produce 2-3 harvests per year. The limitation factors are wind and water erosion. The population used the Mashavera river water for irrigation, despite of its pollution with mining waste from copper and gold mines. The Cu, Zn and Cd concentrations of mud from irrigation channels and the Mashavera river are extremely high. Unfortunately, kastanozems have characteristics with a high potential for heavy metals fixation. Among them, first of all are the clayey texture and the base saturation.

Fig. 6. *River Mashavera and waste waters*

After the Chernobyl nuclear catastrophe in 1986, Georgia was the fourth heavily polluted country after the Ukraine, Belarus and Russia due to the radioactive fallout. The capacity of the exposure doses (PER) in some regions of the Black Sea basin in May 9-10, 1986 exceeded the maximum permissible background values by thousand. Recently, the degree of radioactive pollution of the country before the 1986 Chernobyl catastrophe was determined . It has to be taken into account that Georgia is situated in the zone with the highest atmospheric radionuclide fallout. It was found that the west of the country was more affected than the east. The problem of pollution reduction is rather urgent. Among many ecological threats, radionuclides occupy a large area regarding the specificity of its activities and its high danger. Usually radionuclides are taken up by plants and accumulate in soils, especially in the top layer including the humus. These radionuclides can be transferred from the soil into the plants. A comprehensive research in the zone of Chernobyl has shown that derivatives of humic acids in soils form complexes with radionuclides and limit their movement. Fulvic acids, on the contrary, promote the migration of radionuclides.

Western Georgia, where the highest pollution of soils by radionuclides occurred, has a rather acid character, which does not promote the effect of local soil biological agents. It is known that bacteria and fungi bind radionuclides through the growth of mycelium. The remediation of the soils polluted by radionuclides must be started by monitoring of the chosen research sites and by the application of new bio remediation procedures..

Due to the high level of contamination and the impossibility to clean the soils, immediate measures should be initiated in order to protect the population.

Conclusion: Investigation of Soils of Georgia may be content different directions:

1. Genesis and classification,
2. Investigate the fertilizers and find the way to increase soil productive,
3. Investigate ecological problems of soils and prepare the necessary proposals.

REFERENCES

1. *Dokuchaev V.V.* Elective Works // AN SSSR, Moscow, 1949, 520 pp. (in Russian).
2. *Sabashvili M.* Soils of Georgian SSR // “Metsniereba”, Tbilisi, 1965, 549 pp. (in Georgian)
3. *Urushadze T.F., Blum W.E.H.* Soils of Georgia // “Nova”, New York, 2014, 242 pp.
4. *Urushadze T.F., Blum W.E.H.* Soils of Georgia // “Mtsignobari”, Tbilisi, 2014, 331 pp. (in Russian).
5. Guide of Georgian Soils // “Mtsignobari”, Tbilisi, 2014, 135 pp. (in Georgian).
6. *Urushadze T.F.* Main Soils of Georgia // “Metsniereba”, Tbilisi, 1997, 267 pp. (in Georgia).
7. Soil Map of Georgia in scale 1 : 500 000. Editor T.F. Urushadze // Tbilisi, Georgia, 1999.
8. *Urushadze T.F.* Mountain Soils of USSR // “Agropromizdat”, Moscow, 1989, 272 pp.
9. *Ourouchadze T., Ourouchadze A.* Les Sols de Georgie. In: La Geographie en Georgie // “ORSTOM”, Paris, 1997, pp. 55-67.
10. *Urushadze T.F.* Soils of Georgia // Swiss Cooperation Office South, 2015, 46 pp.
11. Guide of Soils // Swiss Cooperation Office South, 2015, 50 pp.
12. *Didebulidze A., Urushadze T.* Agriculture and Land Use Change in Georgia // Georgia in Transition, Peter Lang, 2009, 241-263.
13. *Urushadze T.F.:* Some Problems of Soil Formation in Mountain Regions. Pochvovedenie (Eurasian Soils Science), 1, 1979, Moscow, pp. 131-143 (in Russian).
14. *Urushadze T.F., Winfried E.H. Blum.* Soil Geography and Basics of Soil Science // TSU, Tbilisi, 2011, 425 pp. (in Georgian).
15. *Zonn S.V., Urushadze T.F.* Some Questions of Vertical Distribution of Soils in Georgia// Geography in Georgia, Tbilisi, pp. 100-104 (in Russian).

16. *Urushadze T.F.* About Soils of Mountain Forest Belts of Georgia // Izv. Acad. Science of USSR, 4, 1976, Moscow, pp. 89-93 (in Russian).

17. *Gulisashvili V.Z.* Natural Zones and Nature-Historical Regions of Caucasus // "Nauka", Moscow, 1964, 325 pp. (in Russian).

18. *Urushadze T.F.* Mountain Forest Soils of Georgia // "Sabchota Sakartvelo", Tbilisi, 1977, 244 pp. (in Georgian).

19. *Tarasashvili N.G., Urushadze T.F., Urushadze T.T.* Soil Various of Georgia // Biological and Landscape Various of Georgia, 2000, pp.135-149.

20. *Dobrovolsky V.V., Urushadze T.F.* Soils on Red-Colored of Weathering Products // "Metsniereba", Tbilisi, 1989, 203 pp. (in Russian).

21. *Daraselia M.K.* Red and Podzolic Soils of Georgia and its Use under Subtropical Cultures // Makharadze-Anaseuli, 1949, 290 pp. (in Russian).

22. *Gamkrelidze L.V.* Soil Forming on Red-Color Weathering Mutle // Pochovedenie, 5, 1957, pp. 58-64 (in Russian).

23. *Urushadze T.F., Kvrivishvili T.O., Sanadze E.V.* An Experience in Using the World Reference Base for Soil Resources for the Soils of Western Georgia // Eurasian Soil Science, vol. 47, No. 8, 2014, 752-760.

24. *Urushadze T.F., Kvrivishvili T.O.* Peculiarities of Classification of some Soils of Western Georgia Based on Macromorphological Analysis // Bulletin of the Georgian National Academy of Sciences, Vol. 9, No. 1, 2015, 151-154 pp.

25. *Romashcevich A.I.* Yellow Soils of USSR and their Genetical Peculiarities // Pochvovedenie, 6, 1972, pp. 120-135 (in Russian).

26. *Gedevanishvili D.P.* Soils of Kolkheti Lowland // Works Kolkheti Experimental Station, Tiflis, 1929, pp. 33-52 (in Georgian).

27. *Kostava G.A.* Developing of Soil Forming Process on Kolkheti Lowland as a Result of Melioration and Some Questions of Agromeasures // Works of Soil Science Institute, V, 1952, pp. 120-148 (in Georgian).

28. *Motzerelia A.V.* Colmatage of Bogs in Kolchida // Pochvovedenie, 3, 1958, 110-119 (in Russian).

29. *Zonn S.V.* Soil Cover and Problems of Transformation Natura and Farming in Subtropics of SSSR // "Nauka", Moscow, 1987, 380 pp. (in Russian).

30. *Lezhava V.* Podzolic Orstein Soils of Georgia (Plintosols) // Doctoral Dissertation, Tbilisi, 1995, 360 pp. (in Georgian).

31. *Lezhava V., Iashvili N., Machavariani J.* Some Aspects of Genesis and Geography of the Soils of Georgia // Collection of Works. Institute of Soil Science, Agrochemistry and Melioration, XXV, Tbilisi, 2001, pp. 79-95 (in Georgian).

32. *Urushadze T.F.* Differences in Weathering and Soil Formation in Arid and Humid Subtropics of the U.S.S.R. // 9th International Congress of Soil Science. Adelaide, Australia, vol. 1V, 1968, pp.535-540.

33. *Urushadze T.F.* Yellow-Brown Soils of Georgia // Problems of Forest Soil Science // "Nauka", Moscow, 1974, pp. 177-195 (in Russian).

34. *Urushadze T.F.* Yellow-Brown Soils. In: Genetic Types of the Subtropical Soils of Transcaucasia // "Nauka", Moscow, 1979, pp. 115-125 (in Russian).

35. *Tarasashvili G.M.* Mountain-Forest and Mountain-Meadow Soils of East Georgia // AN GSSR, Tbilisi, 1956, 220 pp. (in Russian).

36. *Zonn S.V.* About Brown Forest and Brown Psevdopodzolic Soils of Soviet Union. In.: Geographic and Genesis of Soils // "Nauka", Moscow, 1966, 120-146 pp. (in Russian).

37. *Urushadze T.F.* Soils of Mountain Forest of Georgia // "Metsniereba", Tbilisi, 1987, 243 pp. (in Russian).

38. *Nakaidze E.K.* The Grey-Cinnamonic and Black Soils of Georgia // "Metsniereba", Tbilisi, 1980, 185 pp. (in Russian).

39. *Urushadze T.F.* Soils of Arid Low Density Stands of Georgia // Pochvovedie, 6, 1971, pp. 55-64 (in Russian).

40. *Urushadze T.F*. Soils of Arid Low Density Stands. In: Genetic Types of the Subtropical Soils of Transcaucasia // "Nauka", Moscow, 1979, pp. 185-198 (in Russian).

41. *Anjaparidze I.E*. Cinnamonic Soils of Georgia // "Sabchota Sakartvelo", Tbilisi, 1979, 180 pp. (in Georgian).

42. *Gerasimov I.P.* Cinnomic Soils of Dry Forests and Bushes of Meadow-Steppe // Works of Soil Institute named Dokuchaev, XXX, 1949, pp. 55-87 (in Russian).

43. *Gerasimov I.P.* The Black Compact Soils. In: Genetic Types of the Subtropical Soils of Transcaucasia // "Nauka", Moscow, 1979, pp. 78-105 (in Russian).

44. *Machavariani J. Sc.* The Soils of Shida Kartli // "Sabchota Sakartvelo", Tbilisi, 1980, 89 pp. (in Georgia).

45. *Machavariani J.Sh., Lezhava V.V.* Processes of Perturbation in Vertisols // Collection of Works of State Agrarian University of Georgia and Armenian Agrarian Academy // Yerevan, 1999, pp. 57-60 (in Russian).

46. *Urushadze T.F., Machavariani J. Sh., T.T. Urushadze.* Genetic Peculiarities of the Black Soils of Georgia // Annals of Agrarian Science, vol.12, no.2, 2014.

47. *Talakhadze G.R.* Chernozems of Georgia // "Sabchota Sakartvelo", Tbilisi, 1962, 460 pp. (in Georgian).

48. *Urushadze T.F., Blum W.H., Sanadze E.V., Kvrivishvili T.O.* Andosols of Georgia // Eurasian Soil Science, vol. 44, No.9, 2011, pp. 969-975.

49. *Makhatadze L.B. , Urushadze T.F.* Subalpine Forests of the Caucasus // "Lecnaia Promishlenost", Moscow, 1972, 112 pp. (in Russian).

50. *Urushadze T.F.* Soils of Subalpine Forests of Georgia // Pochvovedenie, 6, 1972, pp. 29-43 (in Russian).

51. *Zakharov S.A.* About Characterization High-Mountain Soils of Caucasus // Izv. Konstantinovskogo Mejevogo Institute, 5, Moscow, 1913, 590 pp. (in Russian).

52. *Fridland V.M.* Soils of High-Mountains of Caucasus. In: Genesis and Classification of Soils // "Nauka", Moscow, 1966, pp. 90 – 149 (in Russian).

53. *Urushadze T.F., Chijikova N.A., Urushadze A.T.* Clay Minerals in the Alluvial Soils of the Mtkvari River Basin // Bulletin of the Georgian Academy of Sciences, 155, № 3, 1996, 417-421.

54. *Urushadze T.F., Urushadze A.T., Chijikova N.A.* Mineralogical Content of Clay Fraction of Alluvial Soils of Georgia // Pochvovedenie, 5, 2006, pp. 578-590 (in Russian).

55. *Zardalishvili O., Urushadze T.* Use of Fertilizers and Environment // "Sabjota Sakartvelo", 1993, 151 pp. (in Georgian).

56. *Zardalishvili O.I., Urushadze T.F., Tkhelidze A.T., Urushadze T.T.* Agrochemical Peculiarities of the Main Soil Types of Georgia // Annals of Agrarian Science, vol.12, 4, 2014, pp. 24-31 (in Russian).

57. *Urushadze T.F., Gogichaishvili G.G., et al.* Soil Erodibility Variation during a Year in Georgia // Bulletin of the Georgian Academy of Sciences, 155, № 3, 1998, pp. 300-303

58. *Gogichaishvili G.P., Urushadze T.F., Urushadze T.T.* The Forecast of the Intensity of Soil Erosion for Main Soils of Georgia // Annals of Agrarian Science, vol..6, No. 1, 2008, pp. 22-30.

59. *Gogichaishvili G.P. Urushadze T.T. Gordzomeladze O.I.* Universal Soil Loss Equation for Application in Georgia // Eurasian Soil Science, Vol. 36, No. 2, 2003, pp. 227-230.

60. *Gogichaishvili, G.P., Urushadze, T.T.* Estimation of Eroded Lands by the Reclamation Fund in Georgia. J. of Agriculture and Rural Development in the Tropics and Subtropics, Vol. 107, # 1, 2006, pp. 85-94.

61. *Gambashidze G.O., Blum W.H., Urushadze T.F., Mentler A.* Heavy Metals in Soils // Annals of Agrarian Science, vol.4, No. 3, 2006 pp. 7-11.

62. *Felix-Henningsen P., Urushadze T.F., Narimanidze E.I., Wichmann L., D. Steffens D., Kalandadze B.B.* Heavy Metal Pollution of Soils and Food Crops due to Mining Wastes in an Irrigation District South of Tbilisi, Eastern Georgia // Annals of Agrarian Science, Vol.5, No.3, 2007, pp. 11-27.

63. *Felix-Henningsen P., Urushadze T., Steffens D., Kalandadze B., Narimanidze E.* Uptake of Heavy Metals by Food Crops from Highly-Polluted Chernozem-Like Soils in an Irrigation District South of Tbilisi, Eastern Georgia // Agronomy Research 8 (1), 2010, pp. 781-795

64. *Hanauer T., Felix-Henningsen P., Steffens D., Kalandadze B., Navrozashvili L., Urushadze* T. In situ Stabilization of Metals (Cu, Cd and Zn) in Contaminated Soils in the Region of Bolnisi, Georgia // Plant Soil, 10, 2010, pp. 46-62.

65. *Felix-Heningsen P., Sayed M.A.H.A., Narimanidze-King E., Steffens D., Urushadze T.F.* Bound Form and Plant Availability of Heavy Metals in Irrigated, Higly Polluted Kastanozems in the Mashavera Valley, SE Georgia // Annals of Agrarian Science, vol. 9, No. 1, 2011, pp. 111-119.

66. *Hanauer T., Navrozashvili L.V., Schnell S., Kalandadze B.B., Urushadze T.F., Felix-Henningsen P.* Soil Pollution with Cu, Zn and Cd by Non-ferrous Metal Mining Affectts Soil-microbial Activities of Kastanozems in the Mashavera Valley // Annals of Agrarian Science, vol. 9, No. 2, 2011, 38-44.

67. *Urushadze T.F. Kvachantiradze M.N., Chankseliani Z.O.* Content of ^{137}Cs Radionuclide in some Landscapes of Georgia // Problems of Agrarian Sciences, XXXV, 2006, pp. 100-102 (in Russian).

ПОЧВЫ ГРУЗИИ И ПРОБЛЕМЫ ИХ ИСПОЛЬЗОВАНИЯ

Т.Ф. Урушадзе, В. Блюм, Д.Ш. Мачавариани,
Т.О. Квривишвили, Р. Д. Пирцхалава

Статья посвящена основным свойствам основных почв Грузии (краснозема, желтозема, болотной, желтоземно-подзолистой, желтоземно-подзолистой глеевой, желто-бурой, бурой лесной, буро-черной дерново-карбонатной, серо-коричневой, лугово - серо-коричневой, коричневой, лугово-коричневой, черной, черонозема, андосоля, горно-лесо-луговой, горно-луговой, горно-луговой черноземовидной, засоленной, аллювиальной), их распространению, истории исследования, экологии – материнской породе, рельефу, климату, растительности – морфологии, основным генетическим показателям – pH, содержание гумуса, азота, обменных катионов, механический состав, содержание валовых оксилов, различные формы железа и их использование. Работа обобщает результаты многолетних исследований почв и намечает пути их оптимального использования.

Fig.7. *Red Soil (Haplic Nitisol)*

Fig.8. *Yellow Soil (Ferric Luvisol)*

Fig. 9. *Bog Soil (Dystric Gleysol).*

Fig. 10. *Yellow Podzolic Soil (Stagnic Acrisol).*

Fig. 11. *Yellow Podzolic Gley Soil (Gleyic Acrisol).*

Fig. 12. *Yellow Brown Forest Soil (Humuc Lavisol)*

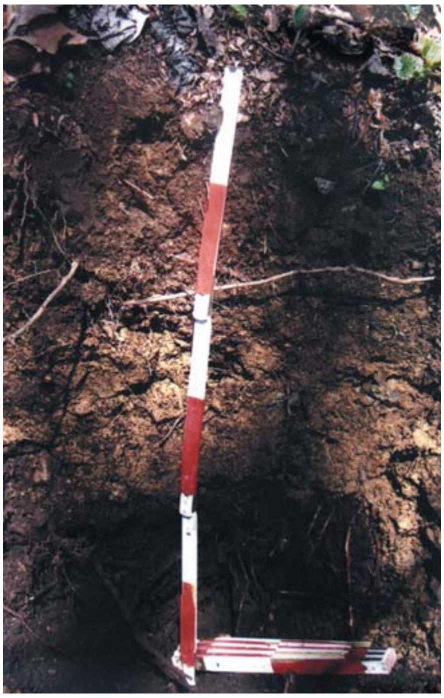

Fig. 13. *Brown Forest Soil (Dystric Cambisol)*

Fig. 14. *Brown Forest Black Soils (Haplic Chernosems)*

Fig. 15. *Raw Carbonate Soil (Rendzic Leptosol)*

Fig. 16. *Grey Cinnamonic Soil (Calcic Kastonozem)*

Fig. 17. *Meadow Grey Cinnamonic Soil (Haplic Kastanozem)*

Fig. 18. *Cinnamonic Soil (Humic Cambisol)*

Fig. 19. *Meadow Cinnamonic Soil (Chromic Cambisol)*

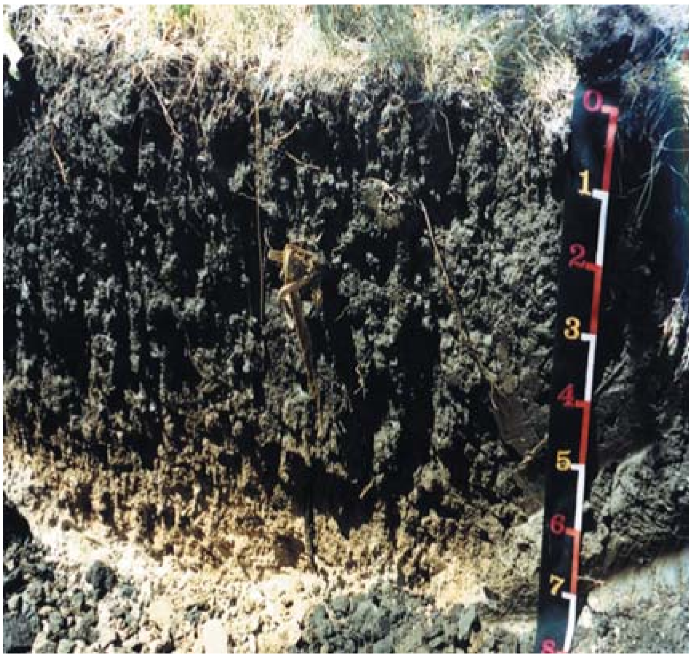

Fig. 20. *Black Soil (Haplic Vertisol)*

Fig. 21. *Chernozems (Voronic Chernozem)*

Fig. 22. *Mountain Forest Meadow Soil (Haplic Umbrisol)*

Fig. 23. *Mountain Meadow Soil (Hyperdystic Umbrisol)*

Fig. 24. *Mountain Meadow Chernozems Soil (Phaeozem)*

Fig. 25. *Saline Soil (Mollic Solonetz)*

Fig. 26. *Alluvial Soil (Dystric Fluvisol)*