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«AN ASSAY OF THE LEGEND CONSTRUCTION TO THE 1:5 000 000 WORLD SOIL MAP»

(Report to the Moscow Meeting of the Advisory Pannel
of the UNESCO FAO World Map Project)
August, 1966

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An Assay of the Legend Construction to the I:5.000.000 World Soil Map.

(Report to the Moscow Meeting of the Advisory Panel of the UNESCO/FAO World Map Project, August 1966)

I. General Consideration.

Some great experience of the world soil maps composition was accumulated in the history of soil science. These maps were prepared and published both by single authors and by the collectives. The first World Soil Map was published at the end of the last century by V.V.Dokuchaev. The Dokuchaev's map was based on his conception of the zonality of the global nature and soil cover of the world.

This first World Soil Map has great scientific and historic importance,as a starting point for all the posterior works in this direction. The review of the prepared during later times world soil maps and their legends shows us,that they were mostly constructed on the base of Dokuchaev's conception of soil zonality.

This zonal-geographic approach can be traced also in the existing systems of world soil classifications,which are reflected in the legends to the maps. But,already at the beginning of 30th,it was absolutely clear,that the horizontal zonality of the Euroasia soils is not universal,and that the geography and history of the soil cover of different continents are very complicated and diversified. This was clearly shown by the materials of the All-Union Conference of soil scientists in 1932. Then there was

suggested an idea,approved by the Conference,that in the base of the soil genesis and geography studies there should be historic (historic-genetical) principle.

With the progress of pedology and accumulation of the factual material on the soil geography and soil genesis,in the USSR and in different countries of the world original national schools of soil science were gradually established. They have achieved a great deal of experience on the soil investigation and have collected a great amount of knowledge on soils of different continents and countries. The accumulation of new facts on the soil cover of different continents and countries placed in front of the soil science an important task of generalisation of this material into the system,which could provide the possibility of the experience exchange and mutual understanding. During the latest time the soil maps of some continents and large regions of the world were prepared,that showed in detail and on the base of the generalisation of the newest factual data the great variability and specificity of the continental soil covers (Soil Map of Australia - Stephens,I960; Soil Map of Asia - V.A.Kovda and E.V.Lobova,I964; Soil Map of Africa - D'Hoore,I964; observatory soil maps of the world,edited by I.P.Guerrassimov,I965 and oth.)

The creation of the continental and regional soil maps in such detail scale as I:2.000.000 - I:6.000.000 must be consider as great achievement of the world soil science. At the same time, the variety of approaches to the construction of these maps,to the soil nomenclature and legends,the variety of theoretical positions in soil classification need grand and laborions work on the correlation of original and generalized data for the creation of general conception of soil formation and for the unified approach to the construction of the world soil map and its legend. It is generally recognized that the existing differences in the princip-

les and terminology make difficult all the attempts to correlate the results of soil investigations in different countries and to generalize these results for the continents and for the world as a whole.

At the same time the new materials proved that the zonal-geographical approach to the soil classification and cartography of the soils of the globe as a whole is not sufficient and does not always allow to discover in full the soil genesis and the laws of soil distribution on the earth surface as well as to understand all particularities of the soil covers of different continents and large regions.

In I96I due to the initiative of one of the present wrighters and under the support of the International Soil Science Society the International Consultative Committee on World Soil Map Project was established by two organizations of the United Nations - UNESCO and FAO. The work on the construction of world soil map was started in the framework of this project under the guidance of the Committee with the cooperation of the soil scientists from all countries.

It is not necessary to speak once more about the great importance of this work,which open a new step in the development of soil science. We shall but stress,that only such international creative cooperation of scientists will allow to use and generalize in full all the achievements of national schools and of the world soil science as a whole.

The great and useful work on the correlation of soil types, of the soil classification systems and of the soil maps of different conntries,regions and continents was done by the International Consultative Committee and FAO and UNESCO during the recent time. The correlation symposia on the soils of South America,of the different parts of Europe,of South and Central Asia,of North America as well as on laterites,on the soils on volcanic ashes,on the

saline soils were carried. Much as there are many undecided and discutable points, the large new material was received, which allow us to make some generalizations in the world-wide scale and to start the creation of the general legend to the world soil map.

The first outline of the general legend to the world soil map was prepared by FAO for the discussion at the VIII-th International Congress of Soil Science in Bucharest in I964. This outline was published in I2th issue of FAO materials on the world soil resources. This material was discussed by 5-th Commission of the Congress and it was regarded as the beginning of further creative work of the scientists from different countries. The unified variant of the legend will be created as a result of this collective work. From this point of view it seems necessary to mention both the positive and negative points of the first FAO outline of the legend.

The main advantages of this variant of the legend are connected with the fact, that it is based on the attempt of generalisation of the new factual materials on different continents, the soils of which are studied by the large groups of soil scientists of many countries. It is clearly seen in it, that the authors apparently wanted to marchall the soils in some sequence, dependent on their age and degree of development; but this attempt is not possible to consider as complitely satisfactory.

The main definitions of that soil units, which should be shown on the map, were added. Each of the soil units had its own diagnostic characteristic. Because of the absence up till now in the soil science of the precise and unified soil nomenclature and because of the therminological diversification, the soil diagnostic in a general legend seems to be very important for the understanding and possible unification of the soil units nomenclature. This is also very important from the point of view of the correla-

tion of the materials of different countries and continents for the construction of world soil map. The correlation table, appended to the legend, has an appreciable interest, as it allows the correlation the legends and maps, prepared by different national schools of soil scientists. But the material under consideration has also some appreciable defects.

First of all it is necessary to mention, that this variant of the legend is too generalized and does hot reflect that degree of detailness, which exist on the already published maps of separate continents. It contains only eighty soil units, out of which only thirty seven relate to the main soil types (groups), and others are different combinations and additional symbols.

Numerous publications and maps on different countries and continents had enough clearly shown the exclusive diversity of the continental soil covers, which is determined by the specific complexes of historical, geological and bio-climatical factors. It seems due to this absolutely necessary to keep in the future legend to the world soil map the majority of the soils, which are already shown on the continental maps in such cases, of course, when they are sufficently provided by the genetical and diagnostical data.

Thus, it is necessary to widen the volume of the legend with the inclusion of all the soils, which are shown on the continental soil maps of I:2.000.000 - I:6.000.000 scale. As it is shown below, there are about 250 large soil units on these maps in the legends and in the contours.

The second disadvantage of the presented variant of the legend is in the inconsequence of the basic theoretical conception, by which it is underlined. The legend to the soil map should reflect the world soil classification, but it must not repeat completely the latter. But in this case, although there is an attempt to order all the soils in some evolutionaty sequence, this principle is not hold up to the end. The taken sequence of soil order in the legend

variant does not reflect real knowledge on their evolutionary relations. For instance,it is not clear,why brown forest soils follow vertisol,and the soddy-podzolic soils are quite far away from the podzols being separated by chernosems and ferrallitic soils.It is not understandable,why brown and red Mediterranean soils are placed between soddy-podzolic soils,from one side,and red-yellow podzolic soils,which are correlated with krasnozems and zheltozems,from the other. These examples show clear enough the inconsequence of the principal base of the legend construction, from which it follows the necessity of further work of marking it in more orderly system.

The following remark is possible to make in relation of the soil diagnostic. The general principles of soil diagnostic are not explained. Each soil is characterized by its own set of features, among which there are both the soil features and the features of factors of soil formation. In some cases the first ones and in the other - the latter are preferred. From this,the unclearness of the taxonomic position of soil units and their substance follows. As a whole,it is possible to mention unsufficiency of soil proper features in the diagnostic of most distinguished soils. It seems especially disagreable defect in the light of the existing uncertainity and ununity in soil nomenclature. Under the absence of internationally approved and adopted indexes,terms and names,the soil diagnostic should be done especially correctly and in accordance with one scheme. The distinction of a single group of lithosols instead of the large group of mountainous soils is objectionable,even the lithosols being divided according to the parent rocks. The lithosols,as a group of skeletal soils,do not include all diversity of mountainous soils. The mountainous soils in different continents and countries are not less diversified than the soils of the plain areas. Depending on the position of this or that mountainous system on the continent and its age,on the hightness

of the mountains and their petrography,different forms and combinations of soil types will be observed in each special case. The character of vertical zonality of landscapes and the spectra of soil cover changes sharply with the moving from one mountainous system to another.

At the same time it will be not right to show on the world soil map the soils of the mountains as similar to the soils of plains. For instance,mountainous brown forest soils are quite different from the brown forest soils,and the mountainous chernozems-- from chernozems of the plains and so on. It is absolutely clear to everybody,that the agricultural utilization of the mountaineous and plain soils will be quite different. All this make very difficult the decision about the proper place of the mountainous soils in the world soil system. It is necessary to confess that the nature of the mountainous soils is much less studied than that of the soils of the plain areas.

It seems to us,that the term "lithosol" should be much narrowed and should not substitute the large group of mountainous soils, which is necessary to show on the world soil map. Most of the soil units,shown in the legend,are too generalized and should be subdivided. For instance,vertisols,although comprising a united large group of genetically related soils,are enough different in the world and can be shown on the soil map by certain subtypes. In the legend under consideration they include regurs of India,which in their turn can be subdivided into some subtypes,the margalitic soils of Indonesia,soils of gilgai,smolnitzs of Europe,compact chernozems of South Russia and other similar formations. The unification of them into one "formation" or "society" of "family" in the system of soil classification has no objections,but their diversity should be reflected in the world soil map. More subdivisions can be shown in the group of brown forest soils,rendzinas, chernozems,desert soils etc. The accepted scale of the world soil

map permits more detailed characteristic of the world soil cover, than it is determined by the volume of listed in the legend soil units.

Summarising all above remarks on FAO preliminary draft of the legend,it is necessary to mention that it can be accepted as a base for the further creative work,but at the same time it needs very serious reworking according to the above made remarks as well as the remarks of other scientists (part of the remarks was published in the FAO issues on world soil resources).

II. Historic-genetic principle of soil classification.

Trying hot to limit our participation in the discussion by criticism,we had attempted to prepare our variant pf the reworked legend,based on the factual data on the world soils and on the theoretical conceptions,which are outlined below.

The world soil map shows us an interpretation of actual picture of the soil distribution on the earth surface.But this real picture can be interpreted and understood by different ways in the appended legend depending on that theoretical positions,on which it is based.

Thus, we come to the conclusion that there is a very strong connection between soil map,its legend and soil classification. Allthough the legend should not repeat the classification,it must reflect its main points and should be constructed on the same theoretical base. Consequently,inspite of the fact,that the soil classification,as it is,does not comprise an independent subject of the discussion in connection with the world soil map,we could not to stop at the theoretical bases of soil classification,as they should be placed in the basement of the construction of world soil map legend.

Practically speaking,the question is in the discovery of the

main laws governing the geographical distribution of different soils on the earth surface. Combining inductive and deductive methods of the study of soil genesis and distribution and upplying the discovered laws to the further investigation,we can greatly lighten the decision of our task on the creation of the world soil map. It should be mention some attempts of soil classification in the history of soil science at the different periods of science evolution. And now the time came when it is necessary to review some "generally accepted" theoretic positions and to work out new modern conception,reflecting the new level of our knowledge. Not stopping at the history of the qurstion,we shall pass straight to the discussion of modern theoretical conception on this problem.

The experience pf the natural science shows us,that the classification of the fenomena or things reflects most completely and truly the natural laws which is based on the historical evolutionary principle. It is possible to show clearly,that the historical approach to the decision of classification problems is the only correct even from the philosophical point of view. Such approach permit to open internal basic relations between the fenomena under study and their properties. If we shall turn to the experience of other sciences,we can see,that only classifications,based on the principles of the materialistic dialectics,are the most long living,the most fundamental and in the biggest degree promote the scientific progress.

At the base of modern historic science and the poilitcal economy there is a classification of the social-economic formations of the humen society,reflecting the evolution of ways of production and of corresponding to them economic relations.It is absolutely clear to us,that the historical principle is quite lawfull and indispensable in the classification of different formations of the society of mankind,as according to its aim the history has to deal with the changes of its subject with time.

If we shall turn to the biology,we can trace at least at the higher levels of classification,historical approach to the classification of organisms,which reflect the evolution of animal and plant organisms on the earth in accordance with the evolution of geological time.The most convincing in this respect is Darwin's system of the origin of animal species.

The classification of geological formations and systems reflects the main periods of earth crust evolution,and the classification of mountainous rocks by petrographers is based on the hypothesis of gradual evolution and differentiation of magma.

At last,the periodic system of chemical elements in its modern interpretation also has evolutionary character,most consecutively reflecting the theory of atomic nucleus and partices stadial changes. Not all of the above examples of the classifications are possible to consider as consecutive to the last. However,all of them are based on the evolutionary historical principle,taking their objects in the axes of time in such a degree as it is possible at the present level of scientific progress.

If we shall apply the experience of other sciences in the pedology and consider the soil as the independent natural body,we should put in front of ourselves some basic questions and first of all the question,whether the soil evolves with the time,whether the soil cover of different parts of the globe has similar or different history. All the experience,accumulated by world soil science, convinces us that for this question we can answer only positively. Yes,the soil is not something unchangeable,but it evolves with the time from the parent rocks or from the precedent soil types under the influence of certain combinations of soil forming factors. It is not necessary to list the examples for confirmation of this point. They are quite known and after the All-Union Conference of 1932 have received the approval in the USSR and abroad.

In numerous publications on pedology it is possible to find a

great variety of particualr descriptions of soil development and evolution,discovered with the aid of comparative-geographical method by the experimental investigations or by the experience of soil amelioration. Consequently,as the soil is a natural body,which permanently changes with the time under the influence of continuous soil formation process,we can with a full right and must use the historic-dialectical principle in the soil study,the highest synthetic result of which should be the soil classification.

Thus,we have come to the conclusion,that the historic-evolutionary principle can be and should be laid down in the base of soil classification,as it allows us not only to group the soils correctly and to reflect their distribution on the earth surface,but it also permits to open deeper the connections between different soils and their features.

Already V.V.Dokuchaev at the earliest stages of the pedology development had understood the exclusive importance of the time factor in soil formation. Later on the pedologists have many times attempted to apply the evolutionary principle in soil classification To our disappointment,these attempts did not so far lead to the construction of graceful evolutionary system of soil classification.

The first attempt of outlining of historic-genetical principles of soil classification was done in the reports at the Conference of pedologists of the USSR in 1932 (B.B.Polynov,1933;V.A.Kovda,1933). One of the present authors had written at that time,that..."standing on the historical understanding of soils origin,it is necessary in the classification construction to classify soil types not according their geographical distribution (zones),not according to external conditions of their development,and of course not according to their external features (colour),but according to the historic-genetical bonds of the soil types,which are the variable stages of the soil forming process" (V.A.Kovda,1933).

Ap to the present time the soil classifications by the particularities of factors of soil formation, by bioclimatic conditions of natural zones and provinces, by the combinations of genetic horizons or by chemical and physical properties of the solum have predominated in the pedology. At this the soils were considered as a product of the present conditions of soil formation, having not any past history. At the same time, in the soil science not few convincing data have been accumulated on the age and quoternary history of some soil types, on the stadial changes of hydromorphic and automorphic soils, on the evolution of saline soils, on the steppetion and desertation of the soils etc. Introduced during the latest time in pedology the concept of seasonal regimes of soil formation has improved, but did not changed the geographical approach to soil classification. The regimes of soil formation only reflect the influence of present external factors of soil formation, considered allthough in seasonal dynamics, but without of any conneetion with general evolution of landscapes and soil formation, that is outside the parameter of time. But that important fact is known, that the soil regimes themselves evolve with the time together with the evolution of the soils and surroundings and the changes of one lead to the changes of other, and vice versa.

The attempts to put the principle of soil evolution at the base of soil classification is observed in French and Belgian school of pedology. However, these ideas do not receive so far their develop ment. It is impossible to see the evolutionary row of soil development in the classification system. The similar on their genesis soils are separated one from another, and, vice versa, the dissimilar soils are united. That has found its reflection both in the cartographical materials and in the legend to the soil map of Africa. It is possible to hope that the creative findings of French and Belgian pedologists in this direction will lead to further progress in gracefulness of the evolutionary schemes of soil formation.

Concluding the above said, we can determine the following tasks of soil classification, partly using the words, said by one of us thirty years ago and partly adding some new points:

I) to establish and to reflect the main stages of the process of soil beginning and development with aim of the planned directing of their development and the utilization in the mankind interest;

2) to establish and to reflect their historic-genetical bonds;

3) to discover and to understand the main features, contraries and leading factors in them, which move the processes of soil development at each stage;

4) to utilize the classification as a deductive method in pedology, which permit the deepening of soil development study and prediction of their properties and changes;

5) to utilize the classification as the means of economic soil estimation in the interests of their productive usage in agriculture, forestry, mechanics, building and so on.

The consecutive application of historical principle to soil study of the world leads to the discovery of one of the most general low of the soil genesis and distribution (geography), which was formulated at the Bucharest Soil Science Congress and which we can designate as "the principle of heteroageons of the soils of the world" (V.A.Kovda). According to this principle, the analogious or similar soil groups will be situated on the homoageous (and of same type) geomorphological elements of the land of the continents. Heteroageous geomorphological surfaces even situated in the same climate will have different soils.

The above principle could be laid down at the base of soil classification and the legend to the soil map and could be consecutively held in the complete system of taxonomic units only in such ideal case, if the soil development could allways start and proceed in some stable and the same surrounding conditions. In the

reality this is not so in most of the cases. The numerous soils, although have appeared on land at the same time, but in different surroundings, which in their turn have changed with time. From this we inevitably come to second important principle - to the idea of polygenesis of soil formation. This idea in a bit different form has been set of against to the idea of V.R.Willjams on the united process opposed to soil formation (N.N.Rozov, I956). As a result, within the limits of the homoageons earth surfaces it is necessary to distinguish the soils, the development of which has started and proceeded in different surrounding conditions. And vice versa, in the same or similar surrounding conditions the soil formation has started at different time, and that is why the soil cover is often very different being at present in the same climate.

The differences between the soils within homoageous stages, determined by local soil-geochemical cycles, may be so big, that even overcome the ageous differences between the soils. This becomes obvious if we shall find the correct answer to the second question in connection with the evolutionary approach to the soil classification, and namely to the question of what is subjected to the evolution, what develops in the history of soil formation, what lies at the base of soil evolution.

An analysis of the sum of present knowledge shows that the most general phenomena, which develop under soil formation and which is characteristic for all the soils without exclusion, is the balance (ratio of incoming and outcoming) of organic and mineral substances, determined by the interrelation of biological and geochemical circulations of substances. The transformations and changes of the balance of the substances in the history of biological and geological (geochemical) circulation in hypergenic sphere of the planet comprise the base of soil evolution, the moving power of soil formation process. There is no soil formation without biogenic accumulation; but the biogenic accumulation in the soil

is very complicately and differently combined with the geological alterativy denudation, washing out transporation and deposition of substances in the landscape.

In the complex phenomena of the development and history of the balance of substances under soil formation there are such components as the balance of water (the sources and forms of supply evaporation, transpiration, outflow) and connected with the first the geochemical balance of mineral substances, incoming and outcoming in the solum, and especially the synthesis and decomposition of organic matter, accumulation and migration of connected with the latter biogenic elements. Numerous components of these balances can not be so far quantitatively characterised. However, there were some attempts to work out the types of the balances of the ground waters and the soluble substances (V.A.Kovda, A.A.Rode, N.A.Kenessarin and others).

From the geological point of view the soil formation is one of the most general geochemical surface and subsurface processes of so called hypergenesis (A.E.Fersman), which intensivity is determined by the intensivity of processes, going on in the biosphere which in their turn in a great degree depends on the intensity and the completeness of usage of the solar energy.

The biological circulation of substances always develops itself at one of the branches of more wide geological circulation. That is why we can not regard them separately when the soil development study is concerned. Such contrary directed processes as synthesis and decomposition, accumulation, transporation and outflow of the substances, absorbtion and desorbtion of energy in the soils always go on at the same time in some combinations, which make the diversity of soil formation processes and soils. At this, the direction of this or that processes plays an important role.

The geological (geochemical) and biological circulations of

substances at the certain stages of soil formation have the same direction and then especially rich forms of accumulations of substances and soils are formed. Such, for instance, the dark coloured meadow hydromorphic soils of different natural zones. There are the cases of their backward interrelation when the biological and geological circulations are contrary directed as, for instance, in the allitic or podzolic soils. Depending on the components combinations, comprising the geological and biological circulations of substances, different soil types and groups are formed.

It is important to stress, that all processes of substances transformation in the zone of hypergenesis whether mechanical, physical, chemical, biochemical or biological depend in their intensity on the intensity of the income of solar energy to the land surface as the internal earth energy play, it seems, a subordinate role in these processes. Consequently, the energetical coefficient of soil formation should be taken into consideration in the study of the balance of substances and in the soil classification, build up on the evolutionary principle.

As the balance of substances and its evolution in the zone of hypergenesis are closely connected with the energy resources of soil formation, we should outcoming of the principle of polygenesis introduce the new conception of the system of evolutionary rows in different energetical conditions, reflecting the potential energy resources of soil formation. The latter are determined firstly by the solar radiation balance of the earth surface and secondly by the completeness of their possible utilization depending on the present water resources, that is on the coefficient of humidity, as practically all chemical and biochemical reactions of soil formation go on in the water media (V.R.Volobuev, 1963, 1964). Proposed by V.R.Volobuev energetical approach to the understanding of soil formation permits to build up a scheme of the most large soil units, which reflects the gradual changes of the energetical

potential on the earth surface and the completeness of the solar radiation utilization in soil formation.

The changes of the energetical potential on the earth surface may be expressed by different ways, but most generally they are expressed in the system of thermal belts, which are possible to characterise weigher by the radiation balance in calorias per unit of surface or by the sum of active temperatures. Probably, it is enough at the present stage of study to differentiate the following thermal belts, to each of which its own group of the soils corresponds (Table I).

As far as the degree of radiation energy utilization in the dependence of the present water resources is concerned, it is necessary to differentiate in the limits of each thermal belt the facia according to the humidity, which can be also quantitatively characterized by different ways, and in a particular case with the usage of Ivanov's humidity coefficient. Taking into consideration the fact that in this very case the soil classification of the whole world is concerned, and that it has differently been studied in its different parts, the facial differentiation should not be too detail and should include only main and very different units.

Table I.

Nos:	Belts	Radiation balance, ccal/cm^2/year	Annual sum of temperatures higher than+I0^{o}C
I.	Polar	0 - 25	600
2.	Boreal	25- 35	600 - 2,400
3.	Subboreal	35-50	I,800- 4,000
4.	Subtropical	50-75	3,200- 7,000
5.	Tropical	75-I00	7,000- 8,000

That is why we have limited ourselves only by the following large facia of humidity by Ivanov:

1. Cryogenic..... I,0 (with permafrost)
2. Humid..... I,0
3. Arid-humid..... 0,5-I,0
4. Arid..... 0,5

In accordance with above we differentiate the humidity within the thermal belts as follows: in polar belts humid and arid-humid cryogenic facias are distinguished; in boreal belts cryogenic and humid facias are differentiated; in subtropical and tropical belts there are three facias in each: humid,arid-humid and arid; and in the subboreal belts all four facias are differentiated.

Thus,we received a system of energetical groups corresponding to certain potential energy resources of soil formation,within the limits of which it is possible to build the evolutionary soil rows. This approach allows us to take into account in the soil classification and corresponding legend to the world soil map those theoretical principles,which were characterized above namely the principle of heterogenuous soil age,the principle of soil polygenesis, and the principle of the substances balance evolution. At the same time the dependence of substances balance evolution under the soil formation from the energy and water supply is taken into account.

Thus,we have answered for three main questions,connected with the historic-genetical approach to the soil classification: firstly that the evolutionary conception is applicable to the soils as the independent natural bodies; secondly,that the main subject of the transformation,development and evolution under soil formation is the balance of substances;and thirdly,that the soil evolution is going on in a certain energetical medium.The answers for these questions led us to the attempt of construction of the system of rows of soil evolution.However,the question will be rather far from its decision,if we shall be unable to give answer for the last,but probably,the most important for soil classification and mapping

question,arising in connection with the evolutionary conception, namely: how is going on the soil evolution in its real appearance and which stages of this process can be fixed as the separate groups of soil types. In other words,it is necessary to review the existing material from the above point of view with the aim of attempting to create the evolutionary soil rows,which will include the most possible variety of the world soil types. This task is easied by the reviewed earlier at the International Congress of Soil Science in Bucharest (V.A.Kovda,1964) theory on the unity of many elements in the history of land of the countries of the globe.

The newest data on the geography of soil cover and the earth geomorphology allow us to make the conclusion that there is a great similarity,identity and parallelism in the history of the earth surface and in the history of soil formation process on different continents.

The relative geological youngness of the modern earth soil cover is very remarkable. This is expressed: a) in the regular presence in the soils of the rocks debries and slightly weathered minerals,characteristic for the igneous and methamorphic rocks; b) in lithological stratification of the solum,what is not connected with the soil forming processes,but with the formation of sedimentary parent rocks; c) in the relatively little thickness of the solum in most of the regions of continents.

V.A.Kovda has explained this by three general factors,which have determined the relative youngness of the soil cover on bigger part of the earth territory: the great continental glaciation from polar parts to the equator and from the mountainous tops to the plains,Alpic orogenesis and continuous ascending of the world ocean level (the world basis of erosion and accumulation) during the postglacial time.

The relative predominance on the plains and plateau of comparatively young soil cover,formed on the glacial,fluvioglacial,

alluvial and lacustrine deposits,is explained by the accumulative activity pf glaciers,postglacial flows and rivers,Flandria lowland, Scandinavia,East European plain,Western Siberia lowland,Amur plain, the plains and lowlands of North America are the bright examples of the above.

The continuous intensive surface erosion,being a consequency of the gradual ascending of surface level connected with the Alpic orogenes,in its tourn is a reason of the relative youngness of the soil cover of denudation basins and accumulation regions for those territories,which were not liable to the activity of great glaciations.This is the reason of the fact that on the surface of different continents there are enormously large and impressively similar and homogenious great alluvial and deltaic-alluvial plains. The latter have similar elevation from the sea level and similar number and type of development of ancient terrasses and soils;for example,the terrasses of Mediterranean area in Europe,Africa and North America,the terrasses and plains of Argentina,Arabia and Eastern Asia etc. If besides this we shall count that the factor of pressure from the world ocean in the areas of months and lower currents of the world hydrographic network acted contemporarrily with the postglacial flows,Alpic orogenesis and erosion,then it will be not difficult to understand that exclusively wide distribution of proluvial,alluvial and deltaic-alluvial quoternary sedimentary rocks on the different continents and corresponding youngness of the soil cover of these territories. The above said determines sufficiently the second universal peculiarity of the earth soil cover (although with some exclusions): the predominance on the plains at present or recently (during the Quoternary) of hydro morphic (hydrobioaccumulative) type of substances balance in soil formation.[1]

We do not consider the used here and below terminology as final. That is why we give in brackets some possible synonims,which additionally show the content of the terms and concepts.It is quite possible that some other better terms will be found.

Under the hydromorphic (hydrobioaccumulative) type of the substances balance we understand such type of substances balance, which exists at the soil formation under the cover of developed vegetation with indispensable influence of the ground waters,appearing at the depth of 0,3-3,0 m.but not deeper than 7-8 m.

The presence of the ground waters level at these depths is followed by capillary nutrition of the soil forming vegetation and serves as a source of the permanent addition of different substances,present in the ground waters and sedimented in the soil horizons as a result of transpiration and evaporation. It is not difficult to see,that at this stage of the substances balance evolution the wide geologic and the little biologic circulations of the substances coincide partly or totally on their direction. This leads on different continents,but in the similar geomorphologic conditions to the formation of the most fertile gley-meadow,meadow and meadow-chernozem soils,characterized by the higher plant productivity from one side and by the higher density of the fauna - from the other. In the conditions of the deserts because of the insufficiency of utilisation of potential energy of soil formation by the vegetation,the geologic circulation of substances may become sharply predominating over the biologic one and may lead to such intensivity of geochemic accumulation,that about totally infertile saline soils and continental chemical sediments may be formed as for instance the Atakama desert in Chile.

During the active phase of hydromorphic (hydrobioaccumulative) soil forming process,that is when the capillary outskirts,arising from the ground waters,penetrate the soil up to the surface or up to the plant root systems,the secondary minerals and new formations accumulate in the soil from the substances,brought by the ground water. Depending on the conditions of the balance and consequently on the chemistry of the ground water,not only chlorides,sulphates and carbonates of alkalies and alkali earths are accumulated in the

soil,but also the accumulation of the compounds of mangasine,iron, silicon,aluminium,microelements is observed,accompanied by the complex process of formation of secondary clay minerals of the types of illite,montmorillonite,baidellite and others.

Hydromorphic soil forming process leads to the accumulation of dispersed forms of secondary mineral compounds and concretions of specific compact horizons of mineral accumulation,as for instance gypsoferous or calcareous horizons,cemented horizons of secondary opallike silica or sesquioxides accumulations (ground water laterite),the horizons of clay minerals accumulation.In some conditions the hydromorphic accumulation of organic matter in the form of secondary deposits of humus together with sesquioxides is observed. In the distribution of hydromorphic (hydrobioaccumulative) soils on the earth surface it is possible to see certain laws,connected most of all with the interrelation of the outflow and evaporation of the ground waters,that is with the type of their balance, with the value of income and utilization of the energy by the vegetation in the soil formation,including the biogenic taking and accumulation of elements. The varieties of the hydromorphic type of substances balance are clearly reflected in the concentration and chemistry of the solutions,circulating in the soils of this stage. For superhumid areas dilute organic-silicions and under the predominance of anaerobic conditions organic-ferrous-silicions solutions will be characteristic;for humid regions silicions-bicarbonate solutions and sometimes ferrous; for arid-humid regions - bicarbonate-sodic or calcic; for humid-arid regions - bicarbonate-calcic and gypsic; for arid regions - concentrated sulphate-chlorid,chlorid and in the extreme conditions of superarid desert - nitric (with different cations).

It is necessary to take into account,that free circulating surface and subsurface waters carry dissolved oxigen and are the factor of oxidation. In stagnant waters,vice versa,the intensive

reduction proeesses develop,followed by the transformation of iron, manganese and others into soluble forms.

These questions are detaily reviewed by some authors in the schemes of the areas of migration and accumulation of substances in soil formation in different parts of the continents.

Deeply different on the combination of concentrations and composition,these geochemic associations of "migrants" and "accumulants" by the mselves in the conditions of different landscapes are the reflections of stadial transformations of the types of substances and energy balances in the above sense. The dilution and concentration of the migrants in the soil-geochemic waters of the hypergenic sphere under different interrelations of inflow and outflow,transpiration and evaporation of ground waters give the whole spectra of the chemistry of the waters and hydromorphic soils from the enriched by the secondary compounds of sesquioxides in the swamps of humid tropics or the North to the calcareous saline hydromorphic or paleohydromorphic crusts of the superarid deserts. As it is shown below,at this the world geochemic formations (associations) of the soils of correlating landscapes arise,having the exchange and migration of common typomorphic elements.

When the ground waters go out into the depth after the cutting through river network due to the epeirogenic ascendings,the hydromorphic (hydrobioaacumulative) type of the substances balance is changed by the automorphic (bioaccumulative),under which the accumulation of substances in the soil is the result of only little biologic circulation (connected with the plants),and the component of the large geologic circulation of substances has contrary direction and is characterized by geochemic outcome. The accumulative landscapes receive the features of neoerosionic landscapes due to erosion. Of course,the degree of eluviality and the speed of eluviation are very variable depending on the type of the water balance in the soil cover,

The soil cover, kept from the hydromorphic stage of soil formation on the ancient great deluvial, proluvial, fluvioglacial, alluvial and deltaic-alluvial plains of the earth, for a long time and practically forever accepts and keeps in itself the relict marks, formed during the time or earlier soil formation.

Not only the origin of the society of saline soils may be totally explained by the ancient or present hydromorphic process, but the origin and geography of compact soils, laterites, ferrugenious crusts and quirasses in tropics, calcareous-gypsoferous horizons and quirasses in the deserts of Arabia and Africa may be explained and understood only with the taking into account of the ancient hydromorphic soil formation process, followed by the active accumulation of this or that secondary chemical sediments from the ground waters of different chemistry in the conditions of different types of the substances balance.

The characteristic example from this point of view is the large association (formation) of the blach humucified montmorillonite soils. The existing at present materials permit to suppose, that the association of black and dark coloured highly productive soils, including regurs of India, chernozems of the USSR, brunizems of the USA and Canada prairies, meadow-chernozem soils of north-eastern China, black coloured soils of river valleys of boreal belt, black tropical soils of Burma, Africa and Latin America, formed on the ancient alluvial, deltaic-alluvial or fluvioglacial deposits, passed in the past or pass at present through the cycle of hydromorphic soil formation with the participation of sweet bicarbonate-calcic ground water. It is quite understandable from the above the similarity and close resemblance of black coloured meadow-soils of Amur-Sungari basin (Far-eastern prairies), black meadow and meadow-chernozem soils of Siberia, chernozem of Russia, chernozem of Ukraina and North Caucasus, meadow-chernozem soils of Hungarian pushta, thick dark fertile soils of Argentinian pampas and highly fertile black

soils of the USA and Canada prairies. These are the soils at different stages of hydromorphic or posthydromorphic soil formation under the cover of grass and grass broadlived forest vegetation, which are characterized by the same or similar (in its varieties) accumulative type of substances balance.

The more intensive and earlier the ascending of the continents and mountainous systems was during the postglacial period, the less the features of hydromorphic process in the soils were kept at present time under the influence of denudation and organisms activity. On the plains of Canada and the USA the ground waters are now at the depths of I.I-3.0 m., and the dark coloured soils here are the varieties of the grass-meadow soils. The same is in a great degree applicable to chernozem and meadow soils of Siberia and Far East. The chernozem soils of North Caucasus, South Ukraina and Argentina are situated on the plains, which were drained in a considerable degree; and the ground waters here were gone down up to 4-8 m. That is why the hydromorphic type of the substances balance here has only residual character. The chernozems of uplifted parts of the Russian plain, of the Volgian syrts area, and especially the dark coloured soils (hgyluthm) of the north-western China loess plateau have evoluted furthermore. The hydrographic network here have deepened for tens and hundreds of meters, and the ground waters have gone down to the big depths. The hydromorphic type of the substances balance was changed by the automorphic (bioaccumulative) one in the conditions of intensive erosion. However, the calcareous horizons, the concretions of lime and sesquioxides, accumulated during the hydromorphic stage, are the evidences of that past.

The second and not less characteristic example of the hydromorphic and paleohydromorphic formations is a large group of allitic soils, formed on the ferrous accumulative crust of weathering as a result of ancient or modern hydromorphic process. This group of the crusts of weathering and tropical soils types includes the

lake-swampy laterites, ground water laterites, the laterites, formed by the sedimentation of sesquioxides from the temporary (deluvial) ground waters flows at the slopes, especially in their lower parts.

The acception of the above principles as a bach-ground permits to start an attempt of creation of soil classification scheme, reflecting the history of evolution of the substances balance in certain energetic conditions of the earth. In the most general chematic form the stadial types of the substances balance under soil formation may be shown in a system of parallel evolutionary rows, the axes of which are the time and the energetic level. Let us take that the potential energy of soil formation of a given territory "E" is a function of the radiation balance "Q" and of the moisture coefficient "a" of the same territory, that is $E = f(Q,a)$. In this case simbolising the time of soil formation as "T", it would be possible to show the stages of evolution (transformation) of the substances balance types under soil formation as a graphical scheme - the system of historic-genetic (evolutionary) rows of the world soils:

E							
	A_1	A_2	A_3	A_4	A_5	A_6	A_7
			B_3	B_4	B_5	B_6	
	C_1	C_2	C_3	C_4	C_5	C_6	
		D_2	D_3	D_4	D_5	D_6	D_7
			E_3	E_4	E_5	E_6	E_7
		F_2	F_3	F_4	F_5	F_6	F_7
	G_1	G_2	G_3	G_4	G_5	G_6	G_7
			H_3		H_5	H_6	H_7
		I_2	I_3	I_4	I_5	I_6	I_7
		J_2	J_3	J_4	J_5	J_6	J_7
		K_2	K_3	K_4	K_5	K_6	K_7
		L_2	L_3	L_4	L_5	L_6	
		M_2	M_3	M_4	M_5	M_6	M_7
						N_6	T

Taking "E" value as discontinuous, having in mind the above grades of "Q" by the main thermal belts, and understanding "a" as the phases of humidity, we are able to say how many different "E" values or how many parallel evolutionary rows of the substances balance types under soil formation is possible to construct in a system of soil classification under the mentioned conditions. As in the polar belt we have limited ourselves by differentiation of only himid and humid-arid cryogenic series, in boreal belt - cryogenic and humid, in subtropical and tropical belts - humid, humid-arid and arid, we have alltogether I4 different "E" values or I4 evolutionary rows of the soils. Naturally, it is necessary to remember that such differentiation is accepted by us only for the given assay of the world soil systematic; under more detail approach the quantity of "E" values may be much more as it is possible to differentiate some transitional thermal belts as well more detail varieties of the humidity series.

In the above scheme of the system of the world soil historic-genetic rows the energetic rows are marked by the following letter symbols: A - tropical humid, B - tropical arid-humid, C - tropical arid, S - subtropical humid, E - subtropical arid-humid, F - subtropical arid, G - subboreal humid, H - subboreal cryogenic, I - subboreal arid-humid, J - subboreal arid, K - boreal humid, L - boreal cryogenic, M - polar humid cryogenic, N - polar humid-arid cryogenic. The stages of soil evolution are shown by the following numbers: I.- hydroaccumulative, 2. - hydromorphic, 3. - meso hydromorphic, 4. - palcohydromorphic, 5. - proterohydromorphic, 6. - automorphic, 7. - mauntainous. The doubled symbol permits to determine directly the stadial and energetic position of this or that soil. For instance, the symbol A_2 means hydromorphic soils the tropical humid row and D_5 - proterohydromorphic soils of the subtropical humid row. As not all stages of soil evolution are obser-

ved in each of the energetic rows,there are some corresponding missings in the scheme. In some rows the evolution starts only from later stages,and in the others,vice versa,the latest stages are not known. Starting from the general conception of the evolution of the substances balance types and corresponding to them soils on the great continental plains from hydromorphic (hydroaccumulative) stage to automorphic (bioaccumulative) one with the evolution,erosion and draining of the water-accumulative territories,it is possible to imagine the following evolutionary process,which proceed in the natural conditions practically discontinuously,but may be schematically divided approximately into 6-7 separate stages,which include the groups of similar soil types.

III. Possible stages of soil formation (soil evolution)

I. The hydroaccumulative stage - underwater (permanently or temporary) soil formation process. The substances balance at this stage is characterized by the absolute mechanical,chemical and biogenic accumulation of the matter from water suspensions,solutions and sediments under the substantially coincidence of the directions of great geologic and little biologic substances circulations. Generally,these are the areas of tectonic discending. It is,properly speaking,sill pre-soil stage,when the sedimentary parent rock is forming and the soil formation,begins at the same time. At this stage,together with the clastic and chemical matter the accumulation of organic substances and organogenic elements takes place (sometimes very intensively-sapropel,peat);and it is important to stress that not only by allovhtonic way,but by autochtonic one too. Let us remember,that B.B.Polynov and M.Kubiena for a long time ago have distinguished this stage of soil formation. According to the data

of hydrobiology,in the conditions of shallow-water basins there is a great density of the life,and these landscapes themselves are the geochemic boarder line for the organic and mineral substances, carried down by the hydrographic network and by the ground waters, as these substances are in a considerable degree consumed by living here organisms (K.A.Voskresenski,1946,1948). The differentiation of the soils of this stage has mainly theoretical interest for the world soil map,as these soils are not to be shown on the soil maps in the present scale. But for some territories of the world they are of the considerable practical importance. The taken from the sea and utilized in agriculture lands in Holland,the young land of the Caspic sea coast or the alluvial plains of Amasonka and Volga are the best examples of the above. The differentiatior of this stage soils may have a great importance under the large scale survey of such areas as marshes,polders,deltas,estuaries, mangrows,inundated areas near hydroelectric stations. That is why it will be not right to miss out of consideration these formations, where the soil formation is bearing and where many properties are forming,which later on are carried in the landward soils.

In the limits of this type (stage) of the substances balance, in which the determining process is an accumulation of the clastic material,it is possible to distinguish some subtypes depending on the surrounding conditions: maritime,alluvial,lacustrine,swampy, deluvial,colluvial. All the above said on the importance of geochemic conditions,redox,potential,concentration and water composition and on the type of the water balance has especially important role here. Being in a considerable degree variable in their properties, the soils of the hydroaccumulative stage (marked by the symbol I) are widely represented practically in all thermal belts of the planet and especially in humid and arid-humid series of humidity.

The fact,that the formations under consideration appear out

of the water at the land growth already with certain properties, sometimes being of very low fertility and sometimes having a very high level of soil fertility and represent a favourable bed for the higher plants growth or for the cultivation of hydrophylic plants (rice and others),commands to put them into one evolutionary row together with developped soils as a beginning stage of evolution.

2. Hydromorphic (hydrobioaccumulative) stage - hydromorphic soil formation,capillary-upwater soil formation. At this stage of the substances balance development we have to deal with good formed soils under the cover of higher plants. The soils develop under the direct and permanent influence of the ground waters,acid neutral or alkaline,salty or sweet,stagnating reduced or flowing and enriched with oxygen depending on the general geochemic conditions of the landscape,but always in the accumulative or accumulative-transitory landscape,and are characterized by the accumulation of the solved in the ground waters material in the whole solum. The substances balance in the system of soil horizons is directed as a whole to the accumulation as a consequence of the coincidence of positive directions of biologic and geochemic circulations of substances.

The hydrogenous accumulation,depending on geohhemic conditions, includes easily and slightly soluble salts,the compounds of silicon oxides or the elements of iron family,clay minerals,organic matter, the compounds of trace elements etc.

The hydrogenous accumulation at this stage of soil formation is a consequence of evaporation and transpiration of ground waters and is accompanied at the same time by intensive biologic accumulation of substances in the upper part of the soil profile.

The geochemic and biologic accumulation of substances in the soil is accompanied by the weaking of accumulation of clastic material what takes place only on the low flooded terrasses and in the river deltas or in the lake terrasses. At the level of the second

and third terrasses there is only chemical and biological accumulation as for example in gley soils,in meadow turfy soils,in meadow chernozems or in meadow saline soils. As it is not difficult to see, the mentioned differences have also the evolutionary importance.

3. Mesohydromorphic (mesohydrobioaccumulative,semi-hydromorphic stage. The soils of this stage develop in the conditions of accumulative or transitory-accumulative landscape. The staying still quite near the surface (3-5 m.) ground waters have a direct influence only on the deep lower part of the soil profile or on the plant root systems,or only periodically influence on the soil profile during the periods of the ascending of their level. The biogenic accumulation of elements becomes a main factor of soil formation. The accumulation of soluble material from the ground waters is only observed in the lower part of the solum,and the accumulation of clastic material may only take place under the influence of the deluvial flow. In the upper part of the soil profile may take place the combination of two oppositely directed processes: biologic accumulation of elements and their leaching. As a whole,the balance of soil forming substances has an accumulative character under the predominating participance of the organisms in the upper part of the profile and of the capillary zone of the ground waters - in the lower. And at this stage of soil formation it is clearly seen the influence of the general geochemic surroundings (composition,concentration,lability of ground waters,redox potential etc) on the accumulation of certain components in the soil. The intensity of the hydrogenous accumulation itself will be disappearingly low at this stage. However,the productivity of natural and cultivated vegetation and the biological circulation of substances at this stage (especially under the deluted bicarbonate-calcareous waters) will be high and stable. The meadow chernozems of the USSR and Hungary,dark soils of the prairies of the North-East China,North America and pampas of

the South America undoubtedly approve the above.

4. Paleohydromorphic (paleohydrobioaccumulative) stage - paleohydromorphic soils on neoeluvium. The soils develop in the conditions of transitory or eluvial landscape, which was the accumulative one in the past, what can be suggested on the paleogeographic and paleogedologic data (the ancient alluvial plains, the stratification of rocks, the relict new formations of iron, manganese and silicon compounds, concretions etc. The ground waters at present do not have an influence on the soil formation due to their deep position (deeper than 8-10-12 m.), but had an influence in the past, what can be seen from the presence in the soil of some relict features of the past hydromorphic process (single or in some combinations).

The following features of the ancient soil hydromorphism are the doubtless relicts:

a) A considerable quantity of montmorillonitic or amorphous clay and the compactness of the soil material (cracking, strincage, stickness, expansion). This feature, however, may not always be connected with hydromorphism.

b) The presence of silica new formations (powdering, opal crusts, interlayers, concretions, flows, pseudomorphoses, segregations).

c) The formation in the soil profile of compacted interlayers (hardpans), cemented by sesquioxides, silica lime or clay.

d) The presence in the soil profile (in the middle part or in the depth) of bleacked (gleyed) blueish, greenish, rusty, ochra spots; the presence of humic-ferrous horizons.

e) The accumulation in this or that part of the profile of manganese-ferric films, particles or concretions (spherical, conical, porous) or the formation of iron ortstein or quirasse.

f) Microporosity and cavitiness of the soil material (up to the formation of vesicular or vermicular structure), especially clearly

appearing in the lower part of the profile.

g) Some cases of carbonates accumulations in the soils profile as concretions or calcareous horizon - kankar, shoch and others.

h) The accumulation of hypsum (gaza, arzik) and easily soluble salts.

i) The presence of the hydrophilic phlora remnants (the cane roots) or the shells.

The carefull differentiation of ancient soil horizons, parent rock stratification, traces of the water accumulation of the rock has a great importance when the mentioned features are analysed. The paleohydromorphic soils are usual for the great ancient alluvial and postglacial plains, ancient river terrasses, dry deltas, uplifted up to a high elevation by the tectonic processes during the postglacial time.

In the soils of the stage under consideration the total balance of the substances is characterized (on the base of accumulated during previous stages material) by the predominance of geochemic leaching and biological accumulation in the humic horizons as a result of the contrary directions of biologic and geologic circulations of the substances. Numerous brown forest soils and podzolic soils of the Europe and Asia, the soils of Russian plain and Western Siberia (chernozem, chestnut, brown), the soils of arid plains of the Middle Asia (sierozems, takyrs), the calcareous quirasses and dry solonchaks of the soils of paleohydromorphic type. The soil properties are taken from the hydromorphic past, but are in a considerable degree, explained by the eluvial fenomena of the current history.

5. Proterohydromorphic (proterohydrobioaccumulative) stage of soil formation - the soils are developped on the neoeluvium. The soils develop in the conditions of the ancient eluvial landscapes under the absence of any influence of the ground waters, which are now at the depth of more than 15-20 m. The paleogeo-

phic and paleopedologic data permit to suggest the previous position of the landscape,in the accumulative hydromorphic conditions. The features of the past hydromorphic process,characteristic for the soils of previous stages,are expressed much weaher,but still are traced in the soil profile.

At present time the soil formation is going on in the eluvial conditions and the geochemic balance of the substances has clearly expressed negative character. The relicts of the hydromorphic accumulation of the substances compensate the eluvial branch of the geologic circulation only in a small degree,and the biologic circulation and the biogenous accumulation are going on at the relatively (comparatively to the previous stages) narrowed base. The relict features of the ancient hydromorphism may be doubtful,controversary or even complitely lost. To this group belong our grey forest soils,acid brown forest soils and podzolic soils of watershades,chernozems,zheltozems and krasnozems of the ancient high (IV,V) terrasses. The features of the past hydromorphism in these soils may be kept only in a small degree and may be rather doubtfull.

6. Automorphic (bioaccumulative) stage - typic automorphic ("eluvial") genetically independent soils. The soils develop,at least at present geologic period,without any influence of the ground waters and do not have any features of the past hydromorphic accumulative process,in their profile. Only the accumulation of substances,included into biologic circulation,opposite to the predominating here geochemic leaching of the substances from the weathering crust. The summary balance of substances in the solum is negative under the annual influence of the downward flow. In the most typical form the automorphic bioaccumulative soils are formed on the ancient denudated plains or on the plain surfaces, composed by the igneous and methamorphic rocks. Such are,for example,krasnozems and zheltozems of the South China and Western

Georgia. Andosol,formed on the volcanic ashes and tuffes,belongs here too. Rendzinas of the boreal and subboreal belts,the Mideterranean terra rossa,bocsitic allitic tropical soils of Hawajas, some ferrallitic soils of Africa are the typical representatives of this stage of soil formation,genetically not connected with the previous hydromorphic process.

A part of the brown forest soils,some podzolic soils,formed on the igneous rocks,possibly also some varieties of chernozems and sierozems are the primary automorphic soils. The automorphic soils may achieve a great absolute age in the subtropics and tropics,where there was not any glaciation,erosion or covering with the new alluvium. Such are krasnozems,zheltozems,ferrallitic and allitic (bocsitic) soils,having their history from the fertiary time. On the slopes and in the conditions of hilly or mauntainous relief,at the automorphic stage of soil formation a considerable mechanical outflow,that is erosion,may be added to the geochemic leaching the negative balance,of substances increases in these cases. The tectonic and erosion may transform the relief so much and elaminate the ancient crusts of weathering and soils,that no features of the previous soil formation in the soil horizons will be observed in the result.

The reviewed stages of the substances balance in the soil formation process represent some certain qualitative-quantitative stages of the evolutionary process on the surfaces of the water-accumulative origin,included into the tectonic uprising. However, as in any historic process,there is a possibility or real missing of some stages in the concrete geographic conditions.Thus,it is absolutely lowful to imagine the possibility of the beginning of soil formation process in certain geographic conditions not from the hydroaccumulative (underwater) stage,but straitly from the bioaccumulative one (for example,soils on the rock outcrops,soils of the mauntainous plateau and slopes,have usually such genesis.

And vice versa,on the relatively young surfaces the soil formation is at the first,second or third stages and does not come to later ones. It seems to us that the mauntainous eluvial soils of the automorphic biaccumulative type,but liable to the normal erosion, should be ragarded as the independent seventh stage of soil formation. Certainly,we are not satisfied with this solution. The soil formation in the mauntainous countries is very specific and stiff is very little studied. But it is already clear that the fenomena of the side outflow,redestribution and temporary accumulation (on the way of transport) of the chemical,mechanical and biogenic products of soil formations represent the determining peculiarity of the mauntainous soil formation,about unobserved under the soil formation on the plains. The balance of substances in the mauntainous soil formation is negative in a tendency and in the absolute sence. Naimly here that water,chemical,solid and biogenic outflow of the material is formed,which form the parent rocks and soils of the accumulative landscapes,characterized by the absolutely positive balance of the substances.A great theoretical work is necessary for the study of all particularities of the mauntaineous soil formation and for more sound conclusion as to the place of the mauntaineous soil in the soil classification.

From the moment of the beginning of the human agricultural ctivity,the soil formation on the earth has come into the modern newest stage.With the progress of science and technics and especially with the industrialization of agriculture,the society of cultural soils is more and more distinguishing. In these soils the balance of substances and the regime are purposely changed and are gowerned by man for the achievement of certain economic results. Although the peculiarities of the previous soil formation may be kept very strongly,in many cases the man creates quite new soil types,not known in the nature.

The above conception of soil formation and soil classification

permit to outline the following system of taxonomic units for the proposed project of the legend for the world soil map.

The lowest taxonomic units are disirable to be kept as they are approved by the Soviet school of soil scientists,in the same value and meaning,that is differentiating the variants by the degree of culturness[x],the varieties by the texture,the species by the degree of the main process development,the generus by the character of the parent rocks,the subtypes and types by the similarity and complex of diagnostic horizons,the identity of the regimes and the internal soil properties.

The soil types and subtypes are combined on the base of the same substances balance into the groups,corresponding to the above described six-seven stages of evol ution. Its own row of the stadial groups of the soil types corresponds to each energetic level of soil formation. Thus,the highest taxonomic unit is an energetic soil row.There are fourteen of them,as it was shown above. In the limits of an energetic row,from one to six-seven stadial groups are differentiated. Each stadial group consists of some soil types,subdivided furthermore into smaller taxonomic units in accordance with the possibilities of the scale of the soil map.

IV. The Soil-Geochemic Formations.

If we shall take as a whole the soil cover of the planet as a product of biogeochemical transformation of the earth crust surface, it will be still possible to come to a row of the important general theoretic conclusions.

As the biogenic-accumulative process,the soil formation is followed by the formation of a special humic cover on the earth and in the shallows of the seas and lakes,the thickness of which varies from santimeters up to 1.5-2.0-2.5 meters. This thickness is negligible

x) By the culturness,the taxons of any level may be differentiated (from the type as for instance paddy soils and meliorated soils,up to the subtypes and varieties.It depends on the degree of soil transformation under the influence of culture.

in the comparison with the other covers (spheres) composing the globe. But this cover is exclusively active biochemically and geochemically and determines the soil fertility and the plant productivity. The conception of humic cover was introduced into the scientific literature in 1958. At that time it was mentioned, that naimly in the humic cover the lively important for the plants organogenic macro-and microelements are accumulated as well the complex of organic and organomineral compounds. The processes of biogenic accumulation, which form the humic cover, combining with the surface geochemic processes (weathering, eluvium formation, transport, differentiation, accumulation of mechanical and chemical sediments), lead to the formation of special soil-geochemic formations ("association of M.A.Glasovskaja, 1965, or "communities" of V.A.Kovda, 1964), reflecting the particularities of the most general state of development and transformation of the earth crust at its surface.

The soil-geochemic formations are the regular and the most general forms of combinations of the soil cover of geochemically related landscapes: bioaccumulative (eluvial, automorphic), transitory, hydrobioaccumulative (hydromorphic, accumulative) and hydroaccumulative (underwater, aquatic, amphibian).

Between these so different landscapes there are always these or those forms of interrelations and exchange of substances by denudation, erosion, outflow of the surface and ground water transporting organic and mineral compounds in soluble or suspended form. These forms of local geochemic relations are simpler and understandable at the phase of general gradual uprising of the territory and difining of high plateau, watershades and the system of terrasses and lowlands. These connections and the horizontal exchange of substances are more complicated and less studied, less clear to us in the territories, which are at the phase of general regional gradual discending or interchange (in time) of continuous discending

and ascending. The soil-geochemic formations may be chemically near, similar (homogenious) or chemically different (heterogenious). The origin of the chemical similarity or unsimilarity of the formations may be different and complicated.

In the simplest case the geochemic homogenious may be due to the fact, that all formation is still very young, and the redestribution (differentiation) of the movable components is still not developped in the space and in the time. But with the age (absolute or relative) there will be a differentiation of movable and residual products of weathering and soil formation in the soil-geochemic formation. The more movable components will be carried away out of the automorphic landscapes and will be in this or that degree stopped on the way of transport and in the accumulative landscapes.

In the first case the soil forming rocks, soils and ground waters of eluvial (automorphic) and accumulative (hydromorphic) landscapes will be characterized by the homogeniousness of the chemical media and by the presence of the same minerals and chemical compounds: for example, easily soluble salts, gypsum, calcium carbonate, silica sesquioxides and so on. This will be the primary stage of material redistribution without its deep differentiation according to the degree of lability. Thus, in arid regions the soils and grounds of the mauntainous plateau and watershades will contain the residual compounds of calcium carbonate, gypsum, easily soluble salts. The soils and sedimentary rocks of the terrasses and lowlands will contain the same components, which in a tendence will grow on account of the decreasing of their content in the eluvial landscapes of the same soil-geochemic formation.

In the second case (in the heterogenious formations) the automorphic (eluvial) landscapes have not got already of that compounds which were leached out of them and have been accumulated in the transitory and especially in the accumulative landscapes. For example, under the predominance on the watershades of podzolic or brown

forest soils,in the river walleys and lake lowlands the calcium carbonate is accumulated and dark meadow soils are formed. At the formation of allitic soils,krasnozems or zheltozems on the watershades,the formation of sodic montmorillinitic black soils takes place in the depressions,lowlands and low river terrasses (India, Kenia).

However,if the predominance of the processes of geochemic outflow in a given territory continues,then under the favourable natural drainage all more movable components,such as easily soluble salts,gypsum,calcium carbonate,silica of the aluminosilicates,phosphates,will be carried away during the geologically continuous leaching not only from the automorphic landscapes,but from the hydromorphic ones too (from the latters,however,with the residual traces). There will be a secondary homogeniousness,typical for the most ancient soil-geochemic formations,for example,-in the humid tropics. Thus,in the humid tropical areas of China,Brasilia or equatorial Africa,the allitic and ferrallitic soils are formed not only on the watershades,but on the low river terrasses and lowlands too where deluvial and alluvial material is composed of the allitic sediments,in which the chemical sedimentation of sesquioxides in a form of laterite takes place. Only silica compounds from the ground waters may be detained here,resulting the kaolinization fenomena by the neosynthesis of allitic sediments. However,even here the youngest terrasses and sediments of the lakes contain the mineral material with more wide ratio of silica to sesquioxides.

It is not difficult to see that in the three mentioned varieties of the soil-geochemic formations there is a common process of redestribution of mobile products of soil formation and weathering But the dwgree of differentiation and the stages of this general process of evolution are very different and,of course,are fare of complete understanding. The soil-geochemic formations (or societies

or associations),including the soils of coordinated landscapes,cro cross by their fields of distribution the thermal belts and include the groups of similar soils. The soil-geochemic formations,as the soils,in their turn,represent a series of the historically consequent (that is not occasional) stages of the soil-geochemic development of the earth surface. Qualitatively,the soil-geochemic formations depend on the direction and correlation of accumulative and eluvial (leaching) processes,that is they are connected with the types of water regime and the water balance of the earth and with the development of the tectonic process of the earth crust surface. The areas of uprising will indespencable have the soil-geochemic formations the more leached of soluble salts,gypsum, calcium carbonates,exchangeable bases,silicon and so on,the more eluvial and the more ancient according to the continuence of the soil formation is the continent or its part.At this,the unsaline saturated with cations soils,then unsaturated acid soils,and at last the allitic soils will be consequently formed.

It is important to mention,that both bioaccumulative automorphic and hydromorphic or transitional stages of soil formation will be characterized by the homogeniousness of typomorphic elements. The formation (society) of allitic (acid) soils in the most extreme cases of development in rainy tropics includes both on the watershades and on the terrasses and in the lowlalnds the soils, mineralogically represented by the oxides of iron,aluminium,manganese with the permanent presence of the secondary minerals of I:I lattice type. For the formation (society) of black humic montmorillonitic soils,as the chernozems and meadow and meadow-gley soils (that is both in automorphic and hydromorphic landscapes), the migration and redistribution of calcium carbonate,the presence of exchangeable calcium and the neutral-alkaline reaction are characterized. Probably,the geochemic trend of development of the soil cover in the areas of tectonic downward movement will be in

some degree opposite to that,which exist at the general uprising of the earth.

There are still very few observations in our desposition for our judgement on this trend of development of the soil-geochemic formations.The processes of uprising predominate all over the earth. But,judging on the relicts of the hydromorphism,it is necessary to expect,that with the downward movement of a country there will be in the accumulative and neoaccumulative landscapes the accumulations of SiO_2 compounds,then will beginn the resynthesis of secondary minerals of 2:I lattice type,then will appear carbonates and later on sulphates and chlorides of sodium,magnesium and calcium. Thus,there are examples of calcification of the ancient allitic crust in the steppe Ural region. The hydromorphic conditions are very responsible to the change of water balance of an area and especially to the decrease of outflow portion in a favour of the increasing of evaporation portion,which lead to the increasing of the processes of geochemic accumulation of "migrants"

At all unclearness of the problem of soil-geochemic formations, the Soviet scientists of different research centres,basing on different facts and conceptions,come to the conclusion of the necessity of establishment of the planetar categories of the soil cover (not soils,but soil cover). In connection with this the names of A.E.Fersman,A.P.Vinogradov,B.B.Polynov should be mentioned. V.A.Kovda,A.I.Perelman,M.A.Glasovskaja,V.R.Volobuev have not once written on the subject and made numerous reports.Generalising the ideas of the latter scientists,it will be possible to propose to introduce into the world soil taxonomy as a second (after energetic rows) taxonomic level "the soil-geochemic formations" (the soil-geochemic classes). It would be possible to classify them as follows, taking into account the above analysis of this formations.

The main soil-geochemic formations of the earth (SGF)

I. formation of acid allitic soils (boesitic,allitic)
humid rainy tropics
typical minerals: boemite,gibbsite,hydrargillite.

II formation of acid allitic-kaolinitic soils (kaolisol,ferruginious) humid tropics
typical minerals: kaolinite,gibbsite,goetite.

III formation of acid kaolinitic soils (krasnozems,zheltozems, rubrozems) humid subtropics
typical minerals: kaolinite,goetite,hydromicas.

IV formation of acid siallitic soils (podzolic,brown-podzolic, brown forest,loessic)
humid subboreal and boreal belts.
typical minerals:hydromicas,kaolinite,vermiculite, residual primary minerals.

V formation of neutral and slightly alkaline siallitic soils (cinnamon,grey forest)
moderately arid subtropics,temperate climate typical minerals: polygorskite,chlorite,montmorillonite,calcite)

VI formation of alkaline montmorillonitic humic soils (chernozems, meadow,brunizems,vertisol,grumosol)
different climate,but mostly arid or periodically arid climate of savannas,steppes,prairies
typical minerals: montmorillonite,calcite (aragonite, sometimes gypsum)

VII formation of alkali and saline soils (solonetzs,solonchoks, sodic soils)
different climate,but mostly arid or periodically arid
typical minerals: primary minerals,montmorillonite, calcite,gypsum,semihydrate,halite,mirabilite,bernalite.

VIII formation of volcanic soils on ashes (andosol, hydrol soils, curobocu, trumao)

different climate

typical minerals: primary minerals, especially volcanic glasses, palagonite, allofanes.

Doubtless, this is not final version of the new conception of the Soviet scientists on the soil-geochemic formations, and probably their number and possible subdivision will be changed. But even in such form the conception of soil-geochemic formations as the highest taxons of the world soil classification at the classes level will be useful. It is to the point, however, to tell some words here on the smallest (lowest) subdivisions of soil systematic - those subdivisions, which are beceassary in the detail soil mapping for the practical necessities of agriculture. The Soviet soil scientists have allways understood the conditional (relative) character of soil boundaries, shown on the soil maps. The soil cover is characterized by the property of continuousness and by the gradual transitions. However, it was allways taken into account that it was impossible to carry on this point up to an absurdity. Inspite of the continuousness of the transitions, the real differences in scientific and economic considerations between the soils had been allways too obvious. There are two particularities in the heterogenity and continuity of the soil changes in the space. If counted, studied and mapped the complexity of soil cover, connected with meso-and microrelief, vegetation, lithology or petrography of rocks etc, then the individual identification of soils is much easier than at the "blind" statistic approach to the territory. Thus, yet at the end of 20th and beginning of 30th it was introduced by S.S.Neustruev and B.B.Polynov the conception of the elementar unit of soil cover (EUSC) of the element of a soil complex (ESC) and of the elementar lanscape (EL). Now, at the middle of 60th a similar

conception is introduced by the American pedologists under the term of pedon and polypedon. Under this or that name, but is is necessary to use this conception of individual and really homogenious soil unit or their combinations.

The other way of counting and estimation of soil variability even in the limits of similar forms (units) of soil cover, is an accumulation of sufficiention the quantity (on the replication) statistic material for the creation of distribution curves, the security curves and the quantitative estimation of the limits of variability of the properties inside of a given soil type, genera or species. Summing up the data, given in the fourth part of present report, we discovered an interesting general planetar dependence of the number of soil types in the limits of each stage of soil formation on the relative position of this stage in our scheme of soil evalution (fig.I). The higher is the position of the stage of soil evolution, the greater it appears, is the quantity of established soil types in its limits.

This is a straight correlative connection between the diversity (number) of soil types and the degree of soil maturity (development) in a historic-genetic row. This dependence is expressed by the equation of regression: $y = 8.1 + (5.9 \mp 0.6)x$ and by the correlation coefficient $r = 0.98$, proceeding from the appended list of soil types, numbering alltogether more than two hundreds.

Probably, this is a result of "occasional" circumstances, for instance, of the preferential general passion for the study of "typical" soils of uplands (that is automorphic and proterohydromorphic soils). Possibly, however, that this is a reflection of the world trend of the complication and repeated differentiation of the earth soil cover from the young alluvial sediments and the hydroaccumulative (underwater) stages of soil formation in a direction of more mature and aged paleohydromorphic, bioaccumulative (automorphic) and mauntaineous soils.

It is possible that the chief leading factor of this regularity of complication is the complication and differentiation of the potential energetic resources of soil formation in the connection with bigger differences in water regimes and vegetation on more aged ascending earth surfaces.

V. The system of soil taxonomy and marking of horizons.

As a result the proposed system of taxonomic units may be schematically expressed as follows:

Energetic soil row: A,B,C,D,E,F,G,H,I,J,K,L,M,N.

Soil-geochemic formation: I, II, III, IV, V,...

Stadial soil group: I,2,3,4,5,6,7....

Soil type

Soil subtype

Soil genera

Soil species

Soil variety

Soil variant (by cultural state)

The above system of taxonomic units will permit to work out and unificate the system of standard international symbols for the marking of soil units shown on the maps. The symbols will probably be multinomial,reflecting the classificational position of this or that soil and correspondingly the main data on its economic potential. This is only the question of an agreement and approaval by one of the Congresses of soil scientists on the system of international obligatory indexes,based on the combination of roman and arabic figures,with latin or greec alphabet. The system of indexes will stop the creation of new artificial words and terms,leaving to each country a possibility to select for its use the generally accepted national or international soil names.

At the classification of different soil types according to this or that stage of evolution,especially great attention should

be builded on the same principal scheme for all soils. In the proposed system the soils are classified on their own properties and features,reflecting their evolution in time,but not on the surrounding conditions,as it was in some of the earlier classifications. It is necessary,however,to say objectively that the reliability of our knowledges of the soil evolution is still unsatisfactory. That is why it is often necessary to resort to some suppositions. As a consequency of this,the united system of soil diagnostic, including the agreed nomenclature of diagnostic features,appears to be of primary factic importance.

It is possible to propose the following system of soil diagnostic characteristic:

I. The typical combination and consequency of soil genetic horizons among which it is necessary to distinguish following indicatory horizons:

a) horizon of peat accumulation - T,

b) horizon of leaf litter or steppe felt accumulation - Ao,

c) horizon of humus accumulation - A_1,

d) eluvial horizon - A_2,

e) illuvial horizon - B,

f) hydrogenous accumulative horizon - H,

g) gley horizon - G,

h) parent soil forming rock - C,

i) bed rock (underlying rock) - D.

It is necessary to stop the usage of symbol B for marking of soil horizons,transitional from A to C. The genetic heterogenousness of the above main horizons may be expressed by additional letter marks,for example,in the case of hydroaccumulative horizon:

Hc - calcareous,

Hs - salty,

Hg - gypsic,

Hf - ferrugenous,

Hl - lateritic,

Hsi - silicious,

in the case of eluvial horizon:

A_2 - podzolic, A_{2p} - pseudogley, A_{2s} - solodic,

in the case of illuvial horizon:

B - not differentiated, Bh - humus illuvial,

Ba - clay illuvial, Bf - iron illuvial,

Bc - carbonates illuvial.

2. The character and the intensity of expression of the indicatory soil horizons (including relict ones).
3. Type and quantity of humus, ratio C/N.
4. The prédominating clay minerals.
5. The value of exchange capacity the relative quantity of cations Ca,Mg,Na,K,H,Al in the exchangeable state.
6. Soil pH value in water and salt suspensions and their changes with the depth.
7. The molecular ratios of $SiO_2:R_2O_3$ in clay fraction and their distribution in the profile.

Besides the above characteristics without which the soil diagnostic is absolutely impossible it is necessary to have the following indexes,permitting to show fuller and more objectively the genesis and agricultural potential of the soil:

I) The primary biologic productivity (the mass of dry organic matter,produced per year per unit of area - in centners per hectar,including the roots);

2) The rate and character of annual biologic circulation of mineral substances and nitrogen in kg/ha;

3) Energetic index of soil formation;

4) The presence or apcance of relict features in the soil profile;

5) The depth of ground waters,their chemistry and regime;

6) The character of economic utilization of the soil and the potential productivity;

7) The main conditions of soil formation (geomorphology,climate, vegetation).

Maid on the united scheme and sufficiently complete soil diagnostic will permit with a big confidence to relate the soils to this or that type,to devide or combine the soils of different continents,to solve the question of soil origin and of the stage of evolution,to transfer the experience of soil utilization of analoguous and similar soils.

The above theoretic ideas are laid down at the base of construction of presently proposed project of the general legend to the world soil map of I:5.000.000 scale. This is not final system of soil classification,but an assay of creation of the legend to the map. The legend,so constructed,reflects the theoretic ideas,based on the historic (evolutionary) principle.All soils,included into the legend,are taken from the continental maps,published earlier by certain authors.

The graphic mounting of the legend may be different,but we have preferred to stop at the consequent list of the evolutionary rows with the aim of the convinience of the desposition of main diagnostic features of the soils in the future.

As the soil nomenclature is concerned,we have accepted the principle of preservation of original national soil names,given by the authors of the continental maps.

Some cultural soils as oasys,paddy,ameliorated and such non soil formations as rock outcrops,sands,glaciers and so on, are shown in the legend by special symbols. The character of soil forming rocks and soil texture are also shown by special symbols as their introduction into the general legend will create an enormonsly large list of the soils,which will be impossible to make cartographically.

The mauntainous soils are separated in the legend into special group,as they differ strongly from the soils of plain territories by all their properties and economic utilization. The differentia-

tion of mauntainous soils is made less dails due to the scarcity of factic materials; the further combined enforcesments will be needed for their classification.

The present authors especially emphasize the fact, that the proposed assay of the construction of the legend to the world soil map on the base of evolutionary conception, as every first experience, is far off satisfaction and needs a future work. It is possible to hope, that only in the common creative work of the pedologists of different countries it will be possible to find out a final decidion and to create the legend to the world soil map, objectively leflecting the main regularities of genesis, geography and agricultural potential of the soils of the world.

Below the project of the legend to the world soil map is appended as it appears in the light of the evolutionary conception. This project represent sooner some material to the future legend to the world soil map to be discussed. This project is build up so far without a general world soil map, without taking into consideration the real soil countours and their areas, without taking into consideration the scale of the general map, which forces to combine different soils into some combinations during the generalization of some countours on the map. However, this is compensated by the fact, that all included into this project soils are really exist according to the data of investigators, who have showed them on the published maps of the continents and their parts.

The present report is written by Prof.V.A.Kovda and Dr.B.G. Rozanov on behalf of the above authors who have participated in different parts of the report.

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