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SOILS OF RUSSIA
Correlated with the Revised Legend of the FAO Soil Map of the World

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ABSTRACT

The *Soil Map of Russia* at scale 2.5 M was compiled through the joint efforts of many pedologists around the country. Practically all scientific pedological centres and institutes in Russia contributed to the map their expertise and scientific knowledge accumulated during more than two decades. The map legend comprises the latest soil-genetic classification concepts in which soil characteristics have been considered in harmony with soil forming factors. The map soil-geographical background introduces a variety of geographical regularities of soil spatial distributions among which the soil zonality and the soil cover structure have been comprehensively represented.

Although the *Soil Map of Russia at scale 2.5 M* is regarded as the major inventory document at the country scale, it is not well known and introduced. The complexity of the legend and specific soil nomenclature have been the main confounding factors for the map implementation.

To make the *Soil Map of Russia at scale 2.5 M* accessible, the study relies on two basic documents, the *Revised legend of the Soil Map of the World* (FAO, 1990) and the *Programme of the Soil Map of the USSR at scale 1:2.5 M.* The main purpose of the report is to introduce a complete, full and transparent correlation of the *map legend* with the FAO *Revised legend of the Soil Map of the World*.

PREFACE

This research resulted from several discussions with Drs. W. Sombroek (FAO), R. Brinkman (FAO), and R. Oldeman (ISRIC) which took place at the International Soil Reference Information Center (ISRIC) in 1988-89. The discussions were initiated through research being carried out by the project on Global Assessment of Human-Induced Soil Degradation which urgently required reliable soil information on the territory of Russia. It was recognized that a lot of other environment-related activities were facing a similar problem.

The author, as coordinator of the USSR-Mongolian part, and Dr. E.N. Rudneva, as a collaborator on the compilation of the soil background, worked out the first version of the soil correlation based on the generalized version of the list of soils compiled for the scale 1:15 M for this region. However, neither the *Legend* nor the *Soil Map of Russia at scale 1:2.5M* (SMR) was used for that first version. So the question of compiling, fully correlating, and updating the *FAO Soil Map of the World* on this territory was raised again.

In 1993 FAO funded the updating of the soil information based on the SOTER manual and SMR. This task was successfully fulfilled and the results were transferred to FAO for digitizing. However the compilation of a digital database could not be completed at that time.

In 1995 all materials were passed to the International Institute for Applied Systems Analysis (IIASA), Austria, with the aim of finalizing this work in the form of a digital database. Considerable efforts by the GIS group of the project "Modeling Land-Use and Land-Cover Changes in Europe and Northern Asia" at IIASA were put into checking, correcting, linking the digital data and making it consistent.

This report presents an important part of this effort that deals with soil correlation. After completion of a draft report by the author, the manuscript was carefully reviewed and edited by Mr. Maurice Purnell, a soil scientist working for FAO

ACKNOWLEDGMENTS

This work could not have been compiled in its present form without the strong support of the Food and Agriculture Organization of the United Nations which initiated and sponsored the updating of the *Soil Map of Russia at scale 1:5 M* as part of the *Soil Map of the World*. FAO also provided funding and technical competence to facilitate highly professional editorial work.

I am very much indebted to Mr. Maurice Purnell whose expertise as editor of this report, as fellow soil scientist, and as consultant for FAO, has ensured the very high standards of this publication.

Many thanks are extended to Drs. W. G. Sombroek, R. Brinkman, F.O. Nachtergaele, from the Land and Water Development Division (AGLS), FAO, Rome, and to Dr. R. Oldeman ISRIC, The Netherlands, for their support and consultation during the production of this work.

I am especially grateful to Dr B.V. Sheremet for his cooperation in providing the improved version of soil correlation.

The author would also like to thank Dr. Günther Fischer, Leader of the Land Use Change Project at IIASA, for his helpful comments and suggestions and Cynthia Enzlberger for her help in reviewing, and polishing earlier drafts as well as preparing the final version of this report.

ABOUT THE AUTHOR

Vladimir Stolbovoi is a distinguished doctor in soil geography. He has intensive experience in both academic and applied soil classification, mapping and interpretation. He did a lot of field research in European Russia, Siberia, Central Asia, Syria, Cuba and the Seychelles. He was co-author of the Global Assessment of Soil Degradation status (GLASOD) for the Former Soviet Union and Mongolia, and led an updating of the Soil Map of the World at the scale of 1:5 M (FAO) for the USSR and Mongolia. Currently, he co-ordinates research of the Forer Soviet Union European Republics within the project "Assessment of Soil Degradation in Central and Eastern Europe (SOUVEUR). He is author of more than 100 publications.

Vladimir Stolbovoi joined IIASA's project on Modeling Land-Use and Land-Cover Changes in Europe and Northern Asia in 1995 developing a comprehensive digital georeferenced database on the land of Russia. Since 1998 he has been working with the Forest Resources project contributing to the analysis of forest land, land use, full carbon account, and elaboration of the integrated land information system for Russia.

ABOUT THE EDITOR

In 1976, Mr. Maurice F. Purnell took up the position of Senior Officer for Soil Resources at FAO's headquarters in Rome after a long service career as a soil surveyor and project manager in FAO field projects in Ghana, Brazil, Burundi, Myanmar and Sudan.

He was particularly active in developing FAO's *Revised Legend, Land evaluation procedures*, the *Guidelines for Soil Profile Description* and the *Guidelines for Land Use Planning*.

Since his retirement in 1992 Mr. Purnell has remained actively involved in FAO as a freelance consultant and editor of various soil-related publications.

ABOUT FAO

FAO has been collaborating with IIASA, ISRIC, UNEP and other international organizations and national institutes with the objective of updating the *Soil Map of the World* according to the principles developed by the Soil and Terrain database (SOTER). These regional soil and terrain datasets will provide up-to-date information on physical and environmental conditions worldwide.

The Soil and Terrain database for North-East Africa was published this year, and the SOTER for South America and the Caribbean is due for release shortly. The present documentation of the *Soils of Russia* describes the work undertaken in a larger context of building up revised soil and terrain databases for the former Soviet Union, China and Mongolia. It fits well with more detailed work presently undertaken by FAO and ISRIC with national soil institutes in Eastern Europe, as well as with efforts of the European Soils Bureau in the same region.

FAO's AGLS Website Address:

http://www.fao.org/waicent/FaoInfo/Agricult/AGL/AGLS/AGLSHOME.HTM

DISCLAIMER

GLOSSARY

A2 horizon: equivalent to the FAO E horizon

Accumulative: Refers to soil horizons where soil forming processes lead to accumulation of substances (clay, sesquioxides, organic matter, carbonates) both by movement (illuvial) or by neoformation in situ.

Automorphic: (After S.S. Neustruev) Soils clearly manifesting climate influence with normal atmospheric moistening, formed from loams on the uplands.

Autonomous relief positions: soils formed on the uplands and geochemically independent.

CEC: cation exchange capacity

Cha:Cfa ratio: refers to the ratio between humic and fulvic acids in the organic matter.

cmol(+) kg-1: S.I. unit the same as milliequivalents per 100g soil.

Curdled, curd-like: soil structure, irregular platy structure caused by freezing.

Differentiated: indicates that the soil profile horizons vary as a result of soil formation (in clay content, sesquioxides, structure, etc).

Facial sub-types of soils: term refers to specific features of the soil hydro-thermic regime caused by climate differences within one soil zone in continentality (latitude) or temperature (altitude).

Far East: traditional geographical name (not an administrative unit) for the huge territory in the eastern part of the country from the Chukotka peninsula to Khabarovsk and Vladivostok.

Iced permafrost: as distinct from dry permafrost.

Meadow: This term as part of a soil name indicates a hydromorphic soil water regime in the forest-steppe and steppe zones. Meadow implies groundwater at less than 3 m deep and meadowish with the groundwater at more than 3 m. (Contact-meadow soils have perched water above the contact between two different textures)

Podzolized: Is used in the original sense of bleached by leaching of the iron and aluminium sesquioxides and organic matter, without necessarily any accumulation of the organic matter or the iron and aluminium in a spodic horizon, although rusty stains and thin bands are common. (FAO Podzols must have a spodic horizon).

R_2O_3: sesquioxides of iron and aluminium

Residual calcareous: with carbonates remaining from the parent material or rocks after leaching.

Retinization: Gelic soils with a second humus horizon formed above a permafrost layer, which has humic acids whereas the topsoil has mainly fulvic acids.

Spot soils: Gelic soils without any clearly distinguished pedogenetic horizons, a component of cryogenic complexes occurring in the centre of the polygons.

ACRONYMS

FAO	Food and Agriculture Organization of the United Nations
GLASOD	Global Assessment of Soil Degradation (1990)
GUGK	Central Administration of Geodesy and Cartography
SMR	*Soil Map of the Russian Social Federal Soviet Republic (1988)*
SMW	*FAO-Unesco Soil Map of the World (1971-81*)
SMW Legend	*The FAO Revised Legend 1990* (unless otherwise stated)
SOTER	Soils and Terrain Digital Database (1993)
Unesco	United Nations Educational, Scientific and Cultural Organization
VASHNIL	All-Union Academy of Agricultural Sciences

SOILS OF RUSSIA
Correlated with the Revised Legend of the FAO Soil Map of the World

Vladimir Stolbovoi

INTRODUCTION

The Soil Map of the World for Russia

The FAO-Unesco *Soil Map of the World* (SMW) at 1:5 M scale (FAO-Unesco 1974) is one of the most important documents aimed at standardizing soil information for communication between scientists and practical specialists in different countries. The legend of this map is regarded as a general scientifically based language for such communication and exchange of experience. It forms a bridge between different national pedological schools using various traditions and methods.

The SMW is based on a very broad international consensus which fixed the state of knowledge of soil distribution at a given historical time. However, this map was compiled in 1971-1981 and during the intervening years great progress has been achieved in various branches of soil science and in the methods used. For example, tremendous efforts to improve soil diagnostic practice and soil classification resulted in the Revised Version of the SMW legend (FAO 1990).

At the national level the recent decades of development of pedology in Russia were characterized by intensive accumulation of empirical soil-mapping knowledge and clarification of fundamental issues (genesis, diagnostics, classification, cartography, etc.).

At present a great amount of new materials are being collected that significantly change conceptions of soils diversity and soil geography of the country. Vast amounts of new soil data have been obtained on the territory of northern Eurasia, Siberia and the Far East. For the forested territories complete soil maps were compiled at scale 1:100 000. For agricultural regions soil maps were produced at scale 1:10 000 and 1:25 000. These maps were used for compilation of the district maps at scale 1:300 000 and finally applied to the *State Soil Map* at scale 1:1 M. Finally all current knowledge on the soil environment of the country was scientifically summarized in one product the *Soil Map of the Russian Soviet Federative Socialist Republic* (SMR) at scale 1:2.5 M., (Fridland, 1988).

There is no direct information about the sources for the USSR which were used to compile the original FAO SMW in the nineteen seventies. It might be assumed that it was a composition of several sources; for instance, the soil maps compiled by N.N. Rozov (1964), and V.A. Kovda and E.V. Lobova (1975). However, concerning these materials there are several opinions. Firstly, the maps were based on the authors' soil classifications, which were not officially accepted. The first national soil classification of the USSR was published only in 1977 (Kolos) and therefore could not have been used. The earliest “Guidelines to soil classification and diagnostics” (Kolos, 1967) appeared after publication of Rozonov’s map in 1964. The analysis of the second map (Kovda and Lobova, 1975) shows that soil classification and nomenclature is quite original and did not follow the Russian traditional school. Secondly, the maps were compiled by a very limited group of scientists and therefore many of the local sources of soil data have not been involved.

All recent developments at the national and international levels are applied to the present process of updating the SMW. For the Russian territory the updating is based on two documents: the SMR (Fridland, 1988) and the programme for this map (Fridland, 1972a). However, neither of these documents is widely known or accessible inside or outside the country. This fact has necessitated a fuller treatment of certain aspects of the description of the map legend.

OBJECTIVES

The central aim of this report is to give a transparent description of the correlation between the soils of the FAO SMW legend and the legend of SMR. It provides an account of the following themes and includes tables showing the results:

1. An introduction to the SMR legend;
2. Procedures adopted for correlation between the SMR and the FAO SMW legends.;
3. Correlation of the SMR and FAO SMW legends.

The study relies on two basic documents, the Revised legend of the Soil Map of the World (FAO, 1990) and the Programme of the Soil Map of the USSR at scale 1:2.5 M (Friedland, 1972a).

THE SOIL MAP OF THE RUSSIAN SOVIET FEDERATIVE SOCIALIST REPUBLIC (SMR) AT SCALE 1:2,500,000

Definition of soil horizons

The soil classification used for the SMR is partly based on soil horizons identified in the field and laboratory. These soil horizons are therefore listed below together with their definitions and symbols. These horizon notations are also necessary for the understanding of the correlation between the SMR and SMW in Section 7. They are not shown on the map or in the legend.

Traditionally the identification of soils deals with their horizons and profile definition. In spite of the fact that many documents were made in Russia on standardization of soil description, including translations, and implementation in some investigations, of the FAO system, no universally accepted system was officially established. This can be explained by the tremendous extent of the country, great variety of geographical features, huge number of soil classes, and the division of soil survey among different organizations, such as agriculture, irrigation, forest survey, etc., which have their own priorities and preferences.

The first attempt to combine all existing knowledge on soil diagnostics was made in the framework of the programme of the SMR. The advantage of this system is that it deals with all the soils of Russia in one standard way. The definition of the soil horizons which have been developed as diagnostic for the soils in the SMR is presented below.

The programme of the SMR (Fridland, 1972a) assumed that genetically different soil types have specific combinations of genetic horizons. In principle, a soil profile would have a few main horizons which determine the soil genetic type. The following main horizons are distinguished in the SMR programme.

O - organic horizons. They contain more than 70% by volume of organic matter with different rates of decomposition. Any minerals present are mostly a mechanical admixture. The horizons are usually at the soil surface or, if buried, anywhere within the soil profile. These horizons may form the entire soil profile (in the case of peat soils).

Organic horizons are subdivided as follows:

O1 horizons formed mainly of well-preserved or slightly decomposed plant remains, which retain the main features of their initial composition.

O2 horizons formed mainly of moderately decomposed plant residues, partially retaining their initial features (such as portions of plant fabric).

O3 horizons formed by well-decomposed plant residues which have completely lost their initial features.

AO the upper organo-mineral horizons containing considerable quantities (30-70% by volume) of organic matter at different stages of decomposition. They usually have a mechanical mixture of organic with mineral material, which however could be easily separated.

A1 the upper mineral horizons, usually the most dark-colored within the soil profile. They contain well-humified organic material, formed in situ which is closely linked to the mineral phase.

A2 usually underlying horizons O, AO or A1, but in heterogeneous profiles may occur under any horizon of the overlying profile. They are the most bleached and colourless horizons in the soil profile, and have no morphological features of gleying characteristic of the G horizon.

B mineral horizons, underlying horizons AO, A1, A2 (or O horizon if the above-mentioned are lacking). They are identified by any differences of colour, structure or texture in comparison with the overlying horizon A and underlining horizons G and C.

G mineral gley horizons that reveal uniform or alternating bright blue, blue-grey, green or rusty colors throughout the dominant part (not less than 70%) of the freshly cut surface. They include:

G1 gley horizons with uniform or alternating bright blue and dark blue colors;

G2 gley horizons mottled with blue, grey-blue and rusty tints;

G3 mineral horizons, that have olive, green or greyish-green colors.

C parent material, mostly unchanged by soil formation.

D underlying rock, different from the soil parent material, underlies the soil profile and has no features caused by soil forming processes.

S horizons, cemented in both moist and dry conditions, may form an impermeable layer, and resist sheet erosion. They are formed by the concentration of various chemical compounds (oxides of iron, silica, carbonates of calcium and magnesium, salts, etc.) cementing the soil mass.

K fragile, porous crusts, not more than 5 cm thick, forming the surface of the profile.

Any of the main horizons (O1, O2, A1, A2, B, G1, S, etc.) may be further subdivided into sub-horizons according to differences in the main characteristics within the given horizon. In this case the horizon code bears an additional subscript arabic figure ($O1_1$, $O2_2$, $A2_1$, $A2_2$, etc.).

The transitional horizons which show properties of both the overlying and underlying horizons are labeled with codes referring to both of them. The code index for the dominant horizon comes first (for example A2B1, or B1A2).

The transitional horizons in which the features of overlying and underlying horizons are expressed equally, are marked with indexes of both horizons separated by a slash (A2/B1, A1/B1).

Buried soil horizons are shown in square brackets [A1].

Frozen, impermeable, ice-cemented soil horizons, found at the time of soil profile description. are labeled with the code for the main horizon accompanied by a special sign (⊥).

Horizons which have temperatures below freezing at the time of description but are not impermeable are marked with the main horizon code plus the prefix of a down arrow (↓).

Characteristics of the main horizons, such as soluble salts, carbonates, morphologically expressed solonetz features, etc., are shown with latin small letter symbols located to the right of the main code. The small symbols indicate features (characteristics) of genetic soil horizons as shown below (with examples of their application given in brackets):

- ca (Bca, Aca, Cca) - carbonates of calcium or magnesium;
- pca (Bpca, Apca) - calcareous gravel among non-calcareous matrix;
- cs (Bcs) - visible gypsum formations;
- s (Bs) - visible features of soluble salts;
- fe (A1fe, Cfe) - ferralitic composition of the mineral mass (lower than 5% content of primary minerals, except for the most resistant ones, such as quartz, rutile, etc.); the clay fraction is dominated by kaolinite, halloysite, iron and aluminium oxides;
- fa (A1fa, Bfa) - ferralitized composition of the mineral mixture (together with various primary minerals, a considerable part of the mineral mass is kaolinite, halloysite, iron and aluminium oxides);
- sl (Bsl) - solonetz horizons and properties;
- m (Bm) - mineral horizons whose main morphological features were formed as a result of initial material transformation in situ (m for metamorphosed).
- n (Bn) - presence of hard nodules (of any composition) which may be derived from the soil mass;
- a (A1a, A2a) - horizons showing considerable changes in their morphology due to human impact (ploughing, irrigation, compaction due to vibration, application of manure, peat, etc.);
- g (A2g, Bg) - morphological features of gley, that are not enough to describe this horizon as G1, G2, G3;
- h (Bh) - illuvial humus horizons of dark brown and reddish-brown colour;
- f (Bf) - illuvial-ferruginous horizons with bright yellow, red and brownish yellow colors.
- t (Bt) - horizons of finer texture than overlying ones, with visible signs of transport of fine material in the form of clay skins along cracks, pores, and aggregate surfaces;
- p (BCp) - presence of stones coarser than 1 cm (gravel, stones and boulders, etc.) in quantities more than 10% by volume;
- h (A2h, Bh) - horizons that do not come to the surface, do not directly contact horizons O and AO, are a darker colour of black or grey in comparison with the overlying horizon; and are not buried (including a second humus-accumulation

horizon, accumulations of grey and dark-grey humus above an impermeable barrier including permafrost, and illuvial humus horizons in neutral and alkaline soils);

- z (A1z, Oz) - numerous traces of soil fauna activity (coprolites, cysts of insects, krotovinas, etc.);
- v (Av, O2v) - horizons containing 50% or more of living parts of plants (steppe web, sod, meadow-sod, moss, etc.);
- su (BCsu) - mineral, black and dark-grey colored horizons, smelling of sulphuretted hydrogen, H2S, and containing iron sulphides;
- d (BCd) - signs of dynamic intermixing of soil mass;
- ve (Ave, Bve) - signs of compaction;

If the small symbol is underlined it indicates that a particular diagnostic feature reaches the maximum expression within that horizon.

If several small symbols refer to one and the same horizon, they are separated by commas (B1m,f,g).

If a horizon contains soluble salts, then the presence of carbonates and gypsum is not indicated.

If gypsum is morphologically identified, the presence of carbonates is not indicated.

A successive designation of soil genetic horizons makes a profile formula; the horizon codes and symbols are separated by a hyphen: O-A2-A2B-B-BC-C.

If a horizon is replaced by another one, the symbol of the substituted horizon is written in brackets: O-A1-A2(A1A2)- B-BC-C.

When the presence of a certain horizon is not obligatory for a particular soil, the formula cites it in parenthesis: O-A1- A2-(A2B)-B-BC-C.

When parent material layers are present, and their thickness is comparable to that of the soil horizons, the layers are designated with Roman figures (II, III, etc.). The designation of layers starts with Figure II, on the assumption that the overlying layer would be Figure I, which is dropped when the profile is indexed: A1- B1-IIB2-IIBC.

The legend of the SMR

The legend of the SMR at scale 1:2.5 M consists of three groups of data:

I. Soils, (classification and mapping);

II. Texture and petrography of parent materials;

III. Soil topography.

I. Soils

- *Classification*

The soils which have been shown on the SMR represent different taxonomic levels. Some of them are identified as soil genetic types (e.g. Sod-gleyic soil, Solods, etc.), while others refer to sub-types (e.g. dark-grey, grey, light-grey Forest soil; dark Chestnut, light Chestnut soil, etc.), genus (podzolic soil with second leached horizon; solodized Meadow-chernozems, solonetzized Chestnut, etc.). The soil species, being the lowest soil classification taxon, are shown only for podzolic soils (based on the depth of the lower boundary of podzolic horizons) and Chernozems (based on high, medium and low humus content), for which the systematic classification is most developed. There are a few soils which have no clear place in the soil classification (pine growth sands, high-mountain desert soil, etc.).

The sub-types of Chernozems and Chestnut soils are shown as individual mapping units in steppe and dry steppe zones.

Thus, a number of new soil types, sub-types and genera were shown on the SMR.

In the naming of soils, preference was given to traditional terms and short symbolic terms. The use of landscape terms and terms based on presumed soil genesis have played a subordinate role. Landscape terms were used for soils of inadequately studied territories and also for explanatory and traditional reasons (grey Forest soil, Meadow soil, etc.).

- *Cartographic design*

The features used for cartographic design of the mapping units are as follows.

Soils occurring as simple homogeneous soil mapping units or those forming the dominant components of complex heterogeneous soil mapping units are represented by different colors, and corresponding symbols (letters and numbers) forming the index on the map. Soils which occur as secondary components within complex soil mapping units are shown by colored figure signs.

All the soils which represent authomorphic genetic types (Podzol, Grey Forest soil, Chernozems, Chestnut soil, etc.) are colored pink, brown, yellow and other colors, derived from the red and yellow spectrum range. The Alluvial, Meadow and Bog soils, Solonetz and Solonchaks have green, blue, and violet colors derived from the blue and violet spectrum range.

The intensity of colour corresponds to the natural darkness of the soil (mainly due to higher humus content);

The soil sub-types are marked by different tints in accordance with the colour of the main soil type.

The alpha-numeric index code consists of three parts:

A capital and a small letter, more rarely two capitals and two small letters, indicate the soil types;

Small superscript letters (one or two, more rarely three) on the right of the main part of the index, indicate the soil sub-types;

Subscript letters or numbers indicate soil genera or species.

However, it should be noted that there is not full correspondence between the alpha-numeric index and the taxonomic units, because of the space requirements for indexing.

- *Composition of the soil mapping units*

The mapping units of the SMR are either homogenous (simple) or heterogeneous (complex).

Homogenous mapping units are shown where one soil comprises more than 85% of a mapping unit, or slightly less than 85% if the other soils are not contrasting. Such soil mapping units have the colour of the dominant soil marked with its index code. The minimum size of simple mapping units is defined as 15 mm^2, with width not less than 2 mm.

Heterogeneous mapping units include soil sequences, mosaics, complexes and altitude- or exposure-differentiated soil patterns. (For more detailed information see V.M. Fridland, 1972b.)

Soil sequences are regular alternations of rather large areas of significantly different soils, formed of similar parent material, and revealing genetic relationship; the repeated differences determined by local changes of hydro-thermal regime and vegetation, mostly due to meso-relief.

Soil mosaics are similar to the soil sequences but formed on different contrasting parent materials. The genetic links between the components are not close and the spatial soil pattern is not regular.

Soil complexes represent an alternation of small (5-30 m^2) spots of different soil types or, more rarely, sub-types, interdependent in their genetic development and mostly linked to the elements of micro-relief. The agricultural value of these components may differ greatly, but the potential land utilisation is determined by the properties of the soil complex as a whole. Two big groups of soil complexes are distinguished on the SMR: for cold regions (arctic, tundra, and the northern taiga) and for hot regions (steppes and semi-deserts).

The soil sequences and mosaics are shown on the map by the colors, alpha-numeric symbols, and colored out-of-scale signs. The background colour and symbol reflect the dominant soil in the mapping unit, while the colored signs show the subordinate components. The minimum size of mapping unit of this type is 80 mm^2, with a width not less than 5 mm, to provide space for a symbol and a colored sign.

The complex mapping units are shown by colour lithographic cross-hatching. The shape of the cross-hatching reflects the genetic and geometric (spatial) pattern of the soil complex, while the colour and symbol show the dominant soil component. The complete list of components for each soil complex is given in the map legend.

II. Texture and petrography of parent materials

The parent materials are either unconsolidated (loose) or hard rocks. Texture classes for deposits are represented by:

- clays and loams;
- clays and loams with debris;
- sandy loam and sands;
- sandy loam and sands with boulders;
- layered deposits;
- loose volcanic;
- hard rock with debris.

The textures of alluvial soils and parent materials as well as the texture of peat-boggy soils are not shown.

A system of black-hatched patterns throughout the unit is used for soils formed on loose deposits. The soils formed on hard rock are shown with signs reflecting the rock petrology (igneous or metamorphic; acid, medium or basic; calcareous limestones, shales, sandstones). In addition, such important properties as stones and boulders on the surface are noted.

III. Soil topography

The soil topography is represented by two general groups: soils of plains and soils of mountains.

The soils of plains are not marked by any particular sign on the map, other than those showing the main characteristics of any given soil mapping unit (colour, symbol, hatching, signs). The soils of the plains comprise soils of level, undissected or rolling lowlands, and also soils of more dissected, rolling and hilly, upland plains and plateaus. Their typical range in elevation is 100-200 m.

The mountain soils are shown by colored angle cross-hatching. The altitude exceeds 500 m, the relative change in elevation is considerable, and the main elements of relief are steep slopes.

Additional explanatory maps

Two additional explanatory maps at 1:15 M scale accompany the SMR. They have been developed to illustrate the main agricultural uses plus the structure of soil cover patterns, and the soil ecological regions of Russia.

The first map shows the agricultural use and the structure of soil cover patterns. The agricultural use is considered by 11 economic regions within natural agricultural zones. It displays the percentages of land use in the region by main categories (cultivated, perennial crops, forage land and pastures). It also contains information on the percentage of zonal soils, loamy-sand and sandy authomorphic soils, sands, wet and bog soils, meadow-steppe soils, soils with solonetz properties, alluvial soils and solonchaks.

The structure of soil-cover patterns demonstrates major forms of soil cover combinations, their causes and spatial geometry: soil sequences (caused by meso-relief), mixed sequence-mosaics (caused by meso-relief plus contrasting parent materials), soil complexes caused by micro-relief and vegetation heterogeneity. Two types of soil cover patterns (altitudinally-differentiated and exposure-differentiated) were identified for the mountainous regions.

The second explanatory map illustrates the soil-ecological regions of Russia. It shows 9 lowland zones and 50 lowland soil provinces, indicating the characteristics of the main climatic and soil temperature-moisture regimes. It also includes 5 mountain zones and 17 soil provinces with data on climatic parameters (average temperature in July, sum of temperatures above 100°C, annual precipitation and annual moisture coefficient).

CORRELATION OF THE SMR AND THE FAO SMW LEGENDS

Generalisation procedure

The problem of aggregation (generalisation) always arises when it is necessary to transform a map at a larger scale to a less detailed map of smaller scale. In this case the aggregation is caused by the differences in scales between the original *Soil Map of Russia* (scale 1:2.5 million) and the *FAO-Unesco Soil Map of the World* (scale 1:5 million). Generalisation procedures and some new approaches to solve the problem are discussed below (5.12, 13). Usually generalisation deals with two main types of aggregation: 1) a generalisation of the substantive content or attributes, and 2) a generalisation of the geometry of the mapping units or polygons.

The first aspect of generalisation is rather complicated and appears more like an art. Usually the process of deleting and combining soils is based on arguments, not always clearly defined, such as taxonomic unity of the aggregated classes, their representativeness, purposes which the aggregated product will serve, professional skill of the author, etc.

The second aspect, the generalisation of mapping units, is caused by the fact that some polygons which exist at a larger scale cannot be shown on a smaller scale. This generalisation deals with manipulation of the geometry of the polygons. In this study the geometry was generalised in accordance with a traditional rule of observational cartography that the minimal size of a mapping polygon should not be less than 1 cm^2.

In practice, the generalisation was done in two steps. At the first step all soil groups of the SMR were correlated with the FAO SMW soil units. A full list of the correlated soils is in

Appendix 1. Next, all soil polygons of the original SMR were described by attributes according to the FAO basic guidelines for compilation of the SMW (FAO-Unesco 1977) and the FAO revised legend FAO 1990. Thus, each soil polygon of the SMR was provided with a set of the following characteristics:

soil name, including ranking of dominant, associated and included soils;

- texture classes;
- slope classes;
- phases.

In the second step, neighboring soil mapping units were combined when they contain genetically, morphologically and analytically related soils. Naturally this procedure caused a decrease in some soils when their extent was less then 4% of the newly united polygon area. In order not to lose important information when combining a soil, a soil phase of significant practical meaning was shown.

When a map unit was complex, including more then one soil, it was composed of a dominant soil (the most extensive one) and of an associated soil, or soils, covering at least 20% of the polygon. Important soils which covered less than 20% of the polygon area were called inclusions. The average number of soils in a mapping unit varied from 2 to 3. However in some cases it increased up to 6-7. Compilation of complex polygons was made on the basis of accurate calculation of their composition. The latter was done in accordance with the recommendations of FAO-Unesco (1971-81) shown in Table 1.

Table 1. Composition of complex mapping units (% of polygon)

Dominant soil	Associated soil	Inclusions
	0	0
	0	10
	0	10+10
	0	10+10+10
	30	0
	30	10
	20+20	0
	20+20	10
	30	10+10
	30	5+5+5+5
	20+20	5+5+5+5
	30	10+10+10
	20+20	10+10
	20+20+20	10
	20+20	10+10+10
	20+20+20	5+5
	20+20+20	5+5+5
	20+20+20	4+4+4+4

Texture classes

Texture reflects the relative proportions of the fractions of clay, silt and sand in a soil. Difficulties in creating the data on soil texture were caused by the different information on texture shown on the SMR and required by the SMW. Practically new data on the texture of soils in Russia was collected for a large number of the soil map polygons. Where literature sources did not exist, expert judgment, based on information shown on the SMR, was applied.

Another problem is the differences in defining textural fractions between the Russian and FAO soil maps. This raises the problem of data compatibility. In general these differences are shown in Table 2. It is apparent that fewer textural fractions are defined in the FAO soil map than are proposed in Russia. This is because the FAO system is intended to serve at global scale. On the other hand the differences are not very great, and the generalized textural classes could be correlated adequately for practical tasks at global scale. For more precise analysis for scientific research this correlation needs to be done in greater detail.

As shown in Table 2, three textural classes were distinguished:

- Coarse textured, corresponding to FAO sands, loamy sands and sandy loams with less than 15% clay and more than 70% sand;
- Medium textured, corresponding to FAO sandy loams, sandy clay loams, silt loams, silt, silty clay loams and clay loams with less than 35% clay and less than 70% sand; the sand fraction may be as high as 85% if a minimum of 15% clay is present;
- Fine textured, corresponding to FAO clays, silty clays, sandy clays, clay loams and silty clay loams with more than 35% clay.

These texture classes were established for the dominant soil and refer to the texture of its upper 30cm.

Table 2. Correlation of particle size distribution between FAO and Russian systems.

Name of texture fraction	Particle size (mm), FAO system (1990)	Particle size (mm), Russian system (1967)
Gravel, fine gravel	> 2	> 1
Sand coarse medium fine	- 0.06	 - 0.5 - 0.25 - 0.05
Silt coarse medium fine	- 0.002	 - 0.01 - 0.005 - 0.001
Clay	< 0.002	< 0.001
General classes		
Coarse	- 0.06	0.05
Medium	- 0.002	- 0.001
Fine	< 0.002	< 0.001

Slope classes

The slope conditions which are shown on the SMR do not meet the FAO requirements. It was therefore necessary to create these characteristics, as was done for texture. The principal problem was that the topographic maps at scales 1:2.5 M and 1:5 M are very rough for this task. For example, the basic map at scale 1:2.5 M, published by GUGK in 1976 and used for compilation of the SMR, has contour intervals of 50m up to 300m above mean sea level, 100m from 300m to 800m., then 200m, and 250m above 1000m. To fulfill the task a number of calibration plots were established at positions of different relief around the country. Topographic maps at scale 1:100 000 have been analysed on these plots. This procedure facilitates correlation between the actual slope conditions and the density of contour lines on the basic map at the scale 1:2.5 M. This correlation was applied to create slope classes which referred to the prevailing slopes in a soil mapping unit.

These slope classes correspond to FAO:

- level to gently undulating: dominant slope ranging between 0 and 8%;
- rolling to hilly: dominant slope ranging between 8 and 30%;
- steeply dissected to mountainous: dominant slopes are over 30%.

Phases

Phases are features of the land which are significant for its use and management. They are not necessarily related to soil formation. It is assumed in the original manual (1977) that phases usually cut across soil boundaries and hence have not been used to define individual soil units, particularly when some phases are not related to present soil formation. This means that in the FAO SMW phases could be shown by signs without precisely defining their spatial dimensions. This approach was absolutely correct and could be achieved when compiling traditional paper maps. It is not acceptable when digitizing the final product because each characteristic belongs to a specific polygon and is stored in an attribute file. Thus, phases were created as an additional attribute outlined on the original soil map as separate polygons. The total list of phases for Russia are given in Appendix 2.

SOIL RESOURCES OF RUSSIA

The correlation procedure identified 19 FAO major soil groupings (Figure 1) out of the 28 described by FAO (1990). These are listed in Table 3 (together with their subdivisions).

The total land area, covered by soils and other surface formations excluding water, is 16,703.4 km^2 (1,670,340,000 ha).

Table 3. Extents of FAO major soil groupings and soil units in Russia.

Major soil groupings and soil unit (FAO, 1990)	Extent million ha	Percent of total land area of country	Percent of major soil grouping
1	2	3	4
FLUVISOLS	57.37	3.43	
Eutric	3.25	0.19	5.66
Dystric	30.38	1.82	52.95
Umbric	22.33	1.34	38.91
Thionic	1.42	0.08	2.47
GLEYSOLS	275.19	16.47	
Dystric	70.06	4.19	25.46
Mollic	9.25	0.55	3.36
Umbric	46.85	2.80	17.04
Gelic	149.03	8.92	54.16
REGOSOLS	4.35	0.26	
Gelic	4.35	0.26	100.00
LEPTOSOLS	144.54	8.65	
Dystric	7.32	0.44	5.07
Rendzic	87.00	5.21	60.19
Mollic	3.77	0.23	2.61
Umbric	5.62	0.34	3.89
Lithic	34.42	2.06	23.81
Gelic	6.41	0.38	4.44
ARENOSOLS	5.58	0.33	
Cambic	5.58	0.33	100.00
ANDOSOLS	15.64	0.94	
Haplic	11.18	0.67	71.47
Vitric	2.73	0.16	17.47
Gelic	1.73	0.10	11.06
VERTISOLS	0.21	0.01	
Eutric	0.21	0.01	100.00
CAMBISOLS	212.03	12.69	
Eutric	49.33	2.95	23.26
Dystric	91.16	5.46	42.99
Humic	1.84	0.11	0.87
Calcaric	5.44	0.33	2.57

Major soil groupings and soil unit (FAO, 1990)	Extent million ha	Percent of total land area of country	Percent of major soil grouping
Chromic	1.31	0.08	0.62
Gleyic	6.69	0.4	3.16
Gelic	56.26	3.37	26.53
CALCISOLS	4.57	0.27	
Haplic	1.75	0.11	38.37
Luvic	2.82	0.17	61.63
SOLONETZ	11.16	0.67	
Haplic	2.56	0.15	22.95
Gleyic	8.60	0.51	77.05
SOLONCHAKS	0.98	0.06	
Haplic	0.64	0.04	65.14
Gleyic	0.34	0.02	34.86
KASTANOZEMS	25.80	1.54	
Haplic	17.28	1.03	66.97
Calcic	0.15	0.00	0.58
Luvic	8.37	0.50	32.46
CHERNOZEMS	99.71	5.97	
Haplic	30.41	1.82	30.50
Calcic	26.48	1.59	26.56
Luvic	27.51	1.65	27.59
Glossic	8.44	0.51	8.47
Gleyic	6.85	0.41	6.87
PHAEOZEMS	19.41	1.16	
Haplic	0.96	0.06	4.95
Luvic	17.62	1.05	90.77
Gleyic	0.83	0.05	4.28
GREYZEMS	44.96	2.69	
Haplic	44.54	2.67	99.06
Gleyic	0.42	0.03	0.94
PLANOSOLS	2.26	0.14	
Eutric	0.00	0.00	0.00
Mollic	2.26	0.14	100.00
PODZOLUVISOLS	207.37	12.41	
Eutric	119.41	7.15	57.59
Dystric	24.07	1.44	11.61
Stagnic	8.04	0.47	3.88
Gleyic	55.71	3.34	26.87
Gelic	0.13	0.00	0.06

Major soil groupings and soil unit (FAO, 1990)	Extent million ha	Percent of total land area of country	Percent of major soil grouping
PODZOLS	371.13	22.22	
Haplic	147.82	8.85	39.83
Cambic	117.67	7.04	31.71
Ferric	62.41	3.74	16.82
Gleyic	26.79	1.60	7.22
Gelic	16.42	0.98	4.42
HISTOSOLS	118.74	7.11	
Terric	44.31	2.65	37.31
Fibric	54.94	3.29	46.27
Histosols undifferentiated	19.50	1.17	16.42
Sands	3.55	0.21	100.00
Rock Outcrops	41.94	2.51	100.00
Glaciers	3.85	0.23	100.00
Total	1670.34	100.00	

Of the nine FAO major soil groupings not listed above, most are more typically tropical soils, but three may in fact exist in Russia. There are Anthrosols of various kinds, too fragmented to appear on the map and therefore not described in this report. There may be small areas of Gypsisols, included within the Calcisols in semi-desert regions.

There may well be small areas of various kinds of Luvisols unrecognized as such, but they are rarer than might be expected because the generally quartzitic parent materials, and the prevalent acid forest litter in a cold humid climate, favours the movement of organic matter and sesquioxides and the destruction and leaching of clay (podzolization in the original sense) when drainage is good, or gleyization and organic matter accumulation when drainage is poor. The soils therefore typically form Podzoluvisols, or Podzols on sandy parent materials, Gleysols and Histosols. Argic horizons, or at least textural B horizons, of clay accumulation by neo-formation and eluviation, are fairly common but Luvisols are not.

The most extensive major soil groupings on the territory of Russia is Podzols. It occupies more than 371 million ha or about 22% of the total land area.

In second place is the major soil grouping Gleysols, with about 275 million ha or more than 16%.

Two major soil groupings, Cambisols and Podzoluvisols, cover about 210 million ha each or about 13% and 12% respectively.

Leptosols have the huge extent of more than 144 million ha or about 9% of the land area.

More than 118 million ha (about 7% of the land area) is covered by Histosols.

The most agriculturally valuable major soil grouping - Chernozems - occupies about 94 million ha, or less than 6% of the land area.

Four major soil groupings which are also favorable for agriculture are Fluvisols, Greyzems, Phaeozems, Kastanozems. They occupy about 160 million ha or approximately 10% of the land.

Other major soil groupings, together with nonsoil formations, occupy about 90 million ha or a little more than 5% of the total land area.

DESCRIPTION OF THE FAO SMW SOIL UNITS AND THE CORRELATED SOIL GROUPS OF THE SMR

FLUVISOLS

These soils occupy 57.37 million ha or 3.47% of the land of Russia (Table 3). Such soils are widespread, (Figure 2.1) particularly in West Siberia, Southern Siberia, and the Northern European part of the country.

This major soil grouping corresponds to a wide range of so-called intra-zonal alluvial soils in Russia. The soils are developed in flood plains and characterised by regular flooding (but not necessarily every year), and deposition of fresh alluvial material on the soil surface. These processes determine the specific features of alluvial soils, the character of their water regime, and genesis.

Fluvisols are generally formed on alluvial deposits. They have fluvic properties and have no diagnostic horizons other than an ochric, a mollic or an umbric A horizon, or a histic H horizon, or a sulfuric horizon, or sulfidic material within 125 cm of the surface, or salic properties.

The following FAO soil units of the Fluvisols have been identified and the corresponding soil groups in the SMR are indicated.

- Eutric Fluvisols (FLe)
  - Slightly acid and neutral Alluvials
  - Saline Alluvials
- Dystric Fluvisols (FLd)
  - Acid Alluvials
- Umbric Fluvisols (FLu)
  - Meadow Alluvials
  - Boggy meadow Alluvials
- Thionic Fluvisols (FLt)
  - Marshy saline and solonetzic Alluvials

Eutric Fluvisols (Fle)

This soil unit occupies 3.25 million ha, which corresponds to 0.19% of the land area of the country or 5.66% of the area of the Fluvisols major soil grouping. These are soils having a base saturation (by NH_4O_{Ac}) of 50 percent or more at least between 20 and 50 cm from the surface but not calcareous at the same depth; with no sulfuric horizon, no sulfidic material within 125 cm of the surface, and no salic properties.

The Eutric Fluvisols correlate with the slightly acid and neutral Alluvial soils. Some saline Alluvial soils are included in the mapping unit though they correlate with salic Fluvisols.

Slightly acid and neutral Alluvial soils have the profile A1-B-CDg. The humic horizons vary in colour from light grey to dark grey and have a thickness of 5 to 25 cm. The A1 horizon is succeeded by a transitional B horizon. The parent material is layered or laminated. The texture varies from sands to clay loams. The soil reaction is slightly acid or neutral. Saline

Alluvial soils are characterised by their alkaline soil reaction and the presence of soluble salts.

Dystric Fluvisols (Fld)

This soil unit occupies 30.38 million ha, which corresponds to 1.82% of the land area, or 52.95% of the Fluvisols major soil grouping area. These soils have a base saturation (by NH_4O_{Ac}) of less than 50 percent at least between 20 and 50 cm from the surface; and do not have a sulfuric horizon or sulfidic material within 125 cm of the surface.

This unit correlates with alluvial acid soils, which have layered soil profiles with varying humic and mineral horizons and acid soil reaction.

Umbric Fluvisols (Flu)

This soil unit occupies 22.33 million ha, which corresponds to 1.34% of the land area or 38.91% of the Fluvisols major soil grouping. These soils have an umbric A horizon or a dystric histic H horizon; and do not have a sulfuric horizon, sulfidic material within 125 cm of the surface, or salic properties. This soil unit corresponds to alluvial Meadow soils and alluvial boggy Meadow soils.

Alluvial Meadow soils have a profile A1-B-Bg-CDg. The 30-50 cm humic horizon is dark-grey or brownish-grey with 3-5 cm of sod in the upper part. It is loamy, with granular structure, rusty spots and veins, on flat relief. The second group (O-G-Gt-G) is formed from loams and clay-loams in conditions of poor external drainage (flat relief) or sometimes where stratified rock layers are close to the surface. It is characterised by the thin (3-4 cm) O horizon, poor in oxalate-soluble and total Fe_2O_3, which is distinguished (but only chemically) beneath the litter horizon. The Gt horizon has weak micro-morphological features of illuviation.

These soils are found in the middle and northern taiga and forest-tundra; the first group dominates in the European part of Russia, the second in West Siberia.

Alluvial boggy Meadow soils are characterised by gley features, and often have an organic peaty horizon at the top. The B1 is a transitional horizon with spots of gley and iron staining. The Bg is a bluish-grey gley horizon, commonly with layers which vary in extent of gleying. The CD is layered alluvium with thin layers of buried peat.

These soils are formed in central flood plains with deposits of relatively small quantities of clayey and loamy alluvium. The vegetation is typically humid meadows of the forest and steppe zones.

Thionic Fluvisols (FLt)

These soils occupy 1.42 million ha, which corresponds to 0.08% of the land area of the country or 2.47% of the Fluvisols major soil grouping. They have a sulfuric horizon or sulfidic material, or both, at less than 125 cm from the surface.

This soil unit correlates with saline and alkaline Marsh soils. They form on marine shores periodically flooded with brackish marine waters.

GLEYSOLS

This major grouping occupies 275.19 million ha or 16.47% of the land area (Table 3). It is widespread (Figure 2.2) particularly in the Northern part of Siberia and Far East and is very common in West Siberia.

These soils are developed under excess of water and formed from unconsolidated material, exclusive of coarse textured material and alluvial deposits which show fluvic properties. They show gleyic properties within 50 cm of the surface; have no diagnostic horizons other than an A horizon, a histic H horizon, a cambic B horizon, a calcic or a gypsic horizon. They do not have the characteristics which are diagnostics for Vertisols or Arenosols; salic properties; or plinthite within 125 cm of the surface.

This major soil grouping is not distinguished as a separate class in the soil classification of Russia. In general it corresponds to so-called azonal soils which also can occur in any natural zone. However their characteristics (humus content, reaction, base saturation, etc.) strongly depend on the zonal conditions. The FAO soil units and correlated equivalent classes from SMR are described below:

- Dystric Gleysols, GLd
    - Peaty and peat boggy Gleyzems
    - Taiga differentiated Gleyzems
    - Taiga Gleyzems
    - Podzolized Sod-gleys
- Mollic Gleysols, GLm
    - Solonetzic and solonchakous Meadow
    - Meadow-boggies
    - Solonetzic and solonchakous Meadow-boggies
- Umbric Gleysols, GLu
    - Sod (muck)-gleys
    - Meadows
- Gelic Gleysols, GLi
    - Arctic Gleyzems
    - Arctotundra muck-gley Gleyzems
    - Peat and peaty-humic tundra Gleyzems
    - Weak-gley peaty-muck tundra Gleyzems
    - Differentiated peaty-muck tundra Gleyzems
    - Peaty and peat tundra Gleyzems
    - Peaty-muck taiga Gleyzems
    - Weak-gley peaty-humic taiga Gleyzems

Dystric Gleysols (Gld)

This soil unit occupies 70.06 million ha which corresponds to 4.19% of the land area or 25.46% of the major soil grouping. The soils have a base saturation (by NH_4O_{Ac}) of less than 50% at least between 20 and 50 cm from the surface; they have no diagnostic horizons other than an ochric A horizon and a cambic B horizon; and no andic properties nor permafrost within 200 cm of the surface.

The Dystric Gleysols correlate with taiga Gleyzems, taiga differentiated Gleyzems, peaty and peat boggy Gleyzems, and podzolized Sod-gley soils.

Taiga Gleyzems (syn. taiga gley and undifferentiated slightly gley soils) are characterised by two types of soil profiles: O3-G-Bh,t-C and O-G-Gt-G. The first group (O3-G-Bh,t-C) is formed from clay-loamy parent materials, with slow internal drainage of the topsoil. The soil profile consists of raw humus organic horizons O3 (5-12 cm) and mineral gleyed layers with varying internal structure and degree of gleying. The upper part of the mineral layer is saturated with exchangeable bases. It contains a significant amount of colourless humus compounds. These soils are not differentiated by clay content or minerals, Al_2O_3 nor, usually, Fe_2O_3. In the first group, gleying is localised in the topsoil, above stratified finely dispersed material, with the maximum of oxalate-soluble Fe. The subsoil is ungleyed and has features of clay illuviation. A vast amount of Mn-Fe concretions is deposited along the boundary with the gley layer. The mineral soil is gleyed and the degree of gleying increases downward to a maximum in the parent material; it is medium to heavy textured, sometimes stratified on flat relief. The second group (O-G-Gt-G) is formed from loams and clay-loams in conditions of poor external drainage (flat relief) or sometimes where stratified rocky impermeable layers are close to the surface. It is characterised by the thin (3-4 cm) O horizon, poor in oxalate-soluble and total Fe_2O_3, which is identified (only chemically) beneath the litter horizon. The Gt horizon has weak micro-morphological features of illuviation. These soils are found in the middle and northern taiga and forest-tundra; the first group dominates in the European part of Russia, the second in West Siberia.

Differentiated taiga Gleyzems (synonyms: differentiated taiga gley and weak gley, including podzolized taiga soils) have the profile: O-GA2-Bg(G)-G(C). The O horizon (5-12 cm thick) overlies the gleyed mineral horizon which is characterised by one or the other of the morphological features described below:

The degree of gleying may gradually decrease downward to non-gleyed parent rock. Sometimes the horizon underlying the O horizon is a lighter colour.

Alternatively, very well expressed gleying properties increase downward. The topsoil is permeated with a significant amount of colourless humus (down to a depth of 20-30 cm). Two variants of a weak mineral profile are distinguished, which are not visible in the morphology: 1) differentiated by the distribution of total and oxalate-soluble Fe_2O_3 or Al_2O_3, or both; 2) podzolized by interdependent R_2O_3 and clay eluvial-illuvial distribution.

These soils are formed on loams and stony-loams in the middle and northern taiga and forest-tundra of the European part of Russia, also in Siberia and the Far East.

Peaty and peat-boggy Gleyzems (syn. taiga differentiated gleyed peaty soils, Gleyzems and peaty differentiated slightly gleyed soils, including taiga podzolized soils) have the profile: O-GA2-Bg(G)-G(C). They are similar to differentiated taiga gley soils but differ by having more distinctive features of wetness, gleying and weak bog formation. This results in the formation of a peaty horizon in the surface 15-25 cm.

The soils are found in depressions of the relief under dark, sphagnum moss, coniferous forests with hydrophilic bushes in the taiga parts of Siberia.

Podzolized Sod-gley soils have the profile: A1v-A1-A2g, n-Bt, g-G2. The litter horizon O, or muck O3 horizon is 5-30 cm thick, depending on the degree of waterlogging, and is underlain by a dark grey or steel-grey colored humus horizon A1 (20-30 cm thick) with granular structure when it is loamy. Sometimes it contains solid concretions and features of gleying. The A2g horizon has podzolization features, expressed by bleaching in the lower part of the A1 horizon or by bleaching of the particle surfaces. The transitional B horizon (25-50 cm) is dirty-brown colored often with hard iron concretions, always gleyed but the degree of gleying varies (blue-grey stripes, rusty stains, continuous gley horizon). Gleying may be expressed not in the whole soil profile but only in the topsoil (surface waterlogging) or in a lower layer within the parent rock (ground waterlogging). When the texture is loamy the structure is curds-like or granular. Manganese stains and concretions are common. The C horizon can be strongly gleyed or even be an aquifer, but also an absence of gleying features is possible. These soils are characterised by high humus content (3-14%). Humic acids linked with calcium prevail. The topsoil reaction is neutral and subsoil slightly alkaline. Base saturation is high (70-90%).

These soils are influenced by seasonal surface waterlogging and relatively high groundwater levels. They develop from calcareous parent rocks under coniferous (spruce) and mixed forests with mossy grass and grass groundcover in poorly drained or depressed relief or under meadow vegetation in the northern, middle and southern taiga sub-zones.

Mollic Gleysols (Glm)

This soil unit occupies 9.25 million ha which corresponds to 0.55% of the total land area or 3.36% of the major soil grouping area.

These soils have a mollic A horizon or eutric histic H horizon; and do not have andic properties, or permafrost within 200 cm of the surface.

This soil unit corresponds to Meadow-boggies, solonetzic and solonchakous Meadow and solonetzic and solonchakous Meadow-boggy soils.

Meadow-boggy soils have the profile (O)-Av-A1g-Bg-G. The upper part of the profile may contain a thin peat layer (up to 10 cm thick) succeeded by some 15-20 cm of muck or sod. The lower part of this horizon has distinct gley features. The transitional horizon contains a considerable amount of humus. It is profoundly gleyed and gradually passes into a gley parent material. The soils are characterised by high base saturation; the pH varies from acid to slightly alkaline (in calcareous varieties). These soils are formed under grass in depressions of lowlands or on river and lake terraces. They are periodically flooded and the ground water table is at 1-2 m. Such soils are found in forest steppe and some drier zones.

Solonetzic and solonchakous Meadow soils (syn. meadow alkaline and saline) with profile A1(sl)- A1B(sl)-Bca,(cs),(s),(g)-Cg,ca,(cs),(s), differ from the Meadow soils in having a horizon with nut (subangular blocky) and nutty-prismatic structure, containing exchangeable sodium. Either the humic or the transitional horizon may have solonetz features, sometimes with solod bleaching above them. The solonetz features are usually accompanied by salinization of the middle and lower parts of the soil profile. In saline soils gypsum may also be found at a depth of 30-80 cm, but there is no close correlation in depth between soluble salts and gypsum accumulation. The alkaline and saline Meadow soils are found in the same landscapes as the calcareous Meadow soils.

Solonetzic and Solonchakous Meadow-boggy soils (syn. alkaline and saline Meadow-boggy) differ from those described above due to the presence of soluble salts. Such soils occur in the same territories as meadow boggy soils.

Differentiated Meadow (including solodized) soils have a profile A1-A2(A1A2)-Bt, (g)-Bca, (g)-Cg. They differ from typical Meadow soils in having a bleached platy A2 horizon or bleached material. These soils usually have exchangeable sodium. Differentiated Meadow (including solodized) soils occur together with calcareous Meadow soils.

Umbric Gley (Glu)

This soil unit occupies 46.85 million ha which corresponds to 2.80% of the land area of the country or 17.04% of the major soil grouping.

These soils have an umbric A horizon or a dystric histic H horizon; and do not have andic properties nor permafrost within 200 cm of the surface.

They correlate with peaty-muck taiga Gleyzems, weak-gley peaty-humic taiga Gleyzems, Sod-gleys, Meadow soils.

Peaty-muck taiga Gleyzems (syn. peaty-muck taiga Gley, peaty-muck humus taiga Gleyzems) have the profile O1(2)-G(Gd)-G(C). The O1(2) peaty-muck horizon (10-15 cm) is interbedded with undifferentiated (morphologically and chemically), gleyed mineral layers with dirty grey, brown and light brown colors. Thixotropic and cryogenic deformation phenomena are common. Permafrost at 60-100 cm depth constrains soil profile development. The reaction is acid or slightly acid. The soils are formed on loamy-clay rocks (sometimes stones) in middle and northern plain and mountainous taiga of East Siberia and the Far East.

Weak-gley peaty-humic taiga Gleyzems have the profile: O3-Gd-G(C). The Humus-peaty humic O3 horizon (10-15 cm) is interbedded with undifferentiated (morphologically and chemically) very wet mineral gley layers of dirty-grey or brown colour. Soil development is limited by permafrost (usually to about one meter). Features indicative of cryogenic mixing are common in the soil profile. The soil reaction is acid to slightly acid. The soils are developed on loamy and stony-loamy parent materials in plain and mountainous middle and northern taiga of East Siberia and the Far East.

Sod-gleys have the profile: O-O3-A1(g,n)-Bg,(n)-C(g)(G2). The thickness of the litter horizon O, or muck O3 horizon, (5-30 cm) depends on the degree of overwetting). They are underlain by a dark grey or steel-grey colored humic horizon A1 (20-30 cm) with granular structure when it is loamy, which sometimes contains solid concretions and features of gleying. The transitional Bg horizon (25-50 cm) is dirty-brown colored, often with hard iron concretions, always gleyed but the degree of gleying varies (blue-grey stripes, rusty stains, or continuously gleyed horizon). Gleying can be present not throughout the profile but only in the topsoil (surface waterlogging) or in a lower layer within the parent material (ground waterlogging). When the texture is loamy the structure is curds-like or granular. Manganese stains and concretions occur. Cg horizons may be strongly gleyed or even be an aquifer (G2), but an absence of gleying features is also possible. These soils are characterised by high humus content (3-14%) with humic acids linked to calcium prevailing. The topsoil reaction is neutral and subsoil is slightly alkaline. Base saturation is high (70-90%).

These soils are developed under coniferous (spruce) and mixed forests with mossy-grass and grass groundcover on depressed or slowly drained relief positions over calcareous parent rocks. Such sites are characterised by seasonal surface waterlogging and relatively high groundwater levels. They form meadow vegetation in the northern, middle and southern taiga sub-zones.

Meadow soils have a strongly differentiated profile A1-A1B-Bg,ca-Cg,ca. They have a well-developed powdery-crumby-granular humic A1 horizon. Rusty spots are common within the transitional brownish-grey A1B horizon with nutty or coarse-crumby structure. Bg,ca horizon is brown, calcareous, with rusty spots. The Cg,ca is the gleyed calcareous parent material. Meadow soils are formed under conditions of excessive soil surface wetness permanently linked to fresh ground water at a depth of 1-3 m. They are characterised by seasonal changes in moisture flows: abundant downward flow in spring down to the groundwater, and predominantly upward flows during summer and autumn. These soils occur in depressions of poorly-drained plains under meadow grasses.

Gelic Gleysols (Gli)

This soil unit occupies 149.03 million ha which corresponds to 8.92% of the land area or 54.16% of the major soil grouping area. All the soils have permafrost within 200 cm of the surface.

It correlates with arctic Gleyzems, arctotundra muck-gley Gleyzems, peaty and peaty-muck and weak-gley peaty-muck tundra Gleyzems, differentiated peaty-muck Gleyzems, peaty and peat (shallow and deep peat) tundra Gleyzems.

Arctic Gleyzems have the profile: O1(2)-G-⊥G, the thawing depth is not more than 50 cm. Organic horizons O1(2) are thin (a few centimetres) and saturated with water. The reaction is near neutral. They are formed under grain-moss arctic peatlands in the southern part of the arctic zone.

Arctotundra muck-gley Gleyzems have the profile: O3-G-⊥G. The peaty-muck horizon O3 (1-5 cm) is underlain by a mineral, blue-grey colored layer, homogeneously gleyed down to the lower boundary of seasonal thawing (60-80 cm). The profile is undifferentiated in clay content and sesquoxide distribution. The reaction is acid to slightly acid and slightly base-unsaturated. Such soils exist mainly in humid arctic tundra.

The peaty and peaty-muck tundra Gleyzems have the profile O1(2)-Gd-⊥G. the upper peaty or peaty-muck horizon is from 5-15 cm (peaty) to 30-40 cm (peat) thick, and is underlain by a strongly gleyed mineral layer, sometimes thixotropic. Permafrost exists at the depth of 60-100 cm. The soil profile is thoroughly acid, with no clay content or sesquioxides differentiation, but with common features of cryogenic deformation of soil horizons. They are generally in the temperate continental permafrost subarctic tundra and forest-tundra zones.

Weak-gley peaty-muck tundra Gleyzems have the profile: A1-Bg-!C. The A1 horizon (1-3 cm) is underlain by a mineral layer with features of weak local gleying (small mottles on brown ungleyed background). The permafrost is at a depth of 40-60 cm. The mineral layer is undifferentiated by clay content or sesquoxides content. The upper layer is slightly acid with incomplete base saturation, while the lower horizon is neutral with full base saturation. Such soils are limited to the continental arctic tundra.

Differentiated peaty-muck and peat tundra Gleyzems have the profile: O-G-3A2-G-2B(G1B)-⊥G. The peaty and peaty-muck O horizon (5-10 cm) is underlain by gleyed mineral material, over permafrost at a depth of 1.0-1.5 m. The upper part of the mineral horizon (up to 50-60 cm) is periodically oxidized and eluvial, as compared with the lower one which is continuously anaerobic and is illuvial above the permafrost. There is clear differentiation in clay content, iron and aluminium oxides, and also in the amount of organic matter accumulated above the permafrost (frost retinization). The profile is acid throughout and significantly base-unsaturated. These soils generally overlie mild continental permafrost and deep permafrost in the southern tundra and forest-tundra with dissected relief.

Peaty and peat tundra Gleyzems have the profile: O1(O2)-Gd↓G. The raw humus organic horizon O (5-15 cm) overlies a thoroughly homogeneous gleyed and chemically undifferentiated mineral layer that is sometimes thixotropic, underlain by permafrost at the depth of 80-100 cm. Seasonally frozen layers are fully thawed out by the end of the warm period. Such soils occur in the continental permafrost regions in the middle and southern tundra of Kolsky peninsula.

REGOSOLS

This major grouping occupies 4.35 million ha or 0.26% of the land area of Russia (Table 3). It occurs in the North of Taimyr peninsula, South of Novaya Zemlia islands and the North of Novosybirsk islands (Figure 2.3).

In general Regosols are formed from loose material underlain by hard rock. They are formed on unconsolidated parent materials, exclusive of coarse-textured material more than 100 cm deep (Arenosols) or that show fluvic properties; they have no diagnostic horizons other than an ochric or umbric A horizon; they do not have gleyic properties within 50 cm of the surface; the characteristics which are diagnostic for Vertisols or Arenosols; nor salic properties.

This major soil grouping does not appear in the soil classification of Russia. It corresponds to a broad collection of weakly developed soils which are dispersed among other kinds of soils. Only one FAO soil unit and correlated class from SMR are recognized.

- Gelic Regosols (RGi)
    - Arctic soils (Cryozems)

The Gelic Regosols (RGi) soil unit occupies 4.35 million ha which corresponds to 0.26% of the land area of the country. It corresponds to the Arctic soils (Cryozems).

Arctic soils (Cryozems) have the profile: A1-C ↓Cca. A very shallow (1-2 cm) humic horizon with humus content of about 1% overlies an undifferentiated ungleyed layer. Dry or slightly iced permafrost is present. These soils usually contain carbonates and are weakly alkaline or neutral. Such soils are common in "pockets" and spots in the sparse vegetation patches in the northern and central part of the arctic zone.

LEPTOSOLS

This major soil grouping occupies 144.54 million ha or 8.65% of the land area (Table 3). It is widespread (Figure 2.4) particularly in the Ural and Altai mountains, East Siberia and the North-East of the country.

In general Leptosols are shallow weakly developed soils. They are limited in depth by continuous hard rock, or highly calcareous material (calcium carbonate equivalent of more than 40%), or a continuous cemented layer, within 30 cm of the surface; or have less than 20% of fine earth over a depth of 75 cm from the surface; they have no diagnostic horizons other than a mollic, umbric. or ochric A horizon, with or without a cambic B horizon.

This major soil grouping is not distinguished in the soil classification of Russia. In general it corresponds to a broad collection of shallow soils which are dispersed among other soil types. The following FAO soil units and their correlated classes from SMR are defined.

- Dystric Leptosols, LPd
    - High mountain Sod-baldy
- Rendzic Leptosols, LPk
    - Calcareous tundra Muck
    - Calcareous Muck
    - Calcareous Sod
- Mollic Leptosols, LPm
    - Shallow Chernozem
    - Mountain forest Chernozemic
    - Mountain Meadow-steppe
    - Mountain-meadow Chernozem-like
- Umbric Leptosols, LPu
    - Mountain forest-meadows
    - Mountain-meadow Sod
- Lithic Leptosols, LPq
    - Mountain primitive (less than 10 cm deep)
- Gelic Leptosols, LPi
    - Spot soils (saline, arctic and tundra) with permafrost.

Dystric Leptosols (Lpd)

This soil unit occupies 7.32 million ha which corresponds to 0.44% of the land area of the country or 5.07% of the major soil grouping area. The soils have an ochric A horizon and a base saturation (by NH_4O_{Ac}) of less than 50% in at least some part of the soil; they do not have hard rock or a continuous cemented layer within 10 cm nor permafrost within 200 cm of the surface. This soil unit correlates to high mountain Sod-baldy soils.

High mountain sod-baldy soils have the profile O-A1p-Bp- BCp-Cp. The O horizon (1-2 cm) is presented by weakly decomposed litter material. The A1p horizon (3-13 cm) has a brownish-grey or dark-brown colour, loose structure and stony loam texture. The muck in these horizons contains about 11% of humus. The ratio between humic and fulvic acids (Cha:Cfa) is 0.7-0.8. The Bp horizon (15-20 cm) has loamy-skeletal texture with abundant gravel and rock fragments. The yellowish brown colored fine earth fills the space between rock fragments and covers the upper surfaces of stones and boulders. The undersides of rock fragments and gravel are usually covered by iron-humus films. The fine earth contains 1.5 - 4.0% of humus. The BCp is a gradual transition to eluvial and eluvial-deluvial material derived from hard rocks. Gley properties are absent or weak. cryoturbation, solifluction, and frost sorting are well developed. Base saturation is high.

Such soils are formed in cold dry climates of highlands under driade and cobresia grasslands, and are widespread on well-drained surfaces of the Altai, Sayan and Trans-Baikal mountains.

Rendzic Leptosols (Lpk)

This soil unit occupies 87.0 million ha which corresponds to 5.21% of the land area of the country or 60.19% of the major soil grouping area. The soils have a mollic A1 horizon that contains or immediately overlies calcareous material with a calcium carbonate equivalent of more than 40%; they do not have hard rock or a continuous cemented layer within 10 cm nor permafrost within 200 cm of the surface.

This soil unit correlates with calcareous tundra Muck, calcareous Muck and calcareous Sod soils.

Calcareous tundra Muck soils have the profile: O3-Bpca-BCcap-Ccap. The organic peaty humus O3 horizon (up to 10 cm thick) covers a very stony layer with a small amount of dark-colored silt material. Pieces of calcareous rock are covered by dark films of organic-mineral compounds. Silt of the organic horizon is leached of carbonates, while that of the subsoil is partly leached or still contains carbonates. The profile is very stony and shallow. The permafrost is dry or absent.

These soils and formed on exposed solid calcareous rocks in the tundra zone.

Calcareous Muck soils have the profile: O-AO-A1pca-BCcap-Dca. They have a shallow 20-30 cm profile. The O horizon, characterized by weakly decomposed peaty litter (3-5 cm), overlies a thin (1-2 cm) organo-mineral AO horizon, consisting of differently decomposed fractions of organic matter with small additions of silt and calcareous debris material. The muck organic horizon A1pca is easily distinguished, it is dark grey or dark brown, rich in calcareous debris, though silty material is often leached of carbonates. Rock pieces are strongly effervescent. The transitional horizon to parent rock, Bccap, is lighter in colour, the silt and calcareous debris material are strongly effervescent. This merges into weakly weathered calcareous eluvium at the depth of 20-30 cm, which is underlain by massive calcareous rocks - horizon Dca. The Apca horizon has well expressed microstructure, soil reaction near neutral, humus content from 8 up to 22%, with Cha:Cfa ratio close to one (0.8-0.9), high base saturation (95-98%), and fairly high cation exchange capacity (35-50 cmol(+) kg-1. The profiles do not show any differentiation in texture and total chemical composition. Such soils are common in humid regions and forest-tundra, and in the northern and middle taiga. They are formed on calcareous rocks under dark and light (larch) coniferous forests with moss groundcover, in plains or mountains of the northern taiga and forest-tundra regions. The humid and moderately cold climate, together with a percolating water regime, favours rapid carbonate leaching. Therefore typical forms of calcareous Muck soils are quickly transformed into podzolic soils with residual carbonates.

Calcareous Sod soils have the profile: O-AO-A1pca-Bcap-Ccap-Dca. The litter horizon (O1, 1-5 cm) is often present, consisting of decomposed leaf fall. The AO horizon contains a significant amount of mineral particles. The humus horizon (10-35 cm) is dark with granular structure and contains calcareous debris. The transitional Bcap horizon has reddish-brown or greyish-brown colour and granular-subangular blocky structure. It is enriched in clay, compacted in its upper part, and has angular blocky (beech-nut) structure in leached and podzolized soils. The thickness of the Bcap horizon varies significantly (5 to 40 cm) and depends on the degree of soil profile development. The Ccap horizon consists of calcareous eluvium weakly transformed by pedogenesis. A Dca horizon is often absent due to the thin loose eluvium layer and close-bedded hard calcareous rocks. These soils are similar to calcareous peaty Muck (by soil reaction, strong aggregation, humus content, base saturation, absent or weak differentiation of texture and total chemical composition throughout the profile, etc.). They differ from them by a clearly expressed humus horizon, greater soil thickness caused by more intensive processes of soil formation and, related to that, a deeper transformation of the mineral part of the soil.

These soils are formed on calcareous rocks in taiga (middle and southern taiga) and forest-steppe zones.

Mollic Leptosols (Lpm)

This soil unit occupies 3.77 million ha which corresponds to 0.23% of the land area of the country or 2.61% of the major soil grouping area. The soils have a mollic A horizon which does not contain or immediately overlie calcareous material with a calcium carbonate equivalent of more than 40%; do not have hard rock or a continuous cemented layer within 10 cm, or permafrost within 200 cm, of the surface.

This soil unit corresponds to shallow Chernozems, mountain forest Chernozemic soils, mountain Meadow-steppe soil, mountain-meadow Chernozem-like soil.

Shallow Chernozems have the soil profile: A1-A1B-BC(ca). The soil has a black, granular A1 horizon. The topsoil is slightly stony and stoniness increases rapidly downward. The reaction is close to neutral in the upper and neutral in the lower part of the profile. The exchange capacity is 45-80 cmol(+) kg-1. These soils are formed from calcareous rocks in semi-humid regions in the Eastern Caucasus.

Mountain forest Chernozemic soils have the soil profile: O-A1-A1B-B(ca)-BCca,p. The humic horizon is up to 30 cm thick. It is dark-grey, crumby-granular with humus content of 9-16%. The humus is mainly humic acids. The B(ca) horizon is slightly compact and weakly structured. Carbonates are leached to different depths and form pseudomycelia, loose aggregates and films on the undersurfaces of rock fragments. The texture becomes coarser with depth and the lower part of the profile contains rock fragments. These soils differ from Chernozems in higher humus content and higher percentage of fulvic acids. They are formed on the middle slopes of the Altai mountains under broad-leaved open forests and grasslands.

Mountain Meadow-steppe soils have the profile: A1v-A1B-BC-C. They have a rather thin (5-15 cm) loose sod horizon of a greyish-brown colour, succeeded by a transitional weakly structured horizon, lighter in colour and 20-40 cm thick. The soils contain a high proportion of rock fragments and, although the transition to parent rock is gradual, they have been included with the Leptosols. The loss on ignition in the upper horizons is 20-25%. They have slightly acid to neutral soil reaction (pH 5.5-7.5) and high base saturation (up to 70-80%). Such soils are formed on calcareous rocks in relatively dry regions of the mountain meadow zone, transitional to mountain steppes, in the Eastern Caucasus and the mountains of Southern Siberia.

Mountain-meadow Chernozem-like soils have the profile: A1-A1B-BC(ca)-C(ca). The soil has black granular sod horizon, succeeded by a distinctive grey transitional horizon and yellowish parent material. The topsoil is slightly stony and stoniness increases rapidly downward. The soil reaction is slightly acid (pH 6.0-6.5) in the upper, and neutral or alkaline (pH 7.5-8.2) in the lower part of the profile. The exchange capacity is 45-80 cmol (+) kg-1.

These soils are formed on eluvium and eluvio-deluvium of limestone and other calcareous rocks in humid regions, and sometimes on basic and ultrabasic rocks in dryer regions. They occur in the Eastern Caucasus.

Umbric Leptosols (LPu)

This soil unit occupies 5.62 million ha which corresponds to 0.34% of the land area of the country or 3.89% of the major soil grouping. These soils have an umbric A horizon; and do not have hard rock or a continuous cemented layer within 10 cm and permafrost within 200 cm of the surface. The soil unit correlates with mountain Forest-meadow soils and mountain-meadow Sod soils.

Mountain Forest-meadow soils have a profile O-A1-A1B- (Bp)-Cp. A thin layer of litter O covers a grey or dark-grey colored, crumby-granular structured, humus-accumulative A1 horizon, which gradually passes into eluvium or eluvio-deluvium and hard rock. The colour of transitional horizons is brownish-grey or brown, depending on the colour of the parent rock. The profile is usually very stony. An illuvial Bp horizon is sometimes identified in deep varieties of these soils. The upper part of the soil profile has a slightly acid or neutral soil reaction, while the lower parts are slightly acid or acid. The humus content in the uppermost horizon varies from 7 to 12%. The exchange complex is highly saturated and total exchangeable bases comprise 20-25 cmol(+) kg-1 of soil. The organic matter is usually humic acids. These soils are formed in the lower parts of sub-alpine sparse forests of various types in the Caucasus, Southern and Middle Urals, and Altai mountains.

Mountain-meadow Sod soils have profiles similar to the mountain-meadow peaty Sod soils, but differ in the character of sod (loss on ignition is 20-30%) and in being less acid (pH 4.6-5.5). They are formed on non-calcareous rocks under subalpine meadows in the Caucasus.

Lithic Leptosols (LPq)

This soil unit occupies 34.42 million ha which corresponds to 2.06% of the land area of the country or 23.81% of the major soil grouping area. The soils are limited in depth by continuous hard rock or a continuously cemented layer within 10 cm of the surface. This soil unit corresponds to mountain primitive soils.

Mountain primitive soils have a weakly developed profile O-Bh,p-Cp with total depth up to 30 cm. A peaty litter (2-5 cm) covers a dark-brown, 6-10 cm thick, B horizon colored by illuvial humus. This horizon gradually passes into stony eluvium and eluvio-deluvium of hard rocks. The content of humus in the fine earth of the Bh,p horizon is 8-10%. The soil reaction is very acid (pHKCl = 3.6-3.8); hydrolytic acidity is 20-50 cmol(+) kg-1.

Such soils are found in the south of Eastern Siberia.

Gelic Leptosols (LPi)

This soil unit occupies 6.41 million ha which corresponds to 0.38% of the land surface or 4.44% of the major soil grouping area. Permafrost occurs within 200 cm of the surface. This soil unit correlates with Spot soils (saline, arctic and tundra).

Spot soils (saline, arctic and tundra) have the profile: Cd-⊥BC. They are formed on unvegetated spots in all natural sub-zones of tundra. They do not have an organic horizon and present an undifferentiated, non-gleyed, mass with the permafrost within 50 cm of the surface.

ARENOSOLS

This major grouping occupies 5.58 million ha or 0.33% of the land area of Russia (Table 3). It is scattered particularly over the south of the European Part of Russia and in the southern part of the West Siberian plain (Figure 2.5).

In general Arenosols refer to weakly developed coarse-textured soils. The texture is coarser than sandy loam, or is sandy loam with less than 8 percent clay, to the depth of at least 100 cm from the surface; materials which show fluvic or andic properties are excluded; and there are no diagnostic horizons other than an ochric A horizon or an albic E horizon.

This major soil grouping is not distinguished in the soil classification of Russia. It corresponds to the assemblage of weakly developed soils formed from sands. Only one FAO soil unit is recognized and the correlated classes from SMR are described.

Cambic Arenosols, ARb

- Grey sands
    - Pine forest sands

This soil unit occupies 5.58 million ha, which corresponds to 0.33% of the soil cover of the country. These soils show colouring or alteration characteristic of a cambic B horizon immediately below the A horizon; they are not calcaric and do not have lamellae of clay accumulation, ferralic properties. an albic E horizon within 50 cm of the surface, or gleyic properties within 100 cm of the surface.

This soil unit corresponds to grey sands and pine forest sands.

Grey sands have the profile: A1-A1B-C. The humic horizon is characterized by lack of structure and a gray colour gradually becoming paler downward. The humus content is rather low (2-4%). The cation exchange capacity varies from 10 to 15 cmol(+) kg-1 of soil. Carbonates are absent and the soil reaction is neutral throughout the profile. They occur in the Chernozem zone on sandy deposits.

Pine forest sands (sometimes slightly podzolized) have a weakly developed, shallow profile: O-AO-AB-C. The organic O horizon (about 1 cm thick) consists of pine needle debris. The AO horizon is 1-3 cm thick and is slightly colored by humus. The horizon AB forms a gradual transition to the sandy parent material.

Slightly podzolized soils, with iron movement, commonly form associations with pine forest sands. They have small bleached mottles or quartz grains leached of iron coatings. Both soils are formed in well-drained relief from thick, sorted, wind blown quartz sand deposits. They occur in the southern part of the taiga and forest-steppe zones under pine forests with sparse ground vegetation, consisting of dwarf bushes, mosses and lichens.

ANDOSOLS

This major grouping occupies 15.64 million ha or 0.94% of the land area of Russia (Table 3). It is common in the Kamchatka peninsula (Figure 2.6).

Andosols formed from materials rich in volcanic glass and commonly have a dark surface horizon. They show andic properties to a depth of 35 cm or more from the surface and have a mollic or umbric A horizon possibly overlying a cambic B horizon, or an ochric A horizon and a cambic B horizon. They have no other diagnostic horizons; lack gleyic properties within 50 cm of the surface and all characteristics diagnostic for Vertisols; and lack salic properties.

The soils are subdivided into zones according to the frequency and intensity of deposition of the ash. Intensely active zones have frequent deposition and the soil consists of thin layers of fresh ash with some organic material. Moderately active zones have somewhat developed profiles with a thick humus horizon and weathering features. Slightly active means that ash falls are rare, the minerals are well weathered and horizons are well developed.

The term ochre, and ochric, used in the description of these soils has the specific meaning of having an f(Bf) horizon or well-weathered properties with clay formation and abundant SiO_2 and R_2O_3.

The following FAO soil units are recognized with their corresponding soil groups in SMR.

- Haplic Andosols, ANh
  - Ochre-banded Volcanics
  - Dry-peaty Volcanics
  - Light-ochre (including podzolized) Volcanics
  - Ochre (including podzolized) Volcanics
  - Podzolized-ochre Volcanics
- Vitric Andosols, ANz
  - Banded-ash Volcanics
- Gelic Andosols, ANi
  - Illuvial-humic tundra Volcanics

Haplic Andosols (Anh)

This soil unit occupies 11.18 million ha, which corresponds to 0.67% of the land area or 71.47% of the Andosols major soil grouping.

These soils have an ochric A horizon and a cambic B horizon, with a smeary consistence and a texture which is silt loam or finer on the weighted average for all horizons within 100 cm of the surface; they do not have gleyic properties within 100 cm of the surface or permafrost within 200 cm of the surface.

This soil unit correlates with banding-ochric, dry-peaty, light-ochric (including podzolized), ochric (including podzolized), and podzolized-ochric Volcanic soils.

Ochre-banded Volcanic soils have a composite poligenetic soil profile, consisting of between four and ten simple sub-profiles, 120-180 cm thick altogether, developed on volcanic ash. All of them have organic and illuvial-weathered horizons. The organic horizons become weaker downward while the illuvial-weathered features become stronger. The lowest horizons have an ochre colour and properties of ochre horizons in the subsoil. These soils develop in volcanic ash deposits under forest vegetation on the Kamchatka peninsula.

Dry peaty Volcanic soils have composite poligenetic soil profiles, consisting of several young undeveloped profiles (3-7). Peaty organic and brown illuvial-humus horizons exist in every profile. The most recent organic horizon is dry peaty (15-25 cm). Such soils are acid and base-unsaturated. They occur under dwarf pine vegetation of the Kamchatka peninsula on moderately active volcanic ash deposited as volcanic sands and ashes falling from the air.

Volcanic light ochre (including podzolized) soils have the profile: O-AO-A2-Bf,h (Bh)-C. They are characterised by a buried humus horizon with amorphous SiO_2 and R_2O_3 in transitional horizons. These soils are formed in the Central Kamchatka depression under grassy birch forests.

Ochre (including podzolized) Volcanic soils differ from typical ochre Volcanic ones by the presence of a light grey-colored (in some places bleached), loamy sand or sandy loam, loose A2 horizon, 3-6 cm thick, formed under forest litter or a raw humus horizon. They are composed of organic debris and volcanic ash particles bleached from the surface down. These soils occur in a moderately active volcanic ash deposition zone under grassy stone-birch forests on the Kamchatka peninsula.

Podzolized ochre Volcanic soils have a soil profile close to that of illuvial-humus podzols. They have a very bright colored B horizon and a buried humous horizon, or its fragments, with a very high humus and amorphous SiO_2 and R_2O_3 content in the lower horizons. The soil profile is developed on aeolian volcanic material. Secondary minerals are represented by allophane and amorphous organo-mineral compounds.

These soils are formed in the slightly active, shallow volcanic ash deposition zone under grassy birch forests on the Kamchatka peninsula.

Vitric Andosols (Anz)

This soil unit occupies 2.73 million ha, which corresponds to 0.16% of the land area of the country or 17.47% of the Andosols major soil grouping area. They are characterised by lacking a smeary consistence or by having a texture which is coarser than silt loam on the weighted average for all horizons within 100 cm of the surface, or both; they do not have gleyic properties within 100 cm of the surface or permafrost within 200 cm of the surface.

This soil unit correlates to volcanic banded-ash soils.

Volcanic banded-ash soils have profiles which consist of many superimposed profiles (usually 10-15). Each original profile has a raw humus organic horizon and a layer of volcanic ash only slightly changed by pedogenesis or weathering. The soil reaction is acid or slightly acid. Humus content, cation exchange capacity and other properties depend very much on the properties of the individual layers.

These soils occur in an intensely volcanic ash deposition zone under coniferous and birch forests on the Kamchatka peninsula.

Gelic Andosols (Ani)

This soil unit occupies 1.73 million ha which corresponds to 0.10% of the land area of the country or 11.06% of the Andosols major soil grouping area. Permafrost exists within 200 cm of the surface. This corresponds to Volcanic illuvial-humus tundra soils.

Volcanic illuvial-humus tundra soils have a three-dimensional anisotropic profile. They are formed in conditions of frost mound relief. No horizons are recognized other than recent peaty-mud and buried peaty horizons (usually two). The latter are folded and torn by cryogenic processes. These soils are acid and characterised by the high content of eluviated humus and amorphous sesquoxides. They are formed in areas of volcanic deposits in a moderately active volcanic ash deposition zone under tundra vegetation, on the Kamchatka peninsula.

VERTISOLS

This major grouping occupies 0.21 million ha or 0.01% of the soil cover of Russia (Table 3). It is confined to the Northern Caucasus (Figure 2.7).

Vertisols have pronounced features related to churning of the surface layer. They have, after the upper 18 cm have been mixed, 30 percent or more clay in all horizons to a depth of at least 50 cm; cracks develop from the soil surface downward and at some period in most years are at least 1 cm wide to a depth of 50 cm (unless the soil is irrigated); intersecting slickensides, or wedge-shaped or parallelepiped structural aggregates, form at some depth between 25 and 100 cm from the surface; gilgai may form at the surface.

Only one soil unit is recognized (eutric Vertisols) and corresponding to it in SMR are the compact Chernozems.

Eutric Vertisols (Vre)

This soil unit occupies 0.21 million ha which corresponds to 0.01% of the land area of the country. The base saturation (by NH_4O_{Ac}) is 50 percent or more at least between 20 and 50 cm from the surface; there is no calcic or gypsic horizon.

Compact Chernozems have the profile: A1-A1B(ve)-B(ve)-Bca-Cca. They are identified by the presence of a compact horizon (not deeper than 100 cm) with extremely high bulk density when dry, and highly plastic when moist. They are characterised by slow percolation. The humous horizon has tonguing along the wavy lower boundary. The B horizons have friable, coarse subangular to prismatic structure and abundant dark mottles on ped surfaces. These soils are identified by a very high content of clay (up to 80%), a significant amount of unaggregated clay, and high cation exchange capacity (up to 65 cmol(+) kg-1). The proportion of humic acids that is linked to sesquoxides is high forming a humus-sesquioxide compound. The soils have no features of solonetzic processes.

They develop from clayey deposits in depressed sites in the southern region of the European part of the country.

CAMBISOLS

This major grouping occupies 212.03 million ha or 12.69% of the land area of Russia (Table 3). It is widespread particularly in the Northern Caucasus, East Siberia and Far East (Figure 2.8).

These soils have a cambic B horizon and no other diagnostic horizons other than an ochric or an umbric A horizon, or a mollic A horizon overlying a cambic B horizon with a base saturation (by NH_4O_{Ac}) of less than 50 percent; they do not have salic properties, the characteristics diagnostic for Vertisols or Andosols, nor gleyic properties within 50 cm of the surface.

The soil units and corresponding soil groups in SMR are described below.

- Eutric Cambisols, CMe
    - Residual-calcareous Brownzems
    - Weakly-unsaturated Brownzems
    - Weakly-unsaturated podzolized Brownzems
    - Mucky Pale-yellow soils
    - Typical Pale-yellow soils
    - Weakly-unsaturated and saturated Sod-brownzems
- Dystric Cambisols, CMd
    - Acid Brownzems
    - Acid podzolized Brownzems
    - Raw-humic Brownzems
    - Raw-humic illuvial-humic Brownzems
    - Granuzems
    - Podzolized Pale-yellows
    - Solodic Pale-yellows
    - Acid Sod-brownzems

- Ferruginous Sod-brownzems
- Humic Cambisols, CMu
    - Muck-humus-accumulative Brownzems
    - Grey Pale-yellows
    - Calcaric Cambisols, CMc
    - Calcareous Cinnamonics
    - Calcareous Pale-yellows
- Chromic Cambisols, CMx
    - Typic Cinnamonics
- Gleyic Cambisols, CMg
    - Gleyic and gley Brownzems
    - Raw-humic gley Brownzems
    - Gley Granuzems
- Gelic Cambisols, Cmi
    - High-humic non-gleyic taiga Peaty-muck
    - Gleyic and gley Sod-brownzems

Eutric Cambisols (Cme)

This soil unit occupies 49.33 million ha which corresponds to 2.95% of the land area of the country, or 23.26% of the Cambisol major soil grouping area.

These soils have an ochric A horizon and a base saturation (by NH_4O_{Ac}) of 50 percent or more at least between 20 and 50 cm from the surface but are not calcareous within this depth; they have a cambic B horizon which is not strong brown to red (the rubbed soil having a hue of 7.5YR and a chroma of more than 4, or a hue redder than 7.5YR); they do not have vertic properties, ferralic properties in the cambic B horizon, gleyic properties within 100 cm of the surface or permafrost within 200 cm of the surface.

The eutric Cambisols soil unit correlates with residual-calcareous Brownzems, weakly-unsaturated Brownzems, weakly-unsaturated podzolized Brownzems, mucky Pale-yellows, typical Pale-yellows, weakly-unsaturated and saturated Sod-brownzems.

Residual-calcareous Brownzems have the profile: O-AO-Bm-BmCpca-Ccap. The humous horizon A1 has a black or brownish-black colour with subangular or angular blocky (beech nut-like) structure. The altered Bm horizon is a reddish brown colour, compact and showing clay movement and neoformation. The transitional BmCpca horizon contains calcareous fragments and gradually merges with increasing stoniness into calcareous parent rock. There is a well developed clay profile with uniform distribution of clay, sesquoxides and SiO_2; a neutral or near neutral reaction in the A1 and Bm horizons; high cation exchange capacity and slight base unsaturation (20-30%) in the topsoil; a high humus content (12-16%) in the A1 horizon with a gradual decrease downward; and a significant content of humic acids and dominant calcium -humates.

These soils are formed on eluvio-deluvium from calcareous parent rocks in the broad-leaved forest zone.

Weakly-unsaturated Brownzems have a profile similar to acid brown forest soils. They differ from them in being slightly acid (pH KCl 4.5-6.0), having significantly higher base saturation

(40-60%) and cation exchange capacity (12-20 cmol(+) kg-1, and the organic matter composition has significant quantities of a humus fraction linked with Ca_2+ as humin). Such soils are widespread in the south of the Far East.

Weakly-unsaturated podzolized Brownzems have the profile: O1-AO-A1-A1A2-Bm,t-BmC-C, similar to that of acid brown forest podzolized soils. They are similar to slightly unsaturated brown forest soils in some chemical properties (acidity, low base saturation, cation exchange capacity, humus composition). They differ from them in colour and texture differentiation of the profile, and also by the weakly developed profile differentiation of the total chemical composition and amorphous R_2O_3. These soils occur in the south of the Far East.

Mucky Pale-yellows have the profile: Ov-AB-B-BC-C. Lichen tissue (2-3 cm) covers the dry peaty dark brown or brown Ov horizon (2-3 cm). The AB horizon (8-12 cm) is light brownish loamy sand or loam. The horizon gradually merges into almost undifferentiated brown subsoil (B-BC). There are no morphological features of gleying nor of clay eluviation. The reaction is slightly acid in the AB horizon and close to neutral in the B. Total R_2O_3 and the oxalate-soluble forms are either evenly distributed down the profile or accumulate. The humus has a humate-fulvate composition. These soils develop in cold and semiarid continental permafrost mountainous regions of eastern Siberian under northern taiga lichen-moss-dwarf bush larch forests.

Typical Pale-yellows have the profile: Ov-A1-AB-B-BC-C. The presence of an A1 horizon differentiates these soils from pale-yellow muck soils. They occur usually in the middle and southern taiga of semi-arid areas of East Siberia.

Weakly-unsaturated and saturated Sod-brownzems have a profile similar to acid sod-brown forest soils. They are identified by their neutral or slightly acid reaction and high base saturation. They are found in the same regions as Brownzems.

Dystric Cambisols (Cmd)

This soil unit occupies 91.16 million ha which corresponds to 5.46% of the land area of the country or 42.99% of the Cambisols major soil grouping area.

These soils have an ochric A horizon and a base saturation (by NH_4O_{Ac}) of less than 50 percent at least between 20 and 50 cm from the surface; they lack vertic properties, ferralic properties in the cambic B horizon, gleyic properties within 100 cm of the surface and permafrost within 200 cm of the surface.

The dystric Cambisols soil unit correlates with the following soil groups in SMR: acid Brownzems, acid podzolized Brownzems, raw-humic Brownzems, raw-humic illuvial-humic Brownzems, Granuzems, podzolized Pale-yellows, solodic Pale-yellows, acid Sod-brownzems, ferruginous Sod-brownzems.

Acid Brownzems have the profile: O1-AO-Bm-BmC-C. The O1 horizon is thin (1-3 cm) and formed by forest litter from trees and grasses. The AO organo-mineral horizon (1-3 cm thick) is grey and loose and contains from 30 to 70% (by bulk) of organic matter in different stages of decomposition which is predominantly mixed with the mineral part of the soil and easily separated from it. The A1 horizon has a greyish-brown colour, granular-subangular structure and contains from 3 to 8% of humus. The Bm altered horizon is pale-brown, is more clayey and compact, and sometimes has weakly expressed illuviation. It gradually merges into parent rock. These soils are identified by the weak differentiation in the profile; very weakly expressed (or non-existent) redistribution of finely-dispersed silicate material; a strongly acid reaction and low base saturation (70-90%) of the topsoil; fulvate humus tightly linked with the mineral fraction, and predominantly humic acids linked to sesquioxides; a narrow C:N ratio (8-10); and a high content of amorphous and crystallized iron and aluminium compounds in the humous horizon (A1).

These soils are developed on stony silicate substrates in flat or mountainous terrain under broad-leaved and mixed coniferous-broad-leafed forests in a humid and moderately warm climate. Accordingly there is significant nutrient recycling and a relatively high rate of weathering, leading to alteration of the clay in all the profile and release of iron from primary minerals. Such processes play an important role in humification and aggregation.

These soils are found in the mountainous regions of south Russia and the Far East.

Acid podzolized Brownzems have the profile: O1-AO-A1-A1A2-Bm,t-BmC-C. They are similar in acidity, low base saturation, cation exchange capacity, humus content, composition and distribution in the profile, to acid Brownzems. Podzolization is shown by colour and texture, and by weak differentiation of both amorphous and crystallized sesquioxides without noticeable illuviation in the Bm horizon. Gleying features (vague pale blue-grey and brownish mottles and small friable manganese-iron nodules) may occur in the lower part of the soil profile.

These soils are formed in the same regions as acid Brownzems from relatively less stony and more weathered loamy eluvium and eluvio-deluvium of silicate rocks.

Raw-humic Brownzems have the profile: O1-AO-A1(A1A2)-Bm-BmC-C. The O1 horizon is weakly decomposed forest litter. The AO horizon (3-5 cm) has greyish-brown colour and consists of partly decayed litter with additions of mineral particles. In the lower part of the horizon this material is humified. The A1 horizon (5-10 cm) has a dark grey or brownish-grey colour, loamy texture, fine subangular structure and 7-15% of humus.

Podzolized variants of these soils have a shallow (2-3 cm) A1A2 horizon below the A1 with features of eluviation. The Bm horizon has a brown colour, loamy and clay loamy texture and compact consistency. It shows signs of alteration and clay neoformation and movement. The horizon gradually merges into parent rock. The typical properties are: weak differentiation into soil horizons, absence or weak redistribution of total R_2O_3 without noticeable illuviation in the Bm horizon. The humus is always humate-fulvate (Cha:Cfa equal to or less than 1). The fraction of humin acids linked to Ca is predominant. The cation exchange capacity of the mineral part is low. Oxalate-soluble Fe (extracted by the Tamm method) is usually evenly distributed in the soil profile or, more rarely, increases downward by accumulation.

Raw-humic Brownzems are developed in well-drained, stony, loamy eluvio-deluvium from hard silicate rocks and ancient alluvial deposits, under larch forests with bushes and grass ground vegetation, providing conditions of high organic matter input with a relatively slow rate of humification, resulting in formation of mobile humus compounds. The soil is seasonally frozen until the first half of the vegetation growth period. These soils are found in mountainous and plain regions in the southern Far East.

Raw-humic illuvial-humic Brownzems have the profile: O(AO)-A1-A1A2-Bm,f,h(Bh,m)-C. The shallow (3-5 cm) weakly decomposed forest litter (O horizon) sometimes overlies a brownish-black, structureless, raw humus AO horizon (2-3 cm). The A1 horizon has a dark greyish brown colour, stony-loamy texture and granular-subangular structure. Sometimes an A1A2 horizon is present represented by a lighter brown colour. The humous horizon is underlain by the Bm,f,h horizon which has rusty-ochre or reddish-brown colors, stony loamy texture, blocky (beech nut-like) structure with signs of humus illuviation.

These soils are characterized by weak differentiation of soil horizons, strongly acid in the upper part and acid in the lower part, a high humus content in the AO horizon (15-28%) and A1 (8-10%), deep humus illuviation gradually decreasing downward into the mineral soil; with organic matter having a fulvate humus character and prevalent humin acids of the first fraction; low content of bases (3-8 cmol(+) kg-1, high base saturation (60-90%), relatively weak differentiation of total iron, aluminium and silica dioxide. The humus horizon is sometimes enriched in quartz and is relatively poor in iron and aluminium because of podzolization. The highest iron and aluminium content (extracted by the Tamm method) is mainly in the humous horizon.

These soils are formed from stony-loamy eluvium of sedimentary and igneous rocks under coniferous forests with dead pine needles, lichen and moss groundcover.

Granuzems have the profile: O1-AO-B-BC -BCg-Cg. The surface horizon consists of forest litter and is up to 10 cm thick with its lower part characteristically peaty-humus material. The topsoil is brown, loose, well aggregated with fine subangular and rounded (granular) structure, 20-30 cm thick. It gradually merges into a platy horizon with a dirty brown colour up to 50 cm thick. Below it (80-100 cm) features of gleying are marked. The topsoil is acid or slightly acid and the subsoil close to neutral. There is no differentiation of texture or total chemical composition. Amorphous R_2O_3 compounds are accumulated in the topsoil.

These soils are formed from rich, loose, loamy deposits developed by weathering and redeposition from basic rocks, in the northern, or more rarely the middle, taiga regions of Middle Siberia.

Podzolized Pale-yellows have the profile: O-AOA1-A1A2-B-BC-C. The O horizon consists of forest litter, mainly pine and larch needles. The AOA1 horizon (2-3 cm) is distinguished by raw humus muck material and contains up to 10-20% of organic matter. The A1A2 horizon (12 cm thick) has a bleached light grey colour, is structureless, and contains up to 1.5-1.8% of humus. The illuvial B horizon has a greyish brown or pale-yellow-brown colour. Lower horizons of loamy soils have the platy structure of frozen soil. The topsoil is acid and the subsoil has a neutral pH. Base saturation is 60-80%. The profile is differentiated by texture and total chemical composition. The podzolized A1A2 horizon is low in clay, R_2O_3 and exchangeable cations with a marked increase of all three in the illuvial B horizon.

These soils are formed from fine loams, loamy sands and sands under larch and pine forests with dwarf bush ground cover, on moderately dissected, well-drained watersheds and their slopes, in the middle taiga zone.

Solodic Pale-yellows have the profile: AO-A1A2-B1-B2ca-BCca-Cca. The AO horizon (2-3 cm) is characterized by weakly decomposed forest litter (needles and leaves of birch and bushes). The A1 horizon (5-6 cm), with sod in the upper part (2-3 cm), contains up to 3-4% of humus and has loamy texture. The A2 horizon (5-25 cm) has light-grey colour, light and medium loamy texture, and features of solodization (ash colour); it is loose and structureless, or thin platy in strongly solodized soils; the humus content is about 3.2%. The B1 horizon (10-20 cm) has a dark brown colour, compact consistency, granular-subangular structure, and no carbonates in the illuvial horizon. The humus content is about 1.5%. The B2ca horizon (20-30 cm) has an irregular colour, light brown less calcareous tongues are mingled with pale-yellow bleached wedges. This calcareous illuvial horizon is characterised by loamy texture, loose fine granular porous structure. It gradually merges into light brown loess-like loam with plate-leafy structure, succeeded by permafrost. These soils have neutral or slightly alkaline reaction (pH 6.5-6.7 in A1 and A2 horizons) and 7.6-8.0 (in B2ca and Cca horizons). The solodized A2 horizon has a smaller sum of exchangeable cations (about 11 cmol(+) kg-1) than the B1 horizon, and exchangeable sodium is 4-5% of the total cations. The exchange capacity is significantly higher in the B1 horizon (30-40 cmol(+) kg-1) and Na+ content is up to 5-10%.

These soils are formed under larch taiga with dwarf bushes and grasses, and have a lower land productivity rating (bonitets).

Acid Sod-brownzems have the profile: O-A1-Bm-C. The forest litter O horizon is 1-3 cm thick. The A1 horizon is 5-10 cm thick and has a grey colour and subangular blocky structure. It gradually merges into a brown altered horizon Bm. These soils are acid and unsaturated. The profile is undifferentiated by texture and total chemical composition. The organic matter (4-8%) in the A1 horizon is humate. The maximum amorphous R_2O_3 content is in the humus horizon. Such soils are formed from fine-textured or stony deposits in southern (partly middle) taiga sub-zones with a severe continental climate.

The ferruginous Sod-brownzems soil profile is similar to acid Sod-brownzems soils, but has good aggregation and a greater iron content in the silt and clay material. These soils are formed in the same regions as acid Sod-brownzems soils but derived from the weathering products of basic rocks.

Humic Cambisols (Cmu)

This soil unit occupies 1.84 million ha which corresponds to 0.11% of the land area of the country or 0.87% of the major soil grouping area.

The soils have an umbric A horizon or a mollic A horizon overlying a cambic B horizon with a base saturation (by NH_4O_{Ac}) of less than 50 percent; and do not have vertic properties, ferralic properties in the cambic B horizon, gleyic properties within 100 cm of the surface and permafrost within 200 cm of the surface.

The Humic Cambisols soil unit correlates with the following soil groups in SMR: humus-accumulative muck Brownzems, grey Pale-yellows, taiga non-gleyic high-humic Peaty-muck. Not described.

Humus-accumulative muck Brownzems have the profile: O-AOA1-A1-A1h-A1Bh-BhC-C. The O horizon is formed by weakly decomposed forest litter, resulting from litter from bamboo and stone birch leaves and pine needles. The OAA1 horizon (4-5 cm) has a dark brown colour and consists of raw organic materials with additions of mineral clay particles. The A1 horizon (10-15 cm) is dark brown and consists of accumulative-muck loam with some stones and debris of quartzite rocks. It has a friable fine porous structure and contains up to 35% of well decayed organic matter, formed in situ due to strong Kuril's bamboo root decomposition. The A1h horizon (30-40 cm) has dark almost black and reddish colors, is loamy with much plant debris, and has subangular to fine granular structure. It has abundant root penetration from Kuril's bamboo, contains up to 40-43% of well decomposed organic matter, of an accumulative-illuvial origin (black, formed in situ, subangular-fine granular organo-mineral peds and rock debris, covered with organo-ferruginous films and streaks of illuvial chemical origin). The ABh horizon (10-20 cm) is transitional to the illuvial-humus one. It is a dark brown, stony loam with abundant rock debris containing up to 20% of humus. It differs from the A1h horizon by the decreasing humus accumulation process (in situ) and a significant increase in the humus illuviation process. The illuvial humus horizon Bh (15-20) is brown, sandy loam with a very fine subangular structure. Loose silt material forms sparse patches among rock debris and contains up to 2-3% of illuviated humus.

These soils are acid (pH KCL is 3.7-4.1). The cation exchange capacity in the A1 and lower mineral horizons is significantly base saturated (77-83%). It becomes much lower in the A1h and A1Bh horizons. The organic matter is fulvate; the Cha:Cfa ratio in the topsoil is 0.7-0.6. The peculiarity of these soils is the presence of two zones of humus accumulation: a zone of residual raw humus accumulation and eluviation of Al-Fe-humus compounds in O and AOA1 horizons, and a zone of black humus accumulation in situ due to bamboo root systems decomposition and humus illuviation from forest litter and raw humus horizons. The upper part of the soil profile has significantly increased clay and ferruginous material as compared with parent materials. The distribution of total and mobile oxalate-soluble forms of R_2O_3 in the soil profile increases downwards. Their maximum content is in the A1, A1h and A1Bh horizons.

These soils are formed on well-drained terrain under stone birch and mixed coniferous-stone birch forests with continuous Kuril's bamboo cover. They are widespread in West Sakhalin, Susunay, Tankino-Anivsky ridges and more rarely in the East Sakhalin ridge.

Grey Pale-yellow soils have the profile: AO-A1-B1-B2ca-C. The AO horizon is shallow (2-3 cm) and characteristically forest litter. The A1 horizon is 16-30 cm thick, a dark grey colour in the upper part and grey or greyish brown in the lower part, with loose fine subangular structure. It contains 4.5-7% humus. The B1 horizon (10-15 cm) has brown colour, is compacted and does not have carbonates. The B2ca horizon (15-25 cm) is light brown and greyish, has carbonates, fine subangular and platy structure, and platy texture ???, the porous. C horizon is from loess-like parent material with platy-leafy structure. These soils are rich in humus, nitrogen and phosphorus, have neutral reaction in the topsoil and are slightly alkaline in the subsoil. The cation exchange capacity is 25-50 cmol(+) kg-1. The dominant cation is Ca2+ (up to 55%) and the Na+ content is 4-8%.

These soils occur on specific alas complexes of central Yakutia region. These are flat depressions of various sizes ($10m^2$ to a few km^2) formed in permafrost regions where thermokarst processes take place, and usually covered by lakes, bogs or meadows.

Calcaric Cambisols (Cmc)

This soil unit occupies 5.44 million ha which corresponds to 0.33% of the land area of the country or 2.57% of the major soil grouping area.

The soils have an ochric A horizon and are calcareous at least between 20 and 50 cm from the surface; lack vertic properties¸ gleyic properties within 100 cm of the surface and permafrost within 200 cm of the surface.

This soil unit correlates with calcareous Cinnamonic, and calcareous Pale-yellow soils.

Calcareous Cinnamonic soils are similar to typic cinamonics and differ only by the presence of carbonates in the topsoil.

Calcareous Pale-yellow soils have the profile: O-A1-A1Bca-Cca. The colour of the profile is pale-yellow-brown. Effervescence from HCl is marked below humus horizon or in a B horizon.

These soils are found in the Lena-Vilyuy and Lena-Angara interstream area. They are formed under larch taiga with various grass, moss and lichen groundcover from loose calcareous loamy deposits. Polygonal cracked nano-relief is well-developed.

Chromic Cambisols (Cmx)

This soil unit occupies 1.31 million ha which corresponds to 0.08% of the land area of the country or 0.62% of the major soil grouping area.

These are soils are having an ochric A horizon and a base saturation (by NH_4O_{Ac}) of 50 percent or more at least between 20 and 50 cm from the surface but which are not calcareous within this same depth; having a strong brown to red cambic B horizon; but no ferralic properties; gleyic properties within 100 cm of the surface or permafrost.

This soil unit corresponds to typic Cinnamonic soils in SMR.

Typic Cinnamonics have the soil profile: A1-Bm-Bm,ca-Cca. The altered horizon (with a higher clay content) is clearly identified and contains carbonates in its lower part (Bm,ca). The upper horizons contain 5-8% of humus under natural vegetation. Humus penetrates deep and humus content at 1 m is 0.8-1%. The middle and lower parts of the profile are marked by a high percentage of clay. The Cation exchange capacity decreases with depth; the exchange complex is completely or almost entirely base - saturated.

These soils are formed under oak and hornbeam xerophytic forests and bush in the Krasnodar Kry and Dagestan.

Gleyic Cambisols (Cmg)

This soil unit occupies 6.69 million ha which corresponds to 0.4% of the land area of the country or 3.16% of the major soil grouping area.

These soils have gleyic properties within 100 cm of the surface but no permafrost within 200 cm of the surface.

The gleyic Cambisols soil unit correlates with gleyic and gley Brownzems, raw-humic gley Brownzems, gley Granuzems, gleyic and gley Sod-brownzems.

Gleyic and gley Brownzems have the profile: O1-AO-A1g-Bm,g,t-BmCg-Cg. They are similar to slightly unsaturated brown forest soils, but excessive moistening by surface rainfall leads to gleying of the soil profile and results in peculiarities of its morphological and physico-chemical properties. Neoformation of clay is typical for all horizons, taking place simultaneously with surface gleying. The soil profile has weak colour differentiation (vague boundaries between horizons) as well as some desaturation in bases (5-20%); slightly acid reaction; absence of leached clay particles, sesquoxides and silica dioxide redistribution; accumulative type of amorphous and crystallized iron forms distribution in the soil profile.

They are formed on slowly drained flat landscapes on loam and clay deposits in the south of the Far East.

Raw-humic gley Brownzems have the profile: O-AO-A1g-Bm,g-BmCg-C. The soil profile is characterised by weak differentiation of the soil horizons. The O horizon (5-10 cm) is distinguished by litter. A1g and Bm,g horizons have a brownish blue-grey colour with rusty and blue-grey mottles of gleying. The humus content in the A1 horizon is up to 18%. It sharply decreases downward, although it permeates the whole soil profile. The reaction is acid and base saturation of the topsoil is 60% or more. The exchangeable acidity is determined by Al. There is some redistribution of clay and amorphous and crystallized iron compounds, and their accumulation in the gleyed altered Bm,g horizon. Gleying is caused by surface waterlogging. Continuous seasonal permafrost is found in the soil..

These soils occur on flat poorly drained relief under moss-larch forests in regions where brown-Forest soils are common.

Gley Granuzems have the soil profile: O1-OA-B-BCg-Cg. They differ from Granuzems by the presence of a gley horizon beneath the structured one. Such soils are formed on very steep, depressed sites in the same areas as Granuzems.

Gelic Cambisols (Cmi)

This soil unit occupies 56.26 million ha which corresponds to 3.37% of the land area or 26.23% of the major soil grouping area.

These soils have permafrost within 200 cm of the surface. They correspond to taiga peaty-muck high-humic non-gleyic soils and gleyic and gley Sod-brownzems.

Taiga peaty-muck high-humic non-gleyic soils have the profile: O1-Bh-BhC-⊥C. The O horizon (10-20 cm) is gradually transformed into the dirty brown or grey colored Bh horizon which is significantly permeated by humus and contains plenty of partly decomposed debris. The profile is always very wet, has an acid reaction and is base-unsaturated. The iced permafrost is marked at the depth of 40-60 cm.

These soils are formed under taiga vegetation, with bush-moss ground cover, in the northern part of East Siberia.

Gleyic and gley Sod-brownzems have the profile: O-AOA1-Ag-Bg⊥. Fresh litter in the O horizon (0-5 cm thick) covers a dark brown peaty forest litter AOA1 horizon (5-20 cm). The Ag gleyed horizon (20-40 cm) has a brown colour and fine texture. It merges into brown seasonally frozen clay. The soil is identified by an acid reaction, significantly unsaturated exchange complex, absence of clay and sesquoxides differentiation down the profile, gleying of the humic horizon by the seasonal waterlogging above the permafrost. These soils are formed from fine textured deposits on flat and depressed relief in the southern and middle taiga zones.

CALCISOLS

This major grouping occupies 4.57 million ha or 0.27% of the land area of Russia (Table 3). It is widespread (Figure 2.9) particularly in the southern part of the European territory of Russia in the Kalmikya Republic.

This major soil grouping has one or more of the following: a calcic horizon, a petrocalcic horizon, or concentrations of soft powdery lime within 125 cm of the surface; it has no diagnostic horizons other than an ochric A horizon, a cambic B horizon or an argic B horizon permeated with calcium carbonate; lacks the characteristics which are diagnostic for Vertisols or Planosols; salic properties, and gleyic properties within 100 cm of the surface.

The following FAO soil units are present and the corresponding soil groups in SMR are described. (Although no Gypsisols are mapped in Russia they are common in the semi-desert zones of Central Asia.)

- Haplic Calcisols, CLh
    - Brown soils
- Luvic Calcisols, CLl
    - Solonetzic and solonchakous Brown soils.

Haplic Calcisols (Clh)

This soil unit occupies 1.75 million ha, which corresponds to 0.11% of the land area of the country or 38.37% of the area of the Calcisols major soil grouping.

These soils are characterised by having no argic B horizon nor a petrocalcic horizon; they correspond to Brown soils in SMR.

Brown (semidesert) soils have the soil profile A1-A1B-Bca-Bcs-Cs. They are characterized by weakly expressed humous horizons with a brownish colour. The A1 humous horizon, 12-15 cm thick, has a loose platy structure,. The transitional A1B horizon extends to the depth of 25-40 cm and has a brownish colour, compact consistency and coarse crumb structure. It is underlain by an illuvial-carbonate horizon, Bca (or Bca,cs), which has a whitish-brown colour, dense consistency, and nut-crumby structure. The carbonates appear in the form of irregular soft spots and powder. Effervescence begins from the depth of 15-20 cm, rarely from the surface. Soluble salts and gypsum appear in considerable quantities (Bcs horizon) at an average depth of 80-100 cm. The Brown (semidesert) soils have a low humus content (0.7-1.4%). The exchangeable cations are almost entirely calcium and magnesium with exchangeable magnesium making up 20-25%. Exchangeable sodium is found in small quantities (1-1.5% of CEC). The soil reaction is slightly alkaline (pH 7.4-7.6) in the upper horizons and alkaline (8.2-8.8) in the lower ones.

The Brown soils are widely spread in the semidesert regions in the Kalmikya.

Luvic Calcisols (Cll)

This soil unit occupies 2.82 million ha, which corresponds to 0.17% of the land area of the country or 61.63% of the area of the Calcisols major soil grouping.

These soils have an argic B horizon but no petrocalcic horizon. They correlate with solonetzic and solonchakous Brown soils.

Solonetzic and solonchakous Brown soils have the profile: A1-Bsl-Bca-Bca, cs-Bcs-Ccs. The A1 horizon (9-14 cm in thickness) has a pale brown colour, weak loose platy structure and a distinct transition to Bsl horizon. This horizon extends to the depth of 30-35 (40) cm and has clear solonetz features: coarse blocky structure, compactness, cracks. The effervescence in such soils usually appears from the depth of 18-35 (50) cm or sometimes in the topsoil. Carbonates impregnate the soil mass as a whole but can also occur as soft spots at the depth of 35-60 cm. Soluble salts and gypsum are present in considerable quantities (Bcs horizon) usually at the depth of 60-110 cm. The gypsum appears at the depth of 40-70 cm. Alkali and saline Brown soils are poor in humus (0.5-1.3%). The exchangeable magnesium is 20-25% of CEC; exchangeable sodium is present in considerable quantities (7-13% of CEC). The soil reaction is alkaline (pH 7.8-8.5) throughout the soil profile.

These soils occur in the same regions as Brown soils.

SOLONETZ

This major grouping occupies 11.16 million ha or 0.67% of the land of Russia (Table 3). It occurs in the Southern part of the European territory of Russia and the Southern part of West Siberia (Figure 2.10).

These soils have a natric B horizon. The following FAO soil units and corresponding soil groups in SMR are distinguished:

- Haplic Solonetz, Snh
  - Solonetz
- Gleyic Solonetz, SNg
  - Meadowy Solonetzes
  - Meadow-like Solonetzes

Haplic Solonetz (Snh)

This soil unit occupies 2.56 million ha which corresponds to 0.15% of the land area of the country or 22.95% of the Solonetz major soil grouping.

These soils have an ochric A horizon; and do not have stagnic properties and gleyic properties within 100 cm of the surface. They correlate with solonetzes (automorphic).

Solonetzes (automorphic) have sharply differentiated soil profile A1A2-Bsl-Bxa,(sl),(s)-(Bcs)-(Bs)-Cs. The humus-solod A1A2 horizon, above the solonetzic horizon, is grey with platy-crumby structure and varies in depth from 10 (shallow solonetz) to more than 18 cm (deep solonetz). The illuvial Solonetz Bsl horizon is brownish-grey with columnar, prismatic or nut structure, deep cracks, very hard consistency, and numerous clay skins. Its thickness varies from 6-8 to 10-15 cm. It is succeeded by the second solonetz horizon Bca,(sl),(s), or directly by a saline horizon. It usually contains soluble salts, mostly chlorides, while sulphates appear at greater depths. Gypsum appears at the depth of about 100 cm. The humus content in the humus-solod horizon is 1.5-2.5%, though it is sometimes higher in the solonetz horizon. The CEC and exchangeable Na+ content are highest in the solonetz horizon (sometimes the second solonetz horizon). Carbonates are usually right under the solonetz horizon and comprise up to 3-8%. Soluble salts appear at 40-50 cm depth beginning with chlorides (0.5%), and by the depth of 1 m the total amount of salts rises to 2.5%, and sulphates start dominating chlorides. The maximum gypsum accumulation is at a depth of 1-2 m. Such soils are found in the steppe and dry steppe zones.

Gleyic Solonetz (Sng)

This soil unit occupies 8.60 million ha which corresponds to 0.51% of the land area of the country or 77.05% of the Solonetz major soil grouping

These soils show gleyic properties within 100 cm of the surface. They correlate with meadowy and meadow-like Solonetzes.

Meadowy Solonetzes (semihydromorphic) are formed with additional moisture input, while groundwater remains at a depth of 3-6 m. They are usually in complexes with other semihydromorphic soils, but may form large individual tracts on river terraces. They differ morphologically from the Solonetz soils described above in the form of the horizons above and below the solonetzic horizon. The horizon above is usually thinner (about 10 cm) and more bleached with fine platy structure. The sub-solonetzic horizon is less dense and better aggregated due to higher salinization; the composition of soluble salts determines its colour, density and structure.

These soils are developed in the same territories as Solonetzes (automorphic).

Meadow-like Solonetz (hydromorphic) are characterised by relatively weak profile differentiation, having an faint B horizon, with undeveloped structure, that gradually merges into parent material.

These soils are formed under the influence of rather shallow ground waters (not deeper than 3 m), mineralized to various degrees, on river and lake terraces, by shores, brackish lagoons, etc., and mostly shaped as narrow bordering areas or small patches in the steppe and dry steppe zones.

SOLONCHAKS

This major grouping occupies 0.98 million ha or 0.06% of the land area of Russia (Table 3). It occurs in the same regions as Solonetzes, the southern part of the European territory of Russia and the southern part of West Siberia (Figure 2.11)

These soils are characterised by having salic properties and not having fluvic properties nor any diagnostic horizons other than an A horizon, a histic H horizon, a cambic B horizon, a calcic or a gypsic horizon.

The following FAO soil units and corresponding soil groups in SMR are distinguished:

- Haplic Solonchak, SCh
    - Typic Solonchaks
- Gleyic Solonchak, Scg
    - Meadow Solonchaks

Haplic Solonchaks (Sch)

This soil unit occupies 0.64 million ha which corresponds to 0.04% of the land of the country or 65.14% of the Solonchaks major soil grouping.

These soils have an ochric A horizon; lack gleyic properties within 100 cm of the surface and permafrost within 200 cm of the surface. They correlate with typic Solonchaks.

Typic Solonchaks have a gleyed, weakly differentiated soil profile, effervescent at the top. Groundwater is usually at 2-5 m depth. Flooding is unusual. The maximum content of soluble salts (never less than 1%) is typically in the upper 5 cm, or on the soil surface (crusts, etc.). Down the profile, the content of salts may decrease or remain constant.

The vegetation is sparse and salt resistant. These soils are formed on unflooded terraces of salt lakes, low river terraces and in the irrigated plains. Such soils are common in deserts, semi-deserts and, more rarely, the steppe zone.

Gleyic Solonchaks (Scg)

This soil unit occupies 0.34 million ha which corresponds to 0.02% of the land area of the country or 34.86% of the Solonchaks major soil grouping.

These soils show gleyic properties within 100 cm of the surface and have no permafrost within 200 cm of the surface. They correlate with meadow Solonchaks.

Meadow Solonchaks differ from typical Solonchaks by the presence of a humus-accumulative horizon in the upper part of the soil profile, related to richer meadow vegetation. The main peculiarity of meadow Solonchaks is periodical flooding with fresh water, causing the periodical leaching of salts against a general background of evaporative water movement.

Such soils are formed around brackish lagoons, on low river terraces and piedmonts in semidesert, steppe or, more rarely, desert zones.

KASTANOZEMS

This major grouping occupies 25.80 million ha or 1.54% of the land area of Russia (Table 3). It occurs in the southern parts of Russia (Figure 2.12).

These soils have a mollic A horizon with a moist chroma of more than 2 to a depth of at least 15 cm; and one or more of the following: a calcic or gypsic horizon or concentrations of soft powdery lime within 125 cm of the surface; they do not have a natric B horizon or salic properties; nor the characteristics which are diagnostic for Vertisols, Planosols or Andosols; nor gleyic properties within 50 cm of the surface when no argic B horizon is present (which would meet the definition of the mollic Gleysols).

The following FAO soil units and corresponding soil groups in SMR are distinguished:

- Haplic Kastanozems, KSh
  - Dark Chestnut
  - Chestnut
  - Light Chestnut
  - Deep dark Chestnut,
  - Deep Chestnut,
  - Deep light Chestnut
  - Leached Chestnut
- Calcic Kastanozems, KSk
  - Calcareous dark Chestnuts
- Luvic Kastanozems, KSl
  - Solonetzic and solonchakous Chestnut
  - Solonetzic and solonchakous dark Chestnut
  - Solonetzic and solonchakous light Chestnut

Haplic Kastanozems (Ksh)

This soil unit occupies 17.28 million ha which corresponds to 1.03 per cent of the land area of the country, or 66.97% of the total Kastanozems major soil grouping.

These soils are characterised by not having an argic B horizon, a calcic horizon or a gypsic horizon. The unit correlates with dark Chestnut, Chestnut, light Chestnut, deep dark Chestnut, deep Chestnut, deep light Chestnut, and leached Chestnut soils.

Dark chestnut soils have the profile A1-A1B-Bca-Bca,cs- Ccs. The A1 horizon has a dark brownish-grey colour, and powdery and fine granular structure; The A1B horizon is brownish and unevenly colored by humus (spots, linguoids). The Bca horizon is more compact, usually with prismatic-crumby structure, and white soft calcium carbonate spots. The Bca,cs is an illuvial carbonate horizon with abundant patches of $CaCO_3$ and some gypsum. The Bcs is the horizon of maximum gypsum accumulation. The Ccs is the parent material with patches of gypsum at a depth of 120-170 cm and increased contents of soluble salts. The humus content of the A1 horizon (upper 15 cm) varies within the limits of 3.0-4.5 (5.5)% in clay loams and 2-3-4.0% in sandy loams and loamy sands. The thickness of the humic layer (A1+A1B) decreases eastwards (the A1 is 25-40 cm and A1+A1B is 40-60 cm in the European part, and respectively 20-25 cm and 35-40 cm in Eastern Siberia). Effervescence starts usually in the lower part of the A1 horizon. The exchangeable cations are mainly represented by Ca_2+ and Mg_2+. The soil reaction changes from neutral (pH 7.0-7.2) in the upper horizons to alkaline (8.3-8.6) in the lower ones.

These soils are formed under dry steppe vegetation in the south of the country.

Chestnut soils have the profile: A1-B-Bca,cs-BCcs-Ccs. They differ from the dark Chestnut soils in lower humus content, in compaction, and by the prismatic structure in B and Bca horizons. In virgin and fallow soils a bleached horizon (up to 3-5 cm thick) with weak fine platy structure is common on the surface above the A1. The content of humus in the A1 horizon (upper 15 cm) varies within the limits of 2.5-3.0 (4)% in clay loams and 2.0-2.5 (3)% in sandy loams and loamy sands. Such soils develop in the southern part of the dark Chestnut soils zone.

Light Chestnut soils have the profile: A1-B-Bca-Bcs-Ccs. The A1 horizon (10 to 18 cm thick) has a brownish-grey colour, slightly stratified texture and poorly expressed crumby structure. The transitional horizon B (30-40 cm thick) has a brownish colour, compact consistency and prismatic-crumby structure. The illuvial-carbonate horizon Bca has yellowish-brown colour, very dense consistence and angular-nut structure. White soft carbonate spots usually appear at the depth of 40-60 cm. The humus content in the upper horizon is 2.0-2.5%. The exchangeable cations are mainly Ca_2+ and Mg_2+. Exchangeable sodium forms 1.5-5.0% of CEC. The soil reaction changes from slightly alkaline (pH 7.2-7.4) in the upper horizons to alkaline (8.2-8.5) in the lower ones.

These soils are developed under sparse, low, artemisia absinthum and grass steppe in the southern dry steppe sub-zone.

Deep dark Chestnut soils have the profile: A1-A1B(ca)-Bca-Bcs. They are characterised by deep penetration of humus and pseudomycelia of calcium carbonate, which already appear within the humus-accumulative horizon. White soft carbonates spots begin 30-50 cm below the lower boundary of the humous horizon. The A1 horizon, 20-30 cm thick, is greyish-brown. The thickness of the A1+A1B horizons is 50-65 cm. The humus content in the A1 horizon (or upper 20 cm) varies from 3 to 4%. The CEC is 25-30 cmol(+) kg-1 per 100g of soil. The white soft carbonate spots start at a depth of 60-70 cm, and gypsum at a depth of 150-200 cm. These soils are found in the southern regions of the European part of Russia.

Deep Chestnut (pseudomycelia) soils have the profile: A1(ca)-A1Bca-Bca-Ccs. They differ from dark Chestnut (pseudomycelia) soils by the thinner humus-accumulative horizon, lower humus content, higher position of white soft carbonates spots and gypsum. The Chestnut pseudomycelia soils have a 20 cm thick A1 horizon and the thickness of A1+A1B horizons is 30-50 cm. The humus content in the A1 (or upper 20 cm) horizon varies from 2.8 to 3.4%. Effervescence occasionally appears from the surface but usually from 30-50 cm. Gypsum is encountered from the depth of 130-200 cm.

These soils are developed mainly in the eastern Pre-Caucasus.

Deep Light Chestnut (pseudomycelia) soils have the profile: A1ca-A1Bca-Bcs-Ccs. The A1 horizon does not usually exceed 18 cm. The lower boundary of the transitional A1B horizon is at 40-45 cm. White soft carbonates spots start at the depth of 55-65 cm. The pseudomycelia of carbonates are not abundant and appear at the depth of 30-40 cm. Effervescence usually begins from the soil surface and gypsum and soluble salts from the depth of 110- 130 cm. The humus content in the A1 horizon is 2.0-2.5%. The exchangeable cations are mainly Ca+ and Mg_2+. Exchangeable sodium is 1.5-5.0 % of CEC. The soil reaction changes from slightly alkaline (pH 7.4-7.6) in the upper horizons to alkaline (8.4-8.6) in the lower ones.

These soils are formed from clay loam and clay parent materials in the Pre-Caucasus.

Leached Chestnut (powdery-lime) soils have the profile: A1(ca)-A1Bca-Cca. They are characterised by the very shallow A1 horizon (8-30 cm) and especially of the A1B horizon (5-10 cm) and the shallow depth (15-30 cm from the surface) to carbonates in the form of soft powdery lime in the fine earth and encrustations on the lower surfaces of stones. They lack both gypsum and soluble salts throughout the soil profile. The effervescence starts from a depth of 15-20 cm, sometimes from the surface. The humus content in the A1 horizon is usually 1.2-3.0%. The exchangeable ions are predominantly Ca_2+ and Mg_2+. Exchangeable sodium is 1-3% of total exchangeable bases. The soil reaction is alkaline throughout the profile (pH 7.8-8.5). Such soils occur in the Trans-Baikal and Tuwa regions.

Calcic Kastanozems (Ksk)

The soil unit occupies 0.15 million ha which corresponds to less than 0.01% of the land area of the country or to 58% of the total Kastanozems major soil grouping area.

These soils have a calcic horizon and no argic B or gypsic horizons.

The calcic Kastanozems soil unit correlates with calcareous dark Chestnut soils.

Calcareous dark Chestnut (including residual calcareous) soils have the profile: A1-A1Bpca-Bpca-Cpca-Dca or A1ca-A1Bca-Bca-Cca,cs. These soils have carbonates in the upper 20 cm. Residual calcareous soils inherit carbonates from calcareous gravel and stones included in the parent material. The soils are characterised by weak structure. Calcareous soils have cracks on the soil surface and blocky structured B horizons. Morphological features of carbonates are not apparent. These soils contain carbonates and remain calcareous because the fine clay texture decreases the leaching processes.

Both soils are formed in the sub-zone of dark Chestnut soils on calcareous loose deposits or, more frequently, hard limestone rocks.

Luvic Kastanozems (Ksl)

This soil unit occupies 8.37 million ha which corresponds to 0.50 of the land area of the country or 32.5% of the Kastanozems major soil grouping.

These soils have an argic B horizon and do not have a gypsic horizon. They correspond to solonetzic and solonchakous dark Chestnut, Chestnut and light Chestnut soils.

Solonetzic and solonchakous dark Chestnut soils have similar soil profiles to dark Chestnut soils. However, some morphological features of solonetz soils can be recognized in these soils (compaction, nut-crumby or prismatic structure of the Bsl horizon, etc.) The content of exchangeable sodium exceeds 5%, and the content of soluble salts at the depth of 50 to 150 cm is higher than in dark Chestnut soils.

These soils are formed from saline deposits in the sub-zone of dark Chestnut soils.

Solonetzic and solonchakous Chestnut soils differ from the typical Chestnut soils by the presence of soluble salts within the upper 50 cm of the profile.

These soils are formed from saline deposits in the regions of Chestnut soils.

Solonetzic and solonchakous Light Chestnut soils differ from the light Chestnut soils by stronger differentiation of horizons. The A1 humus horizon (8-12 cm thick) has a light-brown colour, with fine banded structure. It is underlain by the Bsl horizon (30-40 cm thick), with brownish-yellow colour, compact consistency and prismatic structure with cracks. The Bca horizon (35-50 cm thick) has a whitish-yellow colour, very compact consistency, nut structure and pronounced white spots of soft carbonates. There are considerable quantities of soluble salts and gypsum at a depth of 60-100 cm. The humus content in the A1 horizon is 1.5-2%. The main exchangeable cations are Ca_2+ and Mg_2+. Exchangeable sodium is 5-10% of CEC. In spite of the low sodium content, solonetz properties are clearly identified morphologically.

These soils are formed from saline deposits in the subpoena of light Chestnut soils.

CHERNOZEMS

This major grouping occupies 99.71 million ha or 5.97 of the land area of Russia (Table 3). It occurs in the southern parts of the European territory of Russia, West Siberia and Zabaikalye (Figure 2.13).

These soils have a mollic A horizon with a moist chroma of 2 or less to a depth of at least 15 cm; a calcic horizon or concentrations of soft powdery lime within 125 cm of the surface, or both; and do not have a natric B horizon, the characteristics which are diagnostic for Vertisols, Planosols or Andosols, salic properties, gleyic properties within 50 cm of the surface when no argic B horizon is present[1], or uncoated silt and quartz grains on structural ped surfaces.

The following FAO soil units are recognized and the corresponding soil groups in SMR are indicated.

- Haplic Chernozems, Chh
    - Typic Chernozems
    - Ordinary Chernozems
    - Non-calcareous, deep-effervescing, Chernozems on coarse parent material
    - Leached deep Chernozems
    - Washed Chernozems
- Calcic Chernozems, CHk
    - Southern Chernozems
    - Southern and ordinary mycelial-calcareous Chernozems
    - Residual-calcareous Chernozems
- Luvic Chernozems, CHl
    - Leached Chernozems
    - Solonetzic Chernozems
- Glossic Chernozems, CHw
    - Leached glossic Chernozems
    - Ordinary glossic Chernozems
    - Southern glossic Chernozems
- Gleyic Chernozems, CHg
    - Meadow-chernozemics

[1] Gleyic properties present within 50 cm of the surface in the absence of an argic B horizon meet the definition of the Mollic Gleysols.

Haplic Chernozems (Chh)

This soil unit occupies 30.41 million ha which corresponds to 1.82% of the land area of the country or 30.50% of the Chernozems major soil grouping.

These soils are characterised by not having an argic B horizon, a calcic horizon, or tonguing of the A horizon into a cambic B or into a C horizon.

The FAO haplic Chernozems soil unit correlates to typic and ordinary Chernozems, deeply-effervescing and non-calcareous Chernozems on coarse parent material, leached deep, and washed Chernozems..

Typical Chernozems have the profile: A1-A1Bca-Bca-BCca-Cca. The humus horizons are subdivided into two parts: The A1 is dark grey or black, and has granular or subangular-granular structure. Its humus content is 8-12%, mostly a calcium-humate complex. The reaction is 6.5-7.0 increasing downward. The A1Bca is a browner colour with larger peds. Bleached skeletons are usually absent. The Bca horizon is identified by a variable straw-yellow colour with grey mottles and tongues. It has a coherent structure and maximum of secondary (accumulated) carbonates. The lower part of the A1 or A1B horizons are effervescent. Calcareous accumulations appear in the form of mould, mycelia and veins and below 200 cm depth as loess dolls. There are many mole burrows and sometimes general soil profile perturbation. The cation exchange capacity is 35-60 cmol(+) kg-1. There is no differentiation in distribution of either the clay fraction or the sesquioxides in the soil profile.

These soils occur in meadow steppes and southern forest-steppe zones, mostly under arable cultivation.

Ordinary Chernozems have the profile: A1-A1Bca-Bca-BCca-Cca-Cs. They are similar to typical Chernozems, but have a lower humus accumulation and higher carbonate content and salts in the deeper part of the soil profile. Effervescence appears in the humus horizon (A1 and A1B), white soft carbonate spots in the B horizon, and soluble salts and gypsum at a depth of 300-500 cm. The humus is calcium-humate. The reaction is neutral and the cation exchange capacity is 35-55 cmol(+) kg-1. The distribution in the profile of clay and sesquioxides is undifferentiated.

These soils are formed under cereals or various grasses, often cultivated steppes.

Non-calcareous, deep-effervescing, Chernozems have the following soil profile: A1-A1B-B-C-(Cca). The humus horizon is thick, grey, with a coherent subangular structure, and without bleached skeletons. The calcareous horizon is absent or situated below 200 cm. The humus content is low (3-5%), cation exchange capacity is also low (up to 20 cmol(+) kg-1) and the reaction is about neutral in all the profile. (Note that these soils are not FAO Chernozems or Phaeozems, which must have a calcic horizon. They are an inclusion in the haplic Chernozems and are probably eutric Cambisols or haplic Luvisols.)

They are formed on coarse parent material or stony parent rocks in various grasses and cereals steppes.

Deep leached Chernozems (syn. leached mycelia carbonate Chernozems) have the profile: A1-A1B-Bt,z-BCca,Z-Cca. The thickness of the humus horizon varies from 80 to 120 cm. The humus content is 4-7%. These soils are characterised by the distinct clay increase in the B horizon (like the luvic Chernozems) and the abundant carbonate pseudomycelia. There are numerous deep animal burrows. The soil reaction of the topsoil is slightly acid or nearly neutral (pH 6.2-6.8) and the subsoil is slightly alkaline. Effervescence starts from 100-160 cm. The cation exchange capacity is 40-50 cmol(+) kg-1.

These soils occur in the Precaucausian plains and the south-west part of the European part of Russia.

Washed Chernozems (syn. Chernozems carbonate-impregnated, including leached, typical, ordinary and southern) have the profile: A1-A1B(ca)-Bca-Cca. The humus horizon is comparatively thin (30-45 cm), brown-colored with a weakly expressed structure. A calcareous horizon is always present, but its depth varies significantly (from 20 to 120 cm) over short distances. Carbonates penetrate uniformly in solution to impregnate the whole soil, resulting in a pale colour. Soluble salts and gypsum are usually absent. The humus content is 4-7%, with a Cha:Cfa ratio near 1. The reaction of the humus horizon is close to neutral (6.0-7.0) but when the calcareous horizon lies deep, the reaction decreases to 4.5-5.0 in the middle part of the profile (such soils do not fit the definition of an FAO Chernozem but are an inclusion).

These soils are formed outside the normal Chernozem zone in intermontane depressions of the steppe zone of Eastern Siberia.

Calcic Chernozems (Chk)

This soil unit occupies 26.48 million ha which corresponds to 1.59% of the land area of the country or 26.56% of the total Chernozems major soil grouping.

These soils are characterised by having a calcic horizon; no argic B horizon overlying the calcic horizon; and no tonguing of the A horizon into a cambic B or into a C horizon.

The calcic Chernozems soil unit correlates with southern Chernozems, southern ordinary mycelial-calcareous Chernozems, and residual-calcareous Chernozems.

Southern Chernozems have the profile: A1ca-A1Bca,sl-BCs-Cs. They have a thinner humus horizon as compared to ordinary Chernozems. The humus content (in the A1) is 3-6%. Effervescence begins in the A1 horizon or on the surface. Carbonate concretions are in the form of white soft spots. There are some features of the solonetz process, resulting in prismatic blocky subangular structure. Traces of gypsum and easily-soluble salts appear at a depth of 150-300 cm. The reaction is nearly neutral or slightly alkaline and the cation exchange capacity is 35-40 cmol(+) kg-1.

These soils occur in various dry grass-and-cereal steppes, often under arable cultivation.

Southern ordinary mycelial-calcareous Chernozems have the profile: A1ca,z-A1Bca,z-BCca,z-Cca. The humus horizon is 60-100 cm thick, with a low humus content (3-6%). Some stratification is common in the upper part of the humus horizon. Effervescence starts in the A1 horizon, sometimes from the surface. Abundant carbonate pseudomycelia are usual in the A1ca,z horizon, sometimes with white soft carbonate spots below. Usually neither gypsum nor soluble salts are present. The reaction is neutral or slightly alkaline. The cation exchange capacity is 30-45 cmol(+) kg-1. There are numerous animal burrows.

These soils are formed under various grasses or cereals, usually cultivated, on the Precaucasian steppes and also in some southern areas of the European part of Russia.

Residually calcareous Chernozems have the profile: A1pca-A1Bcap-Bcap-Ccap. They are shallow, their depth depending on the thickness to which the hard limestone rocks have been weathered. They have a thin humus horizon and effervescence at the surface. The presence of calcareous rock fragments is typical.

They are formed in foothills in some regions of southern Russia.

Luvic Chernozems (Chl)

This soil unit occupies 27.51 million ha which corresponds to 1.65 % of the land area of the country or 27.59% of the total Chernozems major soil grouping. The soils are characterised by having an argic B horizon. A calcic horizon may underlie the B horizon and there are no gleyic properties within 100 cm of the surface.

The luvic Chernozems soil unit corresponds to leached Chernozems and solonetzic Chernozems

Leached Chernozems have the profile: A1-A1B-Bt-Bca-Bcca-Cca (very similar to the podzolized Chernozems, but characterised by a weaker degree of differentiation). The humus horizon is subdivided into two subhorizons: A1, that is dark grey or black with a granular structure (it is coarse subangular when ploughed) and A1B, which is browner and has larger peds. Less lightening of the colour, as compared with podzolized Chernozems, is usual in all humus horizons. Especially noticeable in dry soil are the bleached skeletons covering the peds. The Bt horizon has features of clay and sesquoxides illuviation, dark brown colour, well-defined blocky subangular structure, and also often dark films on the ped surfaces. It is compact and does not contain carbonates. These soils do not have a carbonate horizon if formed on non-calcareous parent rocks. The cation exchange capacity is 25-45 cmol(+) kg-1 and almost entirely base-saturated. The reaction is usually higher than that of podzolized Chernozems. (5.8-6.8). The mineral components are not stable and there is evidence of sesquoxides migration and distinct clay redistribution in the soil profile, detected by micromorphological analysis.

These soils occur in meadow and northern forest-steppe zones and are mostly cultivated.

Solonetzic Chernozems have the profile: A1-A1Bslca-Bsl,ca-Cca. They have solonetzic features in the humus horizon A1 (the content of exchangeable Na+ is more than 5% of cation exchange capacity) and distinct compaction (and sometimes stratification) in the upper part or, more often, in A1Bsl or Bsl horizons. Solonetzic process also appear as prismatic-blocky subangular structure, especially evident when dry. A weak clay and sesquioxides soil profile differentiation can be detected analytically. In some places the solonetzic horizon lies above the gypsum horizon (deep-solonetzic Chernozems). Sometimes morphological, physical features of solonetzic processes are due to increased exchangeable Mg+ (more than 25% of the cation exchange capacity) when the exchangeable Na+ content is low (less that 5%). So-called residually solonetzic Chernozems are usually combined with solonetzic Chernozems. These soils have features of solonetzic processes but a low content of exchangeable Mg+ and Na+. They occur in the southern part of West and East Siberia.

Glossic Chernozems (Chw)

This soil unit occupies 8.44 million ha which corresponds to 0.51% of the land area of the country or 8.47% of the total Chernozems major soil grouping area.

These soils are characterised by showing tonguing of the A horizon into a cambic B horizon or into a C horizon; and by lacking an argic B horizon.

The Glossic Chernozem soil unit corresponds to leached glossic, ordinary glossic, and southern glossic Chernozems.

Leached glossic Chernozems have the profile: A1-A1B-A1B/B-BCca-Ccs. The humus horizon (A+AB1) is 35-60 cm thick with a pocket-like or tongued lower boundary. The lower part of the humus horizon (30 -60 cm) is effervescent. Calcareous accumulations are in the form of veins and occur at the depth of 70-90 cm or, more rarely, deeper. A horizon of white soft carbonate spots occurs in Chernozems of the foothills at the depth of 125 cm or more. Gypsum occurs sporadically at the depth of 200-250 cm. The humus content in the A1 horizon is 7-9%, sharply decreasing downward. The amount of humin is very high (up to 50%). The reaction is neutral and becomes slightly alkaline downward. The cation exchange capacity is about 50 cmol(+) kg-1.

These soils are formed under various grasses and cereals, commonly cultivated land, on the steppes of West and Middle Siberia.

Ordinary glossic Chernozems have the profile: A1-A1Bca-A1Bca(Bca)-BCca-Cca. Humus horizons (A+AB1) are 36-60 cm thick with the lower boundary pocket-like or tongued, and effervescent in the lower part. (30-60 cm). Calcareous accumulations in the shape of veins or penetrations start at the depth of 70-90 cm. Tongued Chernozems of foothills have a horizon of white soft carbonate spots at the depth of 125 cm or more. Gypsum appears at the depth of 200-250 cm. The humus content of the A1 horizon is 7-9% and decreases downward. The humus composition is identified by a high content of humin (up to 50%). The soil reaction in the upper part of the humus horizon is neutral and becomes slightly alkaline downward. The cation exchange capacity is about 50 cmol(+) kg-1.

These soils are formed under various grasses and cereals, mainly arable land on the steppes of West and Middle Siberia.

Southern glossic Chernozems have the profile: A1-A1Bca,sl-A1Bca,sl/Bca,sl-BCca,sl-C. The humus horizon is shallow (25-45 cm) with a tongued and pocket-like lower boundary. Tongues and pockets reach the depth of 100 cm. The macrostructure is weakly expressed, typically with high microaggregation simultaneously present. Effervescence starts from the depth of 20-40 cm, but much deeper in tongues and pockets. Calcareous accumulations in the form of infiltrated patches, veins and sometimes white soft carbonate spots occur at 35-40 cm or deeper. A gypsum horizon lies at the depth of 150-200 cm. Weak solonetzic features are present in the lower part of the humus and AB horizons, including compaction, subangular- and angular-blocky structure, a slight increase of clay content and some exchangeable Na+ (1-2% of the exchangeable cations). The humus content in the A1 horizon is 4-6% and decreases downward, decreasing gradually in tongues and pockets. The humus composition is identified by a low Cha:Cfa ratio and a high content of humin. The reaction is neutral and becomes alkaline downward. The cation exchange capacity is 15-45 cmol(+) kg-1.

These soils occur under various sparse grasses and cereals and on cultivated steppes of West Siberia.

Gleyic Chernozems (Chg)

This soil unit occupies 6.85 million ha which corresponds to 0.41% of the land area of the country or 6.87% of the total Chernozems major soil grouping..

The soils have an argic B horizon and gleyic properties within 100 cm of the surface. This unit correlates with Meadow-chernozemic soils

Meadow-chernozemics have the profile: A1-A1B-Bca-Cca(Cca,g), which is similar to those of Chernozems. The humus horizon (A1) is dark grey colored, loose, with granular (or subangular-granular) structure. It merges into the AB horizon, which has a dark grey brownish colour and coarse granular or subangular blocky structure. Effervescence starts in the lower part of the humus horizon. The combined thickness of humus horizons is from 35 to 70 cm with high humus content in upper horizons (up to 17%), sharply decreasing downward. A weakly developed illuvial-carbonate Bca horizon lies below. It is underlain by calcareous parent rock, sometimes with gleying features. These soils differ from automorphic Chernozems by their increased humus content and deep gleying. The last relates to excessive surface or surface and groundwater, generally at the depth of 2.5-5.0 (7) m. The deep gleying may be poorly developed.

These soils are developed on undrained plains of terraces above floodplains, on the lower part of slopes and in closed depressions, under meadow-steppe vegetation in the Chernozem zone or under deciduous forests in the northern forest-steppe zone.

PHAEOZEMS

This major grouping occupies 19.41 million ha or 1.16% of the land area of Russia (Table 3). It occurs particularly in the Southern part of Western Siberia (Figure 2.14).

The soils have a mollic A horizon and a base saturation (by NH_4O_{Ac}) which is 50 percent or more throughout within 125 cm of the surface; they have no calcic horizon, gypsic horizon, concentrations of soft powdery lime; ferralic B horizon; natric B horizon; nor the characteristics which are diagnostic for Vertisols, Nitisols, Planosols or Andosols; nor salic properties; gleyic properties within 50 cm of the surface when no argic B horizon is present2; nor uncoated silt and sand grains on structural ped surfaces when the mollic A horizon has a moist chroma of 2 or less to a depth of at least 15 cm.

This major soil grouping does not have analogues in Russian soil classification. The following FAO soil units have been identified and the corresponding soil groups in SMR are described.

- Haplic Phaeozems, PHh
  - Leached Meadow-chernozemics
  - Meadow-chestnuts
- Luvic Phaeozems, PHl
  - Podzolized Chernozems
  - Solonetzic and solonchakous Meadow-chernozemics
  - Solonetzic Meadow-chestnuts
- Gleyic Phaeozems, PHg
  - Meadow-chernozem-like "Amur prairie"
  - Calcareous Meadow-chernozemics

Haplic Phaeozems (Phh)

This soil unit occupies 0.96 million ha which corresponds to 0.06% of the land area of the country or 4.95% of the total Phaeozems major soil grouping.

These soils are characterised by being non-calcareous from 20 to 50 cm of the surface; not having an argic B horizon nor gleyic properties within 100 cm of the surface nor stagnic properties.

The haplic Phaeozem soil unit corresponds to leached Meadow-chernozemics and Meadow-chestnut soils.

Leached Meadow-chernozemic soils have the profile: A1-A1B-B-Bca-Cca(Cca,g). They have a non-calcareous B horizon, with neutral reaction, lying between the humus horizon and the upper boundary of the calcareous horizon.

They are formed on fine-textured deposits under an intensive percolating water regime in a Chernozem zone.

Meadow-chestnut soils have the profile: A1-B-Bca-Cca (Cca,g). The A1 horizon (20-25 cm thickness) has sod in the upper part, has a dark-grey colour and loose consistency. The B horizon (10-50 cm thick) has a brownish colour, with humus tongues. The Bca has a whitish-brown colour, prismatic structure and is 50-70 cm thick. The parent material is made up of calcareous, sometimes gleyic, deposits. These soils are characterised by a high humus content (4-6%, sometimes more than 8%) in the A1 horizon which gradually decreases with depth. The soil reaction changes from neutral in the upper horizons to alkaline in the lower ones. The CEC is 25-30 cmol(+) kg-1 per 100 g of soil in the humus horizon. Exchangeable sodium occupies about 2% of the CEC.

These soils are dispersed among Chestnut and light Chestnut soils. They are formed in depressions (flat ditches, gullies, etc.) under the influence of excessive surface wetting and sometimes with a rather high groundwater table (2.5-7.0 m).

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[2] Gleyic properties present within 50 cm of the surface in the absence of an argic B horizon meet the definition of the Mollic Gleysols.

Luvic Phaeozems (Phl)

This soil unit occupies 17.62 million ha which corresponds to 1.05% of the land area of the country or 90.77% of the Phaeozems major soil grouping.

These soils have an argic B horizon and do not have gleyic properties within 100 cm of the surface, nor stagnic properties.

This soil unit correlates with podzolized Chernozems, solonetzic and solonchakous Meadow-chernozemic soils, solonetzic Meadow-chestnut soils.

Podzolized Chernozems have the profile: A1-A1B-Bt-Bca-Bcca-Cca. The humus horizon is subdivided into two subhorizons: an A1, that is dark grey or black with a granular structure (or coarse subangular when ploughed) and A1B, that is browner and has larger peds. Abundant bleached skeletons cover the peds. The Bt horizon has features of clay and sesquoxides illuviation, dark brown colour, well-defined blocky subangular structure, and also often dark films on the ped surfaces. It is compact and does not contain carbonates. The thickness of the non-calcareous and humusless layer is not less then 40-50 cm. The calcareous Bca horizon beneath has carbonate accumulations modifiers in the form of veins. The BCca horizon often has patches of carbonates and concretions. The calcareous horizon may be absent in soils developed on non-calcareous parent rocks, which are therefore inclusions of other soil groupings. The humus content in the A1 horizon varies significantly (5-12%) and has calcium-humate composition, which varies down the profile. The reaction is slightly acid (pH 5.5-6.5) in the topsoil but it is usually neutral or slightly alkaline in the subsoil. The lowest pH value is found below the humus horizon. The cation exchange capacity is almost entirely base saturated, but, nevertheless, some exchangeable H may be present in the B horizon. The sum of exchangeable bases is 20-40 cmol(+) kg-1 and hydrolytic acidity usually is not more than 5-7 cmol(+) kg-1. There is a consistent but weak eluvio-illuvial differentiation of the soil profile.

These soils occur in meadow steppes, mostly cultivated, in the northern forest-steppe zone.

Solonetzic and solonchakous Meadow-chernozemic soils have the profile: A1-A1Bsl,ca-Bsl,ca-Cca(g). They are identified by the presence of either a solonetz horizon with more than 5% of exchangeable Na+, or soluble salts, or both, at the depth of 30-80 cm.

These soils are in the south of West and East Siberia.

Solonetzic Meadow-chestnut soils have the soil profile: A1-A1Bsl-Bca-BCca(cs)-Ccs(g). They differ from the Meadow-chestnut soils by the presence of a prismatic A1Bsl horizon, where the content of exchangeable sodium exceeds 5%. Soluble salts are frequent at the depth of 50 cm. Sometimes, salinization is not accompanied by the formation of a solonetz horizon. These soils also have a lower humus content than the Meadow-chestnut soils.

These soils are formed with less influence of surface wetting and with rather shallow saline ground waters (3-5 m deep). Solonetzic Meadow-chestnut soils are usually in depressions among Chestnut soils.

Gleyic Phaeozems (Phg)

This soil unit occupies 0.83 million ha which corresponds to 0.05% of the land area of the country or 4.28% of the total Phaeozems major soil grouping.

These soils show gleyic properties within 100 cm of the surface.

The gleyic Phaeozems soil unit correlates with Meadow-chernozem-like Amur prairie soils and calcareous Meadow-chernozemic soils.

Meadow-chernozem-like Amur prairie soils have the profile: AO-A1n-A1Bt,n-Bt,g,n-BCg,n,t-Cg. The AO horizon is 7-12 cm thick. Below it is the A1 horizon (10-50 cm), black, with granular or fine subangular-granular structure, containing iron concretions. The humus colour becomes lighter downward, disappearing at the depth of 60-80 cm, the structure becomes curdled, and in a lower part caviar-like, with distinctive features of gleying (blue-grey and rusty mottles). The amount of concretions decreases downward. Carbonates and easily-soluble salts are absent from the soil profile. Bleached quartz skeletons are maximal in the middle part of the soil profile, which is characterised by the highest content of clay. The SiO_2: Al_2O_3 ratio and SiO_2: Fe_2O_3 are almost uniform throughout. The content of humus in the A1n horizon varies from 5 to 8-10% and gradually decreases downwards. The Cha:Cfa ratio in this horizon is 1.9- 2.3; the fulvic acids increase relatively with depth. The soil reaction is slightly acid (pH 5.9-6.3). Base saturation is 98-99%, and the sum of exchangeable cations in the humus accumulative horizons is 27-46 cmol(+) kg-1 , while in the Bt,g,n horizon it goes down to 23-26 cmol(+) kg-1. These soils are characterised by deep seasonal freezing to the depth of 2-3 m, and the complete thawing happens only in mid-August. The profile frequently contains surface waters.

These soils are formed under meadow-steppe vegetation with brush, in poorly drained plains, on heavy-textured deposits with deep ground water (more than 10 m), in a monsoon continental climate. They occur in the southern plains of the Amur River basin, especially the Zea-Boorea plain.

Calcareous Meadow-chernozemics have the profile: A1ca-A1Bca-Bca-Cca-Cca(g). They are identified by effervescence from the surface.

These soils are basically developed from fine-textured (clayey) parent rocks or in outlying parts of depressions in a Chernozem zone.

GREYZEMS

This major grouping occupies 44.96 million ha or 2.69% of the land area of Russia (Table 3). It occurs particularly in the southern part of Western and Eastern Siberia (Figure 2.15).

These soils have a mollic A horizon with a moist chroma of 2 or less to a depth of at least 15 cm, uncoated silt and sand grains on structural ped surfaces; and an argic B horizon; they do not have characteristics which are diagnostic for Planosols.

The following FAO soil units are mapped and the corresponding soil groups in SMR are described.

- Haplic Greyzems, GRh
    - Brownish-dark-grey Forest
    - Dark-grey Forest
    - Residual-calcareous grey Forest
    - Grey Forest
    - Non-podzolized grey Forest
    - Grey Forest with a second humic horizon
    - Solodic grey Forest
- Gleyic Greyzems, GRg
    - Gleyic and gley grey Forest

Haplic Greyzems (Grh)

This soil unit occupies 44.54 million ha which corresponds to 2.67 % of the land area of the country or 99.06% of the total Greyzems major soil grouping.

These soils are identified by their lack of gleyic properties within 100 cm of the surface.

The haplic Greyzems soil unit correlates with brownish-dark-grey Forest, dark-grey Forest, residual-calcareous grey Forest, grey Forest, non-podzolized grey Forest, grey Forest with a second humic horizon, and solodic grey Forest soils.

Brownish-dark-grey Forest soils have the profile: A1-AB(A1A2)-Bt-BtC-Cca(C). The sequence of the soil horizon is similar to dark grey Forest soils. They differ from them by pronounced brown hue of the soil profile and greater clay accumulation in the Bt horizon.

These soils are found in the northern Caucasus.

Dark-grey Forest soils have the profile: A1-AB(A1A2)-Bt-BtC-Cca(C). They are identified by a dark (dark-grey) humus horizon (25-30 cm thick) with granular structure. The soil profile differentiation is weak. Podzolization appears as bleached fine material present in a lower part of the humus horizon. An A1A2 horizon is usually absent whereas the AB horizon is present. The illuvial horizon has fine blocky subangular friable structure and sometimes films of humus on peds. The soil reaction is slightly acid or sometimes neutral in the topsoil, and neutral or alkaline in the subsoil. The humus content is 5-12% with calcium-humate composition. The amount of humic acid fractions linked to Ca_2+ often increases downward. Textural and total chemical composition differentiation is weak.

Such soils are formed in the southern part of the forest and forest-steppe zones.

Residual-calcareous grey Forest soils have the profile: A1-A1/A2-Bt(Bt,ca)-BCca-Cca(Ccap). Effervescence is marked in the Bt horizon.

These soils are found southward and eastward from Kazan City in the south-eastern part of the Russian plain. They are formed from calcareous parent rocks (often solid rock).

Grey Forest soils have the profile: A1- A1A2(A2B)-Bt-BtC(BtCca)-C, which is less differentiated than the light-grey Forest soils, from which they differ by the darkness and thickness (15-25 cm) of the humus horizon. The A1 horizon is grey with granular structure. The podzolized A1A2 or A2B horizons are less well expressed in colour and structure than those of the light-grey Forest soils. These horizons have a fine subangular structure with bleached fine material and humic bright films on ped surfaces (these films are usually absent in the forest-steppe "islands" of Middle Siberia). Carbonates appear deeper than one meter in various forms of accumulation. The reaction of the topsoil is slightly acid or acid, and becomes most acid in the illuvial horizon. The humus content in the A1 horizon is 4-8%. The humus has humic acids of the second fraction linked with Ca_2+. Accumulation of exchangeable base cations is evident in the humus horizon. The eluvio-illuvial differentiation of texture and total chemical composition is less marked compared with light-grey Forest soils.

These soils are formed under broad-leaved and narrow-leafed forests and in the forest-steppe zone.

Non-podzolized grey Forest soils have the profile: O-A1-AB-B-BC-C(ca). They do not have morphological and analytical features of podzolization. The O horizon is 4-6 cm thick and consists of forest litter. The A1 horizon (10-25 cm) is dark grey and contains about 5-14% of organic matter with a prevalence of humic acids. The AB horizon has greyish brown or dark brown colour, fine subangular-blocky angular structure with no evidence of podzolization. The B horizon is recognized by its compaction and friable blocky subangular structure. The reaction is slightly acid to acid in the topsoil and neutral or slightly alkaline in the subsoil.

These soils are formed from loamy often enriched parent materials and rocks under birch, larch-birch and larch forests with grasses, on the border between forest-steppe and southern taiga. They also occupy relief depressions in the intermontane steppe of Middle Siberia and the Trans-Baikal region.

Grey Forest soils with a second humic horizon have the profile A1-A1A2(A2Bh)-Bt-BtCca(BtC)-Cca. The profile differentiation is less distinct but horizon A2Bh is clearly expressed. Features of gleying (diffusive ochre and blue-grey mottles) occur in the lower part of deep gleyed variants of these soils.

These soils occur in the same territories as grey Forest soils.

Solodic grey Forest soils have a profile similar to the grey Forest soils: A1-A1A2(A2B)-Bt-BtCca(BtC)-Cca. A morphological feature that differs from grey Forest soils is the presence of a carbonate horizon close to the surface, usually less than one meter deep. Solodized grey Forest soils with a second humus horizon have a dark grey humus horizon in the lower part of the A1 or beneath the A1A2 horizon. The distinctive features of solodized grey Forest soils is accumulation of amorphous quartz (silica dioxide soluble in 5% alkaline extraction) in the topsoil and the presence of exchangeable Na+ up to 2% of the cation exchange capacity.

These soils are developed under birch and pine forests of the southern taiga and forest-steppe zones. They are common on elevated positions of the relief, such as the tops of small ridges, and also occur around the periphery of depressions.

Gleyic Greyzems (Grg)

This soil unit occupies 0.42 million ha which corresponds to 0.03% of the land area of the country or 0.94% of the Greyzems major soil grouping.

These soils have gleyic properties within 100 cm of the surface. They correlate with gleyic and gley grey Forest soils.

Gleyic and gley grey Forest soils have the profile: A1-A1A2-(A2Bh)-Bt,g-BtCg-Cg. They differ from grey Forest soils by the greater thickness and humus content of their A1 horizon, the weak podzolization processes (even including unpodzolized variants), and the usually weakly developed gley features in the B, BC, and C horizons. The gley grey Forest soils, formed under the influence of groundwater, have a pronounced gley horizon. Both soils occur among grey forest soils in depressions of the relief and on lower parts of slopes.

PLANOSOLS

This major groupings occupies 2.26 million ha or 0.14% of the land area of Russia (Table 3). It occurs in the Southern part of the Far East (Figure 2.16).

These soils have an E horizon with stagnic properties in at least part of the horizon, abruptly overlying a slowly permeable horizon within 125 cm of the surface, and without a natric or spodic B horizon.

This major soil grouping does not have an analogue in the soil classification of Russia. The following FAO soil units are recognized and corresponding soil groups of SMR are described.

- Eutric Planosols, PLe
  - Solods
- Mollic Planosols, PLm
  - Solodic Chernozems
  - Solodic Meadow-chernozemics
  - Differentiated (and solodic) Meadow soils

Eutric Planosols (Ple)

This soil unit occupies less than 0.01 million ha which corresponds to less than 0.01% of the land area of the country or less than 0.01% of the total Planosols major soil grouping.

These soils have an ochric A horizon and a base saturation (by NH_4O_{Ac}) of 50 percent or more throughout the slowly permeable horizon within 125 cm of the surface; and do not have permafrost within 200 cm of the surface. They correlate with Solods.

Solods have both chemically and morphologically well-differentiated soil profiles: O-AO-A1-A2-A2Bn-Bt, n-Bca, t-Cca(s). The O or AO horizons overlie a dark-grey nut-granular A1 horizon, which gradually passes into a bleached whitish A2 horizon (sometimes with iron oxide nodules) with fine platy structure. In the lower part, this horizon becomes more compact and the amount of ferruginous concretions increases. The thickness of the solodic A2 horizon varies from 2 to 25 cm. It is formed of primary minerals completely denuded of clay material, partially cemented by iron hydroxides.

The grey-brownish A2Bn horizon is mottled and displays alternations of microzones enriched and poor in clay and iron. The horizon contains a large quantity of ferruginous nodules and thick layered clay skins. The Bt,n horizon is brownish, dense, enriched with iron and manganese. Clay skins are common in the pores and on aggregate facets. The maximum amount of clay skins is present in the middle of this horizon. Here they have a complex layered composition: silt-clay, ferruginous-clay, clay-humus. Density, and clay content, are higher in the lower part of the Bt,n horizon, while the iron and manganese accumulations are succeeded by calcareous concretions (Bca,t horizon). The B horizon gradually passes into parent material C. The lower part of the soil profile is under the constant influence of mineralized groundwater solutions. The humous and solod horizons have slightly acid or neutral pH. The lower horizons have a neutral or alkaline reaction (when the ground waters are alkaline, the pH of the lower horizons may increase up to 9). The eluvial horizons are marked by their decrease in clay content, humus and exchangeable bases in comparison with the humus-accumulative and illuvial horizons. The upper horizons contain 3 to 10% of humus. The humus content sharply drops in the eluvial, and slightly increases in the illuvial horizons. The CEC of humus-accumulative horizons is 40-50 cmol(+) kg-1. per 100 g of soil. It drops to 5-6 cmol(+) kg-1. in the eluvial horizons and increases again to 15-25 cmol(+) kg-1 and more in illuvial parts of the profile. Calcium dominates the exchangeable bases throughout the soil profile. Besides, Ca_2+ and Mg_2+ the upper horizons also contain exchangeable H+ and Al_3+. The illuvial horizons show a decrease in the proportion of exchangeable Ca_2+ in comparison to Mg_2+ and sometimes the appearance of Na+ (up to 10% of exchangeable bases). Solods usually do not contain soluble salts in the upper meter, while the lower strata vary greatly in salinity. Typically, the content of soluble salts does not exceed 2% within the first 2 or 3 meters.

Solods are formed from calcareous, sometimes saline, deposits on stable surfaces in the moist conditions of depressions in the relief, which support birch and aspen wet forests, or wet meadows, because of a shallow groundwater table, in the steppe and dry steppe zones.

Mollic Planosols (Plm)

This soil unit occupies 2.26 million ha which corresponds to 0.14% of the land area of the country or practically to 100% of the total Planosols major soil grouping.

These soils have a mollic A horizon or a eutric histic H horizon; and do not have permafrost within 200 cm of the surface. They correlate with solodic Chernozems, solodic Meadow-chernozemics, differentiated (and solodic) Meadow soils.

Solodic Chernozems have the following soil profile: A1-A1B-Bt-Bca-BCca-Cca. They are recognized by bleached skeletons in the humous horizon and the compact B horizon with blocky subangular structure. The soil profile looks like that of leached or podzolized Chernozems but the soils differ by having strong penetrating humus features. The soil reaction is slightly alkaline in the whole soil profile. There is clear clay and sesquoxides differentiation. They may have an increased amount of exchangeable Na+ and Mg+.

They occur in the south of West- and East Siberia.

Solodic Meadow-chernozemics have the profile: A1-A1A2-Bt(g)-Btca(g)-Cca(g). They differ from typical Meadow-chernozemic soils by having bleached skeletons in the humus horizon, a significant penetration of humous colour, effervescence to a great depth, and clay and sesquioxides differentiation down the profile. They occur in the south of West and East Siberia.

Differentiated (and solodic) Meadow soils have a profile A1-A2(A1A2)-Bt, (g)-Bca, (g)-Cg. They differ from typical Meadow soils by having a bleached platy A2 horizon or bleached material. They usually contain exchangeable sodium. They are intermingled with calcareous Meadow soils.

PODZOLUVISOLS

This major grouping occupies 207.37 million ha or 12.41% of the soil cover of Russia (Table 3). It is widespread particularly in the European part of the country, West Siberia and the southern part of East Siberia. (Figure 2.17).

Podzoluvisols show some features of Podzols (a strongly bleached horizon) and of Luvisols (an accumulation of clay). They have an argic B horizon with an irregular or broken upper boundary resulting from deep tonguing of the E into the B horizon, or from the formation of discrete nodules larger than 2 cm, the exteriors of which are enriched and weakly cemented or indurated with iron and have redder hues and stronger chromas than the interiors; they do not have a mollic A horizon.

The following FAO soil units and their corresponding soil groups in SMR have been recognized and are described briefly.

- Eutric Podzoluvisols, PDe
    - Brownzemish-light-grey Forest
    - Light-grey Forest
    - Residual-calcareous Podzolic
    - Sod podzolics with a second bleached horizon
    - Sod-pale-podzolics (and podzolized-Brownzems)
    - Sod-podzolics
    - Illuvial-ferruginous Sod-podzolics
    - Residual-calcareous Sod-podzolics
    - Sod-podzolics with the second humic horizon
    - Sod-podzolics with a second humic horizon and deep-gley.
- Dystric Podzoluvisols, PDd
    - Podzolics
    - Podzolics with a second bleached horizon
- Stagnic Podzoluvisols, PDj
- Surface-gleyed podzolics
    - Surface-gleyed Sod-podzolics
- Gleyic Podzoluvisols, PDg
    - Gley-podzolics

    - Gley-podzolics with a second bleached horizon
    - Peat and peaty Podzolic-gleys
    - Deep-gleyic and gley Podzolics
    - Gleyic and gley Sod-pale-podzolics
    - Sod-podzolic-gleys
    - Sod-podzolic-gleys with a second humic horizon
    - Deep-gley and gleyic Sod-podzolics
- Gelic Podzoluvisols, PDi
    - Gleyic Podzolics over permafrost

Eutric Podzoluvisols (Pde)

This soil unit occupies 119.41 million ha, which corresponds to 7.15% of the land area of the country or 57.59% of the area of the Podzoluvisols major soil grouping.

These soils have a base saturation (by NH_4O_{Ac}) of 50 percent or more throughout the argic B horizon within 125 cm of the surface; lack gleyic and stagnic properties within 100 cm of the surface and permafrost within 200 cm of the surface.

The eutric Podzoluvisols soil unit correlates with brownzemish-light-grey Forest, light-grey Forest, residual-calcareous Podzolics, Sod podzolics with a second bleached horizon, Sod-pale-podzolics (and podzolized-brownzems), Sod-podzolics, illuvial-ferruginous Sod-podzolics, residual-calcareous Sod-podzolics, Sod-podzolics with a second humic horizon, and deep-gleyic Sod-podzolics with a second humic horizon.

Brownzemish-light-grey Forest soils have a soil profile similar to the light grey forest soils described below. They differ from them by brighter brown colour and more clay accumulation in the Bt horizon. These soils occur in the Precaucausian region.

Light-grey Forest soils have a well differentiated soil profile: A1-A1A2-A2B-Bt-BtC-C(Cca). The humous horizon (7-15 cm in thickness) has a light-grey colour and granular-fine subangular structure. It is underlain by podzolized, greyish-bleached A1A2 horizon with platy or subangular-platy structure and abundant bleached fine material. The A2B horizon has blocky angular (beech nut-like) leafy structure and a brownish bleached colour. The illuvial Bt horizon has brown colour and clear blocky angular structure sometimes with blackish-brown bright films on the ped surfaces. This structure becomes prismatic downward. Carbonates are absent or appear only at a depth of more than 1-1.5 m. The soil is acid with the most acid reaction in the illuvial horizon. Texture and total chemical composition are usually differentiated down the profile. The humus content is 3-7% (increasing from the west to the eastern part of the country). The humus has a humate-fulvate and humin acids composition with dominant first fraction.

These soils are formed from unconsolidated clay and loam parent material under broad-leaved forest (in the European part of Russia) and narrow-leafed forest with some coniferous species (in the Asian part).

Residual-calcareous Podzolic soils have the profile: O1-(A1A2)-A2-A2/Bt-Bt,pca-BCcap-Ccap. The soils are characterised by the effervescence in the illuvial horizon (Bt,pca), which have reddish colour, noticeable compaction and neutral or slightly alkaline reaction.

These soils are formed from carbonate rocks and found in taiga-forest zones in autonomous relief positions.

Sod podzolics with a second bleached horizon have the profile: O-AO-A1-A2-A2g-IIA2/Bt,g-IIBt,g-IIBtC- IIC. The A2 horizon is pale-yellow. The second bleached A2g horizon has blue-grey-bleached colour and occurs on the boundary between coarse and fine-textured layers. These soils are formed on bisequential deposits. They occur in the southern taiga zone.

Sod-pale-podzolics (and podzolized-Brownzems) soils have the profile: O-AO-A1f-A2g,n(A2)-A2/Bt,g(A2Bt) -Bt-BtC-C. The organic horizon O (2-3 cm) is underlain by the shallow (2-5 cm) AO horizon. The humus horizon A1f (5-10 cm) has a greyish-light brown colour and subangular weakly compacted structure. The podzolic horizon A2g,n(A2) has subangular or flake-platy structure, somewhat poorer in iron oxides and enriched (as compared with parent rock) in amorphous and crystallized sesquoxides. It contains a great amount of segregated organo-ferrous nodules. Sometimes the gleying cannot be recognized morphologically. The A2/Bt,g horizon has bleached blue-greyish colour, compact consistency and varies very much in thickness. It forms deep bleached tongues and pockets, penetrating to the Bt horizon. In comparison with the horizon underneath, the A2/Bt,g is somewhat enriched in total iron and poorer in oxalate soluble iron compounds and aluminium. Sometimes gleying cannot be recognized morphologically. The Bt horizon has a compact consistency, clayey or clayey-loam texture, with angular blocky (beech nut-like) or prismatic structure; it has dark manganese films, and is somewhat enriched in sesquoxides and clay. It gradually merges into parent rock through the BtC. The soil reaction is acid, the bionic accumulation is weak, the organic matter content is low (2-4%) and the humus is fulvic, unsaturated, with insufficient amounts of free fulvic acids. The C:N ratio is narrow. The general pattern of sesquoxides and silica distribution is eluvio-illuvial but the distribution of amorphous (oxalate-soluble) iron and aluminium compounds is accumulative.

These soils are formed from homogenous loam and bisequential parent materials, coarse loams, loamy sands and sands, interstratified with fine noncalcareous loams and clays under coniferous-broad-leafed forests and broad-leaved forests with no groundcover grasses. They occur in the Pskov, Novgorod, and Smolensk regions in the Far East.

Sod-podzolics soils have a clearly differentiated profile: O-AO-A1-A2/Bt-Bt-BtC-C. The forest litter horizon O is 3-5 cm thick and consists of organic matter with different degrees of decomposition. A shallow (2-3 cm) organo-mineral horizon AO is often present in the lower part of the O horizon. It contains a significant amount (30% and more) of mineral particles, mechanically mixed with organic debris. The humous A1 horizon (5-12 cm) is a grey colour and contains well-decomposed organic matter, formed in situ and closely bound with the mineral part of the soil. The “podzolic” A2 horizon has a bleached or greyish bleached colour and is loose with platy-leafy structure. This changes through the A2/Bt horizon to the illuvial Bt horizon, which is the most compact and the brightest in the soil profile (brown or reddish-brown). It has the distinctive feature of fine dispersed silicate material illuviated through cracks, pores and along ped surfaces. The Bt horizon gradually merges into parent material at the depth of 250-300 cm.

These soils are well-differentiated eluvio-illuvially by texture and total composition. The reaction is acid, with the pH increasing downward. The most compact horizons are A2 and A2/Bt. The humous horizon compared with the podzolic one is less acid and more base saturated. The humus content varies from 3 to 7% (undisturbed) and from 1.2 to 2.5% (cultivated soils). Fulvic acids are somewhat more than humic acids in the humus composition.

According to the depth of the lower boundary of the podzolic A2 horizon from the mineral surface, Sod-podzolic soils are subdivided into several classes:

- shallow podzolic less then 10 cm;
- moderately deep podzolic 10-20 cm;
- deep podzolic 20-35 cm;
- very deep podzolic more than 35 cm.

Such soils are formed under coniferous-deciduous forests in flat and mountainous areas in the southern taiga

Illuvial-ferruginous Sod-podzolics soils have the profile: O-(AO)-A1-A2-Bf-C. The O horizon is shallow (1-3 cm) and contains significant amounts of mineral particles in its lower part. The A1 horizon has a light grey colour. The A2 horizon is poorly expressed. The illuvial Bf horizon is a light brown or yellow colour and has features of illuvial accumulation from amorphous or crystallized ferrous and aluminium hydroxides and their organo-mineral compounds. These soils are formed from sandy parent rocks under forest vegetation in the southern taiga and forest-steppe zones.

Residual-calcareous Sod-podzolics (including those with a second humic horizon) have the profile: O-AO-A1-A2-A2h-A2/Bt,h-Bf-Bt,pca-BtCcap-Ccap. They are similar to residually-calcareous Sod-podzolic soils. The only difference is the presence of the relict dark humous horizon (Bt,h), inherited from previous phases of soil formation. Such soils are found in the southern taiga subpoena.

Sod-podzolic soils with a second humic horizon have the profile: O-AO-A1-A2-A2h-A2/Bt,h-Bt-BtC-C. They are a relict, inheriting horizons A2h and A2h/Bt,h from previous phases of pedogenesis which are expressed by humus mottles or continuous stripes. These soils occur in southern taiga of the European part of Russia and West Siberia.

Deep-gleyic Sod-podzolics soils with a second humic horizon have the profile: O-AO-A1-A2(h)-A2Bt,h-Bt,g-BtCg-C. Most of their physico-chemical properties are similar to Sod-podzolic soils with a second humus horizon. They are characterised by the presence of gleying features in the B and C horizons. They are formed from clays and loams with slow deep drainage in permafrost regions in West and Middle Siberia.

Dystric Podzoluvisols (Pdd)

This soil unit occupies 24.07 million ha, which corresponds to 1.44% of the land area of the country or 11.61% of the area of the Podzoluvisols major soil grouping.

These soils have a base saturation (by NH_4O_{Ac}) of less than 50 percent in at least a part of the argic B horizon within 125 cm of the surface; lack gleyic and stagnic properties within 100 cm of the surface and permafrost within 200 cm of the surface.

The Dystric Podzoluvisols soil unit corresponds to Podzolic soils, deep-gleyic and gley Podzolics and Podzolics with a second bleached horizon.

Podzolic soils have the clearly differentiated profile: O-(A1A2)-A2-A2/Bt-Bt-BtC-C. They are characterised by a thin layer (5-15 cm) of the weakly decomposed litter O horizon, and the eluvial bleached horizon A2 with plate-leafy structure and significantly varying thickness (5-50 cm). The A2 horizon is succeeded by the eluvio-illuvial bleached-brown A2/Bt horizon and by the dark brown or brown illuvial Bt horizon 35-55 cm thick. The Bt horizon has a finer texture than the A2 or the transitional A2/Bt horizons, and also the distinctive features of fine dispersed silicate material deposited in the form of skins along cracks, through pores and on the edges of peds. It changes gradually through the BtC horizon to the weakly weathered parent rock C at a depth of 300-350 cm.

These soils have an acid reaction, and low base saturation. The clay and sesquoxide distributions clearly distinguish the eluvial and illuvial horizons. Fulvic acid dominates the organic matter composition. According to the depth of lower boundary of the A2 horizon, podzolic soils are subdivided into four classes: shallow podzolic less 10 cm; moderately deep podzolic 10-20 cm; deep podzolic 20-35 cm; very deep podzolic more than 35 cm.

These soils are formed under coniferous-bush-moss forests in well drained conditions on plains and mountainous regions of the taiga-forest zone.

Deep-gleyic and gley Podzolics (sometimes with surface gleying) have the profile: O-A2-A2/Bt-Btg-BCg-C. They have distinct specific gleying features in the Btg horizon and deeper (waterlogging). They can also have surface slight gleyization, or slight gleying in the A2 , and simultaneously distinctive gleying in the Bt. Such soils are formed from fine textured parent rocks with some excessive wetting, in the taiga-forest zone.

Podzolic soils with a second bleached horizon have the profile: O-(A1A2)-A2-B(h,f)-A2gh-IIA2/Bt-IIBt-IIC. These soils are formed on double-layered deposits. The upper layer with fine texture is underlain by a heavier-textured one. This results in formation of the second bleached horizon at the contact of the two layers. The (A2g) is sometimes absent and then the A2 and B(h,t) horizons directly change to mottled, irregularly colored, blue-grey bleached wedges and darker brown wedge-like IIA2/Btg gleyed horizon, transitional to the second illuvial IIBt horizon. If the upper finer-textured layer has sandy, or sometimes loamy sandy, texture, then a thin (5-20 cm) pale-brownish illuvial humus and iron Bhf horizon is present, between the eluvial A2 and the gley-contact A2gh horizons, and has an increased content of mobile iron and humus

These soils are formed from bisequential deposits and found in the taiga-forest zone.

Stagnic Podzoluvisols (Pdj)

This soil unit occupies 8.04 million ha, which corresponds to 0.47% of the land area of the country or 3.88% of the area of the Podzoluvisols major soil grouping.

These soils show stagnic properties within 50 cm of the surface; lack gleyic properties within 100 cm of the surface and permafrost within 200 cm of the surface.

The Stagnic Podzoluvisols soil unit correlates with surface-gleyed Podzolics and Sod-podzolic surface gleyic soils.

1. Surface-gleyed Podzolics have a well-differentiated soil profile: O-A2gh-Bt-BtC-C. They differ from Gley-Podzolics by lower humus content (up to 1%) in the A2gh horizon, better developed podzolization and more noticeable clay eluviation from topsoil.

   These soils are found in the middle and rarely in the south taiga subzones and occur in poor drained relief positions with timely excessive atmospheric moistening. They are formed from fine textured loams and clays of various origin.

2. Surface-gleyic Sod-podzolic soils have the profile: O-AO-A1g-A2g-Bt-BtC-C. They have features of slight gleying in the topsoil (the A1g and A2g), caused by seasonal surface waterlogging by rainfall. They are formed from fine textured parent rocks (loam and clay) and occur in the southern taiga subpoena among areas of Sod-podzolic soils. They occupy poorly drained flat parts of watersheds, micro-depressions and gentle slopes.

Gleyic Podzoluvisols (Pdg)

This soil unit occupies 55.71 million ha, which corresponds to 3.34% of the land area of the country or 26.87% of the area of the Podzoluvisols major soil grouping.

These are soils showing gleyic properties within 100 cm of the surface and with no permafrost within 200 cm of the surface. They correlate with Gley-podzolics, Gley-podzolics with a second bleached horizon, peat and peaty Podzolic-gleys, gleyic and gley sod-pale-Podzolics, Sod-podzolic-gleys, Sod-podzolic-gleys with a second humic horizon, deep-gley and gleyic Sod-podzolic soils.

Gley-podzolic soils have the profile: O-A2gh-A2Bg-Bt-BtC-C. The O horizon consists of weakly decomposed peaty forest litter (5-8 cm). The bleached very shallow (5-10 cm) A2gh horizon has dirty grey and blue-grey colors and is characterised by a high content of light-colored humus (2-4%) and maximal concentration of amorphous and crystallized iron compounds. A lower A2Bg horizon, transitional to illuvial, is also gleyed and characterized by increased iron, extracted by Tamm and Jackson methods. The amount of amorphous and crystallized iron compound is often higher in the A2Bg than in A2gh. The Bt horizon has finer texture with clear features of allochtonous input of fine dispersed silicate material. It gradually (through the BC horizon) merges to non-gleyed parent rock weakly transformed by soil processes.

The soils occur in the northern taiga and are developed on narrow drained watersheds, edges and the well-drained slopes of river ridges ??? levees, terraces???.

Gley-podzolics with a second bleached horizon have the profile: O-A2gh-A2Bg-BtA2g-IIBG-IIC. These soils are formed on double-layered deposits. The upper layer with a relatively coarse texture is underlain by a heavier-textured one. They have morphological and chemical properties similar to Gley-podzolic soils. They are distinguished from them by the formation of a second bleached BtA2g gley-contact horizon on the boundary of a parent rock texture change. The formation of the BtA2g horizon is caused by seasonal waterlogging at the top of the clay loamy layer. Such soils are formed from bisequential deposits (fine loam and coarse loamy sand, underlain by clay loam at the bottom of the soil profile) in the northern and very northern taiga zones.

Peat and peaty Podzolic-gley soils have the profile: O1-A2g,n-Bt,g,n-G2. The O1 horizon (10-30 cm) consists of peaty or muck-peaty material. The podzolic A2g+,n horizon has a white-bleached colour, structureless with gleying features and a significant amount of nodules (shot-like and bean-like). The illuvial Bt,g,n horizon has a dirty-brown or marble-like colour and contains ortsteins. The G2 horizon has motley-colour (bluish, greyish and rusty spots). The typical properties are as follows: acid reaction (pH of KCl extraction is 2.5-4.5), high base unsaturation of the topsoil (60-90%) and noticeable decreasing of it downwards (30-40%). A2g horizon is characterised by a small content (1-2%) of illuviated dirty grey humus. There is no humus illuviation in the Bt,g,n horizon.

These soils are formed from loams and clays in a taiga-forest zone, on slow-draining terrain (flat plains, shallow depressions) characterised by seasonal surface waterlogging, or in relief depressions with relatively high levels of groundwater.

Gleyic and gley Sod-pale-podzolic soils have the profile: O-AO-A1-A2g,n- A2/Bt,g,n-Bt,g-BtCg-Cg. They are similar to Sod-pale-yellow-podzolic and podzolic Brown soils. The specific gleyic features caused by combined surface and groundwater wetting, are clearly developed in the lower part of the soil profile. The distinct colour and textural differentiation are specific features. The humus horizon A1 has a brownish-grey colour with abundant spreading bright-ochre mottles, and small-nut structure. The eluvial horizon A2g,n has a bleached-grey or pale-yellow colour, compact composition, plate-nut structure with abundant ochre mottles and iron-manganese stains. The eluvio-gleyed light-colored contact A2/Bt,g,n horizon has a blue-grey-bleached colour, compact consistency with fine pores, blocky (beech nut-like) and prismatic structure, with ochre mottles and iron-manganese nodules. The Bt,g horizon has a mottled colour (blue-grey mottles and dark films on structural ped faces). The transition to parent rock horizon BtCg and lower Cg are gleyed: bright-ochre mottles are intermixed with bluish-grey streaks.

Sod-podzolic-gley soils have a clearly differentiated profile: A1v-A1-A2g,n-Bt,g-G2. The upper horizon A1v is sod (5-6 cm); the humus horizon A1 (10-20 cm) has grey colour; the gleyed podzolic horizon A2g,n has a greyish-bleached colour with rusty patches and a great amount of ortstein: the illuvial Bt,g horizon is gleyed, sometimes waterlogged and gradually merges into gleyed parent rock Cg or G2. The soil reaction is acid, the topsoil is base unsaturated, the humus is streaked.

These soils are formed on poorly drained plains and in hollows under boggy southern taiga forests with grass cover.

Sod-podzolic-gleys with a second humic horizon soils have the profile: A1v-A1-A2g,n,h-A2Bg,h-Bt,g-G2. The soils are similar to Sod-podzolic-gley, the only difference is the presence of a relict second humus horizon, inherited from previous phases of soil formation, in a lower part of the podzolic horizon or beneath it.

These soils are developed in the same regions as Sod-podzolic-gley soils.

Deep-gley and gleyic Sod-podzolics soils have the profile: O-AO-A1-A2-(A2g)-(A2/Bt,g)-Btg-BtCg-Cg. Morphologically and physico-chemically these soils are similar to Sod-podzolics. The differences are indicated by gleying processes in the BtCg and Cg horizons. Sometimes there may be slight gleying in the A2g and A2Bt,g horizons, and the humus content may also be higher.

These soils are formed from loamy and clayey parent materials, among Sod-podzolic soils in the depressions of the relief.

Gelic Podzoluvisols (Pdi)

This soil unit occupies 0.13 million ha, which corresponds to less than 0.01% of the land area of the country or 0.06% of the area of the Podzoluvisols major soil grouping. These soils have permafrost within 200 cm of the surface. They are correlated with Podzolic over permafrost-gleyic soils.

Podzolic over permafrost-gleyic soils have the profile: O-A2-A2/Bt-Btg-GC. They have a gleyed horizon, formed above an iced permafrost layer, at the depth of 1.0-1.5 m, which forms an impermeable layer.

These soils are found in permafrost plains and mountainous regions of Central and East Siberia in the northern and middle taiga zones.

PODZOLS

This major grouping occupies 371.13 million ha or 22.22% of the land area of Russia (Table 3). It is widespread particularly in the north of the European part of the country, Central and Southern parts of West Siberia, Central Yakutya and Far East (Figure 2.18).

Podzols have a spodic B horizon generally with a strongly bleached eluvial horizon above it. The FAO central concept is rather different from the original Russian one which emphasized the bleached layer rather than the layer of iron and organic matter accumulation.

The following FAO soil units are identified and their corresponding soil groups in SMR are described.

- Haplic Podzols, PZh
    - Dry-peaty Podzols
    - Humic-illuvial Podzols
    - Illuvial-humic-ferruginous Podzols(without subdivision)
    - Ochric Podzols
    - Podzols with a second bleached horizon
- Cambic Podzols, PZb
    - Taiga Podburs (without subdivision)
    - Dry-peaty Podburs
    - Ochric Podburs
- Ferric Podzols, PZf

- Tundra Podburs (without subdivision)
- Illuvial-ferruginous Podzols
- Gleyic Podzols, PZg
  - Gleyic Podzols
- Gelic Podzols, PZi
  - Dark tundra Podburs
  - Light tundra Podburs

Haplic Podzols (Pzh)

This soil unit occupies 147.82 million ha, which corresponds to 8.85% of the land area of the country or 39.83% of the area of the Podzols major soil grouping.

These soils have a spodic B horizon which in all subhorizons has a ratio of free iron to organic carbon of less than 6, but which contains sufficient free iron to turn redder on ignition; a continuous albic E horizon that is thicker than 2 cm, or a distinct separation within the spodic B horizon of a subhorizon which is visibly more enriched with organic carbon, or both; they do not have gleyic properties within 100 cm of the surface nor permafrost within 200 cm of the surface.

The haplic Podzols correlate with dry-peaty, humic-illuvial, and ochric Podzols, illuvial-humic-ferruginous Podzols (without subdivision), and Podzols with a second bleached horizon.

Dry-peaty Podzols have the profile: O-AO-A2-Bf,h(Bh)-C. They are similar to illuvial-humus Podzols (see below) but have a peaty organic horizon O (about 10 cm thick). The Bh horizon is usually dark with a high content of organo-mineral compounds.

These soils usually occur in mountainous areas under dwarf coniferous vegetation.

Humic-illuvial Podzols have the profile: O-AO-A2-Bf,h (Bh)-C. As compared to illuvial-ferruginous Podzols (see below) they have a higher content of amorphous humus, iron and aluminium in the illuvial horizon, which is therefore darker (dark brown to reddish brown). The humus content in the Bh horizon is more than 3%.

These soils are formed in the same areas as illuvial-iron Podzols.

Illuvial-humic-ferruginous Podzols have the profile: O-AO-A2-Bf(Bh,f)-C. The O horizon is shallow (3-8 cm) slightly peaty litter, consisting of dead tissue from mosses, fallen bushes, pine needles. The AO horizon is 1-3 cm thick and consists of partly decayed humus, peaty in the lower part, with additions of bleached mineral grains with their iron coatings leached away. The A2 horizon is strongly lightened in colour, often bleached, poor in total and mobile (amorphous and crystallized) forms of R_2O_3. The Bt or Bf,h horizons have an ochre-brown or brownish-ochre colour, contain 1 to 3% illuviated fulvate humus, have a clear accumulation of total and amorphous organo-mineral iron and aluminium hydroxides or other compounds.

These soils are formed from coarse-textured deposits in forest-tundra and taiga-forest zones.

Ochre Podzols have a soil profile similar to illuvial-humus Podzols. They are characterised by abundant volcanic glass in the A2 horizon, and more rarely in the Bh,f horizon, the presence of allophane in the B horizon, and a high content of amorphous forms of SiO_2 and Fe_2O_3 in the whole profile (but especially in illuvial horizons).

These soils are formed in a zone with thin volcanic ash deposits, under birch and larch forests with groundcover grasses, in the regions of the Kamchatka peninsula and along the coast of the Okhotskoe Sea in the Far East.

Podzols with a second bleached horizon have the profile: O-AO-A2-Bh,f-A2(A2g)-IIB(h)t-C. The upper sandy-loam or sandy layer has the same soil profile as illuvial-iron Podzols. The second bleached horizon is developed at the contact between sandy and loamy layers and is underlain by a brown-colored finer-textured horizon. They are formed from bisequential parent materials (sand and loamy sand over loam deposits) in forest-tundra and forest-taiga.

Cambic Podzols (Pzb)

This soil unit occupies 117.67 million ha, which corresponds to 7.04% of the land area of the country or 31.71% of the area of the Podzols major soil grouping.

These are soils having a spodic B horizon which in all subhorizons has a ratio of free iron to organic carbon of less than 6, but which contains sufficient iron to turn redder on ignition; lacking, or having only a thin (2 cm or less) or discontinuous, albic E horizon; lacking a subhorizon within the spodic B horizon which is visibly more enriched with organic carbon; and without gleyic properties within 100 cm of the surface or permafrost within 200 cm of the surface.

Cambic Podzols soil unit correlates with taiga Podburs (without subdivision), dry-peaty, and ochre Podburs.

Taiga Podburs (without subdivision) have the profile: O(AO)-Bh(Bf,h)-C. Peaty, peaty-muck and muck horizons, more rarely-forest litter horizons, are evident in the upper part of the soil profile. The humus A1 horizon is absent. The upper organic horizons O and AO are in direct contact with illuvial aluminium-iron-humus and mineral horizons Bh or Bg,h. They have a dark-brown or red-brown colour, becoming paler downward. The whole profile or most of it has no morphological features of gleying. There are no micromorphological features of podzolization between O(AO) and Bh (Bf,h) horizons. Sometimes micromorphological and chemical features of bleaching (removal of humus-iron films, bleaching, corrosion of mineral grains, iron and aluminium eluviation) are observed in the mineral and organic compounds. The distinctive shallow mottles, lenses and stripes of bleached podzolized mineral material, are formed in the most podzolized Podburs at the contact of O(AO) and the Bh(Bf,h) horizons. Evidence of illuviation of amorphous humus, iron and aluminium is clear in Bh(Bf,h) horizons when compared with the parent material. (films, brown and reddish-brown exudates on stones, coating skeleton grains in cavities, all enriched in total Fe_2O_3 and Al_2O_3 and in their oxalate-soluble forms). The illuvial humus content in these horizons (2-3%) varies strongly because of the different pedogenetic conditions. The clear differentiation of humus acids is typical for the humus profile, with a dominant accumulation of humic (ulmic) acids in the O(AO) horizons and mobile fulvic acids (groups 1a and 1) in Bh (Bf,h) horizons. The illuvial humus penetration is usually deep. The chemical-physical features of fersiallitization and weak clay formation are often present in the B horizon when it is compared with parent rock.

These soils are formed from internally well-drained stony-silt and sandy-loamy, sandy silicate parent materials in cold humid areas of forest-tundra, and northern and middle taiga zones.

Dry-peaty Podburs have the profile: O-AO-Bf(Bh)-C. These are dominantly dark colored soils with a peaty horizon more than 10 cm thick. They are common under mountainous bush coniferous forest in the taiga zone.

Ochre Podburs have the profile: O-AO-Bfh-C. The soils are characterised by a very high content of SiO_2, Al_2O_3 and Fe_2O_3 (up to 10% of oxalate-soluble SiO_2, 13-20% of Al_2O_3 and up to 8-12% of Fe_2O_3). They are in the form of organo-mineral compounds, free hydroxides and allophonoids. Silicate clay minerals in ochric podburs are absent or present in trace amounts.

These soils are formed under tundra and northern taiga vegetation in young volcanic zones and moderately active volcanic ash deposits beyond the limits of modern intensive agriculture.

Ferric Podzols (Pzf)

This soil unit occupies 62.41 million ha which corresponds to 3.74% of the land area of the country or 16.82% of the area of the Podzols major soil grouping.

These soils have a spodic B horizon in which in all subhorizons the ratio of free iron to organic carbon is 6 or more; they do not have gleyic properties within 100 cm of the surface nor permafrost within 200 cm of the surface.

The Ferric Podzols soil unit correlates with tundra Podburs (without subdivision), and illuvial-ferruginous Podzols.

Tundra Podburs (without subdivision) have characteristics intermediate between dark tundra Podburs and light tundra Podburs (see below).

Illuvial-ferruginous Podzols have the profile: O-AO-A2-Bf(Bh,f)-C. The O horizon is shallow (3-8 cm) slightly decomposed litter, consisting of dead tissue from mosses, fallen bushes and pine needles. The AO horizon is 1-3 cm thick and consists of partly decayed, humus, peaty in the lower part, with additions of mineral grains. It is bleached and the iron coatings have been washed away. The A2 horizon is much lightened in colour, often bleached, poor in total and mobile (amorphous and crystallized) forms of R_2O_3. The Bt or Bf,h horizons have an ochre-brown or brownish-ochre colour, contain 1 to 3% illuviated fulvate humus, and have a clear accumulation of total and amorphous organo-mineral iron and aluminium compounds or hydroxides.

These soils are formed from coarse-textured deposits in forest-tundra and taiga-forest zones.

Gleyic Podzols (Pzg)

This soil unit occupies 26.79 million ha, which corresponds to 1.60% of the land area of the country or 7.22% of the area of the Podzols major soil grouping.

These soils have gleyic properties within 100 cm of the surface but no permafrost within 200 cm the surface. They correlate with gleyic Podzols.

Gleyic Podzols have the profile: O1-A2-Bh-Cg. The O1 horizon (10-30 cm) is peat or peaty-muck. The A2 horizon has a bleached or dirty-white colour due to illuviation of organic matter from the O1 horizon with a few gley features. The illuvial Bh horizon has a brownish-black or bright ochre colour, is enriched with illuviated humus, and often (not always) contains ortsteins. The C horizon has excess water and is gleyed. The soils are acid (pH of KCl extraction is 2.0-4.0) and base-unsaturated, with a clear eluvio-illuvial humus distribution.

These soils are formed from coarse-textured parent materials (sands and loamy sands) under excessive surface or ground moistening in forest-tundra and taiga-forest zones.

Gelic Podzols (Pzi)

This soil unit occupies 16.42 million ha, which corresponds to 0.98% of the land area of the country or 4.42% of the area of the Podzols major soil grouping.

These soils have permafrost within 200 cm of the surface. They correlate with dark tundra Podburs and light tundra Podburs.

Dark tundra Podburs have the profile: O(AO)-Bh(Bh,f)-C. Peat, peaty-muck, peaty humus and sometimes mineral inclusions form the O(AO) topsoil horizon. This is in direct contact with the mineral horizon Bh(Bh,f), containing illuvial aluminium-iron-humus material; the colour is dark-brown or red-brown becoming paler with depth. Such soils are acid, strongly leached, and contain mobile fulvate humus. No morphological features of the gleying process are apparent throughout the whole profile, or most of it. Micromorphological features of the podzolization process are absent from the O(AO) and Bh(Bh,f) horizons. Sometimes the micromorphological and chemical features of bleaching-podzolization (removal of iron-humus films, bleaching, corrosion of mineral grains, loss of iron and aluminium) are evident in the mineral mass of the O or AO horizons. In the most podzolized podburs mottles, lenses and bands of lightened podzolized mineral material, may occur at the contact between O(AO) and Bh(Bh,f) horizons. Features typical of illuviation of amorphous compounds of humus, iron and aluminium are visible in mineral horizons Bh(Bh,f). Brown and red-brown colored films cover stones and skeleton grains and fill cavities (observed macromorphological cracks in thin layers). They are enriched in total Fe_2O_3 and Al_2O_3, and their oxalate-soluble forms, compared to the parent material. The illuvial humus content is about 2-3% and varies significantly according to specific conditions of pedogenesis. The strong differentiation of humus acids is marked throughout the profile, with dominant accumulation of humic (ulmic) acids in the O(AO) horizons and mobile fulvic acids (group 1 and 1a fractions) in the Bh(Bh,f) horizons. Illuvial humification of the soil profile is usually deep. chemico-mineralogical features of desilicification, fersiallitization and weak clay formation are often present in the B horizon as compared to the parent materials.

These soils are formed from coarse-textured deposits in forest-tundra and taiga-forest zones.

Light tundra Podburs have the profile: AO(O)-Bf(Bh,f)-C. They are distinguished from dark podburs by the thinner AO(O) horizons with more decomposed organic matter which is mostly peaty humus and raw humus (AO). They also have lighter colored Bf and Bh,f mineral horizons - pale-reddish-brown, yellow-brown, or strong brown. The features of podzolization are weak and are identified only by micromorphological methods (observing the bleaching of skeleton grains). The whole profile is not so acid as that of the dark Podburs, in fact the subsoil is often only slightly acid. As compared with dark podburs, there is less illuvial humus (<2-3%) and amorphous iron and aluminium compounds in light podburs. They also have only weak accumulation of clay, total Fe_2O_3 and Al_2O_3 and their oxalate soluble forms, in the Bf(Bh,f) horizon as compared to the parent material.

They are formed from the same parent materials as dark Podburs but in colder, more continental and less humid areas, in local xerophytic, flat and mountainous regions of tundra.

HISTOSOLS

This major grouping occupies 118.74 million ha or 7.11% of the soil cover of Russia (Table 3). It is widespread (Figure 2.19) particularly in the Central and Northern regions of the European part of the country, the Central part of West Siberia and the Southern part of the Far East.

Histosols are soils dominated by fresh or partly decomposed organic material. Such soils have 40 cm or more of organic soil materials (60 cm of more if the organic material consists mainly of sphagnum or moss or has a bulk density of less than 0.1 Mg m-3) either extending down from the surface or taken cumulatively within the upper 80 cm of the soil; the thickness of the H horizon may be less when it rests on rock or on fragmental material in which the interstices are filled with organic matter.

The following FAO soil units and their corresponding soil groups in SMR are distinguished.

- Terric Histosols, HSs
    - Boggy banded Peat-ashes
    - Low moor Peats
    - Transitional moor Peats
- Fibric Histosols, HSf

    - High moor Peats
- Histosols (undifferentiated), HS
    - Boggy Peats (without subdivision)

Terric Histosols (Hss)

This soil unit occupies 44.31 million ha, which corresponds to 2.65% of the land area of the country or 37.31% of the area of the Histosols major soil grouping.

These are soils having highly decomposed organic materials with strongly reduced amounts of visible plant fibres and a very dark grey to black colour to a depth of 35 cm or more from the surface; having imperfect to very poor drainage; lacking a sulfuric horizon or sulfidic materials within 125 cm of the surface and permafrost within 200 cm of the surface.

Terric Histosols correlate with peat-ash banded boggy, peat low moor, peat transitional moor soils.

Banded boggy Peat-ash soils are characterised by layers of volcanic sands and ash in the peat horizon.

Peat low moor soils are characterised by the peaty O horizon: more than 50 cm thick. They are light-brownish in colour and acid in reaction. The mineral ash content is less than 6.5% and the organic material is not decomposed or only slightly decomposed.

Peat transitional moor soils differ from low moor soils by their darker colour, higher rate of decomposition of organic material, and higher ash content (6.5-10.0% of ash).

Fibric Histosols (Hsf)

This soil unit occupies 54.94 million ha, which corresponds to 3.29% of the land area of the country or 46.27% of the area of the Histosols major soil grouping.

These soils have raw or weakly decomposed organic materials, the fiber content of which is dominant to a depth of 35 cm or more from the surface; they have very poor drainage or are undrained; they do not have a sulfuric horizon or sulfidic materials within 125 cm of the surface nor permafrost within 200 cm of the surface.

The fibric Histosols soil unit correlates with peat high moor soils.

Peat high moor soils have a dark colored peat horizon, 50 cm or more thick. The ash content is less than 10%.

Histosols (HS) (without subdivision)

These occupy 19.5 million ha, which corresponds to 1.17% of the land area of the country or 16.42% of the area of the Histosols.

This group corresponds to generally recognized Histosols with no clearly defined, or not well-known, characteristics. It can be correlated with combined peat and boggy soils, including soils with hydromorphic organic properties, formed under the influence of excessive stagnating or moving groundwater or surface water, fresh or saline, and the associated hydrophilous vegetation.

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Appendix I. Full correlation of the legends, SMR at the scale of 2.5 M and SMW (FAO revised version, 1988).

Major Soil Groupings and Soil units (index)	Correlated classes of the SMR	
	Name in English	**Name in Russian**
Fluvisols (FL)		
Eutric (FLe)	Alluvials saturated	Аллювиальные слабокислые и нейтральные
Calcaric (FLc)	Alluvials calcareous	Аллювиальные карбонатные
Dystric (FLd)	Alluvials acid	Аллювиальные кислые
Umbric (FLu)	Alluvials meadow	Аллювиальные луговые
	Alluvials swamp meadow	Аллювиальные заболоченные
Tionic (FLt)	Marshy saline and solonetzic	Маршевые засоленные и солонцеватые
Gleysols (GL)		
Eutric (GLe)	Bog-mud	Иловато-болотные
	Bog-mud saline	Иловато-болотные солончаковатые
Calcic (GLk)	Meadow-browns	Лугово-бурые
	Meadow calcareous	Луговые карбонатные
Dystric (GLd)	Gleyzems taiga Differentiated	Глеевемы таежные дифференцированные
	Gleyzems taiga differentiated peaty	Глеевемы таежные дифференцированные торфянистые
	Gleyzems taiga	Глеевемы таежные
	Gleyzems peaty and peat boggy	Глеевемы торфянистые и торфяные болотные
	Sod-gleys podzolized	Дерново-глеевые оподзоленные
Mollic (GLm)	Meadows solonetzic and solonchakous	Луговые солонцеватые и солончаковатые
	Meadow-boggy	Лугово-болотные
	Meadow-boggy solonetzic and solonchakous	Лугово-болотные солонцеватые и солончаковатые
Umbric (GLu)	Sod-(muck-) gleys	Дерново-(перегнойно-) глеевые
	Sod-(muck-) gley calcareouses	Дерново-(перегнойно-) глеевые карбонатные
	Meadows	Луговые
Gelic (GLi)	Gleyzems arctic	Глеевемы арктические
	Gleyzems arctotundra muck-gley	Глеевемы арктотундровые перегнойно-глеевые
	Gleyzems and weak-gley humic tundra	Глеевемы и слабоглеевые гумусные тундровые
	Gleyzems tundra shallow and deep peat	Глеевемы тундровые торфянистые и торфяные
	Gleyzems peaty and peaty-humic tundra	Глеевемы торфянистые и перегнойные тундровые
	Gleyzems tundra differentiated peaty-muck and peat	Глеевемы тундровые дифференцированные торфянисто-перегнойные

	Tundra meadows	Почвы тундровых луговин
	Gleyzems weak-gley peaty-humic taiga	Глеяземы слабоглеевые гумусово-перегнойные таежные
	Gleyzems peaty-muck taiga	Глеяземы торфянисто-перегнойные таежные
Regosols (RG)		
Calcaric (RGc)	Arctic calcareous	Арктические карбонатные
Gelic (RGi)	Arctic desert	Арктические пустынные
	Arctic cryozems	Арктические криоземы
	Arctic hydromorphic non-gleyic	Арктические гидроморфные неглеевые
Leptosols (LP)		
Eutric (LPe)	Grey forest shallow	Серые лесные неполноразвитые
Dystric (LPd)	Podzolics shallow	Подзолистые неполноразвитые
	High-Mountain baldy- soddy	Высокогорные дерново-гольцовые
	High-Mountain semidesert	Высокогорные полупустынные
	High-Mountain desert	Высокогорные пустынные
	Mountain-meadow sod-peaty	Горно-луговые дерново-торфянистые
Rendzic (LPk)	Muck-calcareous	Перегнойно-карбонатные
	Sod-calcareouses	Дерново-карбонатные
Mollic (LPm)	Chernozems shallow	Черноземы неполноразвитые
	Mountain forest chernozemic	Горные лесные черноземовидные
	Mountain-meadow chernozem-likes	Горно-луговые черноземовидные
	Chestnuts shallow	Каштановые неполноразвитые
	Mountain meadow-steppe	Горные лугово-степные
	Mountain steppe and cold-steppe	Горные степные и холодно-степные
	High-Mountain steppe	Высокогорные степные
Umbric (LPu)	Mountain forest-meadows	Горные лесо-луговые
	Mountain forests humic-accumulative weakly-acid	Горные лесные гумусово-аккумулятивные слабокислые
	Mountain-meadow soddy	Горно-луговые дерновые
Lithic (LPq)	Mountain debrital-organogenuos	Горные щебнисто-органогенные
	Shallow weakly developed	Слаборазвитые
	Mountain primitive	Горные примитивные
Gelic (LPi)	Muck-calcareouses tundra	Перегнойно-карбонатные тундровые
	Soils of permafrost cracks	Почвы мерзлотных трещин
	Soils of spots (saline, arctic and tundra)	Почвы пятен (засоленные, арктические и тундровые)
Arenosols (AR)		
Haplic (ARh)	Sierosands	Серопески
Cambic (ARb)	Sands	Боровые пески

Andosols (AN)		
Haplic (ANh)	Volcanics dry-peaty	Вулканические сухоторфянистые
	Volcanics ochric (including podzolized)	Вулканические охристые (включая оподзоленные)
	Volcanics light-ochric (including podzolized)	Вулканические светло-охристые (включая оподзоленные)
	Volcanics podzolized-ochric	Вулканические подзолисто-охристые
	Volcanics bandding-ochric	Вулканические слоисто-охристые
Vitric (ANz)	Volcanics bandding-ashed	Вулканические слоисто-пепловые
Gleyic (ANg)	Volcanics peaty-mud	Вулканические торфянисто-перегнойные
Gelic (ANi)	Volcanics illuvial-humic tundra	Вулканические иллювиально-гумусовые тундровые
Vertisols (VR)		
Eutric (VRe)	Chernozems compact	Черноземы слитые
	Meadow-chernozemics compact	Лугово-черноземные слитые
	Meadow compact	Луговые слитые
	Alluvials compact	Аллювиальные слитые
Cambisols (CM)		
Eutric (CMe)	Brownzems weakly-unsaturated podzolized	Буроземы слабоненасыщенные оподзоленные
	Sod-brownzems weakly-unsaturated and saturated	Дерново-буроземные слабоненасыщенные и насыщенные
	Brownzems weakly-unsaturated	Буроземы слабоненасыщенные
	Brownzems residual-calcareous	Буроземы остаточно-карбонатные
	Pales mucky	Палевые перегнойные
	Pales typical	Палевые типичные
Dystric (CMd)	Brownzems raw-humic	Буроземы грубогумусовые
	Brownzems raw-humic illuvial-humic	Буроземы грубогумусовые иллювиально-гумусовые
	Brownzems acid	Буроземы кислые
	Brownzems acid podzolized	Буроземы кислые оподзоленные
	Sod-brownzems acid	Дерново-буроземные кислые
	Sod-brownzems ferrugenous	Дерново-буроземные железистые
	Pales podzolized	Палевые оподзоленные
	Pales solodic	Палевые осолоделые
	Granuzems	Гранудземы
Humic (CMu)	Brownzems muck-humus-accumulative	Буроземы перегнойно-аккумулятивно-гумусовые
	Grey-pales	Серопалевые
Calcaric (CMc)	Pales calcareous	Палевые карбонатные
	Cinnamonics calcareous	Коричневые карбонатные
Chromic (CMx)	Cinnamonics typical	Коричневые типичные
	Meadow-cinnamonics	Лугово-коричневые

Gleyic (CMg)	Brownzems gleyic and gley	Буроземы глееватые и глеевые
	Brownzems raw-humic gley	Буроземы грубогумусовые глеевые
	Granuzems gley	Грануземы глеевые
Gelic (Cmi)	Taiga peaty-muck high-humic non-gleyic	Таежные торфянисто-перегнойные высокогумусные неоглеенные
	Sod-brownzems gleyic and gley	Дерново-буроземные глееватые и глеевые
Calcisols (CL)		
Haplic (CLh)	Browns (semidesert)	Бурые (полупустынные)
Luvic (CLl)	Browns solonetzic and solonchakous	Бурые солонцеватые и солончаковатые
Solonetz (SN)		
Haplic (SNh)	Solonetzes	Солонцы
Gleyic (SNg)	Solonetzes meadowish	Солонцы луговатые
	Solonetzes meadowous	Солонцы луговые
Solonchaks (SC)		
Haplic (SCh)	Solonchaks typical	Солончаки типичные
Gleyic (SCg)	Solonchaks meadow	Солончаки луговые
	Shor Solonchaks	Солончаки соровые
Kastanozems (KS)		
Haplic (KSh)	Dark chestnuts	Темнокаштановые
	Dark chestnuts deep	Темнокаштановые глубокие
	Chestnuts	Каштановые
	Chestnuts deep	Каштановые глубокие
	Chestnuts leached	Каштановые промытые
	Light chestnuts	Светлокаштановые
	Light chestnuts deep	Светлокаштановые глубокие
Luvic (KSl)	Dark chestnuts solonetzic and solonchakous	Темнокаштановые солонцеватые и солончаковатые
	Chestnuts solonetzic and solonchakous	Каштановые солонцеватые и солончаковатые
	Light chestnuts solonetzic and solonchakous	Светлокаштановые солонцеватые и солончаковатые
Calcic (KSk)	Dark chestnuts calcareous	Темнокаштановые карбонатные
Chernozems (CH)		
Haplic (CHh)	Chernozems typical	Черноземы типичные
	Chernozems ordinary	Черноземыs обыкновенные
	Chernozems podzolized deep	Черноземы оподзоленные глубокие
	Chernozems leached deep	Черноземы выщелоченные глубокие
	Chernozems weakly-leached deep	Черноземы слабовыщелоченные глубокие
	Chernozems washed	Черноземы промытые
	Chernozems deeply-effervescing and non-calcareous	Черноземы глубоковскипающие и бескарбонатные
Calcic (CHk)	Chernozems southern and ordinary mycelial-calcareous	Черноземы южные и обыкновенные мицеллярно-карбонатные

	Chernozems southern	Черноземы южные
	Chernozems residual-calcareous	Черноземы остаточно-карбонатные
Luvic (CHl)	Chernozems leached	Черноземы выщелоченные
	Chernozems solonetzic	Черноземы солонцеватые
Glossic (CHw)	Chernozems leached glossic	Черноземы выщелоченные языковатые и карманистые
	Chernozems ordinary glossic	Черноземы обыкновенные языковатые
	Chernozems southern glossic	Черноземы южные языковатые
Phaeozems (PH)		
Haplic (PHh)	Meadow-chernozemics	Лугово-черноземные
	Meadow-chernozemics leached	Лугово-черноземные выщелоченные
	Meadow-chestnuts	Лугово-каштановые
Calcaric (PHc)	Meadow-chernozemics calcareous	Лугово-черноземные карбонатные
Luvic (PHl)	Chernozems podzolized	Черноземы оподзоленные
	Meadow-chernozemics solonetzic and solonchakous	Лугово-черноземные солонцеватые и солончаковатые
	Meadow-chestnuts solonetzic	Лугово-каштановые солонцеватые
Gleyic (PHg)	Meadow-chernozem-likes "Amur prairie"	Лугово-черноземовидные "Амурских прерий"
Greyzems (GR)		
Haplic (GRh)	Grey forest	Серые лесные
	Grey forest non-podzolised	Серые лесные неоподзоленные
	Grey forest with the second humic horizon	Серые лесные со вторым гумусовым горизонтом
	Grey forest solodic	Серые лесные осолоделые
	Dark-grey forest	Темносерые лесные
	Dark-grey forest with the second humic horizon	Темносерые лесные со вторым гумусовым горизонтом
	Brownish-dark-grey forest	Буровато-темносерые лесные
	Grey forest residual-calcareous	Серые лесные остаточно-карбонатные
Gleyic (GRg)	Grey forest gleyic and gley	Серые лесные глееватые и глеевые
Luvisols (LV)		
Albic Luvisols (LVa)	Podzolised-zheltozems	Подзолисто-желтоземные
Planosols (PL)		
Eutric (PLe)	Solods	Солоди
	Solods boggy	Солоди болотные
Mollic (PLm)	Chernozems solodic	Черноземы осолоделые
	Meadow-chernozemics solodic	Лугово-черноземные осолоделые
	Meadows differentiated (and solodic)	Луговые дифференцированные (и осолоделые)
Podzoluvisols (PD)		
Eutric (PDe)	Podzolics residual-calcareous	Подзолистые остаточно-карбонатные
	Sod-podzolics	Дерново-подзолистые

	Sod-podzolics residual-calcareous	Дерново-подзолистые остаточно-карбонатные
	Sod-podzolics illuvial-ferrugenous	Дерново-подзолистые иллювиально-железистые
	Sod-podzolics residual-calcareous with the second humic horizon	Дерново-подзолистые остаточно-карбонатные со вторым гумусовым горизонтом
	Sod-podzolics weakly-unsaturated and saturated	Дерново-подзолистые слабоненасыщенные и насыщенные
	Sod-pale-podzolics (and podzolised-brownzems)	Дерново-палево-подзолистые (и подзолисто-буроземные)
	Sod-podzolics with the second humic horizon deep-gleyic	Дерново-подзолистые со вторым гумусовым горизонтом глубокоглееватые
	Sod-podzolics with the second bleached horizon	Дерново-подзолистые со вторым осветленным горизонтом
	Sod-podzolics with the second humic horizon	Дерново-подзолистые со вторым гумусовым горизонтом
	Light-grey forest	Светлосерые лесные
	Light-grey forest with the second humic horizon	Светлосерые лесные со вторым гумусовым горизонтом
	Brownish-light-grey forest	Буровато-светлосерые лесные
Dystric (PDd)	Podzolics	Подзолистые
	Podzolics with the second bleached horizon	Подзолистые со вторым осветленным горизонтом
	Podzolics with the second humic horizon	Подзолистые со вторым гумусовым горизонтом
Stagnic (PDj)	Podzolics surfacely-gleyic	Подзолистые поверхностно-глееватые
	Sod-podzolics surfacely-gleyic	Дерново-подзолистые поверхностно-глееватые
Gleyic (PDg)	Gley-podzolics	Глее-подзолистые
	Gley-podzolics with the second bleached horizon	Глее-подзолистые со вторым осветленным горизонтом
	Podzolic-gleys peat and peaty	Торфяно-(торфянисто-) подзолисто-глеевые
	Podzolic-gleys peat and peaty with the second humic	Торфяно-(торфянисто-) подзолисто-глеевые со вторым гумусовым горизонтом
	Podzolics deep-gleyic and gley	Подзолистые глубоко-глееватые и глеевые
	Sod-pale-podzolics gleyic and gley Sod-podzolics deep-gley and gleyic	Дерново-палево-подзолистые глееватые и глеевые Дерново-подзолистые глубокоглеевые и глееватые
	Sod-podzolic-gleys	Дерново-подзолисто-глеевые

	Sod-podzolic-gleys with the second humic horizon	Дерново-подзолисто-глеевые со вторым гумусовым горизонтом
Gelic (PDi)	Podzolics over-permafrost-gleyic	Подзолистые надмерзлотно-глееватые
Podzols (PZ)		
Haplic (PZh)	Podzols humic-illuvial	Подзолы иллювиально-гумусовые
	Podzols illuvial-humic-ferrugenous (without subdivision)	Подзолы иллювиально-гумусово-железистые (без разделения)
	Podzols dry-peaty	Подзолы сухоторфянистые
	Podzols ochric	Подзолы охристые
	Podzols with the second bleached horizon	Подзолы со вторым осветленным горизонтом
Cambic (PZb)	Podburs taigic (without subdivision)	Подбуры таежные (без разделения)
	Podburs dry-peaty	Подбуры сухоторфянистые
	Podburs ochric	Подбуры охристые
Ferric (PZf)	Podzols illuvial-ferrugenous	Подзолы иллювиально-железистые
Gleyic (PZg)	Podzols gleyic	Подзолы глеевые
Gelic (PZi)	Podburs dark tundra	Подбуры темные тундровые
	Podburs light tundra	Подбуры светлые тундровые
	Podburs tundra (without subdivision)	Подбуры тундровые (без разделения)
Histosols (HS)		
Folic (HSl)	Peats boggy degrading (mineralizing)	Торфяные болотные деградирующие (минерализующиеся)
Terric (HSs)	Peats transitional moor	Торфяные болотные переходные
	Peats low moor	Торфяные болотные низинные
	Peats boggy solonchakous	Торфяные болотные солончаковатые
	Peat-ashes bandding boggy	Торфяно-пепловые слоистые болотные
Fibric (HSf)	Peats high moor	Торфяные болотные верховые
Histosols (HS), without subdivision	Peats boggy (without subdivission)	Торфяные болотные (без разделения)
	Nonsoils formations	**Непочвенные образования**
(R)	Rock outcrops	Выходы пород
(S)	Sands	Пески

Appendix 2. Phases distinguished in the soil database for Russia

Gelundic: The gelundic phase marks soils showing formation of polygons on their surface due to frost heaving.

Gilgai: Gilgai is the micro-relief typical of clayey soils, mainly Vertisols, that have a high coefficient of expansion with distinct seasonal changes in moisture content. This micro-relief consists of either a succession of enclosed micro-basins and micro-knolls in nearly level areas, or of micro-valleys and micro-ridges that run up and down the slope. The height of the micro-ridges commonly ranges from a few cm to 100 cm. Rarely does the height attain 200 cm.

Inundic: The inundic phase is used when standing or flowing water is present on the soil surface for more than 10 days during the growing period.

Lithic: The lithe phase is used when continuous hard rock occurs within 50 cm of the surface.

Phreatic: The phreatic phase refers to the occurrence of the groundwater table within 5 m from the surface, the presence of which is not reflected in the morphology of the soil. Therefore the phreatic phase is not shown, for instance, with Fluvisols or Gleysols. Its presence is important especially in arid areas where, with irrigation, special attention should be paid to effective water use and drainage in order to avoid salinization as a result of rising groundwater.

Rudic: The rudic phase marks areas where the presence of gravel, stones, boulders or rock outcrops in the surface layers or at the surface makes the use of mechanized agricultural equipment impracticable. Hand tools can normally be used and also simple mechanical equipment if other conditions are particularly favorable. Fragments with a diameter up to 7.5 cm are considered as gravel; larger fragments are called stones or boulders. Though it could not be separated on a small-scale map, this difference is obviously important for soil management purposes.

Salic: The salic phase marks soils which, in some horizons within 100 cm of the surface, show electric conductivity values of the saturation extract higher than 4 dSm^{-1} at 25°C. The salic phase is not shown for Solonchaks because their definition implies a high salt content. Salinity in a soil may show seasonal variations or may fluctuate as a result of irrigation practice.

Though the salic phase indicates present or potential salinization, it should be realized that the effect of salinity varies greatly with the type of salts present, the permeability of the soil, climate conditions, and the kind of crops grown. A further subdivision of the degree of salinity would be required for more detailed mapping.

Sodic: The sodic phase marks soils which have more than 6 percent saturation with exchangeable sodium at least in some horizons within 100 cm of the surface. The sodic phase is not shown for soil units which have a natric B horizon or which have sodic properties since a high percentage of sodium situation is already implied in their definition.

Takyric: The takyric phase applies to heavy textured soils which crack into polygonal elements when dry and form a platy or massive surface crust.

Yermic: The yermic phase applies to soils which have less than 0.6 percent organic carbon in the surface 18 cm when mixed, or less then 0.2 percent organic carbon if the texture is coarser than sandy loam, and which show one or more of the following features connotative of arid conditions:

1. presence in the surface horizon of gravels or stones shaped by the wind or showing desert varnish (manganese oxide coating at the upper surface) or both. When the soil is not ploughed these gravels or stones usually form a surface pavement; they may show calcium carbonate or gypsum accumulating immediately under the coarse material.
2. presence in the surface horizon of pitted and rounded quartz grains showing a matte surface, which constitute 10 percent or more of the sand fraction having a diameter of 0.25 mm or more.
3. presence of 2 or more palygorskite in the clay fraction in at least some sub-horizon within 50 cm of the surface.
4. surface cracks filled with in-blown sand or silt; when the soil is ploughed this characteristic may be obliterated, however, cracks may extend below the plough layer.
5. a platy surface horizon which frequently shows vesicular pores and which may be indurated but not cemented.
6. accumulation of blown sand on a surface.