NATURAL REGIONS OF THE U.S.S.R.

WORKS TRANSLATED UNDER THE RUSSIAN TRANSLATION PROJECT OF THE AMERICAN COUNCIL OF LEARNED SOCIETIES, AND PUBLISHED BY THE MACMILLAN COMPANY

W. CHAPIN HUNTINGTON, EDITOR

TOLSTOY AS I KNEW HIM
My Life at Home and at Yasnaya Polyana
By T. A. Kuzminskaya, sister-in-law of Leo Tolstoy

THE LAW OF THE SOVIET STATE
By Andrei Y. Vyshinsky, Deputy Minister for Foreign Affairs of the U.S.S.R.

HISTORY OF EARLY RUSSIAN LITERATURE
By N. K. Gudzy, member, Academy of Sciences of the U.S.S.R.

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NATURAL REGIONS OF THE U.S.S.R.
By L. S. Berg, President, All-Union Geographical Society of the U.S.S.R.

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By Y. M. Sokolov

HISTORY OF THE RUSSIAN THEATRE
(*Seventeenth through Nineteenth Century*)
By B. V. Varneke, Philologist and Theatre Historian

and numerous others

Natural Regions of the U.S.S.R.

By L. S. BERG President of
the All-Union Geographical Society
of the U.S.S.R.

Translated from the Russian by
OLGA ADLER TITELBAUM

Edited by JOHN A. MORRISON
Consultant on Soviet Geography, formerly
Chief, Eastern European Branch, Division of
Research for Europe, Department of State

and C. C. NIKIFOROFF
Soil Scientist, Department of Agriculture

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Foreword

THE Russian Translation Project of the American Council of Learned Societies was organized in 1944 with the aid of a subsidy from the Humanities Division of the Rockefeller Foundation. The aim of the Project is the translation into English of significant Russian works in the fields of the humanities and the social sciences which provide an insight into Russian life and thought.

In the difficult problem of the selection of books for translation, the Administrative Committee has had the counsel and cooperation of Slavic scholars throughout the United States and Great Britain. It is thought that the books chosen will be useful to general readers interested in world affairs, and will also serve as collateral reading material for the large number of courses on Russia in our colleges and universities.

Since Russian history is a continuum, the volumes translated are of various dates and have been drawn from both the prerevolutionary and postrevolutionary periods, from writings published inside and outside of Russia, the choice depending solely on their value to the fundamental aim of the Project. Translations are presented in authentic and unabridged English versions of the original text. Only in this way, it is believed, can American readers be made aware of the traditions, concepts, and ideologies by which the thinking and attitudes of the people of Russia are molded.

It should, of course, be clearly understood that the views expressed in the works translated are not to be identified in any way with those of the Administrative Committee or of the Council.

THE ADMINISTRATIVE COMMITTEE
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W. CHAPIN HUNTINGTON

Preface

IT is surprising that out of the hundreds of books on the Soviet Union published in this country and Great Britain there has been, until very recently, no systematic geographic description of that vast country in English. Yet there will be few who will deny that without a knowledge of the natural features and conditions of a country and the manner in which its people have adjusted themselves to their natural environment, there can be no real understanding of that country. One would think that the great contrasts in the natural conditions of the U.S.S.R.—arctic tundras and subtropical rain forests, the greatest lowland plain in the world and mountains over 20,000 feet—and the conspicuous manner in which the natural conditions have affected the development of the Russian State would early have attracted the attention of American geographers. The lack of concern may in part be due to the difficulties placed in the way of individual travel and study in the Soviet Union by the Soviet authorities. But in large measure it must be charged to the willingness of American and British geographers to get their information on the Soviet Union secondhand from the writings of German and French geographers. However, even these sources were unavailable to the average American undergraduate student of geography. The writer of this prefatory note taught a university course on the geography of the U.S.S.R. for several years in the early 1930's; aside from what they could get out of a somewhat propagandistic popular account of Soviet achievements in developing the country's natural resources, the students (with rare exceptions) had to depend entirely on the lectures of the instructor. One of the exceptions was the translator of this work.

Fortunately for the greatly increased number of students now studying the geography of the Soviet Union, two general geographies of the U.S.S.R., one British, the other American, have been published since the war. But while satisfactory as textbooks, they necessarily do not provide the systematic detailed description of the Soviet natural environment which the student needs if his interest is primarily in the physical, rather than in the human or economic aspects of Soviet geography. That lack, it is hoped, this book will fill.

The science of geography—in all its aspects—is no new subject in Russia. Even in tsarist days it was well established as a university discipline, and the Imperial Russian Geographical Society ranked with the national societies of Great Britain, France, Germany, and the United States. Under the present regime, with its concern for inventorying the natural resources of the country and its emphasis on planned economic development, the geographical sciences have developed rapidly. The problem facing the Administrative Committee of the Russian Translation Project was thus one of selection.

Fortunately it was not a difficult one to solve. In the first place, since the Committee had decided to translate also a Soviet economic geography, the field was narrowed to that of physical geography. In the second place, while the literature on the various aspects of physical geography is voluminous, there are few comprehensive treatments of the entire Soviet Union on what we would call in this country the "college level." Finally, the eminence of Professor Berg, the wide range of his experience and interest, and the recognition which he has received both at home and abroad pointed clearly to his *Priroda* S.S.S.R., first published in 1937, as the most authoritative work in the field.

On the occasion of his seventieth birthday and the completion of fifty years of scientific activity, a tribute to Berg by A. G. Grumm-Grzhimailo was published in the *Vestnik* of the Academy of Sciences of the U.S.S.R. (No. 3, 1946). In giving a brief account of Berg's place in Russian geographical science, we cannot do better than to draw extensively from this testimonial.

While Lev Semenovich Berg has been a productive scholar in physical geography and geomorphology, geology, soil science, climatology, limnology, paleogeography, geobotany, zoogeography, ethnography, and the history of geographic discoveries and investigations, he began his scientific career in ichthyology and it is in that field that he made his first and perhaps his greatest contributions. Nevertheless, the fact that he came under the influence, during his student days at the University of Moscow, of the distinguished geographer, anthropologist, and ethnographer, Professor D. N. Anyuchin, undoubtedly laid the basis for the wide range of his interests.

His work in ichthyology provided opportunity for field work in various parts of the vast Russian Empire. In 1895, while still a student in the University of Moscow, he investigated the ichthyological fauna in the basin of the Dniester near his birthplace at Bendery in Bessarabia. In 1897 we find him studying the sturgeon beds at Guryev on the Ural River.

In the summer following, the West Siberian section of the Imperial Geographical Society, jointly with the Moscow Society of the Friends of the Natural Sciences, sent him to western Siberia to make a field study of the region of the lakes of Selety-Dengiz, Teke, and Kyzyl-Kak. With his appointment as supervisor of the fisheries at the mouth of the Syr-Darya in 1899, he began a series of exhaustive field studies of the Aral Sea which occupied him for several seasons. Beginning with ichthyological studies, his investigations broadened out to include all aspects of the hydrography of that as then little known body of water, with particular attention to the causes of the changes in the level of the lake. The results of his studies were later published in his classical monograph *The Aral Sea*, in which he systematized all the data about this basin, displaying a profound understanding of the mutually active phenomena occurring in it and characterizing it as a landscape of the earth's surface. According to Grumm-Grzhimailo, "for completeness of information and definiteness of conclusion, there has been nothing to equal it in Russian geographical literature." In recognition of this achievement, Berg was awarded the P. P. Semenov-Tian Shansky Gold Medal of the Imperial Russian Geographical Society and the University of Moscow named him an honorary Doctor of Geographical Sciences.

Although sent by the Ministry of Agriculture to Bergen in 1902 for oceanographic study at the Oceanographic Institute, his interest in limnological studies in Central Asia continued. In the summer of 1903 he was again in Central Asia, this time on Lake Balkhash. He was intrigued by the extreme shallowness of this large body of water and by the paradox that although located in a desert country and without an outlet, its waters were nevertheless fresh. While in Central Asia that year, he also spent some time investigating the large mountain lake Issyk-Kul, which led the following year to a report on its physical geography, geology, and climatology.

In 1904 and 1905 he studied the fisheries of the Middle Volga, which resulted in the publication "Sketch of Fisheries in the Volga Basin from the River Vetluga to the Mouth of the Kama." In 1905 he was made director of the Department of Fishes, Amphibians, and Reptiles in the Zoological Museum of the Academy of Sciences at St. Petersburg, where he remained, except for summer field trips, until 1914. This was an especially active period even for Berg. Possessed of an astounding capacity for work, in the year 1905 alone he published eight monographs and articles, including his classic work on the fishes of Turkestan and the provocative article "Is Central Asia Drying Up?" which was translated into German and published in the *Geographische Zeitschrift* in 1907.

The concern with both ichthyology, the field in which Berg first won his spurs, and the broader aspects of physical geography which these two studies illustrate, continued throughout his St. Petersburg period. Thus in 1906 and 1907 he worked on the fresh-water ichthyological fauna of the Caucasus, Lake Baikal, the Amur, Manchuria, Korea, North China, Siam, and other countries, using materials at hand in the Zoological Museum. But in the same years he also prepared a note on the sands of Bolshie Barsuki in which he established their aeolian origin from local ferruginous sandstones rather than from the Aral Sea sands to which they had formerly been attributed; he also wrote a report on the results of a trip in the summer of 1907 to the glaciers at the headwaters of the river Isfara in the Turkestan range. In 1909 he published a large work on the fishes of the Amur basin in which he concluded that they bear a strongly relict character and are a survival of a subtropical fauna which was well distributed all over Eurasia at the end of the Tertiary and the beginning of the post-Tertiary era. In the summer of the same year he made an extended trip through the Caucasus collecting ichthyological specimens for the Zoological Museum.

Berg's study of the lakes of Transcaucasia and other new data led him to write the remarkable article "On the Changes of Climate in the Historical Epoch" which appeared in 1911. In this article Berg came to the conclusion that although the so-called "Brückner" periodic variations in climate had taken place in the historical epoch, in general the climate of the Northern Hemisphere had not changed, while in the immediate postglacial period of prehistoric time it was considerably drier and warmer.

His studies of fish life keeping pace with his broader geographic interests, Berg in the same year (1911) published his study "Fauna of Lake Baikal and Its Origin" in which he came to the conclusion that the fauna of this great inland sea could not be of marine origin and assigned it to a special "Baikal" subdivision of the subarctic region. To 1911 also belong two of Berg's great contributions, *The Fauna of Russia* and the article "Forms of the Russian Deserts." In an introduction to the former work he divides the globe into zoogeographical realms, regions, and subregions on the basis of the geographical distribution of fresh-water fish. In the latter he develops an interesting classification of deserts; sandy, clayey, salty, and stony. His increasing interest in geomorphology led him in 1912 and 1913 to undertake a study of the relief of Chernigov *oblast,* in 1913 to publish an article on "An Experiment in Dividing

Siberia and Turkestan into Landscape and Geomorphological Zones," and in 1914 to a sketch on "Structure of the Surface of Asiatic Russia." In the last-named he proposed a division of Asiatic Russia into fourteen geomorphological regions.

During the St. Petersburg period Berg began his close connection with the Geographical Society which has continued to the present. Elected an active member on January 28, 1904, that is, before he took up his post in the Zoological Museum, from the time of his arrival in the capital, Berg was an active member of several committees of the society, among them those dealing with hydrography, sand, meteorology, glaciers, biogeography, and physical geography. With his eager mind and with the stimulation of the other natural scientists of the society, it was inevitable that Berg should attempt a definition of geography, a temptation to which all geographers succumb sooner or later. In a report to the Geographical Society on "The Subject and Aims of Geography," he defined geography as the science which studies landscapes. In his opinion the sphere of geography includes "the entire outer crust of the earth subject to weathering, down to the level of the ground water, and in the sea the whole depth of the water down to the bottom, and the bottom itself to a depth as far as the influence of the ocean water is felt." While few American geographers would accept this as a definition of their field, it is of interest in its bearing on the subsequent development of geographic thinking in Russia. Berg himself later developed these propositions into the integrated theory of landscapes of which the present book is the latest expression.

However, his larger interests did not completely replace his interest in ichthyology. In 1914 he moved to Moscow to accept a professorship in that subject in the Fisheries Department of the Moscow Agricultural Institute. The period of his work in Moscow (1914–1918) coincided with the First World War; nevertheless, even under war conditions he produced more than twenty books and monographs. Among these was his compendium, *Fresh-Water Fishes of Russia* which, along with its other scientific merits, has value as a definitive work, unique in its completeness and detail; a fourth edition of this three-volume work has recently been published. Another outstanding contribution, which but for the war would have received wider attention in the outside scientific world, was his monograph "On the Origin of Loess," in which he departed from the classical aeolian theory to advance an original hypothesis which, although it has not been widely accepted, has aroused much interest among geologists and soil scientists abroad as well as in Russia.

In 1918 Berg's achievements in the broad field of physical geography received official recognition with his appointment to the professorship in that subject at the University of Petrograd. He also lectured on physical geography in the Pedagogical Institute of the university and the newly created Geographical Institute. With his return to Petrograd, Berg immediately renewed his activity in the Geographical Society.

The extremely difficult conditions of life and work in the period of the Civil War did not break him down. On the contrary, he displayed in these years an extraordinary capacity for work and accomplished research notable for its range of interest and valuable for its contents. To the difficult year 1920 belongs his challenging monograph on "Bipolar Distribution of Organisms and the Glacial Epoch," in which he explained the interrupted character of the geographic distribution of organisms in terms of climatic changes which took place during the glacial period. In 1922 there appeared his *Climate and Life,* a collection of articles most of which had already been published but which were rewritten to take into account the most recent materials. However, this volume contains also an article "On the Postglacial Epoch of the Desert Steppe" which had not previously been published. In this article Berg demonstrated that in the glacial epoch the dry zones, both of the Southern and the Northern Hemispheres, contracted strongly, but that in the dry postglacial period they were greatly extended, both northward and southward. This was the epoch of the steppes and of the xerophytes, of the formation of loess, of the drying up of the lakes. In the contemporary epoch, he pointed out, we see the reverse phenomenon: the moist zone broadens at the expense of the dry, forests invade the steppes, the moisture and shade-loving species of trees advance at the expense of the species requiring dryness and light, the chernozems are developed on the loess soils, the steppe fauna is crowded to the south, dry basins are filled with water, and the salinity of previously salt lakes is reduced by the inflow of water.

His long interest in climate culminated in *Principles of Climatology* which appeared in 1926 and which has become a standard Soviet text in this field. It was extensively revised and added to for the 1936 edition.

All of the preceding work in zoogeography, geobotany, geomorphology, soil science, and climatology was preparation for his great synthesis of physical geography, *The Landscape-Geographical Zones of the U.S.S.R.,* which was first published in 1930. A second edition of this fundamental work appeared in 1936; it included a new section devoted to the zone of the forest steppe. Berg's teachings about landscape zones won immediate acclaim, and to meet the needs of students he incorporated them in textbook form in *Priroda S.S.S.R.* (Natural Regions of the U.S.S.R.), which was first published in 1937 and brought out the following year in a second edition. It is this volume which has been chosen for translation as best serving the needs of American students of geography.

Great as has been Berg's work in physical geography, beginning in 1920 he also found time for important contributions to the history of geographical discoveries, especially those of Russian explorers. In 1920 he published a long article entitled "Information About Bering Strait and Its Coasts, from Bering and Cook to the Present." In 1924 appeared his article on "The History of the Discovery of the Aleutian Islands" in *Zemlevedenie* and in the same year a book *The Discovery of Kamchatka and the Kamchatka Expeditions of Bering.* In 1925 *Zemlevedenie* published his article on "The Role of the Academy of Sciences in the History of Geologic Discoveries in the Eighteenth Century" and in 1926 his article on "Services Rendered by the Russians in the Investigation of the Pacific Ocean." In 1927 he wrote "The History of Geographical Explorations of the Yakutsk Region" for the collection *Yakutia* of the Academy of Sciences. A similar study appeared in the Academy's *Turkmenia* collection the following year. In 1929, as part of the *Trudy* of its Commission on the History of Knowledge, the Academy issued his "A Sketch of the History of Russian Geographical Science." Most recently he completed the centennial history of the All-Union Geographical Society.

Although Berg's interest in the geographical sciences has been, as we have seen, wide ranging, he has never given up the field in which he first made his mark—ichthyology. In 1939 he resumed his work as an ichthyologist at the Zoological Institute, and in 1940 produced a study on "The System of Ichthyoids and Fish, Both Living and Fossilized," which, according to Professor I. F. Pravdin, is the best embodiment of all our knowledge of the evolutionary grouping of these fauna. During the last war, while in Kazakhstan (to which he was evacuated on orders of the Academy of Sciences) he occupied himself with a study of the ichthyology of several lakes. On his return to Leningrad in August, 1944, he resumed his work in the Zoological Institute of the Academy of Sciences, where he is now working.

Only a few of the most significant publications of this great Russian scholar have been mentioned here; in all he has published over 480 articles, monographs, and books.

It is not surprising that he has been highly honored. In addition to its

Semenov-Tian Shansky Gold Medal, the Geographical Society in 1915 also rewarded him with its highest award, the Constantinovsky Medal. In 1934 he was elected to the Council of the Society and in 1940 he became its president. On his return to Leningrad in 1944 he devoted himself with his usual energy to restoring the activities of all its departments and committees which had been interrupted by the period of the blockade and siege. His services to science have also been recognized abroad. He is an honorary member of the São Paulo Society of Naturalists and of the Ichthyological Society of America, a corresponding member of the Royal Zoological Society of London and a member of the Masaryk Agricultural Academy of Prague and of the American Geographical Society. In 1936 he was awarded the Gold Medal of the Asiatic Society of India for his work in the study of the zoology of Asia. His achievements have also been recognized by his government. In 1934, on the completion of forty years of scientific endeavor, the Soviet Government awarded him the title of Meritorious Worker in Science, and in 1945 conferred on him the Order of the Red Banner of Labor.

The translation of Berg's *Priroda S.S.S.R.*, which is here presented as *Natural Regions of the U.S.S.R.*, follows the original Russian text scrupulously. Certain sections, notably those on flora and fauna, are probably more detailed than are needed for students in American university departments of geography. On the other hand, it is believed that this detail will be welcomed by plant geographers and zoogeographers. While primarily for students of geography, it is hoped that the book will serve as a reference work on the U.S.S.R. for all students of the natural sciences.

It cannot be emphasized too strongly, however, that no translation of a single work can "open wide the door" to the rich storehouse of Russian geographical literature. At best it can provide an introduction; for this purpose the extensive references to other Russian works make Berg's work especially useful. But the student who wishes to specialize in Soviet geography cannot escape the necessity of learning to read Russian. Only with this essential tool can he hope to have access to what Russian geographers have written about their own country. It is to be hoped that in addition to providing a general survey of the physical geography of the U.S.S.R., this book will stimulate many to learn Russian.

Ability to read Russian is not enough, however. Rich as is Russian geographical literature, it is no substitute for field study in the country itself, for study in Soviet universities and institutes, and for direct contact with Soviet geographers. It is to be hoped that the Soviet authorities will eventually permit the same freedom of study and travel for American students in their country which is accorded by the United States to students and scholars from abroad.

Much credit is due the translator of this work for her devotion to her task, her careful attention to the innumerable minutiae of a work of this kind, and the very considerable amount of research which she undertook to ensure the correct identification of plant and animal names. Only a person herself profoundly interested in Soviet geography and impressed by the great value of the work she engaged to render into English could have produced a translation of this high quality. The writer of this note takes great satisfaction from the fact that his teaching provided the original stimulus for the undertaking.

In presenting the translation of Professor Berg's work to the American reader, the Administrative Committee of the Russian Translation Project believes that it is filling a long-felt gap. It is to be hoped that the book will be useful not only to the students of geography and the natural sciences, but also to the widening circle of serious-minded nonspecialists who wish better to understand the Soviet Union.

J. A. Morrison, *Chairman, Administrative Committee of the Russian Translation Project, American Council of Learned Societies*

Washington
April 1947

Translator's Foreword

MANY of the technical terms which appear in L. S. Berg's *Natural Regions of the U.S.S.R.* cannot be found in any general Russian-English dictionary. A comprehensive list of some seven hundred Russian-language dictionaries, arranged by subject, showed that technical dictionaries in the several special fields with which this book is concerned are few and in large part inaccessible. In order to translate some of the terms, therefore, it was necessary to use other sources. Some discussion of the methods used may help explain any unique treatment of technical terms in this translation.

The translation of plant and animal names was facilitated by the provision in Berg's text not only of the Russian common name for each plant and animal, but of the taxonomic name as well. Since the language of taxonomy is universal, translation directly from taxonomic to common names is likely to be more reliable than translation from the vernacular of one language to another.

Plants. The first source consulted in translating plant names was *Standardized Plant Names,** which is the most recent and most complete among the sources available. Where a plant does not appear in *Standardized Plant Names,* the next source used was L. H. Bailey, *The Standard Cyclopedia of Horticulture,* which often gives alternative taxonomic names by which a given plant is known; some of these names in turn do appear in *Standardized Plant Names.* Where a plant was to be found in neither of these sources, a number of others were used, the most important of which appear in a selected bibliography at the end of this foreword.

In cases where a taxonomic name other than that given by Berg is more widely accepted in this country at present, this other name has been inserted in the text in brackets. It was thought best not to risk introducing errors by substituting outright for the taxonomic names given by Berg, and so both names are given in each such case. A few changes have been made in Berg's spelling of taxonomic names, in order to make the spelling consistent with the *Index Kewensis.*

A few plants for which Berg gives only the common names were iden-

* See Translator's Bibliography for complete reference data for all works cited in this foreword.

tified by means of their taxonomic names as given in a number of Russian sources listed in the bibliography. A good source for validating plant names is V. L. Komarov, *Flora S.S.S.R.* (Flora of the U.S.S.R.).

The advantage of having taxonomic names given deserves comment. In some cases, translation directly from the Russian common name into English, with no mention of the taxonomic name of a plant, would leave the reader uncertain as to the exact plant in question. For example, *zheleznoye derevo* may be translated as "irontree" or "ironwood." *Standardized Plant Names* identifies the irontree as genus *Metrosideros*. L. H. Bailey, *The Standard Cyclopedia of Horticulture,* describes *Metrosideros* as one of several genera of the myrtle family called ironwoods. L. H. Bailey and Ethel Zoe Bailey, *Hortus Second,* identify the irontree as *Metrosideros.* It so happens that *Metrosideros* is a genus of trees or shrubs native to New Zealand, Australia, and the Pacific Islands, and not found in the Soviet Union at all. Under "ironwood," the following entry appears in *Hortus Second:* "ironwood"—*Ostrya virginiana,* the American hop hornbeam; "Catalina ironwood"—*Lyonothamnus floribundus;* and "desert ironwood"—*Olneya Tesota.* But the tree to which Berg is referring when he uses the term *zheleznoye derevo* is not *Metrosideros,* nor *Ostrya,* nor *Lyonothamnus,* nor *Olneya.* It is the Persian parrotia, *Parrotia persica.* If the common name *zheleznoye derevo* were not accompanied by the taxonomic name, and if it were translated directly from Russian into English as "irontree" or "ironwood," an American reader would certainly be misled as to the tree in question.

In many cases dictionary definitions offer several choices in the translation of a given plant name. For example, dictionary definitions of the Russian word *yel* include "fir," "red fir," "spruce," and "pine." When the word *yel* is accompanied by the taxonomic name *Picea orientalis* or *Picea glehni,* it is clear that the exact translation for scientific purposes can be only "spruce."

The word *kedr* has not been translated as "cedar," as it is defined in any number of Russian-English dictionaries. According to *Standardized Plant Names,* there is wide misapplication of the term "cedar." On the basis of the taxonomic names supplied by Berg, *kedr* has been translated in different parts of the book as "Siberian stone pine" (*Pinus sibirica* [*P. cembra sibirica*]); "Japanese stone pine" (*P. pumila*); or "Korean pine" (*P. koraiensis*).

Animals. Animals were identified by means of their taxonomic names in a number of sources, the most important of which appear in the bibliography. A few mammals for which Berg gives only the common names were identified by means of their taxonomic names as given in two Russian sources which also appear in the bibliography. Many of the fish were identified in the same fashion in a book written by L. S. Berg himself, *Ryby presnykh vod S.S.S.R. i Sopredelnykh Stran* (Fresh-Water Fishes of the U.S.S.R. and Adjoining Countries).

In the case of fish, particularly, dictionary translations from the Russian are often misleading, so that identification according to taxonomic names is important. For example, *nalim* appears in the dictionary as "burbot" or "eelpout," while according to Berg's own source, *nalim* is "loach" (*Lota lota*). *Golets,* which is defined in a dictionary as "loach" or "ground gudgeon," may be identified, from its taxonomic name, *Salvelinus,* as "charr."

The word *kulik* (which is defined in one Russian-English dictionary as "woodcock," "wood grouse," or "snipe") is used by Berg in such a broad sense that he is clearly referring to a category larger than that of a single species of birds. A list was made of all the birds to which the name *kulik* is applied in Berg's text, to see what they have in common, and the word was translated as "shore bird."

In the section which deals with the subzone of mixed forests, mention is made of a bird for which the Russian name is *vertlyavy dyatel.* This has been taken to be the wryneck, a member of the woodpecker family, which is characterized by its habit of twisting its head from side to side. The habitat and distribution of the wryneck, as given in H. E. Dresser, *A Manual of Palaearctic Birds,* are not inconsistent with this conclusion.

Soils. In translating the sections concerned with soils and soil chemistry, extensive use was made of the Yearbook of Agriculture, *Soils and Men.* Many soil terms which are peculiarly Russian will be found in the glossary. Two Russian sources which were useful in identifying soil and geological terms are listed in the bibliography.

Place Names. Map sources which were particularly useful in validating place names are listed in the bibliography. Many of the place names with Russian case endings, such as "sky," "skoy," "skoye," "skaya," have been simplified by dropping the suffix after "sk." Thus, "Kronotskaya volcano" appears in this translation as "Kronotsk volcano," "Lake Rakhmanovskoye" as "Lake Rakhmanovsk." In cases where the adjectival form is derived from the name of a particular landscape feature (generally a river), the nominative form has been substituted for the adjectival form. Thus, "Yeniseisky ridge" appears in this translation as "Yenisey ridge," "Bureinskiye Mountains" as "Bureya Mountains," "Zeisko-Bureinskaya Lowland" as "Zeya-Bureya Lowland." The names of Russian administrative units are given in Russian, as in the original, and have not been translated. These terms (*kray, oblast, okrug, raion*) appear in the glossary. The place names *Predkavkazye* and *Preduralye* have been translated, respectively, as "North Caucasus Foreland," and "West Urals Foreland." (The corresponding terms, *Zakavkazye* and *Zauralye,* are familiar as "Transcaucasus" and "Trans-Urals.")

Glossary. Because this book deals with several special fields, it was thought wise to prepare a glossary. This appears at the back of the book, and includes some of the more technical words in each field which may be unfamiliar to a reader well versed in one or several of the other fields treated.

Acknowledgments. A number of biologists at the Smithsonian Institution in Washington (D.C.) helped to identify plants and animals which do not appear in the sources listed in the bibliography, and gave their advice regarding current taxonomic usage. The translation profited greatly from the generous counsel of Dr. Egbert H. Walker, who devoted many hours of his time to checking the sections which deal with plants. Of the animals, the mammals were checked by Dr. Remington Kellogg; the birds, by Dr. Herbert Friedmann. Fish were checked by Dr. Leonard P. Schultz; Mr. Austin H. Clark was kind enough to identify, by reference to Berg's monograph on fish, an entire list of the fish which are mentioned without taxonomic names in the original of this text. Amphibians and reptiles were checked by Dr. Doris Cochran, with the help of Dr. Ernest Schwartz, who is especially familiar with amphibians and reptiles of the Old World. Dr. Waldo L. Schmitt, Dr. E. A. Chapin, and Dr. J. P. E. Morrison gave their advice on the invertebrates. I am indebted also to Dr. John P. Decker, Department of Botany, University of Nebraska, for his generous advice with respect to plants, and for suggesting excellent source material.

The ultimate responsibility for the translation of plant and animal names rests, of course, with the translator. A file has been kept of the source or sources in which each plant and animal was identified, so that any questions in this connection may be answered readily. Some of the taxonomic names missing in the original Russian edition have been added, in brackets, in this translation.

Since it was not possible to reproduce satisfactorily the illustrations which appear in the original work, those for the English translation were selected from several Russian and German sources, care being taken that those selected would be appropriate to the text. The chief sources for the illustrations were the excellent German collection, *Vegetations-*

bilder (Verlag von Gustav Fischer in Jena) and *Aziatskaya Rossiya*, the monumental descriptive work on Asiatic Russia issued by the Imperial Ministry of Agriculture in 1914.

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Olga Adler Titelbaum

Chicago, Illinois
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Introduction

THE area occupied by the U.S.S.R. is so vast and so diverse in its natural features that it would not be expedient to present a physical-geographical description of this entire territory without dividing it into natural regions. We shall distinguish first of all the lowlands and the mountains.

The description of the natural regions of the lowlands will be arranged according to landscape zones. These are regions which correspond to climatic belts, lying approximately in a latitudinal direction, and characterized by more or less uniform natural features throughout their extent.

Among the lowlands of the U.S.S.R. we distinguish, beginning at the north, the following landscape zones: (1) the tundra, (2) the temperate forest, (3) the forest steppe, (4) the steppe, (5) the semidesert, (6) the desert, and (7) the subtropical forest.

Among the mountain landscapes we distinguish: (1) the Caucasus, (2) the mountains of the Crimea, (3) the Urals, (4) the mountains of Soviet Central Asia, (5) the Altay Mountains, (6) the Sayan Mountains, (7) Lake Baikal and the Trans-Baikal region, (8) the mountains of northeastern Siberia, (9) the mountains of the Far East, (10) Sakhalin, (11) Kamchatka, and (12) the mountains of the Arctic. Within each mountain landscape we shall try, so far as possible, to distinguish vertical zones.

At the conclusion of this book there appears a bibliography of the most important literature concerning the Soviet Union or the greater part of it. For a more detailed literature, I refer the reader to the works enumerated in the books listed in this bibliography. In the text, reference is made only to the most important and most recent works. These are taken, moreover, chiefly from among those which are not cited in my other works.

I · The Tundra Zone[1]

General Characteristics

THE zone of the tundras occupies the extreme north of the continents of Europe and Asia. The tundra proper is characterized by the following features: It is unforested, with the exception of trees occasionally found in the valleys. The winter is long and severe. The summer is short and cool, but has long hours of daylight. The mean temperature of the warmest month does not exceed 10° C.* (nor does it fall below 0° C.). Frosts occur even in summer. Cloudiness is extensive, and there are strong winds. There is little precipitation because, due to the low temperature, a negligible quantity of moisture passes into the atmosphere. At a certain depth below the surface of the ground, there is usually a layer of permanent ground frost.

To the south, the zone of the tundra proper merges gradually into the forest zone, through the intermediate zone of the wooded tundra. We shall consider the wooded tundra together with the tundra proper, as does Gorodkov.

Subdivisions

Beginning at the north, the tundra zone may be divided into the following subzones (Map 1):

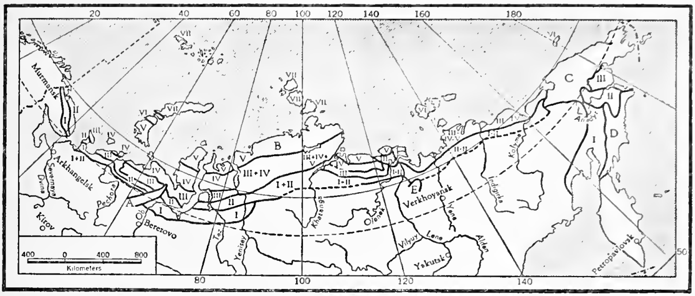
1. Along the northern border lies the *arctic tundra,* where not only trees, but even shrubs are absent (Figs. 1 and 2). The latter, when they do appear, are found only along river courses, or, occasionally, in places especially sheltered from strong winds. There are no sphagnum peat bogs, since peat formation generally dies out as we move toward the

[1] For details and bibliography see L. S. Berg, *Fiziko-geograficheskie (landshaftnie) zony* (Physical-Geographical [Landscape] Zones), I, 1936, pp. 43–94.

* There is no temperature scale indicated in the original text. It would appear, however, that the temperatures given are in the Centigrade scale, and this scale will be indicated throughout the book.—Tr.

north. Vegetation in general is extremely scant. There are large expanses of spotty tundra. The arctic tundra is found on the southern island of Novaya Zemlya, on the north of the Yamal and the Ob-Yenisey peninsulas, on the north of the Taimyr Peninsula, in the delta of the Lena, on the New Siberian Islands, and on Wrangel Island.

2. South of the arctic tundra lies the subzone of the typical, or *shrub tundra* (Fig. 3). While there are no trees, shrub thickets (dwarf birches



MAP 1. The Soviet Arctic (B. N. Gorodkov, 1935).

I—wooded tundra; II—southern tundra; III and IV—typical tundra (IV—northern, lichen-moss portion of the typical tundra); V and VI—arctic tundra (VI—transition into the ice region); VII—ice region (mountains of the Arctic). A—Urals; B—Byrranga range; C—Chukotsk-Anadyr mountains; D—Koryak range; E—Verkhoyansk range.

and willows, and ledum) grow not only along river courses, but are very characteristic also in the areas between rivers. There are some sphagnum peat bogs, but they are not strongly developed. Considerable areas are occupied by lichen (reindeer-moss) tundra. In the northern part of this subzone there are fewer shrub thickets, and lichen-moss tundra predominates. The typical tundra has a wide extent. However, on the Kola Peninsula its area is limited; it appears only in the form of a narrow coastal strip to the north of the mouth of the Ponoy and extending as far as the mouth of the Yokanga.[2]

3. Still farther south lies the subzone of the *southern tundra,* where there are forests, but only along the river courses. In the interfluves, amid the shrub thickets which predominate here, there are found at most individual spruces, birches, larches (Fig. 4). There are many sphagnum peat bogs. Gorodkov calls this subzone the northern wooded tundra.

4. Finally, in the southernmost outskirts of the tundra, where it merges into the zone of continuous forests, lies the transitional subzone of the

[2] See vegetation map in the *Atlas Leningradskoy oblasti i Karelii* (Atlas of Leningrad *oblast* and Karelia), 1934.

wooded tundra, or preforest zone (Fig. 5). Here we find forests not only along the rivers, but also in patches on the interfluves, between the rivers. Tundra vegetation is represented by thickets of shrub birches and willows. In some places there is spotty tundra. Sphagnum peat bogs reach a tremendous development, occupying no less than half the entire area of the subzone. Gorodkov calls this subzone the southern wooded tundra. We regard the subzones of the arctic tundra, the typical (shrub) tundra, and the southern tundra, collectively, as the tundra proper, as distinguished from the wooded tundra.

Boundaries

The southern boundary of the tundra proper, which coincides with the southern boundary of the subzone of the southern tundra, extends from the shores of the Varanger fiord and the southern end of Kola Inlet to the lower course of the Ponoy. The entire Kanin Peninsula is covered with tundra as far south as lat. 67° N. Beyond this the boundary of the tundra crosses the Pechora at Pustozersk, the Gulf of Ob and Taz Bay in lat. 67° N, the Yenisey north of Dudinka; thence it proceeds to the mouth of the Khatanga, the delta of the Lena, Nizhne-Kolymsk, to the middle course of the Anadyr, where it turns in the direction of Gizhiga and the Parapolsky Dol, which connects Kamchatka with the continent.[3]

Where the land mass extends far to the north, as on Taimyr Peninsula, the forests also extend farther north than usual (on the Khatanga as far as lat. 72½° N).

Climate

The southern boundary of the tundra proper coincides approximately with the 10° July isotherm, which runs, in general, parallel to the shores of the Arctic Ocean. Where the mean July temperature is below 10° C., trees are usually unable to survive.

Because of the low temperature, little moisture evaporates, over either land or ocean, and hence there is scant precipitation, the annual mean being 200 to 300 mm. The sparsity of precipitation creates in the tundra conditions which are to some extent similar to those in the desert. Thus, leaching of the surface formations and soils proceeds rather slowly.

[3] Gorodkov (1935) draws the southern boundary of the wooded tundra as follows: from Kola through the southern part of the Kanin Peninsula, thence along the Arctic Circle to Salegard, thence to the lower course of the Taz, across the Yenisey near the mouth of the Khantaika, along the northern border of the Central Siberian Plateau, across the Lena and the Indigirka in lat. 70° N, Nizhne-Kolymsk, along the upper course of the Anadyr, across the Gizhiga River, and terminating at Korf Bay on Kamchatka.

As we move from west to east, the climate of the tundra becomes increasingly continental. The winters grow more severe, and precipitation decreases. The Murman coast, with a climate strongly affected by the Gulf Stream, has considerable precipitation (Kola has about 400 mm.) and very moderate winters; the annual range of temperature in the western Murman is approximately the same as that on the Black Sea coast of the Caucasus. In the delta of the Lena (lat. 73° N), however, the annual precipitation is about 100 mm., and (in 1883) the February temperature, − 42° C., and the July temperature, + 5° C. Beyond the Kolyma the influence of the Pacific Ocean is already apparent, and the climate becomes perceptibly more marine. The winter temperatures are not as low, and the summers are cooler.

The basic factor which controls plant life in the tundra is the summer temperature, particularly the short duration of the summer. The frost period (days on which no thawing takes place) in the tundra lasts from half a year (in Europe) to eight months and more (in Siberia). The vegetative period in the arctic tundra of western Siberia is only two months long; in the typical tundra, three.

The temperature in the Siberian tundra may drop to − 50° C. and lower. We must note, however, that far inland in Siberia the winters are much more severe than along the coast. Thus, at the mouth of the Yana, the mean December temperature is 13° C. warmer than in Verkhoyansk, which lies higher up along the course of the Yana, 3.5° farther south and already within the forest zone. The explanation (even when one takes into account the location of Verkhoyansk in a valley basin, with much lower winter temperatures) is found in the strong winds along the coast, which mix the lower and heavier cold layers of air with the higher warm layers. (In northern Siberia in winter the temperature increases with altitude.) Winters are even milder on the New Siberian Islands; on Kotelny Island, in lat. 75° N, the mean winter temperature is 3° to 4° warmer than on the continent above the mouth of the Indigirka, in lat. 71° N. On the other hand, the summers along the coast are very cool, and, above all, the weather is extremely changeable. Bunge describes the summer of 1884 in the delta of the Lena, in lat. 73° N, as follows:

> At 1:00 P.M. on July 22 the temperature was 21° C. Many insects were flying about, among them many mosquitoes. The night was also warm, 15° to 16° C. The following day it was even warmer. There were many butterflies, and the air was laden with the fragrance of flowers. But presently a northwest wind came up, it turned cold and rainy, and the temperature at night fell to − 4° C.

There may be several warm days, like those just described, during a summer in the tundra. Occasionally (although not in the delta of the Lena) there are very warm days when the thermometer rises to 30° C. and higher (in the shade).

The disposition of isobars over the Arctic Ocean is such that in winter the coastal winds blow from the land, in summer from the sea. Thus, there occurs a shift in winds, somewhat suggestive of the monsoon. Due to the proximity of the ocean, the force of the winds in the tundra is considerable. The winds on the shores of the Kara Sea are particularly strong. On Vaigach Island and in the Gulf of the Yenisey the mean annual wind velocity is 7 to 8 m. per second. In winter snowstorms sometimes occur which last for several days. The force of the wind is occasionally so great as to knock men and deer off their feet. Eastward from the Yenisey the force of the wind diminishes.

Maximum precipitation in the tundra usually occurs in the latter half of the summer, in July and August, and in some parts of the European tundra, in September. Minimum precipitation occurs in February and March. Despite the sparsity of precipitation, it rains often. Snow may fall in the tundra during any month of the year, although it falls least frequently in August. The snow cover is negligible, due both to the small quantity of precipitation in general, and to the strong winds which blow the snow away. The thickness of the snow cover is very important for organic life. In the subzone of the shrub tundra the snow cover protects the shrubs from being frozen in winter. However, in the arctic tundra, as Gorodkov points out, the snow cover has a negative effect on the shrub vegetation, because it melts slowly during the short and cold summer. Soil which is not protected by snow freezes hard in winter; the result is permanently frozen subsoil.

On the seacoast in summer there are frequent fogs. They occur when warm air is carried over the cold surface of the ocean; on Vaigach Island during the summer months there may be as many as fifteen to twenty foggy days.

There is little sunshine in the tundra. It is very cloudy, more so than in any other part of Europe or Asia. The mean annual figure shows approximately three-fourths of the sky covered with clouds. In the European and West Siberian tundra, the most extensive cloudiness occurs in autumn; in the East Siberian tundra, usually in summer. In winter (and spring), however, the tundra, from the Lena eastward, has comparatively clear skies. It must be borne in mind, however, that in summer the *maximum* intensity of direct insolation of the earth's surface in the tundra is no less than in the tropics. Generally there is enough light in the tundra during the vegetative period to support vegetation, but there is not enough heat.

The fact that ultraviolet radiation in the north is far more intense than in the middle latitudes is very important.

In the tundra in summer, even at the shallow depth of 1.5 to 2 m., there is usually permanent ground frost. It is not found on the Kola Peninsula, but from the Kanin Peninsula eastward it occurs throughout the tundra. Between Mezen and the Pechora, the sand, which is a porous medium, thaws by the end of the summer to a depth of 1.5 m. or more; clay, to a depth of 1.25 m.; and peat, which is a poor conductor of heat, to a depth of only 35 to 40 cm. Since peat is a far less effective conductor of heat than mineral soils, permanent ground frost is found sporadically in the peat bogs much farther south than in the clays or sands.

Along the southern border of the tundra, peat mounds are widespread (Fig. 6). It is in these mounds that the southernmost lenses of permanently frozen soil are found; they occur even in the south of the Kola Peninsula.

In Amderma, on the coast of the mainland opposite Vaigach Island, the frozen layer reaches an enormous thickness; a borehole sunk here passed through 216 m. without reaching unfrozen subsoil. Since at a depth of 216 m. the temperature was still − 4.8° C., it may be assumed that the total thickness of the frozen layer here is about 400 m.,[4] the greatest recorded anywhere in the world.

Despite the presence of permanent ground frost, the upper layer of the soil is heated sufficiently to allow the growth of plant life. On Cape Kanin, temperatures above 36° C. have been recorded in the clay loam. The length of the summer day in the tundra must also be taken into account. The frozen layer exerts a great influence on the layer of soil which overlies it. It cools the soil, and does not permit water to penetrate deeply, thus contributing to waterlogging; and it decreases the rate of evaporation from the soil. Flowing ground water hinders the formation of permanent ground frost; at such spots in the tundra one frequently encounters willow clumps. In view of the small amount of precipitation in the tundra, permanent ground frost offers some advantages for the vegetation, since it preserves moisture in the soils. Moreover, it should be noted also that water from melted ice, or ice dissolved in water, has the property of stimulating the growth of plants.[5]

Since about 1919, a marked increase in temperature has been observed

[4] V. Ponomarev, *Sovetskaya Arktika* (The Soviet Arctic), 1936, No. 4, p. 113.

[5] E. Fritzman, "Novy vzglyad na prirodu vody" (A New View of the Nature of Water), *Priroda* (Nature), 1936, No. 2, pp. 30–31.

in the Arctic and in the tundra zone (as well as farther south).[6] Evidence may be found in the very favorable conditions for navigation which have existed in the Arctic for about the last twenty years. The temperature of the water in the Barents Sea has shown a marked rise in recent years. At Mezen the mean annual temperature for the years 1883–1915 was − 1.6° C., while for the years 1916–1930 it was only − 0.7° C.; that is, the temperature rose almost one degree. The mean for the years 1931–1934 was still higher; namely, − 0.15° C.

The city of Mezen is located on the southern border of the region of permanent ground frost delineated by Schrenk in 1837. However, in 1933 no ground frost was found at Mezen. Ground frost was found in isolated patches only 40 km. to the north of Mezen. Apparently the boundary of ground frost retreated to the north with the rise in temperature.

The period during which the Northern Dvina at Archangel is frozen has grown shorter by ten days during the last half century.

	1881–1915	1916–1934	Difference
Thawing	May 12	May 8	4 days
Freezing	November 8	November 14	6 days

Relief

The relief of the tundra zone is generally level, although in some places it is interrupted by elevations, the most important of which are the Ural Mountains and the mountains of northeastern Asia. These will be discussed in the sections which deal with mountainous regions.

The Murman region, the coastal strip reaching inland about 100 km. from the sea, is a dissected plain which drops rather sharply to the sea. Its average elevation is 150 to 200 m. West of the Vorona River, there are points along the southern border of the tundra which reach an elevation of 500 m.[7]

The western Murman is cut by fiordlike bays. These bays are narrow and long and sometimes deep; in Kola Inlet, for example, there are depths of more than 360 m. But in contrast with typical fiords, the shores of the Murman inlets are low and not so steep as are the shores of true fiords.

[6] L. S. Berg, "Nedavnie klimaticheskie kolebaniya i yikh vliyanie na migratsii ryb" (Recent Climatic Fluctuations and Their Effect on the Migrations of Fish), *Problemy fizicheskoy geografii* (Problems in Physical Geography), II, 1935, pp. 73–84.

[7] G. D. Richter, "Orograficheskie raiony Kolskovo poluostrova" (Orographic Regions of the Kola Peninsula), *Trudy Inst. fiz. geografii,* Akad. nauk (Proceedings of the Institute of Physical Geography, Academy of Sciences), XIX, 1936.

In some places there is perfect terracing—evidences of an uplift of the continent. The tundra on the Kola Peninsula (as is the entire peninsula) is underlain by pre-Cambrian schists, granites, and gneisses, folded during pre-Cambrian times. The bedrock is covered by new glacial and postglacial deposits: moraines, eskers, sandy stretches, and peat bogs. There are many lakes. Rybachy Peninsula and Kildin Island, composed of sedimentary strata of the Lower Silurian period, are sharply distinct in relief and geological structure from the rest of the Kola Peninsula, which is composed, as we have said, of pre-Cambrian formations. Rybachy Peninsula is separated from Kola Peninsula by the deep (up to 300 m.) Motovsky Gulf. The origin of this gulf is ascribed to faulting which took place during the Tertiary period. Kildin Island is a plateau, up to 280 m. in elevation; it drops sharply to the sea on the north.

On Kanin Peninsula, from Kanin Nos (Cape Kanin) to the southeast, stretches the Kanin Kamen range, 150 to 175 m. in elevation (and in some places as high as 200 m.). It has a plateaulike appearance, and is composed in part of crystalline schists, and in part of Paleozoic strata overlain by moraine deposits. The southern part of Kanin Peninsula is cut by a trough which reaches from the Gulf of Mezen on the White Sea to Cheshskaya Bay.

The Timan Kryazh (ridge) extends from Cheshskaya Bay to the sources of the Vychegda, and on the north reaches into the zone of the tundra. It consists chiefly of folded Paleozoic strata. On the north the elevation of the ridge does not exceed 255 m. The ridge terminates at the sea in rocky promontories.

Kolguyev Island, composed of Quaternary deposits and covered with mossy tundra, reaches an elevation of 90 m. at its highest points.

Between the Pechora, its tributary the Usa, the seacoast, and the Pai-Khoy range lies the Bolshezemelskaya tundra (Figs. 3 and 5). A large part of this tundra is overlain by moraine deposits. On the watershed between the Arctic Ocean and the tributaries of the Pechora and the Usa, there is a ridge which extends approximately from west to east; it has an absolute elevation of 160 to 230 m. and a relative elevation of 30 to 65 m. This is a moraine ridge, in some places having the characteristics of a typical terminal moraine.

The post-Pliocene marine transgression extended far to the south along the river valleys. In some parts of the Bolshezemelskaya tundra there are a great many small lakes (not over several hectares in area).

Vaigach Island, separated from the continent by Yugorsky Shar (strait), reaches an elevation of 100 m. Here there are zinc-lead, zinc, and copper deposits, while on the continent opposite Vaigach there are beds of fluorite (in Amderma), associated with the limestones of the Lower Paleozoic.

In the northern part of the southern island of Novaya Zemlya, elevations of more than 1000 m. are found.

Near Matochkin Shar, individual peaks reach 1000 m. in elevation. Some 30 to 40 kilometers from Matochkin Shar, on the southern island, glaciers begin to appear. On the northern island, in lat. 74° N, glaciers reach the heads of typical fiords, which are well developed here and extend inland for 30 to 40 km. At lat. 76° N, there is a continuous icecap, from under which hills emerge only at the coast. Here we pass from the zone of the tundra into the ice (Arctic) zone, where the mean temperature of the warmest month very seldom exceeds 0° C., and then only slightly.

The shores of Novaya Zemlya are undergoing an uplift. Admiralteistva Peninsula was an island in the times of Barents and Litke. Kostin Strait contained more islands in 1924 than are indicated on the old maps; some of the former islands, moreover, have been transformed into peninsulas.

As we have said, many of the bays of Novaya Zemlya, particularly on the western coast, are genuine fiords. They lie along fault lines, which have been deepened and worn away by river and ice erosion. Since only the southern island of Novaya Zemlya contains any important rivers, the present drainage system, of course, cannot attain great maturity. On the southern island the rivers flow in canyonlike valleys. Both of the islands are composed of extensively dislocated Paleozoic strata.

There is reason to believe that during the interglacial period the icecap on Novaya Zemlya melted completely and that the southern edge of the ice at that time was to the north of the northern island (M. Yermolayev).

During the glacial period the tundras of western Siberia were covered by an icecap. The ice sheet extended south up the Ob as far as the mouth of the Irtysh and to the Vakh River (a tributary of the Irtysh).

The Quaternary marine transgression penetrated somewhat south of the Arctic Circle along the valleys of the Ob, the Taz, and the Yenisey.

The mouths of the Pechora, the Kara, the Ob, the Taz, the Yenisey, and the Khatanga rivers are distinctive in that, in contrast to the Lena, for example, they do not form deltas where they flow into the Arctic Ocean, but end in bays. Some of the bays, like the gulfs of the Ob, the Taz, and the Yenisey, are very long and narrow. The presence of bays rather than deltas indicates that the sea has encroached upon the land, submerging the lower reaches of the river valleys. At present the rivers are depositing new deltas at the southern ends of the aforementioned bays. The very plausible hypothesis has been advanced that the Ob and the Yenisey were united at one time, and had a common mouth in the Kara Sea at a point considerably farther north than at present. Incidentally, this hypothesis is supported by the great similarity between the fish fauna of the Ob and of the Yenisey.

The northern boundary of the Central Siberian Plateau, which is also the southern boundary of the Taimyr tundra (to which the Central Siberian Plateau drops in steep escarpments), extends from the Pyasina River in lat. 70° N approximately to the lower reaches of the Olenek. In the northern part of the Taimyr Peninsula lies the Byrranga range; composed of dislocated Paleozoic deposits in the vicinity of the Taimyr River, it rises to an absolute elevation of 500 to 600 m.

Between the Byrranga range and the Central Siberian Plateau lies the North Siberian Lowland, 50 to 70 m. above sea level. It is composed of Mesozoic marine deposits, glacial drift, and sediments of the Quaternary marine transgression; outcrops of trap are also very common. There are striking traces of glaciation on the Taimyr Peninsula.[8] But farther east, from the Khatanga to Bering Strait, the Siberian tundra was not covered by a continuous icecap.[9] According to another theory, all of Siberia north of lat. 61° N was covered with ice,[10] but this view is not supported by field evidence.[11]

In the northern part of the Taimyr Peninsula there is a series of terraces which contain fossils of fauna similar to the fauna of the northern seas at the present time. The topmost of these terraces, containing mollusks of the species *Saxicava arctica*, rises to an absolute elevation of 110 m. At Cape Chelyuskin there are terraces, 3 to 5 m. above sea level, which

[8] N. N. Urvantsev, "Chetvertichnoye oledenenie Taimyra" (Quaternary Glaciation on Taimyr), *Byull. Kom. po izuch. chetvert. perioda* (Bulletin of the Committee for the Study of the Quaternary Period), izd. Akad. nauk (publication of the Academy of Sciences), No. 3, 1931, pp. 23–42.

[9] Similarly, the arctic coast of North America from Alaska to Greenland was almost untouched by glaciation.

[10] V. A. Obruchev, *Priznaki lednikovovo perioda v severnoy i tsentralnoy Azii* (Traces of the Glacial Period in Northern and Central Asia), p. 49; N. N. Urvantsev, "Geologiya i poleznye iskopayemye severa" (Geology and Mineral Resources of the North), *Drevneye oledenenie na severe S.S.S.R.* (Ancient Glaciations in the Northern U.S.S.R.), Leningrad, 1936, pp. 129–148.

[11] See also: Ya. S. Edelstein, *Geologiya i poleznye iskopayemye severa* (Geology and Mineral Resources of the North), Leningrad, 1936, p. 110; V. N. Saks, "O chetvertichnom oledenenii severa Sibiri" (Concerning the Quaternary Glaciation of Northern Siberia), *Arctica,* IV, 1936, pp. 3–27.

are covered with driftwood derived from contemporary Siberian species. This indicates that the uplift of northern Taimyr is still in process (G. Aller). Similar observations have been made also in Novaya Zemlya and the New Siberian Islands.

In the vicinity of Khatanga Gulf the presence of salt domes has been discovered recently. (For details regarding this type of structure see below, p. 118.) The salt dome (elevation 120 m.) on the shore of Nordvik Bay, which has been penetrated by boreholes to a depth of 300 m., contains vast reserves of excellent salt. This same dome has provided unmistakable indications of oil.[12]

On Bolshoy Lyakhovsky Island of the New Siberian group, there are elevations as high as 290 m.[13] Outcrops of fossil ice are exposed in the coastal cliffs.

On the surface of the fossil ice, and also in the cracks which formed in the ice back in Quaternary times, there are found numerous remains of Quaternary animals—the mammoth, woolly rhinoceros, bull, deer, horse, musk ox, and a large cat (*Felis spelaea*), which combines the characteristics of the lion and the tiger. (It is sometimes incorrectly called the cave lion.)

Chukotsk *okrug* is a predominantly hilly country, with elevations of 600 to 900 m. It has been partly subjected to glaciation.

Vegetation[14]

The flora of the tundra is unique. The tundra proper is treeless, but almost all the plants, both herbage and shrubs, are perennials. The explanation lies in the fact that the vegetative period is so short that annual plants do not have sufficient time to bear fruit. Many of the plants form patches of sod, like the dryad (in Europe, *Dryas octopetala*, in Siberia, *D. punctata*), or spread along the ground, like the arctic willow and birch, so that they have a better chance to avail themselves of the warmth of the soil in summer, and to protect themselves against evaporation. There are many evergreen plants, but hardly any bulb or tuber plants. Stunted growth is very characteristic. Lichens are numerous in the

[12] N. N. Urvantsev, "Geologiya i poleznye iskopayemye Khatangskovo raiona" (Geology and Mineral Resources of the Khatanga Region), *Problemy Arktiki* (Problems of the Arctic), II, 1937, pp. 17–21.

[13] M. M. Yermolayev, "Geologichesky ocherk Novosibirskikh ostrovov" (A Geological Sketch of the New Siberian Islands), *Trudy Arkt. in-ta.* (Proceedings of the Arctic Institute), Vol. 87, Pt. I, 1937, p. 293.

[14] B. N. Gorodkov, *Rastitelnost tundrovoy zony* S.S.S.R. (Vegetation of the Tundra Zone of the U.S.S.R.), Leningrad, 1935, p. 142, izd. Akad. nauk (publication of the Academy of Sciences).

tundra, especially *Cladonia,* or reindeer "moss" (*Cladonia rangiferina*). These light-loving plants find favorable conditions for development in the tundra, where tree shade is absent. The growth of lichens proceeds very slowly in the north. While in the wooded region the increment during a summer amounts to 4 to 6 mm., in the typical tundra it is 2 to 3 mm., and in the arctic tundra only 1 to 2 mm. (Gorodkov). Sphagnum peat bogs are very widespread in the northern part of the wooded region of the tundra. As one moves to the north, they gradually decrease in significance.[15] The thickness of peat in the tundra is negligible, due to the presence of permanent ground frost and the slow growth of sphagnum mosses. Flowering plants are distinguished by the abundance of flowers, their large size, and the brightness of their coloring (Fig. 1).

The absence of trees in the tundra has been explained by a number of different factors: insufficient warmth in the north, strong and cold winds, high relative humidity in summer. According to Gorodkov, trees die in the tundra as a result of evaporation in summer, since little moisture reaches the shoots by way of the root system from the very cold soil. Winter frosts, however, have no effect upon those species of trees which make up the northern boundary of the forest.

The flora of the tundra is remarkably uniform throughout—in Europe, Asia, and America. There are some species of saxifrage (for example, *Saxifraga cernua*), which may be found in all tundras throughout the polar region. But there are also species which, even though they are widely distributed, do not have a circumpolar distribution. Thus, the tundra sweet grass (*Hierochloë pauciflora*) is absent to the west of Novaya Zemlya as far as the continent of America. A third category of species has a sporadic distribution in the tundras of Europe, Asia, and America. Such, for example, is the endemic draba (*Draba macrocarpa*), a typical tundra plant. A fourth category is distributed within very narrow limits.[16] Endemic species, that is, species of plants not found in regions other than the tundra, are not so scarce as was formerly believed. The tundra contains many plants which are found also in the forest zone. However, there is a group of plants which are found only in the north, and also in the mountains of temperate latitudes above the timber line. Plants found also in the Altay Mountains are especially numerous in the Siberian tundras.

[15] However, small beds of sphagnum mosses are encountered even along Lake Taimyr.

[16] A. I. Tolmachev, "Flora tsentralnoy chasti vostochnovo Taimyra" (Flora of the Central Part of Eastern Taimyr), *Trudy Polyarn. kom. Akad. nauk* (Proceedings of the Polar Committee of the Academy of Sciences), VIII, 1932.

Bogs. Contrary to a common belief, the tundra is not a continuous bog. In the tundra there are extensive dry areas, although, of course, in general there are many bogs. The upland (sphagnum) bog is not widespread in the tundra; the prevailing type of bog is the lowland, or sedge bog. The southern boundary of the typical tundra is usually the northern boundary of upland peat bogs. As we have said, the peat layer in the tundra is not very thick. In the region where permanent ground frost occurs in patches, that is, primarily in the wooded tundra and in the southern tundra, large-mound bog may be found, with peat mounds 3 to 5 m. high and 5 to 25 m. in diameter (Fig. 6). This type of bog is always situated in sheltered, basinlike depressions. Although these basins are not underlain by a continuous layer of permanent ground frost, isolated lenses of permanently frozen soil are always found in the cores of the mounds. The mounds are the result of heaving of the soil caused by the freezing of ground water. The mounds consist of mosses—sphagnum and others—and lichens, and are profusely covered with cloudberry (*Rubus chamaemorus*) (Fig. 2), dwarf arctic birch, bog bilberry, black crowberry, crystal tea ledum, sheathed cotton sedge (*Eriophorum vaginatum*), cowberry, and others. Between the mounds there are long winding depressions (*yersei*), filled with wet sphagnum-hypnum bogs.

Typical shrub tundra is widespread from the Malozemelskaya tundra to the Lena. The vegetation of this tundra falls into three levels: the upper, or shrub layer society; the middle, or herbaceous layer society; and the lower, or lichen-moss layer society. In the upper, or shrub layer society, the dwarf arctic birch (*Betula nana*) predominates (Fig. 3), giving way east of the Yenisey to the closely related form, *B. exilis;* among the dwarf arctic birches there is much crystal tea ledum (*Ledum palustre*), small shrub willow (*Salix glauca, S. pulchra*), and bog bilberry (*Vaccinium uliginosum*). In the middle, or herbaceous layer society, the most conspicuous growth is sedge (*Carex rigida*), black crowberry (*Empetrum nigrum*), fescue (*Festuca supina*), and cowberry (*Vaccinium vitis-idaea*). In the lichen-moss layer society, which covers the ground, brown and green mosses (not sphagnum) and lichens predominate. The river valleys contain the same shrubs as the tundra, but here they reach a greater height (sometimes growing as tall as a man), because in the valleys the ground frost lies deeper and thaws more quickly in summer. The type of tundra described here occupies almost the entire area of the subzone of the typical or shrub tundra, with the exception of bogs and valleys. But in the northern part of this subzone the number of shrubs diminishes rapidly.

On the northern tip of the Kanin Peninsula and in other parts of the subzone of the southern tundra, the small-mound type of tundra takes the place of the type described above. Here the tundra contains scattered low mounds, 20 to 30 cm. and up to 75 cm. in height, composed of peat and overgrown with low birches and willows, under which are found the usual tundra shrubs and herbaceous plants.

East of the Lena, on clayey subsoils, hillock tundra is widespread. The surface of the tundra is covered with hillocks of sheathed cotton sedge (*Eriophorum vaginatum*), sometimes with an admixture of sedge. The plant cover of the hillock tundra also includes sphagnum mosses (both green and brown) and lichens.

Where sandy subsoils are extensive, lichen tundra is widespread. To the west as far as the Yenisey, and in the extreme east, reindeer moss (*Cladonia*) predominates; in the north of Central Siberia, the more hardy alectorias (chiefly *Alectoria ochroleuca*) predominate.

Spotty tundra occupies large level areas of well drained heavy soils. It is characterized by bare, clayey patches, the size of a plate or a wheel, surrounded by a border of mosses and lichens, dwarf arctic birch, ledum (*Ledum*), bog bilberry, cowberry (*Vaccinium vitis-idaea*), black crowberry, alpine ptarmiganberry (*Arctostaphylos alpina* [*Arctous alpinus*]), dwarf willows, and others. Gorodkov explains the origin of the spotty tundra as follows. As a result of the thin snow cover, the surface of the clayey soils cracks from the frost, forming irregular polygons. The edges of the cracks crumble, and in the crevices which result plant life takes root, while on the surface of the patches plants cannot take root because of the winds. In the spring the bare patches thaw quickly and their moisture spreads.

The Wooded Tundra. The forests of the wooded tundra zone are composed of a variety of tree species. On the Kola Peninsula the northernmost forests consist of birch; between the White Sea and the Urals, of Siberian spruce (Fig. 4); between the Urals and the Pyasina, of Siberian larch; between the Pyasina and the upper reaches of the Anadyr, of Dahurian larch; and in the extreme northeast of Asia, along the rivers, are found peculiar small woods of Mongolian poplar (*Populus suaveolens*), Korean willow (*Salix* or *Chosenia macrolepis*), and birch (*Betula cajanderi*).

Extending far to the north, patches of tundra forest are distinguished by their stunted growth (except in the river valleys, the height of the trees is 6 to 8 m.), and by their sparse stand (Fig. 5). As a result, the light in such forests is good, and light-loving lichens reach a considerable development. According to Gorodkov, the reason for the sparseness of the tundra forests lies in the subsoil conditions: where permanent ground frost is present, the tree roots are obliged to spread not downward but laterally, so that there is a smaller number of trees per unit of surface. In general, however, forest vegetation in the tundra zone seeks to avoid areas where there is permanently frozen soil. Since drainage is better in the immediate vicinity of streams, the level of the permanent ground frost is lower along the water courses. This encourages the growth of trees on the banks of rivers and on their flood plains. For this reason, as Tanfilyev has pointed out, the forest border bends sharply to the north along the rivers.

At one time the forests in the tundra extended much farther north than they do today. Evidence is found in the fact that the peat bogs of the typical tundra often contain stumps and trunks of firs, birches, and larches, sometimes as far as 200 km. north of the present northern edge of the wooded tundra. The period during which the forests extended much farther north than they do today must have been the dry and relatively warm postglacial period (the so-called "xerothermic" period). Under present climatic conditions, however, the forest is dying out on its northern boundary and the tundra is encroaching upon the forest. Tanfilyev was not inclined to attribute this encroachment to a change in climate; he regarded the extermination of the outskirts of the tundra forests as being the result of their natural waterlogging, and not as a result of climatic changes. However, as Sukachev has pointed out, the extermination of the forest outskirts in the north of the wooded tundra is not accompanied at all by waterlogging. Gorodkov (1935) notes a great number of forest forms in the plant life of the typical tundra. These bear witness to the fact that in place of the present moss and lichen tundra there extended at one time a forest region, with sphagnum peat bogs and coniferous forests: "The lichen and moss tundras appear as the lower layers of forests which existed here at one time, layers rich in arctic forms and poor in forest forms." Where there are deep peat deposits (4 to 6 m.) in the tundra, they were formed not under present climatic conditions, but during the warmer xerothermic period.

Gorodkov divides the forests of the wooded tundra into several formations. On the sandy and rubbly soils are found lichen forests, or, more exactly, thin forests. Due to the sparseness of the forest stand, the ground vegetation of these forests resembles, on the one hand, the lichen cover of pine groves, on the other hand, the lichen tundra. Lichens (*Cladonia* and others) are the basic species, while under the trees the light-loving lichens give way to mosses. In these forests there is much cowberry, bog bilberry, bilberry, alpine ptarmiganberry, and black crowberry; there are some grasses. The shrub layer society, which consists of dwarf arctic birch, does not grow tall; it reaches only half a meter in height. In the wooded tundra of the Kola Peninsula, lichen birch groves predominate, consisting of the low (3 to 5 m.) and crooked Lapland birch (*Betula kusmisscheffii*), closely related to the pubescent birch. In the wooded tundra of Siberia, lichen forests of larch are widespread; on river terraces these forests attain a greater height and contain a profuse undergrowth of birch and alder (*Alnus fruticosa*).

On the clayey subsoils of the wooded tundra there are many green-moss forests, with a ground cover of green mosses, chiefly hypnum. In the wooded tundra between the Pechora and the Yenisey there are mossy fir groves with an admixture of birch and Siberian larch. In Siberia there are also mossy larch groves. Among the shrubs in the green-moss forests, dwarf arctic birch, willow, crooked birch (*Betula tortuosa*), and alder (*Alnus fruticosa*) are common.

In the river valleys of Siberia there are herbaceous-shrubby larch groves. They contain much willow, dwarf arctic birch, currant, and sweetbrier rose. In the larch forests along the Ob and Yenisey gulfs, where the level of permanent ground frost is lower, the trees grow to a considerable height, up to 15 m.

In the Khatanga basin and apparently farther east, the subzone of the wooded tundra does not appear. The tundra borders directly upon the zone of thin forests.

Fauna

The fauna of the tundra is distinguished in general by its remarkable uniformity throughout—in Europe, Asia, and America. The number of species is not large, but many of the species are represented in extremely large numbers. The land fauna of the tundra is characterized by its small variability. Those species which contain many varieties farther south, manifest either no local forms in the tundra, or only a few. This suggests that the fauna of the tundra [17] is new in its present surroundings. Of the mammals,[18] the reindeer, both wild and domestic, is

[17] G. P. Dementyev, "Ptitsy poluostrova Kanina" (Birds of the Kanin Peninsula), *Sborn. trudov Zool. muzeya* (Collected Proceedings of the Zoological Museum), II, Moscow, 1935.

[18] G. P. Adlerberg, V. S. Vinogradov, N. A. Smirnov, K. K. Flerov, *Zveri Arktiki* (Animals of the Arctic), Leningrad, 1935, izd. Glavsevmorputi (Board of the Northern Sea Route), p. 579.

very characteristic for the tundra, as are, to a lesser degree, the lemming, the arctic fox, and the domestic dog. In the European tundra the wild reindeer (*Rangifer tarandus*) is at present almost extinct. In the fall the reindeer moves from the tundra into the wooded tundra, where it is warmer; but in summer it returns to the tundra, where it seeks refuge from the mosquitoes. The domestic reindeer is a universal animal in the tundra: it is used as a draft animal; its meat is eaten; its skin is used to make clothing, shoes, chamois, and tent coverings. Clothing made of reindeer skin, which retains its elasticity even in severe frost, has no substitute in regions where the winters are severe. The reindeer grazes all winter long, subsisting on reindeer moss and other lichens and mosses; it feeds readily on berries, mushrooms, and young greens. In the Bolshezemelskaya tundra the reindeer stags begin to shed their antlers in the middle of April, and by the end of the month they are all hornless; the does shed their antlers in May, after dropping their fawns. The dogs which tend the reindeer herds are Eskimo dogs—small dogs with long white fur and pointed ears. Tundra Eskimo dogs constitute a distinct group, which differs sharply from taiga Eskimo dogs. Tundra traction dogs, that is, dogs which may be hitched to sledges, are related to the Eskimo dog type, but differ somewhat from the type which tends herds. East of the Yenisey, dogs are used only for haulage, and not to tend reindeer.

Lemmings (genera *Lemmus* and *Dicrostonyx*) are typical tundra rodents. In some years they appear in great numbers. The arctic fox (*Alopex lagopus*), a carnivore of the dog family, has a white coloration in winter, brown in summer. Besides the arctic fox, there is a whole series of white animals in the tundra: the willow ptarmigan, the snowy owl, the varying hare, the polar bear, the white wolf, and the Eskimo dog. Some of these animals are always white, others change to white coat only in winter.

Life in the Bolshezemelskaya tundra does not begin until the middle of June and ends in September. In winter the tundra is inhabited only by the arctic fox and sometimes by the willow ptarmigan (*Lagopus lagopus*). In spring the first birds to appear are the swans, and next the wild goose and the white-fronted goose. In the typical tundra there are no amphibians or reptiles.

Among the fish of the tundra, salmonids predominate: on the Murman coast, the Atlantic salmon (*Salmo salar*); farther east, various whitefish (*Coregonus*), the Siberian *nelma* (*Stenodus* [*S. leucichthys nelma*], a fish which is closely related to the Caspian-Volgan whitefish), and charr

(*Salvelinus*), which is found farther north than any other fresh-water fish (it is found on Novaya Zemlya and on the New Siberian Islands). In the Anadyr, chum and pink salmon (Pacific salmon of the genus *Oncorhynchus*) appear in considerable numbers.

After warm weather sets in, swarms of mosquitoes appear; they constitute a real hardship for the reindeer. There are fewer mosquitoes on the seacoast; but in the wooded tundra they occur in unbelievable numbers.

Professor Birulya (1907) wrote an excellent account of animal life in the arctic tundra of Siberia, particularly on the New Siberian Islands and on northern Taimyr. Apparently, of the birds on northern Taimyr, only the tundra ptarmigan (*Lagopus mutus*) and the snowy owl (*Nyctea nyctea*) remain during the winter. On the New Siberian Islands, the willow ptarmigan (*Lagopus lagopus*) is known to spend the winter. Some of the tundra ptarmigan retire to the south for the winter, to the edge of the forests, while others remain through the winter. On Taimyr, reindeer, wolf, both types of lemming, and ermine remain throughout the winter, along with the tundra ptarmigan and the snowy owl. Migratory birds appear very early in spring. On western Taimyr, in lat. 76° N, the first of the migratory birds to appear at the beginning of May is the snow bunting (*Plectrophenax nivalis*), followed by the shore birds. In the latter half of June the birds begin to nest. In the latter half of July they begin to fly south, and by the middle of August the tundra is empty. However, the snow bunting remains until September, and individual birds remain as late as October. Of the mammals, only the reindeer, wolf, polar bear, arctic fox, hare, ermine, and two types of lemming are found in northern Taimyr. The same species, with the exception of the hare, are found on the New Siberian Islands.

Among the animals of the tundra there are some endemic genera. These include the lemmings (*Lemmus* and *Dicrostonyx*), which are found predominantly in the tundra.[19] Many birds nest exclusively in the tundra. Such, for example, are the eider ducks—the king eider (*Somateria spectabilis*) and Steller's eider (*S. stelleri* [*Polysticta stelleri*]), the white-fronted goose (*Anser albifrons*), the brant (*Branta bernicla*), the red-breasted goose (*B. ruficollis*), Bewick's swan (*Cygnus bewicki*), the black-bellied plover (*Squatarola squatarola*), Rosa's gull (*Rhodostethia rosea*), and others. Some of the birds are circumpolar in distribution,

[19] This is evidence of the fact that the tundra fauna contains archaic elements, which were developed, apparently, under different geographic conditions. This conclusion is not contradicted by the fact that the animals of the tundra are new in their *present* environment (see above, p. 17).

being represented both in the U.S.S.R. and in the tundras of North America by the same species, without even forming different varieties. Among these are the king eider, the red-throated loon, the snowy owl, the glaucous gull, and the phalarope.[20]

Origin of the Tundra Landscape

During the glacial period a large part of the tundra was covered by an ice sheet, and the tundra vegetation, pushed far to the south, was found, in the form of tundra and wooded tundra, along the periphery of the glacial cover. At the same time, during this period the mountain vegetation in the Arctic, as well as in temperate latitudes, was also forced to move down into the lowlands, and the interchange of organisms between the mountains and the tundra was facilitated considerably. This interchange explains a certain similarity which may be observed between the plant and animal life of the Arctic, on the one hand, and of the mountains which have an alpine zone, on the other. To this similarity Forbes and Darwin had called attention even in their time. The plants common to both the tundra and the alpine zone include the dryad (*Dryas*), the dwarf arctic birch (*Betula nana*), the ptarmiganberry, the butterbur, the black crowberry, the spring gentian (*Gentiana verna*), and others. The animals include the tundra ptarmigan (*Lagopus mutus*), which is native to the Pyrenees, the Alps, and the Altay Mountains, and others.

But, in addition, among the plants and animals of the tundra there are also steppe, or, more exactly, chiefly mountain-steppe forms, native predominantly to the tundras of eastern Siberia. Although the tundra and the steppe, as Gorodkov (1935) rightly points out, were never adjacent, nevertheless during the dry postglacial period the steppe, or, more exactly, the forest steppe, extended far to the north—as far as the basins of the Onega and the Northern Dvina rivers, as is indicated by the discovery in these areas of loesslike clay loams. If this conclusion is correct, it would have been easy for the tundra to acquire elements of steppe life. Such plants include the legumes *Astragalus* and *Oxytropis* (Gorodkov calls the tundra species of these genera, mountain-steppe species), and the Siberian campion (*Lychnis sibirica*). The animals include the rough-legged hawk (*Buteo lagopus*) and the arctic horned

[20] Concerning tundra fauna, see N. Ya. Kuznetsov, "Arkticheskaya fauna Yevrazii i yeyo proiskhozhdenie" (The Arctic Fauna of Eurasia and Its Origin), *Trudy Zoolog. Inst. Akad. nauk* (Proceedings of the Zoological Institute of the Academy of Sciences), V, No. I, 1938, pp. 1–79.

lark (*Otocoris alpestris*). The suslik * (*Citellus eversmanni buxtoni*) inhabits the wooded zone of northeastern Siberia (Bunge saw it daily in Verkhoyansk), but it is found also in the tundra. In the tundras of Alaska, in Quaternary deposits, there have been found remains of the camel. The New Siberian Islands were inhabited at one time by wild horses and saiga antelope. And at present, steppe landscapes extend far to the north in eastern Siberia (for example, along the Lena).

The basic element of tundra flora, according to A. Tolmachev (1931), was developed during the early glacial period in the north of eastern Siberia and part of America, where the ice cover was not continuous; in Europe, however, tundra vegetation appeared from the east, as a result of migration. Gorodkov (1935), however, describes the history of tundra vegetation otherwise: The formation of tundras began in the north toward the end of the Tertiary or at the beginning of the Quaternary period, as the climate gradually became cooler. The bog type of Tertiary vegetation was transformed into the peculiar tundra type. Permanent ground frost must have appeared first of all in the Pliocene peat bogs. Those habitats which became inaccessible to trees and arborescent shrubs were occupied gradually by associations of northern peat mosses. Furthermore, plants from the arctic mountains also descended into these regions. The tundra dwarf evergreen shrubs, such as the ledum or the black crowberry, in the opinion of Gorodkov, are descendants of Tertiary forest plants, which at first had become adapted to life in the peat bogs of the northern Pliocene forests, and then, at the beginning of the glacial period, had moved into the tundra. (Litvinov, on the other hand, held that the ledum, the cranberry, and the andromeda were mountain plants which had descended into the lowlands.) But we must keep in mind that in northeastern Siberia and in the Bering Sea region a temperate climate prevailed during Upper Tertiary times, and it is here that the peculiar "Okhotsk" fauna and flora had their beginning, spreading somewhat to the west. In this region some of the vegetation of the tundra may also have had its origin.[21]

* Known in the United States as the ground squirrel.—Tr.

[21] Cf. concurring opinion of B. Stegman, "O printsipakh zoogeograf. deleniya Palearktiki" (Concerning the Principles of the Zoogeographical Subdivision of the Palearctic), *Izv. Akad. nauk, seria biol.* (Report of the Academy of Sciences, Biological Series), 1936, No. 2–3, p. 529, on the subject of the origin of the bird fauna of the Arctic.

II · The Forest Zone[1]

Boundaries

THE forest zone, or, more exactly, the zone of temperate forests with severe winters, is situated between the tundra on the north and the forest steppe on the south. The southern boundary of the forest zone coincides approximately with the southern boundary of spruce. Occupying a vast expanse (close to half the entire area of the U.S.S.R.), this region in eastern Europe extends about as far south as the line through Pulavy (formerly Novaya Aleksandriya-on-the-Vistula), Lutsk, Zhitomir, Kiev, Karachev, Kaluga, along the Oka to Ryazan, Gorky, Kazan, the mouth of the Vyatka, along the Kama to the mouth of the Belaya, north of Birsk, north of the Ufa, and from there south along the Ural range. In western Siberia it extends as far as the line through Tagil, Irbit, Tyumen, along the Ishim below the town of Ishim, somewhat above Tara, Kolyvan, and from there south of Tomsk; that is, in the west as far as lat. 58° N, in the east as far as lat. 56° N, coinciding with the northern boundary of chernozem. In eastern Siberia this region extends as far south as the mountain ranges.

General Characteristics

The forest zone of the temperate latitudes in Europe and Asia is distinguished by the following characteristics: It is covered with forests, both coniferous and deciduous. There are many sphagnum bogs. Sphagnum mosses and cranberry are very characteristic (although these plants extend to the south and to the north beyond the limits of the forest zone). While the winter is severe, the summer is warm, the mean temperature of the warmest month being over 10° C. As a rule, the mean annual precipitation is about 500 mm. The soils are podzolic, and the subsoils leached. The ground water is not alkaline.

[1] For details see L. S. Berg, *Fiziko-geograficheskie (landshaftnie) zony* (Physical-Geographical [Landscape] Zones), I, 1936, pp. 95–289.

Subdivisions

The temperate forest zone may be divided into two subzones: (1) taiga and (2) mixed forests. The zone of mixed forests of the Far East will be discussed in the next chapter.

The taiga is characterized by the predominance of coniferous forests of spruce, larch, fir, and Siberian stone pine (*Pinus sibirica* [*P. cembra sibirica*]); the common pine also occurs (Fig. 8). Deciduous species—birch, aspen, alder—are of secondary importance. There are many sphagnum bogs in the taiga. There is no oak (except in the river valleys near the southern border in Europe).

In the mixed forests, the so-called "broad-leaved" species, of which the oak may serve as an example, appear together with the conifers. The number of sphagnum bogs here is much smaller, and they almost disappear in the south.

In eastern Europe the boundary between taiga and mixed forests is as follows: the southern boundary of Finland, the Karelian Isthmus (Toksovo), Novgorod, the Tikhvin Canal, Bezhetsk, Yaroslavl, Ivanovo, Gorky. This boundary corresponds to the northern boundary of the distribution of oak in the interfluves. In the valleys along the river courses, however, oak extends somewhat farther north.

In the Volga region, at the meridian of Kozmodemyansk (approximately in lat. 57° N), the fir-spruce-oak belt begins. (Here fir-spruce forests occur with an admixture of oak.) The northern edge of this belt runs through Sanchursk, passes south of Yaransk, south of Urzhum, passes near Sarapul, and from there proceeds to the Kungur island of forest steppe (as far as the Irena River).

A. THE TAIGA SUBZONE

Climate

The climate of the taiga, throughout its vast extent, is extremely varied, but is characterized in general by a relatively warm and rather humid summer, and a cool or cold winter. The mean July temperature is nowhere less than 10° C., nor greater than 19° to 20° C. Precipitation is moderate, the mean annual figure being 300 to 600 mm. (but in some places even less than 300 mm.; this will be discussed below). The maximum precipitation everywhere occurs in the latter half of the summer, in July and August. The minimum precipitation in continental regions generally occurs in winter, when the prevailing atmospheric conditions are anticyclonic, with descending air currents which do not favor the condensation of water vapors. In the forest zone, the minimum precipitation comes in February and March, and, in some places, in the subzone of mixed forests, also in January. As one moves eastward away from the influence of the Atlantic Ocean, the climate of the forest zone becomes more and more continental: the summer becomes warmer, the winter more severe, and thus the annual range, that is, the difference between the mean temperatures of the warmest and coldest months, increases.

So far as the climate is concerned, the taiga may be divided into two parts: (1) the western, eastward to the Yenisey, and (2) the East Siberian, from the Yenisey to the watershed of the Pacific Ocean.

The western part is distinguished by cloudy winters, with relatively abundant precipitation. South of lakes Onega and Ladoga, the amount of precipitation reaches 600 mm. per year; in other places it is less. Westward from the Ural Mountains, in the taiga, the 18° C. July isotherm moves to the north, reaching farthest north (to lat. 57° N) in the basins of the Vyatka and the Kama.

The eastern part is distinguished by clear winters with little snowfall. The basic factor which determines the climate of eastern Siberia is the presence of a strong winter anticyclone, which exists here from October to March. During this time, there is a low-pressure area in the northern part of the Pacific Ocean, in the neighborhood of the Aleutian Islands. There is also an area of relatively low pressure over the Arctic Ocean. In summer, on the other hand, the pressure is low in eastern Siberia, while over the northern part of the Pacific and over the Arctic it is relatively high. Due to these conditions, the East Siberian type of climate is distinguished by severe but dry winters, with little snowfall, little cloudiness, and a great many hours of insolation. When the Siberian anticyclone, with its descending air currents, prevails here, the winter winds are very gentle, and the weather is sunny and calm, although very frosty. Such weather is associated with winters in anticyclonic regions in general. In summer, on the contrary, it is relatively hot here, and so dry that in some places near Olekminsk it is necessary to irrigate the fields.

The following table on page 25 gives an idea of the annual temperature pattern in eastern Siberia.

In Yakutsk, in winter, frosts of − 50° C. are not unusual. They occur as low as − 60° C. and even lower. In January the thermometer never goes above − 9° C. The lowest temperatures found anywhere in the

Table 1

TEMPERATURES IN EASTERN SIBERIA (IN ° C.)

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL AVERAGE
Yakutsk *	−43.3	−36.2	−22.9	−8.5	5.2	15.3	19.1	14.9	5.9	−8.5	−28.7	−40.2	−10.7
Verkhoyansk †	−50.1	−44.5	−31.0	−12.6	2.4	13.4	15.5	10.9	2.3	−14.6	−36.7	−46.3	−15.9

* Lat. 62° 01′ N, absolute elevation 108 m., observations for 71 years (during 1829–1923).
† Lat. 67° 33′ N, absolute elevation 100 m., observations for 38 years (1869, 1884–1920).

world, almost — 70° C., are recorded in Verkhoyansk. In summer, on the other hand, in both Yakutsk and Verkhoyansk temperatures of over 30° C. occur. (In Yakutsk almost 38° C. has been recorded.) The absolute range in both places exceeds 100° C., greater than anywhere else in the world.

Along the middle course of the Lena summers are generally hot, relatively unclouded, and dry, with long hours of daylight. This combination of factors results in an altogether peculiar condition: The mean July temperature in Yakutsk is 19° C.; nowhere else in the world is there found such a high temperature in July in lat. 62° N. Here, and even a degree farther north along the Lena, spring wheat, spring rye, barley, oats, watermelon, and melon flourish. Barley and wheat ripen in Yakutsk about the middle of July. But we must keep in mind that the daily range of temperature here in summer is very great; sometimes the daytime temperature reaches 35° C., while after sunset the thermometer drops to 5° C.

Precipitation in eastern Siberia is generally sparse, from 350 to 150 mm. In the basin of the middle course of the Lena, it is 250 to 150 mm., of which only about 100 mm. comes in summer. Such quantities of annual precipitation as in Yakutsk (187 mm.) and Verkhoyansk (128 mm.) may be found also in the deserts of the Turanian Lowland, but the distribution of the precipitation is entirely different. The maximum precipitation in Yakutiya comes in the latter half of the summer, in July and August. In winter (November to April) there is very little precipitation, 3 to 10 mm. per month; the deep freezing of the subsoils is associated with this fact.

One of the characteristic features of the climate of eastern Siberia as compared with the country west of the Yenisey is the relatively small amount of cloudiness in winter—less than in summer. The explanation is found in the descending air currents associated with the winter anticyclone, which bring clear weather with them.

In Yakutsk the maximum cloudiness occurs in October (73 per cent), the minimum in March (37 per cent). The climate of Yakutiya is distinguished by gentle winds, particularly in winter, when the mean wind velocity does not exceed 1 m. per second, and calm predominates. This calm, however, exists only in the lowermost layers of air.

Permanent ground frost is widespread in eastern Siberia. Its southern boundary is a line drawn from a point somewhat north of the town of Mezen to Berezov on the Ob, from here to the mouth of the Lower Tunguska, then south and southeast, to Trans-Baikal and the boundaries of Mongolia; from about the region of Blagoveshchensk, the boundary extends to northern Kamchatka (Map 2).[2] In summer the frozen layer thaws to a depth of 0.5 to 2 m., depending on the subsoil. The frozen layer melts most readily in the porous sandy subsoils, least readily in the peat bogs, for peat is a very poor conductor of heat and is somewhat impermeable to water. As we move from south to north, we find permanent ground frost appearing first in the peat bogs. Where the forests have been felled, the frost extends deeper.

The presence of ice not far from the surface of the earth cools the soil considerably. On the other hand, in droughty places the thawing of the frozen layer in summer provides humidity for the plant roots and permits crop growing in Central Yakutiya. The trees of eastern Siberia are very well adapted to existence over a permanently frozen layer: the Dahurian larch, for example, which is the predominant species in Yakutiya, has a superficial root system and grows readily on soils which thaw to a depth of only 50 to 100 cm. (See above, p. 7.)

The frozen layer in Yakutiya is very deep. In Yakutsk, as far back as the first half of the last century, Middendorff made observations of the temperature in a well dug to a depth of 116 m. The bottom of this well did not reach beyond permanent ground frost, and the mean annual temperature at 116 m. proved to be − 3.0° C. To date the question has not been settled whether this was the temperature of the frozen layer in its natural state or whether a low temperature resulted from the penetration to this depth of cold air from the surface of the earth in winter.

Relief

Almost the entire forest zone of eastern Europe, as well as the northern part of the West Siberian plain and some parts of eastern Siberia, were covered during the glacial period by an ice sheet which left marked

[2] M. Sumgin, *Vechnaya merzlota pochvy v predelakh* S.S.S.R. (Permanent Ground Frost in the U.S.S.R.), izd. 2-e (2nd ed.), Moscow, 1937.

MAP 2. Areas of permanent ground frost (Balzak, Vasyutin, and Feigin, *Economic Geography of the U.S.S.R.*).

traces in the relief. To date there is no agreement as to the extent of glaciation which the Russian plain underwent during the Quaternary period. It is generally accepted that there were three such glaciations, and that the most severe one, which extended farthest south, was the second (the so-called Riss glaciation). This glaciation formed two lobes, extending far to the south along the Dnieper and Don valleys, as is clearly apparent from every map showing the distribution of glacial deposits.

The Kola Peninsula and Karelia are composed fundamentally of strongly dislocated pre-Cambrian crystalline rocks, which either outcrop on the earth's surface or lie not far below the surface. This structure contrasts with the country situated to the east and south, where the bed-rock consists of horizontal sedimentary deposits of more recent date. The boundary between these two regions is a line from the mouth of the Onega River to the middle of the eastern shore of Lake Onega, and extending south along the Svir River.

On the Kola Peninsula, eastward from Lake Imandra (which has a depth of 67 m.[3]), lie the plateaulike Khibin massifs and the Lovozersk tundras. These massifs, with elevations reaching 1300 m., are composed chiefly of basic rocks of intrusive origin (nephelite syenite, much of which is now being exploited). The massifs, which are laccoliths, stand out sharply against the surrounding swampy plain country, which is covered with numerous lakes (the level of Lake Imandra has an absolute elevation of 128 m.), peat bogs, and in some places, low wooded hills composed usually of bouldery material. Traces of Quaternary glaciation have been found on the Khibin massifs; on many of the plateaus there are boulders of granite and other rocks which are foreign to the nephelite-syenite massif.

The mineral resources of the Kola Peninsula, in addition to apatite and nephelite, also include iron and diatomites; the Khibin apatite reserves are the greatest in the world.

In northern Karelia, at Lake Pyavo, the elevations reach over 500 m. West of Lake Segozero, also, the elevations are considerable. In some places the watershed between the White Sea and the Gulf of Bothnia reaches elevations of 255 m.; here a nonexistent chain of mountains was represented formerly. Evidences of the work of the ice sheet appear in Karelia with unusual clarity. Eskers and drumlins, *roches moutonnées,*

[3] G. D. Richter, *Fiziko-geografichesky ocherk ozera Imandra* (Physical-Geographical Sketch of Lake Imandra), Leningrad, 1934, izd. Geogr.-ekonom. instituta (publication of the Geographical Economics Institute).

dome-shaped hills, and numerous lakes bear witness to the former glaciation.[4]

Because of the peculiarities of the relief, Karelia, and also the Kola Peninsula, are distinguished by an abundance of lakes. For the same reason, the rivers are full of rapids. There are many waterfalls; of these, the Kivach waterfall on the Suna River (which empties into Lake Onega), is well known, although it is not the highest on this river. The considerable gradient of the rivers of Karelia and the Kola Peninsula creates conditions favorable for the development of hydroelectric power. In Karelia there are a great many lakes, around four thousand of them. Many of them, as also the bays of the northern part of Lake Onega, extend from NW to SE, along the prevailing direction of the tectonic lines of Karelia.

At the end of the glacial epoch, during the Yoldian period, the White Sea was connected with Lake Onega, and the Gulf of Finland with Lake Ladoga. It is not yet entirely clear whether at this time Lake Onega (the surface elevation of which is about 34 m. above sea level) was connected with Lake Ladoga (elevation 5 m.). K. Markov[5] argues against the possibility of a connection between the White Sea and the Baltic during the Yoldian period. Whether or not he is right, both lakes contain animal forms which are native to both the White and the Baltic seas (of fish, for example, the four-horned sculpin, *Myoxocephalus quadricornis*). Possibly a strait existed between the Baltic and the White seas during the interglacial period.

The most valuable mineral resources of Karelia are pegmatite, iron ores, and various structural stones (marble, the famous red sandstones, diabases, and others).

The relief of the Karelian Isthmus (the area between the Gulf of Finland and Lake Ladoga and bounded on the south by the Neva) is highly dissected. Here are found hills which rise 200 m. above the level of the Gulf of Finland; they are of the kame type. According to Markov's explanation, these kames were formed within an englacial lake, which existed in a thawed patch inside the glacier. The lake was filled with material brought in by subglacial streams. Within the lake individual smaller blocks of ice were preserved, and as the spaces between these blocks were filled with alluvium, kames were formed.

[4] B. F. Zemlyakov, *Chetvertichnaya geologiya Karelii* (The Quaternary Geology of Karelia), Petrozavodsk, 1936, izd. Karel. nauchn.-issled. in-ta. (publication of the Karelian Scientific-Research Institute).

[5] K. K. Markov, "Yoldiyevoye more i problema baltiisko-belomorskovo pozdnelednikovovo proliva" (The Yoldian Sea and the Problem of the Baltic-White Sea Late-Glacial Strait), *Izv. Geogr. obshch.* (Report of the Geographical Society), LXV, 1933.

Lake Ilmen is a shallow basin, almost completely filled with deposits from the rivers which empty into it—the Lovat, Msta, Shelon, and others. As a result, the area and depth of the lake vary extremely, depending upon the amount of water carried by the rivers. In 1922, when the level of the lake was high (23 m. above the Baltic Sea), its area was three and one-half times, and its depth (10 m.) was four times as great as in 1882, when the level was low (16 m. above sea level).

We have spoken already of the Timan ridge. It rises in elevation toward the south, reaching, at the source of the Vychegda, an elevation of 325 m. The watershed between the left-bank tributaries of the Volga on the one hand, and the Sukhona, the Yug, the Vychegda, and the Pechora on the other, is designated on maps as the Severnie Uvaly (Northern hills), 250 m. in elevation. There appear to be no hills here at all, but only a watershed area, in many places level and composed of moraine deposits.

There are rich beds of potassium salts in the Permian deposits in the region of Solikamsk, near the western slope of the Urals.

We turn now to a description of the relief of the forest zone of Siberia. Between the Ural range to the west and the Yenisey to the east lies the West Siberian Lowland, a portion of the earth's crust which has undergone subsidence. This subsidence must have taken place during pre-Jurassic times, judging by the discovery on the Ob (along the Bolshoy Yugan River) of Jurassic and Cretaceous deposits (Edelstein, 1932). There is reason to believe (Meister, 1909; Kassin, 1931) that along its southern boundary the lowland rests against a fault line which runs in a northwest direction and marks the northern boundary of the Kazakh Folded Country (*Kazakhskaya skladchataya strana*). To the north, merging into the tundra, the lowland reaches as far as the Arctic Ocean. To the south, merging into the forest steppe, the steppe, and the semidesert, it extends as far as the line through Kustanay, Semipalatinsk, Yeniseisk, and Achinsk. Considering its vast extent, the lowland has a very small gradient. The low-water mark of the Ob River 3000 km. from its mouth is only 91 m. above sea level.[6]

In the watershed areas of Narym *kray* the prevailing elevations are from 100 to 140 m. The extreme northern part of the West Siberian plain, as Ya. S. Edelstein (1936) points out, is somewhat elevated with re-

[6] Ya. S. Edelstein, "Geomorfologichesky ocherk Zapadno-Sibirskoy nizmennosti" (Geomorphological Sketch of the West Siberian Lowland), *Trudy Inst. fiz. geogr. Akad. nauk* (Proceedings of the Institute of Physical Geography of the Academy of Sciences), No. 20, 1936, p. 19.

spect to the central parts. Elevations of 150 to 175 m. have been discovered recently between the gulfs of the Ob and the Yenisey.

During the first half of the Tertiary period a sea covered the West Siberian Lowland and was connected with the Aral Sea by a strait in the vicinity of the present headwaters of the Tobol. From that time on, western Siberia was no longer submerged, with the exception of the extreme north, where deposits of a Quaternary marine transgression have been found. The lowland is composed fundamentally of horizontal Tertiary and Quaternary deposits. Boring in the Kulundinsk steppe has shown that Oligocene marine deposits occur here to a depth of more than 300 m. Glacial deposits extend approximately as far south as the latitude at which the Irtysh empties into the Ob. An ice sheet moved down from the northern part of the Ural Mountains and another glacier moved down from the northeast, from the Taimyr region.

According to Ya. S. Edelstein, the Ob River found its channel to the north somewhere between the two ice sheets. On the West Siberian plain there is certain evidence of only one glaciation. Interglacial deposits have not been discovered anywhere.

On the watershed between the Ob and the Irtysh lies the enormous Vasyugansk swamp, the highest parts of which reach an absolute elevation of 125 m. This swamp resulted not from the growing-over of lakes, but from the waterlogging of dry land by sphagnum mosses.

On the right bank of the Yenisey below Krasnoyarsk lies the Yenisey mountain ridge, extending north from the mouth of the Kan River and composed of gneisses, granites, crystalline schists, limestones, dolomites, conglomerates, and other rocks. The folds of the Yenisey ridge extend from NW to SE. During the Middle Cambrian and Lower Silurian periods the ridge was submerged by the sea. Somewhat above the point where the Podkamennaya (Middle) Tunguska empties into the Yenisey, the rocks of which the ridge is composed are found on the left bank of the Yenisey. Here the Yenisey breaks through the ridge and becomes wider; at this point lie the Osinovsky rapids. The elevation of the Yenisey ridge to the south of the Angara River is 300 to 450 m. above sea level, and the elevation above the Yenisey is 75 to 100 m. To the north of the Angara River, approximately in lat. 60° N, the ridge reaches an elevation of 1132 m. (Yenashiminsky Polkan). The Yenisey ridge contains gold.

To the east of the Yenisey ridge lies the vast Central Siberian Plateau. It extends beyond the Lena into the basins of the Aldan and the Maya. On the north it is bordered by the North Siberian Lowland; that is, approximately by a line connecting the point where the Pyasina River intersects the parallel of 70° N (in Norilsk *raion*) [7] and the lower reaches of the Olenek. This boundary runs along a fault line, which in some places takes the form of a cliff and is accompanied by extrusions of trap. In Norilsk *raion* the plateau rises to an elevation of 500 to 600 m. above the valley floor. To the east the escarpment declines in elevation, and between the Anabar and the Olenek its elevation is 200 to 300 m. To the south the plateau extends as far as the heights on the southern border of Siberia. To the east it reaches as far as the foot of the Verkhoyansk range, while its southeastern boundary crosses the Olekma in lat. 59° N, and from here continues along the latitudinal course of the Aldan and proceeds toward the left tributaries of the Maya River. The plateau is drained by the rivers Angara, Podkammenaya and Lower Tunguska, Khatanga, Anabar, Olenek, Vilyuy, Lena, and Aldan. The elevation of the watershed between the Lena and the Vilyuy is approximately 500 m., but the plateau decreases in elevation in the direction of the Lena. To the east, between the Lena and the Aldan, the elevation of the plateau is generally 200 to 400 m., while near the source of the Lena, the absolute elevation of the plateau is 600 to 700 m., with valleys cutting 150 to 300 m. into the plateau (Fig. 7). The absolute elevation of Irkutsk is 468 m.

The Lena is a very large river, 4150 km. long. Its tributaries, the Aldan and the Vilyuy, are each more than 2000 km. long. The Lena carries an average of about 15,000 cubic m. of water per second into the Arctic Ocean.[8] Flowing as it does from south to north, this river carries with it a great deal of warmth. The mean temperature of the water near the delta of the Lena for the months of June to September is 10° C., while the temperature of the air here is 1.5° C. lower.[9]

The Central Siberian Plateau is composed fundamentally of horizontal or very slightly dislocated marine deposits of Cambrian and Silurian age. In many places above the Paleozoic marine deposits there occur layers which contain the fossils of Upper Carboniferous or Permian vegetation (the so-called Angara series). Coal of Permian age is found along

[7] S. P. Suslov, "K geomorfologii raiona Norilskikh ozer (oz. Lama)" (Concerning the Geomorphology of the Norilsk Lake Region [Lake Lama]), *Trudy Inst. fiz. geogr. Akad. nauk* (Proceedings of the Institute of Physical Geography of the Academy of Sciences), No. 14, 1935, p. 120.

[8] B. D. Zaikov, "Rechnoy stok v more Laptevikh i Vostochno-Sibirskoye i kolichestvo perenosimovo yim v eti morya tepla" (The River Drainage of the Laptev and East Siberian Seas and the Amount of Warmth Carried by the Rivers into These Seas), *Trudy Arkt. inst.* (Proceedings of the Arctic Institute), XXXV, 1936, p. 78.

[9] *Ibid.*, p. 80.

Fig. 1. The arctic tundra in summer. Note absence of shrubs and abundance of flowers. (*Vegetationsbilder*. Vol. 5; part 5; plate 33)

Fig. 2. Bog vegetation. Cloudberry (*Rubus chamaemorus*) and cotton sedge (*Eriophorum scheuchzeri*) in the tundra on Kolguyev Island. (*Vegetationsbilder*. Vol. 5; part 5; plate 31)

Fig. 3. The typical, or shrub tundra. View in the Bolshezemelskaya tundra near the upper Usa. Note the cover of dwarf arctic birch, *Betula nana,* the complete absence of trees, and the level topography. (*Vegetationsbilder.* Vol. 5; part 4; plate 27)

Fig. 4. Stunted spruce at the northern limit of tree vegetation on Kanin Peninsula. (*Vegetationsbilder.* Vol. 5; part 4; plate 24)

Fig. 5. Wooded tundra along the southern border of the Bolshezemelskaya tundra. (*Vegetationsbilder*. Vol. 5; part 4; plate 22)

Fig. 6. Peat mound in the Bolshezemelskaya tundra. (*Vegetationsbilder*. Vol. 5; part 4; plate 25)

Fig. 7. The Irkut River deeply incised in the Central Siberian Plateau. Pine taiga. (Sovfoto)

Fig. 8. The taiga in winter. Transition from fir to pine near the Angara River. (Sibirskaya Sovetskaya Entsiklopedia. Vol. 3: 81)

Fig. 9. Pine taiga in the basin of the Oka River, a left tributary of the Angara. (*Aziatskaya Rossiya.* Vol. 2: 128)

Fig. 10. Yeddo spruce (*Picea jezoensis*) taiga in Amur *oblast*. (*Aziatskaya Rossiya*. Vol. 2: 129)

Fig. 11. Forest steppe in Voronezh *oblast*. Feather-grass steppe with islands of deciduous forest. (*Vegetationsbilder*. Vol. 17; part 2; plate 8)

Fig. 12. The Baraba steppe in the forest-steppe belt of Western Siberia. (*Aziatskaya Rossiya*. Vol. 2: 32)

Fig. 13. Pine groves in the forest steppe in the Trans-Baikal region. (*Aziatskaya Rossiya*. Vol. 2: 129)

Fig. 14. Meadow steppe in the forest-steppe zone, Voronezh *oblast*. Fescue growing on thick chernozem. (*Vegetationsbilder*. Vol. 17; part 2; plate 7)

the right bank tributaries of the Yenisey, in the so-called Tunguska basin. In some places there are Jurassic terrestrial deposits. The Jurassic transgression extended far up along the Lena valley, all the way to the Vilyuy basin. Lava fields (trap) are widespread here, and consist chiefly of diabases. There is also trap in the western part of the plateau, chiefly in the Yenisey and Khatanga basins. The outpouring of lavas, which took place mainly from fissures, began during the Carboniferous period and ended during the pre-Jurassic.

Under the influence of trap extrusions, the coal in some places was transformed into graphite. (One of the thickest graphite beds is found on the Kureika River, a tributary of the Yenisey.) The trap itself is the source of a series of ore beds. Among these are the Norilsk copper-nickel bed (75 km. east of the town of Dudinka on the Yenisey). It seems probable that the Cambrian strata of the Central Siberian Plateau are underlain throughout by crystalline schists, which have been found so far only in the basins of the Anabar[10] and the Aldan. The greater part of the Central Siberian Plateau was not covered by an ice sheet, but there were glaciers on the bordering heights; for example, on the Verkhoyansk range.

On the maps there are mountain ranges indicated within the plateau, but these ranges are nothing but table mountains, which owe their origin to the uneven erosion of the plateau. While these mountains were formed by erosion, it is possible that the considerable elevation which they attain is a result of epeirogenic uplift. Such are the Tunguska Mountains (1050 m.) on the watershed between the Lower Tunguska and the Vilyuy and a part of the Lena. On the Norilsk plateau, near the source of the Pyasina, there are unusually clear traces of Quaternary glaciation. In the upper reaches of the Pyasina, Lake Lama, about 90 km. long and 12 km. wide, has a depth of more than 200 m. Here the glacier did not extend over the surface of the plateau, but was confined to the depressions in the relief. Lake Lama lies in a valley, which was deepened by the glacier. Elevations rise 800 to 1000 m. above the level of the lake. In the upper reaches of the Kureika there are elevations as high as 1500 m. The Vilyuy table mountains (1040 m.) lie on the watershed between the basins of the Vilyuy and the Olenek.

[10] Of the most recent literature, see B. N. Rozhkov, G. G. Moor, B. V. Tkachenko, "K geologii Anabarskovo dokembriya i okruzhayushchevo yevo nizhnevo paleozoya" (Concerning the Geology of the Anabar Pre-Cambrian and the Lower Paleozoic Which Surrounds It), *Byull. Mosk. obshch. isp. prir.* (Bulletin of the Moscow Society for Natural Research), otd. geol. (Geological Section), XII, No. 4, 1934.

Soils

In the forest zone of the temperate latitudes, the podzol type of soil formation takes place under the forests. With sufficient moisture and a relatively warm summer, which as a rule characterize the climate of the taiga, the upper horizons of the soil become leached. Aluminum and iron oxides and bases are carried by soil waters from the upper (eluvial) to the deeper-lying horizons, where they are precipitated, enriching the lower horizons with alumina, iron oxide, and so forth, as well as with silt particles. On the other hand, in the upper, eluvial horizon, silica remains, and is accumulated, and this horizon becomes sandy. In cross-section, the striking feature of the podzol soils is their three-colored profile: the top layer is grayish, colored by the humus; the middle layer is white, eluvial, sandy, and devoid of color; while the bottom layer is a yellow-brown color, illuvial, clayey and enriched by sesquioxides, and to some extent also by bases and humus. It is from the presence of the middle, white layer that these soils have been given the popular name of podzols ("the color of ash").*

Clay loams are richer in salts and less permeable than sandy soils. As a result, clay loams are podzolized with greater difficulty than the sandy soils, out of which the salts are washed very easily. Moving northward through the taiga, we find that the podzol-forming process gradually decreases. The temperatures become lower, and waterlogging begins to appear, which hinders podzolization. To the south, on the other hand, podzolization is hindered by insufficient moisture. Thus, this process is most intensive in the central part of the podzol zone. In the north, bog prevails; in the center, there are coniferous forests; in the south, there are mixed and deciduous forests. Finally, the degree of podzolization depends upon the relief: on elevated portions of the relief, where the water runs off quickly, slightly podzolized soils are developed; in places with lower elevation, where the water has a longer time to act, there is moderate podzolization, which becomes strong in the most depressed spots.

In the south of the Siberian taiga, degraded soils (gray forest clay loams), which are characteristic for the forest steppe, are widespread. These soils will be discussed in detail under the description of the forest-steppe zone. However, we will say here that these soils are formed as a result of the encroachment by the forest upon the steppe, bearing witness to the change from steppe to forest climate. The degraded soils of

* The Russian word for "ash" is *zola*.—Tr.

western Siberia extend almost as far north as lat. 60° N, much farther north than in Europe. They extend still farther north in Yakutiya.

The soils in the valley of the middle Lena are unusual. While soils of the podzol or bog types generally prevail in Yakutiya, in the valley of the middle Lena—in the region of Yakutsk, on the terrace above the flood plain—there are found solonized and salinized chernozemlike soils.* These soils, developed on carbonated loesslike clay loam, in outward appearance resemble poor chernozem, and are covered with grassy mixed-herbaceous meadows. At a depth of 1 to 1.5 m. below the surface of these chernozemlike soils, there is permanent ground frost. Among the meadow-steppe plants, fescue (*Festuca lenensis*), koeleria (*Koeleria gracilis*), feather grass (*Stipa capillata*), and mother-of-thyme (*Thymus serpyllum*) predominate. The resemblance to the steppe is apparent not only in the vegetation, but also in the presence of the Yakutsk suslik (*Citellus eversmanni jacutensis*). The reasons for the appearance of steppe soils so far north (in lat. 62° N) are, on the one hand, a dry climate with little precipitation and with a hot summer, and, on the other hand, the character of the bedrock, rich in carbonates and to some extent in other salts as well. The presence of permanent ground frost, which impedes washing of the soil and the removal of salts from it, is also a factor.

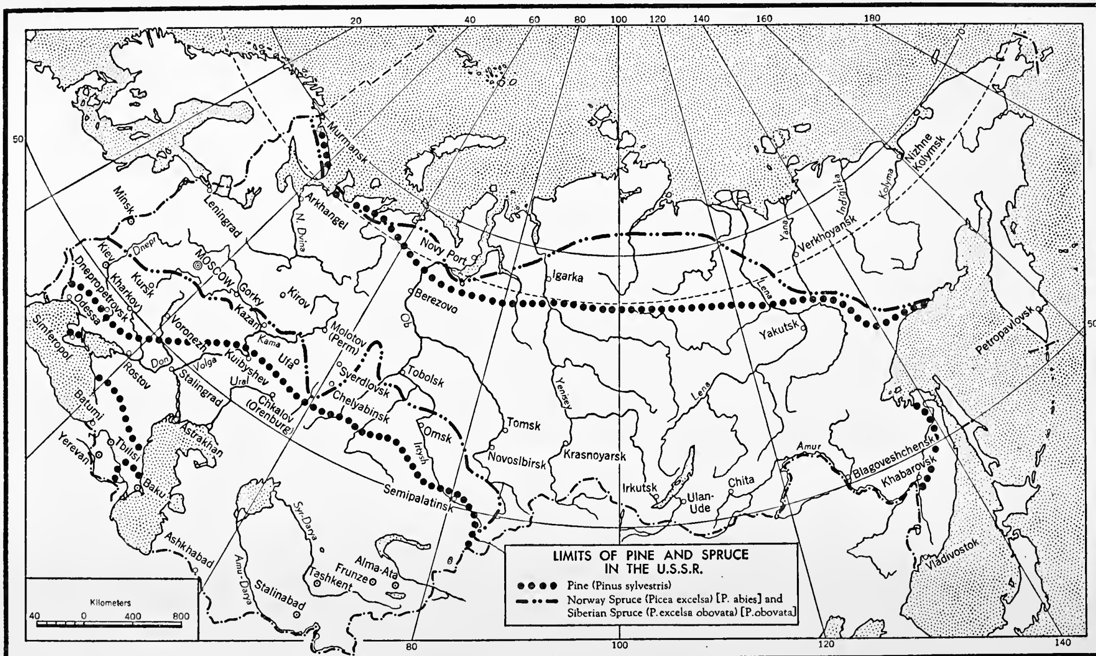
In addition to podzolic soils, on the watersheds of Yakutiya there are also found soils which resemble gray forest clay loams, as well as solonized chernozemlike soils, solonetz soils, solods, and solonchaks.

Vegetation

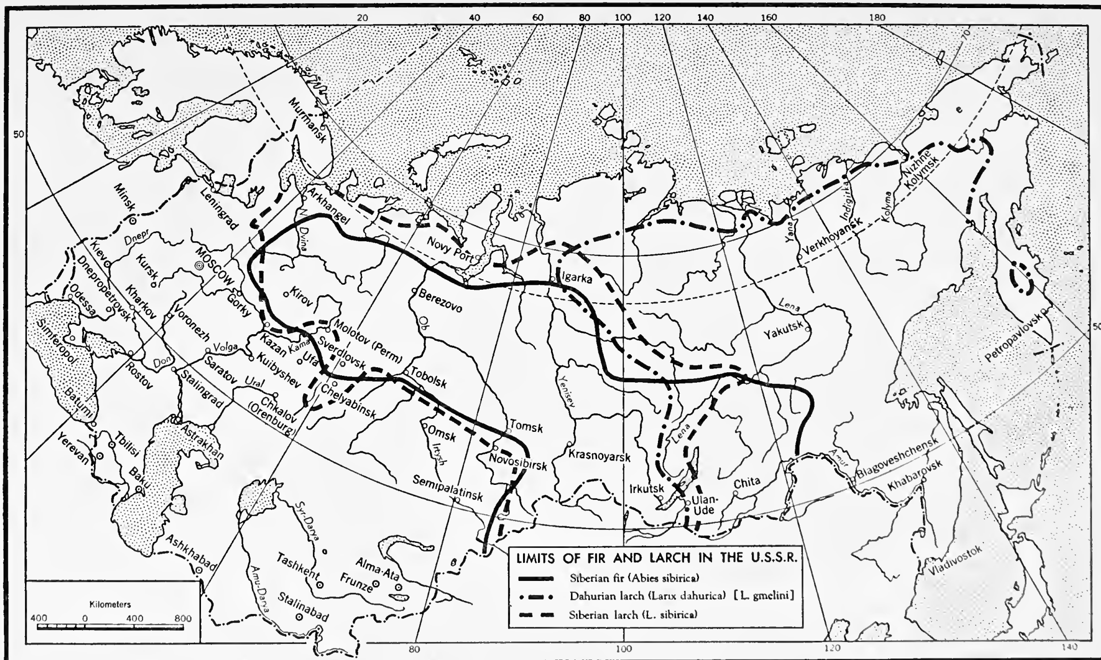
Within the forest zone there are three types of natural vegetation, forests, bogs, and meadows.

Forests. Of the conifers, the European taiga contains spruce, Scotch pine (*Pinus sylvestris*), and, in the northeast, Siberian fir (*Abies sibirica*) and Siberian larch (*Larix sibirica*); there is also some Siberian stone pine (*Pinus sibirica* [*P. cembra sibirica*]) (Maps 3, 4, 5). In the Siberian taiga there are spruce, pine, Siberian and Dahurian larch, fir, and Siberian stone pine. In the Siberian and in the northern part of the European taiga there is also Siberian spruce (*Picea excelsa obovata* [*P. obovata*]), while in the remaining forest zone there is Norway spruce (*Picea excelsa* [*P. abies*]). Siberian larch grows as far west as the line from the southern end of Onega Bay on the White Sea to Lake Beloye, and from there to the upper course of the Kerzhents and the middle course of the

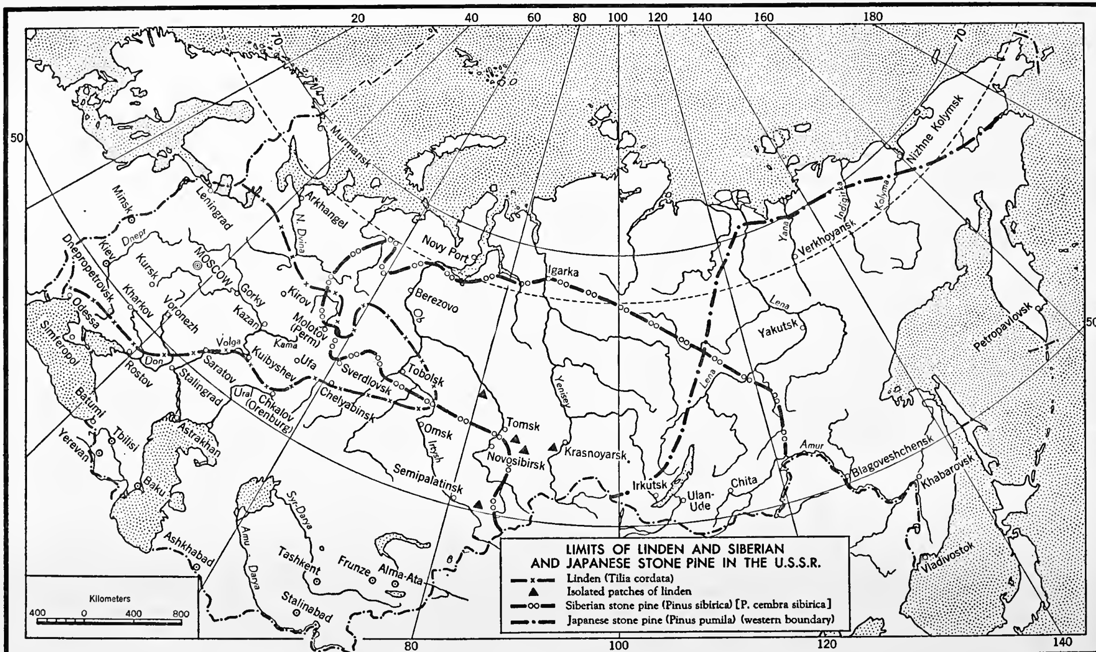
* That is, soils with spots of black and white alkali.—Ed. (The Ed. notes in this text are those of the Editor of the American Edition.)



MAP 3. Limits of pine and spruce in the U.S.S.R.



MAP 4. Limits of fir and larch in the U.S.S.R.



MAP 5. Limits of linden and Siberian and Japanese stone pine in the U.S.S.R.

Vetluga. Siberian fir extends almost as far west as does larch. Siberian stone pine, however, has a limited distribution in Europe, extending not much farther west than the Ural range. Along with the conifers there are also birch, aspen, and alder. Of the broad-leaved species, linden is the most numerous in the southern part of the region, and appears also in some places in western Siberia. Linden is found as far east as Krasnoyarsk.[11] Birch (and sometimes pine) occurs in the form of continuous stands farthest north on the Kola Peninsula. On the Kanin Peninsula and in the Timan tundra spruce occurs farthest north in some parts, birch in others. In the Bolshezemelskaya tundra, spruce occurs farthest north; in Siberia (as also in North America), larch. Thus, the outposts farthest north are occupied by trees which shed their leaves or needles in winter.

The forests along the northern border of the taiga zone are characterized by stunted growth and sparse stands. On their northern boundaries the forests usually extend into the tundra along the river valleys.

It must be noted that deciduous forests (birch groves and aspen groves) in the taiga zone are second growth for the most part. They replace coniferous stands after felling or fires. Birch groves in the extreme north of the taiga zone (on the Kola Peninsula, in northern Karelia, and in other places), occur independently of human activity.

Spruce is a species which can endure shade, but which is exacting as to moisture and as to soil. It requires humid soils, relatively rich in nutrient substances. Because the root system of the spruce is superficial, it can develop over permanently frozen subsoil (for example, in the northern part of western Siberia). Where ground water does not remain too long, spruce grows well. For this reason, in the north there are fine spruce groves close to the river valleys where the relief is more or less dissected and the drainage is satisfactory, while farther from the rivers, in the interfluve areas, are inferior, waterlogged stands of spruce, or only peat bogs. The spruce stands of the taiga may be divided into the following principal types (Sukachev):

(1) The green-moss and spruce complex develops on well drained soils, in places with more or less dissected relief. The soils under this type of spruce stand are fertile and after the forest cover has been removed, are readily tilled. The moss cover of the green-moss and spruce complex is generally continuous, and consists of the so-called "shiny" mosses, *Hylocomium, Hypnum,* and others. The herbaceous cover is scant. Wood sorrel oxalis (*Oxalis acetosella*), ferns, club mosses, and orchids are char-

[11] M. M. Ilin, *Botan. zhurn. S.S.S.R.* (Botanical Journal of the U.S.S.R.), XIX, 1934, pp. 385–391.

acteristic. There is little or no undergrowth. Sometimes there is a small admixture of aspen and birch, and, in the northeast, fir. Three types of green-moss and spruce complex are distinguished: oxalis, bilberry, and cowberry subcomplexes. The last-named develop on the drier, sometimes even sandy soils.

(2) The haircap-moss (*Polytrichum*) and spruce complex develops on strongly podzolic soils, less well drained than those on which the green-moss and spruce complex is found, with less dissected relief, and with a tendency toward waterlogging. A continuous carpet of common haircap moss (*Polytrichum commune*) is very characteristic. Sometimes the moss reaches a thickness of 80 cm. There is some birch, growing in admixture with the spruce. Where there is a herbaceous cover, sylvan horsetail (*Equisetum silvaticum*) is characteristic.

(3) The sphagnum and spruce complex is found in the flat, waterlogged areas. Sphagnum predominates in the moss cover. The spruce is dwarfed in size, and sometimes grows with a considerable admixture of birch, pine, or European alder. In the herbaceous cover there are many bog forms: ledum, bog bilberry, and cloudberry. Sometimes sedges predominate. The sedge, sphagnum, and spruce complex in the north is called *sogra.*

(4) The herbaceous and spruce complex occurs in the valley bottoms of small rivers. The moss cover is poorly developed, but the herbage grows thick and tall. Wherever sphagnum does not grow extensively, spruce grows well, for there is running ground water. The undergrowth is rich, consisting of black and red currants, bird cherry, juniper, sweetbrier rose, willow, honeysuckle, European alder, occasionally linden, and others.

Pine, as distinguished from spruce, is a light-loving species, and is not exacting as to soil or moisture requirements. As a result, it can grow on sands, in sphagnum bogs, or on granite ledges. Because of its light-loving property, the pine often appears, together with birch and aspen, on sites where spruce forests have been felled or burned down. With the passage of time there appear under the canopy of pine, shade-enduring species—spruce, fir, and others, which gradually replace the pine. Pine complexes are associated predominantly with sandy soils (they are then called *bors*) and with bogs. They are divided into types which are analogous in general to the types of spruce stands:

(1) The green-moss, or berry and pine complex is found on dune sands. There is a continuous moss cover of *Hypnum, Hylocomium,* and other forms. The herbaceous cover is thin. Cowberry and pine, oxalis and pine,

and bilberry and pine subcomplexes may be distinguished. The last-named marks the first stage of waterlogging.

(2) The haircap-moss (*Polytrichum*) and pine complex occurs on soils which are becoming waterlogged. There is a continuous moss cover of common haircap moss.

(3) The sphagnum and pine complex develops on sphagnum bogs. The thicker the sphagnum cover, the scrubbier the pine.

(4) In the herbaceous and pine complex the herbage is thick, the moss cover scant, and the pine reaches a fair size.

(5) The shrub and pine complex is found on rich, dry soils. The undergrowth is excellent. This type is more characteristic of the subzone of mixed forests.

(6) The lichen and pine, or white-moss and pine complex usually develops on the summits of sand hills. A very characteristic ground cover consists of a more or less continuous carpet of reindeer moss (*Cladonia*) and Iceland moss (*Cetraria*). The herbaceous cover is sparse and short.

In a pine complex with a spruce layer, the spruce may appear to be taking the place of the pine. Birch groves, as a rule, occur as temporary types.

In western Siberia the taiga begins approximately in latitude 65° N and extends as far south as a line somewhat north of Irbit, through Tyumen and Tara, to the region between Tomsk and Kolyvan. Beginning at the north, it is divided into three subregions:

(1) The narrow spruce and larch subregion lies immediately south of the wooded tundra. Along the Ob this subregion extends as far south as Berezov; along the Yenisey, it embraces Turukhansk. Here spruce and larch forests predominate, with an admixture of Siberian stone pine and birch. The northern boundary of this subregion coincides with the northern boundary of Siberian stone pine.

(2) The Siberian-stone-pine and bog subregion occupies a much larger area. Within the boundaries of this subregion lie Berezov and Surgut. Its northern boundary coincides with the northern boundary of pine. In the well drained areas, spruce and Siberian-stone-pine forests predominate. Where these are burned over, birch and aspen groves appear in their place, while on the sandy soils pine reappears.

(3) The *urman* and bog subregion is somewhat smaller in area than the Siberian-stone-pine and bog subregion. Within the boundaries of this subregion lie Tobolsk and Narym. Interstream sphagnum bogs occupy extensive areas, particularly in the eastern part. The basic type of forest in the drier areas is the *urman* (in some parts it is called *chern*), a dense

coniferous forest with fir predominating. Of the other conifers in this subregion, there are large numbers of spruce and Siberian stone pine, but larches are few. The ground cover consists of green mosses with oxalis, bilberry, cowberry, and other herbage; and the undergrowth, of elder, mountain ash, and linden. On the sands are found ordinary pine groves. On the cut-over areas and deserted plowlands there are coarse-herbaceous meadows and thin deciduous forests with meadow flora, so-called *yelans*.

Beyond the Yenisey the floral composition changes. The Siberian larch is replaced by the Dahurian larch, which predominates here and is a very characteristic feature of the landscape; in Yakutiya the predominant type of forest is the taiga of Dahurian larch. This tree, which has a superficial root system and which forms accessory roots easily, is associated especially with areas where there is permanent ground frost. The Dahurian larch, like the pine, is not exacting as to soil and moisture requirements. In eastern Siberia there is no taiga of the West Siberian *urman* type.

In Yakutiya larch taiga occupies extensive areas, growing on poorly drained podzolic sandy loams and clay loams. Here the frozen layer thaws in summer to a depth of 80 to 120 cm.; under a thick moss cover, to a depth of only 25 to 50 cm. Besides Dahurian larch, there is some pine and pubescent birch. The herbaceous cover contains ledum. The moss cover is continuous, but usually does not consist of sphagnum, which is not favored by the dry climate of this region. On the drier and more fertile soils, which resemble the gray forest clay loams, cowberry-larch taiga is developed; the subsoil here is a loesslike carbonated clay loam; the larches grow quite tall. After burning or felling, in place of the cowberry taiga there appears European white birch, coppices of which serve to indicate soils suitable for agriculture. There are three types of coniferous stands: (1) pure pine (Fig. 9), (2) pine with larch, and (3) pure larch. In the sands under the pine groves the frost thaws toward the end of the summer to a depth of 2 to 2.5 m.

Bogs. By bogs are meant areas in which the soils receive excessive moisture during the greater part of the year, areas which in the low-lying portions are covered sometimes by shallow water, and on which grows the peculiar hydrophytic type of bog vegetation. The excess of moisture and the associated inadequate aeration of the soil bring with them incomplete decomposition of organic remains and their accumulation within the poorly drained soil and on its surface. The result is peat. The overabundance of moisture in the soil may originate from various causes: from an excess of atmospheric, surface, or ground water; from impermeability of the subsoil to water; from the settlement of hydrophytic mosses.

Bog constitutes a very prominent element in the landscape of the forest zone. Bogs are particularly numerous in the taiga of northern Europe and in western Siberia. Beyond the Yenisey, however, there are very few sphagnum bogs. The explanation lies in the scant precipitation, dry air, hot summers, and better drainage of eastern Siberia.

In the bogs the roots of the hydrophytic plants may extend down to the mineral subsoil and obtain nourishment from it. The soils developed on such bogs bear the name "silty-bog" soils. But if masses of dying vegetation, or peat, accumulate in the bog, the bog vegetation may lose its connection with the mineral subsoil. When this happens, nourishment must come from precipitation or from the flow of surface water. In this way a peat bog or *torfyanik* is formed. The soil of such a peat bog bears the name "peat-bog" soil.

The excessive moisture in the upper horizons of bog soils impedes the penetration of oxygen to the lower horizons. As a result, processes of deoxidization of iron begin in the lower horizons, and ferrous oxides are formed; they color the deoxidized (*gley*) horizon bluish, gray, or black.

Between the poorly drained and the podzolic soils there is a whole series of gradations. Forest often overgrows the bog, and still more often it is the other way around—the forest becomes waterlogged. Then one process of soil formation is superimposed upon another. *Half-bog* soils, or bog-podzolic soils result.

According to the manner of origin, two types of bog are distinguished, those which are formed by the growing over of basins (lakes and rivers), and those which are formed by the waterlogging of dry land.

When lakes become overgrown, there takes place a gradual filling-in of the basin with peat, and the transformation of the lakes into sedge or herbaceous bog, and, with the passage of time, into sphagnum bog.

The waterlogging of dry areas is a very common process in the north of the U.S.S.R. and in Scandinavia. Forests are particularly subject to this process. In the spruce forests, and sometimes also in the green-moss and pine complexes, waterlogging is initiated by the appearance of the moss *Polytrichum commune* (common haircap moss) or of sphagnum mosses. Sphagnum is characterized by its capacity to absorb large quantities of moisture. Sphagnum peat is highly impermeable to water, so that thick layers of peat constitute water-resistant strata. Both of these properties of sphagnum mosses promote waterlogging. Soon after sphagnum waterlogging begins, spruce disappears, and the forest changes into pure pine. Then the pine itself begins to grow poorly. Ultimately the pine or spruce forest changes into a sphagnum bog with Scotch pine. Often the waterlogging of an area begins after forest fires or felling in sections which were formerly dry. Forests, which evaporate an enormous quantity of moisture, lower the level of ground water in flat areas, and help keep them drained. With the disappearance of the forest, ground water appears on the surface.

In the first stage of their development, bogs are usually herbaceous (sedge) or mossy (hypnum). As the remains of dead vegetation accumulate, the surface of the bog rises to such an extent that there is no longer access to ground water, and the bog passes from the stage of subsoil nourishment to that of atmospheric nourishment. In this way, conditions are created which favor the settlement of sphagnum mosses. The large sedge (*Carex filiformis*), characteristic for sedge bogs, disappears.

On sphagnum peat bogs, in the first stage of their development, scheuchzeria (*Scheuchzeria palustris*) predominates. This is the *scheuchzeria* peat bog, the wettest of all sphagnum peat bogs. It is almost impossible to walk across it, as there is standing water under the loose moss cover. With the passage of time, the peat mass gradually fills the watery horizon, and the bog becomes somewhat drier and passes on to the next stage, that of the sheathed-cotton-sedge peat bog. In addition to the sod of the sheathed cotton sedge (*Eriophorum vaginatum*), there are many evergreen undershrubs. These plants are mycotrophic; that is, adapted, so far as root nourishment is concerned, to live symbiotically with fungi. Such plants include the small cranberry (*Vaccinium oxycoccos*), crystal tea ledum (*Ledum palustre*), andromeda (*Andromeda polifolia*), and leather leaf (*Cassandra* or *Lyonia calyculata* [*Chamaedaphne calyculata*]). The last forms entire thickets. In this stage the sphagnum (predominantly the red *Sphagnum medium*) forms a compact mossy carpet, overlying the compressed peat. If the red sphagnum develops vigorously, it forms such a dense carpet that only dwarf Scotch pine (*Pinus sylvestris f. litwinowi*), which rises above the surface of the moss carpet only 0.5 to 1 m., is able to survive on it.

Three types of bog are distinguished: (1) lowland, or hypnum and herbaceous bogs; among these there are sedge, reed, bulrush, reed-grass, and horsetail bogs; (2) transitional, or forest bogs, with sphagnum as well as hypnum mosses; among these there are shrub, alder complex, birch complex, birch and spruce, and birch-aspen-coniferous bogs; and (3) sphagnum bogs.

Of the sphagnum bogs the most characteristic for the forest zone are the *red-moss* bogs. On these the sphagnum mosses form a thick carpet of red or brown color (*Sphagnum fuscum, S. medium, S. acutifolium,* and others). Neither flood water nor ground water reaches this bog, which is nourished exclusively by atmospheric moisture: by rain, dew, and snow. Since the outskirts of the red-moss bog receive nourishment from ground water, which is harmful to the sphagnum mosses of which this type of bog is composed, the periphery of the red-moss bog develops slowly. The middle, however, which is watered exclusively by atmospheric moisture, grows quickly, and the bog takes on a protuberant appearance, the shape of an overturned plate. In addition to the unexacting sphagnum mosses, the vegetation of these bogs includes ledum, bog bilberry, andromeda, leather leaf, Scotch heather (*Calluna vulgaris*), cloudberry (*Rubus chamaemorus*), black crowberry, cowberry, bilberry, cranberry, sheathed cotton sedge (*Eriophorum vaginatum*), dwarf birch, pine, and others. Shrubby red-moss bogs, overgrown with dwarf pine, 1 to 1.5 m. in height, are very widespread.

Flood-plain meadows. Meadows, as distinguished from bogs and steppe, are herbaceous expanses which receive a moderate amount of moisture. The roots of meadow herbaceous plants, twining about each other, form a continuous, compact sod cover within the soil. Two types of meadow are distinguished: (1) flood-plain, or wet meadows, flooded annually, or once in several years, by high water in spring; these meadows lie in river valleys, but may be found also on the peripheries of shallow lakes subject to fluctuations of level (such, for example, is the flood plain of Lake Ilmen); (2) upland, or dry-valley meadows, found in interstream areas.

It must be kept in mind that aside from the flood plains there is no independent type of meadow vegetation in the lowlands (that is, outside the mountains) of the forest zone in the U.S.S.R. The upland or dry-valley meadows in the forest zone develop on the sites of cut-over or burned forests. The economic significance in the forest zone of dry-valley meadows, which serve for haymaking and pasture, is very great.

On the flood-plain meadows of the forest zone, vegetation of the meadow, bog, and forest type is developed. Correspondingly, there are also soils of the alluvial-meadow, bog, half-bog (meadow), and podzolic types.

The soils and vegetation of the flood plains are characterized by certain peculiar properties which are associated with the fact that the flood plain, in its entirety or in greater part, is covered for some time every year by water, which, when it recedes, leaves on the flood plain a layer of new sediment. Even at low water (when the high water has receded), the level of ground water remains high in the flood plain. The unsorted sediments of mixed sand and clay which are carried by the river at high water, are sorted on the flood plain, and are deposited according to the size of the particles: the large and heavy sandy particles close to the channel and on elevations in the flood plain; the sandy-loam and clay-loam sediments farther away; and the clay deposits still farther. In this way, the flood plain is marked off into three strips, according to soil and vegetation: (1) the sandy, riverain strip (along the channel), (2) the clay-loam middle strip, and (3) the silt-clay, poorly drained strip on the edge of the flood plain (along the terrace). Let us examine these strips.

(1) In the portion immediately adjoining the stream itself, there is an annual deposit of so much sand, which is subject to shifting and redeposition, that there is no vegetation here at all. On the sands at some distance from the channel, there are continuous pure thickets of butterbur (*Petasites tomentosus*). This plant has a long and rapidly-growing rhizome, capable of breaking through the deposits of sand. Besides the butterbur, among the plants which hold the alluvial sands are the field horsetail (*Equisetum arvense*) and willow stands, which can obtain nourishment through the medium of fungi (mycotrophically). The willows found here most often are the basket willow (*Salix viminalis* or *S. gmelini*) and the almond-leaf willow (*S. triandra* [*S. amygdalina*]). Besides the willows, at some distance from the river there are bird cherry, buckthorn, Siberian dogwood (*Cornus sibirica* [*C. alba sibirica*]), sweetbrier rose, black and red currants, blackberry, and others. Beyond the willow stands lie the flood-plain meadows (*priruslovie luga*). The friable sandy substratum is clearly laminated; from 0.5 to 2 to 3 cm. of sediment is deposited here annually. The soil has a thin cover of vegetation, in which there are many weeds whose seeds are brought by the high water. Here on the sandy soil spread readily grasses of the rhizomic type, which are capable of growing in the friable alluvial soils with the aid of their long underground stems. To this category belong smooth brome, wheat grass, and reed grass. Of these the most typical is brome, which sometimes forms thickets almost as tall as a man. Of the other grasses there are usually redtop, canary grass, blue grass, meadow foxtail, fescue, red fescue, timothy, and others. In addition to grasses, there are many legumes (red clover, meadow pea vine, and others), and also other dicotyledons ("mixed herbage"): yarrow, meadow geranium, sorrel, yellow bed-

straw, pomegranate, Siberian aconite, and others. The meadows of the riverain section do not occupy a large portion of the flood plain.

(2) The meadows of the middle part of the flood plain, however, sometimes extend for several kilometers across the valley. The herbaceous stand here is thick and tall. Sometimes in the associations of canary grass, growths as tall as a man are found. The predominance of certain grasses, legumes, and other plants makes these meadows very important agriculturally. The herbage is highly varied: in some parts there is a monotonous shroud of grasses in pure stands, in others there is a diversity of herbaceous plants, in still others, a variegated carpet of both. That strip of the middle section of the flood plain which borders upon the part next the terrace is characterized (on the Mologa River) by extensive forests of alder (speckled alder, *Alnus incana*), aspen, and oak.

(3) The meadows of the terrace section, bordering upon the terrace which lies above the flood plain, are characterized by the presence of sedge bogs, which are often hillocky. Sedge bogs usually develop on the sites of cut-over groves of European alder (*Alnus glutinosa*), which often grow in the strip next the terrace. In some places large areas are occupied by tufted hair grass (*Deschampsia caespitosa*), a thick grass which sometimes grows as high as a man's waist. Sedge and tufted hair grass yield a "sour" hay of small value.

Fauna

During the historical period the taiga has been inhabited by many large animals: elk, reindeer, roebuck, bear, and lynx, at present either driven back into more remote parts, or altogether exterminated. There used to be squirrels, martens, and beavers throughout the taiga, and sable in the northeastern part of the European Soviet Union and in Siberia. At present, among the principal animals of economic importance in the taiga are the squirrel, varying hare, fox, and ermine, and, of secondary importance, elk, marten, bear, and others.

The other mammals of the taiga include the flying squirrel (*Pteromys volans* or *Sciuropterus russicus*), which is found from the shores of the Gulf of Finland and the forests of White Russia, Moscow *oblast*, and Vladimir and Ryazan *raions*, to the Trans-Baikal region, the Kolyma, and Sakhalin. The chipmunk (*Eutamias asiaticus* [*E. sibiricus*]), a rodent which is very characteristic for the taiga, is found in the northeastern part of the European taiga and in Siberia. The common hare (*Lepus europaeus*), unlike the varying hare (*L. timidus* or *L. variabilis*), occurs in Europe, where it is found from lat. 62° N to the steppes and the Caucasus. The common hare is absent in Siberia. This species avoids continuous forests. In winter it does not turn completely white (in the Crimea and the Caucasus it does not turn white at all).

Among the birds which are typical inhabitants of the taiga are: [12] the capercaillie (*Tetrao urogallus*), which is found as far east as the Lena; another species, *Tetrao parvirostris,** peculiar to the taiga of eastern Siberia; the hazel grouse (*Tetrastes bonasia*), which is found as far as northeastern Siberia; the willow ptarmigan (*Lagopus lagopus*), which, although common in the tundra, also inhabits all parts of the taiga, living predominantly in mossy bogs; the three-toed woodpecker (*Picoides tridactylus*),* native predominantly to the spruce forests; the brambling (*Fringilla montifringilla*) *; the chestnut bunting (*Emberiza rutila*) *; the waxwing (*Bombycilla garrulus*) *; several thrushes; the white-winged crossbill (*Loxia leucoptera bifasciata*),* which is very characteristic for the larch forests; the pine grosbeak (*Pinicola enucleator*); the bullfinch (*Pyrrhula pyrrhula*); the nutcracker (*Nucifraga caryocatactes*), which disperses the seeds of the Siberian stone pine; the Siberian jay (*Perisoreus infaustus*) *; and others. All the birds which have been enumerated nest in the taiga and are permanent residents. Some of these birds may be found also in the subzone of mixed forests. Eastern Siberia is very rich in taiga birds; it contains forty-two species. To the west, however, their number decreases, but even in the Pyrenees there are eight species of birds peculiar to the taiga alone. Stegman suggests that eastern Siberia was one of the centers for the distribution of taiga birds; from here they spread into eastern Europe during the postglacial period.

Passerines predominate among the birds of the taiga. Of the birds of economic importance, the most significant are the hazel grouse, capercaillie, willow ptarmigan, and black grouse.

Of the reptiles, the common viper (*Vipera berus*) is found in all parts of the forest zone. It exists as far north as the forests of the Kola Peninsula, and as far east as Yakutiya and the Primorye. The common lizard (*Lacerta vivipara*) has almost the same distribution in this region. It is common as far as Sakhalin. Of the toads in the Siberian as well as the European taiga, there is found only the common gray toad (*Bufo bufo*). The grass frog (*Rana temporaria*) is widespread in Europe. In Siberia it is replaced by the Amur frog (*Rana amurensis*). This is a land frog

[12] V. Stegman, "Die Herkunft der paläarktischen Taigavögel" (The Origin of the Palearctic Taiga Birds), *Arch. f. Naturgesch.* (Archives for Natural History), I, 1932.

* The asterisk denotes species which do not cross the boundary of the taiga.

which descends into the water only to spawn. The edible frog (*Rana esculenta*) is virtually unknown in the taiga. It may be found only in the west, along the southern outskirts. This frog is not found in Siberia.

Among the insects of the taiga we will enumerate some of the Lepidoptera. Of all the Lepidoptera, the nun moth (*Porthetria monacha*) is considered the most dangerous enemy to the forest; its caterpillar crops the needles. The pine dendrolimus (*Dendrolimus pini*) is another very dangerous enemy to the conifers, while the cutworm moth (*Feltia segetum*, whose caterpillar is called the "winter worm") damages the winter grain.

In Lake Ladoga there is ringed seal (*Phoca hispida ladogensis*). Closely related forms are found in all the arctic seas, as well as in the Baltic and Caspian seas and in Lake Baikal. A singular characteristic of all these seals is that they whelp, as a rule, on the ice.

B. SUBZONE OF MIXED FORESTS

The boundaries of this subzone have been indicated above, on page 23. The subzone of mixed forests is absent in Siberia, where the taiga passes directly into the forest steppe.

Climate

The climate of this subzone is rather uniform. As an example, we will take the climate of Moscow (or, more exactly, Petrovsko-Razumovsk, near Moscow, lat. 55°50′ N, absolute elevation 167 m.). The table below presents the most important climatological data.

Table 2

CLIMATE OF PETROVSKO-RAZUMOVSK, IN THE SUBZONE OF MIXED FORESTS

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
Atmospheric temperature (°C.)	−10.8	−8.9	−5.0	3.6	12.1	16.0	18.3	15.8	10.1	3.7	−2.7	−8.0	3.7
Number of days of frost	30	27	28	16	2.6	0.3	0	0	2.3	14	23	29	175
Relative humidity (per cent)	86	84	80	74	66	71	73	77	81	83	87	87	79
Cloudiness (per cent)	77	75	69	60	56	58	55	58	63	73	86	84	68
Number of clear days	2.5	2.6	3.8	5.2	4.3	3.4	3.8	3.8	3.8	2.6	1.1	1.6	38.5
Precipitation (mm.)	25	22	28	33	48	65	75	76	52	49	38	29	538
Number of days with precipitation	16	15	13	11	12	13	14	14	15	15	16	17	171

In comparison with western Europe, Moscow *oblast* belongs to the category of regions which have a continental climate. The annual range in temperature here is considerable (almost 30° C.). However, the mean spring temperature in Moscow is the same as the fall temperature, or even a little lower. The melting of the snow cover in spring absorbs much heat and lowers the April temperature. As a result, the spring and fall temperature distribution is the reverse of that usually found in a continental climate, where the spring is warm and the fall is cold. In a marine climate it is the other way around.

The snow cover in the vicinity of Moscow usually disappears by April 19. About the same time the mass blooming of aspen, alder, willow, and black poplar begins. On hot summer days the temperature in the shade is 20° to 25° C., but occasionally the temperature may rise to almost as high as 38° C. The nights are rather cool; in July, the thermometer occasionally has dropped at night to 1° C. Winter in Moscow *oblast* is of long duration; there is snow on the ground for 140 days. The first snow falls in the middle of October, and by the latter half of November the snow cover is established. The winter is cloudy, with frequent snowfalls.

The climate of Leningrad, which lies on the border between taiga and mixed forests, is more temperate than the climate of Moscow, because of the moderating influence of the Gulf of Finland. Although Leningrad lies 4° farther north than Moscow, winter in the lower course of the Neva is almost 2° C. warmer. The Moskva River freezes on November 8, eighteen days earlier than the lower course of the Neva.

In this subzone the maximum precipitation occurs in White Russia, in the basins of the Pripyat and the Berezina. Here the precipitation totals 680 to 695 mm. annually.

Relief

The so-called Silurian plateau borders on the southern shore of the Gulf of Finland. Its northern edge, composed of horizontal Silurian and Cambrian deposits, is called the *glint*. The *glint*, which faces the sea, begins at Baltiisky Port in Estonia, where it has an elevation of 25 m. Near the Narova (Narva) River, the *glint* recedes from the seashore and stretches to the east, at a distance of 12 to 20 kilometers from the sea, to a point beyond the Syas River (which empties into Lake Ladoga). The absolute elevation of the plateau reaches 150 m. (for example, in the vicinity of Kopora station), and isolated points rise even higher;

thus, the Duderhof Plateau, the highest part of the Neva region, reaches an elevation of 175 m. In the vicinity of the Duderhof Plateau and near Pushkino, the Cambrian and Silurian strata are dislocated, apparently as a result of mechanical glacial action.

The name "Neva depression" is given to the declivity which is bordered on the north by the hills of the Karelian Isthmus (200 m.) and on the south by the escarpment of the Silurian plateau. In the lower course of the Neva the bed of Quaternary deposits is 11 to 68 m. thick. In Leningrad itself, two moraines may be distinguished, while in the region between the Gulf of Finland and Lake Ladoga some students identify three moraines, others two.

In the eastern part of the Gulf of Finland and in the region of the Neva delta, traces of Quaternary basins, in the form of terraces, coastal banks, and ledges, are well marked. But as yet there is no unanimity of opinion among the investigators concerning the particular late glacial and postglacial seas with which these traces may be associated. One of the well marked terraces is that which was formed by the last of the transgressions of the Baltic Sea, the Littorina transgression. The width of this terrace, along the southern shore of the bay, east of Kopora Gulf, is usually 0.5 to 1 km., in some places less, in others as much as 2 km. Its elevation differs at different points, as a result of the unequal uplift of the earth's crust in these parts during post-Littorina times. At Peterhof its elevation is close to 7 m. above the present level of the Gulf of Finland. To the west the terrace rises in elevation, while to the east it declines (at Ligovo it is 3.4 m.). According to Markov, the borders of Lake Ancylus * and the Yoldian Sea within the region under consideration lie below the level of the Littorina Sea. Above the Littorina terrace, in the eastern part of the Gulf of Finland, there is a series of terraces, which Markov considers to be traces of postglacial lakes which existed prior to the Yoldian period.

In the upper course of the Volga, west of Lake Seliger, lies the southern part of the Valday heights (elevation at Kamennik—322 m.). From here the heights extend to the north as far as Tikhvin, and to the southwest to a point north of Vitebsk. To the west, the Valday heights decline toward the Lake Ilmen Lowland in the form of a rather steep slope, with a drop of 50 to 100 m. On the east the heights have no distinct boundary. The Valday ridge is underlain by projections of Lower Carboniferous strata over which the glacier deposited terminal moraines and other detritus. Thus, at Valday, bedrock lies 200 m. higher than in

* Postglacial.—Ed.

the central parts of the neighboring Ilmen-Volkhovsk Lowland. To the south, the bedrock rises even higher. The Valday heights region is bordered on the east by a multitude of lakes, which give the district a very picturesque character. Some of the lakes are very deep; Lake Valday has a depth of 80 m.

The basins of the Volga, Western Dvina, Dnieper, and Ilmen in effect are interconnected. The Western Dvina has its source in a vast bog, in the middle of which, at an elevation of 221 to 223 m., there lie two lakes. One of them feeds the Western Dvina, while the other belongs to the basin of Lake Pyono, through which the Volga flows. In spring one may see part of the bog waters drain into the basin of the Western Dvina, while part of them drain into the basin of the Volga. The Dnieper has its source in a mossy bog, overgrown with forest, which lies in Smolensk *oblast,* at an elevation of 253 m. Part of the waters of this bog drain into the system of the Obsha River, which belongs to the basin of the Western Dvina. The Obsha itself has its source in a small bog which is also the source of one of the tributaries of the Dnieper. The existence of the connections between these basins inevitably affects the distribution of fresh-water fauna and flora.

The Smolensk-Moscow ridge is described by Nikitin (1896) as a terminal moraine ridge extending from Borisov (White Russia) through the central part of Moscow *oblast* to Gryazovets (Vologda *oblast*). A part of this ridge, which lies within Klin and Dmitrov *raions* of Moscow *oblast,* is called the Klin-Dmitrov ridge; in Dmitrov *raion* it reaches an absolute elevation of 316 m. It must be mentioned, however, that the Klin-Dmitrov ridge does not have the characteristics of a terminal moraine formation. In the northern part of Moscow *oblast* it constitutes a plateau, which drops in a steep shelf to the flat, forested, and poorly drained northern lowland, which extends to the north beyond the Volga. The mean elevation of this shelf is 50 to 60 m. If one travels along the railroad from the north to Moscow, this shelf is hidden by forests, but it can easily be told from the elevations of the stations. Thus, the station of Zavidovo, which lies in the lowland to the north of Klin, has an elevation of 142 m., while Pokrovka, which lies on the ridge to the south of Klin, has an elevation of 208 m.—a difference of 66 m.

The name Polesye is given to the poorly drained, forested lowland area which lies, roughly speaking, in the basin of the Pripyat River. This vast lowland, with differences in elevation between its center and edges of 55 to 80 m., extends to the south as far as the Volyno-Podolsk Plateau.

Polesye has many sandy areas, which are attributed to fluvioglacial origin. Among these sands there are often dunes, which are parabolic in shape. Their crests invariably face west, evidence that they were formed by westerly winds. The sands are usually covered with pine groves, which give Polesye a northern appearance. In general, however, Polesye is a poorly drained country. The bogs belong to the lowland or flood-plain type. The entire vast area of Polesye, says Tanfilyev, "is one continuous flood plain, with a few, predominantly sandy, dry valleys." Polesye constitutes an area in which sandy fluvioglacial and lacustrine sediments were deposited in front of the glacier. Similar sandy areas in the subzone of mixed forests are found also on the left bank of the Dnieper opposite Polesye, of the Oka (Meshchorsk Lowland), and of the middle Volga.

Some parts of Polesye contain "islands" which are foreign to it. Such, for example, is the Ovruch ridge, in the vicinity of Ovruch, which rises 60 m. above the surrounding lowland. (Its absolute elevation reaches 320 m.)

Soils

The fundamental type of soil under the forests in the subzone of mixed forests, as in the taiga, is the podzolic type. But there are also variations which approach the chernozem type.

In the preceding, drier ("xerothermic") epoch, a large part of the subzone of mixed forests belonged to the forest-steppe landscape, where soils of the chernozem type must have been formed. Subsequently these steppe soils were degraded (podzolized) by the encroaching forest. As traces of this epoch, in many places we find podzolic soils with more or less clear remains of the steppe type of soil formation. Such soils are found particularly often on strata rich in carbonates; for example, on loesslike clay loams and loesses. Similar soils, which are called dark degraded, chernozemlike, dark-gray degraded, and light-gray degraded, are found in the north of Chernigov *oblast*, south of Kaluga, in Western *oblast*, and in several other places.

In the Trans-Volga, in the extreme south of the subzone, there are gray forest clay loams (degraded clay loams) and in some places even medium chernozems.

Vegetation

The simultaneous presence of oak and spruce is characteristic of the vegetation of the subzone of mixed forests. To the north, in the taiga, the oak disappears, while to the south, in the forest steppe, there is no spruce (Maps 6, 7, 8).

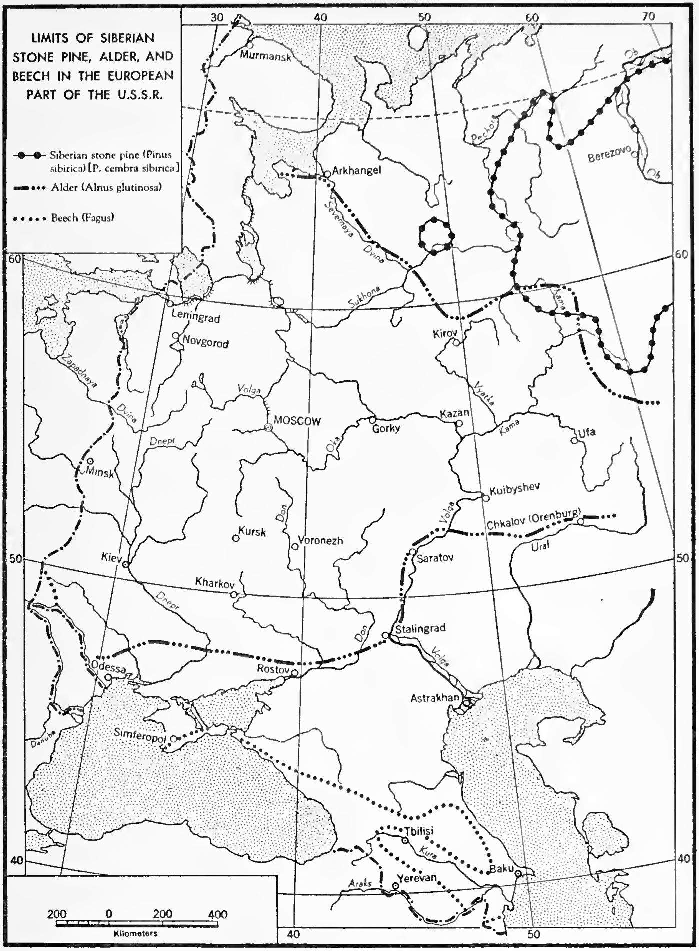
The subzone of mixed forests may be divided into two belts: (1) spruce-oak, without hornbeam; east of the Vetluga it is an oak-fir-spruce complex; and (2) hornbeam, or, more exactly, hornbeam-spruce-oak, in the southwest part of the subzone. The northern and eastern boundaries of hornbeam (*Carpinus betulus*) are as follows: from a point on the Baltic south of Libau (Latvia), the northernmost point to which hornbeam extends, to Vilna (Poland), Minsk, Bykhov on the Dnieper (below Mogilev), Starodub *raion,* west of Konotop, and then in the direction of Poltava, where the boundary turns towards Central Bessarabia. (Hornbeam is found also in the Donets ridge, in the Crimea, and in the Caucasus.)

The characteristic tree of the subzone of mixed forests (and also of the European forest steppe) is oak (*Quercus pedunculata* [*Q. robur*]) —a species which is exacting in its soil and light requirements. Oak thrives best on clay loams. It will not grow on strongly podzolic soils, on which spruce grows readily. On the northern boundary of its range, the oak prefers the flood plains of rivers, where there are unpodzolized, alluvial soils. Oak, as a rule, grows in mixed stands along with pine, spruce, fir, aspen, linden, hornbeam, and others. The European filbert (*Corylus avellana*) is found everywhere in association with oak. Sometimes the filbert forms a continuous undergrowth under the canopy of the light-loving species, oak and pine.

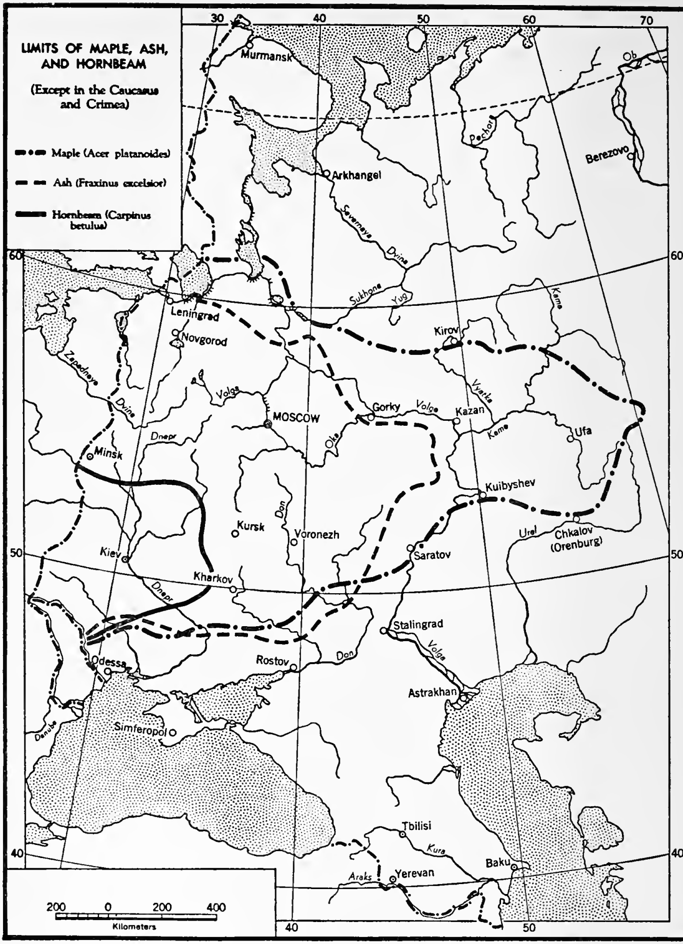
Besides oak, there are found in the subzone of mixed forests the same deciduous species which grow in the taiga, and, in addition, there are elms (Russian elm and Scotch elm), Norway maple (*Acer platanoides*), ash, and, in the west, hornbeam. Linden has a wide distribution.

Spruce-oak belt (without hornbeam): Individual oak trees and small thickets extend as far north as the northern shore of the Gulf of Finland, while small oak woods appear first on the Valday heights and in the region between Lake Ilmen and Lake Pskov. In Central White Russia there are extensive spruce-oak forests; here they prefer loesslike clay loams. In Moscow *oblast* oak and linden forests are found only in spots in the southern part, adjacent to the Oka, where the subzone of mixed forests grades into the forest steppe.

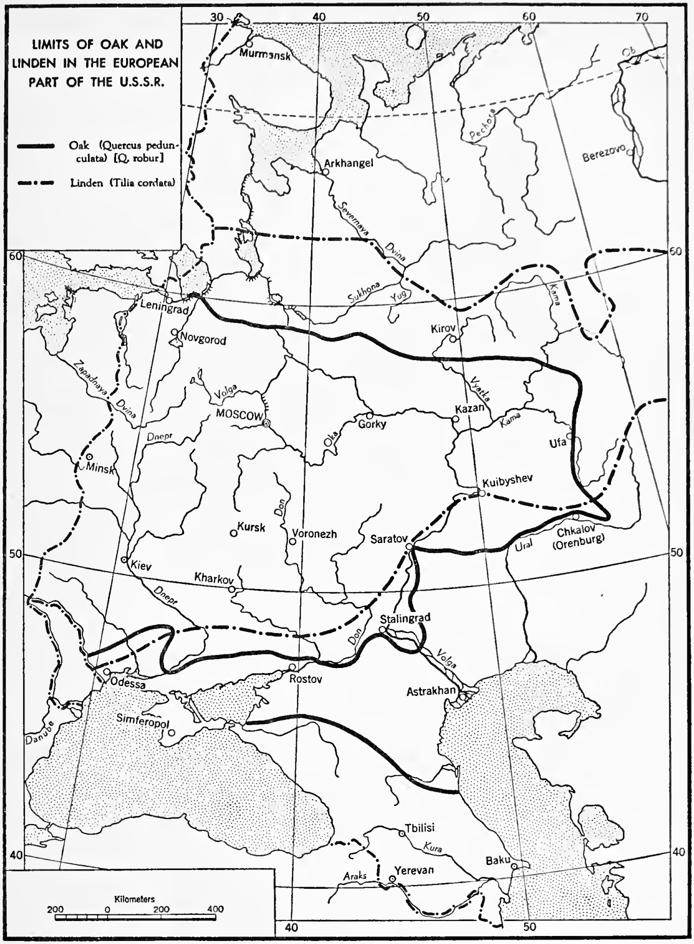
Hornbeam-spruce-oak belt: South of a line through Minsk, Bykhov, and Starodub, grow mixed broad-leaved forests with hornbeam and spruce. The farther south, the less spruce there is, and in the forests of the former Mozyr *okrug* spruce is found only in the form of isolated



MAP 6. Limits of Siberian stone pine, alder, and beech in the European part of the U.S.S.R.



MAP 7. Limits of maple, ash, and hornbeam (except in the Caucasus and Crimea).



MAP 8. Limits of oak and linden in the European part of the U.S.S.R.

island patches. The region of continuous spruce distribution does not extend as far as the Pripyat (except west of Pinsk, within the boundaries of Poland, where spruce forests extend beyond the Pripyat). South of this river, however, and up to the southern border of mixed forests, spruce is found in isolated islands, on the outskirts of bogs, or on valley slopes. Farther west, outside the limits of the U.S.S.R., the boundary of spruce extends to the mouths of the Vistula.

It is noteworthy that in southern Polesye pontic azalea (*Azalea pontica*, or *Rhododendron flavum* [*R. luteum*]), an ericaceous shrub, is found. The azalea grows 1.5 m. tall here, and blooms in large, orange, heavily scented flowers. This plant is found principally in the Caucasus, chiefly in the western Transcaucasus, where it grows from sea level to elevations of 2100 m., forming the undergrowth in the beech and oak forests. It is found also in Asia Minor. In Polesye the azalea grows on the outskirts of pine and spruce-deciduous forests, predominantly on peaty soil, and has a continuous distribution between Ovruch and Sarny (Poland).

An oak-fir-spruce belt is developed in the Volga region east of the Vetluga. Here we see a peculiar landscape, to some extent resembling that which lies to the west, in Poland, where fir (European), spruce, and oak are found growing together. This same combination of trees, although represented by different species, is found also in the Far East, in the Ussuri basin. In the Volga region, the Siberian fir (*Abies sibirica*) as a forest-forming species, reaches far to the south, growing in forests opposite Cheboksary, where it extends almost to the left meadow bank of the Volga. Twenty-five km. northwest of Kazan there are vast fir-spruce forests, with a ground cover predominantly of sphagnum mosses.

In the spruce forests of the Vetluga region (where there is an admixture of fir), the herbaceous cover contains a large proportion of southern species which are characteristic for leafy groves. Such are the European wild ginger (*Asarum europaeum*), common lungwort (*Pulmonaria officinalis*), sweet woodruff (*Asperula odorata*), and others. The existence here of these relicts is explained by the encroachment of taiga vegetation upon the territory of deciduous forests.

Fauna

Of the large mammals in the subzone of mixed forests there are found the elk and the roebuck. Along the northern border, during the nineteenth century, there were still reindeer, while some parts of White Russia are inhabited by beaver (*Castor fiber*) to this day. In the forests there are bear, fox, lynx, wolf, badger, ermine, and squirrel. Among the birds in the broad-leaved forests there are many characteristic forms, common to the same type of forest in the forest steppe: the roller, green woodpecker and wryneck, goldfinch, azure tit, pied flycatcher, icterine warbler, blackcap, blackbird, and others. Somewhat farther west, within the taiga, there are found steppe birds: the hoopoe, roller, and red-footed falcon (P. Serebrovsky).

III · Broad-Leaved Forests of the Far East

General Characteristics and Boundaries

THE subzone of mixed forests, as we have seen, does not extend east of the Ural Mountains. But after a great interval, broad-leaved forests reappear in the Far East, in the Amur basin. Here we find oak again—a different species, it is true, not European, but Manchurian (the Mongolian oak, *Quercus mongolica*), rather closely related to the durmast oak (*Q. sessiliflora* [*Q. petraea*]), which is found in the Caucasus, in the Crimea, and in southwestern Europe. The oak is accompanied again by a series of broad-leaved species—maple, ash, linden, Scotch elm, hornbeam, represented in part by species different from those which appear in Europe, in part by very closely related species.

This zone begins on the Amur between Albazin and Blagoveshchensk, and extends along the Amur almost as far as lat. 50° N. The Ussuri valley is also part of this zone. The zone is characterized by forests of broad-leaved species, hot summers, severe winters, and a monsoon climate. Here, as distinguished from the subtropical landscapes of the western Transcaucasus with its mild winters, we do not find admixtures of evergreen deciduous shrubs and trees.

Climate

The climate along the middle Amur and in Ussuri *kray* is manifestly of the monsoon type. In summer, when a high pressure area lies over the Pacific Ocean, moist and relatively cool SE winds blow in the Far East. But in winter, cold and dry NW and N winds prevail; they blow from the land mass, from the region of the Siberian barometric maximum. Because of these conditions, precipitation occurs during the warm period of the year. Some 85 to 95 per cent or more of the total annual precipitation falls during the months from April to November. The winter, however, is dry; only 5 to 15 per cent of the precipitation comes during the months from December to March. In spite of the southern position, the winters here are bitterly cold, much colder, for example, than on the shores of the Gulf of Finland. The southern part of Ussuri *kray* lies farther south than Yalta, and yet the mean temperature for January here is 25° C. lower than in Yalta. Because there is little snowfall in winter, the cultivation of winter grains is not possible except in the extreme south. In Blagoveshchensk, for example, toward the end of the winter the mean depth of the snow cover is only 5 cm. The snow cover generally disappears by March 24, when the young plants are not yet safe from frost. The annual distribution of precipitation in Blagoveshchensk (lat. 50¼° N, 134 m. absolute elevation) is as follows:

Table 3

Precipitation in Blagoveshchensk (in mm.)

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
3	3	6	22	41	87	118	122	71	18	6	3	501

As we can see, during the cold part of the year, from November to March, there is practically no precipitation. The spring is rather late, cold, and dry. The summer, however, is hot (the mean temperature of the warmest month is 20° C. or higher) and humid, with a great deal of precipitation, which often falls in the form of heavy showers. In the moist and warm atmosphere, vegetation grows very rapidly.

Because of the distribution of air pressure and winds, cloudiness is greatest in summer, least in winter and fall.

The climate of Vladivostok is described as follows: The greater proportion of precipitation falls in spring and summer, while the autumn is the finest period of the year. In summer, although it gets very hot, thunderstorms are very rare. The heat in Vladivostok is oppressive and humid; perspiration does not evaporate. Everything which is exposed to the action of the moisture becomes covered with rust or mold, as in the tropics or in Japan during the period of monsoon rains (*nyubay*). In summer, rain drizzles down sometimes for a week or two at a time, just as in any part of the European forest zone in autumn. Fog obscures all vision, while the sun remains hidden from sight for weeks on end. Often on a clear warm day in Vladivostok, a cold penetrating fog suddenly blows up from the sea, and a fine rain begins to fall. In autumn in Vladivostok people often wear white until the middle of October, but frequently it is necessary to light furnaces even in June, while in museums and libraries it is recommended that heating be continued throughout the summer. In August the rainy season ends, and clearer summer weather sets in. But in place of the rains there come typhoons—hurricanes which carry with them destruction to crops, stock, and so forth, by floods. September and October are the finest months of the year, with azure skies, transparently clear and relatively dry atmosphere, often with complete calm.[1]

The peculiar features of the monsoon climate of Vladivostok (lat. 43°07′ N, absolute elevation 128 m.) are expressed in figures as follows:[2] Of the total annual precipitation of 570 mm., about 65 per cent falls during the period from June to September. There are only 28 mm. of precipitation in winter; that is, about 5 per cent. In winter, cold N, NW, and NE winds prevail; in summer, moist SE and S winds. Relative humidity is greatest in summer (with a maximum in June: 88 per cent), least in winter (68 per cent)—contrary to the conditions usually found in nonmonsoon regions. Cloudiness correspondingly is greatest in summer, least in winter. The number of hours of insolation is at a minimum in July (34 per cent of the number possible), at a maximum in December (75 per cent).

Relief

The relief of this region is rather highly dissected, although in places there are extensive level areas. Throughout its length, the region is traversed by the mighty river Amur. In the section below the mouth of the Bureya, where the Amur breaks through the Little Khingan Mountains, it narrows in some places to half a kilometer, and here the current reaches the rate of 9 km. per hour. At Khabarovsk the river is covered with ice during five months of the year, from the end of November to the end of April. High water on the Amur occurs not in spring, as a result of the melting of the snows, as in the European U.S.S.R., but in summer, as a result of the rains.

East of the lower course of the Zeya lies the Zeya-Bureya (or Middle Amur) Lowland, covered with luxurious herbaceous vegetation and fertile soils. From the eastern slopes of the Little Khingan Mountains (1400 m.), eastward approximately as far as the great Lake Bolen-Odzhal, on the left bank of the Amur, lies the vast, flat, and unforested Lower Amur Lowland, with an average absolute elevation of 50 m. This

[1] V. E. Gluzdovsky and A. N. Krishtofovich, in the publication, *Primorye* (The Maritime Region), Vladivostok, 1923, Pt. I, pp. 3–4.

[2] M. Partansky, *Klimat Vladivostoka* (The Climate of Vladivostok), Vladivostok, 1923.

lowland consists of (1) a meadow terrace; that is, the flood-plain part of the Amur valley, from several kilometers to several tens of kilometers wide; and (2) a terrace lying above the flood plain, of the same width as the meadow terrace. The Lower Amur Lowland, drained by the rivers Bidzhan, Bira, and Tunguska (which empties into the Amur below Khabarovsk), is very flat. However, in some places it contains ranges 800 m. high. Finally, there are the Ussuri valley and the Khanka Lowland, which adjoins the large but shallow Lake Khanka. The depth of Lake Khanka, which is 90 km. long, does not exceed 2 m. throughout its greater part.

Soils

The subsoils in the Amur region are ancient, laminated, alluvial deposits. Neither glacial deposits nor loess is found here.

In the southwestern part of the Zeya-Bureya Lowland, overlying heavy clays, there are found soils of deep black color, lying in plowlands and meadows, and which have the appearance of true chernozems. But these are not chernozems. They have neither the characteristic granular structure of true chernozems in their upper horizons, nor the accumulation of carbonates in their lower ones. In summer the humus horizons are oversaturated with water. These are meadow, half-bog, podzolic soils, which, nevertheless, are no less fertile than the true chernozems. In addition there are some soils of a clearly podzolic type, overgrown with Asiatic white birch, Dahurian birch, and Mongolian oak (*Quercus mongolica*). Investigators of the Zeya-Bureya Lowland believe that at one time this space was covered almost entirely with forest, and was subsequently cleared and put under the plow.

In the Khanka region silty-bog soils are widespread.

Vegetation

The fundamental type of vegetation in the lowlands of the Amur region is the broad-leaved forest.

On the Amur between Albazin and Blagoveshchensk, the Trans-Baikal coniferous forests of Dahurian larch and pine are replaced by deciduous forests of Mongolian oak (*Quercus mongolica*). There are many coppices of Dahurian larch (*Larix dahurica* [*L. gmelini*]), Asiatic white birch, Dahurian birch (*Betula davurica*), Scotch elm, and bird cherry, with an undergrowth of the characteristic Far Eastern shrub lespedeza (*Lespedeza bicolor*). This leguminous shrub forms continuous thickets after felling and burning of the trees. Since it is as nourishing as alfalfa, it serves as an excellent fodder for livestock. There is some ash, linden, Amur maple (*Acer ginnala*), euonymus, and Siberian filbert (*Corylus heterophylla*). Scotch pine (*Pinus sylvestris*) grows in forests along the upper Amur as far as the mouth of the Zeya, but is seldom found along the lower Amur. Often in the second layer society of the pine forests, small oak trees are found. Siberian spruce (*Picea excelsa obovata* [*P. obovata*]) occurs along the Amur as far as the mouth of the Garin, nowhere growing in large stands.

Below Blagoveshchensk, along the Amur as far as the Ussuri, both on the left and on the right banks, lies a vast lowland area, which Maximov called the Manchurian "steppe." This lowland, the Zeya-Bureya Lowland, has been mentioned before. Where it has not been plowed, it bears a sumptuous herbaceous vegetation growing as tall as a man. In the meadows the most common and the predominant species is the reed grass (*Calamagrostis langsdorffii* [*C. canadensis scabra*]), a grass which provides rather good fodder. It is very interesting that in the meadows of the central Amur region there are found several steppe plants and animals. These include the capillary feather grass (*Stipa capillata*), the suslik (*Citellus eversmanni jacutensis*), and the Siberian bustard (*Otis tarda dybowskii*). The penetration of these steppe elements must be attributed to the xerothermic period. However, the spread of the suslik has been promoted by human activity in the form of plowing. At present the suslik has spread as far east as the Bureya, and has even crossed to its left bank. The suslik makes its home in the oak, lespedeza, and filbert thickets.

The forest vegetation of the Zeya-Bureya Lowland consists of the following species: Mongolian oak, Dahurian birch, Asiatic white birch (*Betula platyphylla*), and aspen. At the extreme north there appear herbaceous pine groves.

Along the shores and on the islands of the large rivers, particularly on the Bureya, there are flood-plain forests which bear a rich and varied vegetation of Mongolian poplar (*Populus suaveolens*), Amur linden (*Tilia cordata amurensis* [*T. amurensis*]), very closely related to the common European linden, elms, Manchurian ash, Manchurian walnut (*Juglans mandshurica*), and Amur cork tree (*Phellodendron amurense*). In these flood-plain forests there is a profuse and unique undergrowth, twined by the large vines of Amur grape (*Vitis amurensis*). This Manchurian plant, the stems of which reach a diameter of 15 cm., grows along the Amur north of lat. 51° N. It is found almost as far west as the mouth of the Zeya River. The Amur grape occurs also on southern Sakhalin. It bears black fruit, which ripens in the latter half of September. In Ussuri *kray* the wild grape is gathered by the local population; it is used for wine, preserves, and the like.

Along the Ussuri the vegetation takes on a completely Manchurian appearance. There are great numbers of tree and shrub species, among which many are characteristic southern forms. There are also some vines. In the Ussuri valley grow tall forests of Japanese elm [*Ulmus japonica?*], Amur cork tree, Manchurian walnut (*Juglans mandshurica*), white Amur lilac (*Syringa amurensis*), bird cherry, Manchurian crabapple [*Malus baccata mandshurica?*], Ussurian pear [*Pyrus ussuriensis?*], and hawthorn. There are no conifers here. On the rolling watersheds there is oak with a slight admixture of Asiatic white birch, Dahurian birch, and aspen, while higher up there are coniferous forests of Japanese stone pine, spruce, fir, linden, maple, oak, birch, ash, Scotch elm, and others, with a luxurious undergrowth and vines.

In the southern part of Ussuri *kray* (south of the line from Iman to the Tetyukhe River) the diversity of trees, shrubs, and vines becomes much greater. A total of 150 species of trees and shrubs have been enumerated here. Mixed coniferous-deciduous forests, which have remained intact chiefly on elevated portions, are characteristic. Oak predominates, with an undergrowth of filbert. There are also Korean pine (*Pinus koraiensis*), Manchurian fir (*Abies holophylla*), Yeddo spruce (*Picea jezoensis,* or *P. ajanensis*) (Fig. 10), Manchurian walnut, birch (*Betula costata*), Amur linden, Manchurian maple, and others, as well as many shrubs and vines. The epiphytic fern, *Polypodium lineare,* grows on the bark of many of the trees.

The aquatic vegetation of South Ussuri *kray* is very rich and unique. Here are found the Hindu lotus (*Nelumbo speciosa* [*Nelumbium nelumbo*]); watershield (*Brasenia purpurea*), a genus which, during the Quaternary period, appeared also in Europe; trapa (*Trapa incisa*); and in some places the gigantic Gordon euryale (*Euryale ferox*), the leaves of which reach a diameter of 130 cm.

Fauna

The fauna, like the flora, represents a mixture of northern and southern forms. Side by side with sable, squirrel, and lemming, there are the Manchurian tiger, which lives where there are wild boar; deer; roebuck; leopard; Amur wildcat; raccoon dog; and Japanese deer (*Cervus nippon* [*Sika nippon*]), found in South Ussuri *kray*. (This same deer is native also to Japan.) Among the birds there are many Manchurian forms;

for example, the Ussuri crane (*Grus japonensis*), Japanese ibis (*Nipponia nippon*), mandarin duck (*Aix galericulata*), which is the most variegated of all ducks; and others. Many of the Manchurian birds nest far up the Amur; for example, the ringnecked pheasant (*Phasianus torquatus alpherakii*) and the South Chinese cuckoo (*Cuculus micropterus*) at Kumara, and the azure-winged magpie (*Cyanopica cyanus*), Siberian golden oriole (*Oriolus indicus*), and others. Lake Khanka and the Ussuri are inhabited by the Chinese soft-shelled turtle (*Amyda sinensis*). Among the amphibians are the Ussuri salamander (*Onychodactylus fischeri*), of a genus native to Japan, and the East Asiatic black-spotted frog (*Rana nigromaculata*), which takes the place of the European edible frog (*R. esculenta*). The European tree frog (*Hyla*) and the toad (*Bombinator*) appear in closely related forms in the Far East.

Among the fish, together with northern species, which include, for example, the lamprey, loach, grayling, and whitefish, there is found a whole range of Chinese cyprinids and silurids. The discovery in the Ussuri basin of the snakehead (*Ophiocephalus*), a tropical fish, is worth noting. But, in addition, in the Amur there are found North Pacific ("Okhotsk") forms, such as the Pacific chum and pink salmon (genus *Oncorhynchus*), which go up the rivers in large numbers to spawn, as well as some endemic sturgeons—the Amur sturgeon (*Acipenser schrencki*) and the long-snouted sturgeon (*Huso dauricus*), which in the Amur takes the place of the beluga sturgeon (*Acipenser huso*), a species absent in Siberia. A fresh-water pearl mussel (*Margaritana dahurica*) occurs in the Amur basin. This mussel is found nowhere else in Siberia except in Sakhalin and Kamchatka. In the Ussuri and Amur basins there is found another large fresh-water pearl mussel (*Cristaria plicata*) up to 32 cm. long; it is native to China and Japan. Its shell yields mother-of-pearl. In the Amur basin, and particularly in Lake Khanka, there are shrimps (ten-legged crayfish of the Palaemonidae family). Of the beetles we must mention a large endemic longicorn beetle (*Callipogon relictus*) associated with the broad-leaved forests of South Ussuri *kray*. The other three species of this genus are found in tropical America.

It is very curious to find on the Amur, and in the Far East in general, after a great interval, a series of plant and animal forms peculiar to the subzone of European mixed forests but absent in Siberia, where this subzone is not represented. The oak, so characteristic for the subzone of mixed forests, does not extend east beyond the Ural Mountains, and appears again only along the Amur, in the form of a different species, the Mongolian oak (*Quercus mongolica*). The European oak is accompanied everywhere by the filbert (*Corylus avellana*). The filbert, like the oak, is absent in Siberia, but reappears in the Amur basin, in the form of *Corylus heterophylla,* together with the Mongolian oak. The same interrupted distribution is characteristic for the azure-winged magpie, white stork, green or edible frog, catfish, beluga sturgeon, carp, bivalve mollusk, fresh-water pearl mussel [*Margaritana dahurica*], fresh-water crayfish, and others.

The explanation lies in the fact that in Manchuria (as also in the Caucasus) we see the remains (relicts) of the fauna and flora of the Middle Tertiary, the preglacial, and, finally, the interglacial period. During the preglacial period some species were distributed throughout the continent of Eurasia, from western Europe to the shores of the Pacific Ocean. The colder temperatures which followed during the glacial period resulted in the disappearance of these species everywhere except in localities favored by a milder climate. Southern Europe, the Caucasus, the Tian Shan, Manchuria, and Japan constituted such retreats. In Amur *kray,* in addition to Manchurian forms, some of the Okhotsk forms have been preserved. These organisms inhabited the temperate belt of eastern Asia during the Upper Tertiary period. To this category belong, for example, the Pacific salmonids of the genus *Oncorhyncus,* the fresh-water pearl mussel *Unio,* Yeddo spruce, and others.

IV · The Forest Steppe[1]

Definition and Boundaries

THE forest steppe is a zone of transition between the forest on the north and the steppe on the south. In the typical forest-steppe landscape large masses of forest alternate with vast sections of steppe, or there are coppices scattered in patches over a background of steppe (Figs. 11, 12).

The southern boundary of the forest steppe is as follows: from the northern edge of the Beletsk steppe in Bessarabia to Ananyev, the upper course of the Ingul, Kremenchug (on the Dnieper), Poltava, Valuiki, Borisoglebsk, from here to the Volga somewhat north of Saratov, up the Volga to the mouth of the Samara River; on the left bank of the Volga, the Samara River to the Buzuluk pine grove, with a portion jutting to the north beyond the Kinel River, and to the east as far as Sterlitamak. East of the Kama there are several islands of forest steppe within the subzone of mixed forests, extending in part (the Kungur "island") even into the subzone of the taiga. Similarly, to the south of the southern boundary of the forest steppe, within the steppes, there is a large island of forest steppe; this is the Donets ridge. There is a similar island in Central Bessarabia. These two southern islands owe their existence to the relief.

Beyond the Urals the southern boundary of the forest steppe is as follows: Troitsk, somewhat south of Petropavlovsk, the Irtysh (approximately in lat. 54° N), south of Chanov, and from here southeast to Barnaul and the foothills of the Altay Mountains, between the Biya, the Ob, and the Salair ridge. From the Tom River eastward, the forest steppe in Siberia is found in patches: in the so-called Kuznetsk steppe, and in Minusinsk, Achinsk, Krasnoyarsk, Kansk, Tulun, Verkholensk, and Ir-

[1] For details and bibliography see L. S. Berg, *Fiziko-geograficheskie (landshaftnie) zony* (Physical-Geographical [Landscape] zones), I, 1936, pp. 312–427.

kutsk *raions*. Forest steppe appears again in the Trans-Baikal region, but that portion will be described below, in the chapter on the Trans-Baikal.

Subdivisions

The forest steppe may be divided into two parts, the western and the eastern. In the western forest steppe, the principal deciduous species is oak. In the eastern, or Siberian forest steppe, where oak is absent, birch takes its place (Fig. 12). However, the islands of forest steppe which lie to the west of the Urals—at Kungur and Krasnoufimsk [2]—have a Siberian character; they are forested with birch, and not with broad-leaved species. The forest steppe to the south of Belebey and in some other sections on the left bank of the Volga is also of the birch type.

The forest steppe may be divided into subzones latitudinally as well. On the north lies the meadow-forest subzone, or northern forest steppe. In this subzone there are extensive *oak forests* in Europe, and *birch forests* in Siberia. Here the forest has occupied almost the entire territory of the steppe. To the south lies the subzone of the meadow steppe, or southern forest steppe, in which the forest has not yet emerged completely victorious over the steppe. Here, more or less large sections of steppe are found together with forest masses or coppices. The steppes here are underlain by thick and somewhat leached chernozem; in Siberia, by medium (common) chernozem.

Climate

The northern boundary of the forest steppe coincides approximately with the 20° C. July isotherm (corrected for sea level), while the southern boundary coincides with the axis of the area of barometric maximum for temperate latitudes, which extends approximately from northern Bessarabia through Kharkov and Uralsk, to Lake Baikal. This high-pressure area divides the forest and forest-steppe zones from the steppe zone. In summer, particularly in July, the high-pressure area is almost absent, while in winter it is very sharply in evidence. North of it there are frequent cyclones, which come from the Atlantic and generally move from west to east. North of the area, southwest and west winds prevail; south of it, in the steppes, north, northeast, and east winds. The southwest and west winds of the forest zone bring moisture. In contrast, the

[2] Concerning these, see L. I. Prasolov and A. A. Rode, "O pochvakh sredneuralskoy lesostepi" (Concerning the Soils of the Forest Steppe of the Central Urals), *Trudy Pochven. inst. im. Dokuchayeva* (Proceedings of the Dokuchayev Soils Institute), X, No. 7, 1934, p. 60.

winds of the steppe blow from cold sections into warm, and because they gradually get warmer, their moisture is unable to condense; for this reason they bring dry air. Lying on the boundary between the forest and the steppe zones, the forest steppe is subject to the effects of both forest and steppe climates.

The average July temperature in the forest steppe ranges from 20° C. in the north to 21° to 22° C. in the south. The January isotherms run from northwest to southeast. The January temperature decreases to the east, from − 5° C. in the western Ukraine, to − 16° C. in the West Urals Foreland. West of the Dnieper, along the southern border of the forest steppe, the annual precipitation is about 450 mm. Maximum precipitation comes in June (as in the steppes), except in the north of the western forest steppe, where it comes in July (as in the forest zone). Minimum precipitation comes in January and February (in some places in March). In the forest steppe of western Siberia the climate is even more continental. In July the temperatures here are the same as in the European part of the zone, but in January they are lower, from − 19° C. to − 21° C. In the north, there are 450 to 400 mm. of annual precipitation; in the south, 300 mm.

The Donets ridge, due to its elevation, stands out as a sort of island of higher precipitation—450 mm., while the surrounding steppe has only 400 mm. annually.

The distribution of forest and steppe sections in the forest steppe depends upon not climatic but historical causes. Given time, with the present climate, the forest, if left to itself, would occupy the remaining steppe sections within the forest steppe.

Relief

The relief of the forest steppe differs in many respects from the relief of the forest zone. This is due to the fact that the greater part of the forest steppe is covered by loess, a material which is distinguished by a number of peculiar properties. It is an unlaminated, porous, calcareous material, with half or more of its entire mass consisting of particles 0.05 to 0.01 mm. in diameter. Loess has the property of crumbling in vertical walls. Loessial landscapes are characterized by steep, bare bluffs of yellow loess, deep, branching gullies, and plateau-shaped interstream areas. All of these features are completely unlike the gently rolling relief which we see farther north in the region of moraine deposits, where a loess cover is absent.

The origin of loess is explained in different ways. According to Richthofen (1877, 1886), loess is a deposit which originates from wind-transported dust; the wind carries fine products of weathering from the deserts and deposits them in the steppes, where the dust is held down by the herbaceous vegetation, and is transformed into a porous unlaminated stratum—aeolian, or typical loess. However, many of the facts contradict such an explanation: Contrary to the foregoing hypothesis, in Central Asia, along the borders of the desert, no "aeolian" loess is being formed at the present time; the loesses here are usually overlain by sierozems—a normal zonal soil. It is not clear why the wind must carry particles predominantly 0.01 to 0.05 mm. in diameter. The extensive distribution of laminated loesses remains unexplained, and the existence of such strata as the loesslike boulder clay loams, and so forth, is obscure.

Concerning the Ukrainian loess, the hypothesis has been advanced that the dust of which it is supposed to be composed was brought by the wind from the deserts along the periphery of the glacial cover. But it is well known today that along the southern border of the glacier lay not desert but tundra and wooded tundra, while still farther south tree vegetation sprang up immediately in the wake of the receding glacier. In short, the moraine which was left by the glacier was covered immediately by vegetation, and there is no reason to believe that the surface of the moraine was subject to wind erosion, or that the land in front of the glacier (that is, to the south of it) ever constituted a desert. Another source which has been suggested for the dust is deposition by rivers which drained from under the ice sheet; that is, fluvioglacial deposition. However (Berg, 1926; S. Sobolev, 1937), if one were to believe that the loess dust came from the blowing asunder of sands, the area of sand would have had to be many times greater than the area of the Ukrainian and South Russian loess.

In the loesslike clay loams on the shores of the Ob River (below the mouth of the Tom River), V. N. Sukachev[3] discovered the pollen of the water lily (*Nymphaea*, an aquatic plant), pollen which is not adapted to transportation by wind. This fact is evidence that the loesslike clay loams, or, more exactly, the material from which the clay loams were formed, was deposited by water, and not by wind. As for fauna, in the loesses there are found rather abundant remains of both aquatic and land animals. The latter are represented by both mollusks and mammals—rodents, the mammoth, the horse, the bull, and others. However, it can

[3] V. N. Sukachev, "Ob iskopayemykh rastitelnykh ostatkakh v lyossovykh porodakh v svyazi s yikh proiskhozhdeniyem" (Concerning the Fossil Vegetation Remains in Loessial Strata and Their Origin), *Doklady Akad. nauk.* (Report of the Academy of Sciences), XV, 1937, No. 4, pp. 183–188.

be shown that the remains of land fauna in the loess are of a secondary origin, while the original fauna consisted of aquatic forms.

In accordance with the theory I developed in 1916,[4] loess and loesslike materials may be formed from the most varied silts, rich in carbonates, as a result of processes of weathering and soil formation under dry climatic conditions. The origin of the parent material must be distinguished from the origin of its loesslike appearance; the parent material may be of alluvial, diluvial, fluvioglacial, glacial, or other deposition, but it receives its loesslike appearance, as we have indicated, as a result of processes of weathering and soil formation which take place in a dry climate. Some materials of a uniform mechanical composition give rise particularly readily to loesses and loesslike formations; for example, certain alluvial and fluvioglacial deposits. This explains the frequent association between glacial and loess regions.

Some parts of the forest steppe are extensively gullied, with considerable damage to agriculture; for example, along the right bank of the Desna in Chernigov *oblast*, or along the upper course of the Don. The ravines usually do not exceed several kilometers in length, occasionally reaching 10 km. Forests retard the formation of gullies. The presence of gullies in forested areas testifies to the predominance here in the past of steppes, upon which the forest encroached with the passage of time. The extensively developed ravines which are found often today are a result of the clearing of forests in the ravine basin, the plowing of slopes, and the grazing of stock along the slopes. Forestation of the ravines quickly halts their development.

In the eastern part of the European forest-steppe zone it has been remarked that in the gullies which are disposed latitudinally, the steep slope, devoid of vegetation, faces south, while the gentle slope, covered with vegetation, faces north. The explanation lies in the fact that the slope which faces north, lying as it does in the shade, does not dry, crack, and crumble as quickly, and therefore gives the vegetation a chance to develop. Furthermore, the snow lies longer here in spring and melts more slowly. All of these factors lead to a leveling of the slope which faces north, and to the accumulation of fine outwashed products. On the contrary, on the slope which faces south, the snow melts very quickly, and the thawed water brings about intensive erosion, forming steep

[4] See L. S. Berg, "O proiskhozhdenii lyossa" (Concerning the Origin of Loess), *Izv. Geograf. obshch.* (Report of the Geographical Society), 1916; *Klimat i zhizn* (Climate and Life), Moscow, 1922, pp. 69–110, and also the latest summary in my article: "Problema lyossa" (The Problem of Loess), *Priroda* (Nature), 1927, No. 6; 1929, No. 4.

slopes. This type of asymmetry is not confined to the slopes of the river valleys in the forest steppe (and the steppe), but appears in the interstream areas as well.

A characteristic feature of the forest-steppe relief is the great number of hollows, or "saucers"—shallow, round depressions of different size, sometimes occupied by small ponds, bogs, or temporary pools of water. They are found predominantly in flat interstream areas. In some parts of Poltava *raion* there are so many depressions that the distance between them is only 2 to 60 m. The depth of the depressions is usually from 0.75 to 1.5 m., occasionally 2 m.; the diameter, 10 to 50 m. In the forest steppe between the Don and the Volga, the depressions overgrown with aspen and willow are known as "aspen bushes." In the forest steppe of western Siberia, the depressions overgrown with birch are known as *kolki.* As for the origin of these saucerlike depressions, they are due in part to the mechanical effect of water which at one time covered the present-day steppe, and in part to the sinking of the ground as a result of the leaching out of salts.

The West Siberian forest steppe is characterized by gently undulating topography: long, gently sloping ridges, or *grivy,* alternate with hollows. In the Ishim and Baraba steppes they run chiefly from northeast to southwest and have a relative elevation of 1 to 4 m., and occasionally 6 to 10 m. They measure hundreds of meters in width and reach several kilometers in length. The hollows between the ridges often are basins for solonchaks, bogs, small lakes, and streams. The origin of these ridges has not been determined.

We now pass on to a description of the major features of the relief. The Volyno-Podolsk Plateau extends from the lowland which adjoins the Carpathians (the sources of the Sana and the Dniester, in Poland) into the U.S.S.R. as far as the middle Dnieper on the east; on the north this plateau, composed of loess and dissected by ravines, is bordered by an escarpment beyond which lies the Polesye Lowland; on the south it reaches as far as a line connecting Balta and Zaporozhye, or to the Black Sea Lowland. At the source of the Southern Bug the plateau has an elevation of 392 m.; at Krements, in Poland, it reaches an elevation of 407 m. Along the Zbruch, which empties into the Dniester on the Polish border, the elevations along the left bank also reach 385 to 390 m.

The Volyno-Podolsk Plateau is composed of loess and horizontal Tertiary and Cretaceous rocks. Along the river valleys in some places there are outcrops of crystalline rocks (gneisses, granites, and others). They belong to the Volyno-Azov (or Ukrainian) crystalline massif, which extends from southern Polesye to the Sea of Azov. This massif constitutes an island of ancient, pre-Cambrian mountains, which have been worn down to their foundations. In the western part of the Volyno-Podolsk Plateau there are peculiar elevations, usually ridge shaped, composed of limestones and called *Toltry*. These ridges extend from NNW to SSE for a distance of about 250 km. This Podolian *Toltry* belt is 3 to 4 km. wide; differences in elevation amount to 50 to 60 m. and the absolute elevation reaches 360 to 380 m. The *Toltry* are developed most typically at Kamenets-Podolsk. They originally were the barrier reefs which were formed in the ancient Miocene sea. Bryozoa, mollusks, calcareous algae, and occasionally corals contributed to the formation of these reefs. Karst phenomena are developed in the limestones of which the *Toltry* are composed.

The valleys of the streams which drain from the Volyno-Podolsk Plateau into the Dniester are incised deeply into the plateau. They have the appearance of canyons, 100 m. or more in depth.

That part of the Ukrainian forest steppe which adjoins the left bank of the Dnieper constitutes a lowland (the Dnieper Lowland), which merges into the Central Russian heights on the east. The mean elevation of the lowland is 90 to 150 m. But elevations in the area between the sources of the Oka and the Don reach more than 300 m. The Dnieper lobe of the ice sheet extended over the Dnieper Lowland, but the southern part of the Central Russian heights is free of boulders.

A large part of the area adjoining the left bank of the Dnieper is occupied by the Dnieper terraces, which at one time extended to the east as far as Priluki, Piryatin, Liven, and Khorol. Between Kiev and Priluki this zone reaches a width of 125 km. To the north it extends beyond Chernigov into the forest zone; to the south it reaches as far as Dnepropetrovsk, which lies in the steppe zone. According to different authorities, there are anywhere from three to six terraces in this plain. Dmitriev, for example, describes six, beginning with the meadow terrace: [5]

(1) The meadow, or flood-plain terrace, which reaches a width of 10 to 12 km., is well defined along the middle Dnieper. At Kiev its absolute elevation is 94 to 95 m. and it rises 3 to 4 m. above the level of the river.

(2) The second terrace (the first terrace above the flood plain), or the "pine-grove" terrace, at Kiev lies at an elevation of 103 to 119 m. It is covered with dunes up to 20 m. high which are overgrown with

[5] N. I. Dmitriev, "O kolichestve i vozraste terras srednevo Dnepra" (Concerning the Number and Age of the Terraces of the Middle Dnieper), *Zemlevedenie* (Geography), [Vol. 39] No. 1, 1937.

pine forest. It is best developed at Kiev, on the left bank, where it reaches a width of 12 km. This terrace is well represented also at Kremenchug. According to Dmitriev, it was formed during the Upper Würm glaciation.

(3) The third terrace, which belongs to the Lower Würm period, is poorly defined.

(4) The fourth terrace rises 30 to 40 m. above the Dnieper (absolute elevation, 106 to 126 m.). It is believed to have been formed during the Riss period.

(5) The fifth terrace occupies an enormous area, reaching as far as Khorol, Lubny, Piryatin, Priluki, and Borzna. In the latitude of Priluki it reaches a width of 75 km. This terrace rises 40 to 50 m. above the level of the Dnieper. In some places on the surface of the terrace there are great numbers of saucer-shaped depressions, formed by arms of the Dnieper which lay here at one time. In the region of Gradizhsk, Pivikha hill (absolute elevation, 169 m.; elevation above the Dnieper, 102 m.) rises above the fifth terrace. This hill, formerly attributed to tectonic origin, is actually a terminal moraine. The fifth terrace is believed to have been formed during the Mindelian period.

(6) On the watershed between the Psyol and the Khorol, the absolute elevation of the sixth terrace usually does not reach 150 m., while the watershed plateau reaches 160 to 170 m. in elevation, and even higher at individual points. Dmitriev relates this terrace to the Günz glaciation.

East of the Dnieper we find again a large "island" of massive crystalline rock, most of which lies beneath the surface; it is a continuation of the Volyno-Azov massif. This "island" includes the region of the Kursk magnetic anomaly, which stretches from Fatezh through Shchigry and Novy Oskol as far as Pavlovsk. At Shchigry, pre-Cambrian ferruginous quartzites have been discovered at a depth of 162 m.

In the vicinity of Lubny lies the famous Isachkovsky hill (absolute elevation, 147 m.), which rises very slightly above the level of the Sula River. The composition of this hill includes diabase, the eruption of which took place along a fissure, probably during the Lower Cretaceous period. During the glacial period, the hill was covered by the ice sheet, which left a moraine. The moraine is overlain by loesslike clay loams, and they, in turn, are overlain by loess.[6]

[6] N. I. Dmitriev, "K morfogenezisu Isachkovskovo kholma" (The Morphogenesis of Isachkovsky Hill), *Izv. Geogr. obshch.* (Report of the Geographical Society), 1935, No. 1.

The Donets ridge constitutes an island of forest steppe within the steppe. The presence of forests here in the past was due to the rather considerable elevation of the ridge; in Mechetnaya Mogila (between Debaltsevo and Zverevo), the elevation reaches 369 m. In general the ridge has the characteristics of a gently rolling plateau, stretching from WNW to ESE for a distance of 370 km. and reaching 160 km. in width. Along the northern base of the ridge flows the Northern Donets; the river then turns sharply to the south and cuts across the ridge. The interstream areas of the ridge have a steppelike, gently rolling appearance and are completely under the plow. The ridge is very rich in mineral resources: coal (both bituminous and anthracite), salt, and others. The upper section of the Carboniferous system is richest in coal, while the Permian deposits are very rich in salt.

The Volga heights, which will be discussed in greater detail in the chapter on the steppes, are situated on the right bank of the Volga, and at the south extend into the steppe zone. Here we will consider only the highest part, the Zhigulevsk hills, which rise 371 m. above sea level and 354 m. above the level of the Volga at the mouth of the Samara River. The Zhigulevsk hills are the product of complex dislocations. During the first half of the Mesozoic period, a domelike uplift occurred here. Then the northern part of the dome began to subside. This subsidence, which took place along the northern border of the Samara bend, continued into the Oligocene period and later (but no later than the Upper Pliocene). The extent of the displacement in some places reaches 1200 m.[7]

In the relief of the southern part of the forest steppe, on the left bank of the Volga, the influence of the Ural uplift already begins to be evident; the area rises in elevation and to the south of Belebey lie the Belebey heights, which reach an altitude of 449 m. and serve as a water divide between the basins of the Kama and the Belaya.

The Ufa Plateau, which lies partly in the subzone of mixed forests, is situated between the Ufa River and its tributary, the Ayem. This plateau, 270 to 300 m. in elevation, is a gentle anticline of Upper Carboniferous limestones. Here, as in the region of Permian strata, karst phenomena are extensive.

[7] E. N. Permyakov, "K poznaniyu geologicheskoy istorii raiona Zhigulevskovo kupola" (Toward the Understanding of the Geological History of the Zhigulevsk Dome Region), *Byull. Mosk. obshch. isp. prir.* (Bulletin of the Moscow Society for Natural Research), otd. geol. (Geological Section), XIII (1935), No. 4, 1936, pp. 461, 471. N. I. Sokolov, "K voprosu o tektonike Samarskoy luki" (On the Question of the Tectonics of the Samara Bend), *ibid.*, XV, No. 3, 1937, pp. 275–292. A. N. Mazarovich, *ibid.*, XIV, No. 6, 1936, pp. 535–536.

The West Siberian forest steppe is characterized in general by flat relief. We have spoken already of the *grivy* (ridges) and depressions found here. As distinct from the European forest steppe, the Siberian forest steppe has many land-locked lakes, both salt and fresh water. Of these lakes mention may be made of the large, slightly saline Lake Chany in the Baraba steppe. The Kokchetav heights, composed of granite and reaching an elevation of 948 m., also may be noted here. There are several lakes at the foot of the highest part, at an elevation of 300 to 400 m.

Soils

The soils of the forest steppe are unique. Some of the soils here were formed under the forest, while others originated under steppe vegetation.

The forest steppe to the west of the Urals may be divided according to soil cover into a series of subzones, from north to south: (1) gray forest soils (degraded clay loams), (2) degraded chernozem, (3) leached chernozem and "northern" chernozem, and (4) thick and rich chernozem.

The forest steppe of western Siberia, beginning at the north, may be divided into the following soil subzones: (1) northern, strongly leached chernozem; (2) solonchak (meadow-solonchak); (3) rich chernozem; between the Irtysh and the Ob rich chernozems are absent over a large area, and here solonchak soils lie adjacent to medium chernozems; and (4) medium (common) chernozem.

In western Siberia the forest steppe extends as far south as the southern boundary of medium chernozem. Since the subzone of southern chernozem (which belongs to the steppe zone) is narrow here, the forest steppe extends almost as far south as the southern boundary of chernozem; the true steppes begin only a little north of the subzone of chestnut soils. P. Krylov classifies as forest steppe the entire region of West Siberian chernozem. Thus, there is a great difference between the forest steppe in Siberia and the forest steppe which lies to the west of the Urals. In eastern Europe the southern, very broad part of the chernozem zone is occupied by steppe, while forest steppe is found only in the northern part.

First a few words about chernozem, which is representative of the steppe type of soil formation. The profile of chernozem on virgin steppe is as follows: The surface of the soil is usually covered by a mat of vegetation, 2 to 4 cm. thick. The soil itself consists of two horizons: one rich in organic materials, the other a horizon of carbonate accumulation. The humus horizon, which is generally 70 to 100 cm. thick, has a fine granular structure at the top. The humus usually comprises 6 to 10 per cent of the content of chernozems. Soils rich in humus are found overlying heavy clay-loam subsoils and limestones; chernozems which overlie sandy strata are poor in humus. An essential condition for the formation of chernozem is the presence of a considerable quantity of calcium carbonate in the parent material. Loess, unleached loesslike clay loams, boulder clay loams, marl, limestones, and chalk are particularly favorable to the development of chernozem. Without calcium, says Tanfilyev, there can be no chernozem. Both the mineral and the organic absorption complexes of chernozems are saturated with calcium and magnesium. As a result, chernozem easily resists the decomposing and dissolving action of soil solutions. And, in general, the washing and leaching of the soil in the forest steppe and the steppe cannot be very great, in view of the relatively small amount of precipitation and the considerable evaporation. Soil solutions in chernozem always contain calcium, which promotes the coagulation of the soil particles. For this reason chernozems have a firm granular structure, which favors aeration and permeability of the soil.

The gray forest clay loams, which are found along the northern boundary of the forest steppe, according to Glinka, are secondary podzolic soils, as distinct from primary podzolic soils, since they formerly belonged to the chernozem (steppe) type of soil formation, but subsequently were degraded as a result of the leaching out of carbonates and other salts and oxides. The degradation of chernozems consists of the leaching out of carbonates and humus, the reduction in thickness of the humus horizons, the appearance of a podzolized horizon and a horizon in which sesquioxides accumulate, and the disappearance of the typical granular structure which is peculiar to the chernozems. The gradual stages in the degradation of chernozems are as follows: leached chernozem, degraded chernozem, dark degraded clay loams, and gray degraded or forest clay loams. Degradation, which takes place under conditions of relatively abundant precipitation, consists of a gradual transition from the chernozem (steppe) type of soil formation to the podzolic (forest) type.

The gray forest clay loams have a gray humus horizon, the lower portion of which has a characteristic nutlike structure with a distinct podzolic (siliceous) sprinkling on the "nut" particles; the carbonates are leached out to a considerable depth. In degraded chernozems gray-white shades appear in the lower portion of the humus horizon.

Thick chernozems are typical chernozem soils. The humus horizon reaches a thickness of 80 to 100 cm. and more. In the Trans-Volga and in western Siberia, rich chernozems take the place of thick ones. The humus horizon is not as deep, only about 50 cm., but the humus content is greater, often as high as 15 per cent, and sometimes even higher. This is attributed to the large clay content of the subsoils. The rich (or leached) chernozems of western Siberia are noticeably podzolized; in the humus horizon there is a distinct sprinkling of silica.

Among the intrazonal soils, *solods* are very characteristic for the forest steppe in both Europe and Siberia, just as *solonetz soils* (Fig. 18) are characteristic for the steppe and the northern part of the semidesert, and *solonchaks* are characteristic for the semidesert and the desert. (However, all three are found in both the forest steppe and the steppe.) Each of these types of soil, associated predominantly with depressions in the relief, is related genetically to the others. As Gedroits has shown, solonchaks, under conditions of increasing moisture, pass over into solonetz soils, which, in turn, as the climate becomes still more moist, pass over into solods. The origin of these soils explains their zonal succession. The sequence, solonchak, solonetz, solod, is simply the succession of stages in the development of one and the same soil. The transformation of one soil into the other is related to the constantly increasing moisture of the climate.

Solonchaks are soils which contain readily soluble salts (sodium or magnesium, or calcium, or mixtures of these salts). If we assume that solonchak soil (which contains sodium in its absorption complex) undergoes leaching as the climate changes in the direction of greater moisture, the soluble salts will be removed, while the sodium remains in the absorption complex. The new soil, which does not contain large quantities of soluble salts, but which does contain sodium in the absorption complex, is called *solonetz*. Solonetz soils are very unstable soils, easily degraded. They are transformed readily into *solods*—soils which are poor in humus and in which the mineral part of the absorption complex is more or less leached.

Solonetz soils and solods are very common in the forest steppe of both eastern Europe and Siberia. There is reason to believe that the greater part of the chernozems of western Siberia at one time also passed through a stage of salinization, and that salinized soils generally had a wider distribution here in the past than they do at present. But even today solonchaks occupy a large area in the West Siberian forest steppe; carbonated solonchaks are particularly numerous here.

The soil cover of the forest steppe clearly testifies to a recent change in climate in the direction of greater moisture, as a result of which the forest began to encroach upon the steppe. At one time, during the warm and dry sub-boreal period, chernozems extended as far north as the northern boundaries of the forest steppe. Then, during the relatively cool and moist sub-Atlantic period, the climate became more humid, and forest vegetation, which had moved into the steppe, partly from the north, partly from the west, began to change the chernozem into podzolic soils. The encroachment of the forest on the steppe is still in process at the present time.[8]

Vegetation

According to the predominant tree species, the European part of the forest steppe may be called the *oak* forest steppe, while the Siberian part may be called the *birch* forest steppe. However, the birch forest steppe begins, as we have said, west of the Urals.

We shall describe first the forest landscapes of the forest steppe: broad-leaved forests, aspen bushes, birch forests, and pine groves.

Oak groves are characteristic between the Dnieper and the Volga. In addition to the oak (*Quercus pedunculata* [*Q. robur*]), they include ash, linden, aspen, smoothleaf elm (*Ulmus campestris* [*U. carpinifolia*]),[9] and maples (Norway maple—*Acer platanoides;* hedge maple—*A. campestre;* and Tatarian maple—*A. tataricum*). Tatarian maple and European filbert (*Corylus avellana*) often form the undergrowth; both are very common in the forest outskirts.

The following herbaceous plants are characteristic for these oak forests: mercury (*Mercurialis perennis*), common blue squill (*Scilla cernua* [*S. nonscripta*]), common lungwort (*Pulmonaria officinalis*), bishop's-goutweed (*Aegopodium podagraria*), European wild ginger (*Asarum europaeum*), Archangel dead nettle (*Galeobdolon luteum* [*Lamium galeobdolon*]), giant fescue (*Festuca gigantea*), reed fescue (*F. sylvatica*), hairy sedge (*Carex pilosa*), and others. All of these herbaceous plants have wide blades. There are few mosses in the oak groves, or none at all.

The oak, ash, Norway maple, linden, and hornbeam forests to the right of the Dnieper in the Ukraine are called hornbeam groves. These forests always have two layer societies: in the upper layer society there are oak and ash, in the lower layer society, hornbeam or hedge maple. In western Podolia (and in northern Bessarabia), in areas which have a mild and moist climate, there are beech forests. (In the beech forests on the Khotinsk heights in Bessarabia there is a great deal of English ivy

[8] For details, see L. S. Berg, *Klimat i zhizn* (Climate and Life), Moscow, 1922.
[9] Or, according to the present nomenclature, *Ulmus foliacea.*

(*Hedera helix*), which spreads along the ground and climbs up the trunks of the beeches.)

On the southern border of the forest steppe, in the right-bank part of the Ukraine (west of the Dnieper), lies the Cherny [Black] forest. The leading species in this forest, which is near Znamenka station, is oak, with hornbeam occupying second place, and hedge maple, third. It is interesting that this forest contains a sphagnum bog, on which grow pyrola and orchids; some birches (one of them, *Betula verrucosa*) have been found here also; thus it has a whole colony of northern elements.

In the forests near Balta (Moldavia), in addition to the common (English) oak, there is often found another, the durmast oak (*Quercus sessiliflora* [*Q. petraea*]), a western species. Northwest of Balta there is another western species, the silver linden (*Tilia argentea* [*T. tomentosa*]).

In the Mius basin on the Donets ridge there is hornbeam.

Aspen bushes, or, more correctly, aspen coppices, of which we have spoken already, are associated with the forest steppe east of the Don. They extend to the south as far as the border of the forest steppe, in some places penetrating into the northern outskirts of the steppe zone. Where aspen bushes are found, they coincide in their distribution with the areas covered by solonetz soils and solonchaks. From what we have said above about solods, this may be understood readily. In Voronezh *oblast* the first trees and shrubs to appear in the depressions are the gray willow (*Salix cinerea*) and its companion, the European dewberry (*Rubus caesius*). Next to appear is aspen, which crowds the willow out to the periphery. As time passes, elms (*Ulmus*), European white birch, oak, Norway maple, and even linden settle in the aspen "bush." Thus, the aspen groves represent one of the stages in the transformation of the depressions into forest areas.

In the Kungur forest steppe, birch coppices are found growing on slightly degraded chernozems rich in humus. This forest-steppe complex in some places is developing before our very eyes; on two- or three-year-old formations, young birches may be found growing already beside ten- to fifteen-year-old and older birch coppices. Individual specimens of spruce occur among the birch. Under natural conditions the Kungur forest steppe apparently would turn quickly into a continuous massif of birch forest.

In western Siberia, *kolki* are analogous to the aspen bushes. These are small woods of pubescent birch (*Betula pubescens*), with an admixture of aspen and European white birch (*B. verrucosa*), and with an undergrowth of willows. These coppices, like the aspen bushes, are associated with depressions which contain salinized soils. To the north, the *kolki* merge gradually into larger forest massifs.

Pine groves. The pine, growing chiefly on sands and sandy loams, is almost the only coniferous tree found in the forests of the forest steppe (Fig. 13). Occasionally pine may be found growing on exposures of chalk and on granite (for example, on the Kokchetav heights); in a few places it may be found growing on peat bogs. The southern boundary of the distribution of pine coincides approximately with the southern boundary of the forest steppe. Spruce and Siberian larch are found only rarely in the forest steppe.

The scheme of distribution of vegetation in the forest steppe between the Dnieper and the Sura is approximately as follows: On the left bank, on the terrace above the meadow terrace, we usually find the sands occupied by pine. Sometimes within these pine stands there are sphagnum bogs. Farther from the river, on the sandy loam, we find pine-oak stands. The soil under these stands is degraded chernozem sandy loam. In the first layer society here, the pine has an excellent development; in the second layer society there is oak, with an admixture of smoothleaf elm, birch, and aspen, and with wartybark euonymus [*Euonymus verrucosus?*] predominating in the undergrowth. Oak is poorly developed on sandy-loam subsoils. Still farther from the river, on thick chernozem, is the steppe, in the midst of which here and there are scattered aspen "bushes." On the right bank, on gray forest soils near the river and on degraded chernozems farther away, there grow "upland" leafy groves—oak woods with more or less admixture of ash. Still farther from the river there are thick chernozems covered with steppe vegetation.

In the pine groves in the north of Voronezh *oblast,* and east of the Voronezh River, many northern elements may be found. In addition to reindeer moss in the white-moss pine groves, cowberry, bilberry, and pyrola are found in profusion in the peat bogs; in some places there is cranberry, and heather is very common. However, side by side with forest forms there are also steppe forms, such as the common woadwaxen (*Genista tinctoria*), broom (*Cytisus ruthenicus*), and others. Like the flora, the fauna of the forest steppe also shows a mixture of forest and steppe forms.

The Zhigulevsk hills are covered with broad-leaved and mixed forests. Mention may be made of the Buzuluk pine grove on the right side of the Samara River, in the Trans-Volga. It grows on slightly podzolized dune sands. These sands, which reach an absolute elevation of 200 m., are of ancient alluvial origin and are found in broad basinlike depressions in the relief.[10]

On the Kokchetav heights there are pine groves growing on granite rocks and on quartzites. In the wetter places there is an admixture of birch (predominantly European white birch) with the pine. But it is interesting to note that in the peat bogs in the neighborhood of Lake Borovoy there is found pollen of alder, elm, oak, Siberian stone pine, larch, spruce, and fir (Zharkova, 1930).

The pine groves in the Kulundinsk forest steppe, on the left bank of the Ob, are very curious. The sands which lie in the river valleys here are occupied by pine groves. The interstream areas are covered with medium chernozems, underlain by loesslike substrata. Birch *kolki* (with some aspen and willow) are associated with the depressions in the interstream areas. Since the pine groves lie in narrow strips from southwest to northeast along the rivers, they are called "ribbon" pine groves in the literature. These pine groves lie perceptibly lower than the interstream steppes, and for this reason the ground-water level here is very high. The sands form mounds which resemble dunes or ridges. In the depressions between the mounds in the north there are sphagnum bogs; in the south, solonchak meadows.

Steppes. The steppe portions of the forest-steppe zone constitute the remains of what was once continuous steppe, disrupted by the forests which have encroached upon its territory. At present these sections, covered with fertile soil, are almost entirely under cultivation. Patches of virgin steppe have been preserved only in a very few places.

In the north of the forest-steppe zone, herbaceous vegetation occupies the soils of the steppe expanses more or less uniformly, forming a continuous cover. The herbaceous cover is tall. In the southern half of the forest steppe, the herbage appears at first glance also to be continuous, but if the blades are moved apart, it will be seen that the sod does not cover the soil continuously. The plants grow in separate tussocks, while between the individual plants or tussocks there are intervals of completely bare space, 2 to 10 cm. wide. To the south, in the steppe zone, these spaces grow increasingly larger, until in the semidesert they become striking. It should be added that in the steppes in the southern

[10] A. N. Mazarovich, "Geologicheskoye stroyenie Zavolzhya mezhdu g. Kuibyshevym i Orenburgom" (The Geological Structure of the Trans-Volga Between Kuibyshev and Orenburg), *Byull. Mosk. obshch. isp. prir.* (Bulletin of the Moscow Society for Natural Research), otd. geol. (Geological Section), XIV, 1936, pp. 521–522.

subzone of the forest steppe, the herbage does not grow as tall as in the northern subzone. And in the steppe zone proper, the stand is still shorter.

Because dicotyledons, with their striking bright colors, grow here in abundance, the steppes of the forest-steppe zone are called *meadow* or *mixed-herbaceous steppes* (Fig. 14). They are also called northern, as distinguished from southern (the steppes of the steppe zone proper, where grasses predominate). At the beginning of the summer, the meadow steppes are covered in large quantities by a very few species of grasses, which belong to the broad-leaved group adapted to the relatively moist climate of the northern steppes. These include hairy oat (*Avena pubescens*), meadow brome (*Bromus erectus*), and velvet bent grass (*Agrostis canina*). Feather grasses, which are so characteristic for the southern steppes, are also found in the forest steppe, but do not predominate here. Two feather grasses of the pinnate group (*Stipa pennata* in the broad sense) are characteristic for the forest steppe of the Central Chernozem region (Kursk, Voronezh, Tambov). These are the broad-leaved feather grass (*S. joannis*), which is especially peculiar to the northern steppes, and the narrow-leaved feather grass (*S. stenophylla*), which grows just as profusely in the southern steppes. Fescue (*Festuca sulcata*) and koeleria (*Koeleria gracilis*), which are characteristic for the southern steppes, also are common here, particularly the former, but they occupy a subordinate position. In early spring the soil is covered with a continuous carpet of moss (*Thuidium abietinum*), which grows 2 cm. tall. This moss cover, which is very characteristic for the northern steppe, has a great significance: it protects the surface of the soil from erosion by the melt-water.

As we have said, in the northern steppes (the steppes within the forest-steppe zone) dicotyledons, which smother the grasses with their luxurious height, predominate. But Alekhin points out that in the virgin steppes of the forest steppe (those which are not only unplowed, but even unmowed), grasses, and particularly feather grass (*Stipa stenophylla*), must have had a much greater significance. Thus, the virgin northern steppes were feather-grass, mixed-herbaceous steppes.

We will present, according to Alekhin's data,[11] a description of the seasonal changes in the vegetation on the mixed-herbaceous virgin Streletsk steppe near Kursk: After the snow has melted, the steppe is covered with a profusion of the large purple flowers of the spreading pasqueflower

[11] V. V. Alekhin, *Tsentralno-chernozemnie stepi* (The Central Chernozem Steppes), Voronezh, 1934, izd-vo. "Kommuna" (published by "Communa"), 91 pp.

(*Pulsatilla patens* [*Anemone patens*]). After several days there appear the brilliant golden flowers of the spring adonis (*Adonis vernalis*). Both these plants are very characteristic at the end of April or the beginning of May. They fade quickly, yielding to the bitter pea vine (*Orobus albus*),* the stool iris (*Iris aphylla*), the snowdrop anemone (*Anemone sylvestris*), and others. At the beginning of June the pale-blue woodland forget-me-not (*Myosotis sylvatica*) begins to predominate; it is accompanied by the steppe groundsel (*Senecio campester*), with its yellow flowers, and by others. At the same time some of the grasses begin to bloom, and the broad-leaved feather grass (*Stipa joannis*) throws off its plumose awns. Toward the middle of June the steppe becomes dark purple with the blossoms of the meadow sage (*Salvia pratensis*); at the same time, the tall grayish panicles of the meadow brome (*Bromus erectus*) strike the eye. After several days the inflorescences of the velvet bent grass (*Agrostis canina*) unfold. At the end of June the mountain clover (*Trifolium montanum*), oxeye daisy (*Leucanthemum vulgare* [*Crysanthemum leucanthemum*]), and dropwort (*Filipendula hexapetala*) bloom in profusion. The plumose awns of the narrow-leaved feather grass (*Stipa stenophylla*) appear. In the middle of July the steppe assumes a dull-pink shade from the profusion of blooming Hungarian sainfoin (*Onobrychis arenaria*). During the latter half of the summer the steppe no longer has the appearance of a blooming carpet, but appears rather brown from the mass of withered plants. Although some new plants do blossom, they appear only as individual specimens; such are the larkspur (*Delphinium litwinowi*) and the black false hellebore (*Veratrum nigrum*).

Altogether, on the Streletsk steppe, in an area of about 1200 hectares, there have been enumerated 220 different plants, of which 180 belong to the category of herbaceous vegetation. Among the grasses the most significant are meadow brome (*Bromus erectus*) and velvet bent grass (*Agrostis canina*). In comparison with the southern or grassy steppes, the mixed-herbaceous steppes lead in number of grass species (about 20), but trail in number of individuals. Of the sedges, we must mention the low sedge (*Carex humilis*), a squat plant, which blooms at the same time as the adonis. It is considered one of the most important factors in the formation of chernozem. We must add that the surface of the soil here, in the spaces between plants, is covered completely by the green moss, *Thuidium abietinum*, of which we have spoken earlier.

The abundance of species on the Streletsk steppe, as presented by

* Probably a horticultural form of *Lathyrus vernus*.—Tr.

Alekhin,[12] is very interesting. On areas 1 m. square there have been enumerated as many as 77 species, and on areas 100 m. square, as many as 120.

In the steppe sections along the southern border of the forest steppe there are found thickets of xerophytic steppe shrubs—ground cherry (*Prunus fruticosa*), sloe (*P. spinosa*), Russian almond (*Amygdalus nana*), broom (*Cytisus ruthenicus*), spiraea (*Spiraea crenifolia*), and Russian pea shrub (*Caragana frutex*).

Vegetation of the chalky cliffs. We have mentioned already that in the relatively elevated, and consequently gullied, section of the central forest steppe, as for example, the regions of Orel, Kursk, and Kharkov, there is an area in which glacial deposits are absent. In this area, and also along its eastern boundary, along the river banks, outcrops of chalk are often exposed. On these chalky cliffs there is found a peculiar "cretaceous" flora (Fig. 15), which has a distinctly relict appearance. It is regarded as a remnant of Upper Tertiary (Pliocene) vegetation, which, in areas which were never covered by the ice sheet, survived all the adversities of the glacial epoch. The outcrops in the basin of the upper Oskol, near the boundary between Kursk and Voronezh *oblasts*, is particularly rich in relict forms. Among such relicts may be mentioned the small shrubs of *Daphne cneorum julia* and *D. altaica sophia;* the yellow alpine skullcap (*Scutelleria alpina var. lupulina*), of the labiate family; a crucifer (*Schivereckia podolica*), closely related to the draba; the rock jasmine (*Androsace villosa*), of the primrose family; and the umbellifer *Bupleurum ranunculoides.* According to Alekhin, the chalky hills at Barkalovka (Kursk *oblast*) in some places are covered continuously over areas as large as 30 hectares by the bushes of *Daphne cneorum julia.* In spring, when this plant blossoms, all the hills appear red, and the air is saturated with the odor of its flowers. This little shrub, 10 to 20 cm. high, grows best on virgin chernozem. In the southern Alps, *Daphne cneorum* extends as far as the alpine zone.

The vegetation of Galichya hill, on the right bank of the Don, near the crossing of the Don by the railway from Yelets to Gryazi, is very rich in relict forms. This hill is really a plateau, 235 m. in elevation, composed of Devonian limestones and covered with leached chernozems. In former times Galichya hill was covered entirely by an oak forest. On this low eminence, on an area of about 15 hectares, there grow some 500 species of plants, a remarkable abundance for our relatively scant flora. The vegetation of Galichya hill is, without doubt, a remnant of preglacial flora.

[12] *Ibid.*, p. 65.

Recently many relict forms have been discovered on the Donets ridge and in adjoining areas. Among such species are the arum (*Arum orientale*), a Mediterranean plant, which is found from the Balkan Peninsula as far east as the Crimea, the Caucasus, and Turkmenia, and which was found recently in the region of the Azov heights as well; the speedwell (*Veronica umbrosa*), native to the mountains of the Crimea and the Caucasus; and the West European horsetail (*Equisetum majus*). In some places on the Donets ridge there is hornbeam. All of these plants are remains of either Upper Tertiary or interglacial flora.

Bogs. The forest-steppe zone as a whole does not present conditions favorable to the development of interstream bogs. Because of the hot summers, evaporation is great here. The subsoils are usually loesses or loesslike clay loams, materials which are not watertight. Finally, the geographic circumstances in general do not favor the development of sphagnum mosses. Nevertheless, individual patches of sphagnum bog are found as far as the southern boundary of the forest steppe, while along the northern boundary of the West Siberian forest steppe they are numerous.

On the sphagnum bogs in Kharkov, Zmiev, and Kupyansk *raions*, a whole series of northern forms penetrates far to the south. Such are the cranberry, sundew, cotton sedge, some orchids, and so forth.

In the forest steppe the first noticeable signs of salinization are found on the flood-plain meadows. Thus, on the meadows in southern Tambov *raion* may be found such typical solonchak plants as the umbellifer silaus (*Silaus besseri*) and the grass *Atropis distans* [*Puccinellia distans*]. The greater portion of the forest-steppe meadows was covered at one time with forest. Even today, along the Sura, some sections of the flood plain are overgrown with oak, bird cherry, and Tatarian maple.

Fauna

The fauna of the forest steppe, like the flora, shows a mixture of forest and steppe forms. There are no animals especially associated with the forest steppe. The species which inhabit the forest steppe are typical of either the forest or the steppe.

In the forests of the forest steppe there was formerly an abundance of bear, elk, deer, and roebuck. In some parts there is still squirrel, marten, elk, and roebuck. In addition to these animals, suslik, jerboa, and bobac may be found in the steppe portions. Vladimir Monomakh says that he captured wild horses, or tarpans (*Equus gmelini*), in the Chernigov region and on the Ros River, a tributary of the Dnieper. In 1768 Gmelin visited the Voronezh region. According to him, about twenty years before his visit, the tarpan was common in the vicinity of Voronezh. At the time of Pallas (1769), saiga antelope inhabited the southern forest steppe on the left bank of the Volga in great numbers. The aurochs (*Bos primigenius*), a wild ox which is now extinct, inhabited the steppe, forest steppe, and subzone of mixed forests only recently; about three hundred years ago it was still found in Poland. The aurochs played a part in the development of the present domestic ox, particularly the longhorn species. Marmots or bobac (*Marmota bobak*) have practically disappeared in the European forest steppe; they are still found along the southern boundary of this zone, between Bityug and Khoper, and in a few other places. Generally speaking, the Dnieper constitutes the western boundary for the distribution of this species; however, during historical times the bobac was found on the right bank of the Dnieper as well, in the region of the rapids. The beaver was widely distributed at one time in the forests of the forest steppe;[13] also the roebuck, which is found occasionally even today. At the time of Gmelin (1768), black grouse (*Lyrurus tetrix*) were common in the neighborhood of Voronezh; today they are rare. At the beginning of the twentieth century the Kokchetav heights were inhabited by red deer (*Cervus elaphus canadensis sibiricus* [*C. elaphus sibiricus*]).

Dormice, small rodents of the Muscardinidae family, are very characteristic for the broad-leaved forests.

In the oak forests of the European forest steppe, and in the birch forests of the West Siberian forest steppe, there nests a series of birds which, according to Stegman (1936), must be of western European origin. These include the kite (*Milvus milvus*), stock dove (*Columba oenas*), wood pigeon (*C. palumbus*), turtle dove (*Streptopelia turtur*), green woodpecker (*Picus viridis*), golden oriole (*Oriolus oriolus*), thrush nightingale (*Luscinia luscinia*), robin (*Erithacus rubecula*), and others. The imperial eagle (*Aquila heliaca*), although it is called the steppe eagle, is found in the forest steppe, and nests only in trees. All of the species which have been mentioned are typical for central, and to some extent for southern Europe, and decrease in number to the east and north. In short, the picture is the opposite of that for the distribution of taiga birds. In general, the bird fauna of the deciduous forests of the forest steppe differs sharply from the bird fauna of the taiga (Stegman). But the fauna of the forest steppe has some features in common with the fauna of the Far East, which has been described earlier (pp. 65–67).

[13] Beavers are found even today in the forests of the Voronezh River basin, but they are raised commercially here.

The steppe portions of the forest steppe are very poor in steppe fauna. The large jerboa (*Allactaga jaculus* [*A. major*]) and the spotted suslik (*Citellus suslicus guttatus*) range almost as far north as the Oka. Thus, they are found somewhat south of Kashira, where, in patches amid the moderately podzolized soils there are developed dark-gray forest-steppe soils overlying loess. Here, among the oak and linden forests, there are areas of northern mixed-herbaceous steppe, with its characteristic vegetation: feather grass (*Stipa joannis*), nepeta (*Nepeta nuda*), dropwort (*Filipendula hexapetala*), meadow sage (*Salvia pratensis*), and Italian aster (*Aster amellus*). These flora and fauna are remains of the xerothermic period, which have survived here under the favorable conditions afforded by chernozemlike soils; the latter, in turn, were preserved due to the presence of limestones.

V · The Steppe

Definition and Boundaries

THE name "steppe" is given to an area which is more or less level, unforested, not flooded by high water in spring, well drained, and covered throughout the entire vegetative season with a more or less dense herbaceous vegetation growing on chernozem soils. Outside the steppe zone, steppes are found also in the forest steppe and in the semidesert, and also in some places in the mountains.

Within the steppe zone, in addition to steppes there are also other natural landscapes: flood-plain meadows, flood-plain forests, solonchaks, solonetz areas, and so forth, but the steppe predominates, and there are no trees except in the river valleys. In the steppes of the steppe zone, the predominating soils are medium and southern chernozems and dark-chestnut soils.

To the north the steppes extend into the forest steppe (see Chapter IV). To the south, in the Black Sea region, they reach to the sea. In the North Caucasus Foreland they reach as far as the lower course of the Kuban, and approximately to the line: Krasnodar, the mouth of the Laba,[1] Labinskaya, Pyatigorsk, and Grozny. (Farther south in this region we have the forest steppe of the mountain zone.) To the southeast the steppes extend to the western boundaries of the light-chestnut soils: approximately to a line extending from Grozny through Nizhnechirskaya on the Don to the right bank of the Volga somewhat north of Dubovka. Beyond the Volga, the southern boundary is as follows: the line of the railroad between Saratov and Uralsk, thence a line passing through Temir, Turgay, to the northern shore of Lake Kurgaldzhin-Dengiz, thence south to Akmolinsk, to the Irtysh below Semipalatinsk. The Kulundinsk steppe belongs partly to the steppe zone. The higher elevations in

[1] On the old maps forests are indicated along the right bank of the Kuban from Krasnodar to the mouth of the Laba (Mishchenko, 1928).

the Akmolinsk and Bayan-Aul and Kyzyl-Ray massif region, the Chingiz range, and the area to the east of this range as far as the Irtysh also belong to the steppes (the chestnut steppes). Then, after a big interval, we find chernozem and chestnut steppes again on the banks of the Yenisey in the Minusinsk region.

Climate

The steppe zone has warm and relatively dry summers. The mean temperature for July does not fall below 20° C., nor does it rise above 23½° C. In June and July the relative humidity at 1:00 P.M. averages 35 to 45 per cent. The annual precipitation is moderate, 450 to 300 mm. (in the south, in the region of the chestnut-soil steppes, it may be as low as 200 mm.), with the maximum coming during the first half of the summer, in June. In some years there may be no precipitation at all for a month or more during the summer. There is little cloudiness in the steppes; it reaches a maximum in December, a minimum at the end of the summer. The snow cover is not deep; in the north its maximum depth ranges from 20 cm. in the west, to 30 cm. in the east. On the Black Sea coast and on almost the entire coast of the Sea of Azov the maximum depth of the snow cover is under 10 cm.; in Yevpatoriya and Ochakov it does not reach more than 3 cm.

In the steppe zone (and to some extent in the forest steppe), a dry, usually hot, southeast or east wind or *sukhovey* is frequent; grain suffers severely because of these winds. The following table shows temperature and humidity during the period of a typical *sukhovey* in Voronezh *oblast* (village of Saguny):

Table 4

TEMPERATURE, HUMIDITY, AND WIND DURING "SUKHOVEY" IN SAGUNY
(Observations at 7 : 00 A.M., 1 : 00 P.M., and 9 : 00 P.M.)

AUGUST 1895	TEMPERATURE (°C.)			HUMIDITY (per cent)			WIND (direction and velocity in m. per second)		
	7	1	9	7	1	9	7	1	9
4	25.5	38.6	28.4	46	15	34	0	S5	SSE2
5	26.1	35.0	27.9	39	21	31	ESE3	S12	SE1
6	26.9	35.2	30.0	40	19	25	SSE6	S16	SSW12

As we can see, the temperature rose during the day to 40° C.; the humidity fell below 15 per cent and did not rise above 50 per cent; and the southerly winds reached a considerable velocity—16 m. per second.

There is little cloudiness during the *sukhovey*. It is believed by some authorities that the *sukhovey* brings heat and dryness from the deserts and semideserts of Asia. But this is not the case. According to Kaminsky, the *sukhovey* usually sets in when the edge of an anticyclone passes over a given region; the *sukhovey* is associated with descending masses of air.[2] In Voronezh *oblast* the *sukhovey* occurs most frequently in August, July, and May, and blows from SE, E, ESE, and S, but may blow also from other points of the compass.

Relief

The Volyno-Azov crystalline massif, which extends from southern Polesye to the northern shores of the Sea of Azov, has been mentioned already above (pp. 73–74). In the steppe west of the Dnieper, this massif, covered with sedimentary material, is revealed in outcrops of crystalline rocks in the valleys of many of the rivers. Outcrops of granite-gneisses in the Dnieper channel give rise to the Dnieper rapids, ten in number, between Dnepropetrovsk and Zaporozhye. At present the rapids are under water as a result of the construction of the dam at Kichkas village. Before the dam was built the Dnieper dropped 33 m. in a distance of 66 km. At a distance of 3 to 5 km. from the right bank of the river, the steppe here has an elevation of 125 to 140 m.; at the same distance from the left bank, the elevation is 110 to 125 m. The Dnieper does not cut very deeply into the crystalline massif, seldom deeper than 40 m.

In the Krivoy Rog region (in the basin of the Ingulets—a tributary of the Dnieper), there occurs a synclinal fold of Krivoy Rog metamorphic rocks in the granite-gneiss massif. This formation includes a bed, about 50 m. thick, of so-called "ferruginous" quartzites, which contain enormous deposits of rich iron ores (hematite).

Outcrops of granite are found also along the Don near Pavlovsk. In Boguchar on the Don, boring has disclosed granite at a depth of 81 m., while in Taganrog boreholes have reached crystalline rocks at 580 m.

In the break between the Dnieper and the Azov crystalline massifs, the crystalline formation dips far below the surface to reappear near the Molochnaya River and extend to the east beyond Mariupol. The Azov crystalline massif consists of gneisses, granites, and other rocks, in some places transected by veins of igneous (extrusive) rocks. There are also some laccoliths, which are apparent in the relief. One example is the

[2] A. A. Kaminsky, "Tipy zasukh i ravninnykh sukhoveyev S.S.S.R. (Types of Droughts and Dry Winds of the Plains in the U.S.S.R.), *Trudy Glav. geofizich. observ.* (Proceedings of the Central Geophysical Observatory), I, 1934.

breadloaf-shaped laccolith composed of andesitic rock near the junction of the Volnovakha and the Kalmius rivers; it was formed by the lifting of Paleozoic rocks by lavas.

The highest point of the Azov crystalline region is the granite dome-shaped height of Tokmak-mogila, 308 m. in elevation. This eminence lies on the watershed between the Dnieper and the Sea of Azov, northeast of the Verkhny Tokmak station (elevation 205 m.) on the railroad to Berdyansk.[3]

In all of the places which have been mentioned, we are dealing with outcrops of pre-Cambrian crystalline bedrock, which in some places are exposed at the surface, and in others are covered by the undisturbed sedimentary formations of the Russian lowland.[4]

The left bank of the Dnieper below Kakhovka, and the left bank of the Dnieper estuary lie in a region of sands, which were covered at one time by continuous forest.

The Kerch Peninsula[5] is divided by the bow-shaped longitudinal Parpachsk ridge into two sharply distinct parts, the northeastern and the southwestern. The northeastern part has a hilly relief, and at 20 km. west of Kerch reaches an elevation of 183 m. It is composed of Miocene and Pliocene deposits, in the form of numerous synclines and anticlines; these folds merge into corresponding folds on the Taman Peninsula. Mud volcanoes are associated with many of the folds. The southwestern part constitutes a plain, composed of Oligocene clays, which lie in folds oriented to the northeast. These formations are a continuation of the Oligocene deposits which are found on the northern slope of the mountains of the Crimea. In general, there seems to be a relation between the southwestern part of the Kerch Peninsula and the mountains of the Crimea; as for the northeastern part, it has no immediate relation to

[3] On the hypsometric map of the Ukraine (1:1,000,000, published in 1937 by the Gos. uchebno-pedagogicheskoye izdatelstvo Ukrainy [State Educational-Pedagogical Publishing House of the Ukraine], under the editorship of N. I. Dmitriev) east of Tokmak-mogila appears Belmakh-mogila, 327 m. in elevation. In M. J. Dmitriev's *Relyef U.S.S.R.* (Relief of the U.S.S.R.), Kharkov, 1936, p. 113, this same elevation is shown, and it is noted that on the 3-verst map this elevation is given incorrectly as 250 m. The Sea of Azov may be seen from the summit of Belmakh-mogila on clear days.

[4] However, among the crystalline rocks of the Volyno-Azov massif there are some more recent than pre-Cambrian.

[5] A. D. Arkhangelsky *et al.* "Kratky ocherk geolog. stroyeniya i neftyanykh mestorozhdeny Kerchenskovo p-va." (Brief Sketch of the Geological Structure and Oil Beds of the Kerch Peninsula), *Trudy Glav. geol.-razv. upr.* (Proceedings of the Central Geological Survey Board), No. 13, 1930, containing a geological map. E. V. Wulff, "Kerchensky p-v. i yevo rastitelnost" (The Kerch Peninsula and Its Vegetation), *Zap. Krym. obshch. yestestv.* (Report of the Crimean Nature Society), XI, 1929.

the folds of the Caucasus. On the Kerch Peninsula there are rich deposits of limonite, which are associated with the Upper Pliocene (Kimmeriisk layers).

The heights on the right bank of the Volga to the south of Saratov have the character of a plateau which narrows and decreases in elevation to the south. At Saratov it has an average absolute elevation of 250 m., while individual points reach 300 m. Farther south, in lat. 51° N, higher portions of the plateau, 300 to 327 m. in elevation, lie 30 to 50 km. from the banks of the Volga, on the watershed between the Ilovlya and the Medveditsa (left tributaries of the Don). At Kamyshin the watershed between the Volga and the Don lies only 110 to 120 m. above sea level. The more elevated points (300 to 327 m.) are associated with ridges of Lower Cretaceous sandstone which have emerged from under the beds of Upper Cretaceous and Paleocene strata as a result of tectonic processes.

A characteristic feature of the middle and lower Volga regions is the difference in elevation between the right and the left banks. The Trans-Volga area is considered a region of subsidence.

In the Trans-Volga the Obshchy Syrt heights are to be noted. In Novouzensk *raion* they reach an elevation of 100 to 190 m.; farther east they reach 280 m. The Obshchy Syrt is of tectonic origin. Its western part constitutes a system of dome-shaped eminences, or brachyanticlines, which extend crosswise (NW or WNW) of the watershed of the western Obshchy Syrt. To the east, the Obshchy Syrt reaches as far as the southern part of Sterlitamak *raion.*

The Manych valley will be discussed below, in the chapter on the semidesert.

The Mugodzhar Mountains are the southern continuation of the Ural range (Fig. 16). They extend from north to south, the northern part lying within the region of chestnut soils, while the southern part extends into the region of light-chestnut soils of the semidesert.[6] These mountains lie in two parallel ranges. The western, or main range, reaches an elevation of 653 m. in Ver-Chogur peak (near the crossing of the range by the railroad). Some 15 to 20 kilometers to the east of the main range lies the other, lower range. The western slopes of the Mugodzhar Mountains are steep, the eastern slopes gentle. The lowland between the two ranges is composed of Paleozoic, sedimentary strata, chiefly Devonian.

[6] E. N. Ivanova and A. A. Rode, "Pochvy Mugodzharskikh gor i prilegayushchikh ravnin" (The Soils of the Mugodzhar Mountains and the Adjoining Plains), *Trudy Pochven. inst. Akad. nauk.* (Proceedings of the Soils Institute of the Academy of Sciences), X, 1934, p. 82, bibliography, divided according to regions.

The western range, however, is composed predominantly of diabases and diabase-porphyrites. In general, the Mugodzhar Mountains have a monotonous cover of steppe vegetation. Only in some places in the deep ravines are there found coppices of birch, aspen, willow, bird cherry, and the like. On the slopes and in the dry defiles, shrub steppes of pea shrub [*Caragana* sp.], spiraea, wild cherry, and Russian almond are common.

In the steppes of the Ishim basin, and those farther east (and also farther south), the relief consists of *melkosopochnik*. This is the name given in western Siberia to gently sloping low hills, composed of granites, syenites, porphyries, diorites, and some sedimentary Paleozoic strata. The hills are usually low, from a few meters to several tens of meters high; only a few rise to 80 to 100 m. The higher points are usually composed of more resistant rocks—quartzites.

The *melkosopochnik* region is part of the Kazakh Folded Country, which extends to the south into the region of the semidesert. To the north, southward from the West Siberian Lowland, the *melkosopochnik* region extends somewhat north of Kokchetav; to the west, as far as the Ulu-Tau Mountains (elevation 1137 m.); to the south, as far as Lake Balkhash. Amid the *melkosopochnik* there are scattered individual massifs, relatively high and composed of the same rocks as the *melkosopochnik*. These massifs include: the Bayan-Aul granite massif, 1000 m. in elevation; the heights at Karkaralinsk (1463 m.); Kyzyl-Ray (1468 m.); Chingiz-Tau (793 m.), and others. In vegetation these massifs all belong to the steppe region; on some of them there are pine forests, growing on degraded chernozems.

These massifs and low hills of the Kazakh Folded Country are of the same age as the Altay and the northern chains of the Tian Shan. As in these systems, the most intensive folding took place during the Lower Paleozoic (Caledonian) period. However, there was also considerable folding (in a northwest orientation) during the Upper Paleozoic (Variscan) period. From the end of the Paleozoic to the beginning of the Tertiary this region was dry land. During the course of long periods under continental conditions, the mountain systems were worn down into the present massifs and hills. During the Lower Tertiary maritime transgression (which in the Lower Oligocene extended as far east as the Irtysh and as far south as the Chu River) marine deposits were laid down between the elevations and are everywhere disposed horizontally. Such dislocations as occurred during this period were of a thrust character and resulted in displacement of the strata composing the mounds in northwest and northeast directions.[7]

In the *melkosopochnik* region there are many enclosed depressions, often occupied by salt lakes. In the Carboniferous strata of Karaganda there are enormous reserves of coal.

The Minusinsk basin will be discussed below, in the section on the Western Sayans (pp. 290–291).

Just as in the forest steppe, there are many saucerlike depressions in the steppes. In the southern part of the Black Sea steppes, these are called *pods.* These hollows occasionally reach a diameter of several kilometers, and when the snows melt they sometimes turn into temporary lakes. The Agaimany *pod,* near the Askaniya-Nova (Chapli) preserve, is about 10 km. in diameter, and the area of its basin is greater than 1700 sq. km. In some places, for example on the western shore of the Sivash, the *pods* at one time were subject to marine transgression (see below, p. 97).

The Black Sea plain extends as far south as the northern shores of the Black Sea and the Sea of Azov, and as far north as Kodry (Bessarabia), the Volyno-Podolsk Plateau, and the Azov crystalline massif, and coincides with the northern boundary of the Lower Pliocene Pontic Sea. The Dnieper valley cuts 40 to 125 m. into the Black Sea plain. The flood plain of the Dnieper is called *plaven.*

A noteworthy feature of the Black Sea coast are the *limans*—the long and narrow bays or estuaries into which the Dniester, Bug, Dnieper, and other rivers empty. These estuaries are the drowned valleys of the lower river courses. The period during which the invasion of the sea took place cannot be determined without a brief account of the Quaternary history of the Black Sea, as it has been ascertained on the basis of the most recent investigations.[8]

The depression now occupied by the Black Sea has been in existence, in one form or another, since the Upper Miocene period. At the end of the Tertiary and the beginning of the Quaternary periods it was occu-

[7] N. G. Kassin, "Ocherk tektoniki Kazakhstana" (Sketch of the Tectonics of Kazakhstan), *Problemy sov. geologii* (Problems of Soviet Geology), II, No. 6, 1934, pp. 161–180.

[8] A. Arkhangelsky and N. Strakhov, "Geologicheskaya istoriya Chernovo morya" (Geological History of the Black Sea), *Byull. Mosk. obshch. isp. prir.* (Bulletin of the Moscow Society for Natural Research), otd. geol. (Geological Section), 1932. A. D. Arkhangelsky and N. M. Strakhov, *Geologicheskoye stroyenie i istoriya razvitiya Chernovo morya* (Geological Structure and History of the Development of the Black Sea), Moscow-Leningrad, 1938, Akad. nauk S.S.S.R. (Academy of Sciences of the U.S.S.R.).

pied by the *Chaudinsk* lake, a brackish body of water containing fauna of the Caspian type; it probably was connected by way of the Manych depression with the so-called Baku Lake, which then occupied the Caspian depression. During the subsequent *Paleo-Euxine* epoch, the Chaudinsk lake expanded its area. The fauna continued to have a Caspian character. At the end of this epoch the Dardanelles strait was formed. Through this strait salt waters penetrated into the Black Sea depression, and with them also the fauna of the Mediterranean Sea. At this time the slightly saline *Uzunlar* body of water was formed, containing the Mediterranean mollusks, *Cardium edule, Syndesmia ovata,* and *Mytilaster.* It was replaced by the more saline *Karangatsk* water body, containing a rich fauna of the Mediterranean type, richer than contemporary Black Sea fauna. About one-fourth of all the mollusks found in the *Karangatsk* waters no longer inhabit the Black Sea, while they continue to exist in the Mediterranean. It is interesting to note that the Karangatsk basin contained sea urchins (although very small ones), which are absent from the Black Sea today. During this period, or during the preceding Uzunlar period, *Cardium edule* penetrated into the Caspian by way of the Manych strait. During the next stage, that of the semifresh *Neo-Euxine* "lake-sea," the water area contracted; on the bottom of the northwest part of this sea there have been found terrestrial deposits at a depth of 40 m. The fauna of this basin resembles the contemporary Caspian fauna. At the end of the Neo-Euxine epoch a subsidence of the coast took place; the lower reaches of the rivers were flooded and transformed into estuaries; the ancient Black Sea basin was formed, with water less saline than at present, but with Mediterranean forms in evidence. As a result of the subsidence, the depth and the salt content were increased, and the basin became the *contemporary* Black Sea.

As we have seen, the estuaries were formed at the end of the Neo-Euxine epoch. Since that time several of the estuaries have become completely separated from the sea by spits; as, for example, the estuary at Odessa, which is famous for its curative muds.

The deep part of the Black Sea was formed by a series of subsidences, which, as Arkhangelsky points out, took place recently. Shells, sands, and gravel of the Karangatsk and the Neo-Euxine epochs, which could have been formed at a depth of not more than 30 m., have been discovered at depths up to 1500 and even 1800 m.

Almost everywhere throughout the steppes the subsoil is loess, a formation which we have discussed already (p. 70 ff.). As a result of the subsidences which have just been mentioned, in the region of the lower

Dnieper loess containing mole holes may be found below the level of the Black Sea. There are also mounds (kurgans) which apparently were piled up on dry land, but whose bases at present are flooded by the sea.[9]

Soils and Vegetation

On the basis of its vegetation, the steppe zone may be called a zone of *grassy steppes* (Figs. 17, 18). The steppe areas in the forest steppe, because of the abundance of dicotyledons, are called *meadow steppes* (Fig. 14), while in the semidesert, where *polyn* * [*Artemisia* spp.] and grasses predominate, there are *polyn-grass* and *polyn* steppes (Fig. 20).[10]

Among the grasses in the grassy steppes, the narrow-leaved varieties predominate, since these are better adapted to the dry climate of the steppes. Thus, in the chernozem steppes we find the narrow-leaved feather grass (*Stipa stenophylla*) of the pinnate group, capillary feather grass or *tyrsa* (*S. capillata*), fescue (*Festuca sulcata*), and koeleria (*Koeleria gracilis*). Fescue, unsuited for mowing, provides excellent green fodder for sheep and horses. At the end of the summer it produces a second growth, which serves as fodder during the autumn and winter. The grassy steppes also contain a rather large number of dicotyledons.

Feather-grass steppes, with Lessing's feather grass (*Stipa lessingiana*) predominating, accompanied by capillary feather grass, are found occasionally on chernozems; for example, to the south of Boguchar, on chernozems which are intermediate between the common and the southern types (Fig. 19). But the feather-grass type of steppe is particularly characteristic on chestnut soils, where Lessing's feather grass and the feather grass *S. tirsa*, accompanied by capillary feather grass, predominate. These are the dry steppes.

[9] B. V. Pyaskovsky, "Geologicheskoye stroyenie korennovo lozha i sostav allyuvialnykh otlozheny nizhnevo Dnepra" (Geological Structure of the Basic Channel and Composition of the Alluvial Deposits of the Lower Dnieper), *Zemlevedenie* (Geography), Vol. 35, No. 2, 1933, p. 127.

* In *Standardized Plant Names* (see Translator's Bibliography), species of *Artemisia* growing in the western United States are called "sagebrush," while those growing in the Old World are called "wormwood." However, this usage is not accepted by all authorities in this country. For this reason it was decided to retain the Russian word *polyn* throughout this translation.—Tr.

[10] I. V. Novopokrovsky, *Zonalnie tipy stepey Yevropeiskoy chasti S.S.S.R.* (Zonal Types of Steppe in the European Part of the U.S.S.R.), *Zemlevedenie* (Geography), Vol. 39, No. 3, 1937, pp. 198, 201, does not give the name "grassy" or "fescue and feather-grass" steppes to all of the herbaceous vegetation of the steppe zone, but only to that which is developed in the southern parts, on the southern chernozems, dark-chestnut soils, and the drier varieties of Azov and North Caucasus Foreland chernozems.

On the basis of soils and vegetation, the steppe zone may be divided into two subzones: (1) the northern, where the soils are typical chernozems, and (2) the southern, or dry steppe, where the soils are dark chestnut.

(1) In the chernozem subzone the following types of chernozem are developed: common, or medium chernozem; southern, or poor chernozem; and, finally, Azov, or North Caucasus Foreland chernozem. In western Siberia the northern steppe subzone is an area of southern chernozems (since the area of typical, or medium chernozems there is occupied by forest steppe); this belt is very narrow.

We have discussed chernozem already. As one moves to the south, the thickness of the horizons colored by organic matter and their humus content as a rule decrease. The northeast shore of the Sea of Azov and the steppes of the western North Caucasus Foreland have a special type of chernozem—the so-called Azov type. Although it lies to the south of the belt of common chernozem, nevertheless in its great thickness (up to 140 to 150 cm. and more) this type seems to approach the thick chernozems of the forest steppe. The origin of these chernozems is problematical. They may have been formed at the time when the Azov steppe lay at a higher elevation than it does today (Berg); we have spoken already of the recent subsidences along the northern shore of the Black Sea (p. 97).

Tanfilyev (1898)[11] describes the vegetation of the virgin chernozem steppe in Starobelsk *raion* (to the north of Donets *oblast*) as follows: In spring as soon as the snow is gone (usually no later than the middle of April), the small bright-green moss *Tortula ruralis* appears, and beside it the filaments of the blue-green alga *Nostoc commune*. At the end of April the first spring flowers appear—the common tulip (*Tulipa schrenkii* [*T. gesneriana*]), very closely related to the garden tulip, the anemone (*Pulsatilla nigricans* [*Anemone nigricans*]), and the spreading pasqueflower (*P. patens* [*A. patens*]); these are followed by the colewort (*Crambe tatarica*, a crucifer), dwarf iris (*Iris pumila*), adonis (*Adonis vernalis* and *A. volgensis*), and others. In the middle of May the slopes bloom with whole thickets of the magnificent dark-red fernleaf peony (*Paeonia tenuifolia*). In the middle of June the steppe wears a continuous blue carpet of blooming sage (*Salvia nutans*), and is covered with the silver plumose awns of the feather grasses. In addition to the feather

[11] More recent and more detailed data appear in E. Lavrenko and G. Dokhman, "Roslinnist Starobilskikh stepiv" (Vegetation of the Starobelsk Steppes), *Zhurn. biobotan. tsiklu Ukrain. Akad. nauk* (Journal of the Bio-Botanical Section of the Ukrainian Academy of Sciences), No. 5–6, 1933, pp. 23–133.

grasses the rest of the vegetation consists chiefly of grasses—fescue and koeleria—which grow in clusters, with intervals of black soil between them. There is no continuous, coherent sod here, as in the forest zone. Toward the end of the summer the capillary feather grass begins to predominate. In autumn, after the rains, the first representatives of the spring flora reappear—the moss *Tortula* and the alga *Nostoc.* On the Starobelsk virgin steppe, in addition to the herbaceous plants, there are numerous dense thickets of shrubs, which reach a height of about 0.75 to 1 m. and a diameter of several tens of meters. These thickets, which are called *dereznyaks*, or *visharniks*, consist of the shrubs which were mentioned above (p. 86).

In the southern steppes the vegetation naturally begins to develop earlier. Thus, in the vicinity of Odessa, the autumn crocus *Colchicum montanum* blooms in February, sometimes within the first ten days; the bulbous perennials—the crocus (*Crocus reticulatus*), lion's-leaf (*Leontice altaica*), starch grape hyacinth (*Muscari racemosum*), and twinleaf squill (*Scilla bifolia*)—also bloom in February in this region.

For a picture of the southern chernozem steppe on southern chernozems, we may take Pachosky's description of the virgin steppe in the Askaniya-Nova preserve between the lower courses of the Dnieper and the Molochnaya rivers: [12] The annual precipitation here is less than 300 mm.; the winters have little snowfall. In the middle of March life begins to awaken in the steppe. On sunny warm days the susliks (*Citellus pygmaeus*) come out of their burrows. The sod of the steppe grasses (the most striking of which is the sod of the capillary feather grass, *Stipa capillata*) does not form a continuous cover; in the spaces between grass tussocks appear the first white flowers of the spring draba (*Draba* or *Erophila verna*); it grows particularly readily on places somewhat trampled by grazing stock, where it is not smothered by the tall steppe herbage. The gageas (*Gagea pusilla* and *G. bulbifera*) also bloom between the sod tussocks, and almost at the same time as the draba; the gageas are small liliaceous plants with yellow flowers. Pachosky calls these ephemeral spring plants which grow in the spaces between the grass tussocks, *ingredients.*[13] They finish blooming quickly, before the full

[12] I. K. Pachosky, "Opisanie rastitelnosti Khersonskoy gubernii" (A Description of the Vegetation of Kherson Guberniya), II, *Stepi* (The Steppes), Kherson, 1917, pp. 6–19. More recent data appear in M. S. Shalyt, "Geo-botanichesky ocherk gos. stepnovo zapovednika Chapli (b. Askaniya-Nova)" (Geobotanical Sketch of the State Steppe Preserve at Chapli [Formerly Askaniya-Nova]), *Byull. Fitotekhn. stantsii stepn. inst. "Chapli"* (Bulletin of the Phytotechnical Station of the "Chapli" Steppe Institute), I, 1930, pp. 29–52.

[13] *Zhurn. Russk. botan. obshch.* (Journal of the Russian Botanical Society), X, 1925, pp. 123, 124.

development of the grass sod. Pachosky calls the grasses, *components.*[14] Toward the middle of April the viviparous bulbous blue grass (*Poa bulbosa var. vivipara*) begins to grow green; on its panicles, in place of flowers, there appear small bulblike buds, which are trampled into the ground by the stock and serve the plant in place of seeds. This blue grass is thick on heavily grazed virgin soils, and sometimes covers large areas continuously; but on virgin steppes which are not grazed very heavily blue grass does not attain predominance. By the middle of April the needleleaf sedge (*Carex stenophylla*) begins to bloom in the pasture steppe. The red tulip (*Tulipa schrenkii* [*T. gesneriana*]), which is found also on the Starobelsk virgin steppe, blooms about the twentieth of April. Sometimes this species bears yellow flowers, occasionally pink or other colors. Another tulip (*T. biebersteiniana*), with smaller yellow flowers, is found here also; in some places it grows in great profusion. In spring the dwarf iris (*Iris pumila*) brightens the steppe with its variegated flowers. Some of the irises are violet blue, some are yellow. Among the other flowers which bloom in spring are the steppe valerian (*Valeriana tuberosa*), *Ornithogalum tenuifolium* (Liliaceae), two astragali, the buttercup (*Ranunculus oxyspermus*), a hyacinth which bears dull-purple flowers (*Hyacinthus sarmaticus*), and others.

The basic steppe grasses (the *components,* according to Pachosky's terminology) which constitute the vegetative cover of the steppe, bloom later, in May. These are the steppe fescue (*Festuca sulcata*), and the pinnate feather grasses (Lessing's *Stipa lessingiana,* and others). We must mention also the koeleria (*Koeleria gracilis*) and crested wheat grass (*Agropyron cristatum*).

If there has been enough moisture since spring, the steppe presents an unusually beautiful appearance at the time of the mass flowering of the pinnate feather grasses. At this time the steppe is covered by a continuous silver-gray shroud. This peculiar shroud, composed of the innumerable "plumes" of the feather grasses, is tossed by the wind just like the surface of an endless expanse of water. Like water-waves, the gray masses of feather grass rise and fall, covering and hiding in their bosoms the remains of the plants which bloomed in early spring. Even those plants which bloom simultaneously with the feather grasses can be distinguished only as exceptions from the background of feather grass, and usually it is only at close hand that their presence may be noticed. The foremost among these taller and more noticeable plants is the steppe bristle thistle (*Carduus uncinatus*); its large red heads interrupt the monotony of the feather-grass mass.

Many dicotyledons grow in the steppe at the same time as the feather grasses.

[14] *Ibid.*

Toward the middle of June the awns of the pinnate feather grasses begin to fall off. About this same time the steppe fescue matures. The steppe takes on a yellowish coloring. Dicotyledons become more noticeable, and a whole series of new dicotyledons begins to bloom. If there is much moisture in the soil toward the middle of the summer, the capillary feather grass blooms luxuriantly. Toward the end of July, the steppe under favorable conditions becomes covered with a continuous carpet of flowering capillary feather grass. This feather grass in its usual position (that is, with bent panicles) grows as high as an adult person's knees and higher (the entire bush, when straightened, is as tall as a man and may reach even 180 cm.). If there is not sufficient moisture during the summer, the capillary feather grass does not grow so exuberantly; the flowers do not emerge, but remain hidden within the vagina of the upper leaf (this, however, usually is not harmful to the development of the seeds).

Toward autumn the stalks of the capillary feather grass turn yellow, while the awns with the caryopses in part fall off, and in part curl up spirally. By winter the surface of the steppe is studded with the stubble of the upright stalks of capillary feather grass. Between the stalks the snow is packed more or less evenly. "A great deal of moisture is condensed on the stalks of the capillary feather grass from the fogs which are usual here in autumn, winter, and spring; the dew which is formed rolls down in the form of drops and contributes considerably to the accumulation of moisture in the soil." The grazing of sheep on the capillary feather-grass steppes at the time when the seeds and awns are easily detached can be very dangerous for the sheep; the caryopsis with the awn, when it gets caught in the wool of the sheep, is screwed into the skin because of the hygroscopic winding of the awn, and may penetrate into the interior of the body.

The root system of the steppe grasses does not reach very deep. The deeper-lying horizons of soil moisture are utilized by the roots of dicotyledonous plants. When the grass cover is impoverished by grazing, the moisture has a chance to penetrate into the deeper layers, and thus on the cropped sections dicotyledons develop in large numbers; an example is the steppe euphorbia (*Euphorbia gerardiana*), which sometimes grows in almost continuous thickets over enormous areas (Pachosky, 1924).

On the southern chernozems in western Siberia, in the region of the large Omsk lakes, capillary feather-grass steppes prevail. The sod of the grasses covers less than half of the surface of the soil. In the spaces between tussocks brown spots of soil are visible, in some places covered with dead herbage.

(2) The subzone of southern, or dry steppes, lies on the chestnut soils. These soils extend in a narrow strip along the northern shore of the Black Sea, along the right bank of the lower Dnieper, in the northern Crimea, in the western part of the northern shore of the Sea of Azov, along the middle course of the Don and the Kuma, along the Volga somewhat below Kamyshin, in the Trans-Volga, and farther east in the steppes of Kazakhstan. In western Siberia these soils extend approximately as far north as the parallel of the northern end of Lake Selety-Dengiz (lat. 53½° N), that is, north of the parallels of Tambov and Orel. Beyond the Irtysh we find chestnut soils in the Kulundinsk steppe, and also on the left bank of the Yenisey in the Minusinsk region. Chestnut soils contain less humus than chernozems—only 3 to 4.5 per cent of the soil mass; this reflects the smaller number of plants in the southern steppes; the color of the horizons in which organic matter accumulates is not black, but dark brown ("chestnut"); the thickness of these horizons does not exceed 60 cm.; lamination is observed in the upper part of the humus horizon and compaction in the lower. The above account refers only to the dark-chestnut soils, since the light-chestnut soils are peculiar to the semidesert zone.

Forests. In the steppe zone forests are found only on the flood plains of rivers (the *plavens* of the lower Dniester and Dnieper), on the slopes of river valleys, or on the sandy terraces which lie above the flood plain.

In low places in the flood plain of the Don there grow poplar, black poplar, willow, and alder; on higher places, forests of oak, aspen, Russian elm (*Ulmus pedunculata* [*U. laevis*]), smoothleaf elm (*U. campestris* or *U. foliacea* [*U. carpinifolia*]), Tatarian maple (*Acer tataricum*), euonymus, and buckthorn. The forests in the flood plain (*plaven*) of the Dniester are distinguished by the great variety of tree species. Thus, in the Kitskansk forest, opposite Tiraspol, there is Russian elm, smoothleaf elm, oak, ash, black poplar, silver poplar, willow, hedge maple, hawthorn, filbert, and others. The woodland European grape (*Vitis silvestris* [*V. vinifera silvestris*]) is also present; its stems climb up to the tops of the oaks; at their base the grape stems are sometimes as thick as a person's hand. On the meadow terraces above the point where the Dniester River branches, there are coppices of European alder (*Alnus glutinosa*).

On the slopes along the high right bank of the lower Dnieper, there may be found pear, hawthorn (*Crataegus monogyna*), scrub smoothleaf elm, oak, apple, sloe (*Prunus spinosa*), spiraea, woodland European grape, and so on. On the sandy terraces which lie above the flood plain in the steppe zone of the Dnieper and the Don, there are forests. The big pine grove on the Samara River (which empties into the Dnieper from the left at Dnepropetrovsk) is well known. It lies on the left bank of the stream, in Novomoskovsk *raion.* On the shore itself there is an alder grove (*Alnus glutinosa*), with a belt of oaks beyond, and finally, still higher, the pine grove. This pine grove contains cowberry; in the depressions there are small sphagnum bogs, so foreign to the steppe zone; the lichen *Cladonia sylvatica* grows in the open spaces. The oak forest contains large aspens, as well as smoothleaf elm and ash.[15]

A vast area of sands stretches along the left bank of the Dnieper from Kakhovka to the sea. In the depressions there are coppices of oak, birch, aspen, and pear. The birch belongs to the form *Betula pubescens var. glabra,* the same as that found on the sands along the lower Bug and along the Samara. In some places in the coppices there is lilac and drug Solomon's-seal (*Polygonatum officinale*) under the oak. In the vicinity of the town of Aleshki there is European alder (*Alnus glutinosa*), from which this ancient town (properly called Oleshki) * received its name. In the flood plain (*plaven*) of the lower Dnieper there are no real forests, only groups of willow, black poplar, and European alder.

Some of the sands in the Golubinsk forest on the Don (lat. 49° N) are in motion. They were covered at one time with fescue and feather-grass steppe, while in the depressions there were birch-aspen *kolki.* On the shifting sands along the Archeda River (a tributary of the Medveditsa) grows the creeping savin juniper (*Juniperus sabina var. radicans*). (The name of the river is taken from the word for juniper, *archa.*) On the sandy terrace of the Archeda are found remains of pine, which is absent here at present. This region also contains small sphagnum bogs with their typical vegetation, foreign to the steppes—roundleaf sundew (*Drosera rotundifolia*), club mosses (*Lycopodium clavatum* and *L. inundatum*), and others.

Various hypotheses have been advanced to explain the origin of the sands along the middle Don. Some authorities (Sokolov, 1884) believe them to be river dunes, others (Dubyansky, 1911) believe them to be fluvioglacial deposits, while a third group regards them as terrace deposits of the Don. The latter two views must be considered correct.

[15] M. I. Kotov, "Botaniko-geografichesky ocherk doliny nizovyev r. Samary" (Botanical-Geographical Sketch of the Valley of the Lower Samara River), *Trudy Ikhtiol. opytn. stan.* (Proceedings of the Ichthyological Experiment Station), Kherson, VI, No. 1, 1930, pp. 57–99.

* The Russian word for alder is *olkha.*—Tr.

The Don sands are ancient alluvial and alluvio-lacustrine terrace formations, which have as their basis fluvioglacial deposits.[16]

Flood-plain meadows, with quack grass (*Agropyron repens*) predominating, are very typical for the steppes. This grass is of great agricultural importance.

Fauna

It is not true, as some reports would have it, that the virgin steppe at one time had a continuous uniform herbaceous cover tall enough to conceal a horse and rider. There have always been different types of steppe vegetation, depending upon the relief (Pachosky). In the virgin steppes there were great numbers of wild herbivores: wild horses (tarpans), saiga antelope, deer, and roebuck; they roamed in herds, grazing and trampling large sections, fertilizing the soil, and breaking paths. In general, as Pachosky points out, the role of the large mammals in the steppes is very important. The animals trample the seeds of the steppe grasses into the soil, clear the spaces between the sod tussocks of superfluous vegetation, crop the dry, dead stems, and so forth. In Odessa *oblast*, in one place there was preserved a portion of steppe on which in the course of fifteen years there was neither pasture of stock nor mowing. After this period of time a multitude of weeds and plants appeared which are not found usually in the typical virgin steppe. The plant which appeared in greatest numbers was the smooth brome (*Bromus inermis*), which, although it does grow on virgin steppe, does not predominate there. Previously, when there had been grazing in this section, the steppe had been covered chiefly by fescue (*Festuca sulcata*).

The grazing of stock kills off the feather grasses first of all, and the order in which they disappear is as follows: *Stipa stenophylla, S. dasyphylla, S. lessingiana,* and *S. capillata;* next to disappear is koeleria. Trampling that is only moderate does not harm fescue; under heavy trampling, fescue is replaced by viviparous bulbous blue grass (*Poa bulbosa var. vivipara*). This blue grass is remarkable for the fact that on its panicles, instead of flowers there appear bulblike buds which are trampled into the soil by the stock and which serve as seeds for the plant. On heavily grazed virgin steppes, this blue grass sometimes forms a continuous cover over large areas (Pachosky).

Small mammals—rodents—are also important in the natural economy of the steppe. They bring a tremendous quantity of earth to the surface.

[16] A. G. Gayel, "Peski verkhnevo Dona" (The Sands of the Upper Don), Izv. Geogr. obshch. (Report of the Geographic Society), LXIV, 1932.

It is estimated that in some places the suslik excavates about 20 cu. m. of earth per hectare. In some steppes there may be several hundred burrows of the spotted suslik per dessiatine,* sometimes more than a thousand.

In the virgin steppes along the left bank of the lower Dnieper, there are many bobac burrows; that is, low mounds at one time excavated by bobac, or marmots (*Marmota bobak*), which have disappeared here completely at present. The width of a bobac burrow is about 2 m., the height ⅓ m.; sometimes there are as many as 200 to 250 such small burrows per hectare, "so that from a distance it looks as though the steppe were covered by small ricks of hay" (Brauner). The bobac burrows attract attention by virtue of the tall weeds which grow on them: sisymbrium (*Sisymbrium pannonicum*), common Russian thistle (*Salsola kali*), the grass *Bromus squarrosus*, and others. There are no bobac left in the steppe zone of Europe today, but they are found in the steppes of western Siberia.

Of the large mammals, the saiga antelope (*Saiga saiga* [*S. tatarica*]) was found as far west as the lower course of the Dniester as late as the end of the eighteenth century; even in the latter half of the last century it was not rare in the Novouzensk steppes, and along the right side of the Volga it was found approximately as far as lat. 49° N. The roebuck (*Capreolus*) is represented by two species in the Ukrainian steppe: the Siberian roebuck (*C. pygargus*), which only recently was found also south of Zaporozhye, inhabits the forests along the Samara River mentioned above (p. 104); the European roebuck (*C. capreolus*) is peculiar to the remaining part of the Ukraine.[17] The red deer (*Cervus elaphus*) also was widespread at one time in the steppes and forests of the Ukraine; Bronevsky, in his description of the Crimea, tells us that the steppes around Ochakov and Perekop were inhabited by deer; today they have disappeared, however, remaining only in the mountains of the Crimea. The Transylvanian wild boar (*Sus scrofa attila*) had disappeared from the Dnieper by the middle of the last century. There is evidence that a hundred years ago the beaver was found on the shores of the Dnieper near Kherson. The wild horse or tarpan (*Equus gmelini*) at one time roamed the steppes in tremendous droves. In 1768 Gmelin saw a herd of six tarpan 50 km. south of Bobrov. Even in the first half of the last century the tarpan was rather numerous in the steppes along

* 2.7 acres.—Ed.

[17] According to the studies of K. K. Flerov, the Siberian roebuck is only a variety of the European species.

the left bank of the lower Dnieper, and it is known from authoritative sources that the last remaining tarpan mare was killed in 1876 on the Agaimany *pod,* in the region of the present Askaniya-Nova, or Chapli preserve. This horse was not very tall; it was mouse-colored, with a dark stripe down its back, and had long and heavy hair, a short, almost erect mane, and a short tail.

Brauner correctly points out that in the past, when the life of the steppe mammals was more mobile, they were able to take better advantage of the natural conditions. They moved out of the steppes into the forests, *plavens,* and sand dunes (*kuchugury*) in winter, and returned to the steppes in summer. This was the migratory cycle of the deer, roebuck, bison, aurochs, and tarpan. Hunting by man forced the deer and roebuck to seek shelter in the forests, and the saiga antelope in the semidesert and desert; the aurochs and tarpan became altogether extinct.

In addition to those named above, the following animals are also characteristic of the steppe. The spotted suslik (*Citellus suslicus* [*C. suslicus guttatus*]) is very common, while the gray suslik (*C. pygmaeus brauneri*) is found only east of the lower Dnieper. The large jerboa (*Allactaga jaculus* [*A. major*]) lives in the steppe zone from the Dnieper eastward. (It is found also west of the river, but not far from it.) The three-toed sand jerboa (*Scirtopoda telum*) is peculiar to sandy areas from the left bank of the lower Dnieper eastward. There are also the common hamster (*Cricetus cricetus*), gray hamster (*Cricetulus migratorius*), short-tailed steppe vole (*Lagurus lagurus*), social meadow mouse (*Microtus socialis*), mole rats (*Ellobius talpinus* and *Spalax microphthalmus*), and the European polecat (*Putorius eversmanni*).

Of the birds, the great bustard (*Otis tarda*), which prefers the feather-grass steppes, and the European partridge (*Perdix perdix*) are permanent residents in the steppes. Other birds which are characteristic of the steppes include the little bustard (*Otis tetrax*), which has almost disappeared in the Ukraine with the plowing of the steppes; the demoiselle crane (*Grus virgo* [*Anthropoides virgo*]); the steppe eagle (*Aquila nipalensis orientalis*), which nests on the ground, and therefore, because of the plowing of the steppes, has almost disappeared in the Ukraine; and the Calandra lark (*Melanocorypha calandra*), which feeds readily on blue grass. The aquatic birds include the glossy ibis (*Plegadis falcinellus*), spoonbill (*Platalea leucorodia*), pelican, heron, sheld duck (*Tadorna tadorna*), ruddy sheldrake (*Casarca ferruginea*), and several shore birds: the black-winged stilt, avocet, and stone curlew. Several mountain birds, which are found also in the southern Urals, are native to the Mugodzhar Mountains. Such, for example, is the rock thrush (*Monticola saxatilis*).

Of the lizards, the steppe lizard (*Eremias arguta*) is found as far west as the Dobrudzha,[18] while the toadhead (*Phrynocephalus caudivolvulus*) is found as far as the Don (in the sands of the Golubinsk forest); the sand lizard (*Lacerta agilis exigua*) is common everywhere; the common lizard (*L. vivipara*) is not found in the steppes. The tortoise *Testudo ibera* is found as far west as Mariupol. Among the snakes are the steppe viper (*Vipera renardi*), the European whip snake (*Coluber jugularis*), and the four-striped snake (*Elaphe quatuorlineata sauromates*).

The insect pests include the migratory locust (*Locusta migratoria*), which is hatched predominantly in the reed thickets in the lower reaches of the rivers (this locust at present has been decreased in number significantly in the steppe zone); the locust *Calliptamus italicus* and its companions the striped locust (*Pachytylus nigrofasciatus*) and the blue-winged locust (*Oedipoda coerulescens*); and the caterpillar of the beet webworm (*Loxostege sticticalis*). The solpugid *Galeodes araneoides* (an arachnid) is found as far west as the west bank of the Dnieper.

The Absence of Forests in the Steppes

Except in the river valleys, there are no forests in the steppes. There are various opinions regarding the explanation for this fact.

From the time of Pallas (1787), the opinion was widespread that man was to blame for the absence of forests in the steppes. It was believed that at one time the steppes were covered with forests, which were destroyed by nomads. This view is mistaken. As we know, chernozems are formed not under forests, but under steppe vegetation. When a forest grows upon chernozem, the soil undergoes degradation, that is, podzolization. As a result, we can always determine by examining the soil whether or not forest ever grew upon it. But perhaps soils degraded by forest may resume the characteristics of chernozem, if the forest is destroyed and replaced by steppe vegetation. This is possible, but only on strongly carbonated subsoils (for example, on marls and limestones), or in places where ground water rich in carbonates rises to the surface. As a rule, however, degraded soils cannot be restored to chernozem without the intervention of man. Thus, the hypothesis that the steppes were covered at one time by continuous forests may be dropped.

Many authorities explain the absence of forests by the peculiarities of

[18] It is found as far north as Voronezh.

the steppe climate, pointing out the insufficiency of precipitation, the length of the dry period (according to Behr), the dryness of the air in summer and the considerable evaporation (Kaminsky's view), and the low level of ground waters. Without a doubt the relation of steppe vegetation to ground water has great bearing on the question, but it is not the decisive factor. Herbaceous vegetation, generally speaking, extracts moisture from the surface horizons, while a forest extracts moisture from the deeper layers. Accordingly, steppes are developed in places where ground water occurs far below the surface, and atmospheric moisture penetrates in insufficient quantity to the levels which would be reached by tree roots—because of the small amount of precipitation, the nature of the seasonal distribution of precipitation, or, finally, because of the properties of the soil and subsoil. All of these facts are indisputable. However, in the forest zone there are found tree species with superficial root systems, species which, nevertheless, do not inhabit the steppes.

It is our opinion that the steppe zone is a regional phenomenon which represents an intermediate phase between the forest and desert zones. As such, it is the result of the regional disposition of climatic factors. The entire combination of climatic features in the steppes is unfavorable to the development of forests. All the remaining natural factors—the salinization of the soils and subsoils, their mechanical composition, and so forth—are of secondary and subordinate importance. The fundamental reasons for the absence of forests in the steppes are: insufficient moisture in summer and dryness of the air with a resulting high rate of evaporation. This explanation may be confirmed by pointing out that in eastern Europe the soil and vegetation zones in the south extend, not from west to east, but from southwest to northeast, corresponding to the disposition of climatic factors.

Other hypotheses which have been advanced to explain the absence of forests in the steppes are as follows:

Tanfilyev (1894) held that the reason for the absence of forests in the steppes is the salinization of the subsoils, particularly the high content of chlorides and sulphates. According to Tanfilyev's observations, soils under forest cover react to hydrochloric acid at a greater depth than do soils in the neighboring steppe; thus it is apparent that the forest soils are more leached. If the steppe subsoils were to be leached, says this scientist, the forests might extend as far as the shores of the Black Sea. The following must be said regarding this view. The content of chlorides and sulphates in the steppe subsoils is not so great as to impede the growth of forest upon them. With suitable artificial irrigation, broad-leaved species grow very well on steppe soils and subsoils. Furthermore, in the western Ukraine large forest massifs are found growing on considerably salinized subsoils.

P. Kostychev (1890) and Sprygin (1922) call attention to the fact that steppe vegetation is found growing on soils of fine composition, for example, on loess, while forest grows on soils of coarser composition, for example, on sands. Thus, the right bank of the lower Dnieper, composed of loesses, has a chernozem topsoil and is covered with steppe vegetation, while the sandy left bank is covered with forest. But we know also that in the forest steppe extensive areas of loess are found at present covered with forests.

Pachosky (1917) presents the hypothesis that the natural stages in the development of vegetation are desert, steppe, and forest, and that, passing from one stage to another, the vegetation affects and changes the climate accordingly. Thus, it is not the climate which is responsible for the changing types of vegetation, but the other way around—the changes in the vegetation bring about changes in the climate. However, the history of the climates and vegetation of the Quaternary period, in so far as it has been revealed by geology and paleontology, does not confirm this hypothesis. Nor do contemporary climatic fluctuations bear any visible relation to changes in the vegetation cover.

VI · The Zone of the Semidesert

General Characteristics

THE zone of the semidesert, or desert steppes, constitutes the transition from the steppes to the desert. While in the steppes the vegetation as a rule forms a continuous cover, in the semidesert bare earth is visible in the spaces between plants; but in contrast to the desert, the area under vegetation is greater than the area of bare spaces. The plant and soil cover is variegated. Feathergrass and *polyn* steppes predominate (Fig. 20). The soils are light chestnut; both soils and subsoils are usually strongly salinized. There are many salt lakes, among them some containing salt deposits. There are also many solonchaks and solonetz areas; the latter, however, disappear to the south. The surface and ground waters are usually salinized. The climate is dry, with maximum precipitation in June and May.

Boundaries and Subdivisions

Lying to the south of the subzone of dry steppes (which are found on dark-chestnut soils), the semidesert occupies the lower Volga region and extends as far south as the lower course of the Sulak west of the Caspian; beyond the Ural River the southern border coincides approximately with the escarpment of the Ust-Urt Plateau, and extends eastward somewhat north of the Aral Sea (leaving the southern part of the Bolshie Barsuki,[1] the Kara Kum which adjoins the Aral Sea, and the Tertiary plateau in the desert zone), and slightly to the north of Lake Balkhash.

Formerly I classified the northern belt of light-chestnut soils with the steppe zone, but at present, in accordance with the findings of Neustruyev (1928),[2] I classify it with the semidesert.

[1] Approximately from the railroad station at Chelkar.

[2] S. S. Neustruyev, "K voprosu o geograficheskom rasprostranenii stepey i pustyn v pochvennom otnoshenii" (Concerning the Geographical Distribution of Soils in the Steppe and the Desert), *Trudy Pochv. inst. Akad. nauk* (Proceedings of the Soils Institute of the Academy of Sciences), V, 1931.

Climate

The climate of the semidesert is intermediate between the climates of the steppe and of the desert. There is less precipitation than in the steppes—250 to 160 mm. (Akhtuba, 247; Astrakhan, 171; Guryev, 161; Baskunchak, 241; Irgiz, 158; Turgay, 249).

On the shores of the Caspian there is less precipitation than at some distance inland; this is generally characteristic for low-lying sea coasts. The maximum precipitation in the northern part of the semidesert comes in June, as in the steppes (there is a secondary maximum in autumn); in the south the maximum comes in May, as in the desert. Correspondingly, the minimum precipitation in the northern part, as in the steppes, comes at the end of the winter (February and March), while in the extreme south it comes in summer (July, for example, in Irgiz), as in the desert. The annual range of precipitation may be judged from data for the stations at Astrakhan, Emba, and Irgiz, as shown in the following table:

Table 5

Precipitation in the Semidesert (in mm.)

Station	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Astrakhan*	12	11	13	14	19	20	13	14	16	12	12	15	171
Emba railroad station †	8	5	6	13	37	28	17	16	15	22	16	17	197
Irgiz ‡	9	7	10	14	18	17	6	11	15	17	13	12	158

* 1850–1915, lat. 46° 21′ N, absolute elevation 13 m.
† 1906–1915, absolute elevation 232 m.
‡ 1875–1915, lat. 48° 37′ N, absolute elevation 112 m.

The monthly totals of precipitation fluctuate sharply from year to year. Thus, in Astrakhan there is most precipitation in June, an average of 20 mm., but there are years when there is no precipitation at all during the entire month. On the other hand there is one case on record when 107 mm. of precipitation fell here in June—more precipitation than in the forest zone. The snow cover is very slight: in February, when it reaches a maximum, it is only 10 cm. This permits stock to graze even during the winter.

The summer is warmer than in the steppes. The mean July temperature is 24° to 26° C. The winter is severe. Where the winters are not moderated by the influence of the Caspian (for example, in Astrakhan), the mean January temperature is from − 16° C. to − 12° C., significantly lower than on the shores of the Gulf of Finland. There are years when the mean January temperature is lower than − 25° C., while on individual days the thermometer may drop to − 40° C. In summer, on the other hand, the temperature may rise sometimes to 40° C. The winter cold is followed very quickly by hot weather, and there is almost no spring.

Relief

Partly within the steppe zone, partly within the semidesert, lie the valleys of the Manych rivers[3] or the Kuma-Manych depression, which during the Quaternary period was a strait connecting the Caspian with the Sea of Azov. The Western Manych belongs to the Black Sea basin, while the Eastern Manych flows in the direction of the Caspian. The Western Manych is a system of saline lakes and streams which drain into the Don near Manych stanitsa. Of the lakes which compose the Western Manych system, the largest is Bolshoy Liman or Gudilo, which reaches more than 100 km. in length during years when water is abundant (for example, 1932); its depth reaches 3 m.; its waters are brackish. On its shores are found deposits containing the mollusk *Cardium edule*, which penetrated into the Caspian from the Black Sea basin during one of the late epochs of the Quaternary period. East of Lake Gudilo lies the Eastern Manych system, which is fed by the Kalaus River. In some years this river drains part of its waters into the Western Manych system. The Eastern Manych depression is bordered on the north by the slopes of the Yergeni Plateau. The highest point of the watershed between the Western and the Eastern Manych lies at the mouth of the Kalaus River, at an elevation of 26 m. above the Black Sea. Bogachev discovered the shells of *Cardium edule* on the water divide itself. The Eastern Manych loses itself in the Gaiduk sands, which border on the Kuma River. At present the Manych Canal for navigation and irrigation is under construction. This canal, 620 km. long, will connect the Sea of Azov with the Caspian.

At the point where the Volga turns sharply to the southeast, the Volga heights merge into the Yergeni Plateau; this falls away abruptly to the Caspian Lowland, which will be discussed below. The greater part of

[3] K. Lisitsyn, *Geologichesky putevoditel po r. Manychu* (Geological Guidebook for the Manych River); *Putevoditel 2-y chetvertichnoy geol. confer., 1932* (Guidebook of the 2nd Quaternary Geological Conference, 1932); "Problema Manychey" (Problem of the Manych Rivers), Azovochernom. geol. trest (Azov-Black Sea Geological Trust), *Trudy* (Proceedings), No. 15, Rostov-on-Don, 1936. I. V. Novopokrovsky, *Rastitelnost Sal-manychskovo vodorazdela* (Vegetation of the Sal-Manych Watershed), Moscow, 1931, izd. Inst. agropochvovedeniya (publication of the Soil Science Institute).

the plateau is covered with light-chestnut soils containing numerous solonetz areas; dark-chestnut soils are developed in the west. The higher points are in the southeast and rise above 190 m. To the west, in the direction of the Don valley, the plateau decreases in elevation. On the south the plateau borders on the Manych depression. The Yergeni Plateau is covered with a herbaceous vegetation of fescue and feather grasses.

Between the Yergeni Plateau, the lower reaches of the Sulak, and the lower reaches of the Emba River lies the northern part of the Caspian Lowland. Under this heading we include the entire area which was submerged during the last major transgression of the Caspian Sea, the Khvalynsk transgression, which extended as far north as the line from the mouth of the Yeruslan River to Uralsk, and rising to an absolute elevation of approximately 50 m. This transgression, which it is believed took place during the epoch of the last, or Würm glaciation, extended along the Volga valley far above the mouth of the Yeruslan; in the Samara bend its deposits are found up to an absolute elevation of 50 m.[4] A large part of the lowland, which borders on the Caspian Sea, lies below sea level (– 26 m.). The steppe along the Volga reaches sea level between Yenotayevsk and Cherny Yar. The surfaces of the large salt-saturated lakes, Lake Baskunchak (– 18 m.) and Elton salt lake (– 17.5 m.), lie below sea level. The steppe which surrounds these lakes lies 10 to 15 meters above sea level. The Volga valley is bordered both on the right and on the left (Akhtuba) sides by rather steep banks, which rise some 20 meters above the river. Low-water marks which lie below sea level extend along the Volga valley as far as the village of Rovnoye, between Kamyshin and Saratov, while along the Ural they extend somewhat north of Kalmykov. It is interesting to note that approximately 600 km. above the mouth, the *bottom* of the Volga is lower than the surface of the Caspian. The following are some of the recorded absolute elevations for the lower sections of the Volga: a little above Astrakhan, – 58 m.; at Astrakhan, – 45 m.; somewhat below Astrakhan, – 53.3 m.; at Biryuchya spit, – 26.7 m. These figures indicate that either the level of the Caspian Sea has risen recently, or else the land mass in the lower reaches of the Volga has undergone subsidence. On the northern shores of the Caspian there are many traces of a relatively recent (geologically speaking) rise in the level of the sea. Evidence is found in the dissected shore line between the mouths of the Kuma and the Volga, the character of the isobaths at the mouths of the Volga, and

[4] E. Permyakov, *Byull. Mosk. obshch. isp. prir.* (Bulletin of the Moscow Society for Natural Research), otd. geol. (Geological Section), XIII, 1935, No. 4, p. 467.

also the discovery of terrestrial deposits on the sea bottom at the mouths of the Volga.

As has been noted above, the entire Caspian Lowland was submerged at one time by the Caspian Sea, and salinized clays, numerous solonchaks, and extensive sandy areas were left on the surface of the lowland. The Caspian is a gigantic salt lake, the largest lake in the world (its area is 422,100 sq. km.; including islands—424,300 sq. km.).[5] From north to south it stretches about as far as from Moscow to the southern shores of the Crimea. The northern part is shallow; in many places where the depth is 2 m., the shore is invisible. The southern part, however, reaches a depth of 1014 m. Next to Lake Baikal, the Caspian is the deepest lake in the world. Its level is 26 m. lower than that of the Black Sea. As in the case of all lakes lacking outlets, the level is subject to considerable fluctuation, although not so great as is commonly supposed. During the entire historic period, the level has not risen more than about 5 m. above the 1925 level, when the water was very low. Of this we may judge by the fact that undisturbed deposits containing the mollusk *Cardium edule* (which penetrated into the Caspian from the Black Sea during the prehistoric period) are found on the shores of the Caspian Sea nowhere higher than 5 m. above its present level.[6]

The mean annual evaporation from the surface of the Caspian is equivalent to a layer of water about 1 m. deep. This loss is compensated for by the influx of water from the rivers, of which the Volga contributes the most (about 61 cm. per year), and also by rainfall (about 20 cm.).

We may judge of the ancient extent of the Caspian in the lower Volga region by the ancient Caspian deposits which are found there. These consist of two layers—the lower, Khazarsk, and the upper, Khvalynsk, of which we have spoken already.

The Lower Caspian, or Khazarsk transgression, which took place, it is believed, simultaneously with the Riss glaciation, was not very extensive. Along the Volga its deposits are not found beyond Kamenny Yar, or approximately to an elevation of 0 m.

The Khvalynsk deposits, or the deposits of the last Caspian transgression, extend much farther north, but even they do not reach as far as Saratov (see above, p. 114). It is interesting to note that the

[5] G. R. Bregman and A. I. Mikhalevsky, *Vodny balans Kaspiiskovo morya* (The Water Balance of the Caspian Sea), Baku, 1935, izd. Azerbaidzhan. fil. Akad. nauk (publication of the Azerbaidzhan Branch of the Academy of Sciences), p. 9.

[6] L. S. Berg, "Uroven Kaspiiskovo morya za istoricheskoye vremya" (The Level of the Caspian Sea During the Historic Period), *Problemy fiz. geografii* (Problems in Physical Geography), I, 1934, pp. 11–64.

Khvalynsk deposits extend in lobes along the stream valleys and even along the ravines which empty into the streams of the high west bank of the Volga. Thus, not only was the Volga in existence during the Khvalynsk period, but even the relief of this area was developed before the advance of the Khvalynsk Caspian transgression.

The towns of Dubovka and Kamyshin are located on the terrace of the Volga valley which lies next to the flood plain and which here is covered by Khvalynsk deposits, while Saratov and Syzran, which are located on the same terrace but farther from the mouth of the Volga, lie beyond the limits of the Khvalynsk transgression.

The accepted scheme of the history of the Caspian during the Quaternary period is as follows (chiefly according to Mazarovich, 1928,[7] and Milanovsky, 1931):

Table 6

Quaternary History of the Caspian Sea

Geological Epoch	History
Postglacial epoch	Level dropped to −26 m.
Würm	Khvalynsk transgression, Upper Caspian layer, elevation 50 m., connection with the Black Sea
Riss-Würm	Atelsk layer, fresh-water deposits, loesslike clay loams
Riss	Khazarsk transgression, Lower Caspian layer, elevation 0 m.
Mindel-Riss	Astrakhan layer, estuary, bog, and river deposits
Mindel	Baku layer
Günz-Mindel	Gurovsk layer, fresh-water deposits
Günz Pliocene	Apsheron, Akchagyl

It should be kept in mind that the parallel with alpine glaciations is provisional.

In the Volga delta, so-called "Behr's mounds" are very characteristic. These ridges, which consist of more or less clayey sands, were described first by Behr in 1856. They are from 400 m. to 8 to 10 km. long (and even up to 20 km.), and about 200 m. wide. Above Astrakhan their height is usually not more than 6 m., while below Astrakhan they may be as high as 8 m. On the right bank of the Volga in the Astrakhan region the mounds lie approximately in an east-west orientation, while in other places they are oriented southwest or southeast. The mounds usually are the sites of settlements in the delta; the central part of Astrakhan lies

[7] A. N. Mazarovich, "Opyt skhematicheskovo sopostavleniya neogenovykh i posletretichnykh otlozheny Povolzhya" (Experiment in the Schematic Comparison of Neogene and Post-Tertiary Deposits of the Volga Region), *Izv. Akad. nauk* (Report of the Academy of Sciences), 1927, pp. 1090–1093.

on one of them. To the north they are found as far as the Yenotayevsk district, to the west as far as the mouth of the Kuma, and to the east as far as the mouth of the Emba. The mounds overlie deposits of the Khvalynsk transgression; they are composed of diagonally laminated Caspian sands which contain contemporary Caspian shells (but no *Cardium edule*), and appear to have been the coastal banks of the receding Khvalynsk sea.

The elongated depressions between the Behr's mounds in the region of the Volga delta are called *ilmens*. They are very numerous to the west and to some extent to the east of the Volga delta. Many of them are cut off from the sea by extensions of the delta. But within the delta the lakes (which are found usually in the deltas of big rivers) are also called *ilmens*. In one *ilmen* of the delta not far from the sea there is Hindu lotus (*Nelumbo nucifera* [*Nelumbium nelumbo*]); this is the only place in Europe where this plant is found.

The Kuma River in dry years does not reach the Caspian, while the Emba flows to the sea only at high water. In summer the water in the Emba, as in all shallow rivers of the semidesert, is brackish.

Large areas of the Caspian Lowland are covered with sands.

Eastward of a line from Lake Elton to Lake Baskunchak lie the Ryn (or Naryn) sands. Here sand mounds and sandy steppe predominate. These sands are held fast by tree-shrub and herbaceous vegetation, but upon excessive grazing of stock and destruction of sand vegetation, they turn into shifting sands.

East of the Volga delta there is a large area of shifting sands. There are sands also to the west, between the lower Volga and the Yergeni Plateau. In a natural state the sands are generally held fast; they are set in motion as a result of the unwise use to which they are put.

On the shores of salt-saturated Elton, Baskunchak, and Inder lakes there are outcrops of Permian deposits, rich in gypsum and rock salt. It is the leaching of the rock salt which gives rise to the salt in the lakes.

In the semidesert part of the Caspian Lowland there are several isolated hills. Among these is Bolshoye Bogdo hill, which may be seen from a great distance in the steppe, rising 171 m. above Lake Baskunchak and 125 to 130 m. above the surrounding steppe. It is composed of dislocated Triassic strata. The Inder hills beyond the Ural River rise 56 m. above Lake Inder, the absolute elevation of which is − 24 m.[8] These hills are composed of Permian, Triassic, Jurassic, Cretaceous, and Upper

[8] Z. V. Yatskevich, "Karst Inderskovo podnyatiya" (The Karst of the Inder Uplift), *Izv. Geogr. obshch.* (Report of the Geographical Society), Vol. 69, 1937, p. 940.

Tertiary (Akchagyl and other) deposits, which are all dislocated. In the Inder region, in the layers containing gypsum, rich beds of boric salts have been discovered in recent years.

In the region of the Inder hills, karst phenomena, in the form of sinks of different shapes and sizes, are developed extensively. These sinks are associated with leaching of the gypsum bed (Yatskevich).

Another series of low eminences, no higher than 60 m. in relative elevation, is found between the Volga and the Ural. Beyond the Ural, on the watershed of the Saghyz River and the Emba, lie the Imankara (absolute elevation 225 m.) and the Koi-Kara (125 m.) hills. But in addition to these more prominent hills in the region between the lower Volga and the Emba (and also somewhat beyond the Emba), there are scattered a large number of low hills (as many as 400). All of these eminences, including the Inder hills, belong to the salt-dome type: These are local uplifts (brachyanticlines), brought about by the intrusion of salts and gypsum from the lower strata into the more recent surface formations.[9] The rock salt and gypsum are of Lower Permian age. The thickness of the salt series in the domes is tremendous: a borehole sunk at Dossor (between the lower Ural and the Emba) passed through salt from 774 m. to 2804 m., and still had not reached the end of the salt-bearing series. The domes were formed in several stages by a series of tectonic movements. In Emba *raion* the first signs of domes are attributed to the end of the Jurassic, but they acquired their present appearance only during the Upper Tertiary period, between the Sarmatian and the Akchagyl strata (Shumilin). The area of the Caspian salt domes merges on the north with the Obshchy Syrt (Bogdanov). In the continental Jurassic deposits along the Emba there are rich beds of petroleum.

Between the Caspian Lowland and the Mugodzhar Mountains lies the Emba Plateau, composed of horizontal Cretaceous and Tertiary deposits. In many respects it is analogous to the Turgay tableland, which lies on the other side of the Mugodzhars. Here, to the south of the Emba, there are many low table mountains separated from the plateau by erosion. But the Emba Plateau is distinguished from the Turgay country by the presence of salt domes.

[9] V. E. Ruzhentsev, "Osnovy tektoniki Uralo-Embenskovo raiona" (Tectonic Foundations of the Ural-Emba Region), *Byull. Mosk. Obshch. isp. prir.* (Bulletin of the Moscow Society for Natural Research), otd. geol. (Geological Section), VIII, 1930; S. V. Shumilin, "O tektonike Embenskovo raiona" (Concerning the Tectonics of Emba *Raion*), *ibid.*, XI, 1933; A. A. Bogdanov, "Solyanie kupola Nizhnevo Zavolzhya" (Salt Domes of the Lower Trans-Volga), *ibid.*, XII, 1934.

Only the southern part of the Mugodzhar Mountains lies in the semidesert. To the south these mountains drop in the steep escarpments of the Dzhaman-Tau range, which is composed of igneous and metamorphic rocks, and merge into the plain with very little relief.

To the east of the Mugodzhar system, between it and the Ulu-Tau Mountains (elevation 1120 m.) lies the Turgay tableland. On the north it passes into the West Siberian Lowland, on the south into the Turanian Lowland. The relief of the Turgay tableland is extraordinarily unique. Here we see isolated low plateaus and table mountains, with intermittent depressions. The table mountains were separated from the plateau proper by water and wind erosion. They often protrude amid wide surrounding lowlands in the form of "mountain islands," 100 to 200 m. in elevation. Absolute elevations here sometimes reach 300 m., but are generally lower. The Aral Sea never extended into this area. The table mountains are composed of horizontal Tertiary deposits.

The southern outskirts of the Kazakh Folded Country, which has been mentioned already (pp. 95–96), extend into the zone of the semidesert.

Soils

Under the conditions which obtain in the dry climate of the semidesert (and desert), the soils are characterized by low humus content and a thin humus horizon (characteristics which are associated with the sparse vegetation), and by the lesser intensity of chemical processes in the soil, and, consequently, by lesser decomposition of the mineral mass. Soils which are only slightly leached contain a large quantity of calcium and magnesium salts, and some sodium and potassium salts; water extracts from these soils have a slightly alkaline reaction. The horizon at which effervescence from hydrochloric acid occurs lies not far from the surface of the soil, sometimes even at the very surface. The horizon in which salts accumulate is also near the surface.

In the semidesert, in proportion as water plays an increasingly smaller role in soil formation (as Neustruyev points out), the influence of the parent rock begins to predominate. Clayey soils are subject to greater salinization than sandy soils. Consequently the desert types of soil formation and vegetation are manifested more clearly on clayey substrata than on sands; the latter appear to carry us back into more northern zones. In the semidesert and desert "each parent rock has its own corresponding boundary of soil landscapes, or regions. As a result the regional and subregional boundaries are very tortuous and irregular" (Neustruyev). The character of the parent rock is responsible also for the unusual diversity of colors ("complexity") of the semidesert soil and vegetation cover, which is determined predominantly by that element which is found in least quantity—in this case, water. The slightest increase or decrease in the supply of soil moisture, as a result of the relief and the composition of the parent rock, quickly results in a change in the soil and vegetation cover.

In the semidesert under its normal moisture conditions, *light-chestnut* soils predominate. They contain carbonate salts at some depth, but not at the surface, as do the desert soils. Light-chestnut soils are solonized; that is, their absorption complex includes sodium. The humus horizon is only 30 to 40 cm. thick. The amount of humus is small, only 1 to 3 per cent in the upper horizons, and the humus is distributed unevenly through the soil profile. Below the surface horizon, which is 10 to 15 cm. thick and has a laminated structure, there lies a compact, slightly solonized horizon which has a prismatic structure. Below this there is a distinctly solonized and compact carbonate horizon. The lower portion of the soil profile contains soluble salts. As we have said, at a depth of about 0.5 m. these soils contain a large quantity of carbonates, while in the lower horizons, from a depth of about 1.8 m., there is usually gypsum.

At one time the semidesert soils were classified as brown earths, but at present the trend is to classify them with the light-chestnut soils.

The semidesert contains a great number of salt lakes, solonchaks, and solonetz areas (which originate, as we know, from solonchaks). Even the rivers often carry salt water. Thus, the water of the Saghyz River (between the Ural River and the Emba) is suitable for drinking during only one or two months of the year. The soils and subsoils are usually salinized. The salts are derived in part from salinized bedrock and subsoils (for example, in the area of Permian salt-bearing rocks, or in that part of the Caspian Lowland where the Caspian deposits are saline). In part, however, the salts are derived from the chemical weathering of rocks which yield salinized soils. As a result of the dry climate, the salts are not removed completely from the soil by water, but accumulate to some extent in the soils and subsoils. The dry (xerothermic) epoch, which preceded the present period, particularly favored the accumulation of salts.

Solonchaks are formed where ground water, rising by means of capillary action, is able as it evaporates to precipitate salts on the surface of the soil. Solonetz soils, however, are found where ground water is unable to rise, and the process is reversed—the salts are leached downward. As a result, these soils have a conspicuous structural, compact, brown, illuvial horizon 3 to 8 cm. thick, which breaks down into compact, usually columnar particles. This compact horizon (*B*) is almost impermeable to water; as a result, water accumulates on the solonetz soils during the rainy part of the year. Extracts from the *B* horizon have a distinctly alkaline reaction, showing the presence of sodium, or soda, which is injurious to most vegetation. We have discussed already the degradation of solonetz soils (p. 79).

Vegetation

The flora of the semidesert may be characterized briefly as *polyn* [*Artemisia* spp.] steppe (Fig. 20). In the north the vegetation is of the *polyn*-grassy type, that is, with grasses predominating. As we move southward, the proportion of grasses decreases and *polyns* begin to predominate. In the south of the semidesert, halophytes assume considerable importance. In the semidesert, as distinguished from the steppe zone, the herbaceous cover is very thin. The plants are rather widely dispersed, with small sod-forming species predominating (Fig. 21). The vegetation is stunted and therefore less susceptible to evaporation; however, the root systems are very well developed, and the available soil moisture may be utilized intensively.

Of the *polyns*, the most important are the white and black *polyn*. The slightly salinized clay loams are covered with white *polyn* (*ak-dzhusan*) —different forms of *Artemisia maritima* (*A. incana, A. terrae-albae,* and others) (Fig. 22). The clayey, more salinized soils are covered with black *polyn* (*kara-dzhusan*)—different forms of *Artemisia pauciflora*. The black *polyn* straightens its leaves only after a rain, while in dry weather its black stems, which rise 5 to 10 cm. above the soil, appear to be completely without leaves (Fig. 23). During the dry period this plant sheds its leaves altogether. *Polyn* blooms in autumn, when it rapidly develops rhachides 20 to 25 cm. high, which die with the onset of frost. Its roots extend from the surface to a depth of 1 m. or more. Black *polyn* contains large quantities of volatile oils; the odor of *polyn* is very characteristic for the semidesert zone.

In addition to *polyns*, perennial sod-forming grasses of the same species as those found in the steppe zone, or species closely related to them, play a large role. Fescue (*Festucu sulcata valesiaca*) (Fig. 22) is particularly abundant here, so much so that the term "fescue-*polyn*" would more exactly characterize the vegetation of the semidesert. Koeleria

(*Koeleria gracilis*) and feather grasses—predominantly of the capillary feather-grass group (*Stipa capillata*), but some of the pinnate group as well—are also numerous. Another plant is the small undershrub, prostrate summer cypress (*Kochia prostrata,* Chenopodiaceae). In some places saltbush (*Atriplex canum*) takes the place of *polyn* (Fig. 21). This squat undershrub is very characteristic of the semidesert.

Annuals ("ephemerals") are very prominent. They develop in spring, when there is relatively more precipitation, but fade quickly with the coming of hot weather. These include tulips (*Tulipa biebersteiniana, T. schrenkii* [*T. gesneriana*]), buttercups (*Ranunculus polyrhizus*), the rhubarb *Rheum tataricum* (*tyuie-dzhaprak,* or camel's grass; the camel is supposed to eat it readily), and others. In the semidesert around Astrakhan, the soil in the spaces between the shrubs of white *polyn* is covered with mosses so black that the ground appears charred. In the Trans-Ural region these mosses are sometimes replaced by lichens (chiefly *Parmelia vagans*).

On the solonetz soils, in addition to black *polyn,* there grow *biyurgun* (*Anabasis salsa*) (Fig. 24), camphor fume (*Camphorosma monspeliaca*), saltbush, prostrate summer cypress, *ebelek* or sand ceratocarpus (*Ceratocarpus arenarius*), the umbellifer *Ferula caspia,* tulips, and Siberian sea lavender (*Statice gmelini* [*Limonium gmelini*]). During the rainy season on the solonetz soils there appear colonies of the alga *Nostoc commune;* this alga sometimes grows in the form of black, hairlike threads, over 30 cm. in length, pressed close to the ground. Lichens grow readily on solonetz soils. Some species of the lichen *Aspicilia* lie freely on the surface of the earth, sometimes in the form of compact lumps which at first glance do not look like plants.

Various halophytes (among them *sarsazan, Halocnemum strobilaceum*) (Fig. 25), black *polyn,* shrubs of tamarisk, the shrub *Nitraria schoberi,* and the sea lavender *Statice suffruticosa,* grow on the solonchaks.

There are extensive areas of sand in the Trans-Volga in the vicinity of Astrakhan. A large part of these sands is in motion at present; shifting began as a result of overgrazing by the herds of the nomads. The pioneer sand binder of the semidesert is the mammoth wild rye or *kiyak* (*Elymus giganteus*), incorrectly called the sand oat. This is a large plant, 1.5 m. tall (sometimes even taller), which is eaten readily by horses and cattle. Another grass found here is the Siberian wheat grass or *yerkek* (*Agropyron sibiricum*), which is an important fodder crop, particularly for horses. In the moist depressions in the sands there often grow willow or *tal* (*Salix*), Russian olive, and other shrubs. In the Ryn sands, in the depressions among the sand mounds where fresh ground water is very close, there grow white poplar, black poplar, aspen, rosemary creeping willow (*Salix rosmarinifolia* [*S. repens rosmarinifolia*]), Russian olive (*Elaeagnus angustifolia*), and sweetbrier rose. Poplar grows even on the summits of the mounds, while the willow *Salix caspica* (*naryn-tal*) grows on both the slopes and summits. The stabilized sands are very important for cattle raising: they are a constant source of fodder; besides, an ice crust never forms on the sands (Dubyansky). The rubber-yielding *Chondrilla* grows in the sands along the desert border. In the flood plain of the Volga there is oak (which extends as far south as the latitude of Lake Baskunchak), elm, and black poplar, which disappear in the region of Yenotayevsk.

Fauna

Among the fauna of the semidesert the suslik is very prominent: the sand, or yellow suslik (*Citellus fulvus*), which is found from the Volga eastward, and the small suslik (*C. pygmaeus*), which is native to the clayey steppe. There are also jerboas, gerbils which inhabit the sands (*Meriones meridianus, M. tamaricinus,* and the like), hamsters, and others. In the sands between the Volga and the Ural there are saiga antelope (1934); they are found also in the Trans-Ural region. The corsac fox (*Vulpes corsak*), which is found also in the desert, and to some extent in the steppes, occurs throughout the semidesert. Of the larks, the black lark and the small lark are common. The flood plains and deltas of the large rivers are havens for many birds. They are particularly abundant in the Volga delta, where the special Astrakhan preserve has been established. The most numerous and most characteristic bird of the Volga delta is the European cormorant (*Phalacrocorax carbo*), which nests in colonies in the willows (*Salix alba*) along the coast; it feeds almost exclusively on fish. The gray sea eagle (*Haliaeetus albicilla*) is also very common. Of the geese, only the gray-lag goose (*Anser anser*) nests in the delta. The white egret (*Egretta alba* [*Casmerodius albus*]) and the little egret (*E. garzetta*), which were common at one time, are rare today, but both are common among the birds which nest in the preserve. The brilliantly colored Indian gallinule (*Porphyrio poliocephalus*) of the Rallidae, and the pheasant (*Phasianus colchicus*) are found occasionally in the Volga delta.

In the maritime strip of the delta the bearded tit (*Panurus biarmicus*) is common; it is found here all the year round. For some species the Volga serves as the western boundary; for example, the yellow suslik, the reddish suslik, and the Eversmann hamster. Other species, however, are not found east of the Volga; for example, the spotted suslik.

The Caspian Sea is inhabited by a unique fauna, some of which are relicts from the period when the site of the Caspian was occupied by Upper Tertiary saline basins, while some migrated from the north during the Quaternary period by way of the rivers and lakes.[10] The latter include the Siberian whitefish (*Stenodus leucichthys*), which is closely related to the Siberian *nelma* [*S. leucichthys nelma*]; a crustacean marine isopod (*Chiridothea entomon caspia*); several mysids (for example, *Mysis caspia*, very closely related to the arctic *M. oculata*); other crustaceans; and, possibly, the Caspian salmon. The origin of the Caspian seal (*Phoca caspica*) is obscure.

[10] L. S. Berg, "O proiskhozhdenii severnykh elementov v faune Kaspiya" (Concerning the Origin of Northern Elements in the Fauna of the Caspian), *Dokl. Akad. nauk* (Report of the Academy of Sciences), 1928, pp. 107–112.

VII · The Desert Zone

Boundaries and Definition

THE desert zone lies to the south of the semidesert, that is, approximately south of the line from the northern outskirts of the Ust-Urt Plateau to a point somewhat north of Lake Balkhash, and extending as far south as the base of the mountains which border the Turanian Lowland. With certain exceptions, the lower courses of the Kura and the Araks also may be included here.

The deserts of the middle latitudes have the following characteristics: There is very little precipitation, usually less than 150 mm. per year (only in the vicinity of the mountains is there more), with the maximum coming in the spring. The summers are hot and almost without rain. In winter there are frosts, although in the south they are usually not severe. The vegetative cover is scant and a larger proportion of the surface is bare than is covered with vegetation. Halophytes predominate in the latter. The soils are of the sierozem type and contain little humus. There are many solonchaks.

Subdivisions

The desert zone of the Turanian Lowland and its northern outskirts may be divided into the following three subzones, beginning at the north:

(1) The northern Tertiary plateaus, covered with solonized gray-brown clay loams and including: the Ust-Urt, the plateaulike elevations in the parts of the Kara-Kum and Kyzyl-Kum which adjoin the Aral Sea, the southernmost outposts of the Turgay tableland, and the Bet-Pak-Dala, or Northern Golodnaya Steppe. This subzone constitutes the transition to the semidesert.

(2) The subzone of sandy deserts including the lowland which adjoins the Caspian, the Trans-Caspian or Turkmenian Kara-Kum, the Amu-Darya delta, the Kyzyl-Kum, the Syr-Darya Lowland, the Muyun-

Kum, and the Semirechye sands. This subzone is traversed by large rivers.

(3) The subzone of loessial piedmont plains from the Kopet-Dagh on the west to the Trans-Ili Ala-Tau on the east.

The second and third subzones together constitute the Turanian Lowland.

Climate

The climate of the desert zone is unique. Its characteristic feature is scant precipitation, distributed very unevenly among the seasons. The summer is almost or entirely without rain; it is cloudless and hot. The maximum precipitation comes in spring.

The summer is hotter than in the tropics; the heat, together with the abundant insolation, is very favorable for the cultivation of cotton, grapes, and melons. The mean July temperature is 26° to 30° C., while in the tropics it is 24° to 28° C. But due to the dryness of the air, the heat in the desert may be endured much more easily than in the tropics. Turkmenistan, where the mean July temperatures reach 30° C., and in some places even higher, has the hottest summers. In the southern Turanian Lowland the temperature on some days in summer may reach 50° C. in the shade; such temperatures have been recorded in Termez on the Amu-Darya. Observed mean temperatures at 1:00 P.M. are as follows:

Table 7

TEMPERATURES IN THE DESERT (AT 1 : 00 P.M.)

LOCALITY	TEMPERATURE (°C.)		
	July	October	January
Kazalinsk	32.2	13.7	8.1
Tashkent	33.3	18.6	3.2
Golodnaya Steppe	35.4	19.8	2.1
Margelan	33.9	19.0	1.9

From this table it is clear that the temperatures normally observed at 1:00 P.M. in the desert in July are such temperatures as have been reported in the forest zone only for exceptionally hot days. The soil becomes very hot in summer; in Tashkent soil temperatures as high as 70° C. have been noted; while at Repetek in Turkmenistan on June 20, 1915, a temperature of 79° C. was recorded on the surface of the sand. The diurnal range on the surface of the sand in Repetek reaches 60° C.

The diurnal range in temperature is great. It reaches a maximum in August and September, when cloudiness is least, as a result of which the temperature rises sharply during the day and drops at night. In September the mean diurnal range at Tashkent is 16° C., while in the Golodnaya Steppe it is even greater—19° C.

The autumn is very beautiful. It is dry (particularly the first half), sunny, and warm.

The first frosts come in October, in the north at the beginning of the month, in the south in the middle, and in Turkmenistan at the end. The winters in the north of the desert zone are severe. The northern part of the Aral Sea freezes every year for four or five months. Sometimes even in the middle of May there are still ice floes. The mean January temperature on the lower Syr-Darya is – 12° C., that is, lower than on the shores of the Gulf of Finland (lat. 60° N). In the southern desert the winters are much milder and shorter. In Tashkent the winter is wet, and the frosts do not last long; the mean January temperature is –1.3° C., but in 1900 it was – 8.3° C. (In Kazalinsk in that year the mean for January was – 24.3° C.) At times the temperature in Tashkent in winter has dropped to – 30° C., and in Kushka (lat. 35°17′ N) even to – 33° C. These low temperatures are due to cold waves from the north, the advance of which is favored by the relief—the absence of mountains from the Arctic Ocean to Iran. In southern Turkmenistan it is normally very warm in winter. In Repetek there have been years when the mean January temperature was + 7° C. Every year in January there are some days in Repetek when the thermometer rises to 20° C., and in general the mean diurnal maximum in January is about 11° C.

The snow cover remains in Kazalinsk for an average of 70 days; in Tashkent, 37; in Khodzhent, 18. Spring, which comes in the south at the beginning of March or even at the end of February, is very short; hot weather follows quickly, in the middle of May or even sooner. April is considerably warmer than October, as is generally the case in a continental climate.

As we move to the north, the summer temperature drops rather slowly, while in winter, on the contrary, it drops very quickly. This condition explains the long duration of the snow cover in the north of the desert zone.

In summer the air is very dry. The relative humidity at 1:00 P.M. in Kazalinsk and Tashkent averages 33 or 34 per cent. There have been instances when the humidity in the desert dropped to 5 per cent.

Since the humidity is so low, evaporation from the water surfaces is very great. Thus, from the surface of the Syr-Darya at Zaporozhye station the evaporation is about 2 m. per year; the precipitation is one-tenth that figure.

Because evaporation exceeds precipitation in the Turanian Lowland, some students have advanced the view that this land is undergoing desiccation continuously, that the rivers and lakes are decreasing in depth, that the water resources are diminishing, and that the desert threatens to engulf the oases. This view, however, is entirely mistaken.[1] While there is indeed very little precipitation in the lowlands of the desert zone (200 to 100 mm., and in some places even less), the rivers which water this desert have their sources in the Pamir Mountains and the Tian Shan, in areas which have 1000 mm. of precipitation, or more, annually. If, in the region of Khodzhent, 2 m. of water per year are evaporated from the Syr-Darya, this does not mean that 2 m. of moisture per year evaporate also from the soils of the adjoining loessial desert; there is no such supply of moisture here to start with. Moisture is preserved very well in the sands of the desert, as is evident from the relatively rich vegetation that grows on the sands. The following paragraphs explain this phenomenon.

The water-holding capacity of sand, as distinguished from clay, is small. The larger the particles of which the sand is composed, the smaller the water-holding capacity. As a result, the moisture (from the autumn and spring rains and from the melting of the snows) which does not run off the surface, descends to the lower horizons, from which evaporation is negligible. In summer, when the temperature of the sand is higher, its capacity to retain water becomes still smaller. While it is true that capillary rising of water in sand takes place very quickly, the water rises to only a negligible height. Because of the low water-holding capacity and the weak capillary action of sand, there is generally little evaporation from the surface. When the top layer of the sand dries, evaporation drops to a minimum; the deeper the surface layer of the soil dries, the less evaporation takes place from the sand, and the more certain is the preservation of the supply of moisture in the deeper layers of the soil and subsoil. As a result of the negligible content of colloidal particles, the sandy substratum loses its salts (is leached) very easily. All of these factors go to explain that phenomenon which appears so strange at first glance, that in the desert sands, especially in sandy mounds, ground moisture is very well preserved, particularly fresh water. For this reason

[1] For details see L. S. Berg, *Klimat i zhizn* (Climate and Life), Moscow, 1922, p. 160.

Fig. 15. Vegetation of the chalk cliffs. Undergrowth of *Daphne sophia* in an oak grove in Voronezh *oblast*. (*Vegetationsbilder*. Vol. 19; part 7 8; plate 43)

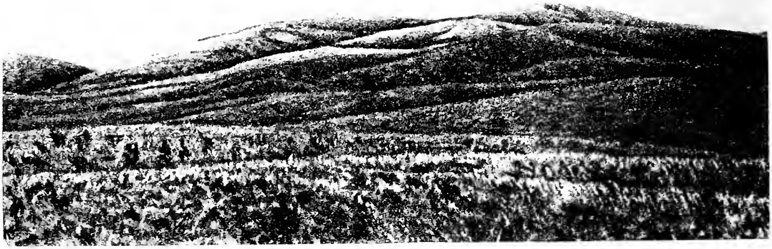


Fig. 16. The steppe in the low Mugodzhar Mountains, the southern extension of the Urals. (Bolshaya Sovetskaya Entsiklopedia. Vol. 56: 183)

Fig. 17. Typical feather-grass (*Stipa*) steppe on chernozem soil in Voronezh *oblast*. (*Vegetationsbilder*. Vol. 17; part 2; plate 9)

Fig. 18. The chernozem steppe in Western Siberia. Solonetz patches in foreground. (*Aziatskaya Rossiya*. Vol. 2: 17)

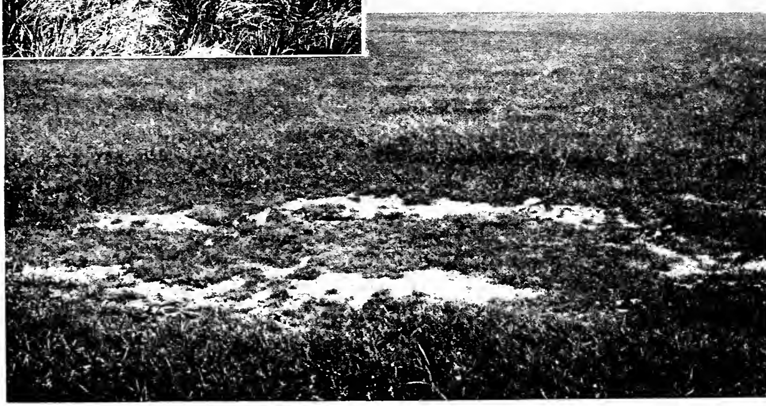


Fig. 19. Feather-grass (*Stipa lessingiana*) steppe in Voronezh *oblast*. (*Vegetationsbilder*. Vol. 17; part 2; plate 10)

Fig. 20. The *polyn* (wormwood) steppe near Krasnoarmeisk (Stalingrad *oblast*) in the semidesert zone. (*Vegetationsbilder*. Vol. 18; part 4; plate 19)

Fig. 21. Saltbush (*Atriplex canum*) in the semidesert near Lake Baskunchak. Note sparseness of vegetative cover. (*Vegetationsbilder*. Vol. 18; part 8; plate 46)

Fig. 22. White *polyn* (wormwood, *Artemisia maritima*) and fescue (*Festuca sulcata*) association in the semidesert near Krasnoarmeisk, Stalingrad *oblast*. Note patches of bare ground. (*Vegetationsbilder*. Vol. 18; part 4; plate 20)

Fig. 23. Black *polyn* (*Artemisia pauciflora*) in the semidesert near Krasnoarmeisk, Stalingrad *oblast*. (*Vegetationsbilder*. Vol. 18; part 4; plate 22)

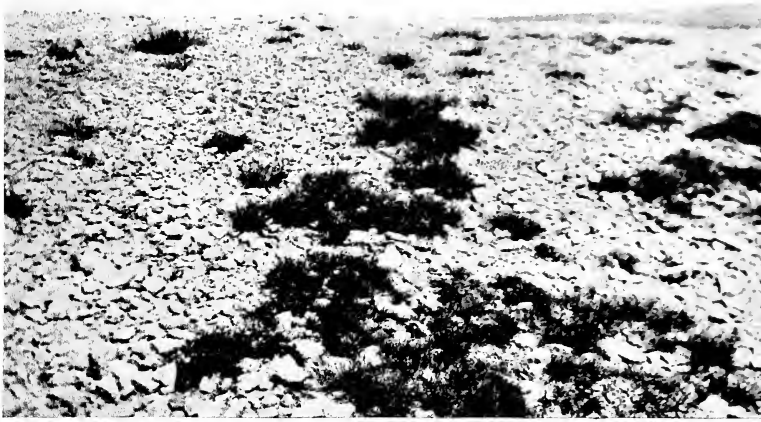


Fig. 24. *Biyurgun* (*Anabosis solsa*) and stony solonchaks on the shores of Lake Baskunchak. (*Vegetationsbilder*. Vol. 18; part 8; plate 46)

Fig. 25. Clumps of the halophyte *sarsazan* (*Halocnemum strobilaceum*) on the shore of a salt lake (presumably Baskunchak). (*Vegetationsbilder*. Vol. 18; part 8; plate 44)

Fig. 26. Ak-Tyube barkhan sands on Mangyshlak Peninsula. (L. S. Berg, *Formy Russkikh Pustyn*. Fig. 13)

Fig. 27. The eastern shore of Lake Balkhash. (*Aziatskaya Rossiya*. Vol. 2: 57)

Fig. 28. Barkhan dunes in the Kara-Kum, 12 miles east of the Amu-Darya. (*Vegetationsbilder*. Vol. 3; part 2; plate 7)

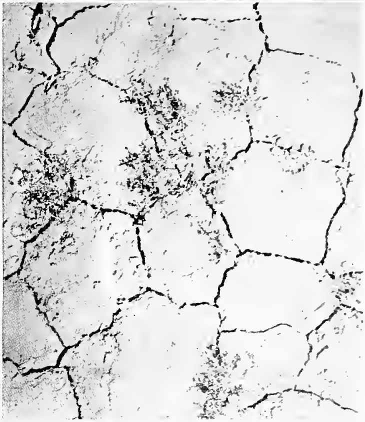


Fig. 29. Surface of a *takyr* in summer. (L. S. Berg, *Formy Russkikh Pustyn*. Fig. 1)

Fig. 30. Sand dune stabilized by saxaul (left) and reeds (right). Ak-Tyube sands. (L. S. Berg, *Formy Russkikh Pustyn*. Fig. 24)

Fig. 31. Clay desert on the Ust-Urt Plateau, north of Lake Sam. (L. S. Berg, *Formy Russkikh Pustyn.* Fig. 8)

Fig. 32. *Bayalych* (*Salsola arbuscula*) and tamarisk (*Tamarix*) on stabilized sand dunes near Farab (several miles east of the Amu-Darya). (*Vegetationsbilder*. Vol. 3; part 2; plate 8)

sands greatly favor the settlement of shrub and semiarboreal vegetation, the long roots of which are able to reach ground water.

In addition to the moisture which the sand receives from precipitation, water vapor also penetrates from the atmosphere into the sand and is condensed in the surface layer. This happens, as A. F. Lebedev [2] has pointed out, when the vapor tension is greater in the atmosphere than in the top layer of the soil. During the cold part of the year this condition is realized. The absolute humidity of the air in Repetek from October to February is from 2 to 5 mm., which at temperatures of $-10°$ C. to $+1°$ C. saturates the air. If the temperature of the surface of the sand is lower, water vapor from the air can penetrate deeply into the sand (B. P. Orlov). In this manner *verkhovodka*—a humid layer, which at Repetek, for example, lies in summer at a depth of 0.2 to 0.3 m.—is formed in the sandy subsoil.

All the evidence that has been presented shows that there is no basis for the assertion that under the present precipitation and temperature regime the desert zone is undergoing continuous desiccation. On the contrary, there is much historical evidence that during the past two to three thousand years the climate of Soviet Central Asia has not only not become drier, but appears to have become even more moist. In any case, the rivers in this area during the past two thousand years have not decreased in depth. In the fourth century before our era, just as today, the Zeravshan River was lost in the sands, and did not reach the Amu-Darya; there is evidence to this effect in the classical writers, Arrian and Strabo. The latter writes: "The Politimet [Zeravshan], after watering Sogdiana [a province of Samarkand], enters the desert country and there is engulfed by the sands." Incidentally, in 1874, when there was abundant precipitation, the Zeravshan ran so full that it forced its way through to the Amu-Darya. Of fertile Margiana (that is, the Merv oasis), Pliny reports that it was hard to reach, because it was surrounded on all sides by sands. Thus, two thousand years ago, even as today, the Murgab River, which waters this oasis, was lost in the sands. This was true also, according to the testimony of Arabian writers, during the ninth and tenth centuries.

Under present climatic conditions, the sandy deserts of Central Asia, if left alone, would not expand their area. They would be overgrown with vegetation, and would be held fast.

We pass on to the subject of precipitation in the desert zone. There

[2] A. F. Lebedev, *Pochvennie i gruntovie vody* (Soil and Subsoil Waters), Leningrad, 1930, Gos. s.-kh. izd. (State Agricultural Publication).

are 80 to 200 mm. of precipitation annually, and only in the vicinity of the mountains is this amount increased. In Tashkent (absolute elevation 478 m.) precipitation is 350 mm. The distribution of precipitation among the seasons is unusual. There is least precipitation in *summer*. The maximum precipitation, close to half the annual quantity, comes in *spring*, when vegetation comes to life for a short time in the desert. On the northern boundary of the desert zone there is most precipitation in May; in the middle part, in April; in the south, in March. In the north, the precipitation is distributed more evenly among the seasons of the year than in the middle subzone, and particularly more evenly than in the south. In some parts of the desert the summer is entirely without rain. Thus, at Bairam-Ali (lat. 37°40′ N) in Turkmenistan, for ten years not a single drop of rain fell during July, August, and September, while in 1903 there was no rain from June through November. In Repetek (Turkmenistan) in 1928 there was no rain for half a year, from June through November. In Tashkent also, it has happened repeatedly that no rain has fallen from the beginning of July until the end of September; normally, for these three months there is one rain per month, yielding 2 to 3 mm. of precipitation. In the Turanian Lowland there is a minimum of precipitation in August, when precipitation is at a maximum on the shores of the Gulf of Finland. The precipitation in spring and winter is explained in large measure by the fact that at this time moisture-bearing cyclonic storms pass over the southern part of Soviet Central Asia from the west.

The desert is characterized by clear skies. While in the forest zone of the Soviet Union the mean annual figure for cloudiness is 65 to 75 per cent, in the Turanian Lowland it is only 35 to 45 per cent, and in some places (for example, at Termez on the Amu-Darya) it is less than 30 per cent. Cloudiness is least in August and greatest in winter, usually in January. In winter cloudiness is relatively great (50 to 60 per cent), but the summer is practically cloudless. At Termez, according to observations over a period of twelve years, the mean cloudiness in August is 3 per cent; the number of clear days during this month is 30, and there is not a single cloudy day. In general, there are 202 clear days per year here, and only 37 cloudy days. Nowhere else in the Soviet Union do we have such clear skies in summer as are found on the middle Amu-Darya and in southern Turkmenistan. (The winters are less cloudy in the Trans-Baikal region.)

In general, Soviet Central Asia is a sunny land. Insolation is much greater here than in the forested tropics. Thus, at Bairam-Ali in August there is 94 per cent of the possible insolation. The summer and the month of September in Turkmenistan have a greater number of hours of sunshine than has even Cairo (lat. 30°05′ N),* which lies 6° to 8° farther south. The great quantity of light and heat, together with the fertile soil (and the soil is fertile because, due to the scant precipitation, it is not leached), make the region of Soviet Central Asia very well suited for agriculture, particularly for the cultivation of cotton. The abundant heat promotes the accumulation of sugar in fruits. The wine and raisins, dried apricots, and Chardzhuy melons from this region are famous for their sweetness. The spring rains are very favorable for grains, while the dry month of September is advantageous for the harvesting of cotton and fruits. With the use of artificial irrigation, farmers in the desert zone may regulate the water supply to the needs of their crops; there is no need to fear either drought or excessive moisture. Side by side with rice, which requires abundant water, crops which require little water may be cultivated.

Winds in the desert zone generally do not reach a great velocity; calms and very gentle winds predominate. In Dzhizak, for example, 62 per cent of all periodic observations at the meteorological station show calm. The diurnal range in wind velocity conforms to that which is characteristic for all continental regions. On clear days the evenings and nights are calm, while in the daytime there blow rather strong winds, which reach a maximum during the afternoon. Thus, in Repetek, according to all mean monthly figures, the wind velocity at 1:00 P.M. is considerably greater than in the morning or in the evening, as can be seen from the table which appears below, showing the months with the highest and the lowest wind velocity.

Table 8

WIND VELOCITY IN REPETEK (M. PER SECOND)

Hour	Wind Velocity		
	August	October	Year
7:00 A.M.	3.6	1.8	3.1
1:00 P.M.	7.1	4.3	5.3
9:00 P.M.	2.7	2.1	2.7

Soviet Central Asia lies southwest of the region of the Siberian anticyclone, and in winter the pressure decreases to the southwest. For this reason, cold northeast winds prevail here in winter. The low winter

* The original reads "lat. 31°17′ N." This is a manifest error.—TR.

temperatures here are also explained by this condition. In summer, however, the isobaric gradient lies from northwest to southeast. This accounts for the prevalence of northwest winds in summer. However, in the south, closer to the mountains, there are some departures from this scheme. There are exceptions also in some other places.

Mention may be made of several of the local winds. In the area from the Dzhungarian Gates (the pass between the Dzhungarian Ala-Tau and the Barlyk range, which leads into the basin of Lake Ebi-Nor in China) to the eastern end of Lake Balkhash, there blows, during the cold period of the year, a southeast or east wind called the *ibe*, or *ebe*. This wind, analogous to the foehn, is distinguished by a relatively high temperature. Sometimes after frosts of − 20° to − 30° C., a thaw may accompany the *ibe*. Since this wind is also dry, it reduces or altogether removes the snow cover, and thus favors stock raising.

Along the upper course of the Amu-Darya, particularly at Termez, a very dusty southwest or west-southwest wind, called the *afghanets*, often blows. In Termez the *afghanets* blows 40 to 70 days of the year. This wind is associated with the intrusion of cold masses of air from the north or northwest. The dust shroud during the period of the *afghanets* sometimes rises as high as 4000 m.

Relief

We shall describe the relief of the Turanian Lowland according to subzones. But first we shall say something about that part of the lowland adjoining the Caspian (see above, pp. 114–115) which lies within the desert zone. We are interested now in that part of the lowland which adjoins the eastern shore of the Caspian Sea from the northern boundary of the Ust-Urt Plateau to the boundary of Iran (the Atrek River).

During the epoch of the Khvalynsk transgression, the Caspian extended rather far to the east along the foot of the northern escarpment of the Ust-Urt. Shells of Caspian mollusks have been discovered on the slopes of the Chegan basin, the bottom of which in 1915 lay 20 m. below the level of the Aral Sea, that is, at an absolute elevation of 32 m. The dry basin of Lake Batyr (or Karagie) on the Mangyshlak Peninsula reaches 130 m. below sea level.[3] We have here the deepest depression on dry land within the boundaries of the Soviet Union. The famous Lyukchunsk basin near Turfan (China) reaches the same depth.

[3] E. M. Murzayev, "Novie dannie po gipsometrii besstochnykh kotlovin Turanskoy nizmennosti" (New Data on the Hypsometry of the Landlocked Basins of the Turanian Lowland), *Izv. Geogr. obshch.* (Report of the Geographical Society), 1936, p. 744.

Kara-Bogaz-Gol Gulf of the Caspian, with an area of 18,346 sq. km. and an average depth of 10 m., constitutes a sort of vast natural laboratory at the bottom of which there is deposited Glauber's salt ($Na_2SO_4.10H_2O$), as well as some sodium chloride and gypsum. About 23.5 cu. km. of water from the Caspian flow into Kara-Bogaz-Gol Gulf annually (S. Shcherbak) and evaporate here. This bay, by extracting salts from the Caspian Sea, makes the latter somewhat less saline.

At Krasnovodsk, on the shores of Balkhan Bay, and on the slopes of the Great and Little Balkhan, there is a series of terraces and beaches, traces of former levels of the Caspian Sea. The highest of these terraces, which contain Caspian mollusks (but no *Cardium edule*), lie at an elevation of about 75 m. above the present surface of the Caspian (that is, at the elevation of the surface of the Aral Sea). During the epoch of the transgression [which produced these terraces], Caspian waters submerged the lowlands of western Turkmenistan east of a line from Kizil-Arvat to Kurtysh (on the Uzboy). Between the Great and Little Balkhan there was a strait, by means of which the Caspian was connected with the Uzboy valley (see below). Of the various Tertiary transgressions of the Caspian, the one which extended farther east than any other was the Sarmatian, which covered at least a part of the Aral Sea, and extended along the foot of the Kopet-Dagh almost as far as the meridian of Geok-Tepe.

The Caspian petroleum-bearing region of Turkmenistan is worth noting; it is delimited approximately by Cheleken, Nebit-Dagh (Neftedagh), and Chikishlyar.[4] Cheleken Island, which rises 119 m. above the surface of the Caspian, lies at the entrance of Krasnovodsk Bay. Faults are of fundamental importance in the relief of Cheleken Island; Andrusov likens this island to a broken plate. According to some authorities, Cheleken is underlain at a certain depth by a massif of young igneous rocks, to which the faulting is attributed. Cheleken is composed of Tertiary deposits, which are petroleum-bearing. On the island there are mud volcanoes from which there is seepage of petroleum. There are many springs, some of which precipitate sodium chloride, others limonite. One of the ferruginous springs has a temperature of 63° C. Many of the springs emit gaseous hydrocarbons. The streams contain so much salt that with the extensive evaporation here in summer, they become dammed by deposits of sodium chloride. On the island there is a circular salt

[4] For details and bibliography, see L. S. Berg, *Relyef Turkmenii* (The Relief of Turkmenistan), Sbornik "Turkmeniya" (Collection "Turkmenia"), II, 1929, izd. Akad. nauk (publication of the Academy of Sciences).

lake, Porsu-Gyol, which is the crater of an ancient mud volcano. Today there is emission of gases and seepage of petroleum in the center of the lake. The desert characteristics of Cheleken are very conspicuous. Here we see fine examples of wind erosion of bedrock: niches, pillars, and "mushrooms." *Kir,* sand which has been cemented by petroleum, is very resistant to wind erosion. For this reason crusts of *kir* form plateaus with steep edges. As it dries, the *kir* crust breaks into prisms which resemble basaltic prisms.

On the continent opposite Cheleken, amid the flat surfaces composed of the latest deposits, individual low hills (Nebit-Dagh [Neftedagh], Monzhukly, Boya-Dagh, and others) appear unexpectedly; they consist of dislocated Tertiary strata. Some authorities consider these eminences laccoliths of a sort, that is, beds of sedimentary rocks lifted by masses of lava which hardened at some depth, before they had time to break through to the earth's surface. Others, however, regard these eminences as salt domes, which appears to be more likely (see above). Nebit-Dagh (Neftedagh), with an absolute elevation of 45 m., rises sharply above the surrounding vast solonchak, Baba-Khodzha, which will be discussed below. In this hill, which is composed of dislocated Upper Tertiary deposits, there are petroleum beds, which are being exploited at present.

In the region of Chikishlyar there are several mud volcanoes. Some, like Zeleny hill, rise 96 m. above the level of the Caspian. A number of them emit gases and mud. On the sea bottom in the region of Chikishlyar there are some submerged volcanoes which emit gases.

1. Relief of the northern subzone—the *Tertiary plateaus.*

The Ust-Urt [5] is a plateau between the Caspian and Aral seas, bounded on almost all sides by distinct escarpments. The eastern escarpment, which drops to the Aral Sea, in some places reaches a relative elevation of 190 m. The surface of the Ust-Urt, composed of Sarmatian strata, is flat. It contains scattered depressions, occupied by sands, solonchaks, or salt lakes. The Sam sands (absolute elevation 75 to 85 m.), which lie next to the lake of the same name, are well known. Here, at the shallow depth of 2 to 3 m. there is fresh ground water. However, in parts of the Ust-Urt which are not sandy, the ground water lies very deep, at 20 to 50 m. and even 70 m., and the water is seldom fresh; it is usually more or less brackish. There is no fresh surface water on this plateau. The

[5] O. S. Vyalov, "Gidrogeologichesky ocherk Ust-Urta" (Hydrogeological Sketch of the Ust-Urt), *Trudy Vsesoyuzn. geol.-razved. obyedin.* (Proceedings of the All-Union Geological Survey Association), No. 319, 1935, p. 66, geological map, bibliography.

highest points of the Ust-Urt reach an absolute elevation of more than 300 m.

The Aral Sea is an enormous saline lake, second to the Caspian in size among the lakes of the Old World. But this expansive basin is shallow; depths of 10 to 20 m. are typical, and only near the steep western shore does the depth reach 68 m. The water is rich in sulphates. The fauna include Caspian elements, which point to a previously existing connection with that body of water. It is noteworthy that the mollusk *Cardium edule,* which is found on the shores of the Caspian in fossil form at levels no higher than − 21 m. absolute elevation (or 5 m. above the surface of the Caspian), inhabits the Aral Sea, the surface of which lies at an absolute elevation of 52 m. (the mean figure for the years 1911–1931). Deposits containing *C. edule* on the shores of the Aral Sea rise no higher than 3 m. above the present surface of this basin. The Aral region and the Turanian Lowland were formerly mistakenly called the Aralo-Caspian Lowland. At the time this name was used, it was believed that a large part of the Turanian Lowland was covered by the waters of the Aralo-Caspian Sea during the Quaternary period. This is not the case. As we can see, the Aral Sea could not have been connected with Lake Balkhash during the Quaternary period; the absolute elevation of Lake Balkhash is 340 m., and at its greatest extent it reached beyond its eastern and southeastern shores no farther than several tens of kilometers from the present shore line. It may be that the Aral Sea, or, more exactly, its fresh-water arms, extended as far northeast as Lake Chalkar,[6] the surface of which lies at the same elevation. The Aral Sea cannot have reached beyond Chalkar, since to the north of this lake there are hills composed of Tertiary deposits which rise more than 120 m. above the lake.

At the time of its maximum extent, the Aral Sea was connected with the Caspian by way of the Uzboy (see below).

The Kara-Kum sands adjoin the northeast shore of the Aral Sea. A large part of this area of sand is covered with stabilized sandy mounds, and there are shifting sands (barkhans) only where the vegetation has been destroyed by man (Fig. 26). In some parts of the Kara-Kum there are individual tablelike eminences of the same type as those found in the Turgay tableland. The northern part of the Kara-Kum belongs to the zone of the semidesert. West of the Kara-Kum as far as the Aral Sea lie the Malie Barsuki sands, and still farther west, the Bolshie Barsuki sands, a large part of which also belong to the semidesert.

[6] Not to be confused with Lake Chelkar at the railroad station of the same name.

The Bet-Pak-Dala plateau, or the Northern Golodnaya Steppe, extends as far south as the Chu River. Here its absolute elevation is about 130 m. It increases in elevation to the north. On the west the plateau drops to the Sary-Su River in an escarpment 40 to 60 m. high. On the west it is composed of horizontal layers of clay and sandstone, predominantly of Tertiary age. On the east, however, toward Lake Balkhash, the Bet-Pak-Dala constitutes a continuation of the area of *melkosopochnik* (see above, pp. 95–96).

Lake Balkhash is an enormous landlocked basin, about 600 km. long, but very shallow; its average depth is only 6 m. (Fig. 27).[7] The level of the lake, which lies at an elevation of about 340 m., fluctuates widely, depending on climatic changes. It is interesting that the water of the western part of the lake, into which the Ili River empties, is fresh, while the water of its eastern part is slightly brackish. The presence in the desert of such a lake, partly fresh and partly saline, constitutes a geographic paradox. It may be that Lake Balkhash came into existence relatively recently and has not had time as yet to turn completely saline (Berg).

To the north of Lake Balkhash there are terraces which rise to an elevation of 130 m. above the surface of the lake, that is, up to 470 m. in absolute elevation. At the time these terraces were formed, the lake reached as far as the basin of Ebi-Nor in China. At Kounrad, near the northern shore of the lake, there are rich deposits of copper ore, sprinkled in the igneous rocks (quartz diorite-porphyries).

2. Relief of the *subzone of sands*.

As to the origin of the desert sands, it was believed formerly (Walter) that the sandy massifs were formed by wind erosion of desert rocks. But Penk (1909), Neustruyev (1915), and Lichkov suggest that the greater part of the sandy areas of the Turanian Lowland are of fluvial origin: The Kara-Kum which adjoins the Aral Sea may have been formed by deposition from the lakes and the river, which at one time emptied into the Aral Sea. The Kyzyl-Kum is traversed by old river channels. Many rivers lose themselves in the Trans-Caspian Kara-Kum; and there are old river channels here also (see below). The epoch during which the Turanian rivers abounded in waters and transported large quantities of sand must belong to the glacial period. Explorers of the Sahara (Gautier and

[7] P. F. Domrachev, *Issledovaniya ozer S.S.S.R.* (Exploration of the Lakes of the U.S.S.R.), izd. Gidrol. inst. (publication of the Hydrological Institute), No. 4, 1933, p. 44. (This also includes a bibliography on Balkhash.)

Chudeau, 1908–1909) believe that the sands of this desert also are the result of the weathering of Quaternary alluvium by wind.

The Trans-Caspian Kara-Kum[8] is the vast area of sand which is bounded on the east by the Amu-Darya, and which extends as far west as the Uzboy valley, as far north as the escarpment of the Kara-Kum (Unguz) Plateau, and as far south as the Kopet-Dagh piedmont. The Kara-Kum contains a tremendous area of shifting sands. Thus, between Mary and Chardzhuy (and also farther east), the railroad passes through a sandy sea of bare, shifting sand mounds—barkhans. The height of the barkhans reaches 9 to 10 m., but most of them rise only 5 to 7 m. above the depressions. These shifting sands were produced in the Kara-Kum as a result of the grazing of cattle, the plowing of sands on the outskirts of the oases, and the destruction of saxaul thickets and other sand-binding agents. Fundamentally, with very few exceptions, the Kara-Kum sands were at one time held fast. The original shifting barkhan sands exist only along the Amu-Darya, where they were formed by wind erosion of the sandy-clayey alluvial deposits. All of the remaining area of the Kara-Kum is covered with sands which in their natural state would have been covered with vegetation. The weight of opinion at present is inclined to attribute an alluvial origin to the sands of the Kara-Kum.

Four types of sandy landscapes are distinguished in the Kara-Kum: barkhan sands, mound sands, ridged sands, and sandy plain.

Barkhan sands are developed along the Amu-Darya. The barkhan strip at Chardzhuy is 40 to 50 km. wide. Individual barkhans often combine into barkhan chains, from 3 to 4 m. to 6 to 8 m. high (Fig. 28). The barkhan chains, like the individual barkhans, lie in a northeast-southwest direction, showing the prevalence of N and NW winds (in summer) and S and SE winds (in winter). Depending on the winds, the chains shift their position, in summer to SE, in winter to NW. The annual range of their movement is about 20 m. No continuous movement of the sands in one direction (which formerly was believed to take place) has been observed, however. This same kind of movement is found in the barkhan chains at Repetek and throughout the Kara-Kum in general. Only the top of the chain shifts, while the foundation remains more or less stationary. Crescent-shaped barkhans, with crests which face in the direction of the wind, are found only rarely in the Amu-Darya valley; in the Kara-Kum they are altogether absent.

Mound sands are extensive in Turmenistan. The height of the mounds

[8] See *Kara-Kum, izd. Akad. nauk* (publication of the Academy of Sciences), 1930 f.

may reach 8 to 10 m., but more often is 6 to 8 m. They are held fast by shrubs, among them white saxaul (Fig. 30). Under the crown of sand vegetation, the sand becomes compacted, cemented, and a radical change in the water regime results. Atmospheric moisture can no longer be absorbed into the deep layers so quickly; in large measure it remains on the surface and evaporates. Thus, conditions favorable to the settlement of the black, or solonchak saxaul are created (Dubyansky).

The *ridged sands* are characterized by long, parallel ridges, running approximately north and south. In some places the ridges are connected by cross ridges. The average height is 15 to 20 m.; in some places it reaches 25 to 30 m. The depressions between the main ridges are usually 60 to 80 m. wide. The eastern slopes of the main ridges are more gentle than the western slopes. Among the ridged sands there are many *takyr*s (compact clayey areas) and solonchaks, which will be discussed below. The ridged sands are held fast by vegetation. The origin of this type of sands is obscure. They may have been formed during the Quaternary period at the time when the large lakes in the Kara-Kum region contracted their areas. In the central Kara-Kum, Quaternary lacustrine deposits have been found. Some authorities (B. Petrushevsky, 1937) ascribe an aeolian origin to the ridged sands.

Sandy plains. Some areas are covered with more or less flat or slightly rolling sand. There are extensive sandy plains, held fast by vegetation, between the Murgab and the Kelif Uzboy.

*Takyr*s, which are very widespread in the desert zone in general and are common in the Kara-Kum, are flat clayey spaces, which lie in the gentle depressions. In spring, during the rainy season, many of the *takyr*s are turned into shallow lakes, and sometimes even into very large ones. They dry up in summer, and their clayey surface cracks in the manner of parquet floor (Fig. 29). A typical *takyr* is not covered with vegetation. At some depth in the *takyr,* salinization by gypsum and sodium chloride appears. Thus, a *takyr* is a deep solonchak. The thin surface crust (compacted and containing some absorbed sodium), on the other hand, according to I. Gerasimov (1931), constitutes a rudimentary solonized horizon. According to him, the *takyr* results from the leaching of salinized clayey or clay-loam soils by atmospheric waters, which in the desert always contain alkali. The upper horizons become more dispersed, and as they dry, give rise to a *takyr* crust. The *takyr*s often become salinized from the surface, turning into typical solonchaks.

Shor, or *sor,* is a native word for solonchak. The *shor*s which lie at the southern boundary of the ridged sands are elongated depressions, 2 to

5 km. long. Their banks, which are sometimes terraced, are rather high, 15 to 20 m. The bottom of a *shor* is swampy and covered with salts. Some authorities regard the Kara-Kum *shors* as the result of karst processes.

Turkmenistan has several dry river channels, concerning which there exists an extensive literature. Let us consider first the Uzboy system.

By "Uzboy system" we mean the aggregate of channels and their associated basins along which at one time the waters from the Aral basin drained into the Caspian. Subsequently this system became a bed for the drainage of part of the waters of the Amu-Darya into the Caspian. The Uzboy system consists of (1) the dry channel of the Kunya-Darya, (2) the Sarykamysh basin, and (3) the dry channel of the Uzboy.

The Kunya-Darya is the old channel (now dry) of the Amu-Darya which flowed in the direction of the Sarykamysh basin. It is partitioned by two large dams. When the river is at high water, a small quantity of water enters the Kunya-Darya, but does not travel very far. However, in 1878 the waters of the Amu-Darya broke through into the Kunya-Darya and reached as far as the Sarykamysh lake, raising its level by about 8 m.

The Sarykamysh basin lies southwest of the delta of the Amu-Darya. The borders of the basin, which were the shores of the old Sarykamysh lake, have an elevation of 3 to 4 m. above the level of the Aral Sea. The outlet of the Uzboy from the basin also lies at this elevation. To the north and west the basin is bounded by the escarpments of the Ust-Urt; to the south it has extended approximately as far as the wells of the Charyshla, where the old Sarykamysh lake joined the series of lagoons and lakes in which the Uzboy had its source. The lowest part of the basin is occupied by the two Sarykamysh lakes, which in dry years may evaporate completely, turning into solonchaks, as happened, for example, in the years 1913 and 1914. The level of the lakes in 1881 was 39 m. below sea level; obviously, the depression in which they lie is a deep one. On the bottom of the basin in some places there are shells of *Cardium edule*, sometimes in large numbers; they occur up to a height of 7 to 12 m. above the basin floor; that is, up to 32 to 27 m. below sea level. In other parts of the Sarykamysh depression there are "Sarykamysh" deposits which contain numerous shells, but no *C. edule*. These deposits belong to an earlier period than those which contain *C. edule*, which penetrated into the Caspian and Aral seas during the most recent geological period. During the epoch when the Sarykamysh strata were deposited, the slightly brackish Sarykamysh basin was connected on the one hand with the Aral Sea, on the other, by means of the Uzboy, with the Caspian.

The method by which *Cardium edule* penetrated into the Sarykamysh and Aral basins is still obscure. In the Sarykamysh basin the shells of this mollusk are found only as far as the elevation of the present level of the Caspian Sea (− 26 m.). In the Aral basin, however, they are found up to an absolute elevation of + 55 m.

The Uzboy, as we have said above, has its source in the southern end of the Sarykamysh basin. The total length of this channel, measured as far as the base of the Great Balkhan Mountains, is 550 km. In this distance the floor of the channel drops 75 m.; thus, it corresponds to the difference in elevation between the Aral Sea and the Caspian. In some places the Uzboy has worn its channel through the Sarmatian limestones of the Ust-Urt, which form ledges in the channel 6 and even 8 m. high. At 3 km. below its crossing by the railroad, the channel disappears. Here at one time the Uzboy emptied into a bay of the Caspian Sea, which today is the vast Baba-Khodzha solonchak. From this solonchak the Aktam channel (about 40 km. long), which empties into Balkhan Bay, leads into the Caspian. The Aktam is therefore the terminal portion of the Uzboy. In the Aktam channel lies the Molla-Kara salt lake, where there is a health resort.

There are shells of *Cardium edule* in the Baba-Khodzha solonchak. Although, as we have seen, this mollusk is absent along the entire extent of the Uzboy channel in the Sarykamysh basin, other Caspian mollusks are present.

Classical authors talk about the debouchment of the Amu-Darya (the Oxus) into the Caspian Sea. It may be that at one time a part of the waters of the Amu-Darya drained into the Caspian by way of the Uzboy. From the middle of the thirteenth century until 1573, as Barthold pointed out, water flowed again in the Uzboy. At that time only a part of the waters of the Amu-Darya can have flowed here; the rest were directed toward the Aral Sea. There is direct evidence of this in the works of the Iranian author Kazvini (1339).

In addition to the Uzboy, there are other dry channels west of the Amu-Darya. The so-called Kelif Uzboy, which has its source in Afghanistan, belongs to this category. In 1907 water from the rivers of Afghanistan penetrated into this indistinct channel.

The Kara-Kum sands reach northeast as far as the edge of the Kara-Kum Plateau, which rises 60 to 80 m. above the desert sands. To the north the plateau, which is composed of horizontal rocks of Upper

Tertiary age, declines gradually. At the foot of the escarpment lies the so-called Unguz—a series of dry depressions and *shors* (that is, hollows occupied by solonchaks)—which some authorities believe to be one of the ancient channels of the Amu-Darya. Along the bottom of the Unguz the absolute elevation fluctuates between 95 and 115 m.

In the Kara-Kum south of the edge of the plateau, there are round, conical, and plateau-shaped hills, which have been detached from the edge of the plateau. These hills rise 20 to 60 m. above the surrounding country. Some of them, for example, in the region of the Shie wells, are noted for their sulphur beds. The origin of the sulphur is obscure; it is believed that its accumulation took place as a result of chemical processes in sedimentary rocks rich in sulphates.

The delta of the Amu-Darya begins at Nukus. The position of the branches of the delta changes continuously, partly as a result of the work of the river itself, partly because men have dammed or diverted some of the branches.

The Kyzyl-Kum desert borders on the eastern shores of the Aral Sea in the area between the deltas of the Amu-Darya and the Syr-Darya. The sands of the Kyzyl-Kum are almost completely stabilized. The northern part of the desert is traversed by the dry channel of the Yany-Darya (Dzhany-Darya), which branches off from the middle course of the Syr-Darya and empties into the Aral Sea. Along its shores there are traces of settlement and ancient irrigation canals (*aryk*s). In some parts of the Kyzyl-Kum there are elevations composed of Paleozoic rocks (on the north, Bukan-Tau, 700 m.; Tamdinsk Ak-Tau, 1029 m.). The folds of these elevations extend latitudinally; they form the tectonic continuation of the Sultan-Uiz-Dagh. The Tamdinsk Ak-Tau rises 600 to 650 m. above the Kyzyl-Kum.

The Syr-Darya Lowland, which borders both sides of the Syr-Darya to its mouth in the Aral Sea, is bounded on the east by the Kyzyl-Kum and the Southern Golodnaya Steppe. The lowland consists of the present flood plain and the ancient valley of the Syr-Darya. To the north of the Kara-Tau Mountains, the lowland reaches as far as Lake Tele-Kul, in the lower reaches of the Chu River. From the accounts of local inhabitants, Neustruyev reports that about 1898, when water was abundant, the waters of Tele-Kul penetrated into the Syr-Darya and rushed along the escarpment of the Kara-Kemir. This escarpment, which is only 2 to 5 m. high, and bounds the Syr-Darya valley on the east, forms the western edge of the Bet-Pak-Dala Plateau. The floor of the ancient valley of the Syr-Darya lies 5 to 10 m. above the present flood plain, and extensive areas are occupied by solonchaks and *takyrs*. The present flood plain or *tugay* belt of the Syr-Darya is covered with salinized meadows, sandy mounds, and in some places puffy solonchaks. The flood plain may be recognized from a distance in the desert by its verdant reeds, individual poplar trees, and spiny thickets of Siberian salt tree, a leguminous shrub (*Halimodendron argenteum* [*H. halodendron argenteum*]), in which pheasants take shelter. The Syr-Darya deposits so much alluvium in its channel that in its lower course the channel lies higher than the surrounding country, and the river flows along the crest of a low and gently sloping ridge.

Between the Kara-Tau range and the Chu River lie the Muyun-Kum sands, which extend for more than 500 km. The elevation of the central part of these sands is 300 to 380 m.

The Semirechye plain, drained by the Ili, Karatal, and other rivers, descends to Lake Balkhash, of which we have spoken already. Vast sandy areas stretch as far as the low southern shore of Balkhash.[9] Between the Ili and the Karatal rivers these sands are traversed by dry channels (*Bakanasy*) which branch from the Ili River. Along these dry channels there are vast thickets of saxaul.

3. We come now to a description of the *loessial piedmont plains,* where most of the arable land is found. These plains are covered by loess or loesslike material.

The origin of the Central Asiatic loess is explained by the same hypotheses as the origin of the European loess (see above, p. 70 ff.). The adherents of the wind hypothesis believe that the dust, so characteristic for Central Asia, gives rise to the loess. But, in the first place, this loess, as we shall see (p. 147), is not a contemporary but a geological formation, as it is overlain by sierozem soils. In the second place the loessial dust of Central Asia is an artificial product, a result of the plowing of the soils which are developed on the loess, the wind erosion of the sands trampled by livestock, and the erosion of soils on the public roads. As observations at the special dust station at Osh have shown, the Fergana dust is formed from loesses. There is no reason to believe that aeolian loess was deposited here in the geological past as well. It is our opinion that deposits of various origins may have served as the parent material for the Central Asiatic loesses: glacial mud, carried onto the plain by mountain streams during the glacial period; river (fluvioglacial)

[9] S. A. Nikitin, "Peski zapadnovo Pribalkhashya" (The Sands of the Western Balkhash Region), *Trudy Pochv. inst. Akad. nauk* (Proceedings of the Soils Institute of the Academy of Sciences), XI, 1935, pp. 147–225, with a map. (This article deals also with the sands of the southern Balkhash region.)

deposits of the same period; and alluvial fan deposits of the postglacial period. On the slopes of the Kopet-Dagh in Turkmenistan, the gravel on the lower slopes gradually grades into loesslike clay loams, sometimes alternating with beds of fine gravel, sometimes completely free from gravel. The piedmont loesses are always interbedded with layers of gravel, which also testifies to the large part played by alluvial fans in the formation of these loesses. In the southeastern Kara-Kum there are extensive areas of alluvial sands, which have changed into loesslike sands under the influence of the processes of weathering and soil formation in a dry climate. Similarly, the contemporary alluvium in the delta of the Amu-Darya is assuming a loesslike appearance. The loesses of the Golodnaya Steppe without a doubt are deposits of the ancient Syr-Darya; they are interbedded with layers of sand and gravel. All of these facts testify to the fluvial origin of the parent material of the loesses and loesslike strata in this area.

Loess is a material which is easily pulverized. In summer the towns of Central Asia may be recognized from a distance by the heavy shroud of loessial dust which hangs over them. This dust is a characteristic feature of all the settlements of Central Asia. Carried by winds and convectional currents, the fine dust rises to a height of at least 6000 m. Often during the dry period of the year when gales are blowing, the whole sky is covered by a continuous turbid shroud. In general a whitish, foggy atmospheric coloration is very characteristic for the landscape here.

On the loesses of Soviet Central Asia sierozems are developed; they are among the most fertile soils on earth. Thus, it is easy to understand why the loessial piedmont plains of Central Asia were the sites of very ancient culture. The sloping loessial piedmont plain marks the first step toward vertical zonation.

The elevation of the piedmont plain in Turkmenistan, judging from the elevations of the railroad stations, is from 100 to 300 m. Among the other loessial regions, the Golodnaya Steppe between Dzhizak and the Syr-Darya, which on the north merges into the Kyzyl-Kum sands, varies in elevation between 240 and 290 m. The Golodnaya Steppe falls away to the Syr-Darya in a clearly defined bluff, 6 to 20 m. high. Here extensive irrigation works are under construction. Another loess plain is the vast Fergana Lowland, which is about 300 km. long and 170 km. wide, although its entrance at Khodzhent (absolute elevation 320 m.) is only 9 km. wide. The floor of the lowland has an elevation between 350 and 500 m. and is covered by loess and sands. The Syr-Darya runs along the full length of the lowland.

Loessial piedmont plains are developed also at the foot of the Aleksandrovsk range and the Trans-Ili Ala-Tau, but they are absent at the foot of the Dzhungarian Ala-Tau.

Drainage

The Turanian Lowland is watered by several large rivers—the Amu-Darya, the Zeravshan, the Syr-Darya, the Chu, and the Ili; but they all lie in interior basins, and have no outlet to the ocean. These rivers have their sources high in the Tian Shan and the Pamirs, which are covered with snow and glaciers. As they flow through the desert, they lose a tremendous amount of water by evaporation. Much water is taken also for irrigation. These rivers carry a maximum amount of water in summer, when the melting of ice and snow takes place most intensively in the mountains. Those rivers which are fed largely by the melting of low-lying mountain snows, reach their maximum flow at the beginning of the summer. Thus, the Naryn River, which belongs to the category of rivers which are fed by mixed sources (that is, by the melting of ice and both high-mountain and low-mountain snows), reaches its maximum discharge at the beginning of June.

The waters of the Amu-Darya are extremely muddy. During the year 1911, at Kerki the river carried about 50 cu. km. of water and about 0.2 cu. km. of mud; of this figure, 92 per cent was recorded for the summer half-year. In some years there is even more drift. Due to the large quantity of mud, the river forms sand bars in its channel very rapidly, which it shifts just as rapidly, because of the swift flow. The quantity of soluble substances in the waters of the Amu-Darya is also tremendous. In February, when the salt content of the water of the Amu-Darya is greatest (as is usual for rivers in temperate latitudes), a liter of water at Kerki contains 0.601 gram of salt. The average daily turnover of soluble substances here was 81 thousand tons* for the summer half-year of 1912, while for the winter half-year it was 42 thousand tons. An enormous quantity of salts was carried past Kerki for the year as a whole—almost 22.5 million tons.

The range of fluctuation in the level of the Amu-Darya along its middle and lower course is one to three meters. This imposing river is composed of a series of separate channels, divided one from another by shoals and sandy islands. In these separate branches the river flows at different rates of speed and has different gradients, and consequently, different levels.

* This is the metric ton, which equals 1000 kilograms, or 2200 pounds.—Tr.

The difference in the levels of the river on opposite shores may be as great as 0.5 m.

Soils

Like the semidesert soils, the soils of the desert are poorly developed, due to the small role played by water and vegetation in the soil-forming process (see above, pp. 119–120).

According to the character of its soils, the desert as a whole may be divided into four categories: (1) clayey, or, more exactly, clay-loam desert, (2) stony desert, (3) sandy desert, and (4) solonchak desert.[10] Solonchak desert is scattered in patches among the other types of desert. We will examine the soil cover of the desert by subzones, beginning at the north.

1. On the *Tertiary plateaus of the northern subzone* structural sierozems are developed (Fig. 31).[11] Neustruyev formerly called these the *gray-brown solonized clay loams,* or *solonized sierozems.* The surface of these soils is usually strewn with rubble, or the rubble is incorporated into the surface crust of the soil (desert pavement), or the entire soil mantle in general is rich in skeletal elements, so that the region of the gray-brown clay loams may be considered a part of the stony desert. In these soils the maximum quantity of carbonates is found in the surface horizon, a characteristic which is explained as the result of plant activity. The quantity of carbonates decreases with the depth, which is not the case in the so-called "desert" sierozems and the light-chestnut soils. The surface horizon is not salinized, but not far below the surface (12 to 20 cm.) there lies a more clayey, compact (solonized) illuvial horizon, brownish in color, sometimes with an efflorescence of carbonates. The lower portion of this (illuvial) horizon contains accumulations of gypsum, which begin at 25 cm., and sometimes at 80 to 90 cm. (On the Ust-Urt Plateau, the thickness of the gypsum horizon may reach two meters or more.) These soils contain little humus; the humus content in the upper horizons usually does not exceed 1 per cent, and the humus is distributed more or less evenly throughout the soil profile. Sometimes these sierozems contain soluble salts all the way to the surface; that is, they are salinized. Sometimes they contain soda from the surface down;

[10] L. S. Berg, "Formy russkikh pustyn" (Types of Russian Desert), appendix to Walter's book, *Zakony obrazovaniya pustyn* (Principles Which Govern the Formation of Deserts), St. Petersburg, 1911, pp. 164–178.

[11] I. P. Gerasimov, "O strukturnykh serozyomakh Turkestana" (Concerning the Structural Sierozems of Turkestan), *Trudy pochv. inst. Akad. nauk* (Proceedings of the Soils Institute of the Academy of Sciences), V, 1931.

that is, they are distinctly solonized. On the Ust-Urt Plateau there are found platy-columnar solonetz soils, which are generally foreign to the desert zone.

2. In the *sandy desert* processes of soil formation may take place, of course, only when the sands have been stabilized. Dubyansky describes the stabilization of the sands in the Kara-Kum as follows: [12]

As tree vegetation develops on the sands, a change takes place in the chemical and mechanical properties of the surface horizons of the sand. The dying vegetation (particularly saxaul) which covers the surface enriches the soil with salts and silt, at the expense of ash substances and the products of the more energetic decomposition of the mineral constituents of the sand. These processes take place especially vigorously in the thickets of solonchak saxaul. The sand of the bare barkhans at Repetek contains almost no particles smaller than 0.05 mm. in diameter. (There are only 0.1 per cent of these.) As the sand becomes overgrown by the pioneer sand binders, three-awn and *dzhuzgun* (*Calligonum caput-medusae*), such particles become more numerous and the quantity of silt increases to 0.5 per cent. Under sand saxaul the proportion of particles smaller than 0.05 mm. reaches 9 per cent, while under solonchak saxaul it may reach 40 and even 50 per cent. The quantity of silt decreases as the depth increases. As the surface layer is enriched with silt, an increase in its soluble salt content also takes place.

Even with the naked eye, compacted, cemented sand may be seen to appear under the crown of desert vegetation; for example, under three-awn and *Calligonum arborescens,* where the thickness of the cemented sand crust reaches 5 to 10 cm. The cementation of the sand is particularly vigorous under saxaul. The thickness of the soil under saxaul plantations may reach 1.5 to 2 m.

The compaction of the surface horizons of the sand brings about a radical change in the water regime of the sands. Atmospheric moisture can no longer be absorbed so rapidly into the deeper layers, but remains in large measure on the surface where it evaporates. As a result, the pioneer sand binders die out and are replaced by thickets of solonchak saxaul.[13]

[12] V. A. Dubyansky, "Peschanaya pustynya yugo-vostochnykh Kara-Kum" (The Sandy Desert of Southeast Kara-Kum), *Trudy po prikl. botan.* (Works in Applied Botany), XIX, No. 4, 1928.

[13] However, at present there is inclination to believe that the solonchak, or black, saxaul has its own associational sequence, which does not enter into the cycle of changes which take place among the other types of vegetation in the sands. See M. P. Petrov, "K voprosu o proiskhozhdenii rastitelnosti peschanoy pustyni Kara-Kumy" (On the Question of the Origin of the Vegetation of the Kara-Kum Sandy

3. On the *loessial piedmont plains* and to some extent higher up, at elevations of 300 to 500 m., typical sierozems are developed—soils which were regarded by former investigators simply as loess, and which were called loess and aeolian-loess soils. However, Neustruyev pointed out that this conception was wrong. Sierozem is not a dust deposit at all, but undisturbed zonal soil, underlain most frequently by loess, but capable of being developed on other materials as well. There are no great differences between the typical sierozem and the above-described structural sierozem. If the typical sierozems are of "aeolian" origin, then the same origin should be ascribed to the structural sierozems as well; this, however, is not done.

Typical sierozems are soils of light grayish-brown color, with high content of carbonates but containing little humus. They usually overlie loesses and differ very little in chemical and mechanical composition from loesses. The soil-forming process is apparent in the accumulation of some humus in the upper loess horizons, while the carbonates are washed to some extent into the lower horizons; thus, the maximum amount of carbonates in the typical sierozems is found not in the surface horizon (as in the above-described structural sierozems), but at some depth below the surface. Furthermore, the upper loess horizon (10 to 12 cm.) assumes a gray coloration and a platy-laminated structure. Lower down lies a lumpy, more compact (*B*) horizon. At the bottom it merges into a layer which is thoroughly burrowed by worms and grubs, and becomes saturated with moisture during the wet period of the year. Below this porous horizon, and sometimes even within this horizon, the efflorescence of carbonates begins. From a depth of 80 to 100 cm. down there is usually unmodified loess.

The sierozems are very rich in carbonates. The content of carbonates may be 10 to 15 per cent in the upper horizon, and as high as 25 per cent lower down. This fact is responsible for the remarkable fertility of the sierozems.

Since ground water in the loessial piedmont plains as a rule occurs far below the surface, the sierozems which overlie loess are usually not salinized, because of the physical properties of the loess—its water-permeability and its susceptibility to leaching; water extracts from these soils up to a depth of 1 and even 2 m. do not contain soluble salts in noticeable quantities. The deeper horizons may be salinized, containing

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Desert), *Khozyaistvennoye osvoyenie pustyn Sredney Azii i Kazakhstana* (The Economic Utilization of the Deserts of Central Asia and Kazakhstan) collected articles edited by E. P. Korovin, Tashkent, 1934, pp. 31–40.

gypsum. Where ground water is easily accessible to their surface, the loesses are salinized quickly and turn into salinized sierozems, and sometimes even into solonchaks.

The sierozems are extremely fertile, and vegetation develops quickly and luxuriously when they are irrigated. Enormous poplars, half a meter in diameter, grow within 20 to 25 years in Tashkent and Samarkand.

Having described the zonal types of desert soils, we pass on to the intrazonal formations.

In some places, where ground water is able to reach the surface of the earth and evaporate, solonchak soils are developed. They are very extensive here and are particularly abundant in the valleys of contemporary and ancient rivers and along lake shores.

Puffy solonchaks, or *kebirs*, are of interest. They lie in the vicinity of water basins, but in places not subject, or seldom subject, to inundation. As a result of the great heat in summer, the salts (predominantly sulphates and sodium chloride) rise to the surface from the moist subsoil and are precipitated here, loosening the surface horizon of the soil and forming a friable puffy layer. Farther down, in the sticky and wet layer, there is an abundance of gypsum crystals. The quantity of water-soluble salts in the upper puffy layer may reach 36 per cent of the weight of the air-dry soil. A solonchak covered by white salts is called a *sor* or *shor.*

There are no typical columnar solonetz soils in the desert. But platy-columnar solonetz soils are found as far as the extreme south of the Ust-Urt, while in northern Semirechye there are platy-lumpy solonetz soils. Farther south the processes of leaching decrease in intensity, the carbonate content increases, and solonetz soils are found only under exceptional conditions.

In the region of the ancient valley of the Syr-Darya (and in some other places), *takyrs* are very widespread. These may be considered rudimentary soil formations (see above, p. 138).

Vegetation

The vegetation of the desert is unique. There is no continuous vegetation cover in summer, autumn, or winter. The plants grow far apart, and the bare soil may be seen in the spaces between them; the area of bare soil is larger than the area under vegetation. However, during the spring rainy reason, the ground is covered, sometimes completely, by a short-lived carpet of vegetation which fades quickly—the so-called *ephemera,* composed of grasses, sedges, and some dicotyledons. Among these there are many annuals. By the middle of spring all this vegetation fades and is replaced by typical desert xerophytes, among which there are many spiny plants and sometimes *polyn*, as well as halophytes.

We will describe the vegetation of the desert according to subzones:

1. The *northern subzone,* where structural sierozems are developed, constitutes the transition to the semidesert, and some botanists classify it with the semidesert. In the soils of this zone, as explained previously, there is an accumulation of gypsum not far from the surface; therefore, the vegetation, the roots of which penetrate into the medium which has a high salt content, must be able to withstand such salinization. Chief among such plants are the halophytes.

The preponderant species of this group are *boyalych* (*Salsola arbuscula* [Fig. 32], which is replaced in the Bet-Pak-Dala by the Mongolian species, *S. laricifolia*) and *biyurgun* (*Anabasis salsa*) (Fig. 24). *Boyalych* is an undershrub, 30 to 50 cm. high, and is characteristic for the semidesert and the northern part of the desert zone. The individual plants of this species lie 0.5 to 2 m. apart. *Biyurgun* is a small undershrub, 10 to 15 cm. high, which covers large areas on the water divides, slopes, and even in the valleys, but is found predominantly in shallow depressions. In addition, there is the peculiar xerophytic halophyte *tasbiyurgun* (*Nanophyton erinaceum*), a small procumbent undershrub with small spiny leaves. There is also a good deal of *polyn* here.

The *polyns* are represented by white *polyn* (*Artemisia terrae-albae*), which is widely distributed in this subzone, as well as in the south of the semidesert; Turanian *polyn* (*A. turanica*); and black *polyn,* or *maikara* (*A. maikara*), which replaces *A. pauciflora* here. The *polyns* grow 30 to 50 cm. tall. Five to ten shrubs grow to a square meter.

In shallow depressions there is Caucasian pea shrub, the legume *Caragana grandiflora var. steveni,* which grows in bushes up to 1 m. high. On the ground, the lichen *Aspicilia alpino-desertorum* grows in abundance.

This subzone may be called the *polyn*-halophyte desert. In some places *polyn* (which, as we have seen, is characteristic for the semidesert) predominates in the vegetation cover.

Because precipitation is at a maximum during the latter half of spring, this subzone is very poor in ephemera—plants which complete their life cycle for a given year quickly during the spring. Hot weather here sets in very soon after the period of maximum precipitation. There is practically no spring; winter is followed after a very short interval by summer. Nevertheless, there are some ephemera here, for example, tulips.

As in the semidesert, the distribution of vegetation and soils in this subzone is complex. One type of vegetation is replaced by another within a short distance, depending on local elevations and depressions in the relief. Thus, on the southern Ust-Urt and in the Bet-Pak-Dala three vegetational groupings are widespread: on slightly elevated portions of the relief we find (1) *polyn*, or (2) *boyalych* together with *polyn*, while in depressions we find (3) *biyurgun*.

The sands in this subzone (the Barsuki and the Aral Kara-Kum; Korovin includes also the Muyun-Kum and the Balkhash sands) have a great deal in common with the sands of the more southern subzone, which will be described below. But there are some differences. The saxaul *Ammodendron conollyi* is replaced here by the closely related species *A. karelini*, which the Kazakhs call *kuyan-suyek* ("hare's bone"). The vegetation of the northern sands includes Siberian wheat grass (*Agropyron sibiricum*), some feather grasses (*Stipa szowitsiana* and *S. hohenackeriana*), Old World winter fat (*Eurotia ceratoides*), and the *polyn Artemisia terrae-albae*. On the sodded sands wheat grass is abundant and sometimes covers as much as half the surface of the soil; there are also feather grasses. In spring ephemeral vegetation develops here: viviparous bulbous blue grass, brome, and sand sedge [*Carex physodes*]. On still more compact, sandy-loam areas, wheat grass is replaced by the *polyn Artemisia terrae-albae*. Wheat grass and *polyn*, which are characteristic for the northern sands, are not found as a rule on the southern sands; here the stabilized sands are covered with sand sedge. This is easy to understand, since the northern subzone constitutes the transition from the semidesert (with its preponderance of *polyn* and grasses) to the southern desert. But we must keep in mind that *polyn* of the *A. terrae-albae* group is found also in the two southern subzones of the desert, while in the ridged sands of the Trans-Caspian Kara-Kum, wheat grass often acts as the sand binder.

2. The vegetation of the *sands of the central subzone* shows a distinct adaptation to the surrounding environment. Many of the plants here are adapted for struggle against dryness of the air and against becoming covered by sand. Thus, some shrubs, in order to decrease evaporation, are either entirely devoid of leaves, or have very small or narrow leaves. *Dzhuzgun*, a buckwheat shrub (genus *Calligonum*), which is found from the Sahara to Mongolia and is very characteristic for the sands of the Turanian Lowland (where it is represented by almost thirty species) (Fig. 35), has short, filiform leaves, which it sheds quickly. The twigs

which bear the fruit are assimilative organs. They drop off also at the end of June, after the fruit is ripe. In this way evaporation is reduced to a minimum. New assimilative twigs appear the following spring, during the rainy season. Saxaul (*Arthrophytum*)[14] has a similar structure. It is represented by two species—the white, or sand, saxaul (*A. persicum,* or *A. acutifolium*) and the black, or solonchak, saxaul (*A. aphyllum,* or *A. haloxylon*) (Fig. 33). The latter is entirely devoid of leaves, while the white saxaul bears small leaflets. In autumn, when the fruit ripens, the saxaul sheds its assimilative twigs. The leguminous sand shrub *Eremosparton* is completely devoid of leaves. The desert shrub halophytes and the sand astragali have very few leaves. Some plants have thorns in place of leaves. Many arenaceous plants have the faculty of developing accessory roots and shoots, which make it possible for them to withstand becoming covered by the sand.

The first pioneer to appear on the barkhan sands of the Trans-Caspian Kara-Kum is three-awn grass, *Aristida pennata var. karelini,* which sometimes grows a meter tall. When the three-awn becomes covered with sand, long rhizomes develop from buds in the axillae of the leaves; these rhizomes grow quickly through the sand and develop a new stem along the ground. Three-awn is followed by the shrub *dzhuzgun* (*Calligonum turkestanicum*). The accessory roots of the *dzhuzgun,* which grow tremendously long (over 30 m.), are disposed chiefly horizontally, in the moist subsoil horizon. The "sand acacia," *Ammodendron conollyi* (Fig. 34), which sometimes grows into small trees as tall as 7 m., has an equal facility for developing accessory roots when covered by the sand; Dubyansky observed accessory roots on this plant growing at a distance of more than 3 m. from the base of the trunk. *Syir-kuiryuk* (*Eremosparton flaccidum*) has similar properties.

On the sand mounds, in addition to the above-mentioned plants, there grows *kara-kandym* (*Calligonum eriopodum*), a tall shrub or small tree, 3 to 3.5 m. high; and the arborescent halophyte *cherkez* (*Salsola richteri*), which also reaches 3 m. in height. The grass *Aristida pennata var. karelini* is replaced on the sandy mounds by another, squat variety, *var. minor,* which, so far as the struggle against the sand is concerned, does not have the same properties as *var. karelini.* Between the shrubs the sand is overgrown by the sand sedge *Carex physodes* (*ilyak* in Turkmen).

Sedge, by desiccating the sand, soon kills off the pioneers: *dzhuzgun,* "sand acacia," *syir kuiryuk* (*Eremosparton*), and particularly three-awn

[14] Now it is called *Haloxylon* once more.

(*Aristida pennata var. karelini*), which is the first to disappear. The dead bushes of three-awn, which are preserved for several years, indicate clearly the beginning of a change in the vegetation.

In the second stage of the development of plant cover on the sandy mounds, in addition to the above shrubs, several new ones appear: *dzhuzgun, chakish* (*Calligonum setosum*), the halophyte *chogon* (*Salsola subaphylla*), the ephedra *bordzhok* (*Ephedra strobilacea*), and the sand or white saxaul. The latter is very widespread. Among thickets of sand saxaul, on the bottom of the more overgrown depressions, there appears solonchak, or black saxaul.

Gradually the sand pioneers die out and are replaced by thickets of solonchak saxaul. According to Dubyansky (1928), this is the final stage in the development of the vegetation in the central Kara-Kum, the stage of "sandy mounds with stands of solonchak saxaul."

Under present climatic conditions these groves of saxaul do not tend to die out. However, as noted earlier,[15] some authors are of the opinion that the black saxaul does not replace the white, but appears as part of a different cycle of changes.

In areas of sandy mounds sand saxaul grows on the mounds, while in the bottoms of the depressions, as pointed out above, solonchak saxaul bushes are common. Sand saxaul always grows with an admixture of shrubs—in Turkmenistan, with *Calligonum setosum, kandym* (*C. eriopodum*), the arborescent halophyte *cherkez* (*Salsola richteri*), *chogon* (*S. subaphylla*), and the astragalus *singren* (*Astragalus ammodendron*). The last provides excellent fodder for livestock. The herbaceous cover consists of sand sedge (*Carex physodes*). The level of ground water here lies far below the surface, at 30 to 60 m.

On the ridged sands there is no such wealth of shrubs. These sands are held fast by herbaceous vegetation—wheat grass, brome (*Bromus*), and sedge. Of the shrubs, there is some *dzhuzgun*, white saxaul, "sand acacia," and others.

On the sandy plains of the Kara-Kum, where the sand layer is thin, *polyn* predominates, and the spaces between the *polyn* bushes are occupied by sand sedge [*Carex physodes*] and grasses. Where the sand layer is thicker, there appear the usual sand shrubs.

In the Balkhash sands there is a great deal of ephedra (*Ephedra lomatolepis*), which promotes the stabilization of the sands, but which is not important as fodder. Less numerous are *polyn* thickets, and still less numerous, black saxaul. On the relatively stable, but at the same

[15] See footnote on pp. 146–147.

time sparsely overgrown sands of the Balkhash area, the rubber-yielding *Chondrilla* is found.

In spring, during the rainy season, on all types of more or less stable sands there appears an ephemeral vegetation, which dries up by the middle of May. It consists of sand sedge (*Carex physodes*) and various grasses—predominantly viviparous bulbous blue grass; also wheat grass, brome, and others, as well as dicotyledons. In number of individuals, perennials, such as the sedge and the blue grass, predominate in the plant cover, but there are also many annuals—grasses, papilionaceous plants, and others. Sedge covers not more than half the soil surface. This plant is the only member of the group under discussion which is capable of developing long rhizomes that bear shoots and accessory roots. While the vegetation of the shifting sands does not include any tuber or bulb plants, there are some plants of these types on the stable sands.

In winter among the sandy mounds on the northern slopes there may be found thickets of mosses and lichens.

Among the sands there are some solonchaks and *takyrs*. A *takyr,* when it is not covered with sand, does not support vegetation, but halophytes settle on the periphery. The first plant to take hold on a *takyr* is the small undershrub *Salsola gemmascens,* a crooked, squat halophyte typical in southern Turkestan; it is followed by S. *rigida,* which resembles it in appearance. In the north of the desert zone the pioneer on the *takyrs* is *biyurgun,* the halophyte *Anabasis salsa,* which is also a small undershrub; this plant is found from the lower Volga region to Mongolia.

In the sands—in the Kara-Kum, the Kyzyl-Kum (along the branches of the Dzhany-Darya and the Kuban-Darya), the valley of the Syr-Darya at Chiili, the Muyun-Kum, and between the Ili and the Karatal —there grow large thickets of black saxaul. They are associated not with the sandy areas, where shrub sand saxaul grows in mixed stands, but with the salinized sandy-loam and clayey areas. Saxaul is one of the most peculiar woody plants of the desert. Korzhinsky has written (1896):

> Thickets of saxaul can be compared neither with forests nor with shrub vegetation of the temperate belt, and, in general, not one of the terms used in literature and science may be applied to them. They constitute a completely unique type of vegetation, so original and curious that I believe it can never be erased from the memory of anyone who has had occasion to see it even once in his life.

Another student (Shnitnikov, 1925) describes the thickets of black saxual as follows:

The saxaul forest makes a strange and even an awe-inspiring impression on a person who is not accustomed to it. First, in spite of its dense stand, it has about it a kind of luminous quality, due to the pale bark and the arrangement of the branches, which do not give shade. In hot weather it is hotter within the saxaul thicket than outside it, because it cuts off the wind and at the same time gives little protection against the sun. Furthermore, there is usually silence in the saxaul forest, as the bird population is far from rich in either species or number of individuals. An awe-inspiring effect is produced by the mass of dead saxaul lying about, which is dark in color and has the oddest, most fantastic shapes. A dead saxaul forest presents a particularly gloomy aspect: some of the trees have fallen and lie in lifeless, black heaps, while others stand upright, stretching out their branches, which appear to be writhing in convulsions. (See Fig. 33.)

Black saxaul often reaches a height of 4 to 6 m., and occasionally even 8 m. The stand in such a "forest" is not dense; there are about 300 trees (more than 2 m. high) to a hectare. Sometimes individual specimens may measure as much as 120 cm. in diameter near the ground. Contrary to former opinion, saxaul grows rather rapidly; on abandoned plowlands there may be found saxaul four years old which is 1.5 m. high. The heavy wood of the saxaul provides an excellent fuel. The specific gravity of black saxaul wood is 1.2 (while that of pine is 0.5). The saxaul tree is so hard that it is difficult to chop it with an axe. But virgin saxaul groves, as has been pointed out already, are filled with masses of windfalls, the total quantity of which sometimes exceeds the amount of wood that is standing, and these windfalls can lie for decades without deteriorating. (White saxaul, on the contrary, may be preserved for only a short time.) Saxaul can survive neither strong salinization of the subsoil, nor inundation by water. Black saxaul grows best on slightly salinized, clay-loam soils associated with the valleys of former rivers, in places where there is, even temporarily, an influx of ground water. In the Trans-Caspian Kara-Kum large flocks of sheep graze all year round in the thickets of black saxaul.

3. Vegetation of the *loessial piedmont plains.* The vegetation on soils which are not excessively saline, in the Golodnaya Steppe between Dzhizak and the Syr-Darya, may serve as an example of this plant association. In spring, during the rainy season, a solid stand of ephemera covers the surface, but fades as soon as the rainy season is over. The summer and autumn vegetation has a typical desert character, or the vegetation may even fade completely. Ephemera are plants which have a very short vegetative period. They begin to develop in March and drop their seeds by the end of April. The speed with which these plants de-

velop, as Popov points out, is due in part to the fact that they are winter plants, which germinate in late autumn when the rains begin to fall. The great majority of these ephemera are blue grasses and sedges. It is interesting to note that these perennials, in spring, usually form a continuous cover, denser than the cover formed by steppe vegetation.

> It may be said that the plant associations of the ephemera-covered desert develop the maximum density which may be reached by herbaceous vegetation. The soil is completely covered with herbage; furthermore, its surface is a continuous sod, so compact that the soil is penetrated with difficulty by a spade (Korovin).

Viviparous bulbous blue grass (*Poa bulbosa var. vivipara*) is a perennial grass which usually grows 30 to 40 cm. tall, in small tufts 2 to 3 cm. in diameter. Its stem at the base forms what appear to be small bulbs, which are capable of surviving drought over very long periods. These bulbs have germinated after having lain for ten years in a herbarium. But this blue grass also has another sort of small bulb, from which it gets the name "viviparous." In the ears, that is, in the axillae of the floral leaves, instead of flowers there develop small bulbs, fifty in number, which serve the plant as seeds; when they fall off, they give rise to new plants. The grazing of livestock does not injure the blue grass, since the stock, by loosening the sod, scatters in different directions the small bulbs which lie at the base of the stem, and permits new sod to form. The root system of the blue grass reaches a depth of 12 to 15 cm. According to the observations of Spiridonov, in 1915 in the Golodnaya Steppe the blue grass began to ear on April 5, while the small bulbs in the ears began to develop on April 16.

The narrow-leaved sedge, *Carex pachystylis* (*C. hostii*), is also a perennial plant, very closely related to the sand sedge *C. physodes*. Its upright stem is 15 to 20 cm. tall. In the Golodnaya Steppe in 1915 it bloomed on March 27, while on April 12 most of the plants bore fruit. It reproduces chiefly vegetatively, by means of growing rhizomes.

During the early days of March the vegetation of the loessial piedmont plains awakens. By the end of March the earth has a continuous low cover of sedge and blue grass, among which may be distinguished the flowers of prostrate knotweed, speedwell, and geranium. In the middle of April poppies bloom in large numbers, in some places covering the steppe with a continuous red carpet. The perennial buttercup (*Ranunculus severzovii*), which reproduces vegetatively, and the liliaceous *Ixiolirion tataricum* [*I. montanum tataricum*], which reproduces by small tubers developed on a rhizome, also blossom at that time. At the end of April the steppe begins to turn yellow, and by the middle of May it already takes on its summer and autumn appearance: Sedge, blue grass, and other spring plants fade, and in their place there appears the small, insignificant, prostrate euphorbia, or *taban-kok* ("green sole," *Euphorbia chamaesyce var. canescens*). This euphorbia does not form a close cover, but is scattered in patches 3 to 8 cm. in diameter, with spaces 3 to 12 cm. between. It grows until autumn. Sometimes in the interspaces there are lichens. In 1915 young sprouts of euphorbia were observed on May 10; flowers appeared in the middle of May. According to Spiridonov (1921), euphorbia provides fodder for sheep.

Among the ephemera there are annuals as well as perennials. The annuals include *Malcomia turkestanica,* a crucifer, the violet flowers of which in some places stud the steppe in a continuous cover; also poppies, legumes, and the curious plant *Diarthron vesiculosum,* which continues to bloom even at the beginning of May, when all the other plants have faded, and grows until autumn, while the other annuals have a total life cycle which is only one to one-and-a-half months long.

In the Golodnaya Steppe is found the gigantic umbellifer devil's-dung giant fennel, or *sasyk-kuray* (*Ferula foetida*), which yields a foul-smelling, resinous substance used in medicine. The resin is contained in the vigorously developed roots. The devil's-dung giant fennel is a perennial plant, but it dies after its seeds have ripened.

In some places in the Golodnaya Steppe grow thickets of *ak-kuray* (*Psoralea drupacea*), a large papilionaceous perennial, which grows up to 1 m. high. It blooms in the middle of May, bearing pale-violet flowers. In some parts of the steppe there are areas covered by the *polyn Artemisia scopaeformis.*

The same type of vegetation is found on unplowed loessial areas in the neighboring Tashkent *raion.* Levant *polyn,* or *darmina* (*Artemisia cina*), is characteristic for the region of Arys station. The flower heads of this plant yield a well known anthelmintic, santonin.

Large areas of the Golodnaya Steppe are occupied by solonchaks, on which grow the halophytes *sarsazan* (*Halocnemum strobilaceum*), *karabarken* (*Halostachys caspica*), *balyk-kuz* (*Salsola lanata*), *kuyandzhun* (*Halocharis hispida*), and the annual halophyte *Gamanthus gamocarpus,* as well as tamarisk, and others. Where ground water lies rather deep (3 to 4 m.), the *polyn Artemisia maritima* predominates. On the moist solonchak shores of water basins, the halophyte *Salicornia herbacea* appears in large numbers.

4. Vegetation of the *river valleys*. Because of the saline subsoils, the abundance of salt in the river waters (see above, p. 144), and the intense evaporation, the meadows in the desert zone, as a rule, are salinized.

In the *tugay* belt or the contemporary flood plain of the Syr-Darya, so-called *azhrek* meadows are widespread. *Azhrek* is the grass *Aeluropus litoralis,* which belongs to the rhizome group, and is characterized by leaves covered with grains of salt emitted by the leaf tissues. It has a powerful root system. In some places this solonchak grass, which is eaten readily by livestock in autumn and winter, forms a rather dense ground cover. *Azhrek* is accompanied by two other grasses, the Bermuda grass, *Cynodon dactylon* (also a rhizomic plant), and *Atropis distans* [*Puccinellia distans*], which is sod-forming. In addition to the *azhrek* meadows, in the flood plain we find enormous reed thickets (*Phragmites communis*) (Fig. 36), in some places thickets of the spiny shrub Siberian salt tree (*Halimodendron argenteum* [*H. halodendron argenteum*], a legume), and individual poplars. The flood plain also contains some puffy solonchaks with scattered bushes of *dzhingyl* or tamarisk (*Tamarix*), as well as sands.

The ancient flood plain of the Syr-Darya, or the terrace which lies immediately above the meadow terrace, constitutes a *takyr,* in the broad sense of the word. In addition to the bare patches of *takyr,* there are solonchaks; thickets of black saxaul, white *polyn* (*Artemisia terrae-albae*), and *biyurgun;* and sands. The southern boundary of the distribution of *biyurgun* along the Syr-Darya is the latitude of Tashkent; the southern boundary of white *polyn,* Arys. Because of the predominance of these plants, this desert is called the *biyurgun-polyn* desert.

The thickets of *polyn* are separated sharply from the patches of *biyurgun.* Among the *polyn* is found the squat halophyte *itsegek* (*Anabasis aphylla*). In some places the latter achieves great development, and such places may be called *polyn-itsegek* deserts.

Biyurgun is a plant which is characteristic for the northern zone of the desert (and for the semidesert). Nevertheless, along the Syr-Darya valley it penetrates far into the subzone of sands, bordering upon the southernmost subzone.

We have referred above to the *tugay* belt, by which name geographers designate the flood plain. But *tugay* in the language of the local population means forest. The tree vegetation along the rivers of the Turanian Lowland is most unique. It consists of a very small number of species. The Euphrates poplar (*Populus diversifolia* [*P. euphratica*]) predominates; this tree has narrow and long lower leaves, like the willow, while its upper leaves are broad. There is an admixture of another poplar, the bloomy poplar (*P. pruinosa*). The maximum age of the poplars is thirty to forty years. These trees are accompanied by a number of shrubs: willow or *tal,* Russian olive or *dzhidá* (*Elaeagnus angustifolia*), several species of tamarisk (*Tamarix*), whose pink and violet flowers add much to the color of the landscape, the above-mentioned spiny shrub Siberian salt tree, and, finally, the wolfberry (*Lycium*).

Among the herbaceous plants of the *tugay* are vines which twine the trees and shrubs. These include oriental clematis (*Clematis orientalis*) with stems sometimes as thick as a man's hand, *Cynanchum acutum,* and hedge glorybind (*Calystegia sepium* [*Convolvulus sepium*]). In the *tugay* regions the common reed (*Phragmites communis*); dogbane (*Apocynum venetum*), which yields a valuable fiber (in the flood plain of the Ili River the dogbane grows taller than a man); common licorice or *miya* (*Glycyrrhyza glabra*); camel's-thorn or *dzhantak* (*Alhagi camelorum* [*A. pseudalhagi*]); and Syrian bean caper (*Zygophyllum fabago*) are common.

The thickets of tall grass in the lower courses of the Surkhan and the Vakhsh (tributaries of the Amu-Darya) are of interest. The common reed (*Phragmites communis*) and the bamboolike giant reed (*Arundo donax*) sometimes grow as tall as 6 to 8 m. In addition there are also the giant grasses *Erianthus ravennae* (which grows 3 m. high) and *Saccharum spontaneum.* In some places these thickets spread over tens of kilometers, and tigers and deer take shelter in them.

In the river valleys there are dense thickets of tamarisk, which sometimes form impassable brakes.

The valley forests of Semirechye have a different appearance. Here there are no poplars. In some places in Semirechye along the river valleys (Chu, Talas, Ili, Karatal, and also the western shore of Lake Issyk-Kul) there are found unique chee-grass meadows (*sazy*) (Fig. 37). Chee grass (*Lasiagrostis splendens* or *Stipa splendens*) is a tall grass, up to 1.5 m. high, which forms a sod. Its shiny, elastic stems are used for weaving matting. It also yields excellent raw material for the manufacture of paper. Chee grass is found also in the mountains. The sod tufts of the chee grass never grow entangled with each other. In the Kara-Kum which adjoins the Aral Sea chee grass grows in the depressions among the sands. In these depressions soils of the meadow type are developed; sometimes they are saline.

Fauna

The fauna of the desert is unique. Here many of the animals are clearly adapted to withstand dryness, high temperatures, and the peculiarities of the sandy, clayey, solonchak, and stony soil. Many of them require very little water. Some of them, during the hot season of the year, go into a dormant state. Many which live in the sandy areas have feet which are adapted to locomotion on the surface of shifting sands (susliks, beetles, and others). Protective coloration is widespread: the sand animals are yellow; the *takyr* animals, gray; and the animals which live in stony areas, variegated.

Some of the elements of the desert fauna of the Turanian Lowland are distributed widely throughout the entire desert belt of the Old World, from Syria to Central Asia—for example, the desert bullfinch (*Bucanetes githagineus*). There are many such forms, which may be found from Africa to the deserts of Central Asia. The following may serve as examples: the giant desert monitor lizard, jackal, hyena, Macqueen's bustard (*Otis macqueeni*), desert nightjar (*Caprimulgus aegyptius*), desert lark (*Ammomanes deserti*), carpet viper (*Echis carinata*), and the sand locusts *Platypterna*.

The fauna of the *northern subzone* differs very little from the fauna of the semidesert. The Mugodzhar suslik (*Citellus pygmaeus mugosaricus*), which is associated with the clayey soils, is found as far as the northern shores of the Aral Sea. The typical yellow suslik (*Citellus fulvus*) and its southern brother (subsp. *oxianus*), which goes into a dormant state in summer, are found on sandy soils. The suslik is of economic importance. In this subzone there are also jerboas: the large jerboa, *Allactaga jaculus* [*A. major*], and two small jerboas, *A. elater* and *Alactagulus acontion* [*A. pumilo*].

The Ust-Urt was inhabited at one time by large numbers of kiang or wild ass (*Equus hemionus*), saiga antelope, and goitered gazelle; the two latter are encountered occasionally even today. Mountain sheep (*Ovis orientalis*) are found sometimes along the western and southern escarpments.

The fauna of the *subzone of sands* is far more unique. Here we find the typical long-toed sand suslik (*Spermophilopsis leptodactylus*), which inhabits the sands from Turkmenistan to Semirechye. Its long, thin toes are beautifully adapted for running along the sand. This suslik does not hiberate in winter. In the sandy mounds a large jerboa (*Rhombomys opimus*) is found in great numbers; in the Turkmenian Kara-Kum there are sometimes more than a thousand of its burrows to a hectare. Where this jerboa is abundant, it is impossible to ride across the sands on horseback because of the burrows. By excavating the sand, the jerboas promote its desiccation and the resulting destruction of shrub vegetation. The small gerbil (*Meriones meridianus*) has a similar distribution. The three-toed jerboa (*Dipus sagitta*) is also very characteristic for the sands. The brush-toed jerboa (*Paradipus ctenodactylus*) is known in Repetek and farther east. The hare is common. The neighborhood of Repetek is inhabited by the peculiar barkhan cat (*Eremaelurus thinobius*). Of the large mammals on the stable sands there are kiang (*Equus hemionus*), goitered gazelle (*Gazella subgutturosa*), and saiga antelope (*Saiga saiga* [*S. tatarica*]). Today these have almost disappeared. The Central Asiatic red deer, or *khangul* (*Cervus elaphus bactrianus*) is found sometimes in the Kyzyl-Kum, in the saxaul groves as far east as the Syr-Darya.[16]

Among the birds, Pander's chough-thrush, *kum-tauk,* or *kum-sauskan* (*Podoces panderi*), a bird of the crow tribe, is characteristic for the sand saxaul. The sands, particularly the sandy mounds, are its native habitat. It is not found in the clayey desert, nor in the mountains of the desert. It does not leave the sands even during the winter. In spring and summer it feeds on the grubs of beetles and the seeds of grasses, while in autumn and winter it feeds on the seeds of saxaul, *dzhuzgun,* and other shrubs. Other birds in the sandy desert are the desert wheatear (*Oenanthe deserti*); the desert warbler (*Sylvia nana*); the tiny Trans-Caspian scrub warbler (*Scotocerca inquieta platyura*), native to the Turkmenian Kara-Kum (this species is distributed from the Sahara to Beluchistan); the desert raven (*Corvus corax ruficollis*); and the desert great gray shrike (*Lanius excubitor pallidirostris*). The mountains of the Kyzyl-Kum are inhabited by the rock partridge (*Caccabis chukar,* or *Alectoris graeca*), which is found often in the sands as well.

The sands are the realm of the reptiles. Here there are many tortoises (*Testudo horsfieldi*) and a great many lizards: the toadheads (*Phrynocephalus*), including the large and curious long-eared toadhead (*Phrynocephalus mystaceus*) and the sand toadhead (*P. interscapularis*), which dig themselves quickly into the sand; the fringe-toed gecko (*Teratoscincus scincus*), that peculiar night lizard, which looks as though it were covered with scales; another night lizard, the lobe-footed gecko (*Crossobamon pipiens*); the Russian house agama (*Agama sanguinolenta*),

[16] N. A. Bobrinskoy, "Geograficheskoye rasprostranenie oleney Sredney Azii" (Geographic Distribution of the Deer of Central Asia), *Zool. zhurn.* (Zoological Journal), XII, p. 84.

which can change its color; the burrowing lizards (*Scapteira*), reticulated and striped; and the *ichkemer*, a gigantic desert monitor lizard (*Varanus griseus*), which reaches a length of more than 1.5 m., and can bite fiercely. Of the snakes, the following are characteristic: the small sand boa (*Eryx miliaris*), up to 0.75 m. long; the *strela-zmeya* ("arrow-snake"), or *ok-dzhilan* (*Taphrometopon lineolatum*), a long and slender snake, which gets its name from the unusual speed of its locomotion; and, in Turkmenistan, the poisonous carpet viper (*Echis carinata*), which is found from North Africa to India.

Of the sand beetles there are many apterous carabids (*Discoptera*), which resemble cockroaches. The following beetles are characteristic: the chafer, *Rhizotrogus*, which looks as though it were covered with flour (the grubs of the chafer feed on the roots of *dzhuzgun*); the translucent, reddish, sand-colored darkling beetle, *Ammozoum;* the large, black and white darkling beetle (family Tenebrionidae), *Sternodes caspia,* one of the most characteristic insects of the sands; and the saxaul longicorn beetle, *Turcmenigenia.* One of the most characteristic sand beetles is the "sand burrower," *Thinorycter,* which is found in the barkhan sands along the middle Amu-Darya near Farab. This small beetle, 3.5 mm. long, is a dung beetle (*Aphodiini*), but unlike other dung beetles, it has lost its lower wings, since it feeds not on the droppings of mammals, but on the remains of vegetation in the sands. The feet of the sand-burrower beetle represent an advanced stage in the development of the fossorial foot of the typical sand burrower.[17]

The fauna of the *loessial piedmont plains* includes the suslik, gerbil, jerboa, mole rat (*Ellobius talpinus*), hedgehogs, Russian desert fox, Macqueen's bustard (*Otis macqueeni*), crested lark (*Galerida cristata*), tortoise, desert monitor, toadheads, and *strela-zmeya* ("arrow-snake"). The suslik, *Citellus fulvus oxianus,* according to Kashkarov, is as much a desert ephemeral as the plants described above. In March it emerges from its burrow, puts on fat, reproduces, and at the end of spring, when the vegetation fades, returns to its burrow, where it sleeps for eight to nine months, until the following spring. In the Syr-Darya Kara-Tau this suslik is found up to an elevation of 1000 m. The desert tortoise (*Testudo horsfieldi*) has the same life cycle as the suslik. The gerbil (*Meriones erythrourus eversmanni*) is found in large numbers as far as Semirechye; it is a pest because of its habit of storing wheat in its burrows, sometimes by the tens of kilograms. Lizards—for example, the Caspian sand gecko

[17] A. P. Semenov-Tyan-Shansky, *Russk. entom. obozr.* (Russian Entomological Review), XIX, 1935, p. 83.

(*Gymnodactylus caspius*)—are found often in the houses. The large jerboa of the northern deserts is replaced here by the closely related species *Allactaga severtsovi.* Among the insects are termites, which are common in the Golodnaya Steppe; and, among the arachnids, a phalangid.

The *tugay* is the habitat of the Turkestan tiger, or *dzhulbars* (*Felis tigris virgata*); in some places this tiger occurs in large numbers (for example, in the deltas of the Amu-Darya and the Ili), while in other places it has been driven out (for example, in the lower course of the Syr-Darya, where it was found as late as the middle of the nineteenth century). The tiger hunts wild boar, which appear in large numbers, and which, in the delta of the Amu-Darya do serious damage to the crops. In the reed thickets the jungle cat (*Felis chaus*), which hunts pheasants, is common. In the shrubs which grow on the river flood plains there are many pheasants, or *kargaul,* of different species. Sometimes one may see the peculiar nests of the tit. The numerous aquatic birds include the glossy ibis (*Plegadis falcinellus*). Hares and jackals (*Canis aureus* [*Thos aureus*]) are numerous in the *tugay.* In the *tugay* along the Amu-Darya, the Turkestan red deer (*Cervus elaphus bactrianus*) is found occasionally as far as the delta, occasionally also in the Kyzyl-Kum, in the saxaul thickets. It is rather more numerous in the *tugay* along the Vakhsh and the Pyandzh.[18]

The Asiatic or migratory locust (*Locusta migratoria*) reproduces in the reeds. Among the locusts native to the *tugay,* there are many subtropical and tropical genera, particularly Indian. There are even some Indian species. The flood plains of the rivers serve as nesting places for hosts of mosquitoes.

The *aquatic fauna* is very unique. Representatives of European fauna (more exactly, Pontic-Caspian-Aral fauna), such as bream, carp, pike-perch, catfish, pike, and minnow [*Aspius aspius*], mingle with representatives of Central Asiatic fauna like the Old World minnow (*Schizothorax*), a peculiar cyprinid with a poisonous black peritoneum (the rest of it being quite edible). This minnow is peculiar to the mountains and to the region of the loessial plains. However, it also inhabits Lake Balkhash. But it is not found in the Aral Sea, for which the following fish are characteristic: the *ship,* a small sturgeon (*Acipenser nudiventris*); the cyprinid barbel (*Barbus brachycephalus*), which reaches a weight of 15 kg.; and, very rarely, the Aral brown trout (*Salmo trutta aralensis*), which goes up into the Amu-Darya. The shovelnosed sturgeon, or

[18] K. K. Flerov, "Turkestansky olen ili khangul" (The Turkestan Deer or *Khangul*), *Trudy Tadzhik. kompl. eksp.* (Proceedings of the Tadzhikistan Expedition), X, 1935.

skafirinkh (*Pseudoscaphirhynchus*), native to the Amu-Darya and the Syr-Darya, is interesting. It is a peculiar member of the sturgeon family whose nearest relatives are found in the Mississippi. The unique Balkhash perch (*Perca schrenki*) is found only in Lake Balkhash and its basin, while the other species of this genus, the common perch (*Perca fluviatilis*), is native to the basin of the Aral Sea, northern Asia, Europe, and North America.

In those rivers of Turkmenistan which drain from the Kopet-Dagh but which do not belong to the basin of the Caspian Sea, we find a unique fauna of the Iranian type.

Near the town of Turkestan (and only there) is found the Turkestan fresh-water crayfish, *Astacus kessleri*. Representatives of this genus generally are absent farther east (and in Siberia); they reappear in the Amur.

A few words now about the fauna of the *oases*. The Senegalese turtle dove (*Streptopelia senegalensis ermani*) nests in the towns and villages which lie no higher than 1600 m. in absolute elevation. The characteristic cooing of this bird, which is heard beginning in the spring, lends a peculiar charm to the settlements of Central Asia. It spends the winter in Tashkent. The stork (*Ciconia ciconia*) is common. Sparrows, which nest in large numbers in the oases, do great damage to the crops. They belong to three species: the house sparrow, the Spanish or black-breasted sparrow, and the field sparrow. Some of them build their nests in the trees. The Indian golden oriole (*Oriolus kundoo*) is common. The unusual Indian paradise flycatcher (*Tchitrea paradisea turkestanica*), which is found also in the mountains, nests in the oases.

The deserts of the Transcaucasus will be discussed below, in the chapter on the Caucasus (pp. 235–239).

VIII · Mountains of Soviet Central Asia

Relief

IN Soviet Central Asia four mountain systems may be distinguished, according to the period during which the most intensive folding took place (Berg, 1936). These are (see map):

(1) The Caspian system, in which the most intensive folding took place during the Mesozoic period. This system includes the Mangyshlak Mountains, the region of Krasnovodsk Plateau, and the Great Balkhan.

(2) The Kopet-Dagh-Pamir system, which is the youngest. This system underwent the most intensive mountain-forming processes during the Tertiary period. It belongs to the alpine type of mountain system (or, at any rate, is closely related to the alpine type). This system includes the Little Balkhan, Kopet-Dagh, Paropamiz, and the southern arcs of the Tian Shan (that is, the Hisar, Peter I, and Darvaza ranges), as well as the Trans-Alay range and the Pamir. The Himalayas are a continuation of this system.

(3) The central arcs of the Tian Shan, in which the most intensive folding took place during the Upper Paleozoic period: the Alay, Turkestan, Zeravshan, Karategin, Fergana, and Kokshal ranges; the ranges along the left bank of the Naryn, the Khan-Tengri, the Dzhungarian Ala-Tau, the Tarbagatay, and the Saur. The Kuen-Lun is a continuation of this system.

(4) The northern arcs of the Tian Shan, in which the most intensive folding took place during the Lower Paleozoic period: the Sultan-Uiz-Dagh, the Kyzyl-Kum Plateau, the Nura-Tau, the Chatkal range, the Pskem range, the Syr-Darya Kara-Tau, the Talas Ala-Tau, the Aleksandrovsk range, the Susamyr, the Dzhumgol, the ranges along the right bank of the Naryn, the Terskei-Ala-Tau (?), the Kungei-Ala-Tau (?), the Trans-Ili Ala-Tau (?), and the Chu-Ili Mountains. Our inadequate knowledge at present makes it impossible to distinguish clearly the northern from the central arcs of the Tian Shan.

1. *The Caspian system.* The Mangyshlak Mountains lie between Kochak Bay on the west and the Gulf of Kaidak on the east (Fig. 38). Here the Kara-Tau ridge, composed of strongly dislocated marine Triassic strata on which are superimposed Jurassic and Cretaceous sediments, extends WNW to form an enormous anticline. To the north and to the south there lie two ranges composed of Upper Cretaceous strata and known as the Northern Ak-Tau and the Southern Ak-Tau; they are separated from the Kara-Tau by elongated depressions. A large part of the Mangyshlak Kara-Tau is a plateau which drops in a steep escarpment to the depression which separates it from the Northern Ak-Tau. The absolute elevation of this plateau on the west is 300 to 340 m. The highest points of the Kara-Tau rise to 557 m.; of the Ak-Tau, to 320 m.

The Krasnovodsk Plateau lies between Krasnovodsk Bay and Balkhan Bay on the south, and the Gulf of Kara-Bogaz-Gol on the north. To the east it stretches as far as the Chilmamet-Kum sands. The plateau drops to Kara-Bogaz-Gol Gulf in a precipice 260 to 280 m. high; the mean elevation of the plateau above sea level, however, is about 200 m. The plateau is composed of almost horizontal Tertiary strata; at the southern edge of the plateau these strata overlie the eroded Krasnovodsk anticlinical fold, which is composed fundamentally of Mesozoic rocks (Jurassic to Cretaceous). At Krasnovodsk there is a massif of igneous rocks, the Sha-Kadam ("shah's foot"), 185 m. in absolute elevation, composed of porphyrite and diorite.

At its eastern end the Krasnovodsk Plateau adjoins the Great Balkhan range (elevation 1867 m.). In form the Great Balkhan, with many reservations, may be considered a plateau. The Great Balkhan system consists of several anticlinical folds. These mountains are composed largely of a thick bed of limestones, which date from the Upper Jurassic to the Lower Cretaceous.

2. *The Kopet-Dagh-Pamir system.* The Kopet-Dagh, or Turkmen-Khorasan mountain range lies in southern Turkmenistan. It is possible that this range is tectonically an eastern extension of the Elburz Mountains, which overlook the basin of the Caspian Sea from the south, but little is known on this subject as yet. On the east the Kopet-Dagh extends as far as the Tedzhen; beyond this river, in Afghanistan, it merges into the Paropamiz. The main body of the Kopet-Dagh lies in northern Iran; only the outskirts of the range lie within the boundaries of the Soviet Union. South of Firyuza there is a peak 2940 m. in elevation, while to the south of the international boundary there are elevations of over 3300 m. Within Turkmenistan the Kopet-Dagh is composed of Creta-

ceous and Tertiary deposits. From the middle of the Miocene period the open sea no longer penetrated into the region of the present Kopet-Dagh; only inland seas, like the Caspian, extended into this area. Of the deposits left by such seas, the Sarmatian, developed in the foothills, extends not quite as far east as the meridian of Geok-Tepe. Very intensive folding took place here between the Sarmatian and the Akchagyl (the middle of the Pliocene). There were severe dislocations also at the end of the Pliocene. The Kopet-Dagh, which nowhere reaches into the region of everlasting snows, in general has a desert aspect. There are no forests growing on it; the trees on its slopes include individual specimens of *archá* (*juniper*), and only in the deep valleys are there found maple, elm, fig, and other trees. The Kopet-Dagh is very poor in water, especially its northern slope, which is drained by only insignificant streams which lose themselves in the desert.

On the east, as we have said, the Paropamiz is a continuation of the Kopet-Dagh; it constitutes the connecting link between the Kopet-Dagh and the Hindu Kush. Only the foothills of the Paropamiz lie within the boundaries of the Soviet Union. This is the Badkhyz country, which lies between the Tedzhen and the Murgab; it reaches an absolute elevation of 1255 m. The Paropamiz range, which lies within Afghanistan, is visible from the hills in the vicinity of Kushka.

Beyond the Amu-Darya, the Kopet-Dagh-Pamir system continues in the Peter I range, near the eastern end of which, not far from the place where it borders upon the Akademii Nauk (Academy of Sciences) range, a majestic peak was discovered recently; this is Stalin Peak, the highest point in the U.S.S.R., 7495 m. in elevation (Fig. 39).[1] East of the Akademii Nauk range, at the source of the Muk-Su River, which empties into the Surkhob (Vakhsh), lies the Fedchenko Glacier, the longest valley glacier in the world; it is 77 km. long, and descends from an elevation of 5330 m. to 2900 m. A characteristic feature of the Peter I range and of the other ranges of the Pamir-Alay is that they are convex to the north. This is evidence that the fold-forming impulse came from the south; there was a vigorous development of seas during the Upper Paleozoic, Mesozoic, and Cenozoic, and, finally, a very intensive folding toward the middle or at the beginning of the Tertiary period.

Pamir is the name given to the mountainous country which stretches from the Trans-Alay range on the north to the Hindu Kush on the south. On the east the Sarykol range serves as its boundary; on the west, the

[1] This elevation appears in the report, *Tadzhiksko-pamirskaya ekspeditsiya 1933 g.* (Tadzhik-Pamir Expedition, 1933), Leningrad, 1934.

Pyandzh valley. The Pamir constitutes a lofty desert upland, a miniature Tibet, where the ranges reach 5000 to 5500 m. in elevation, while the valley bottoms (in the eastern Pamir) lie at 3600 to 4000 m. (Fig. 40). Lake Kara-Kul, which has no outlet, lies at an elevation of 3954 m.[2] Lake Zor-Kul, at the source of the Amu-Darya, lies at about the same elevation. This lake is the source of the Pamir River, which, together with the Vakhan-Darya, forms the Pyandzh (as the Amu-Darya is called above the mouth of the Vakhsh).

Lake Sarez, in the Bartang or Murgab valley, is of interest. It was formed on February 18, 1911, as a result of a colossal landslide which dammed the course of the Bartang at Usoy village and formed a ridge 800 m. high across the valley. From that time the level of the lake has risen, and the lake itself has grown larger in size. In October, 1913, it was 28 km. long, 280 m. deep, and its surface lay at an elevation of 3077 m.[3] In August, 1915, it was 350 m. deep. In 1934 its depth had reached 500 m., and it was 60 km. long.[4] The mountains which surround the lake rise to an absolute elevation of almost 6000 m. The descent of the tremendous mass of crumbled material at the time of the landslide was accompanied by an earthquake, which some believe to have been the cause, others (I. Preobrazhensky, 1920), the result, of the landslide.

The Pamir is divided into western and eastern parts; the former constitutes a strongly dissected mountain country, while high plains predominate in the latter.

The ranges of the Pamir in general form arcs convex to the north. They consist of intensely dislocated strata, from pre-Cambrian to Tertiary. Ancient glaciation in the Pamir was very extensive. In the Murgab valley at one time there was a glacier 240 km. long, which received more than 55 lateral glaciers, some of which were 80 and even 90 km. long. According to the investigations of D. V. Nalivkin, two, and in some places three phases of glaciation are distinctly apparent in the Pamir. At present, glaciers of the hanging and cirque types predominate, but there are also some valley glaciers.[5]

[2] Its depth reaches 236 m.—N. L. Korzhenevsky, "Oz. Kara-Kul [fiz.-geogr. ocherk]" (Lake-Kara-Kul [Phys.-Geogr. Sketch]), *Tadzhiksko-pamirskaya ekspeditsiya 1934 g.* (Tadzhik-Pamir Expedition, 1934), Trudy (Proceedings), XLII, 1936, p. 34).

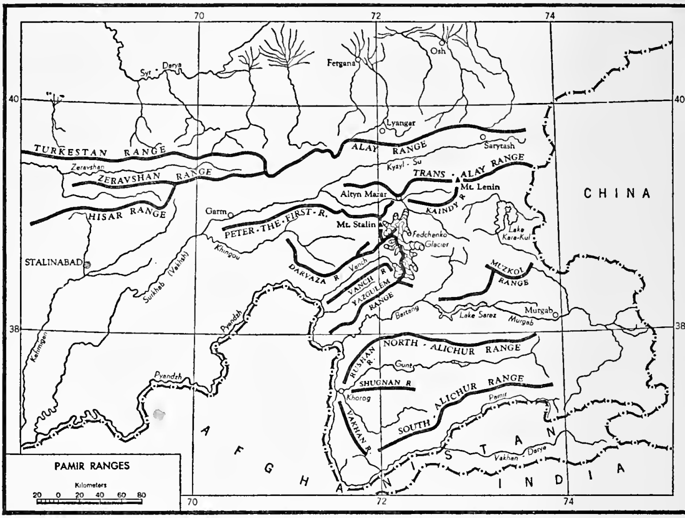
[3] G. Shpilko, *Izv. Geogr. obshch.* (Report of the Russian Geographical Society), Vol. 50, 1914, Nos. 1, 2.

[4] P. P. Chuyenko, "Sarezskoye ozero" (Lake Sarez), *Tadzhiksko-pamirskaya ekspeditsiya 1935 g.* (Tadzhik-Pamir Expedition, 1935), Moscow, 1935, pp. 357–370.

[5] Concerning the glaciation of the Pamir, contemporary and ancient, see K. K. Markov, "Istoriya relyefa i oledeneniya Pamira" (History of the Relief and Glaciation of the Pamir), Sborn. *Pyat let po Pamiru* (Collection, Five Years in the Pamir) izd. Akad. nauk (publication of the Academy of Sciences), Moscow, 1935, pp. 249–324.

In the western Pamir, up to an elevation of 4500 m., extensive areas are covered by loess of diluvial origin.

The Pamir is bounded on the north by the mighty Trans-Alay range, in the middle of which rises the high Lenin Peak[*] (7129 m.), discovered in 1871 by A. P. Fedchenko. The mean elevation of the ridge is



MAP 9. Pamir ranges.

5000 to 6000 m. Kyzyl-Art Pass, which leads from the Alay valley to the Pamir, has an elevation of 4082 m. The Trans-Alay range, according to its structure, appears to be an intermediate link between the Pamir and the southern arcs of the Tian Shan.[6] The most vigorous tectonic folding, which determined the present character of the range, took place during the Upper Tertiary period.[7]

The Peter I, Hisar, and Darvaza ranges belong to the southern arc of the Tian Shan. The chains of the central and northern arcs have been enumerated already (p. 164).

[*] Originally named Mount Kaufman.—Ed.

[6] A. P. Markovsky, "O nekotoroy zakonomernosti raspredeleniya tektonicheskikh elementov Pamiro-Alaya" (Concerning Some of the Principles of the Distribution of Tectonic Elements in the Pamir-Alay), *Tadzhikskaya kompl. eksp. 1932 g.* (Tadzhik Expedition, 1932), Trudy (Proceedings), II, Leningrad, 1934.

[7] V. P. Rengarten, "Zaalaisky khrebet" (The Trans-Alay Range), *ibid.*, p. 38.

The name Tian Shan is given to the aggregate of ranges of different age, which lie to the north of the Trans-Alay range and to the east of the Amu-Darya. However, there is no sharp boundary between the Tian Shan and the Pamir-Alay. The Tian Shan was regarded formerly as a system of folded mountains which were formed during the Tertiary period, and was considered to be of the alpine mountain type. But we have seen already (p. 164) that this view is mistaken. Only the southern arcs of the Tian Shan were formed during the Tertiary period; the other ranges of this mountain system were formed by folding which took place during the Lower and Upper Paleozoic period. In the course of the long continental period which followed, the folds of the northern and of some of the central arcs were denuded and turned into those peculiar flat, bare summits (*syrts*) which we find south of Lake Issyk-Kul, in the Dzhungarian Ala-Tau, and in other ranges. In the Tertiary period the Tian Shan region closely resembled the present Kazakh Folded Country (see above, p. 95). During that period, and, in the opinion of some authorities, at the beginning of the Quaternary, new dislocations took place; these gave the Tian Shan its present character. Until recently these dislocations were supposed to have been caused by thrust faulting. However, it may be pointed out that as a result of such movements, there should have been found young volcanic effusions, of which there is no trace in the Tian Shan. Consequently, at present there is inclination to consider these dislocations as faults of tangential origin. However this may be, the Tian Shan ranges are formed of massifs in the shape of chains.

Traces of the glacial epoch are less in evidence in the Tian Shan than in the Alps. Some students believe there were two glacial epochs, while others (Makhachek) believe there was only one. The snow line during the glacial period was 600 to 800 m. lower than at present, while within the mountains, it was as much as 400 to 500 m. lower; that is, much lower than was the case in the Alps. As for the present glaciers, we have spoken already of the Fedchenko Glacier. Another large glacier, the Inylchek, which has its beginning in the region of Khan-Tengri (elevation 6992 m.),[8] is more than 70 km. long; its lower end lies at 2880 m. (Fig. 41).

A very characteristic feature of the glaciers of the Tian Shan is the accumulation of moraine material in their lower extremities. A third or a fourth of the length of some of the glaciers is so cluttered with detritus that the surface of the ice is completely obscured by it. On the Inylchek

[8] The elevation of Khan-Tengri is given according to the data of the military-topographical survey of 1912 (22,940 ft.).

Glacier the rock fragments form a continuous cover over the entire lower 20 km., reaching a thickness of 100 m. The same condition exists on the Zeravshan Glacier and on many others (Fig. 42). The explanation lies in the fact that in the dry climate of Central Asia, weathering and disintegration of rocks proceed very intensively.

Another characteristic of many glaciers of the Tian Shan (this is particularly noticeable in the Peter I range) is the absence of any *névé* basin at their heads. The glaciers are fed by avalanches of snow, falling from the steep walls which surround the glacier.

The snow line in the Tian Shan, as a result of the dryness of the climate, reaches a considerable elevation. In the northern chains it lies at 3400 to 3600 m., that is, about a thousand meters higher than in the northern chains of the Alps. The snow line is lowest in one of the northernmost ranges, in the Dzhungarian Ala-Tau, where it lies at 3200 m. To the south, and also to the east, the snow line rises. In the central Tian Shan, passes which lie even higher than 4000 m. are free from snow in summer. In the western part of the Peter I range, the snow line lies at 4300 m.; in the eastern part, at 4600 m. In "desert" Pamir it lies extremely high, at 5000 m. and even higher.

The Tian Shan has few lakes. Conspicuous among them is Issyk-Kul, a large and brackish mountain lake which is bordered on the north and south by the snow-clad chains of the Tian Shan (Fig. 43). Along its northern shore stretches the Kungei-Ala-Tau, with a mean elevation of 4000 m., while the Terskei-Ala-Tau, with a mean elevation of 4000 to 5000 m., rises above its southern shore. The highest summits reach elevations of over 5000 m. The surface of the lake itself lies at 1624 m. At its western end the Kungei-Ala-Tau is cut by the majestic long and narrow Baum Gorge, along which the Chu River takes its tumultuous course. This river flows within several kilometers of the western end of Issyk-Kul, but instead of emptying into the lake, cuts across the Kungei-Ala-Tau. The lake is very deep; near the southern shore its depth reaches 702 m.[9] On the slopes of the Terskei-Ala-Tau there are several hot springs, from which the lake received its Kirghiz name (Issyk-Kul, "hot lake"). The waters of Issyk-Kul contain 5.8 grams of salt per kilogram of water; [10] that is, approximately half as much salt as the waters of the

[9] L. S. Berg, "Gidrologicheskie issledovaniya na Issyk-Kule v 1928 g." (Hydrological Explorations on Issyk-Kul in 1928), *Izv. Gidrol. inst.* (Report of the Hydrological Institute), No. 28, 1930.

[10] V. P. Matveyev, "Gidrologicheskie issledovaniya na oz. Issyk-Kul v 1932 g." (Hydrological Explorations on Lake Issyk-Kul in 1932), *Ozero Issyk-Kul* (Lake Issyk-Kul), izd. Sov. po izuch. prirodnykh resursov, Akad. nauk (publication of the Council for the Study of Natural Resources, Academy of Sciences), 1935, p. 37.

Aral Sea. The temperature of the water in the open part of the lake does not fall below 4° C. even in winter;[11] for this reason, with the exception of several bays, Issyk-Kul is not covered by ice in winter.

Climate

In the Kopet-Dagh there is a weather station at Gaudan (lat. 37°40′ N), to the south of Ashkhabad, at an elevation of 1485 m. The temperature and precipitation at this station for the years 1898–1914 are shown in Table 9.

Table 9

Temperature and Precipitation in Gaudan, 1898–1914

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Temperature (°C.)	−1.3	1.7	4.2	9.4	15.4	19.9	21.8	21.4	16.8	10.5	7.9	2.5	10.8
Precipitation (mm.)	20	11	23	22	46	10	0	0	8	30	29	18	217

As compared with Ashkhabad (elevation 227 m.), the summer is considerably cooler, and the annual temperature range is smaller. There is almost as much precipitation as at lower altitudes; the maximum, however, occurs not in March, but in May. This shift in maximum rainfall retards the development of vegetation at Gaudan. There is more precipitation in autumn than in winter in Gaudan; in Ashkhabad and in the lowlands, it is the other way around.

In Kheirabad (Kopet-Dagh, above Ashkhabad), at an elevation of 2027 m., the following amounts of precipitation were observed for the years 1928–1931 (for comparison, the figures for Ashkhabad are given for the same period):[12]

Table 10

Precipitation in Kheirabad and Ashkhabad, 1928–1931 (in mm.)

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Kheirabad	21	30	46	57	60	28	35	16	7	25	17	24	365
Ashkhabad	34	27	42	37	31	7	13	3	1	16	11	24	244

Just as in Gaudan, the maximum precipitation comes in May. The dryness of this locality, situated so high up in the mountains, is remarkable.

There is far more precipitation in some parts of the western Tian Shan

[11] V. P. Matveyev, *Priroda* (Nature), 1936, No. 4, pp. 74–77.
[12] M. Pashinsky, *Klimat i pogoda* (Climate and Weather), 1932, p. 176.

which lie at corresponding elevations. Thus, in the Hisar range, on the southern slope, at an elevation of 1700 m., more than 1500 mm. of precipitation annually has been recorded; the maxima come in January and May, while the minimum comes in August (11 mm.).[13]

In the mountains of Soviet Central Asia, the phenomenon of temperature inversion is very common. In winter (and at night in summer) the temperature is higher on the mountain slopes (but not on the plateaus) than in the valleys. Thus, in Irkeshtam (elevation 2850 m.), it is noticeably cooler in summer than in Narynskoye, which lies 835 m. lower, while in winter it is considerably warmer. Another factor which must be taken into account is that the cold waves which spread from the north usually do not reach above elevations even as low as 500 m. For this reason, Tashkent (elevation 479 m.), for example, is considerably warmer in winter than Turtkul, which lie in the same latitude, but 400 m. lower.

Sometimes, however, cold air masses affect considerably higher elevations as well.

The foehn is a very common phenomenon in the foothills of the Central Asiatic mountains. In winter an anticyclone lies over Central Asia. As a result, when cyclones pass over the western Tian Shan from the west (which happens often there in winter), conditions are created which favor the appearance of eastern foehns. Foehns, which are frequent in the region of Tashkent, sweep from the mountains out of the valley of the Chirchik. Sometimes in December when the foehns are blowing, the temperature here rises above 22° C. Foehns are especially frequent from November to April.

Lake Issyk-Kul has a remarkably moderating effect upon the temperature of the surrounding areas. Although Karakol (which is situated near the shore of the lake) lies 900 m. higher than Alma-Ata (775 m.), the mean January temperature in Karakol is − 5.1° C., while in Alma-Ata it is − 8.6° C.; that is, on the shores of Issyk-Kul, which never freezes, the temperature is 3.5° C. higher.

Very low winter temperatures are observed on the high plateaus; at Pamir station (elevation 3650 m.) frosts as low as − 47° C. have been recorded. The warmest month, July, has a mean temperature of about 14° C. The frost-free period here usually lasts about two months, in some years even less. The diurnal temperature range in the Pamirs is very

[13] I. S. Shchukin and M. A. Gilyarova, "Kukhistan," in the publication "Tadzhikistan," *Trudy Tadzh.-pam. eksp. 1933 g.* (Proceedings of the Tadzhik-Pamir Expedition, 1933), No. XXIII, 1936, p. 248.

great; in winter a temperature of − 20° C. may be followed in the afternoon by a rise in temperature to several degrees above 0° C. The temperature of the soil in summer may reach over 50° C. In the eastern Pamirs there are extensive areas of permanent ground frost. Cloudiness is small, the mean annual figure being only 39 per cent. It is greatest in spring and winter, least in autumn (in October, 21 per cent), when there is also a minimum of precipitation. There are only 45 cloudy days on the average during the year.

The distribution of agriculture and fruit growing is a good indication of the climate in the mountains. On the shores of Issyk-Kul, which lies at an elevation of 1624 m., grains are grown—winter and spring wheat, barley (which grows here as high up in the mountains as 1850 m.), and oats. In the village of Tamga, on the southern shore, apples, watermelon, pumpkin, cucumbers, tomatoes, and corn are raised, but grapes and melons will not ripen. In Karakol excellent apples, apricots, and plums are cultivated. To the south of Issyk-Kul wheat will ripen at elevations of 2100 to 2400 m. In the Alay valley wheat is sown up to 2700 m., and barley up to 3000 m. In Shugnan (on the Gunt River) fields of barley and peas rise to 3350 m. and wheat up to 3250 m., while apricots are cultivated up to 2400 m. On the Shakh-Dar, a tributary of the Gunt, the cultivation of apples and pears extends up to 2700 m., apricots up to 3000 m.. wheat up to 3000 to 3200 m., and barley and vegetables up to 3400 m. Along the Pyandzh River, grapes are cultivated up to 2000 m. (Kala-i-vamar).

Table 11 shows the limit of cultivation for crops which grow in the Zeravshan valley:

Table 11

Crops Cultivated in the Zeravshan Valley

Crop	Limit of Cultivation
Rice	1200 m.
Corn	1300
Peaches	1400
Grapes	1800
Millet	1950
Apricots	2100
Barley	2500

For comparison we may point out that in the Alps the boundary of grain culture, and of cultivation in general, does not rise above 1900 m.; it rises this high only on the southern slope.

In the Turanian Lowland the maximum precipitation, as we have seen

(p. 130), comes in spring, the minimum in summer. In the mountains, however, the maximum comes in summer, and the minimum in winter. Tashkent (479 m.), Khodzhent (329 m.), and Andizhan (500 m.) have their maximum precipitation in March; Osh (990 m.), in April; Narynskoye (2031 m.) and Irkeshtam (2850 m.), in May; Pamir station (3650 m.), in June; and the upper course of the Naryn (3600 m.), in July. Minimum precipitation comes not at the end of the summer (in August), as in the lowland, but in winter, in January and February. The delay in the precipitation maximum in the mountains is related to the fact that the higher the mountains are, the later the vegetation develops, and the farther the precipitation of local significance advances into the months of the warm season. However, on the Pamir Plateau, with its desert landscape, the vegetation has no effect on the precipitation. Here the maximum precipitation comes in June; this is an echo of the climate of Tibet.

The steppe and even the desert extend far up into the mountains of Central Asia. The Pamir Plateau, as we have said, is conspicuous for its desert character, especially the eastern Pamir. At Pamir station the mean annual precipitation is about 60 mm. During the entire month of May, 1914, there were only 2 mm. of precipitation (all in one day).[14] However, in the snow-clad region of the mountains, where the glaciers originate, there is probably no less than 1000 mm. of precipitation per year.

Landlocked basins in the mountains are characterized by their dryness, since the air is carried here by descending winds, which bring no precipitation. The Issyk-Kul basin (about 1600 m. in elevation), over which western air currents predominate, may serve as an example. The western shore of the lake has a desert aspect; Rybachye has only 100 mm. of precipitation per year. But at the eastern end, where, because of the relief, the air has to ascend, there is far more precipitation; Karakol has about 500 mm. In winter in the western part of Issyk-Kul there is almost no snow, while in the eastern part there is an abundant snowfall. On the northern slopes of the Terskei-Ala-Tau, forests of Schrenk's spruce are found only in the eastern part, beginning in the vicinity of Ton Bay, where there is abundant rainfall. Correspondingly, the snow line in the Terskei-Ala-Tau in the western part lies at 3850 to 3950 m., while in the eastern part it lies at 3500 m. Similarly, Lake Iskander-Kul, which lies on the northern slope of the Hisar range in the Zeravshan basin, at an elevation of 2268 m., has only about 300 mm. of precipitation annually (Fig. 44).

[14] Western Pamir also has a desert character; but there is more precipitation here; in the lower parts of the valleys the precipitation is about 200 mm. per year.

Soil Belts

Our discussion of the vertical zonation of the mountain soils will be restricted to certain mountain districts which have been studied thoroughly.

On the northern slopes of the Dzhungarian Ala-Tau, in what was formerly Lepsinsk *uyezd* (district), the soils, beginning at the lowest elevation, appear in the following order (Prasolov, 1909):

Up to 600 m.	Soils of the sierozem type, solonchaks, and desert sands.
600 to 800 m.	Chestnut soils of the dry *polyn*-grassy steppes and shrub steppes.
800 to 1200 m.	Chernozem steppe. Dry-land (unirrigated) fields.
1200 to 2000 m.	Chernozemlike mountain-meadow soils under tall meadow herbage.
2000 to 3000 m.	Mountain-meadow leached and peaty soils under subalpine and alpine short meadow herbage.
3000 to 4300 m.	Everlasting snows and glaciers.

In some places the steppes extend much higher up. Thus, in the mountains of Chimkent *raion* chestnut soils extend up to 1500 m., and chernozems up to 1800 m.

South of Naryn, *polyn*-fescue steppes lie at 2500 to 3000 m.

As we see, there is no zone of mountain forest podzolized soils here, since forests are represented poorly in the Tian Shan. However, in some places, between the chernozem (steppe) and meadow zones there is wedged a forest-steppe zone. This zone is found, for example, on the slopes of the Fergana range, where, in Andizhan *raion,* the zonal sequence of soils is as follows (Neustruyev):

1. Lowlands. (Andizhan lies at an elevation of 500 m.) *Polyn*-halophyte solonchak desert; solonized sierozems, solonchaks, and meadow soils. Thanks to artificial irrigation, this is the most important agricultural region: cotton, rice, barley, millet, and wheat are grown here.

2. *Adyrs*—foothills. Semidesert on sierozems, which change quickly with the elevation; up to 1100 to 1200 m., light sierozems. *Polyn*-grass and mixed-herbaceous vegetation. Region of dry farming, which suffers often from drought.

3. Grassy steppe with dark sierozems rich in organic matter, which grade into soils analogous to chernozems. These soils are characterized by a high (up to 12 per cent) content of organic matter, nutlike struc-

ture, and accumulation of carbonates not very far from the surface. Solonchaks and solonetz soils are absent. Reliable crops without irrigation. In the dells and ravines, thick-shell Persian walnut (*Juglans fallax* [*J. regia fallax*]) occurs. This zone extends up to 1600 m.

4. Forest zone, or, more correctly, forest steppe: strips of forest of thick-shell Persian walnut, plum, and apple alternate with meadows and grassy steppes. Under the forest the soils are strongly humus (over 21 per cent), with a distinct nutlike structure, which is reminiscent of forest clay loams or brown forest soils (Pankov, 1935).[15] In the unforested sections there are chernozems.

5. Meadow steppe (*dzhailyau*), 1700 to 2500 to 2700 m. on the slopes facing Fergana and up to 3000 to 3200 m. on the opposite slope of the range. On prominent parts of the relief, on soils which are very similar to chernozems, there is steppe with *polyn* and capillary feather grass. Extensive meadows on chernozemlike meadow soils occur. In the upper parts of this zone (the meadow steppe), there are small coppices of Schrenk's spruce, thickets of juniper, and, in the valleys, maple, poplar, and birch. The soils of this zone are chernozemlike, and, up to the zone of mountain-solonchak soils, are characterized by high humus content and a distinct horizon of carbonate accumulation. The meadow steppe may be cultivated up to 2500 m. (Fig. 45).

6. The subalpine zone begins at 2700 to 3000 m. This is a zone of high-mountain meadows. Here and there at elevations over 3000 m. there is feather grass. In some places the soils are calcareous and resemble chernozem; in others they are lacking in carbonates, lighter in color, and have a brown sod horizon.

From the examples cited, it is plain that the influence of the desert extends far up into the mountains. The air in the mountains is so dry that we find chernozem steppes with feather grass and *polyn* at elevations which in the Alps are covered by everlasting snows.

Vegetation Belts

It must be kept in mind that, with such big differences in latitude as there are, for example, between the Kopet-Dagh (lat. 38° N) and the Dzhungarian Ala-Tau (lat. 44° to 46° N), corresponding vegetation belts are bound to differ considerably. On the other hand, because of the pecul-

[15] Brown forest soils, reported in Tadzhikistan and apparently found also in the mountains of Fergana, occur at elevations from 1500 to 2200 m. Thick-shell Persian walnut grows well on them (M. A. Pankov, "Pochvennie resursy Sredney Azii" [Soil Resources of Central Asia], *Subtropicheskie kultury v Sredney Azii* [Subtropical Crops in Central Asia], Tashkent, 1935, pp. 108–110).

iar climatic conditions which obtain in certain parts of the Tian Shan, the scheme of vertical zonation, such as we presented above for soils, cannot be the same in all the ranges. Thus, at the very same elevation we may find in some places alpine meadows, in others, steppes and semidesert. In the Pamirs, high-mountain desert is found at an elevation at which on ranges of the Tian Shan there lie everlasting snows and glaciers.

The absence of pine and oak in the mountains of Central Asia must be noted. Pine is replaced by arborescent junipers. Spruce and fir have a limited distribution; they are found only in the east. However, in the mountain forests here, there are many wild fruit trees and shrubs: thick-shell Persian walnut, apple, pear, wild myrobalan plum (*Prunus divaricata* [*P. cerasifera divaricata*]), apricot, almond, pistache, Russian olive, grape, and others. The mountains of Tadzhikistan [16] and Fergana were among the first centers in the world where fruit plants were cultivated.

The following scheme reflects roughly the vertical zonation of vegetation for the Tian Shan as a whole: [17]

1. On the low foothills, covered with sierozems, is found the same *desert* vegetation which was described for the loessial piedmont plains (pp. 154–156). There is somewhat more precipitation here than lower down. In spring, in addition to desert sedge and blue grass, many bulb plants bloom here: crocus (*Crocus korolkowi*), hyacinth, gagea, irises, and tulips. Of the summer plants, the first to bloom is the peculiar umbellifer *Scaligeria,* which blooms and bears fruit for three to four years after germination, and then dies. About half the species are annuals. Among the perennial herbaceous plants, more than half are tuber and bulb plants. The perennials grow as scattered individuals, one or two to a square meter. The spaces between them are filled with ephemera; the species are few in number, but each of them is represented by an astonishingly large number of individual plants. Thus, in Tashkent *raion* there are as many as five thousand or more plants to one square meter (Korovin, 1934, p. 273).

The species composition of the foothills vegetation differs somewhat according to individual regions, but in general, the fundamental species everywhere is desert sedge. On the mounds (*bairs*) in Turkmenistan between the Tedzhen and the Murgab and farther east, among the plants

[16] "Plodovie Tadzhikistana" (Fruit Plants of Tadzhikistan), Leningrad, 1935, izd. Akad. nauk (publication of the Academy of Sciences) (*Tadzhik. eksp. 1932 g.* [Tadzhik Expedition, 1932]).

[17] Cf. Korovin, 1934.

which form the background of the vegetation, the desert sedge is accompanied by the gigantic umbellifer *Ferula badrakema.* This plant forms peculiar thickets; it yields resin. East of the Amu-Darya the sedge is accompanied by different species of the labiate *Phlomis,* in some places (in southern Turkmenistan, along the Zeravshan, and in Tashkent *raion*) by the papilionaceous drupe scurf pea, *ak-kuray* (*Psoralea drupacea*), and in the foothills of the Fergana and Aleksandrovsk ranges and farther east, by *polyn.*

2. Higher up, where there is more precipitation, the desert vegetation of the low foothills gradually assumes a semidesert character. In many places, in the Kopet-Dagh, at Samarkand, in the mountains of Tadzhikistan, in Fergana, in the Tashkent-Chimkent region, and in the Aleksandrovsk range, it is replaced by wheat-grass semidesert. Here the wheat grass *Agropyron popovii,* characteristic for this semidesert, predominates, forming a thin cover. The stems of this rhizomic grass grow half a meter high. Another grass is the bulbous barley (*Hordeum bulbosum*), which grows a meter high; its sod is composed of rhizomes. Among the dicotyledons, the inula (*Inula grandis*) is distinguished by its large leaves, and the gigantic umbellifer *Ferula* by its height. Sometimes the vegetation forms a rather dense cover about half a meter tall; but the soil is not covered with sod, as in the true steppes. At the beginning of April this semidesert is overgrown with ephemeral vegetation, among which the viviparous bulbous blue grass is the most numerous species. Near Tashkent at the beginning of April there are many tulips (*Tulipa greigi*) and irises. In the middle of June the wheat grass begins to bloom. In the middle of July the vegetation of the semidesert fades. Korovin (1934) calls this zone the ephemeral steppe, but it is really semidesert, of course; it might be called mixed-herbaceous and wheat-grass semidesert. As distinguished from the semidesert of the lowlands, there is no *polyn* here. This semidesert contains many endemic species and even endemic genera.

In Semirechye this semidesert is replaced by *polyn* and feather-grass semidesert.

In the semidesert and steppe zones, beginning at an elevation of 600 m., from the Kopet-Dagh on the west as far as the western shore of Issyk-Kul there are found thickets of common pistache (*Pistacia vera*), a shrub or small tree which grows in thickets with a thin canopy (Fig. 47). In southern Tadzhikistan and in some places in Fergana pistache grows together with almond. Thickets of pistache are particularly common in Kushka *raion.*

3. Above the semidesert belt of the foothills lies the belt of mountain *dry steppes* on chestnut soils. This zone is well expressed everywhere, from the Kopet-Dagh on the west to the Tarbagatay on the east. These grassy steppes may be called feather-grass and fescue steppes, since capillary feather grass (*Stipa capillata*) and fescue (*Festuca sulcata var.*) predominate. The soil here is covered as densely with the sod of these grasses as in the steppes of the lowlands. In addition to these grasses we may find koeleria (*Koeleria gracilis*) and the pinnate feather grass *Stipa kirghisorum.* In some places, for example in the southern Kara-Tau, there are bushes of spiraea (*Spiraea hypericifolia*). In general, in the Tian Shan these steppes are very similar in character to the steppes of the lowlands of Kazakhstan. In the Kopet-Dagh other species of feather grass are found.

4. At an elevation of 1200 to 1500 m., on chernozems there appear *meadows,* usually accompanied by trees. Often at the same elevation there are steppes, which occupy the southern slopes and the flat watershed areas, while the meadows are associated with the northern slopes. This is a region of dry-land (unirrigated) agriculture.

The vegetation consists of tall herbaceous plants, 70 to 80 cm. and up to a meter high, which form a close stand, but the surface of the soil is not covered with sod so densely as in the flood-plain meadows. There are extensive thickets of shrubs in this zone: sweetbrier rose, the above-mentioned spiraea, honeysuckle, and others, which grow in a close cover. The average height of the shrubs is 1 to 2 m. Dense thickets of different species of sweetbrier rose, up to 1 m. high, are especially characteristic.

Two types of low-mountain meadows may be distinguished (Korovin, 1934) in the mountains of Central Asia: one is found on the northern ranges from the Dzhungarian Ala-Tau (and even from the Tarbagatay and the Altay) as far as some parts of the Talas Ala-Tau and the Fergana and Alay ranges; the other is found on the ranges which lie farther west and south. In the part of the Kopet-Dagh within the Soviet Union, there are generally no meadows.

The northern low-mountain meadows: The large *Ligularia altaica,* or *sasyk-kuray* (Compositae), which grows up to a meter in height and bears yellow flower clusters, is characteristic for these meadows. Another large plant found here is the tall *Eremurus* (Liliaceae). These meadows bloom about the end of July, when the blue *Delphinium confusum,* pink scabious (*Scabiosa alpestris*), geranium, and other flowers form a striking carpet. Smooth brome (*Bromus inermis*) and orchard grass (*Dactylis glomerata*) are found in both northern and southern meadows. Sometimes the grasses are numerous (capillary feather grass, timothy, koeleria, and fescue), and the meadows merge into meadow steppe, changing into steppe on the southern slopes. In some of the meadows the capillary feather grass yields to the pinnate feather grass *Stipa kirghisorum.* Pinnate feather-grass steppes are particularly extensive on the slopes of the Fergana range and in the Dzhungarian Ala-Tau.

The southern meadows: The tall umbellifers, *Ferula* and especially prangos (*Prangos pabularia*), are characteristic for these meadows. Prangos, which grows as tall as 1 m., sometimes forms a dense cover. It bears yellow flowers. The desert candle (*Eremurus robustus*) also grows on the southern meadows. In some places (for example, on the Alay range) the gigantic umbellifers *Ferula jaeschkeana* and *F. ovina* are prominent. At lower elevations the meadow plants are accompanied by many dry-steppe plants (wheat grass, inula, and others).

Many plants of the southern foothill meadows lose their leaves with the coming of hot weather and drought. Such plants include prangos, *Eremurus,* various shrubs, and others. Korovin calls these the ephemeral meadows.

In the southern meadow zone of the Tian Shan there are patches of deciduous *forest,* although they are not very extensive. Their lower boundary in the western Tian Shan lies at an elevation of 1400 to 1500 m.; their upper boundary in Fergana reaches 2000 m.; in Tadzhikistan it reaches 2800 m. Forests of thick-shell Persian walnut (*Juglans fallax* [*J. regia fallax*]) [18] are characteristic for the ranges which lie as far north as the Talas Ala-Tau and as far east as Fergana (Fig. 46). There are numerous apple trees (*Pyrus malus* and *P. korshinskii*) in these forests, represented by a large number of different strains. Sometimes thick-shell Persian walnut forms a dense canopy in the forests. Individual walnut trees grow in Darvaza at elevations up to 2300 m. In some walnut forests in the Arslanbob valley in Fergana, maple (*Acer turkestanicum*), apple, wild myrobalan plum (*Prunus divaricata* [*P. cerasifera divaricata*]), euonymus, and honeysuckle grow together with the walnut. Pure stands of maple may be found above the walnut forests in some parts of Fergana. In the Fergana range there are wild almond and apricot. In the Ugam Mountains (Tashkent *raion*), the trees include thick-shell Persian walnut, apple, maple, wild myrobalan plum, and pear (*Pyrus heterophylla*); there is also a great deal of honeysuckle, spiraea, hawthorn, barberry, and *Celtis australis.* Often the trees are twined with grape vines. In the mountain forests of Tadzhikistan there is much maple. In this same zone, in

[18] This is a form of the common Persian walnut, *Juglans regia.*

addition to deciduous trees, there are thickets of arborescent juniper—*archa, Juniperus polycarpos seravschanica* (*kara-archa*)—on the rocky slopes. Within this zone, at an elevation of 1432 m., lies the weather station of Chimgan, where 995 mm. of precipitation were recorded in 1922.

Stands of hawthorn (chiefly *Crataegus monogyna*) and apple, which have more nearly the character of shrub thickets, are very extensive in the Tian Shan.

In the mountains of central Tadzhikistan [19] the forest zone occupies a belt between 1500 and 2800 m. Turkestan maple (*Acer turkestanicum*) and thick-shell Persian walnut predominate among the trees at elevations up to 2200 m. The shrub or sapling of the Turkestan pearlbush (*Exochorda alberti* [*E. korolkowii alberti*], which belongs to the rose family and is related rather closely to the spiraea) is common. In some places there is flowering plum (*Prunus ulmifolia* [*P. triloba*]) as well. The Turkestan maple is a relict form, the closest relatives of which are found in the Mediterranean countries, the Caucasus, the Himalayas, and the Far East. Other ancient types which have an interrupted distribution are the thick-shell Persian walnut, pearlbush, and flowering plum. Higher up, between 2200 and 2800 m., tree and shrub vegetation is represented by the Turkestan maple, juniper (*Juniperus polycarpos seravschanica*), Austrian brier rose (*Rosa lutea* [*R. foetida*]), and honeysuckle.

In the Trans-Ili Ala-Tau the thick-shell Persian walnut is absent. Here in the low-mountain meadow zone grow sparse, deciduous forests of apple, mountain ash, white birch (*Betula tianschanica*),[20] aspen, poplar, maple, apricot, elm, and others. From these forests, which abound in apples, the town of Alma-Ata got its name (from *almá*—apple). In the neighborhood of this town the cultivation of a famous variety of apple, the Vernensk Aporta, has been developed. Wild apple grows in Semirechye at elevations from 800 to 1500 m., and in some places even higher. (There are some apples on the shores of Issyk-Kul.) The upper limit of deciduous forests here lies at 1500 to 1700 m.

5. Above the low-mountain meadows lie the *subalpine meadows.* (It is not possible to draw a clear boundary between them everywhere.) In the Trans-Ili Ala-Tau they begin at an elevation of 1500 to 1600 m.; on the Fergana range, which is drier, a thousand meters higher, at 2500

[19] N. F. Goncharov, *Ocherk rastitelnosti tsentralnovo Tadzhikistana* (Sketch of the Vegetation of Central Tadzhikistan), Moscow, 1936, izd. Akad. nauk (publication of the Academy of Sciences).

[20] White birch, in general, is widespread in the valleys of the Tian Shan mountain streams.

to 2700 m.; in central Tadzhikistan, at 2700 m.; in the Alay valley still higher, at 3100 to 3200 m. In this same belt, or a little above it, there are usually *coniferous forests* of spruce and fir, and also juniper groves.

Although the herbaceous vegetation of the subalpine meadows is distinguished from that of the low-mountain meadows by its shorter stand, the height of the herbage here is still considerable. The flowers are brightly colored. They bloom simultaneously, and there are a great many species. The soils are of the mountain-meadow type. Several species of *Trisetum* are characteristic among the grasses; occasionally there is pinnate feather grass (*Stipa kirghisorum*), which in some places extends into the alpine zone (up to 3000 m.). Among the other plants are the composite *Senecio soongoricus;* the labiate *Phlomis;* the composite *Ligularia altaica;* and in some places (in the mountains of Tashkent *raion* and in Tadzhikistan), the umbellifer prangos.

In central Tadzhikistan the subalpine meadows lie at elevations from 2700 m. to 3000 m. The most numerous plants here are the composite cousinia (*Cousinia stephanophora*) and the spiny shrub astragalus (*Astragalus nigricalyx*), but the large umbellifer *Ferula* occurs also. According to Goncharov, in the meadow region there is less precipitation than in the forest belt.

On the southern slopes in central Tadzhikistan the cousinia meadows extend up to 3500 m., while on the northern slopes between 3000 and 3500 m. there are high-mountain fescue steppes. Fescue grass (*Festuca sulcata*) is the dominant species in these steppes. There is also much cousinia and *polyn* (*Artemisia lehmanniana*). In general the vegetation of the high-mountain fescue steppe has a xerophytic appearance, and in summer there is less precipitation here than in the belt of cousinia meadows.

Spruce and fir do not extend west of long. 72° E. Only in some places in the mountains of northern Semirechye do we find coniferous forests, which resemble the taiga to some extent; they are on the northern slopes, associated with ravines. Schrenk's spruce (*Picea schrenkiana*) is a magnificent shapely tree with a narrow crown, which is found in the Dzhungarian and Trans-Ili Ala-Tau, in the eastern part of the Aleksandrovsk range, in the Issyk-Kul basin, in some places in the mountains to the south of Issyk-Kul, in the Fergana range, in the eastern part of the Trans-Alay, and on the southern slopes of the Chatkal range and the Talas Ala-Tau. Przhevalsky describes Schrenk's spruce as follows: In form it "resembles a sugar loaf: the short, extremely dense branches nowhere protrude from the general mass; the whole tree looks a great deal as though it had been artificially pruned." Schrenk's spruce grows as tall as 50 m., and reaches a diameter at breast height of 2 m. Students of the spruce-forest soils in the Dzhungarian Ala-Tau classify them as slightly-podzolized forest types. (Perhaps they are brown forest soils.) The spruce forests here contain aspen, bird cherry, raspberry, and juniper. On the northern slopes of the Tarbagatay there is Siberian spruce (*Picea excelsa obovata* [*P. obovata*]). Siberian fir (*Abies sibirica*) is found in some places in the Dzhungarian Ala-Tau, while a closely related species, the Turkestan fir (*A. sibirica semenovi*), is found in the Talas Ala-Tau and in the Chatkal range. In all the rest of Central Asia, the only conifer is the juniper. Spruce and spruce-fir forests nowhere occupy large areas. In addition to spruce and fir there are the small Tian Shan mountain ash (*Sorbus tianschanica*), several species of honeysuckle, Semenov's euonymus [*Euonymus semenovii*?], raspberry, and sweetbrier rose. In some places the undergrowth contains the singular shrub abelia ("Moses' staff," *Abelia corymbosa*), 3.5 to 4 m. high; staves are made from its solid wood. Often the soil is covered with moss. In the herbaceous cover northern forest forms may be found—orchids, pyrola, and stone bramble.

Of the junipers in the zone of subalpine meadows, the arborescent, so-called "semiglobular" juniper, or *saur-archa* (*Juniperus semiglobosa*) is widespread; it grows in true forests on the slopes of the Turkestan and Alay ranges. The ground in these juniper groves is covered with moss.

In the dry climate of the Tian Shan, spruce and fir extend up to an elevation at which in the Alps there is usually everlasting snow, and first appear at an elevation at which conifers usually terminate in the Alps. Thus, the spruce zone on the northern slope of the Dzhungarian Ala-Tau lies between 1500 and 2300 m.;[21] in the Trans-Ili Ala-Tau, between 1800 and 2800 m.; in the Kungei-Ala-Tau, between 1850 and 2850 m.; in the Terskei-Ala-Tau, between 2100 and 2800 m.; and in the Chatkal range, between 1800 and 2850 m. Juniper grows even higher. The upper limit of juniper in the Peter I range is 3000 m.

6. Above the zone of subalpine meadows lie the *alpine meadows*. The alpine herbaceous plants are distinguished from the subalpine by their small height. Many have leaves at the base of the plant in the form of a rosette. Small undershrubs are represented by cushionlike forms. These include the saxifrage (*Saxifraga alberti*), prickly thrift (*Acantholimon marmoreum*), rock jasmine (*Androsace villosa*), and others. Masses of

[21] L. Rodin, *Trudy Bot. inst. Akad. nauk* (Proceedings of the Botanical Institute of the Academy of Sciences) (3), No. 1, 1934, p. 274.

flowers lend a variety of color to the alpine glades. Of the shrubs, the trailing Turkestan juniper, *uryuk-archa* (*Juniperus pseudosabina turkestanica*), is widespread in the alpine zone. Cobresia meadows are very characteristic for the alpine zone of the central Tian Shan; these meadows are named after the sedge *Cobresia,* which in some places covers the soil with a continuous sod. Sometimes the entire vegetation of the meadow consists of one species of cobresia (for example, *C. capillifolia*); sometimes there are also dicotyledons, for example, the common edelweiss, *Leontopodium alpinum.*

The sequence of zones for southern and central Tadzhikistan according to N. F. Goncharov (1936) is shown in Table 12.

Table 12

Zonal Sequence of Vegetation in Southern and Central Tadzhikistan

Type of Vegetation	Elevation
Desert, semidesert, and steppe vegetation	up to 1800 m.
Thickets of shrubs (chiefly *Rosa*)	1800 to 2000
Forest belt	
Maple forests with pearlbush and thick-shell Persian walnut	2000 to 2200
Maple thickets with shrubs (*Rosa* and others)	2200 to 2700
Subalpine meadows	
Mixed-herbaceous meadows with cousinia or bent grass	2700 to 3000
High-mountain steppes with cousinia and fescue	3000 to 3500
Alpine meadows	
Alpine short meadow herbage	over 3500

Having examined the vegetation zones of the mountains, we should mention several types of xerophytic plants which do not fit into the above scheme; their appearance depends upon local conditions of relief and climate. They are found in the Kopet-Dagh (and several other ranges), in the Pamir, and in the *syrts* to the south of Issyk-Kul.

The Kopet-Dagh. These are desert mountains which within the Soviet Union are unforested. The desert here extends high up into the mountains; thus conditions are created which lead to the appearance of a peculiar type of plant, the so-called "mountain" xerophyte. We will describe briefly the zonal sequence in Ashkhabad *raion:*

Up to an elevation of about 350 m., on sierozems, there is desert vegetation of the type peculiar to the loessial piedmont plain. At an elevation of 320 to 440 m. there is *polyn* semidesert on "desert-steppe" sierozems (closely related to the light-chestnut soils), with a very thin herbaceous cover. The *polyns* belong to the *Artemisia maritima* group. After the middle of June, the vegetation fades. In this zone typical spiny mountain xerophytes appear, growing on schists. These plants include *Acantholimon* (Plumbaginaceae), which grows in cushions, with spiny, awl-shaped leaves; and *Acanthophyllum* (Caryophyllaceae), which is very similar to *Acantholimon* in appearance and in the arrangement of the leaves. At an elevation of 500 to 1150 m., on light-chestnut soils, there is wheat-grass and mixed-herbaceous steppe. Here feather grasses are numerous. This is a region of pastures and meadows. In some places wheat and barley are grown here without irrigation. At an elevation of 1100 to 2200 m., on dark-chestnut soils, we find feather-grass and fescue steppes. In the steppe zone mountain xerophytes reach an extensive distribution; often they grow in the form of spiny, cushion-shaped undershrubs. *Acantholimon* and *Acanthophyllum* have been mentioned already. The typical xerophyte, *Gypsophila aretioides* (Caryophyllaceae), native only to the Kopet-Dagh, also is worth noting. It is found, for example, at Gaudan, at an elevation of 1500 m. It grows in the form of pale gray-green cushions, 1 to 1.5 m. in diameter, sometimes flat, sometimes semi-globular. The cushion consists of a multitude of stems which grow so close together that a horse may walk across them without leaving a trace; the cushion is so compact that rain will not penetrate it. This gypsophila blooms in a host of white sessile flowers. Sometimes other plants, which also form cushions, settle on the gypsophila; for example, *Dionysia tapetodes*. Gypsophila burns well, and is used for fuel. Other xerophytes are the shrub tragacanth astragali. These small shrubs, which grow half a meter high and have spiny leaves, yield a resinous substance, tragacanth gum. Another legume found here is *Onobrychis cornuta*, which has spiny leaves. Sometimes the cushions of this plant grow interwoven with *Acantholimon*, forming one continuous, enormous cushion.

In the steppe zone on the northern slopes, beginning at an elevation of 1000 to 1200 m., there may be found at first individual specimens, and, higher up, thickets of arborescent juniper (*Juniperus polycarpos turcomanica*), growing 15 to 17 m. tall. In some places, as an admixture with the juniper, there is maple. Beginning at an elevation of 1500 m., the juniper thickets are developed rather more profusely. Usually they do not form continuous stands, nor do they extend high up into the mountains.

Mountain-xerophytic vegetation reaches its most typical development in the Kopet-Dagh above the steppe belt, at elevations of about 2000 m. and higher.

In the gorges of the central Kopet-Dagh, which are usually dry, grow shrub thickets of hawthorn, sweetbrier rose, honeysuckle, barberry, myrobalan plum (*Prunus cerasifera*), and cotoneaster (*Cotoneaster racemiflora*). Occasionally there are blackberry and woodland European grape. Here and there in the wetter gorges there are trees of Persian walnut (*Juglans regia*), willow, maple (*Acer monspessulanum*), poplar, ash, elm (*Ulmus densa* [*U. carpinifolia*], of the smoothleaf elm group) (Fig. 48), and juniper. In some places there are many wild fruit trees; in addition to the walnut and myrobalan plum, which have been mentioned, there are also almond, pear, plum, common fig (*Ficus carica*), and white mulberry. These shrubs and trees do not extend higher than 1200 m.

The flora of the southern slope of the western Kopet-Dagh, for example in Karakalinsk *raion,* contains a large number of Iranian elements, such as the yellow jasmine (*Jasminium fruticans*), Christ's-thorn paliurus (*Paliurus spina-christi*), common pomegranate (*Punica granatum*), *Vitex agnus-castus,* common jujube (*Zizyphus vulgaris* [*Z. jujuba*], plane tree (*Platanus orientalis*), almond, pistache, and others.

Mountain xerophytes are found in several other mountain ranges besides the Kopet-Dagh—the Nura-Tau, Mogol-Tau, Kara-Tau, and others. Among the plants found on the Kara-Tau is the rubber-yielding *tau-saghyz* (*Scorzonera tau-saghys*), a composite undershrub.

The Pamir Plateau, with its dry and cold climate, constitutes a typical desert with all the various attributes of deserts—soils of the sierozem type, *takyrs*, solonchaks, and shifting sands. The vegetation is sparse, and the mountain slopes, as well as the valleys, are far from covered with verdure. Among the characteristic plants are the small squat halophytic undershrub, Old World winter fat (*Eurotia ceratoides,* native to the stony desert of the Pamirs), which is used for fuel; *Acantholimon diapensioides,* which is flattened in the form of a cushion, and rises 3 to 5 cm. above the stony soil; the cushion-shaped legume, crazyweed (*Oxytropis*); the high-mountain *polyn, Artemisia skorniakovii;* and the feather grass *Stipa orientalis.* In the Pamirs, just as on the Kopet-Dagh, other plants often settle on the cushion-shaped plants. Thus, on the large cushions of *Oxytropis* there have been found as many as ten species of other plants. Lichens and mosses grow on the *takyrs*; sometimes they cover as much as half the surface. On the solonchaks there are very few plants; one of them is the annual crucifer *Dilophia ebracteata.* In moist places in the valleys there are cobresia meadows (see above, p. 184); solonchak sedge meadows are common. But there are alpine meadows as well.

South of Issyk-Kul, the normal mountain zonation of vegetation is not observed on the *syrts,* since they have a more or less flat surface. Where the climate is dry, even at high elevations, steppes and high-mountain desert predominate, while in the wetter places there are cobresia meadows.

Along the Naryn River, steppes rise to an elevation of 2800 m. Here grasses predominate: pinnate feather grass (*Stipa kirghisorum*), fescue, koeleria, desert oat (*Avena desertorum*), timothy (*Phleum boehmeri*), wheat grass (*Agropyron ferganense*), and capillary feather grass (*Stipa capillata*).

In the upper Naryn basin the *syrts* are occupied by high-mountain desert, which resembles the Pamir desert to some extent. Here we find the familiar cushion-shaped prickly thrift, *Acantholimon diapensioides.* The peculiar high-mountain squat *polyn, Artemisia rhodantha,* is prominent; its leaves rise 2 to 3 cm. from the ground, while the rhachides rise 8 to 10 cm. The small bushes of this *polyn* are scattered sparsely over the gray soil. Among them are found cushions of the above-mentioned prickly thrift and tussocks of feather grasses. We have spoken already of the cobresia meadows.

Fauna

The fauna [22] of the semidesert and the lower zones of the foothill steppes does not differ greatly from that which we find in the lowland loessial plain. The European and the bearded partridges (*Perdix perdix* and *P. daurica* [*P. barbata*]) are permanent residents here. In the desert mountains of Tadzhikistan there are fox, wolf, hyena, and porcupine (*Hystrix hirsutirostris* [*H. leucura hirsutirostris*]), while higher up in the mountain semidesert and the mountain steppe there are mountain sheep (*Ovis vignei*). In the foothills the goitered gazelle (*Gazella subgutturosa*) is common.

The following animals are native to the *deciduous forest:* porcupine (*Hystrix hirsutirostris satunini* [*H. leucura satunini*]), which does not go high up into the mountains; wild boar, found from the *tugay* belts to the source of the Naryn (3300 m.); and the Tian Shan badger (*Meles meles tianschanensis* [*M. leptorhynchus tianschanensis*]), which is found also in the desert. The Siberian roebuck (*Capreolus pygargus tianschanicus*) is common here, although more usually it inhabits the coniferous forests. Birds characteristic for the nut-bearing forests are: the Indian

[22] Cf. Kashkarov, 1931. V. N. Shnitnikov, *Mlekopitayushchie Semirechya* (The Mammals of Semirechye), Leningrad, 1936, izd. Akad. nauk (publication of the Academy of Sciences).

paradise flycatcher (*Tchitrea paradisea turkestanica*), which extends as far north as the Talas Ala-Tau; the stock dove (*Columba oenas tianschanica*); and the Old World goldfinch (*Acanthis caniceps* [*Carduelis caniceps*]).

In the *spruce-fir forests* there is Siberian roebuck, or *ilik,* which changes its reddish summer coloration for gray in winter; red deer, or *bogu* (*Cervus elaphus canadensis n. sibiricus* [*C. elaphus sibiricus*]), in the Dzhungarian Ala-Tau; lynx; stoat (*Mustela erminea ferghanae*); the Turkestan weasel (*Arctogale nivalis pallida* [*Mustela nivalis nivalis*]); and the mouse hare (*Ochotona rutila*). In addition there are bear and manul cat (*Otocolobus manul* [*Felis manul*]) in Semirechye. Among the birds in the spruce groves of Semirechye are many northern types, such as the nutcracker (*Nucifraga caryocatactes rothschildi*), which feeds on the seeds of Schrenk's spruce; the crossbill (*Loxia curvirostra*); the bullfinch (*Pyrrhula pyrrhula*); several tits; and the three-toed woodpecker (*Picoides tridactylus tianschanicus*). All of these birds except the bullfinch are permanent residents in the spruce groves of Semirechye. The bullfinch, and also the pine grosbeak (*Pinicola enucleator*) and Siberian rose finch (*Uragus sibiricus*) come here to spend the winter. Near water in the region of the spruce forest (and also to some extent in the deciduous forest) lives the Himalayan blue thrush (*Myophonus coeruleus temmincki*); in some places this member of the thrush family remains to spend the winter; the bird is the size of a jackdaw. In the spruce groves the large Asiatic turtle dove (*Streptopelia orientalis meena*) occurs in large numbers. Some birds nest in the spruce forest, but in winter many of them are found in the deciduous forest also. In Semirechye these include the black-breasted accentor; the Tian Shan kinglet, which resembles the warbler *Leptopoecile sophiae;* several creepers; a northern taiga bird, the hawk owl (*Surnia ulula tianschanica*); and the mountain serin (*Serinus pusillus*), which may be seen in winter in the towns of Semirechye. The spruce forests of Semirechye contain black grouse (*Lyrurus tetrix*), which nests also in other places.

The white-winged hawfinch (*Mycerobas carnipes*) is characteristic for the juniper thickets. Because of its thick beak, it is called *baltá-tumsuk* ("ax-nose") by the Kirghiz. This variegated bird of the finch family feeds on juniper seeds. In Semirechye it lives in the spruce forests also, and in winter it may be found on the streets of Karakol. The rock partridge (*Caccabis chukar* [*Alectoris graeca*])—without sufficient basis it has come now to be called *Alectoris kakelik* [*A. graeca falki*]—is common in the juniper groves.

The subalpine and alpine zone. Here bobac are very characteristic—the red or long-tailed *Marmota caudata;* the two-colored, or Altay-Tian Shan *M. baibacina centralis;* and the Talas *M. menzbieri,* occur at elevations from 200 to 4500 m. On the high-mountain fescue steppes of Fergana, in some places there is found a small relict suslik (*Citellus relictus*). The high-mountain sheep *Ovis polii* and *O. vignei* graze on the high-mountain fescue steppes. In the alpine zone, amid the rocks and rubble, the mouse hare (*Ochotona rutila,* a rodent the size of a rat) is common. This animal is called the "hay stacker," because of its habit of preparing stores of hay in the form of small ricks for the winter. It is interesting that the bobac, suslik, mouse hare, and sheep all appear in the lowlands—in the steppes and to some extent even in the desert (for example, the mountain sheep *Ovis orientalis,* which inhabits Mangyshlak)—as well as in the subalpine and alpine zones. Different explanations have been proposed for this similarity between steppe and high-mountain fauna. Menzbier (1914) believes that the mountain sheep, snow pheasant (*Tetraogallus*), and rock partridge (*Caccabis* [*Alectoris*]) first settled in the lowlands, and subsequently turned into mountain forms as the lowlands were uplifted and transformed into mountains. This view is maintained by A. Semenov-Tian-Shansky for beetles, and by Uvarov for orthoptera. However, by analogy with the vegetation, the opposite view may be upheld—that the steppe forms are derived from mountain forms which were forced to descend into the lowlands during the glacial period. Some steppe forms, however, may have moved into the mountains during the xerothermic period.

Among the other animals found in the subalpine and alpine zones are the following: The Asiatic ibex, or *kiik* (*Capra sibirica*) does not descend below 2500 m., and ranges as high as the boundary of everlasting snows. The snow leopard, or *kaplan* (*Leopardus uncia* [*Felis uncia*]), which hunts goats and sheep, ranges almost as high. The Tian Shan bear (*Ursus arctos leuconyx* [*U. arctos isabellinus*]), closely related to our brown bear, is found not only in the alpine zone, but also in the forest zone. In the alpine zone it feeds on bobac, digging up their burrows; it eats herbaceous plants, chiefly alpine fleeceflower (*Polygonum alpinum*), and descends into the valleys when the berries and fruit (myrobalan plum, apple, and apricot) ripen. In Semirechye the northern dhole (*Cuon alpinus hesperius*) is found in a form which is also native to the Altay. The common wolf and fox also enter the alpine zone. Among the birds is the large Himalayan snow pheasant (*Tetraogallus himalayensis*), a bird which appears at very high altitudes; it is the companion of the ibex and the mountain sheep. The alpine chough (*Pyrrhocorax graculus*), which is found in great numbers in the mountains of southern Europe and southern Asia, is common also in the alpine zone of the Tian Shan, and is found in the Pamirs. A related form, the red-beaked chough (*P. pyrrhocorax*), appears at somewhat lower altitudes. The following birds are very characteristic: the alpine horned lark (*Eremophila alpestris* [*Otocoris alpestris*]), water pipit (*Anthus spinoletta blackistoni*), alpine accentor (*Prunella collaris rufilata*), and the finches *Leucosticte nemoricola altaica* [*Montifringilla nemoricola altaica*] and *L. brandti* [*M. brandti*]. It is interesting to note that the European martin (*Chelidonaria urbica meridionalis*) in Central Asia never nests in the towns. It nests usually in the alpine zone (sometimes close to the snow line), but also in the foothills and in the forest zone.

In the Dzhungarian Ala-Tau the zone of subalpine meadows is inhabited by the endemic Siberian newt (*Ranodon sibiricus*), which does not descend below 1800 m.

The following fish are native to the mountains of Central Asia, from the Kopet-Dagh as far east as the Balkhash basin: the Old World minnow (*Schizothorax*), a peculiar fine-scaled cyprinid which replaces the trout here; the cyprinid *osman* (*Diptychus*), which occurs east of the Syr-Darya; and the loach (*Nemachilus*). Trout are found in Central Asia only in some of the mountain streams of the Amu-Darya basin; for example, in the Alay valley. The sisorid catfish, *Glyptosternum stoliczkai,* native to the mountains of the Amu-Darya and Syr-Darya basins, is unique.

In the subalpine zone of the Tian Shan appear the singular flightless apterous locusts, *Conophyma,* characteristic also for other mountain regions in the Caucasus and in Europe.

The fauna of the *Pamir* has much in common, on the one hand, with Tibet, and, on the other, with the *syrts* of the Naryn basin, which lies south of Issyk-Kul. The huge mountain sheep, *Ovis polii,* which is native also to the *syrts*, is characteristic for the high-mountain desert of the Pamir. The long-tailed marmot (*Marmota caudata*), red mouse hare (*Ochotona rutila*), Pamir hare (*Lepus europaeus tibetanus*), and yak, or *kutas* (which is bred by the Kirghiz), also are widespread in the Tian Shan, Tibet, and the Himalayas. The following birds nest here: the Tibetan snow pheasant (*Tetraogallus tibetanus*); griffon vulture (*Gyps fulvus himalayensis*); mountain or Indian goose (*Anser indicus*), which also inhabits the *syrts*; Tibetan sand grouse (*Syrrhaptes tibetanus,* of the sand-grouse family); desert wheatear (*Oenanthe deserti*); and isabelline chat (*O. isabellina*). Both the wheatear and the isabelline chat, which appear in the *syrts*, are common in the desert of the Turanian Lowland as well.

Of the fish on Pamir, the cyprinid genus *Schizopygopsis* is characteristic for Tibet.

While the Pamir is distinguished by the presence of eastern, Tibetan elements, the *Kopet-Dagh*[23] contains a large number of western Asiatic forms native to Asia Minor, the Transcaucasus, Iran, and Afghanistan. The following large mammals are found here: the wild goat (*Capra aegagrus* [*C. hircus aegagrus*]); mountain sheep (*Ovis orientalis cycloceras*), which still inhabit Dushak mountain in large numbers; leopard (*Leopardus pardus* [*Felis pardus*]); cheetah (*Acinonyx jubatus* [*A. venaticus raddei*]), which is native to the loessial foothills; manul cat (*Otocolobus manul* [*Felis manul*]); the very rare Syrian bear (*Ursus arctos syriacus*); and the honey badger (*Mellivora indica*). The reddish mouse hare (*Ochotona rufescens*), the white-footed mouse (*Calomyscus bailwardi hotsoni*), and the hare *Lepus europaeus tibetanus* are rodents which are found in the Kopet-Dagh and on the Great Balkhan. The alpine meadow mouse (*Microtus nivalis*), which inhabits the Caucasus, is found in the neighborhood of the snow patches. Of the birds, the Caspian snow pheasant (*Tetraogallus caspius*) is native to the high mountains. Lower down, in the belt of juniper groves, we find the white-winged hawfinch and rock partridge, which were mentioned above. The wood pigeon (*Columba palumbus*) is numerous here. The beautiful seesee partridge (*Ammoperdix griseogularis*), which inhabits western Asia, is native to the Kopet-Dagh foothills. Among the snakes in the Kopet-Dagh may be found the poisonous spectacled cobra (*Naja naja cocca*), which reaches a length of 1.8 m., and the equally poisonous blunt-nosed viper (*Vipera lebetina*), which grows as long as the cobra. In some places in the foothills termites (*Hodotermes turkestanicus*) are numerous. The Moroccan locust and the locust *Calliptamus italicus* are insects which breed in the Kopet-Dagh.

Of the fish, the Old World minnow (*Schizothorax*), a representative of a Central Asiatic genus, is characteristic for the Kopet-Dagh. This region is the western boundary of its distribution.

[23] S. I. Ognev and V. G. Heptner, "Mlekopitayushchie srednevo Kopet-Daga i prilezhashchey ravniny" (Mammals of the Central Kopet-Dagh and the Adjoining Plain), *Trudy nauchno-issled. inst. zoologii* (Proceedings of the Zoological Scientific-Research Institute), III, No. 1, Moscow, 1929.

IX · The Soviet Humid Subtropical Regions

THE region of subtropical lowland forests is represented in the U.S.S.R. only by two unconnected sections of the Transcaucasus: (1) the Colchian Lowland in the western Transcaucasus and (2) the Talysh Lowland in the eastern Transcaucasus.

Definition

The region of subtropical forests is characterized by a hot summer. The winter is so moderate that many plants are able to vegetate the year round without interruption. Rainfall is heavy. The vegetation consists of broad-leaved forests, which include an admixture of evergreen species. This type of climate and vegetation is found also on the lower slopes of the adjoining mountains.

1. THE COLCHIAN (KOLKHIDSKAYA) LOWLAND

Boundaries

The Colchian Lowland is situated along the lower course of the Rion; it reaches up the river about as far as Kutais. Narrowing gradually, it extends along the Black Sea coast approximately to the mouth of the Kodor (south of Sukhum); to the south it extends as far as Kobuleti (north of Batum). The lowland measures approximately 90 km. from west to east. This area slopes gently to the sea; a large part of it is occupied by swamps.

Climate

The climate of Colchis is moist and warm. There is much precipitation, more than 1000 mm. annually—in some places as much as 2500 mm. In no other lowland in the U.S.S.R. is there so much precipitation (if Batum, which we have classified with the mountain zone, is included here).

Fig. 33. Saxaul (*Haloxylon ammodendron*) in the Trans-Caspian sandy desert near Repetek. (Lipsky, *Lesnaya Rastitelnast v Turkestane*. Fig. 5)

Fig. 34. "Sand acacia" (*Ammodendron conollyi*) in the Trans-Caspian sandy desert near Repetek. (Lipsky, *Lesnaya Rastitelnost v Turkestane*. Fig. 1)

Fig. 35. *Calligonum erinaceum* on a mound in the Bolshie Barsuki sands. (Lipsky, *Lesnaya Rastitelnost v Turkestane*. Fig. 6)

Fig. 36. Reed thickets on the shore of Lake Balkhash. (*Aziatskaya Rossiya*. Vol. 2: 135)

Fig. 37. Chee grass (*Lasiagrostis* [*Stipa*] *splendens*) in the region of Lake Zaisan. (*Vegetationsbilder*. Vol. 18; part 8; plate 48)

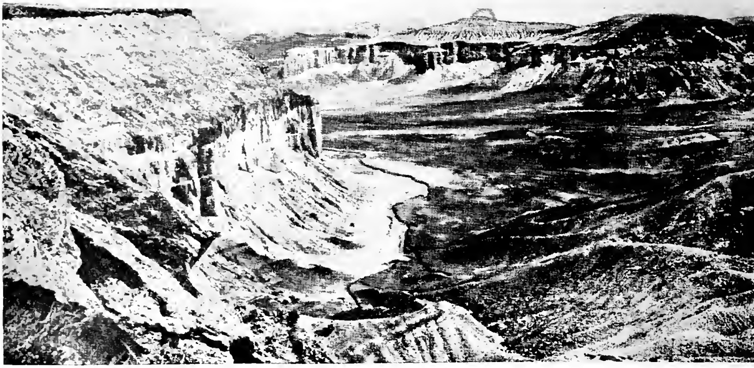


Fig. 38. The Airakli table mountains on Mangyshlak Peninsula. (L. S. Berg, *Formy Russkikh Pustyn*. Fig. 5)

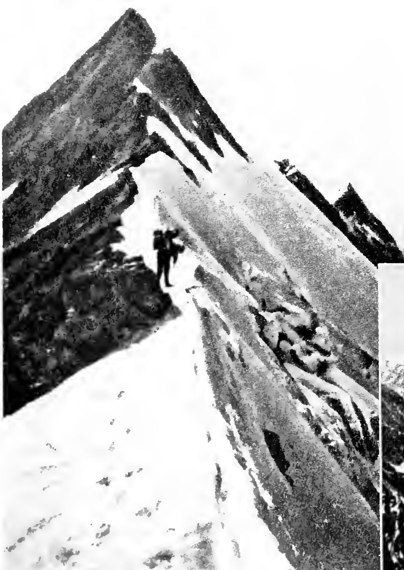


Fig. 39. Stalin Peak, the highest point in the U.S.S.R. (Bolshaya Sovetskaya Entsiklopedia. Vol. 44: 31)

Fig. 40. The high Pamir. (Bolshaya Sovetskaya Entsiklopedia. Vol. 44: 31)

Fig. 41. Khan-Tengri, the highest mountain of the Tian Shan. (*Aziatskaya Rossiya*. Vol. 2: 50)

Fig. 42. The detritus-covered lower end of the Zeravshan Glacier. (*Aziatskaya Rossiya*. Vol. 2: 44)

Fig. 43. Lake Issyk-Kul in the Tian Shan. (*Aziatskaya Rossiya*. Vol. 2: 53)

Fig. 44. Lake Iskander-Kul in the Hisar range (Samarkand *oblast*). (*Aziatskaya Rossiya*. Vol. 2: 44)

Fig. 45. Harvesting wheat at an elevation of 2000 meters in the Pamirs. (Stalin collective farm in Verkhny Khorog). (Sovfoto)

Fig. 46. Thick-shell Persian walnut (*Juglans failax* [*J. regia fallax*]) in Fergana *oblast*. (*Aziatskaya Rossiya*. Vol. 2: 137)

Fig. 47. Pistache shrubs in Fergana *oblast*. (*Aziatskaya Rossiya*. Vol. 2: 137)

Fig. 48. *Karagach* (*Ulmus densa* [*U. carpinifolia*]) in Samarkand *oblast*. (*Aziatskaya Rossiya*. Vol. 2: 136)

Table 13

PRECIPITATION IN COLCHIS (IN MM.)

Locality	Precipitation												
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Kutais *	105	111	95	94	80	123	84	87	104	106	131	139	1259
Poti †	127	94	81	79	57	133	163	230	201	157	147	130	1598
Ozurgeti ‡	191	215	115	92	80	125	158	167	250	210	272	193	2077
Batum §	256	186	150	148	87	172	160	235	303	247	327	265	2465

* 31-year means. † 43-year means. ‡ 13-year means. § 25-year means.

The precipitation is distributed (see table) more or less evenly throughout the year, and the fact that *there is no dry period* has a pronounced effect on the vegetation.

The minimum precipitation comes in May, the maximum in autumn and winter; but at Poti and in other parts of the Colchian coast, the greatest precipitation comes in August, which is the warmest month. The monthly total of precipitation varies greatly. In Kutais in one year 493 mm. fell during the month of February; in other years, however, there has been almost no precipitation (0.5 mm.) during this month. The precipitation falls chiefly in the form of heavy showers. In Poti 207 mm. of precipitation once fell in June in one day.

Cloudiness is relatively great; in Poti the mean annual figure is 62 per cent. As one moves away from the sea, cloudiness decreases. The annual range in cloudiness is not great; in Poti the maximum (in January and February) is 69 per cent, the minimum (in October), 55 per cent.

The winds have a monsoon character. In summer they blow moist and cool from the sea; in winter they blow rather warm and dry from the land. The summer winds from the sea are due to the fact that in summer the pressure over the Black Sea is higher than the pressure over the land. In winter the pressure over the Black Sea is low, while over the Caucasus, particularly over the Armenian Plateau, the pressure is high.

Because of the monsoon character of the winds, the relative humidity in the western Transcaucasus, as Voyeikov has pointed out, is greater during the warm season than during the cold. For example, in Poti the relative humidity is 86 per cent in summer, and 77 per cent in winter, while in areas which do not have the monsoon it is usually the other way around.

In Kutais the summer monsoon is poorly expressed, while the winter monsoon (NE, E, SE) is quite distinct. The winter monsoon here is a dry and warm wind. It blows in spring also, in the form of a sultry and even drier wind. When it lasts as long as a week, the vegetation suffers severely. From November to April in Kutais the monsoon blows an average of at least 11 days (and as many as 15 days) a month.

The monsoon in Kutais has a foehnlike character. However, typical foehns (warm and dry descending winds) are very frequent also. In Kutais there are 114 days during the year when the foehn blows; that is, two and one-half times as many as in those parts of the Alps which are celebrated for foehns. In December in Kutais the foehn blows about one day out of two. In summer, however, foehns are much less frequent. In June and July there are 3 to 4 days a month with foehn. These winds are dry and warm, like the monsoon, and they raise the winter temperature of Kutais perceptibly. Foehns result when masses of cold air descend into the Rion valley from anticyclones in the Caucasus, and particularly from the Armenian Plateau; they undergo compression and their temperature rises as they descend. When a cyclone passes over the Black Sea, the velocity of the foehn wind may reach the force of a tempest. When foehns occur in winter in Kutais, the temperature rises an average of 2° to 5° C., and sometimes even more. During the foehn of March 24–27, 1899, the temperature in Kutais reached 30° C., while the relative humidity fell to 9 per cent.

Shore breezes arise along the coast during calm noncyclonic weather. During the day they blow from the sea, at night from the land.

The Colchian Lowland, protected by mountains from the cold east winds, and warmed by the sea, has a very mild winter. However, the summer here is hot. In the table which appears below, the mean monthly temperatures for Poti are given:

Table 14

MEAN MONTHLY TEMPERATURES IN POTI (IN °C.)

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
Mean diurnal temperature	4.9	5.2	8.8	12.0	16.1	20.2	22.8	23.3	20.2	16.7	11.6	8.2	14.3
Mean temperature at 1 : 00 P.M.	7.3	8.7	11.6	15.0	19.4	23.2	25.7	26.1	23.6	20.4	14.9	10.7	

The diurnal range, 18° C., is very small, smaller than anywhere else in the U.S.S.R., with the possible exception of the western Murman coast. The winter is very mild; the mean temperature of the coldest month is over 4° C., which permits the cultivation of a number of subtropical plants—tangerines, lemons, and bamboo.

The warmest month is not July, but August, as in marine climates. Autumn in the Colchian Lowland is extremely warm. (October is warmer than April by 4° to 5° C.) This is due in part to the high temperature of the sea along the southern part of the Caucasian littoral. In September the sea has a surface temperature of 22° C.; in October, over 18° C.; in November, over 13° C. Also, the warm foehns begin to blow in autumn.

The absolute maxima in some years may reach over 18° C. in January, and 39° to 40° C. in July and August. However, there are sometimes rather severe frosts in winter. Thus, in Poti the thermometer has dropped occasionally to − 11.5° C. On the average, however, in Poti there is only one day annually when there is no thaw; that is, when the maximum temperature does not rise above 0° C.

Soils

The soils of the Colchian Lowland belong to the bog and half-bog types. Brown forest soils [1] and alluvial soils are developed in the more elevated places. There are no red soils on the plain, but they are developed in the foothills and in the mountains.

Vegetation

The special features of the vegetation cover are related to the peculiarities of the warm and humid climate of Colchis. Plant life is unusually luxurious; there is an admixture of evergreen plants, and a profusion of vines and ferns. Growth is extremely vigorous, and it is extraordinarily difficult to subdue the forest here. In Guriya, along the Choloku River, according to Medvedev, an area which has been under a cornfield may be overgrown in the space of one or two years by a six-meter undergrowth of alder and Caucasian wing nut, so that only the remains of the stalks of dry corn among the thickets of trees show that there was a field here recently. Bracken (*Pteridium aquilinum*) achieves a profuse growth here very rapidly, growing as tall as a man in the course of one summer; this weed is difficult to destroy here.

On the sandy seacoast grow two spiny shrubs, common sea buckthorn (*Hippophaë rhamnoides*) and blackberry (*Rubus discolor*). These shrubs are twined with the vines of traveler's-joy (*Clematis vitalba*) and sturdy greenbrier (*Smilax excelsa*—Liliaceae). Beyond the coastal vegetation lie bogs covered with a dense forest of hairy alder (*Alnus barbata*, a species closely related to the European alder, *A. glutinosa*),

[1] Concerning these soils, see below, pp. 250–251.

brittle willow (*Salix fragilis*), and Caucasian wing nut (*Pterocarya fraxinifolia;* in Georgian, *lapini*). All of these trees are twined with sturdy greenbrier vines, common hop (*Humulus lupulus*), blackberry, hedge glorybind (*Calystegia sepium* [*Convolvulus sepium*]), and Grecian silk vine (*Periploca graeca*). Alder grows here very quickly; in 5 to 6 years it reaches dimensions which require 25 to 30 years to achieve in other parts of the U.S.S.R. Forests in which alder predominates spring up as a result of lumbering and stock grazing.

On slightly elevated places there is oak (*Quercus hartwissiana*), European hornbeam (*Carpinus betulus*), some oriental beech (*Fagus orientalis*) (Figure 49), and common pear (*Pyrus communis*). The epiphytic common polypody (*Polypodium vulgare*) is found growing on some of the trees. The trees are twined with vines; in addition to those enumerated above, the vines found here include the evergreen Colchis ivy (*Hedera colchica*), and also the European grape (*Vitis vinifera*). Among the other evergreen plants occasionally there are English holly (*Ilex aquifolium*) and butcher's-broom (*Ruscus aculeatus* and *R. hypophyllum*), and even common box (*Buxus sempervirens*). Such is the picture, for example, near Poti. In the vicinity of Lake Paleostom on the sedge peat bogs, there is found the enormous arborescent royal fern, *Osmunda regalis,* which grows also farther north, in the alder bogs at Adler, and farther south, at Kobuleti.

Somewhat farther in the interior, the country rises a little in elevation and becomes drier. Here we find either forests on dry soils, or cultivated fields. Oak and hornbeam predominate, with an admixture of a great many other trees and shrubs: zelkova (*Zelkova carpinifolia*), pontic azalea (*Azalea pontica* [*Rhododendron luteum*]), hawthorn (*Crataegus oxyacantha*), European filbert (*Corylus avellana*), oriental hornbeam (*Carpinus orientalis*), European chestnut (*Castanea vesca* [*C. sativa*]), common pomegranate (*Punica granatum*), and others. Near the dwelling places grow century-old thick-shell Persian walnut trees.

The Colchian forests, like the Talysh forests, contain a series of relict Upper Tertiary forms, analogous to the flora of Ussuri *kray,* Japan, and the Atlantic states of North America (N. I. Kuznetsov, 1909). Colchis, and the western Transcaucasus in general, served during the glacial period as a shelter where thermophilic Upper Tertiary flora were able to survive. Among the characteristic Tertiary species of the Rion Lowland there are first of all the Caucasian wing nut and zelkova. The Caucasian wing nut (*Pterocarya fraxinifolia*), an enormous tree up to 30 m. tall, which belongs to the same family as the thick-shell Persian walnut, grows in abundance on moist soils subject to flooding along the river shores and on the outskirts of the bogs. This tree is associated particularly with the lowland, and is not found in the foothills. It extends about as far east as Kutais. The rapid growth of the Caucasian wing nut has been mentioned already. Its light wood, which has little durability, is put to various incidental uses. The zelkova (*Zelkova crenata* [*Z. carpinifolia*], which belongs to the elm family), unlike the Caucasian wing nut, grows on the drier and more elevated portions, predominantly within oak stands, up to an absolute elevation of 300 m. The hard and solid wood of the zelkova serves many purposes. It provides a first-class building material, since it can withstand the humid climate of Colchis for tens and hundreds of years. For piles, bridges, and so forth, zelkova has no substitute; it excels oak in durability.

Both these trees have an almost identical intermittent distribution; they are found not only in the western Transcaucasus, but also in Talysh and on the southern shore of the Caspian, as well as in some parts of the eastern Transcaucasus. Species closely related to the Caucasian wing nut and the zelkova are found also in the Far East, in China and Japan; and on the island of Crete there grows a species very closely related to the Caucasian zelkova. Closely related and perhaps even identical species of both genera grew during the Tertiary period in Europe, Asia, and North America, extending into the extreme north. Zelkova (the species *Z. carpinifolia*) was discovered recently in Pliocene deposits in the neighborhood of Sofia in Bulgaria, together with other plants which are typical for the western Transcaucasus: box, holly, yew, and chestnut. Of the other Tertiary types which grow in the Rion Lowland, Kuznetsov lists the shrub evergreen pontic rhododendron (*Rhododendron ponticum*) and the annual herb *Rhamphicarpa medwedewii*, which was found first in the neighborhood of Poti and which is very typical for the Colchian Lowland. This semiparasitic plant of the figwort family (Scrophulariaceae) belongs to a genus which is found in the tropics, chiefly in Africa. The Colchis trapa (*Trapa colchica*) also belongs to this group of relict forms.

During the glacial period many European forms came down into this area from the north. On the bogs of the Rion Lowland, the following northern plants are found: the roundleaf sundew (*Drosera rotundifolia*), the common bog bean (*Menyanthes trifoliata*), sphagnum mosses, the beak rush *Rhynchospora alba* (of the sedge family), and others.

Fauna

The fauna of Colchian, unlike the flora, is neither abundant nor unique. Among the birds is the pheasant (*Phasianus colchicus*). The fish are closely related to those found along the Black Sea coast of Asia Minor. The Colchis cyprinids, barbel (*Barbus tauricus escherichi*), *khramulya* (*Varicorhinus sieboldi*), minnow [*Leuciscus cephalus*], *shemaya* [*Chalcalburnus chalcoides*], and *rechnoy rybets* (*Vimba vimba tenella*) are characteristic. There are many mollusks, myriapods, a kind of fresh-water crayfish (*Astacus colchicus*), and a host of malarial mosquitoes. Two scorpions are found here, the Mediterranean (*Euscorpius italicus*) and the Mingrelian (*E. mingrelicus*).

2. THE TALYSH LOWLAND

The Talysh, or Lenkoran, Lowland lies to the south of the Mugan Steppe, in a narrow strip 5 to 30 km. wide and 100 km. long, between the Caspian Sea and the Talysh Mountains. It is drained by the Vilyazh-Chay, Lenkoran, Putasar-Chay, and Astará rivers (the last-named lies along the boundary with Iran). The lower valleys of these rivers are largely occupied by swamps.

Along the coast there are fresh-water and salt lakes and ponds, which are separated from the sea by chains of dunes, 4 to 6 m. high. A small body of water such as this is called a *mortso*. The longest *mortso* extends from Lenkoran to the mouth of the Kumbashinka.

Climate

As in Colchis, precipitation is abundant (about 1200 mm. annually), but here it is distributed unevenly among the months. During the first half of the summer, in June, there is a dry period; the maximum precipitation comes in autumn, in September and October. In Lenkoran the mean annual precipitation for the years 1847–1904 was 1252 mm., being greatest in September (216 mm.), least in June (24 mm.). However, sometimes there is less than 1 mm. of precipitation during the entire summer.

The summer is hot, the winter moderate. In Lenkoran, in lat. 38¾° N, the mean July temperature is almost 26° C., the mean January temperature, + 3° C. But occasionally there are very severe winters. Thus, in January 1925, the temperature in Lenkoran dropped to − 15° C.; the

Araks River and Kizil-Agach Bay were frozen and a great number of aquatic birds were destroyed. (Flamingoes perished by the thousand.)

The winds in Lenkoran have a monsoon character. In summer and spring ESE and SE winds prevail, while in winter (from November to February) WNW winds prevail, blowing from the land. These variations in wind direction correspond to the distribution of atmospheric pressure over the southern part of the Caspian Sea and over the continent. The winds from the land blow in the form of foehns, warm and dry winds which descend from the mountains; sometimes they raise the winter temperature to 19° C. On the coast there are marked sea breezes in summer.

Soils

The soils on the shore itself are alluvial, while farther inland from the coast there are red soils, which are replaced in the foothills by brown forest soils.

Vegetation

The vegetation [2] in general has the same Tertiary appearance as in Colchis, but the composition of the flora is somewhat different. The flora of Talysh belongs to the Hyrcanian province, the boundaries of which correspond to the northern slopes of the ranges which border the southern coast of the Caspian. There are very few evergreen plants in Talysh.

In the forests of the Talysh Lowland the prevailing species is the endemic Persian parrotia (*Parrotia persica*), which often grows in dense thickets. This tree is distinguished by the unusual durability of its wood and by its very slow growth. It does not reach a great height, standing only 6 to 20 m. tall; its trunk begins to branch very low, almost at its base. Usually the very characteristic chestnut-leaf oak (*Quercus castaneaefolia var. obtusiloba*) grows together with the Persian parrotia. This oak is a rather shapely tree, although it does not reach the mighty stature of the typical chestnut-leaf oak, which grows higher up in the mountains. The association usually includes European hornbeam (*Carpinus betulus*) and zelkova (*Zelkova carpinifolia*). The latter, as in Colchis, is extensively cut over. On the forest outskirts and in the glades, vines grow in profusion: Grecian silk vine, greenbrier, and ivy (*Hedera pastuchovii*); the vines of traveler's-joy (*Clematis vitalba*), which grow so densely in Colchis, are absent here. The naturalized American grape vine

[2] A. A. Grossheim, *Flora Talysha* (The Flora of Talysh), Tiflis, 1926, p. 247.

(*Vitis labrusca orientalis*) is very common here. Flowering plants, as well as mosses, lichens, and ferns, appear as epiphytes on the trees. Thus, bitter cress (*Cardamine hirsuta*), herb Robert geranium (*Geranium robertianum*), oxalis (*Oxalis corniculata*), and others may be found blooming on the trunks of the Persian parrotia. In the herbaceous layer society, sedges and Mazanderan blue grass (*Poa masenderana*) grow in profusion. Evergreen shrubs of the Talysh Lowland are the butcher's-broom, *Ruscus hyrcanus*, and the Alexandria laurel (the local Russian species, *Danaë racemosa*).

"The lowland forest," writes Grossheim, "begins to develop somewhat later than do the mountain forests; the flowering of some of the species occurs later, and the forest itself begins to turn green and to blossom at the time when the forests of the lower and middle mountain zone already stand in the full adornment of their spring verdure." This condition without any doubt is a consequence of temperature inversion. Down below, where the cold air descends, the temperature is lower than up above. (In the same way also, the vegetation in the river valleys of the Soviet Union flowers later than in the interstream areas.)

Today the lowland forests have been cut down almost entirely, and have been replaced by rice fields, gardens, and settlements.

On the waterlogged sections there grow low forests of almost pure thickets of alder (*Alnus barbata*), profusely tangled with vines. These alder groves are analogous to those found in Colchis. Among other vines, the endemic Lenkoran blackberry (*Rubus raddeanus*), which bears pink flowers in May, is characteristic. The Persian parrotia and the shrub butcher's-broom are absent here, but individual specimens of chestnut-leaf oak, Caucasian wing nut, zelkova, and fig are encountered sometimes. The undergrowth contains much hawthorn (*Crataegus monogyna*).

The coastal dunes are covered with a herbaceous vegetation, while the inland dunes bear shrub vegetation, with ephedra (*Ephedra vulgaris* [*E. distachya*]) predominating in the north, and common pomegranate (*Punica granatum*), in the south. The pomegranate grows as tall as a man, and sometimes even 3 to 4 m. high. Holy bramble (*Rubus sanctus*), often growing taller than a man, is widespread throughout the dunes; this plant, which is almost evergreen, flowers and bears fruit up to the end of December. Sweetbrier roses grow in profusion; medlar (*Mespilus germanica*) and common quince (*Cydonia oblonga*) are common. In some places there are Grecian silk vine and grape.

On the shores of the lakes there are reed bogs which contain vast thickets of the tall common reed, *Phragmites communis*. The surface of the lakes is covered by a mass of trapa (*Trapa hyrcana*). In the bogs between the dunes, iris (*Iris pseudacorus*) predominates.

Fauna

The pheasant (*Phasianus colchicus*) feeds readily upon the berries of the holy bramble, and the jungle cat (*Felis chaus*) hunts the pheasant in the holy-bramble thickets and the reeds. The flowers of the honey locust attract large numbers of bees, and the bees attract whole bevies of bee-eating birds. Tigers, which hunt the numerous wild boar of the region, are found in Talysh (most often encountered in the vicinity of Prishib village); occasionally they penetrate into other parts of the eastern Transcaucasus; in 1923 a tiger was killed not far from Tiflis. In both the mountains and the lowlands, there is leopard (*Leopardus pardus tullianus* [*Felis pardus tullianus*]). The porcupine (*Hystrix hirsutirostris* [*H. leucura hirsutirostris*]) also appears occasionally. Lake Kaladagny (south of Lenkoran) was noted at one time for its great number of swans. On Sara Island (south of Kizil-Agach Bay) there was formerly an enormous colony of Caspian herring gull (*Larus cachinnans* [*L. argentatus cachinnans*]), the eggs of which were an item of economic importance. In 1908 an area of ten hectares was covered entirely with the nests of the herring gull. A large number of these gulls have been preserved in the reservation on Kulagin Island, north of Sara. Great flocks of birds spend the winter on the *mortso* between Lenkoran and Kumbasham; these include swans (now exterminated), ducks, coots, and shore birds. The curious Indian gallinule (*Porphyrio poliocephalus*), a southern bird, also nests here, and the glossy ibis and flamingo, as well as the Smyrna kingfisher (*Halcyon smyrnensis*), are encountered. One of the insects in the Lenkoran forests is the unusual longicorn beetle, *Parandra caspia*, which is found along the southern coast of the Caspian from Astrabad to Lenkoran; other species of this genus are native chiefly to the neotropical region.

Among the domestic animals the zebu is to be noted.

X · Mountains of the Caucasus

Relief

THE North Caucasus Foreland, in general, is a continuation of the Ukrainian and South Russian steppes, and to some extent also of the semidesert. However, in the central part it rises in elevation to form the Stavropol Plateau (827 m.), composed of Tertiary strata. This plateau, which lies on the watershed between the Kuban basin on the one hand, and the Terek and Kuma basins on the other, separates the western North Caucasus Foreland from the eastern. The Stavropol Plateau lies nearest to the mountains of the Caucasus in the vicinity of Mineralnie Vody.

We will describe the mountains of the Caucasus under the following four subdivisions: (1) the Glavny (Main) range of the Caucasus, (2) Daghestan, (3) the Armenian Plateau and the dry regions of the eastern Transcaucasus, and, finally, (4) Talysh.

1. THE GLAVNY (MAIN) RANGE OF THE CAUCASUS

Relief

The Caucasus range[1] is a system of folded chains, which extend ESE from Anapa on the Black Sea. The town of Ilkhi-Dagh, near the point where the Sumgait River empties into the Caspian (lat. 40½° N) is generally considered the eastern end of the Caucasus range. Tectonically, however, the range ends somewhat north of this point, in the region of Kilyazi station, where the folds either disappear beneath the Caspian, or are cut away by the coast line (Rengarten, 1930). The length of the range is over 1100 km. Its width in the region of Mount Elbrus is nearly 180 km.; in the region of the Georgian Military Highway, 110 km.

[1] Concerning the relief, see I. S. Shchukin, "Ocherki geomorfologii Kavkaza" (Sketches of the Geomorphology of the Caucasus), I, *Bolshoy Kavkaz* (The Greater Caucasus), Moscow, 1926.

The Caucasus consists of the Vodorazdelny (Water Divide) range, which is not crossed by any rivers, and the ranges which adjoin it on the north and south, which in some places are higher than the Vodorazdelny. In the central part, west of Krestovy Pass and between the meridians of Elbrus and Kazbek (both these peaks, as we shall see, lie in the Peredovoy range), the Vodorazdelny range has an average elevation of 3600 m. (Fig. 51); in this section it is covered throughout its entire length by everlasting snows, and in spots by glaciers (Fig. 50). Many of the peaks are higher than Mont Blanc. At the head of the Shkhar River the Vodorazdelny range reaches an elevation of 5148 m. The core of the range here is composed of granites and gneisses, which are pierced by veins of greenstone. On the north and on the south the granite core is bordered by belts of metamorphic schists. East of Krestovy Pass, the Vodorazdelny range drops in elevation, and the granites disappear. Only some of the peaks (Bazar-Dyuzi, elevation 4487 m., and others) rise as high as the snow line and are covered by glaciers.

In the region of Elbrus, the mighty Peredovoy range branches off from the central part of the Vodorazdelny range at a distance of 10 to 15 km. to the north of the water divide. The highest point of the Peredovoy range, and also the highest point of the entire Caucasus, is Mount Elbrus whose twin peaks reach 5629 m. and 5593 m. This mountain is an extinct volcano which was formed during the Upper Tertiary period. Twenty-two glaciers, with a total area of 144 sq. km., descend from Elbrus; its glaciers and snow feed the Kuban and some of the tributaries of the Terek. Although Elbrus is an extinct volcano, a sulphurous gas is emitted on its eastern border, while along the descending streams (for example, along the Malka) there are a great many mineral springs; in these there is a copious emission of carbonic acid, and some of them have temperatures as high as 22° C. Elbrus and many other peaks of the Peredovoy range are considerably higher in elevation than the peaks of the Vodorazdelny.

The other giants of the Peredovoy range include Dykh-Tau (5198 m.), Koshtan-Tau (5145 m.), the volcanic andesite cone of Kazbek (5043 m.), and others.

Orographically, the Peredovoy range is not a distinct chain. In general, it is composed of the northern spurs of the Vodorazdelny range. In some places the Peredovoy is connected by cross ranges with the Vodorazdelny. These connections give rise to mountain basins, which have a relatively dry climate.

To the north of the Peredovoy range lie much lower ranges, which do not rise as high as the snow line. These include the Skalisty, which stretches from the Belaya River to the boundary of Daghestan, and which rises over 3300 m. in elevation, and the Cherny, which is well defined from the sources of the Kuma to the Terek; Mount Bermamyt (elevation 2591 m.; 30 km. from Kislovodsk) in the Cherny range is famous for its fine view of Elbrus.

The following ranges branch from the Vodorazdelny to the south: the Gagry (3260 m.) and Bzyb (3000 m.) ranges, which are composed predominantly of limestones; the Kodor range (over 3800 m.); the Svanetiya range (4000 m.), which feeds a large number of glaciers (Fig. 52); and the Lechkhumsk and Rachinsk ranges. In the longitudinal valleys between these ranges lie the sources of the Bzyb, Kodor, Ingur, Tskhenis-Tskhali, and Rion rivers. The Kartalinsk range (between the Pshavsk Aragva, Iora, and Kura) and the Kakhetinsk range (between the Iora and the Alazan) branch from Great Borbalo peak (elevation 3295 m.) in the eastern part of the Vodorazdelny range. Both these ranges, composed of Tertiary deposits, have an elevation of about 3000 m. on the north, but drop in elevation to the south.

Between Great Borbalo and Bazar-Dyuzi the main range does not exceed 3700 m. in elevation. Beyond Baba-Dagh it drops considerably in elevation and branches into a series of chains.

The snow line on the Caucasus rises from west to east, due to the fact that moisture comes from the west. The following figures show the elevation of the snow line in selected localities (Reinhard):

Table 15

Elevation of Snow Line in the Caucasus

Locality	Elevation (in m.)
Oshten-Fisht	2650 to 2750
Upper Mzymta	2950
Upper Teberda	2925
Ullu-Uzen valley	3250
Northern slope of Elbrus	3850
Southern slope of Elbrus	3575
Gimarai-Khokh-Kazbek	3675
Krestovy Pass	3400
Shakh-Dagh	3635
Southern slope of Bazar-Dyuzi	3900

There are about 1400 glaciers on the Caucasus range, and they cover a total area of 2000 sq. km. One of the largest is Dykh-Su, which descends from Dykh-Tau and Shkhar peaks; it is over 15 km. long. The glaciers on the southern slope are smaller than those on the northern. The largest, with a length of 13.5 km., is the Lekzyr in the Svanetiya range, in the Ingur basin. It descends to an elevation of 1734 m., lower than any other of the present glaciers in the Caucasus.

During the glacial period the center of glaciation in the Caucasus was in the Elbrus region. In Daghestan, then as today, there were only isolated centers of glaciation. On the northern slope of the Caucasus range, the glaciers reached farthest down in the valleys of the Kuban and the Ardon—as low as 900 m., but they did not descend into the plain. Ancient moraines are found still lower in the western Transcaucasus. In the Kodor valley they are found at 350 m., in the valleys of the Bzyb and the Mzymta, at 450 m. To the east, the lower boundary of diluvial glaciers rises abruptly, and along the Belaya Aragva it is found at 1450 m. Almost all the ancient moraines belong to the last glacial epoch (Würm). In some places, however (for example, along the Vaksan and the Terek), older moraines have been preserved. In the foothills and on the plain there are several fluvioglacial terraces; for example, on the Kuban, Vaksan, and Terek there are no less than three terraces, the lowest of which corresponds to the last glaciation.

During the last glacial epoch the snow line in the western Caucasus was 1200 to 1300 m. lower than at present. The distribution of winds and of precipitation in the West and Central Caucasus during the glacial period were about the same as they are today; at that time, according to Reinhard, moisture was brought chiefly by west winds. The névé basins of the large glaciers contained only slightly more snow than at present; their growth took place chiefly at the lobes. Thus, the increase in the size of the glaciers was brought about not by a greater influx of new masses of ice from above, but by slower thawing at the lower extremities. From this fact, Reinhard draws the fair conclusion that the glaciation of the Caucasus, and also of the Alps, must be explained by lowered temperature, rather than increased precipitation.[2]

On the Black Sea coast of the Caucasus, between Novorossiisk and Zugdidi, there is a series of distinct terraces, 200 and even 240 m. above the level of the sea. In Abkhaziya six such terraces are described,[3] in

[2] A. L. Reinhard, "K voprosu o chetvertichnom oledenenii Kavkaza" (Concerning the Quaternary Glaciation of the Caucasus), *Doklady Akad. nauk* (Reports of the Academy of Sciences), 1927, A, pp. 319–323.

[3] O. N. Mikhailovskaya, "Chetvertichnie terrasy Abkhazii" (Quaternary Terraces in Abkhaziya), *Trudy I Vsesoyuznovo geograf. syezda 1933* (Proceedings of the First All-Union Geographical Convention, 1933), III, 1934, pp. 82–94, map.

other places as many as eight. On some of the terraces marine fauna have been discovered; for this reason they are ascribed to the Quaternary period, but it is difficult as yet to determine their age more exactly.

During the postglacial period the Caucasus experienced an interval when the climate was drier than it is at present. Evidence of this, as Reinhard points out, is the fact that at one time there was much more talus than at present. In the upper valleys the glacial formations are buried under talus, which is held in place by the vegetation cover. This epoch—the xerothermic, as it is called by botanists—had its effect on the flora and fauna of the Caucasus.

Earthquakes are frequent in the Caucasus. They are particularly frequent in Shemakha, which experienced severe quakes in 1828, 1859, 1869, 1902, and 1920.

The first folding on the site of the present Caucasus range took place during the pre-Cambrian period (perhaps during the Huronian). There is no clear evidence of Lower Paleozoic (Caledonian) dislocations, but the possibility of such dislocations cannot be denied. Folding which took place during the Upper Paleozoic period (Variscan)—at the end of the Lower and the beginning of the Middle Carboniferous—is quite obvious. The dislocation at the end of the Triassic and the beginning of the Jurassic was very marked. Further dislocations took place during the Liassic period, when a geosyncline began to form on the site of the Caucasus range; also during the Upper Jurassic, and at the end of the Cretaceous. Finally, a very severe dislocation occurred between the deposition of the Sarmatian and the Meotichesk strata, which affected the entire Caucasus (according to Rengarten). Powerful tectonic processes continued throughout the Pliocene. They were accompanied by volcanic eruptions in the region of Kazbek (Rengarten, 1932).

A peculiar feature of the Caucasus range, as compared with the Alps, is the presence of volcanoes, which are found predominantly in the central part (Elbrus, Kazbek), and which were still active relatively recently (speaking geologically). Elbrus was still active during the Upper Pliocene (post-Akchagyl) period. In the Nalchik basin thick beds of volcanic tuffs have been discovered, overlying Tertiary deposits. In the vicinity of the Georgian Military Highway, Levinson-Lessing found the moraine of a Pleistocene glacier, covered with lavas. There were eruptions here even after the end of the glacial epoch. Another point of contrast with the Alps is the relatively poor development of glacial lake basins.

According to Rengarten,[4] in crossing the Caucasus by the Georgian Military Highway the following orographic units may be observed:

1. The sloping plain of North Ossetia, composed of gravel. The elevation at the city of Ordzhonikidze is about 630 m.
2. Rolling foothills, composed of unconsolidated Tertiary deposits. Mount Lysaya, elevation 1036 m.; Tarskaya, elevation 1226 m.
3. High foothills, composed of Cretaceous deposits. Mount Fetkhus, elevation 1743 m.
4. The Peredovoy range, composed of Upper Jurassic limestones. Mat-Lam, or Mount Stolovaya, elevation 3002 m. This zone is 7 to 8 km. wide. The Terek cuts across the zone in a gorge 300 m. wide.
5. A zone of Liassic argillaceous shales. Because this zone is eroded easily, longitudinal valleys are developed along the tributaries of the Terek.
6. The highest zone: Liassic slates, quartzites, and granites. Its width, from the former postal station at Lars to the point at which the Gudoshaursk Aragva empties into the Terek, is 16 m. Kazbek, elevation 5043 m.; Kuri (near Kazbek station, on the right bank of the Terek), elevation 4090 m. The Terek cuts across this zone by way of the Gorge of Daryal, which pierces the granites at elevations from 1140 to 1700 m.
7. The southern zone of Liassic argillaceous shales. Here, as in the northern zone, longitudinal valleys are developed along the tributaries of the Terek. This zone extends as far south as Kobi.
8. Includes the watershed ridge and reaches as far south as the confluence of the Belaya and the Gudomakarsk Aragva rivers. This is the southern zone of Upper Jurassic calcareous strata. Krestovy Pass, elevation 2381 m. (leading into the valley of the Belaya Aragva); Kvena-Mta Pass, elevation 2377 m. (leading into the valley of the Gudomakarsk Aragva). The highest point of the watershed ridge is the volcanic cone of Great Khurisar, elevation 3722 m.; next to it lies Little Khurisar, an extinct volcano with a crater, elevation 3000 m. (Both lie to the west of the Georgian Military Highway.) The width of this zone is 12 to 16 km. Little Khurisar stopped erupting during the postglacial (post-Würm) period. In general, eruptions in the Kazbek region began during the Akchagyl and ended during the post-Würm period.
9. Mountains of medium elevation on the southern slope between Pasanaur and Ananur. Lower and Upper Cretaceous. The width of this zone is about 24 km. The elevation of the watershed varies from 2600 m. in the north, to 1600 m. in the south. The Aragva at Pasanaur has an elevation of 1060 m.; at Zhinvan (below Ananur), 740 m.
10. Tertiary foothills with gentle relief. Ananur-Dushet zone. The width is about 8 km. Tectonically it is very complex in structure, a region of thrusts.
11. Bazaletsk Plateau (elevation 940 m.), south of Dushet. Composed of thick Pleistocene conglomerates, into which the Aragva has cut a gorge 280 m. deep.

[4] V. P. Rengarten, "Geologichesky ocherk raiona Voyenno-gruzinskoy dorogi" (Geological Sketch of the Georgian Military Highway), *Trudy geol.-razved. obyedin.* (Proceedings of the Geological Survey Association), No. 148, 1932.

In Zheleznovodsk *raion,* eighteen separate volcanic domes, partly covered with forest, rise from the flat, unforested steppe. The highest is Beshtau ("five mountains"), which reaches an elevation of 1440 m. Pyatigorsk is situated at the foot of Mount Mashuk (elevation 1200 m.). To the north of Beshtau rises Mount Zheleznaya (elevation 851 m.), at the foot of which lies Zheleznovodsk, famous for its iron springs which have a temperature of 15° to 55° C. The cores of these mountains are composed of igneous rock (trachytic-liparites). At the foot of the mountains the edges of the Tertiary strata are more or less uplifted, sometimes at angles of 40° to 50°, instead of the 2° which is more common on the plain. The intrusions occurred during the Upper Pliocene period.[5] These mountains belong to the laccolith type. However, on Mashuk and Lysaya mountains outcrops of igneous rock are entirely absent.

The Little Caucasus (as the mountain country of the Transcaucasus is called) is connected with the main range by means of the Suram or Meskhiisk massif, which, together with the Adzharo-Akhaltsykhsk or Imeretinsk range (elevation 2803 m.), serves as the water divide between the Rion and the Kura basins. Through Suram Pass (elevation 1197 m.) in the Meskhiisk range passes the tunnel (4 km. long) of the railroad which connects Batum and Poti with Tiflis and Baku.

The mineral resources of the Greater Caucasus include coal (at Tkvibuli east of Kutais, and Tkvarcheli in Abkhaziya) and manganese. The very rich Chiaturi manganese bed lies in western Georgia, in the basin of the Kvirila River, a tributary of the Rion; the ore deposits are associated with Oligocene strata. The warm (47° C.) sulphur springs in Tiflis are worth noting; they are regarded as the last traces of former volcanic activity. (In the neighborhood of Tiflis there are small laccoliths.)[6]

[5] A. P. Gerasimov, "Geologicheskoye stroyenie Mineralovodskovo raiona" (Geological Structure of Mineralovodsk *Raion*), *Trudy Geol.-razv. inst.* (Proceedings of the Geological Survey Institute), No. 30, 1935, p. 46.

[6] A. N. Zavaritsky, *Trudy Geol. inst. Akad. nauk* (Proceedings of the Geological Institute of the Academy of Sciences), V, 1936, pp. 79–84.

VERTICAL ZONES OF THE GLAVNY (MAIN) RANGE OF THE CAUCASUS

Steppe

On the northern slope of the range, the steppe, as pointed out earlier (p. 90), reaches south approximately as far as the line through Krasnodar, Pyatigorsk, and Grozny.[7]

Forest Steppe

Above the steppe lies the forest-steppe zone. Within the forest steppe of the western (Kuban) North Caucasus Foreland lie Krymskaya station, Maikop, and Podgornaya; farther east the forest steppe extends toward Kislovodsk. The following are some climatic data for this area:

Table 16

TEMPERATURE AND PRECIPITATION IN THE FOREST-STEPPE ZONE IN THE GLAVNY (MAIN) RANGE OF THE CAUCASUS

LOCALITY	ABSOLUTE ELEVATION (M.)	TEMPERATURE (° C.)		ANNUAL PRECIPITATION (MM.)
		JANUARY	JULY	
Maikop *	230	−2.0	22.2	565
Kislovodsk †	827	−4.5	18.1	553

* Lat. 44° 36′ N. † Lat. 43° 54′N.

The maximum precipitation comes in June, the minimum in January. Clouds hang low over the western part of the Caucasus range in winter (lower than 800 m.). In winter cloudiness and humidity are less and the number of days with precipitation and fog are fewer in Kislovodsk than in Zheleznovodsk (elevation 637 m.), Yessentuki (elevation 616 m.), and Pyatigorsk (elevation 519 m.), which lie at lower elevations.

In the forest steppe of the western North Caucasus Foreland, meadow-steppe areas alternate with forest islands of oak (*Quercus pedunculata* [*Q. robur*], *Q. sessiliflora* [*Q. petraea*]), hornbeam, ash, smoothleaf elm (*Ulmus campestris* [*U. carpinifolia*]), maple, pear, and apple. The undergrowth contains filbert, wild myrobalan plum (*Prunus divaricata* [*P. cerasifera divaricata*]), hawthorn (*Crataegus monogyna*), and pontic

[7] More exactly, according to Bush (1933), the line is as follows: from the *plavens* of the Kuban along the right bank of this river as far as the mouth of the Laba River, thence through Labinskaya and Vladimirskaya, along the southern escarpment of the first foothill ridge somewhat south of Batalpashinsk, north of Dzhegonas, to Suvorovskaya.

azalea (*Rhododendron flavum* [*R. luteum*]). In the meadow-steppe sections the soils are chernozems; under the forests they are chernozems, degraded chernozems, and gray forest clay loams.

The forests of the Stavropol Plateau also belong to the zone of the forest steppe. Here, at an elevation of about 600 m., there are almost 700 mm. of precipitation; the most comes in June, the least, in February. The temperature of the warmest month is 20° C. The central part of the plateau is occupied by mixed-herbaceous meadow steppe growing on rich and common chernozems. The horizon of effervescence here is very low—at a depth of 2 m. Of the feather grasses, there are *Stipa joannis* and *S. pulcherrima*. On the periphery of the plateau grow oak and ash forests with hornbeam: in the upper layer society there is oak, ash, and linden; in the second layer society there is Scotch elm, hornbeam, and Norway maple; the undergrowth contains euonymus, wayfaring tree viburnum, privet, hedge maple (*Acer campestre*), dogwood, and others. There is some aspen, silver poplar, and (very rarely) birch. However, the vines of the woodland European grape may be found here also. Under these forests there are degraded chernozems, and sometimes gray forest soils. On the northern slope there are hornbeam or hornbeam and beech forests on podzolic soils. The hornbeam forests contain some mazzard cherry. It is believed that the hornbeam forests have appeared in place of beech forests (Novopokrovsky, 1927).

In the eastern North Caucasus Foreland the forest steppe occupies a narrow strip in the foothills. The vegetation on the Tersk and Sunzhensk ranges is also forest steppe. The forests here consist of oak, ash, smooth-leaf elm (*Ulmus campestris* [*U. carpinifolia*]), and pear. Vines are represented by woodland European grape. The shrub thickets consist of sloe (*Prunus spinosa*), Russian almond (*Amygdalus nana*), Scotch rose (*Rosa pimpinellifolia* [*R. spinosissima*]), Christ's-thorn paliurus (*Paliurus spina-christi* or *P. aculeatus*), hawthorn (*Crataegus monogyna*), and others. Christ's-thorn paliurus grows in almost pure thickets along the periphery of the thickets of other shrubs. The meadow-steppe sections contain the feather grasses *Stipa capillata* and *S. pulcherrima*.

The forest steppe in the Transcaucasus occupies elevations between 450 and 500 m., and 750 and 800 m. Here lie Gori (elevation 600 m.), Tiflis (elevation 404 m.), Telav (elevation 738 m.), Tsinondali (elevation 602 m.), Napareuli (elevation 423 m.), Signakh (elevation 792 m.), and Nukhá (elevation 748 m.). The climate is that variety of Mediterranean climate which Koeppen calls the "maize climate." Lying on the periphery of the Mediterranean climate, it constitutes the transition to the climate of the steppe. The annual precipitation is from 500 mm. (in the east) to 800 mm. The maximum precipitation comes in May, the minimum in January. In Tiflis, which lies near the boundary of the steppe, the annual precipitation is 496 mm., the monthly maximum (in May) being 80 mm., the monthly minimum (in January), 15 mm. In the more elevated portions the precipitation is greater; thus, in Telav there are 815 mm. annually. The precipitation in spring and summer often comes in the form of heavy downpours (*seli*, noted particularly in Nukha *raion*), which sometimes cause severe damage in the foothills. In June and July there are many thunderstorms, often accompanied by hail. The summer is hot, the mean temperature being over 20° C. In Tiflis the mean temperature for July is 24.5° C.; in Napareuli, 23.8° C.; and in Tsinondali, 23.4° C. Sheltered by the Caucasus range from the cold north winds, the forest steppe of the Transcaucasus has a very moderate winter. The mean January temperature in Tiflis is + 0.2° C.; in Napareuli, + 1.6° C. Snow falls rather often, but the snow cover does not last long—only until the middle of February; sometimes there is no snow at all. Spring comes early, and work in the fields begins in the middle of February or at the beginning of March. In occasional years, some of the fruit trees (almond) and meadow flowers of Kakhetiya (in the Alazan valley) are in bloom already at the end of January, while apricot, peach, and pear trees bloom in February. Kakhetiya is noted for its wine production and gardens. Grapes are cultivated here up to an elevation of 900 m. (in Tiflis *raion* the best grapes grow up to 720 m.). Cloudiness is least in August, greatest in February. In Tiflis foehns are frequent; there are 45 days a year here with foehn, the greatest number coming in April; in the valley of the Kura, mountain-valley breezes blow during the warm period of the year.

The soils in the Alazan valley are calcareous alluvial soils, while higher up there are brown forest soils. In the Kura valley at Tiflis there are light-chestnut soils; higher up, brown forest soils and some degraded chernozems.

At present the forests have been cut down in the lower areas, and in their place are thickets of Christ's-thorn paliurus (*Paliurus spina-christi*) and other shrubs, and, in some places, steppe covered with East Indies bluestem (*Andropogon ischaemum*). Closer to the mountains grow Iberian oak (*Quercus iberica*),[8] hornbeam, and hedge maple. In the Alazan valley there are groves of hairy alder (*Alnus barbata*); these groves con-

[8] This oak of the *Q. sessiliflora* [*Q. petraea*] group is found in both the western and the eastern Transcaucasus. See V. P. Maleyev, "Obzor dubov Kavkaza" (Survey of the Oaks of the Caucasus), *Botan. zhurn. S.S.S.R.* (Botanical Journal of the U.S.S.R.), XX, 1935, Nos. 2, 3.

tain some Caucasian wing nut (*Pterocarya fraxinifolia*). There are many vines here: ivy (*Hedera pastuchovii*), Grecian silk vine, and greenbrier. In the shrub thickets on the sites of cut-over forests, woodland European grape (*Vitis silvestris* [*V. vinifera silvestris*]), traveler's-joy (*Clematis vitalba*), and blackberries are common.

Mediterranean Belt

The western Transcaucasus, from Novorossiisk to Dzhubga and somewhat farther south (but not as far as Tuapse), has a Mediterranean climate. The summer is hot and dry; the winter, in general, is moderate. The greatest precipitation comes in January, December, and November; the least, in August and May. In Novorossiisk the mean precipitation for January is 89 mm.; for August, 33 mm.; for the year, 688 mm. The mean August temperature is 24.0° C.; the mean January temperature, 2.1° C. Cloudiness is greatest in December and January, least in August.

The mountains in this region rise to elevations of 800 to 900 m.; near Novorossiisk they are only 600 m. high.

In Novorossiisk Bay in winter there often blows a cold and strong northeast wind, the *borá*, or the *nordost*, as it is called there. The *bora* arises when a barometric minimum lies over the sea while the pressure increases sharply over the land. In Novorossiisk this wind sometimes reaches the force of a hurricane. Sometimes when it is blowing the temperature drops below – 20° C., and the harbor, which is usually free from ice, freezes over. During the *bora* of December 17 to 20, 1899, all the buildings on the embankment were covered with an ice crust up to 2 m. thick. In January the mean wind velocity during the *bora* reaches 23 m. per second. The *bora* blows most frequently from November to March; in November it occurs an average of seven days. It usually lasts a day, often two or three days, but it has been known to last a week.

The distribution and character of the vegetation of Novorossiisk *raion* [9] resemble in general those of the shores of the Mediterranean, or, more exactly, of the shores of the northern part of the Balkan Peninsula. There are many relict Mediterranean elements associated with the rocky cliffs, the juniper forests, and the forests of Aleppo pine. The coastal hills, from the sea to an elevation of 150 to 200 m., are covered with stunted woods

[9] V. P. Maleyev, "Rastitelnost raiona Novorossiisk-Mikhailovsky pereval" (Vegetation of the Region from Novorossiisk to Mikhailovsky Pass), *Zap. Nikit. botan. sada* (Report of the Nikitsky Botanical Garden), XIII, No. 2, 1931.

and shrub thickets of xerophilous species which shed their leaves in winter. This type of vegetation in Mediterranean countries is called *shiblyak*. The *shiblyak* of Novorossiisk *raion* consists fundamentally of the dwarf pubescent oak (*Quercus pubescens*), with an admixture of Oriental hornbeam (*Carpinus orientalis*), and, in the drier places, of the spiny Christ's-thorn paliurus (*Paliurus spina-christi*)—a shrub which covers large areas, and appears in abundance on the sites of cut-over oak woods. Occasionally the Turk terebinth pistache (*Pistacia mutica*), native to the southern shore of the Crimea, is found in the *shiblyak* association. In the same zone, near the sea, there lie forests and more often coppices or individual trees of Aleppo pine (*Pinus pityusa* [*P. halepensis pityusa*]). There are some individual specimens of arborescent prickly juniper (*Juniperus oxycedrus*). On the coastal cliffs there often grow the tall, erect stems of the characteristic endemic umbellifer, the meadow saxifrage (*Seseli ponticum*, related to the Crimean *S. gummiferum*). In August it covers the cliffs and areas of talus with white patches of blooming plants. Another plant found here is the Crimean-Balkan tragacanth astragalus (*Astragalus arnacantha*). Colchian plants are represented at Novorossiisk and Anapa by the greenbrier. There is also some woodland European grape. Novorossiisk *raion* is noted for its vine growing and wine production.

Above the *shiblyak* zone there grow juniper forests of the arborescent junipers *Juniperus excelsa* and *J. foetidissima;* a third species, *J. oxycedrus,* occurs as an admixture. These forests occupy the zone between 150 and 300 m. At present, as Maleyev points out, here (and in the Crimea) the junipers (and Aleppo pine) are being displaced gradually by deciduous species.

Above the juniper zone there grow forests of durmast oak, hornbeam, smoothleaf elm, Scotch elm, linden (*Tilia caucasica* [*T. dasystyla*], *T. cordata*), ash, mazzard cherry, and in some places individual oriental beech trees (*Fagus orientalis*), which extend to the north almost as far as Anapa. Near Dzhubga there is chestnut. In the wetter sections of these forests there are vines—greenbrier, Grecian silk vine, traveler's-joy, and grape.

Beginning at an altitude of 400 to 450 m., the mountains are unforested, covered with mountain-steppe and mountain-meadow vegetation. At elevations of about 500 m., feather-grass and fescue mixed-herbaceous stands appear. The explanation for such an abrupt drop in the boundary of forest vegetation lies in the strong winds.

The flora of Novorossiisk *raion* contains some elements in common with that of the Crimea. The exchange of plants took place not across the Taman Peninsula, where such elements are absent, but, it is believed, by way of the "Pontic land mass," which occupied a considerable part of the Black Sea basin until the end of the Tertiary period (Wulff, 1929; Maleyev, 1931).

Forest Zone

In the northern Caucasus the forest zone lies above the forest steppe; in the western Transcaucasus it lies above the Mediterranean belt in the north, and above the subtropical belt in the south. From west to east the amount of precipitation decreases as a rule, and in the forests the number of hydrophytic and thermophilic species, in which the mountain forests of Colchis are so rich, diminishes. We will begin our description with the western Transcaucasus.

Western Transcaucasus

The western Transcaucasus includes the entire slope of the Caucasus mountains which faces the Black Sea. Two parts of the western Transcaucasus—the Colchian Lowland and Novorossiisk *raion*—have been described already. We shall turn now to the region of mountain forests of the Colchian type, which lie to the south of Dzhubga.

In Tuapse *raion* the mountains rise to an elevation of 1500 m.; in the latitude of Sochi, to 3000 m.; at Sukhum, to 4000 m.; at Batum, to 2000 m.

The climate of the lower, foothill zone (to the south of Dzhubga and as far as Batum) is the same as that of the Colchian Lowland: humid, with abundant precipitation, a hot summer, and a relatively warm winter. In summer in Sochi the temperature during the day reaches 24° to 28° C., while at night it seldom falls below 20° C. The warmest place in the western Transcaucasus is Gagry, which has the same mean annual temperature (15.1° C.) as Nice (15.0° C.). But in Gagry the summer is hotter and the winter colder than in Nice. Mean monthly temperatures in Gagry (lat. 43°19′ N, absolute elevation 22 m.) for the period 1903–1915 are given in the following table.

Table 17

Temperature in Gagry, 1903–1915 (in ° C.)

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
7.3	7.5	9.0	12.5	17.1	21.2	23.9	24.1	20.6	16.9	12.4	9.2	15.1

The winter here, as we can see, is warm, permitting plants to vegetate the year round. Nevertheless, there are some frosts on the coast every year. In Sochi the mean number of days per year when the thermometer drops below zero is 16. Snow usually lies no more than 3 to 5 days in Sochi, but during the severe winter of 1910–1911 there were 25 days with snowfall, and the snow cover lay on the ground for 37 days; it reached a thickness of 80 cm. As a result of temperature inversion, the zone which is least subject to frost in Sochi *raion* lies at an elevation of about 100 m.; lower down (and, of course, higher up) the incidence of frosts is greater.

The average dates at which different wild and cultivated plants bloom in Sukhum (lat. 43° N) are good indices of the normal character of the winter. In the vicinity of Sukhum, the Caucasian hellebore (*Helleborus caucasicus*), violet, and speedwell bloom in December; the European filbert (*Corylus avellana*), in January; the apricot, at the end of February; the almond, at the beginning of March; the peach, about the middle of March; the azalea, plum, mazzard cherry, pear, and cherry, at the beginning of April. The first strawberries ripen about April 22.

The rainfall is heavy, more than 1000 mm. per year. Sochi has 1410 mm.; Sukhum, 1371 mm.; Batum, 2465 mm.[10] Precipitation is greatest in winter or autumn, least in May, and in some places in June or August; but there is no dry period; the precipitation is distributed more or less evenly throughout the year. Thus, at Sukhum, even in May, the driest month, the precipitation is about 100 mm., that is, more than the average in Moscow for the rainiest month; in Batum or Chakva the mean precipitation in August exceeds 200 mm. (an altogether tropical amount). With so much rain, a high summer temperature, and a mild winter, the vegetation naturally has a subtropical appearance. A whole series of cultivated subtropical plants bloom in winter in the region from Sochi to Sukhum (not to mention the Batum coast). These plants include the Japanese camellia, Australian acacia, and loquat [*Eriobotrya japonica*]. But even the indigenous native plants, as we have seen, bloom throughout the winter.

On the Black Sea coast the summer rains fall predominantly at night or in the morning, and are not of very long duration. The number of rainy days for the three months of July, August, and September, and the amount of precipitation per rainy day, are as follows:

[10] *Materialy po agro-klimaticheskomu raionirovaniyu subtropikov* S.S.S.R. (Materials on the Agro-Climatic Regional Subdivision of the Subtropics of the U.S.S.R.). Leningrad, 1936, izd. Yedinoy gidro-meteor. sluzhby (publication of the Hydro-Meteorological Service), p. 274.

Table 18

PRECIPITATION ON THE BLACK SEA COAST

	TUAPSE	SOCHI	SUKHUM	BATUM
Number of rainy days, July through September	33	36	44	49
Precipitation per rainy day (in mm.)	14	10	10	18

The finest season of the year on the coast is autumn, particularly after the middle of September. The weather turns cooler, and the atmospheric humidity decreases; at the same time there is abundant sunshine. However, in autumn there are heavier showers than in summer. The autumn in the western Transcaucasus is very warm; October in Batum is warmer than April by 5.5° C. October in Gagry is almost as warm as July in Moscow. The forest begins to turn yellow at the end of October, and loses its leaves by the middle of November.

The winds have been mentioned already in the description of the Colchian Lowland. The eastern (winter) monsoon often assumes the character of a foehn. Thus, in Batum, such a foehn raised the temperature on the evening of February 28, 1915, to 24° C., while the humidity dropped to 16 per cent. In Gagry there have been occasions during the foehn when the relative humidity at night has dropped to below 10 per cent.

The southern plants which are cultivated here give a good indication of the climate. Among the ornamental plants, the palms are striking. The Chinese coir palm (*Trachycarpus excelsa* or *Chamaerops excelsa*) is abundant; it withstands frost very well, and for this reason is found even in Dzhubga, which lies north of Tuapse. There are also the date, Washington, fan, and other palms, the sago cycas (*Cycas revoluta*), magnolia, Chinese wistaria (*Wistaria chinensis*), Lenkoran acacia, oleander, camellia, many Japanese conifers (among them *Cryptomeria*), Japanese banana, agave, yucca, and many others. The southern plants of economic significance include the following which are native to the climate of Japan: the Satsuma orange (*Citrus unshiu* [*C. nobilis unshiu*]), which is found as far north as Sochi *raion*, but is of economic importance only from Gagry south; oranges; lemons; the Japanese kaki persimmon (*Diospyrus kaki*), the fruits of which are eaten; date-plum persimmon (*Diospyrus lotus*), which grows here in the wild form; loquat (*Eriobotrya japonica*), of the Rosaceae; flowering quince (*Cydonia japonica* [*Chaenomeles*]); common camellia (*Camellia japonica*); camphor tree (*Cinnamomum camphora*); bamboo, some species of which in the U.S.S.R.

reach a height of 15 m. and a thickness of 15 to 18 cm.; and, finally, tea. In Sukhum and Batum one may see gigantic specimens of eucalyptus. The cultivated plants which are not subtropical include the garden plum (which is grown at Sochi), tobacco, corn, peaches, grapes, and other fruits grown in Abkhaziya.

Of the characteristic Colchian plants, the chestnut grows as far north as Dzhubga, while the European hop hornbeam (*Ostrya carpinifolia*) and the laurel cherry extend as far as the mountains at Tuapse. In the western Transcaucasus the northern boundary of holly, box, and Caucasian wing nut is somewhat south of Tuapse.

The soils in the foothills are red earths, which border the Colchian Lowland on the northeast and southeast. To the north they extend as far as the latitude of Ochemchiri; to the south, somewhat south of Batum. At Batum these soils were formed on thick weathered andesitic tuffs. The red earths are rich in hydrates of ferric oxide and aluminum oxide, poor in silicic acids and bases. While they are poor soils, they are exactly the soils required by tea. Higher up, the red soils are replaced first by brown soils,[11] and then by gray forest soils.

Vegetation. A peculiar feature of the forests of the western Transcaucasus is the presence of a series of evergreen deciduous trees and shrubs, which we have mentioned already in the description of the Colchian Lowland. No less characteristic is the profusion of vines, herbaceous as well as woody. Greenbrier, traveler's-joy, Grecian silk vine, grape, Colchis and English ivy, sweet honeysuckle (*Lonicera caprifolium*), and blackberries are the woody vines found here; yam (*Dioscorea caucasica*), glorybind (*Calystegia sylvatica* [*Convolvulus silvaticus*]), and *Tamus communis* (Dioscoreaceae) are the herbaceous vines.

On the seacoast, the often swampy lowlands at the mouths of some of the rivers are covered with a vegetation of the Colchian type. Thus, the mouth of the Mzymta River is bordered on the south by a waterlogged area, a part of which has been cleared of forest, drained, and turned into cornfields; an alder forest (*Alnus barbata*), with an admixture of Caucasian wing nut, ash, hedge maple, and mulberry, covers the unreclaimed swamp. The trees are twined with greenbrier, Grecian silk vine, ivy, and blackberry. In the drier portions, where the soil is sandy, the swamp is dominated by thickets of common box (*Buxus sempervirens*), among which are scattered enormous individual specimens of yew and oriental beech. There is some arborescent royal fern (*Osmunda*

[11] Concerning these soils, see below, under the description of the Crimea (pp. 250–251).

regalis). On the calcareous coastal slopes there is Aleppo (Pitsunda) pine (*Pinus pityusa* [*P. halepensis pityusa*]), which appears in the Caucasus from Anapa to Pitsunda (and is found also in the Crimea, in Asia Minor, in Syria, and near Constantinople); it is accompanied by the Crimean rockrose (*Cistus tauricus* [*C. villosus tauricus*]).

Up to this point we have talked about the coast. Now we will discuss the succession of belts as we ascend into the mountains.

In the virgin forests the predominant species are oak, beech, and chestnut. To the south, in Adzhariya, they are beech and chestnut.

In Sochi *raion* and in Abkhaziya, the foothills up to an elevation of 600 to 1000 m. are covered with an oak forest of typically Colchian appearance, with a mass of vines. The vines here, with the exception of ivy, are associated only with the outskirts of the forest or with the clearings.

In Abkhaziya forests of Imeritian oak (*Quercus imeretina*) with an undergrowth of azalea grow on the lower terraces. The higher terraces, up to an elevation of 200 to 240 m., are covered with forests of Iberian oak (*Q. iberica*), with an admixture of hornbeam and beech, and sometimes with an undergrowth of pontic rhododendron. At elevations from 240 to 650 m. grow oak forests with an undergrowth of oriental hornbeam.

In addition to oak, hornbeam, beech, and oriental hornbeam, other trees which grow here include the oak *Quercus hartwissiana,* elms, ash, linden, zelkova, hornbeam, chestnut, maples, Grecian laurel (*Laurus nobilis*), box, date-plum persimmon (*Diospyrus lotus*), and a great many shrubs. In some places there are found the remains of Circassian and Abkhazian gardens, abandoned by their owners during the 1860's, when the migration into Turkey took place. These gardens contain wild myrobalan plum (*Prunus divaricata* [*P. cerasifera divaricata*]), plum, mazzard cherry, fig, thick-shell Persian walnut, apple, pear, and mulberry. These escaped fruit trees include many excellent strains. Along the river valleys there are forests of typically Colchian appearance, with a mass of vines; they contain some box and English yew (*Taxus baccata*), both almost exterminated (Fig. 53). (These trees have been preserved best in Abkhaziya, where they are found growing from sea level up. Box grows here predominantly on calcareous soils in the hornbeam and beech-hornbeam forests; it ascends into the mountains as high as 900 to 1000 m. Yew is found in the mixed and beech forests along the deep, moist river gorges and on the northern slopes, up to an elevation of 1500 m.) In spots there is European hop hornbeam (*Ostrya carpinifolia*) (a tree closely related to the hornbeam) and also zelkova. In the southern parts an undergrowth of evergreen species is well developed: pontic rhododendron (*Rhododendron ponticum*), common laurel cherry (*Laurocerasus officinalis* [*Prunus laurocerasus*]), butcher's-broom (*Ruscus hypophyllum, R. ponticus*), common box (*Buxus sempervirens*), and phillyrea (*Phillyrea vilmoriniana* [*P. decora*]). There are many epiphytes growing on the trees; these include the fern *Polypodium serratum*, and also some flowering plants. Lichens grow on the leaves of the box. The lower horizons of the oak zone, approximately up to an elevation of 400 to 500 m., are best suited for fruit growing of the southern type.

In Abkhaziya the virgin foothill forests consist predominantly of Iberian oak (*Quercus iberica*). On the shaded and moist northern slopes, and also as the forests rise into the mountains, oak is replaced by hornbeam-beech and chestnut-beech forests.[12]

In Adzhariya, elevations from sea level to 800 to 1200 m. are covered with chestnut-beech forests.

In Abkhaziya, above 600 to 1000 m., and approximately as high as 1200 m., there is continuous beech forest, in which the only vines commonly found are Colchis and English ivy (*Hedera colchica* and *H. helix*). The most widespread type of beech forest here contains no herbaceous cover; the undergrowth is absent also, or consists of individual bushes of holly, azalea, and Caucasian whortleberry [*Vaccinium arctostaphylos*]. But in addition there are some beech forests with a ground cover of ostrich fern (*Struthiopteris struthiopteris* [*S. filicastrum*]) and butterbur (*Petasites hybridus*), or of blackberry (*Rubus ponticus*) and wheat grass (*Agropyron caninum*); or with an undergrowth of pontic rhododendron, or azalea, or laurel cherry, with an admixture of butcher's-broom (*Ruscus hypophyllum*), holly, Caucasian whortleberry, and European cranberry-bush viburnum. Beech forests with an undergrowth of laurel cherry often reach as far as the upper boundary of the forest in Abkhaziya. Such a beech forest, with an undergrowth of laurel cherry and individual specimens of holly, butcher's-broom, azalea, and Caucasian whortleberry, may be found at an elevation of 1800 to 1900 m., that is, considerably above the normal boundary of beech forest. Still higher up lie thickets of laurel cherry with an admixture of Caucasian rhododendron, but there is no beech. The types of beech forest which

[12] V. P. Maleyev, "Flora i rastitelnost Abkhazii" (Flora and Vegetation of Abkhaziya), *Abkhaziya, geobotan. i lesovodstv. ocherk* (Abkhaziya, A Geobotanical and Forestry Sketch), izd. Akad. nauk (publication of the Academy of Sciences), Leningrad, 1936, p. 23. Above Gagry, the slopes which face the sea are covered with a forest of Iberian oak, which extends here only up to 1000 to 1200 m.; on the shady slopes it is replaced by a beech forest (pp. 26, 31).

have been described, those with an evergreen undergrowth, do not occupy large areas. The beech is sometimes accompanied by a small quantity of chestnut, which rises here to an elevation of 1200 m.[13]

In some places, however, the beech descends to sea level. In general, as Albov (1896) observed, in the subtropical part of the western Transcaucasus many of the herbaceous, shrub, and even tree species are distributed from sea level as far up as the alpine zone. Such species include the pontic rhododendron, azalea, holly, Caucasian whortleberry, laurel cherry, and filbert; in some places they grow as high as 2000 m. Beech in the form of shrubs ascends to 2100 m.; chestnut is found often at an elevation of 1800 m.; oak, at 1900 m. In Guriya, Albov found ivy twining about spruce trees. Albov explains this phenomenon by the great humidity of the climate, which diminishes the effect of temperature differences at different elevations.

In the Colchian part of South Ossetia, beech forests predominate; there are also some forests of beech with spruce and fir. In these forests an evergreen undergrowth of the Colchian type is developed. There is some box. In places there are thickets of chestnut with an undergrowth of either laurel cherry or azalea.

In Abkhaziya there lies a zone of fir from 1200 to 1900 m. which, unlike the beech zone, does not form a continuous strip. Here, in addition to Nordmann fir (*Abies nordmanniana*), there are beech, maples, hornbeam, and (in the undergrowth) dense thickets of evergreen shrubs: laurel cherry, holly, pontic rhododendron, and a mass of Caucasian whortleberry (*Vaccinium arctostaphylos*). The trees grow in a thin stand and reach gigantic dimensions, as much as 1.5 to 2 m. in diameter (Fig. 54).

The fir in places is accompanied by oriental spruce (*Picea orientalis*).[14]

> Between the trees in some places there are wide glades, overgrown with gigantic subalpine vegetation, often tall enough to conceal a rider on a horse; milky bellflowers (*Campanula lactiflora*) with stems bearing as many as a hundred and more flowers, sumptuous Caucasian lilies, gigantic umbellifers (*Heracleum pubescens*) with inflorescences as big as a platter and with stems a *vershok* * thick, and the like, astonish the traveler who has never seen anything of the kind before (Albov, 1896).

[13] V. A. Povarnitsyn, "Tipy lesov Abkhazii" (Types of Forest in Abkhaziya), *Abkhaziya* (Abkhaziya), izd. Akad. nauk (publication of the Academy of Sciences), 1936, p. 125ff.

[14] Both these trees—the Nordmann fir and the oriental spruce—are found in the mountains of Asia Minor. In Adzhariya, spruce forests may be found at elevations of about 200 m., while fir-spruce forests begin at 500 m.

* One *vershok* = 1.75 inches, or 1/16 of an *arshin* (28 inches).—Tr.

These glades of tall herbaceous vegetation, particularly characteristic for the succeeding, subalpine zone, begin to appear at an elevation of 1200 to 1300 m. On the dry slopes in some places there is Scotch pine (*Pinus sylvestris hamata*); it extends up to the boundary of the forest, and down to 200 to 300 m. above sea level.

At 1700 to 2100 m. lies the subalpine zone. Here there are groves of pubescent birch (*Betula pubescens*), with an admixture of redbud maple (*Acer trautvetteri*) and an undergrowth of dwarf oriental beech, Caucasian rhododendron, pontic rhododendron, azalea, laurel cherry, holly, Caucasian whortleberry, Caucasian honeysuckle, mountain ash, and others. In this zone there is found also the relict Medvedev's birch (*Betula medwediewii*), as well as the Mingrelian birch (*B. megrelica*), pontic oak (*Quercus pontica*), and Caucasian buckthorn (*Rhamnus imeretina*). In some places Caucasian rhododendron (*Rhododendron caucasicum*) occupies large areas; this evergreen shrub, which covers the earth with a dense carpet, suppresses all herbaceous vegetation; it is associated primarily with the shadier and wetter northern and western slopes, and rises in some places to elevations of 2300 m. Large areas in the subalpine zone are occupied by the tall herbaceous vegetation which has been described already. Some authorities are of the opinion that these thickets of gigantic dicotyledons are largely of a secondary character, as they usually occupy sites which at one time were under forest. Others regard the thickets of tall herbaceous plants as relicts of ancient Tertiary hydrophytic vegetation.[15]

The subalpine zone is used for pasture.

The fauna of the western Transcaucasus does not include such characteristic elements as does the flora. In the forests there are: bear (*Ursus arctos* subsp.), distinguished from the typical brown bear by its smaller size; lynx (*Felis lynx orientalis* [*Lynx orientalis*]); wild cat (*Felis silvestris*); Caucasian red deer (*Cervus elaphus maral*); and roebuck (*Capreolus pygargus* and *C. capreolus*). At one time there was some Caucasian bison (*Bos bonasus caucasicus*) at Krasnaya Polyana. The jackal (*Canis aureus* [*Thos aureus*]) is found from the delta of the Kuban to Batum. There is Transylvanian wild boar (*Sus scrofa attila*) throughout the western Transcaucasus. Of the reptiles, the red viper (*Vipera kaznakovi*) is characteristic. The amphibians, in addition to the river frog (*Rana ridibunda*), include a series of endemic frogs and toads (*Rana macro-*

[15] A. A. Kolakovsky, "Rastitelnost Bzybskovo izvestnyakovovo khrebta" (Vegetation of the Bzyb Limestone Range), *Trudy Inst. abkhaz. kultury* (Proceedings of the Institute of Abkhazian Culture), XI, Sukhum, 1937, p. 22.

cnemis, Pelodytes caucasicus), the characteristic Caucasian salamander (*Salamandra caucasica*), and the Caucasian striped newt (*Triturus vittatus ophryticus*).

The North Caucasus Foreland

In the North Caucasus Foreland precipitation in the upper part of the forest zone is 800 to 1200 mm. per year and more; in the lower part, it is less—800 to 500 mm. The maximum precipitation comes in May and June. There is much snowfall in the western part of the Caucasus range; near Klukhor Pass the depth of the snow cover reaches 2.5 m. and more.

The forests in the western part of the North Caucasus Foreland, approximately as far east as Teberda *raion,* still contain a considerable admixture of Colchian elements. Precipitation is greatest in the central part of the western North Caucasus Foreland, with which we are concerned now, particularly in the region of the upper Belaya and Little and Great Laba rivers, where the famous Caucasian preserve is situated. Here, in the zone of broad-leaved forests, the annual precipitation reaches 1500 mm.; accordingly, Colchian elements are relatively numerous; they include not only the oriental spruce and Nordmann fir, but also box, yew, European hop hornbeam, laurel cherry, holly, English ivy, pontic rhododendron, and Caucasian whortleberry, as well as Caucasian buckthorn, Colchis bladdernut (*Staphylea colchica*), Colchis ivy, butcher's-broom (*Ruscus hypophyllum*), and others. In one place there is chestnut. The foothills and low mountains from 800 m. to 1400 m. are covered with deciduous forests of oak, Caucasian beech, and hornbeam, with an admixture of ash, maple, elm, linden, apple, pear, wild myrobalan plum, and others. Beech forests are associated with the northern slopes, oak forests with the southern. Oak groves with an undergrowth of pontic azalea (*Rhododendron flavum* [*R. luteum*]) are common.

Above the broad-leaved forests, in the belt between 1400 and 1900 m., lie coniferous forests of oriental spruce (*Picea orientalis*) and Nordmann fir (*Abies nordmanniana*). Fir forests with an undergrowth of pontic rhododendron and holly are common. Ivy is found here also.

The fir-spruce forests of Maikop *raion* contain the remarkable umbellifer *Osmorhiza brevistylis* [*O. claytoni*]. Other species of this genus are found in the Kuznetsk Ala-Tau and on the Salair range, in Manchuria, on Sakhalin, in Japan, and in the eastern states of North America.

In the higher parts of the belt of coniferous forests, on the southern slopes, there are pine forests of hamate Scotch pine (*Pinus sylvestris* *hamata*). The forest zone ends[16] in groves of pubescent birch with an undergrowth of Caucasian rhododendron; or in pine groves with Andorra creeping juniper (*Juniperus depressa*); or in shrub beech with an undergrowth of Caucasian rhododendron or laurel cherry. Near the upper boundary of the forests usually there are found park-land woods of redbud maple (*Acer trautvetteri*) amid the tall alpine herbage. On the boundary between the forest and the subalpine meadows there are shrub thickets of Caucasian rhododendron, or laurel cherry, or juniper. The Caucasian bison was characteristic at one time for the forests of this part of the North Caucasus Foreland; by this time it has been exterminated. The other animals include the Caucasian red deer (*Cervus elaphus maral*), roebuck, leopard, wild cat (*Felis silvestris*), marten, ermine, and bear.

To the east of Teberda the climate of the western North Caucasus Foreland becomes drier, and the coniferous forests of fir and spruce gradually disappear, although individual specimens of spruce are found as far as northern Ossetia, while fir and yew are found as far as Balkariya. Here beech forests predominate; after felling they are replaced by hornbeam forests with oak. In the beech forests in some places there are Colchian plants: European hop hornbeam, holly, Caucasian whortleberry, and English ivy.

The longitudinal valleys between the Skalisty and Peredovoy ranges and between the Peredovoy and the Glavny (Main) ranges, particularly in the vicinity of Elbrus, are especially dry. Here on the northern slopes there are pine groves of *Pinus sylvestris hamata* (Fig. 55), while on the southern slopes there are mountain xerophytes: thickets of European barberry (*Berberis vulgaris*), sweetbrier rose, and sage (*Salvia canescens,* which covers large areas) (Fig. 58), and also *Thymus*, spiny astragalus (*Astragalus marschallianus*), various composite plants, and cushions of savin juniper (*Juniperus sabina*).

The upper boundary of the forest here (between Elbrus and the Georgian Military Highway), just as farther west, consists of birch groves, but in addition to pubescent birch, there is found also another, relict form, Radde's birch (*Betula raddeana*). Thickets of Caucasian rhododendron are widespread.

East of the Georgian Military Highway, in the Chechen area, the character of the forest zone is about the same as in the central part of the North

[16] A. I. Leskov, "Verkhny predel lesov v gorakh zapadnovo Kavkaza" (The Upper Boundary of Forests in the Mountains of the Western Caucasus), *Botan. zhurn. S.S.S.R.* (Botanical Journal of the U.S.S.R.), XVII, 1932, pp. 227–260.

Caucasus Foreland. In the foothills at one time there were oak forests. Above them grow beech forests, with lindens, Scotch elms, maples, hornbeam, and ash. Occasionally the beech forests contain yew. The upper boundary of the forest consists of groves of pubescent birch (Fig. 56); the undergrowth contains azalea. At an elevation of 1600 m. there is redbud maple (*Acer trautvetteri*). The southern slopes bear the mountain xerophytes which were described earlier. In Tushetiya on the northern slopes there are pine forests.

In the forest zone of the North Caucasus Foreland, the animals include the wild cat (*Felis silvestris*), Transylvanian wild boar (*Sus scrofa attila*), Caucasian red deer (*Cervus elaphus maral*), roebuck, and forest dormouse (*Dyromys nitedula*). The mountain forests of the Kuban basin were inhabited until recently by Caucasian bison. The frog *Rana macrocnemis* ascends as far as the subalpine meadows. There are some tree frogs (*Hyla arborea*). The tree squirrel *Sciurus vulgaris* is absent in the forests of the Caucasus. The taiga birds which nest in the fir-spruce forests of the North Caucasus Foreland, as well as in other parts of the Caucasus, include the black woodpecker (*Dryocopus martius*), the spruce crossbill (*Loxia curvirostra*), and the bullfinch (*Pyrrhula pyrrhula*).

Eastern Transcaucasus

We have spoken already of the western Transcaucasus (p. 214ff.). Now we will describe the forests of the eastern Transcaucasus.

In the South Ossetian autonomous *oblast*, in the basin of the Liakhva River (a tributary of the Kura), there are forests of beech, spruce-fir, and (on the southern slopes) Scotch pine (*Pinus sylvestris hamata*). Here there is no pontic rhododendron or holly in the undergrowth, but there is Caucasian buckthorn, Caucasian whortleberry, and laurel cherry. In the basin of the Little Liakhva, coppices of eastern mountain oak (*Quercus macranthera*) have been discovered. There is some yew. The upper boundary of the forest contains birch groves with Caucasian rhododendron.

East of South Ossetia and west of the meridian of Tiflis, holly and Colchis ivy are still found. But spruce-fir forests are absent.

The Trialetsk range, which is not a part of the Glavny (Main) Caucasus range, still contains many Colchian elements, particularly on its northern slope. Thus, at Borzhom, in the spruce-fir forests, there is an undergrowth of laurel cherry, holly, butcher's-broom (*Ruscus hypophyllum*), pontic rhododendron, Caucasian cherry, and bladdernut (*Staphylea*); there is some chestnut; the vines include English and Colchis ivy and *Tamus communis* (Dioscoreaceae), a perennial plant native to the southern shore of the Crimea.

In Kakhetiya and farther east on the southern slope of the Caucasus range, at elevations of 700 to 1800 m., there grow beech and beech-hornbeam forests. The oaks are represented by the Iberian oak (*Quercus iberica*) and the mountain oak (*Q. macranthera*); of the maples, the Persian velvet maple, *Acer insigne* [*A. velutinum glabrescens*], is widespread. In the Lagodekhi Gorge there is chestnut; in the Belokansk Gorge, laurel cherry. Fifty km. from Telav there is a forest of beech and yew. The undergrowth contains Colchis bladdernut (*Staphylea colchica*) and Caucasian whortleberry. The subalpine birch groves contain thickets of Caucasian rhododendron, and sometimes azalea.

The Subalpine Zone

The subalpine zone in some places begins at 1400 m., in others only at 2400 m. Along the Georgian Military Highway it occupies elevations between 1400 m. and 2400 m.; in the Rion basin, between 1700 and 2000 m.

The following stations, which lie on the Glavny (Main) Caucasus range, along the Georgian Military Highway, may give some idea of the climate of this zone.

Table 19

TEMPERATURE AND PRECIPITATION IN THE SUBALPINE ZONE IN THE GLAVNY (MAIN) RANGE OF THE CAUCASUS

Locality	Absolute Elevation (m.)	Temperature (°C.)		Annual Precipitation (mm.)
		January	August	
Kobi	1990	−8.4	13.8	1192
Krestovy Pass	2390	−12.1	11.3	1693
Gudaur	2210	−7.3	13.3	1477

The warmest month here, as is generally the case in high mountains, is not July, but August; however, frosts occur even in August. Because the cold air drains downward, Gudaur, although 220 m. higher in elevation, has a January temperature 1° C. warmer than Kobi. Winter on the Glavny Caucasus is warmer than winter on a plateau of the same elevation. Thus, in Kars (Turkey), at 1742 m., the mean January temperature is − 12.8° C.; that is, colder than at Krestovy Pass, although Kars lies farther south and lower. There is much precipitation in the western half of the Central Caucasus, more than 1000 to 1500 mm.; farther east, the precipitation is less, and the annual total may drop to 500 mm. Maximum precipitation occurs in the early summer or the late spring.

We have spoken already to some extent of the vegetation of the subalpine zone (p. 221). In this zone forest and alpine plants intermingle. The zone begins everywhere with birch groves, which usually contain thickets of Caucasian rhododendron (*Rhododendron caucasicum*), studded with large flowers at the end of May and the beginning of June. This rhododendron appears in some places (in the western Transcaucasus) at an elevation of 1800 m., and in others rises to an elevation of 3000 m. Of the birches, Medvedev's birch (*Betula medwediewii*) is associated particularly with the subalpine zone of the western Transcaucasus, and Radde's birch (*B. raddeana*) with the eastern North Caucasus Foreland. But other birches, of the pubescent group, are found here in addition. In this horizon redbud maple (*Acer trautvetteri*) and stunted junipers are also very common.

A peculiar feature of the subalpine zone is the meadow of tall herbaceous plants—so-called *vysokotravie* (Fig. 57). These include gigantic umbellifers, up to 3 m. high; monkshood (*Aconitum orientale*); columbine (*Aquilegia olympica* [*A. vulgaris olympica*]); larkspur (*Delphinium*); false hellebore (*Veratrum lobelianum*); valerian (*Valeriana alliariaefolia*); inula (*Inula magnifica*); pink knotweed (*Polygonum carneum*); Caucasian buttercup (*Ranunculus caucasicus*); *Cephalaria tatarica* (Dipsacaceae); Caucasian scabious (*Scabiosa caucasica*); the composites *Telekia speciosa* [*Buphthalmum*] and *Senecio;* and others. According to Medvedev (1915), the tallness of the herbage is explained by the late thawing of the snows; the plants develop at relatively high temperatures on moist soil. This layer society of tall herbage was mentioned above, in the section on the forest zone. Higher up lie the subalpine meadows, distinguished from the alpine meadows by their relatively tall stand (up to 1 m.). These meadows are composed fundamentally of grasses, with an admixture of various dicotyledons.

Bear and wild boar may be found on the subalpine meadows.

The Alpine Zone

Above the subalpine zone lies the alpine zone, which occupies elevations from 2200 m. to 3000 m. and higher. The vegetation here consists of stunted alpine herbaceous plants. The average height of the stand is 10 to 30 cm. The chief plants which compose the sod are various sedges, among them cobresia (*Cobresia*); grasses are of secondary importance.

On the meadows which have been manured by livestock, alpine blue grass (*Poa alpina*) and alpine timothy (*Phleum alpinum*) grow in profusion. Prominent among the alpine herbaceous plants are the short bell-flower with its large flowers, gentian, primula, forget-me-not, violet (*Viola oreades*), corydalis (*Corydalis conorrhiza*), Caucasian dryad (*Dryas caucasica*), and others. Many endemic plants (for example, the Caucasian larkspur (*Delphinium caucasicum* [*D. speciosum*]), Owerin's astragalus (*Astragalus owerini*), and others) are found among the flora of the alpine zone of the Glavny Caucasus.

There are few bogs and lakes in the high-mountain region of the Caucasus. In the Central Caucasus (in Balkariya and Ossetia), on the southern slope as well as on the northern, there are bogs with sedges predominating, often with a thin cover of sphagnum mosses. These bogs are of recent origin (N. Bush).

In the alpine meadows and rhododendron thickets, the Caucasian black grouse (*Lyrurus mlokosiewiczi*) is very characteristic. The snow pheasant (*Tetraogallus caucasicus*) prefers the region above the rhododendron thickets. The *tur,* or Caucasian ibex, is associated particularly with the alpine zone (in the west, *Capra dinniki* [*C. severtzowi dinniki*], *C. severtzowi, C. caucasica;* in the east, *C. cylindricornis* [*C. caucasica cylindricornis*]), although it descends into the forest zone as well. The Caucasian chamois (*Rupicapra rupicapra caucasica*), which is related very closely to the chamois of the mountains of Europe and Asia Minor, is found here; for the winter it descends into the forest zone. The endemic burrowing vole (*Prometheomys schaposchnikowi*), an inhabitant of the alpine and subalpine zone, is found near Krestovy Pass and as far west as Fisht and Oshten. Another high-mountain rodent is the alpine meadow mouse (*Microtus nivalis*), native to the Kopet-Dagh, the Alps, the Pyrenees, and the Apennines (at Gudaur and Kazbek, *M. nivalis gud*). In the subalpine meadows of the Central Caucasus there is found the small suslik (*Citellus pygmaeus musicus*), native, in different forms, also to the steppe and the semidesert.

Having described the Glavny Caucasus range, we pass on to other regions of the Caucasus.

2. DAGHESTAN [17]

The name Daghestan ("mountain country") in the physical geographic sense is given to the region between the Caucasus range on the west and the Caspian Sea on the east. The northern boundary of Daghestan is the Andiisk range, which lies on the watershed between the Terek and the Andiisk Koi-Su (one of the feeders of the Sulak). The western extreme of the Andiisk range lies in the Liklos-Mta massif, which is covered with everlasting snows and glaciers. Beyond the Sulak the eastern continuation of the Andiisk range is called the Gimrinsk (elevation 2000 m.); the Andiisk range is separated from the Gimrinsk by the narrow and deep (500 m.) Sulak canyon. On the south, Daghestan is bounded roughly by a line extending from Mount Bazar-Dyuzi (elevation 4484 m.) in the Glavny Caucasus range to the lower course of the Samur River.

Daghestan may be divided into the following zones: (1) the Caspian Lowland, (2) the foothills, (3) mountainous interior Daghestan, and (4) high-mountain Daghestan.

The *Caspian Lowland* of Daghestan extends as far south as the delta of the Samur River, and then merges into the Kuba Lowland. Within Daghestan the lowland reaches a width of 25 km. only along the lower course of the Samur; most of it is narrower, while in some places the mountains reach to the very shore. The lowland is composed of Quaternary Caspian deposits. Immediately beyond the coastal dune strip lies a belt of semidesert soils—solonized, poorly developed sierozems, light-chestnut soils, and solonetz soils.

But to the south, in the Samur delta, in some places there are broad-leaved forests with a profusion of vines. Along the rivers there is some alder (*Alnus barbata*). The forests in the southern part of the lowland contain hornbeam, oak, ash, maple, thick-shell Persian walnut, and a great deal of filbert. The vines here include greenbrier, Grecian silk vine, traveler's-joy (*Clematis vitalba*), ivy, grape, and blackberry (*Rubus discolor*).

The northern part of the Caspian Lowland contains vegetation of the semidesert type: *polyn* (of the *Artemisia maritima* group), camel's thorn

[17] B. F. Dobrynin, *Geografiya Dagestanskoy A.S.S.R.* (Geography of the Daghestan A.S.S.R.), 1926, with maps, Dagest. gos. izd-vo. (Daghestan State Publication). B. F. Dobrynin, *Landshaftnie (yestestvennie) raiony i rastitelnost Dagestana* (Landscape [Natural] Regions and Vegetation of Daghestan), Moscow, 1925 (Memuary Geogr. otd. obshch. lyub. yest. [Memoirs of the Geographical Section of the Amateur Naturalists' Society], No. 1).

(*Alhagi camelorum* [*A. pseudalhagi*]), and halophytes. There are many solonchaks. The reed thickets in the lowland are inhabited by numerous wild boar, and there are some jungle cats, jackals, hyenas, and pheasants. The *foothills* rise to an elevation of 1000 to 1200 m. They consist of folded Tertiary strata (in the south, Mesozoic). In the north, the climate is of the forest type; in the south, Mediterranean. Precipitation in the south is greatest in autumn and winter. Chestnut soils are peculiar to the lower sections of the foothills; the upper sections have dark-chestnut soils and chernozems (which sometimes reach a considerable thickness).

On the dry slopes of the lower sections of the Daghestan foothills, there are numerous thickets of xerophytic shrubs which shed their leaves in winter; Dobrynin (1925) calls this formation *shiblyak*, pointing out its similarity to the corresponding formation in the eastern Mediterranean and the Crimea. In the *shiblyak* of Daghestan, the spiny xerophytic shrub Christ's-thorn paliurus (*Paliurus spina-christi*) predominates, forming, up to elevations of 400 to 500 m., extensive and dense thickets; next in abundance is Pallas's buckthorn [*Rhamnus pallasi*?]. These thickets also contain shrub pubescent oak, small-leaved hornbeam, dogwood, pear, barberry, juniper, sweetbrier rose, spiraea, and others. Often the climbing blackberry (*Rubus discolor*) tangles the shrubs of the *shiblyak* with its shoots. In some places the *shiblyak* extends into mountainous and even high-mountain Daghestan.

On dry rocky slopes with poorly developed soils there are xerophytes; these spiny herbaceous plants and undershrubs grow in a formation which Dobrynin calls the *frigana* formation—a term also borrowed from the eastern Mediterranean. Other authors use the term *mountain* or *upland xerophytes*, or *mountain-steppe vegetation*.

The following plants are characteristic for the *frigana* of Daghestan: capers (*Capparis herbacea*), viper's-bugloss (*Echium violaceum*, *E. italicum*), thistle (*Cirsium*), the sage *Salvia aethiopis*, *Xeranthemum*, *Thymus*, *Centaurea*, and others. There are few grasses here. Most of the representatives of the *frigana* are Mediterranean plants. In some places on the southern slopes there are sections covered with feather grasses (*Stipa pulcherrima*) and other representatives of steppe vegetation (the dropwort, *Filipendula hexapetala*, and others).

In the higher foothills, at an elevation of 800 to 1000 m., dense forests predominate; but these contain no vines of greenbrier, Grecian silk vine, or ivy. They consist of Iberian oak, oriental beech, hornbeam, elms, maples, and checker-tree mountain ash (*Sorbus torminalis*). In the south, in the upper sections of the beech zone, the xerophytic mountain oak

(*Quercus macranthera*) may be found. The forest glades contain a luxurious meadow vegetation: sage (*Salvia glutinosa*), monkshood (*Aconitum orientale*), and others.

The vines in the beech forests include traveler's-joy (*Clematis vitalba*), sweet honeysuckle (*Lonicera caprifolium*), and *Tamus communis.*

Above 1000 m. the forests grow thin, and above 1200 m. they disappear entirely; this region is the beginning of mountain Daghestan. The Iberian oak ascends highest of all trees into the mountains; it forms shrub thickets at an elevation of 1200 m. In some places above the boundary of the broad-leaved forest there appear thickets of Caucasian rhododendron.

Mountain Daghestan includes the basins of the four Koi-Su rivers, the mountain part of the Sulak, and the headwaters of the Samur. Here the elevations reach 2000 to 3000 m.

Characteristic of the interior parts of Daghestan are high synclinal plateaus, composed of Jurassic limestones, which in many places are cut by canyonlike valleys (Fig. 59). The average elevation of the plateaus is about 1900 m., while the level of the rivers is at about 700 m. elevation. The Gunib Plateau (between the Avarsk Koi-Su and the Kara-Koi-Su rivers), which reaches an elevation of 2364 m., may serve as an example of these high plateaus. The summer is warm; the winter is dry, has little snowfall, and is not cold. Gunib, at an elevation of 1583 m., has a mean July temperature of 17° C., a mean January temperature of $-2°$ C. Cloudiness is less in winter than in summer, as is generally true on high mountains. In Gunib the mean cloudiness in summer is 45 per cent; in winter, 34 per cent; cloudiness is greatest in May (55 per cent). In the lowlands of Daghestan, however (for example, in Derbent), cloudiness is greatest in winter, and least in summer. Furthermore, cloudiness is greater in the lowlands than in the mountains. Although Gunib lies 700 m. higher than Kislovodsk, the winter in Gunib is warmer and considerably sunnier than in Kislovodsk; January in Gunib has only one cloudy day. For this reason Gunib is an excellent winter health resort.[18] Precipitation in mountain Daghestan reaches 400 to 800 mm.; it is greatest in summer and spring, least in winter. In winter there are 3 to 5 days a month with precipitation; in summer, 12 to 15 days, or more. The snow cover is negligible; in Gunib in January, when the snow is thickest, it amounts to an average of 4 to 5 cm. In mountain Daghestan calm weather prevails; in Gunib the mean annual wind velocity is only 1 m. per second. Cyclones from the Atlantic Ocean apparently never

[18] N. A. Korostelev, *Klimat Dagestana* (The Climate of Daghestan), Moscow, 1930, S.-kh. izd. (Agricultural Publication), p. 83.

penetrate into Daghestan. In the southern part of mountain Daghestan the predominant surface formations are dark, friable argillaceous shales of Jurassic age.

The vegetation of mountain Daghestan has a xerophytic character. There are few forests here. Only on the northern slopes, at an elevation of 1400 to 2300 m., are there pine forests, which are replaced after felling by birch groves. In addition to pine, these forests contain oak, hornbeam, linden, ash, aspen, mountain ash, speckled alder, and others. On the Gunib Plateau (1500 to 2000 m.) birch (*Betula pubescens, B. raddeana*) predominates. There are some forests of almost pure hornbeam; for example, Tsudakharsky forest, at an elevation of 1200 to 1300 m.

At the upper boundary of the forests (2000 to 2400 m.), the first birch groves appear; they consist of pubescent birch with an admixture of Radde's birch. The latter is distinguished sharply from the white birches by the shape and large size of its leaves and female catkins, and also by its general appearance. It is related closely to the East Siberian Erman's birch, and also to the western Transcaucasus Medvedev's birch. The bark of Radde's birch is pinkish in color, and on the older trees it is extensively peeled. This birch prefers the steep, rocky precipices, where it forms an undergrowth among the ordinary birch. The herbaceous cover in the subalpine birch groves is tall.

The southern slopes and the plateaus are entirely unforested. The vegetation consists of spiny astragalus (*Astragalus marschallianus*), spiny sainfoin (*Onobrychis cornuta*), shrubs of Christ's-thorn paliurus, barberry, sweetbrier rose, and juniper (*Juniperus isophyllos*); there is much sage (*Salvia canescens*) growing on the limestones; also *Teucrium, Capparis herbacea*, and others. Thistle (*Cirsium sinuatum*), which forms sprawling spiny bushes, is widespread; in some places it is used for fuel. The animals in the forests along the upper course of the Avarsk Koi-Su in mountain Daghestan include deer, bear, roebuck, and mountain ptarmigan. On the Khunzakh Plateau (elevation 1500 m.) the hamster (*Mesocricetus raddei*) damages the grain crops.

High-mountain Daghestan is part of the Glavny (Main) Caucasus range, which has been described already. But the Daghestan slope of the range has a drier climate than is found in the Glavny Caucasus range as a whole, and pine forests predominate in the forest zone here.

3. THE ARMENIAN PLATEAU AND THE DRY REGIONS OF THE EASTERN TRANSCAUCASUS

The *Armenian Plateau* lies between the Trialetsk range on the north, the Agri-Dagh (more exactly, Lake Van, in Turkey) on the south, the Arsiansk on the west, and the Karabakh on the east. The Trialetsk range stretches from west to east, from Borzhom to Tiflis; it forms the eastern continuation of the Adzhar-Akhaltsykh range. On the watershed of the Black and the Caspian seas lies the Arsiansk range (elevation 3121 m.). The Armenian Plateau has an average elevation of 1500 m., but its eastern part, the Karabakh Plateau, is much higher (2500 m. and more). The Armenian Plateau is composed of young (Quaternary) volcanic rocks of andesite-basalt composition, and contains a series of extinct volcanoes: the Samsar-Abul group in the region of Lake Toporovan; the enormous Alagez volcanic massif (4087 m.); Great Ararat (5156 m.), or *Masis* in Armenian, which adjoins the Agri-Dagh range and lies within Turkey; and others. Great Ararat was still erupting during the Quaternary period; its slopes are covered with streams of hardened lava; the snow line lies at an elevation of 4250 m.; many short glaciers descend from the summit. There are several lakes on the Armenian Plateau. The largest is Lake Sevan, or Gokcha,[19] which lies at an elevation of 1916 m. (Fig. 60);[20] its depth reaches 99 m.[21] Individual peaks among the mountains which surround the lake rise to elevations of over 3600 m. At present students are inclined to attribute the formation of the Sevan basin to subsidences. The Zanga River flows out of the lake, and empties into the Araks. The level of Sevan is subject to fluctuations, comparable with the fluctuations in the level of the Aral Sea. The highest level was reached in 1912.

The ranges of the Armenian Plateau contain rich beds of copper ore (for example, the Allaverdy). There is a bed of magnetite on the slope of the Shakh-Dagh range near Dashkesan village.

The mountain-steppe region of the eastern Transcaucasus includes the Armenian Plateau, as well as the Yerevan basin. There are elevations from 1400 to 2000 m. The climate of the plateau is like that of the steppe

[19] Recently this lake and its basin have been explored thoroughly. See *Materialy po issledovaniyu ozera Sevan i yevo basseina* (Materials on the Exploration of Lake Sevan and Its Basin), izd. Sevansk. gidrometeor. byuro (publication of the Sevan Hydrometeorological Bureau), Leningrad, 1931. (Seventeen issues have appeared.)

[20] B. D. Zaikov, "Gidrologichesky ocherk basseina ozera Sevan" (Hydrological Sketch of the Lake Sevan Basin), *ibid.*, 1933, p. 3.

[21] I. A. Kireyev, "Gidrograficheskie raboty na ozere Sevan" (Hydrographic Work on Lake Sevan), *ibid.*, 1933, p. 60, map.

zone in that it is distinctly continental. However, the summers are cool —the mean temperature of the warmest month ranges from 15° to 19° C., and frosts occur. The winters are cold; the mean January temperature ranges from − 8° to − 15° C. The low temperatures are caused by the persistence of a high pressure area over the plateau during the winter and by the heavy cold air which descends onto the plateau from the surrounding mountains; the deep snow cover is also a factor in keeping the temperatures low. In summer the disposition of isobars on the Armenian Plateau is cyclonic. The daily temperature range, as on plateaus everywhere, is great; it is greatest in September: 17° C. In summer north and northeast winds prevail; from October till May, south and southwest winds. The annual precipitation in the north is from 500 to 700 mm.; in the south (which adjoins the dry Yerevan basin), 300 to 500 mm. Precipitation is greatest in spring and part of the summer, least in winter. Evaporation is great, and by the end of the summer the vegetation begins to suffer from drought. Thundershowers and hailstorms are frequent. The soil cover consists of typical and chestnut chernozems, which are formed on highly calcareous products of the weathering of igneous rocks. In some places (the Loriisk steppe, and others) there are thick clayey chernozems (with a humus content as high as 16 per cent), on which the vegetation is feather grass, or feather grass with scabious. The entire plateau is an agricultural region where wheat, barley, and other spring grains are cultivated.

In general the vegetation on the plateau is of the steppe type, with grasses predominating. The feather grasses include capillary feather grass (*Stipa capillata*) and pinnate feather grasses (*S. lessingiana, S. pulcherrima, S. stenophylla*). In addition there are fescue (*Festuca sulcata*) and a number of steppe dicotyledons: catchfly, astragali, and *Nepeta*. In some places on the plateau there are forests of Armenian pine (*Pinus armena*), closely related to the common pine. These forests are rich in steppe plants—feather grasses, dropwort, and others.

On the mountains which lie within the Armenian Plateau and along its borders, the vegetation has a xerophytic character. There are park-like forests of xerophytic mountain oak (*Quercus macranthera*), such as those on the southern slope of Alagez, between 1800 and 2300 m. elevation. In these thin, light forests, the herbaceous cover also consists predominantly of xerophytic and steppe plants—feather grasses, East Indies bluestem (*Andropogon ischaemum*), yellow bedstraw (*Galium verum*), dropwort (*Filipendula hexapetala*), and others. These forests Bush (1935) calls the "wooded steppe." At an elevation of 2300 m. the forest is replaced by creeping juniper (*Juniperus depressa*) and mountain xerophytes (tragacanth astragali). Mountain xerophytes are found on the southern slope of Alagez as high as 2700 m.

In some places in the mountains of Armenia there are juniper forests (usually of *Juniperus polycarpos*); they appear also in the Araks valley. Rhododendrons are absent in the subalpine meadows of Armenia; tall herbaceous stands, so characteristic for the lower layers of the subalpine zone in the Glavny Caucasus range, are absent also.

The following animals are characteristic of the steppes of the Armenian Plateau: the Asia Minor suslik (*Citellus xanthoprymnus*); the Asia Minor mountain jerboa (*Allactaga williamsi*), which is found in the Transcaucasus in general; the mountain mole rat (*Spalax monticola*); hamsters (*Mesocricetus brandti* [*M. auratus brandti*], *Cricetulus migratorius*); and the fox, *Vulpes vulpes kurdistanica.* Among the birds, the pheasant and francolin are absent; but in the mountains there are Caucasian black grouse (*Lyrurus mlokosiewiczi*) and snow pheasant (*Tetraogallus caspius*); ptarmigan and willow grouse are numerous; the sand grouse (*Pterocles arenarius*) is characteristic for the upland steppe. Lake Sevan is inhabited by the Gokcha trout (*Salmo ischchan*).

The semideserts and deserts along the middle course of the Araks in Armenia have an even drier climate. Here the precipitation is 150 to 300 mm.; the maximum comes in spring. The driest locality is Aralykh (elevation 790 m.), which lies within Turkey, at the foot of Mount Ararat; here the average precipitation recorded for the years 1849–1853 was only 158 mm.

Yerevan (elevation 996 m.) has an annual total of 322 mm.; precipitation is greatest in May, least in August. The summer is hot; in Yerevan the mean temperature in July is 25.0° C.; in January, − 5.8° C. There is little cloudiness; the mean annual figure here is 45 per cent (least in August—20 per cent, most in January—69 per cent). Where there is irrigation, wheat, rice, cotton, grapes, peaches, and so forth, can be raised successfully. The soils at the bottom are of the chernozem type.

The vegetation is that of the desert: spiny astragali, prickly thrift, camel's thorn (*Alhagi camelorum* [*A. pseudalhagi*]), the buckwheat shrub *Atraphaxis spinosa,* the Syrian bean caper (*Zygophyllum fabago*), and *Peganum harmala* (also of the Zygophyllaceae). On the sands at the foot of Mount Ararat, in Turkey, there is *Calligonum.* On these sands the fauna also is of a Central Asiatic type: the small jerboa (*Allactaga elater*), Persian gerbil (*Meriones persicus*), gray hamster (*Cricetulus migratorius*), and two hedgehogs (*Hemiechinus calligoni, Erinaceus* *transcaucasicus* [*E. rumanicus transcaucasicus*]); there is some hyena (*Hyaena hyaena*), and at one time there was goitered gazelle (*Gazella subgutturosa*). Among the characteristic lizards are the toadhead (*Phrynocephalus helioscopus*) and the long-legged gold skink (*Eumeces schneideri*).

The *high steppes along the middle course of the Kura*, between Tiflis and Yevlakh, have an elevation of 700 to 800 m. in the north, but they drop in elevation to the south. They are composed largely of folded Tertiary deposits. These steppes have a climate transitional between that of the Mediterranean and that of the steppe. The Shirak (between the Alazan and the Iora rivers), Karayazy, and other steppes are part of this region. Karayazy (lat. 41½° N, elevation 305 m.) may serve to exemplify the climate: January, 0.5° C.; July, 25.3° C.; annual precipitation, 388 mm.; maximum, in May—65 mm., minimum, in January—12 mm. In general the precipitation ranges from 400 to 500 mm. The soils are light-chestnut clay loams, which merge into chestnut soils near the mountains.

On the light-chestnut soils the vegetation [22] is of the semidesert type. In spring there are many dicotyledons and ephemeral grasses, which fade by the middle of the summer. In summer the *polyn Artemisia hanseniana* predominates in some places, the halophyte *kargan* (*Salsola verrucosa*) in others. Sometimes (for example, in the Milsk steppe) *polyn* and *kargan* are found growing together. *Polyn* appears in the alluvial valleys of the Kura and the Araks, as well as on the mountain slopes. The soils under *polyn* and *kargan* are extremely fertile; cotton is cultivated readily on them. Higher up, on chestnut soils, steppes predominate; on these steppes the perennial East Indies bluestem (*Andropogon ischaemum*) is characteristic. Soils on which the bluestem has grown are suitable for cultivation of grains. The valleys of the Kura, Iora, and Alazan are bordered in the dry sections by thickets of Turk terebinth pistache (*Pistacia mutica*), which never grow in a close stand; here among the scattered individual trees grow *kargan* and *polyn*.

Below these steppes lies the *Kura-Araks desert*, which includes the lower courses of the Kura (below Yevlakh) and the Araks, and which is composed of the alluvial deposits of these rivers.

The climate of this desert, a part of which lies below sea level, is char-

[22] A. A. Grossheim, "Ocherk rastitelnosti Kuro-Araksinskoy nizmennosti" (A Sketch of the Vegetation of the Kura-Araks Lowland), *Mat. k obshchey skheme ispolzovaniya vodnykh resursov Kuro-Araksinskovo basseina* (Materials for the General Plan for the Exploitation of the Water Resources of the Kura-Araks Basin), No. 4, Tiflis, 1932, pp. 57–125.

acterized by mild winters; the January temperature is about 2° C. There is almost no snow cover, and on the Mugan steppe, vegetation begins to turn green in January. The mildness of the winter makes it possible to keep stock in pasture all winter long. The summer is very hot; the mean July temperature in Salyany is over 27° C., and in Kyurdamir over 28° C. The autumn is sunny and warm. In the Shirvan steppe, from May until October there is an area of thermal maximum, delineated by closed isotherms. The atmospheric precipitation is less than 300 mm. The summer is dry; the maximum precipitation comes in spring. The hot summers favor the cultivation of cotton, grapes, and sesame.

The soils [23] are of a desert type: sierozems, often solonized, and chestnut-brown soils, also solonized; the presence of solonetz soils is unusual for the desert. There are many solonchaks. The chief vegetative period comes in spring and early summer. In the lower course of the Kura the spring vegetation, which develops completely by April, consists of small annuals; it is replaced temporarily by a grass cover; in the Shirvan steppe this herbaceous cover is short-lived. In May perennials become predominant; among them *polyn* prevails, sometimes constituting the entire cover. The small *polyn* bushes do not form a continuous cover; there are spaces of bare soil between them. On the moist solonchaks, thickets of the halophyte *sarsazan* (*Halocnemum strobilaceum*) are characteristic; usually as the *sarsazan* bush becomes covered with solonchak dust, it gives rise to a mound, on which this chenopod continues to grow. The mound may reach several meters in height, and a peculiar hillocky solonchak results. Large areas are covered by almost pure thickets, 1.5 to 2 m. high, of the halophyte halostachys (*Halostachys caspica*), which grows on dry as well as on wet solonchaks.

Along the lower course of the Araks, and also south of Kyurdamir station, there is Hindu lotus (*Nelumbo nucifera* [*Nelumbium nelumbo*]).

The animals of the lower Kura include the goitered gazelle (*Gazella subgutturosa*), jackal, hyena, and, along the rivers, jungle cat (*Felis chaus*); in the swamps, among the reeds there is wild boar; the Asia Minor jerboa (*Allactaga williamsi*), the small jerboa (*A. elater*), and the hare (*Lepus europaeus cyrensis*) are characteristic.[24] The birds include the

[23] S. A. Zakharov, "Pochvy nizmennosti Kury-Araksa" (Soils of the Kura-Araks Lowland), *Mat. k obshchey skheme ispolzovaniya vodnykh resursov Kuro-Araksinskovo basseina* (Materials for the General Plan for the Exploitation of the Water Resources of the Kura-Araks Basin), No. 4, Tiflis, 1932, pp. 1–56.

[24] K. A. Satunin, "O zoogeograficheskikh okrugakh Kavkaza" (Concerning the Zoogeographical Districts of the Caucasus), *Izv. Kavkazskovo muzeya* (Report of the Caucasus Museum), VII, 1912, with a map.

flamingo (*Phoenicopterus roseus*); the glossy ibis (*Plegadis falcinellus*), of the ibis family; two bee-eaters (*Merops apiaster* and *M. persicus*); the francolin (*Francolinus orientalis*),[25] of the ptarmigan subfamily; the pheasant (*Phasianus colchicus*); and the bustard. There are many snakes, lizards, and tortoises. The domestic animals include the buffalo and the camel.

The *Apsheron Peninsula*[26] is famous for its oil beds. By some students it is considered the direct continuation of the folds of the Glavny Caucasus range. Others (Rengarten, 1930) deny this connection, holding that the peninsula is a part of the fold system of the Transcaucasus.

In the northwest of the peninsula the elevations reach 340 to 350 m. The eastern part is low, and the highest points recorded here do not exceed + 38 m. in absolute elevation. Prominent in the structure of the peninsula are mud volcanoes which often lie in a line along the axes of the anticlinal folds; the largest of these volcanoes are Boz-Dagh (elevation 290 m.) and Atashkya (elevation 274 m.). The peninsula is composed of strongly dislocated Tertiary deposits, beginning with the Eocene, and also Quaternary deposits. The oil deposits occur chiefly in the Middle Pliocene sandy-clayey "productive" horizon, which lies below the Akchagyl layer and above the Pontic layer. The thickness of this strongly dislocated bed reaches 1300 m. The principal oil fields are the Balakhany, Sabunchi, Ramany, Bibi-eibat, Surakhany, and Binagady.

The Tertiary deposits of the peninsula are intricately dislocated. At present students are inclined to ascribe the Baku deposits, also strongly dislocated, to the Lower post-Pliocene.

Post-Tertiary formations consist of ancient Caspian deposits: (1) the lower strata (which contain the mollusk *Didacna crassa*), only slightly dislocated, and rising to elevations from 20 to 160 m. above the level of the Caspian, and (2) the upper strata (which contain *D. trigonoides*), hardly dislocated at all, and lying at elevations from 9 to 35 m. Still younger terraces (which contain *Cardium edule*) border all the shores of the peninsula; as a rule, they do not rise higher than 5 m. above the level of the Caspian (in exceptional cases, almost up to 10 m.).

[25] This Mediterranean bird of a genus distributed predominantly in tropical and South Africa is extinct in Europe. It is found in western Asia and in the Soviet Union in the lower course of the Atrek, as well as in the valleys of the Kura and the Araks.

[26] "Obzor prirody Apsheronskovo poluostrova" (Survey of the Natural Environment of the Apsheron Peninsula), written by a group of specialists; see *Trudy Azerbaidzh. otd. Zakavkaz. filiala Akad. nauk* (Proceedings of the Azerbaidzhan Section of the Transcaucasus Branch of the Academy of Sciences), VI, Baku, 1934, p. 256, maps, bibliography.

The Apsheron Peninsula has a desert climate of a unique type. It has mild winters (as does the Kura-Araks desert), attributable to the moderating influence of the southern Caspian. In Baku (absolute elevation + 2 m.) the mean January temperature is + 3.5° C. As compared with parts of the Kura Lowland which are farther from the sea, the summer is relatively cool; the mean July temperature is 25.7° C. In Baku there are 181 mm. of precipitation per year; the maximum comes in autumn (November, 28 mm.), and the minimum in summer (July, 5 mm.). The snow cover lasts an average of ten days a year. There is little cloudiness; in Baku February is the cloudiest month (78 per cent), August, the least cloudy (26 per cent). The peninsula has strong winds: in Baku the mean wind velocity is 6.0 m. per second; the north wind (*nord*) prevails, often reaching the strength of a tempest; the south wind is the next most prevalent. In Baku dry fogs are numerous (there are an average of 145 days a year with dry fog); they are caused by the dust which fills the atmosphere. Ordinary ("wet") fogs occur most often in winter and spring (Mikhailevsky, 1934).

The vegetation is unique; it has a more northern appearance than might be expected here from the climate. "One gains the impression that local vegetation is typical of a higher vertical zone which spreads down to sea level here, thus invading a country which lies below the normal vertical limit of this zone" (Grossheim, 1934). Grossheim explains this condition by the fact that the peninsula is like an island; marine climate impinges upon desert climate. The Apsheron plant association approximates that of the next vertical zone of the Caucasus, by virtue of the profuse development of feather grasses (*Stipa szowitziana*) and the presence of a number of plants native to the foothill regions of the Transcaucasus; these include several legumes (*Astragalus humilis, Onobrychis vaginalis*) and other plants. The *polyns* are poorly developed, perhaps because man has destroyed this type of vegetation. Nor are the halophytes so widespread here as one might expect. Where the vegetation has not been disturbed by man, ephemera such as blue grass (*Poa bulbosa*) and *Colpodium humile* predominate. Toward the end of May the blue grass fades; it comes to life again in October and November after the first autumn rains, and continues to grow all winter long until spring. On the slopes the blue grass is replaced by the goat grass *Aegilops,* closely related to wheat, and also by oats (*Avena*). In addition there are vast sandy areas. A large part of the peninsula is occupied by dry-land (unirrigated) winter grain crops.

The soils of the peninsula are also unique. One would expect to find sierozems here, but according to soil scientists, the soils of the peninsula belong to the brown and chestnut-brown types.

4. MOUNTAIN TALYSH

South of the lower Araks, and separated from it by the Mugan steppe, lies mountain Talysh, reaching 2582 m. in elevation. The Talysh range appears to be a continuation of the Elburz, on the southern shore of the Caspian in Iran.

There are yellow soils in the foothills, and brown forest soils higher up.

In Talysh there are no conifers except yew and juniper, and there is no rhododendron. The forests of the foothills (up to an elevation of 600 to 700 m.) resemble the forests of the lowland, which have been described above (pp. 199–200). Here, too, the Persian parrotia is the basic species, and hornbeam is common. The chestnut-leaf oak (which occurs here in the typical form) becomes more numerous as the altitude increases; it gradually replaces the parrotia. Small stands of date-plum persimmon (*Diospyrus lotus*) grow in the shady places. The Lenkoran or silk-tree albizzia (*Albizzia julibrissin*) is very characteristic for the forests south of Lenkoran; it does not grow above 400 to 500 m. This magnificent ornamental tree is cultivated in great numbers in the Crimea and in the western Transcaucasus. There is some zelkova (*Zelkova carpinifolia*). The undergrowth contains much medlar (*Mespilus germanica*). In the forest, vines are not uncommon, particularly greenbrier and blackberry, although they are fewer here than in the lowland.

Along the stream valleys in the foothills there are stands of Caucasian alder (*Alnus subcordata*); it is accompanied everywhere by wing nut (*Pterocarya carpinifolia*). The presence in these forests of the endemic Caspian honey locust (*Gleditschia caspica*) is characteristic; in winter its large pods yield fodder for livestock. In some places the common fig (*Ficus carica*) grows in great abundance. In the remote gorges of the foothills one may find the majestic Persian velvet maple (*Acer insigne* [*A. velutinum glabrescens*]). It does not form continuous thickets, but grows as individual trees, which occasionally are colossal in size. It is readily grown as an ornamental tree, for example, in the streets of Lenkoran. In this zone (and in the central zone), under a canopy of Persian parrotia and hornbeam, thickets of box are found. There is a well developed evergreen undergrowth of butcher's-broom (*Ruscus hyrcanus*).

In the central mountain zone (600 to 1200 m.) there are no parrotia (which does not grow above 600 to 700 m.), butcher's-broom, or vines (with the exception of the ivy *Hedera pastuchovii*). Instead of the parrotia, on the northern slopes there appears oriental beech, which reaches colossal dimensions. The chestnut-leaf oak (*Quercus castaneaefolia*) is a mighty and shapely tree. The undergrowth contains holly, and occasionally English yew (*Taxus baccata*).

The forests of the upper mountain zone, at elevations from 1200 to 1800 m., have a different appearance. They consist chiefly of the xerophytic mountain oak (*Quercus macranthera*) and the small Hyrcanian hornbeam (*Carpinus schuschaensis*); beech, hornbeam, and chestnut-leaf oak are less important. The evergreen undergrowth in some places consists of holly. There is much medlar. Much of the forest here has been cleared and turned into wheat fields.

There is no alpine vegetation in Talysh. In the west, particularly in the Dibrar basin, there are mountain xerophytes. At elevations of 1300 to 1800 m. dense cushions (1.5 m. in diameter) of shrublike prickly thrift (*Acantholimon hohenackeri*) are characteristic; there are also some spiny tragacanth astragali (*Astragalus aureus* and others) and sweet-brier rose. On the gentle slopes the soil is covered with a rather dense sod of fescue and other grasses, especially at elevations between 1800 and 2500 m. (Grossheim, 1926).

The animals in the mountain forests of Talysh include deer, roebuck, lynx (*Felix lynx orientalis* [*Lynx orientalis*]), leopard, and bear.

XI · Mountain Crimea

THE boundary between the steppe and mountainous parts of the Crimea may be drawn somewhat north of Sevastopol, Bakhchisaray, Simferopol, Karasubazar, and Feodosia.

Relief[1]

The mountains of the Crimea consist of three parallel ridges in the west, and two in the east. The southernmost of these, which is also the highest, is the coastal ridge; it bears the name *Yaila.* (*Yailá* in Tatar means "summer pasture.")

The Yaila range extends from Cape Fiolent and Balaklava in the west, to Mount Agarmysh near Stary Krym in the east. The southern slope is steep, in some places (especially in the west) precipitous; the northern slope is gentle. The summit is not a crest, but a rolling plain, partly covered by meadows, partly rocky (Fig. 61). The range is not very wide, not more than 3 to 4 km.; only the Karabi-Yaila Plateau is wider, about 7 km. On the summit of the Yaila (which is composed of limestones), there are marked funnels, depressions, furrows, caves (in some places containing stalactites), deep cavelike abysses (sometimes more than 100 m. deep), underground rivers, and other karst formations, caused by the decomposition and leaching of the limestones, not as a result of sinks, as is commonly believed.

In the west, near Balaklava, the Yaila descends into the sea in vertical precipices over 300 m. high. Balaklava Bay cuts deep into the Yaila ridge, evidence that the sea has encroached upon the land; the bays at Sevastopol are further evidence of marine invasion (Dobrynin, 1922). Near Cape Sarych, the southern tip of the Crimea, lies Foros—one of the warmest places in the Crimea, with a mean January temperature of about + 5° C. Behind Foros the limestones of the Yaila are cut by an enormous

[1] See the excellent map of the southern Crimea, 1:200,000, Leningrad, 1936, published by I. I. Babkov.

fault, the so-called Baidar "gate" (elevation 498 m.). Through this depression a paved highway leads from Sevastopol to Yalta. East of the Baidar gate and as far as Ai-Petri (elevation 1233 m.), the Yaila recedes 1 to 4 km. from the shore, dropping toward the south in precipices 300 to 600 m. high. East of the Baidar gate, the Yaila rises gradually in elevation, reaching 1000 m. above Simeiz, over 1200 m. above Alupka, and 1300 m. above Yalta. The highest point of the Yaila, Roman-Kosh (elevation 1543 m.), lies in the Babugan-Yaila, northeast of Yalta. In the east, approximately in the region of Alushta, deep depressions divide the Yaila into a series of individual plateaus; these plateaus include Chatyr-Dagh (elevation 1525 m.), Demerdzhi-Yaila, and Karabi-Yaila. The Salgir has its source on the slopes of Chatyr-Dagh, and empties into the Sivash arm of the Sea of Azov. Beyond Alushta the range recedes from the sea 6 to 8 km. and loses the character of a plateau. At Sudak the mountains again approach the sea.

The surface of the Yaila is composed of light, compact, sometimes marblelike Upper Jurassic limestones, which form abrupt precipices facing the sea. The lower part of the southern slope (that is, the south coast) consists of black, argillaceous, watertight schists, which belong to the Upper Triassic and to the Lower and Middle Jurassic. The fissures in the Jurassic limestones of the Yaila result in landslides. Above Alupka there is an enormous crumbled block of limestone about 300 m. high. On the southern shore there are many rough piles of detritus composed of broken fragments of limestone (so-called "chaoses"). All the strata of the Yaila are strongly dislocated. Occasionally there are dome-shaped outcrops of igneous rocks which constitute laccoliths. One of these, for example, is Ayu-Dagh (at Gurzuf), which is composed of diorite. The igneous rocks, because of their compactness, resist weathering, and consequently are preserved along the shore in the form of capes (Fiolent, Ayu-Dagh, Kastel, and others). The extrusion of these rocks took place during the Jurassic or (in a few cases) during the Lower Cretaceous period. The Crimea contains one long-extinct volcano. This is Kara-Dagh (elevation 574 m.), which lies west of Feodosia. There is reason to believe that it was active during the Jurassic period. At a later date the rocks of which Kara-Dagh is composed were folded, and, finally, a large part of the volcano was submerged below the surface of the Black Sea.

The second ridge, north of the Yaila, the so-called Melovaya, is considerably lower. Its elevation is 450 to 595 m. It is separated from the Yaila by a depression 15 to 20 km. wide, and extends roughly from Inkerman to Feodosia. On the northern, gentle slope lies Simferopol. The ridge is composed chiefly of Cretaceous deposits, in part of Eocene nummulitic limestones. The latter form the upper part of the precipices and the northern slope of the second ridge and are 50 to 60 m. thick. In some places, for example, at Bakhchisaray, they form picturesque crags. The dip of the layers in the second ridge is toward the north and northwest. This ridge, like the third, is actually the southern edge of a series of strata which slope gently to the north. Thus, these ridges are not "mountains," but monoclinal ridges formed by erosion.

The third, or northern, ridge is still lower, only 150 to 250 m. in absolute elevation. It is separated from the preceding ridge by a depression 3 to 5 km. wide, along which passes the railroad from Simferopol to Belbek. This ridge, composed of Upper Tertiary limestones, which slope gently to the north, extends from the mouth of the Belbek (or even from Cape Fiolent) to the town of Stary Krym.

The dissection of the Crimean mountains into three ridges is due, as we have said, to erosion. The southern slope of the Yaila ridge consists of a series of longitudinal faults. In the relief of the Crimean mountains, there is a striking contrast between the long gentle northern slopes and the abrupt southern slopes. Correspondingly, in the central part the principal valleys of the northern slopes are long, while those of the southern slopes are short. The streams of the northern slope of the Yaila cut across both the second and third ridges, instead of following the longitudinal depressions between the ridges. Apparently these valleys were cut in the original surface of the slope before the second and third ridges were formed in their present state (N. Sokolov, 1929). The sharp turn which the Salgir makes to the northeast, in the direction of the Sea of Azov, is very curious. The dry valley which runs toward Yevpatoriya is oriented in the original direction of the river—to the northwest. Apparently at one time the Salgir emptied into the Black Sea; subsequently it became a tributary of the river which flows in the direction of the Sivash (N. Sokolov).

The most intensive folding in the Crimean mountains took place during the Mesozoic period; it began at the end of the Lower Jurassic and the beginning of the Middle Jurassic.[2] By the end of the Upper Jurassic the Crimean mountains had been formed. During the Upper Cretaceous period the entire Crimea, both mountain and steppe, underwent a marked submergence, at times so extreme that perhaps only the highest points

[2] A. S. Moiseyev, "Gidrogeologichesky ocherk glavnoy gryady Krymskikh gor" (Hydrogeological Sketch of the Main Ridge of the Crimean Mountains), *Trudy Glavn. geol.-razved. upr.* (Proceedings of the Central Geological Survey Board), No. 30, 1931, p. 14.

of the mountains extended above the water. At the end of the Cretaceous, uplifts began again and became considerably stronger during the Lower Miocene. This last epoch was the period of the most powerful Tertiary dislocations in the mountains of the Crimea. During the Lower Miocene period the principal faults, dislocations, and thrusts developed. According to Muratov, none of these faults which mark displacements of the older formations affect any deposits younger than the Oligocene (that is, the Mediterranean deposits); therefore there is no basis for ascribing a younger age to these faults. During the Quaternary period slight uplifts took place in the eastern Crimea; the elevation of the marine terraces in the region from Sudak to Feodosia is evidence of these uplifts; however, the form of the coast line at Sevastopol indicates that some subsidence took place along this shore during the Quaternary period.[3]

Dobrynin (1922) regards the Crimean mountains as a single arched anticline, the axis of which extends from WSW to ENE. Its southern border is broken by the fault mentioned above, while the dome is split by a system of longitudinal and meridional faults and thrusts which occurred, as we have seen, during the Lower Miocene period.

Since the Lower Pliocene (Upper Pontic) period, the Crimea has been tied closely to the mainland which adjoins it on the north. At the end of the Pliocene a connection was formed between the Crimea and the northern Caucasus (probably along the line from Feodosia to Anapa), while at the beginning of the Quaternary period they were separated again (Andrusov).

During the Tertiary period mountain Crimea was connected with the Dobrudzha.

On the south coast in June and September, 1927, there were rather severe earthquakes, the epicenter of which lay in the sea near Yalta. According to Arkhangelsky, the sea bottom off the south shore of the Crimea is undergoing a gradual subsidence, accompanied from time to time by dislocations which result in earthquakes.

Climate

Climatologically, mountain Crimea may be divided into three parts: (1) the south coast, which extends from Foros to Alushta, and which has a Mediterranean climate; (2) the Yaila, and (3) the rest of mountain Crimea, the climate of which may be called steppe or forest-steppe.

[3] M. V. Muratov, "Osnovnie cherty tektoniki Krymskovo poluostrova" (Basic Features of the Tectonics of the Crimean Peninsula), *Byull. Mosk. obshch. ispyt. prir.* (Bulletin of the Moscow Society for Natural Research), otd. geol. (Geological Section), XV, 1937, pp. 215–239, map, bibliography.

(1) The south coast of the Crimea lies on the northern outskirts of the region of Mediterranean climate. In the typical Mediterranean climate (for example, along the shores of the Mediterranean Sea) trade winds —dry, northeast winds—prevail in summer. In winter the trade winds do not reach the Mediterranean, and moisture-bearing cyclonic storms and west winds prevail instead. On the south shore of the Crimea the seasonal distribution of winds is no longer typically Mediterranean. In summer the pressure is greater over the Black Sea than over the continent; for this reason southwest winds prevail in the Crimea at this time of the year. In winter the opposite is true; the pressure is greater over the continent than over the sea. During this period of the year a spur of the Asiatic high-pressure area extends westward along the northern boundary of the steppes; as a result, northeast winds usually blow over the Crimea in winter. However, in some years the spur of the Inner Asiatic high-pressure area does not appear, with the result that the West European and Central Mediterranean high-pressure area dominates; during such winters, west and southwest winds prevail in the Crimea, and it is relatively warm.

In any case, on the south coast the seasonal distribution of precipitation is more or less Mediterranean in character. The most precipitation falls in winter, the least in August. However, the spring here, as in the continental part of the Crimea, is dry (the secondary minimum occurs in May), and there is a secondary maximum of precipitation in June and July, a sort of reflection of the summer maximum which is characteristic of the hinterland of the Crimea. With a hot summer and strong evaporation, there is not enough rainfall on the south coast in summer for agriculture, and the problem of irrigation arises. Sometimes in summer there are long droughts. On the other hand, during the rainy season there are occasionally heavy downpours; thus, in Yalta on December 7, 1892, 154 mm. of precipitation fell during the course of 24 hours.

Sheltered by the Yaila massif from the cold north winds, the south coast has a very mild winter, as is indicated by the fact that the vegetative period continues without interruption the year around. "The last of the autumn flowers are followed without interruption by spring flowers." In December and January the Crimean snowdrop (*Galanthus plicatus*), evergreen euphorbia (*Euphorbia biglandulosa*), and (of the woody plants) filbert (*Corylus avellana*) begin to bloom in profusion everywhere. Even during snowy winters, in the thawed patches and on the southern slopes, snowdrops, violets (*Viola odorata*), and crocus (*Cro-*

cus susianus) may be seen in bloom. Many of the herbaceous plants begin their secondary blooming in October and November.

The number of days in the year with a mean diurnal temperature above 15° C. is about 150 on the south coast; in the latitude of Moscow there are half as many; on the shores of the Gulf of Finland, a third as many; and on the shores of the White Sea, almost none. The warmest part of the Crimea lies between Foros and Ayu-Dagh.

Indicative of the character of the climate in these places are the following data for Yalta (lat. 44°30′ N, absolute elevation 4 m.):

Table 20

CLIMATE OF YALTA

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
Precipitation (mm.) 1890–1915	82	56	47	34	28	49	56	27	41	45	63	69	599
Mean temperature (° C.)	3.7	4.0	6.3	10.4	16.1	20.5	24.1	23.8	19.0	14.2	8.8	6.1	13.1
Mean minimum temperature (° C.) 1891–1900	0.2	1.4	2.1	5.3	10.7	14.8	18.2	18.5	13.3	10.3	4.0	1.8	
Absolute minimum temperature (° C.) 1900–1911	−13.5	−12.7	−7.6	−0.9	3.5	7.8	11.4	11.6	6.0	−1.9	−8.4	−9.2	
Cloudiness (per cent of sky covered)	61	66	56	50	46	35	26	22	32	44	56	60	46

As we can see from this table, there are frosts even on the south coast. January in Yalta (1899–1910) averages 14 days with frost; February, 8 days; in Foros (absolute elevation 26 m.), the figures are, respectively, 7 and 10. The annual number of days with frost in Yalta is 43, in Foros, 30. Foros has the warmest winter in the Crimea: December, 7.4° C., January, 4.8° C., February, 4.3° C.; the annual mean, 13.3° C. Magarach (absolute elevation 70 m.), near Yalta, has a warmer summer than Foros, but a colder winter. The average number of days without thaw on the south coast is 7. But there are some winters in Yalta when the mean January temperature is as high as + 8.9° C. (1915). No frosts lower than − 14.5° C. have been observed in Yalta. The summer and autumn have many hours of insolation.

The finest season in the Crimea is autumn—September and October. September in Yalta is warmer than July in Moscow, and October is much warmer than May in Moscow. Furthermore, in Yalta the autumn is calm and there is much sunshine; even in October the mean diurnal duration of sunshine in Yalta is 6 hours. Summer on the south coast is hot, but 300 meters above the sea it is about three degrees cooler. The diurnal temperature range is small, a condition which is especially important for lung patients. The temperature of the sea at Yalta reaches a maximum in September (mean, 21.8° C.) and a minimum in February (8.2° C.). In Sevastopol the summer is warmer but the winter is somewhat colder than in Yalta. There is bathing in the Crimea up to the end of September. On the south coast (particularly in summer), there are breezes—during the day from the sea, at night from the land. Foehns—warm and dry winds which descend from the Yaila range—are frequent. For example, in the Nikitsky Botanical Garden on April 17, 1928, the temperature rose 10° C. within half an hour, while the relative humidity fell 40 per cent. The relative humidity on the south coast is considerable; in Magarach the maximum occurs in December (75 per cent), the minimum in August (57 per cent). There is much sunshine on the south coast, as pointed out above; in Gurzuf (according to observations over a periods of five years), in July the sun shines 69 per cent of the number of hours possible.

(2) The Yaila has a peculiar climate, transitional between the Mediterranean and the climate of deciduous forests of the middle latitudes. At an elevation of 1500 m. the mean July temperature is about 13½° C. The rainfall is rather heavy; the average is 500 to 1000 mm., but during some years it exceeds 1500 mm. The maximum usually comes in winter, but on the eastern Yaila, for example, on Karabi-Yaila (elevation 974 m.), it comes in summer. The minimum precipitation usually comes in August, and the secondary minimum, which is almost as low as the August minimum, comes in spring; but on the eastern Yaila ridge the minimum comes in February. In short, the western Yaila has the same type of seasonal distribution of precipitation as the south coast, while the eastern Yaila (Demerdzhi, Karabi, Dolgorukovskaya) has a climate of the same type as the Crimean steppes. The mean monthly temperature and precipitation for Ai-Petri, 1180 m. above Yalta and slightly to the west, are given in Table 21, on page 248.

As we can see, the number of days with precipitation on the Yaila is considerable; one out of three days in summer, and two out of three in winter, have precipitation. There are about 60 days a year with snow. The snow cover on the Yaila melts slowly in spring and summer and feeds a great number of springs which irrigate the south coast. Sometimes there are exceptionally heavy showers on the Yaila. Thus, once in November on Ai-Petri, 161 mm. of rain fell during the course of 24 hours. Fogs are frequent; more than 100 days a year are foggy. In autumn, winter,

Table 21

CLIMATE OF AI-PETRI

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
Temperature * (° C.)	−4.2	−3.2	−0.6	3.3	9.4	12.8	15.7	15.6	11.4	7.8	1.6	−1.1	5.7
Precipitation † (mm.)	163	102	95	45	57	82	77	34	70	82	105	119	1031
Number of days with precipitation ‡	23	18	17	12	13	12	10	8	11	13	18	21	176
Duration of insolation (per cent of possible number of hours) §	40	39	53	58	65	73	76	85	81	60	47	36	62

* 1895–1915, adjusted to 1881–1915.
† 1901–1920.
‡ 1901–1921.
§ 1902.

and at the beginning of spring, during the anticyclone period which prevails over the entire Crimea, it is sometimes warmer on the Yaila than on the northern and even the southern slope; the sky is clear, and the humidity is very low (this happens during the so-called "foehns"). Thus, on October 18, 1906, at 9:00 P.M., the following observations were made:

Table 22

CLIMATIC OBSERVATIONS AT AI-PETRI AND YALTA ON OCTOBER 18, 1906, AT 9:00 P.M.

	TEMPERATURE (° C.)	RELATIVE HUMIDITY (per cent)	WIND (direction and velocity in m. per second)	CLOUDINESS
Ai-Petri (1180 m.)	15.3	5	ENE3	0
Yalta (4 m.)	11.8	84	N2	0

When the center of an anticyclone lies directly over Yalta, the foehn may blow simutaneously on both the northern and southern slopes (E. Shcherbakova).

At Ai-Petri, as on the western Yaila in general, northwest and southeast winds prevail in winter and summer. On the Yaila the wind everywhere reaches considerable force, but nowhere so great as at Ai-Petri, where the mean annual velocity is 6.2 m. per second. (At Yalta it is only 2.1 m. per second.) The number of days with gale winds (that is, when the wind velocity exceeds 15 m. per second) at Ai-Petri is tremendous—81.5 (at Yalta, only 8.5). Instances are on record of enormous wind velocities at Ai-Petri—up to 42 m. per second.[4]

[4] A. V. Penyugalov, "Klimat Kryma" (The Climate of the Crimea), *Trudy syezda po izucheniyu proizvodit. sil Kryma* (Proceedings of the Congress for the Study of the Productive Forces of the Crimea), II, Simferopol, 1930, p. 91.

(3) On the south coast eastward from Alushta and on the northern slope of the Crimean mountains down to about 500 m. elevation, the prevailing climate may be called the climate of deciduous forests, while at lower elevations on the slope there is a steppe or forest-steppe climate. Precipitation ranges from 300 mm. to 500 mm., with the maximum coming in June and July and the minimum in spring or at the end of the winter; there is a secondary minimum in autumn and a secondary maximum at the beginning of autumn or during the first part of winter.

The Crimean game preserve, which lies on the northern slope of Babugan-Yaila, in the upper course of the Alma River, at an elevation of approximately 670 m., is surrounded by beech forests. Here 786 mm. of precipitation fall annually, with the maximum in July (82 mm.) and the minimum in February (48 mm.). Stary Krym, at an elevation of 500 m., has 466 mm. of precipitation annually, the maximum coming in June (67 mm.) and the minimum in October (18 mm.). The mean February temperature is − 0.8° C.; the mean July temperature, 21.9° C. At Feodosia, and particularly at Sudak, there is even less precipitation; at Sudak, only 296 mm. annually.

Drainage

The surface of the Yaila is almost without water. The Jurassic limestones, which compose the plateau, quickly absorb the rainfall and soak up the moisture from melting snows and the moisture which forms on the limestone beds from condensation of atmospheric water vapor. The thick beds of impervious argillaceous shales which underlie the limestones prevent further penetration, hence the precipitation which falls on the Yaila karst is preserved in caverns in the limestone and the Jurassic sandstones and conglomerates which in some places underlie the limestones. The water which accumulates here emerges onto the surface in the form of numerous (over 2000) springs, which feed the brooks and rivers of mountain Crimea with excellent water. These waters also soften the argillaceous shales, and cause creep of the clayey masses; this process results in landslides which cause great damage on the south coast of the Crimea (especially at Yalta and Alupka). The melting of snows and the occurrence of showers often bring about floods in the basins of the mountain streams. A basic factor in the water regime of the Crimea is the considerable fluctuation in the stream flow; in summer it is slight, while in winter it is relatively great.

Soils

On both the southern and the northern slopes of the Crimean mountains, soils of the brown forest type predominate.[5] These soils are developed under deciduous forests in the warm temperate regions of western Europe, the Crimea, and the Caucasus. They resemble podzolic soils in that soluble salts are leached out of their upper horizons; but they differ in that ferric oxides, alumina, and phosphates are not removed from these horizons at all, or only in moderate quantity. The brown forest soils contain little humus, because organic substances are decomposed more thoroughly than in the podzols and chernozems. Under the beech forests in the central zone on the slopes of the Yaila these soils have the following profile: They are generally yellow brown. Only the uppermost horizon (A_1), directly under the leaf mat and about 3 cm. thick, is colored grayish by the humus. Lower down there lies a bright yellow horizon (A_2), which has a lumpy structure and which changes gradually into a more compact reddish-brown horizon (B). The A_1 and A_2 horizons, which are leached, correspond to the eluvial horizon of the northern, podzolic soils, from which they are distinguished by their lumpy structure and yellow-brown coloring, which is due to the presence of hydrate of iron oxide. Podzolization is found only on the northern slopes, on the clayey products of weathered limestones. It is worth noting, according to Prasolov, that on whatever rock the brown forest soils occur, they are always lacking in carbonates and are generally leached. However, under vineyard cultivation these soils usually become mixed with limestone rubble and become calcareous.

The brown forest soils ascend as far as the boundary of the forest; they descend as far as sea level. But in the lower zone, that is, up to an elevation of 300 to 400 m., they are poorly developed and acquire certain characteristics of a type transitional to red-soil weathering. Above 900 m., on the boundary between the brown forest soils of the slopes and the chernozemlike and mountain-meadow soils of the Yaila, lies a narrow strip of transitional soils with a dark humus horizon, which, according to

[5] L. I. Prasolov, "Burozyomy Kryma i Kavkaza" (Brown Soils of the Crimea and the Caucasus), *Priroda* (Nature), 1929, No. 5; I. N. Antipov-Karatayev, "Pochvy Nikitskovo sada" (Soils of the Nikitsky Garden), *Soobshch. otd. pochvoved. Gos. inst. opyt. agron.* (Report of the Soil Science Section of the State Institute for Experimental Agriculture), 1929, No. 4; I. N. Antipov-Karatayev and L. I. Prasolov, "Pochvy Krymskovo Gos. lesnovo zapovednika i prilegayushchikh oblastey" (Soils of the Crimean State Forest Preserve and Adjoining Regions), *Trudy Pochv. inst. Akad. nauk* (Proceedings of the Soils Institute of the Academy of Sciences), VII, 1932.

Prasolov, resemble some of the soils of the northern forest steppe. This strip, which extends for a width of only 100 to 150 m., lies above the zone of beech forests. The soils on the lower Chatyr-Dagh Plateau are related rather closely to the soils of this transitional strip.

On the lower Chatyr-Dagh Plateau, which is occupied by mountain steppe (analogous to Karabi-Yaila), there are mountain chernozems—both on limestones and particularly on other rocks (conglomerates, shales). Still higher, on the upper Chatyr-Dagh Plateau, chernozemlike mountain-meadow soils are developed (Prasolov).

In general, mountain chernozems and chernozemlike mountain-meadow soils predominate on the unforested areas of the Yaila (Prasolov). This circumstance indicates that these areas of the Yaila have never been forested.

As Prasolov points out, on the northern slope of the Yaila the brown forest soils grade into chernozems, which lie both below and above them (at the lower elevation lie the leached chernozems of the forest steppe). On the southern slope, however, the brown forest soils extend downward almost to sea level; they grade into chernozems only along their upper boundary. On the northern slope, above the leached chernozems and up to an elevation of 800 to 900 m., the slopes which face S, SW, and W are covered with dark-gray humus brown forest soils, transitional to chernozems; on the gentle northern slopes there are normal, more or less podzolized, brown forest soils. The latter are of a type transitional to the subtropical red soils.

In the eastern part of mountain Crimea (at Karasubazar, for example), under beech and oak forests there are brown forest soils which, in the dense beech forests, have a brighter, yellow coloring. On the southern slopes, nearer the sea, there are darker brown forest soils, and also soils closely related to the chernozems and even to the chestnut soils (for example, at Kara-Dagh and Sudak).

Vegetation

The flora on the south coast of the Crimea is very rich. While about 3500 species are known in the entire area of the European part of the U.S.S.R., about 1400 species grow in the narrow confines of the Crimean southern coast. Among these, only thirteen species are native to the Crimea alone, that is, endemic (Wulff, 1927); these include the so-called Crimean "edelweiss" (*Cerastium biebersteinii*—Caryophyllaceae), peculiar to the Yaila. However, there are many native subspecies in the Crimea.

A variety of imported plants and trees are grown on the lower slopes of the mountains.[6] Many Mediterranean, Japanese, and Chinese plants have become well acclimatized here. Among them are: the Italian cypress (*Cupressus sempervirens*); laurel; laurel cherry; magnolia; Chinese wistaria (*Wistaria chinensis*); myrtle; Chinese coir palm (*Chamaerops excelsa* [*Trachycarpus excelsa*]), which withstands frosts of − 14° C. in the Nikitsky Botanical Garden, and grows readily in the village of Nikita; silk-tree albizzia, or *mimosa* (*Albizzia julibrissin*); oleander; cork oak; plane tree; Judas tree (*Cercis siliquastrum*), which has escaped; golden-chain laburnum (*Laburnum vulgare* [*L. anagyroides*]), also escaped; English holly (*Ilex aquifolium*); common box (*Buxus sempervirens*); Italian stone pine; strawberry madrone (*Arbutus unedo*); and others. The Mediterranean dwarf pine cannot survive the winter unless it is sheltered; it blooms in May and June. The fruit trees grown here include the olive, almond, chestnut, fig, common pistache (*Pistacia vera*), pomegranate, thick-shell Persian walnut, medlar, persimmon, and peach. There are many vineyards and tobacco plantations (Fig. 62).

The vegetation of the south coast[7] has Mediterranean features. The presence of evergreen woody plants is characteristic for the Mediterranean region, with its mild winters. This feature, however, is expressed very poorly in the Crimea, as we shall see, due to the fact that the south coast lies on the northernmost outskirts of the Mediterranean region. On the shores of the Mediterranean Sea, particularly in the west, there grow peculiar shrub thickets (so-called *maquis*) of evergreen species—myrtle, laurel, rockrose, buckthorn, oak, and others. This type of vegetation is not found in the Crimea. Although there are some evergreen woody plants in the Crimea, they do not grow in *maquis*-like formations, but are found in associations of different types.

The evergreen plants of the Crimea include the following: *butcher's-broom* (*Ruscus aculeatus*), an undershrub of the lily family, whose stems are flattened into leaflike shape; *madrone* (*Arbutus andrachne*), of the

[6] G. V. Voinov, "Parkovaya rastitelnost Kryma" (Park-Land Vegetation of the Crimea), *Zap. Nikit. botan. sada* (Report of the Nikitsky Botanical Garden), XIII, No. 1, Yalta, 1930, pp. 1–68.

[7] Of the most recent literature, see S. S. Stankov, "Osnovnie cherty v raspredelenii rastitelnosti Yuzhnovo Kryma (Sevastopol-Feodosiva)" (Basic Features of the Distribution of Vegetation in the Southern Crimea [Sevastopol to Feodosia]), *Botan. zhurn. S.S.S.R.* (Botanical Journal of the U.S.S.R.), XVIII, 1933, pp. 66–91 (bibliography). See also the excellent book by the same author, *Yuzhny bereg Kryma* (The South Shore of the Crimea), Botanicheskie ekskursii (Botanical Excursions), Nizhny-Novgorod, 1926, p. 149.

heath family; the low shrub *rockrose* (*Cistus tauricus* [*C. villosus tauricus*]); and, finally, English *ivy* (*Hedera helix*). Butcher's-broom and rockrose usually grow in the form of undergrowth in the light forests of arborescent juniper and oak. Individual madrone plants settle along the rocky precipices, while ivy prefers to twine about the trunks of the large trees; it is found also on the northern slope of the Crimean mountains. But not one of these plants in the Crimea forms *maquis* thickets, so characteristic for Mediterranean countries. "Butcher's-broom and rockrose," says Stankov (1926), "in some places (Gurzuf and others) still grow in rather large continuous stands, but always as an undergrowth in the forests, and never in the open; the madrone, however, is found seldom, while ivy cannot be regarded as a shrub species at all." It must be noted that during very cold winters, the rockrose in the Crimea sheds its leaves.

The Mediterranean vegetation on the south coast of the Crimea does not extend very far up the mountains, only up to 300 to 320 m., and usually not so high. It grows along the coast, its range beginning at Cape Aiya and extending somewhat east of Alushta. The madrone does not reach even as far as Alushta. East of Alushta the amount of precipitation decreases, and the vegetation gradually assumes a steppe, xerophytic appearance. Here are found *polyn* (*Artemisia maritima taurica*), harmel peganum (*Peganum harmala*), thick-leaved nitraria (*Nitraria schoberi*), a buckwheat shrub (*Atraphaxis spinosa*), and many species of feather grass, among them capillary feather grass, which is found in large numbers. The vegetation in the region between Sudak and Feodosia has a distinct steppe character.

On the south coast the following four vertical zones of vegetation may be distinguished:

(1) Open, xerophytic *juniper-oak forests* are characteristic for the lowest belt, up to elevations of 250 to 300 m. The arborescent juniper (*Juniperus excelsa*), the tall trees of which have a brown-red bark that peels in ribbonlike strips, constitutes the basic species of this zone (Fig. 63). But the arborescent juniper has been undergoing destruction for a long time. The pubescent oak (*Quercus pubescens*) grows here in the form of an insignificant-looking, crooked, low tree. Finally, the third element in this forest, the Turk terebinth pistache (*Pistacia mutica*), is a tree which grows to a height of 18 m. and has a dense rounded crown; it is found from Sevastopol to Kara-Dagh, and also at Bakhchisaray; it always grows on open dry slopes with a rocky, calcareous subsoil. This tree yields turpentine, which, however, is not extracted in the Crimea.

The fruit is not used for food. In the Nikitsky Botanical Garden there is a Turk terebinth pistache close to a thousand years old.

In these juniper forests the second layer society and the undergrowth also contain ash, smoke tree [*Cotinus coggygria*], wild jasmine (*Jasminium fruticans*), oriental hornbeam (*Carpinus orientalis*), Crimean pine, another arborescent juniper (*Juniperus oxycedrus rufescens*), rockrose, butcher's-broom, Christ's-thorn paliurus (*Paliurus spina-christi*), madrone, sumac, and a tree of the elm family—the hackberry (*Celtis glabrata*); the climbing plants include traveler's-joy, ivy, and sweetbrier rose. The juniper forest between Yalta and Gurzuf (near the Nikitsky Botanical Garden) has been well preserved.

In this belt also there are found shrub thickets of sumac (*Rhus coriaria*), common smoke tree (*Cotinus coggygria*), shrub pubescent oak, and oriental hornbeam, or combinations of these species.

In some places, in isolated localities, as far east as Sudak, there is found a Crimean form of the Aleppo pine (*Pinus pityusa stankewitschi* [*P. halepensis pityusa stankewitschi*] Fig. 64).

(2) Above this first zone, beginning at about 250 m., on the south coast (for example, at Yalta), *Crimean pine* (*Pinus nigra pallasiana* [*P. nigra caramanica*])[8] predominates (Fig. 65); sometimes this tree descends as far as sea level, while at Ai-Petri it reaches into the Yaila region. It extends as far east as Otuzi *raion,* and is found also at Sevastopol and Bakhchisaray and occasionally on the northern slope (in the forest preserve). This pine is distinguished by its gray-black trunk, long needles, and large cones. In some places it grows in pure stands (Fig. 65). This is a typical Mediterranean mountain species, found in closely related forms from the Pyrenees to the Crimea and in some measure as far as the Novorossiisk coast of the Caucasus.[9] Without a doubt this pine (as an admixture with other species) was at one time widespread also in the lower zone of the Crimea, but it has been destroyed since then. When the Crimean pine grows on calcareous rocks, it forms an easily recognizable horizontal crown. At an elevation of 300 to 450 m. the pine forests have a continuous undergrowth of rockrose. The second layer society usually contains pubescent oak (*Quercus pubescens*). In some places the Crimean pine has been destroyed even in its own proper zone of distribution (above 200 to 250 m.), and in its place grow durmast oak

[8] Usually it is known as *Pinus laricio pallasiana* [*P. nigra poiretiana*].

[9] The Crimean pine (*P. nigra pallasiana* [*P. nigra caramanica*]) grows in Novorossiisk *raion* (at Arkhipo-Osipovka), and in Asia Minor and Greece, as well as in the Crimea.

(*Q. sessiliflora* [*Q. petraea*]), European hornbeam (*Carpinus betulus*), dogwood, and other trees.

(3) Still higher lies a belt of *beech forests* with an admixture of pine (Crimean and Scotch), maple (*Acer hyrcanum*), hornbeam, and euonymus (*Euonymus latifolius*). The characteristic species of this zone are Scotch pine and beech. Crimean pine does not predominate here. The Scotch pine belongs to the Caucasian form (*Pinus sylvestris hamata*), while the beech represents a form intermediate between the European (*Fagus sylvatica*) and the Caucasian (*F. orientalis*).[10] In the upper parts of the beech belt there are individual ancient yew trees (*Taxus baccata*). The beech forests extend into the Yaila region (1000 m. and higher) and end abruptly at the edge of the unforested plateau. On the boundary between the beech forests of the slopes and the mountain meadows of the Yaila there lie thickets of creeping juniper (*Juniperus depressa*).

(4) The summit of the Yaila is almost unforested. Only occasionally, under the shelter of crags, are there found thickets of beech, maple (*Acer campestre* and others), ash, mountain ash, hornbeam, and others, as well as individual Scotch pines [11] and yew. However, in some parts of the Yaila there are beech forests; for example, near the summit of Ai-Petri, at an elevation of 1240 m.; on the summit of Karabi-Yaila (at 1255 m.); on the southeast part of Demerdzhi-Yaila (at 1280 m.); and on the lower plateau of Chatyr-Dagh (at 1280 m.). The beech is accompanied by an admixture of hornbeam, maples, ash, and mountain ash. A characteristic feature of the Yaila forests is the complete absence of young trees; these have been destroyed by livestock. There is almost no undergrowth, except for individual bushes of filbert and hawthorn. The slope connecting the upper and lower plateaus of Chatyr-Dagh is covered almost continuously with thickets of creeping juniper (*Juniperus depressa*), among which there grows another creeping juniper, the savin juniper (*Juniperus sabina*). These thickets are found also on the lower plateau.

On the drier sections of the Yaila, meadow-steppe vegetation predominates. Grasses are the most numerous: fescue (*Festuca sulcata*), koeleria

[10] E. V. Wulff ("Kavkazsky buk, yevo rasprostranenie i sistematicheskoye polozhenie" [The Oriental Beech, Its Distribution and Systematic Position], *Botan. zhurn. S.S.S.R.* [Botanical Journal of the U.S.S.R.], XX, 1935, p. 534) holds that both the European and the Caucasian beech are found in the Crimea, as well as transitional or hybrid forms between these two.

[11] Wulff (1925, p. 94; full title appears in the following footnote) says that on Babugan-Yaila at an elevation of 1450 m. in 1914 he saw two Scotch pines, the trunks of which measured two arms'-lengths in circumference.

(*Koeleria gracilis*), and brome (*Bromus*). This vegetation may be recognized from a distance by its dull, gray-green color. In the moister depressions in the relief, rich, bright-green meadows and, to some extent, subalpine vegetation prevail (Babugan, Chatyr-Dagh); dicotyledons predominate: lady's-mantle (*Alchemilla*), kura clover (*Trifolium ambiguum*), and dropwort (*Filipendula hexapetala*); the Crimean "edelweiss" (*Cerastium biebersteinii*—Caryophyllaceae) and the sedge *Carex humilis* (which is characteristic for the steppes of the forest-steppe zone—see above, pp. 84–86) are numerous; on the Yaila, *Carex humilis* settles in the sunny rocky places. The pubescent rock jasmine (*Androsace villosa*), draba (*Draba cuspidata*), and Altay violet (*Viola altaica,* which grows in two varieties, which bear lilac-colored and yellow flowers, respectively) are among the characteristic alpine plants of the Yaila. As Wulff rightly points out, these few alpine plants are relicts of a former colder climate. It would be a mistake to classify the Yaila with the alpine belt because of the presence of these plants. On the Yaila, chernozemlike mountain-meadow soils predominate; sometimes they contain much humus (as high as 18 per cent). The numerous herds of sheep which have grazed on the Yaila for many hundreds of years have disturbed greatly the natural character of the vegetation here.

A vast literature exists concerning the absence of forests on the Yaila. Some students believe that the Yaila was covered by forests at one time, and that man cut down the forests. Wulff (1925), who holds this view, develops the following argument:[12] One may speak only of the scarcity, rather than of the absence of forests on the Yaila, because, as we have noted above, forests are found up to an elevation of 1280 m. on the Yaila plateau, and even up to elevations of 1400 m., if the thickets of light-loving creeping juniper on the slope from the upper to the lower plateau of Chatyr-Dagh may be regarded as evidence of forests which formerly existed in these parts. On the slopes of Chatyr-Dagh the boundary of the forest in some places extends even higher, up to 1500 m. Amid the herbaceous vegetation of the Yaila there are species characteristic of the beech forests of the Crimea. The transition from the beech forests of the slopes of the Yaila to the unforested summit is abrupt; the shrub forms of beech which in western Europe are characteristic of the natural upper boundary of beech are absent. For these reasons Wulff believes that the upper boundary of beech in the Crimea has been determined by human agency.

[12] E. V. Wulff, *Rastitelnost vostochnykh Yail Kryma* (Vegetation of the Eastern Yailas of the Crimea), Moscow, 1925, izd. "Nov. derevnya" (publication of "The New Village").

Fig. 49. Beech forest with undergrowth of *Rhododendron ponticum* near the Black Sea coast south of Gagry in the Colchian Lowland. (*Vegetationsbilder*. Vol. 11; part 6/7; plate 31)

Fig. 50. The Glavny (Main) range of the Caucasus, from the glaciers of Mt. Elbrus. (Sovfoto)

Fig. 51. Crossing the Glavny (Main) range of the Caucasus at 10,500 feet. (Sovfoto)

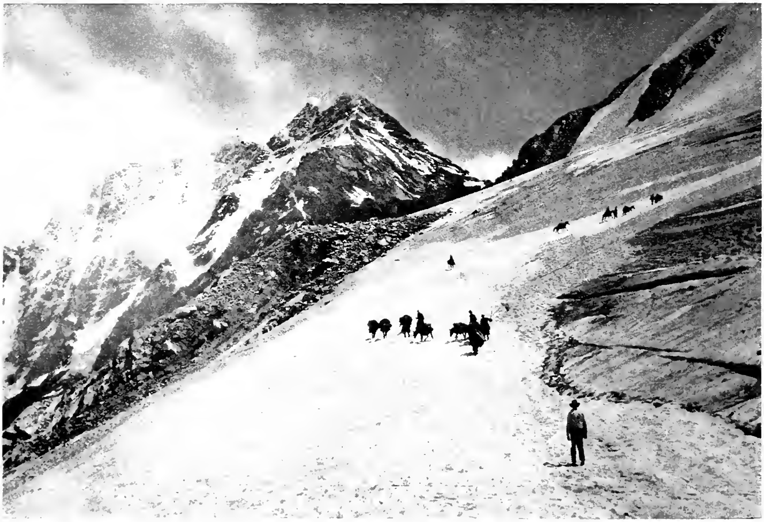


Fig. 52. A mountain meadow in the Svanetiya range, Kobardino-Balkarian A.S.S.R. (Sovfoto)

Fig. 53. A yew forest in the mountains of the Caucasus. (Sovfoto)

Fig. 54. Nordmann fir (*Abies nordmanniana*) in the mountain forest above Gagry. In foreground tall meadow herbage. (*Vegetationsbilder*. Vol. 11; part 6/7; plate 37)

Fig. 55. Pine forest (*Pinus sylvestris*) on the northern slope of the Caucasus near Klukhor-Kazarma. Elevation 2100 m. (*Vegetationsbilder*. Vol. 11; part 6/7; plate 35)

Fig. 56. Grove of birch (*Betula pubescens*) at the timber line above Kazbek station on the Georgian Military Highway. In the foreground shrubs of false hellebore (*Veratrum album*) and thistle (*Cirsium obvallatum*). (*Vegetationsbilder*. Vol. 11; part 6/7; plate 40)

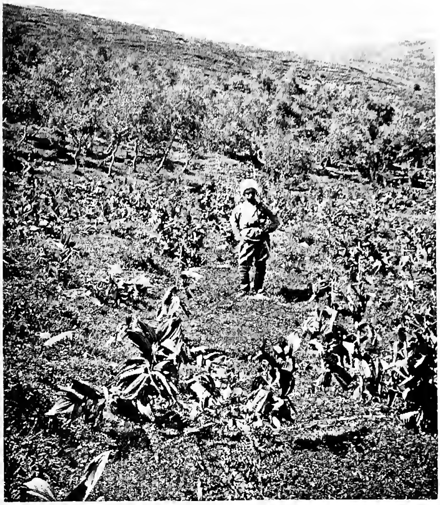


Fig. 57. A subalpine tall-herbaceous meadow in Kabardino-Balkaria. (*Vegetationsbilder*. Vol. 20; part 3/4; plate 16)

Fig. 58. Alpine rock vegetation in the mountains of Kabordino-Balkaria: (a) *Campanula anomala* and *Gypsophila tenuifolia*; (b) *Astragalus aureus*; (c) *Salvia canescens*. (*Vegetationsbilder*. Vol. 20; part 3/4; plate 20)

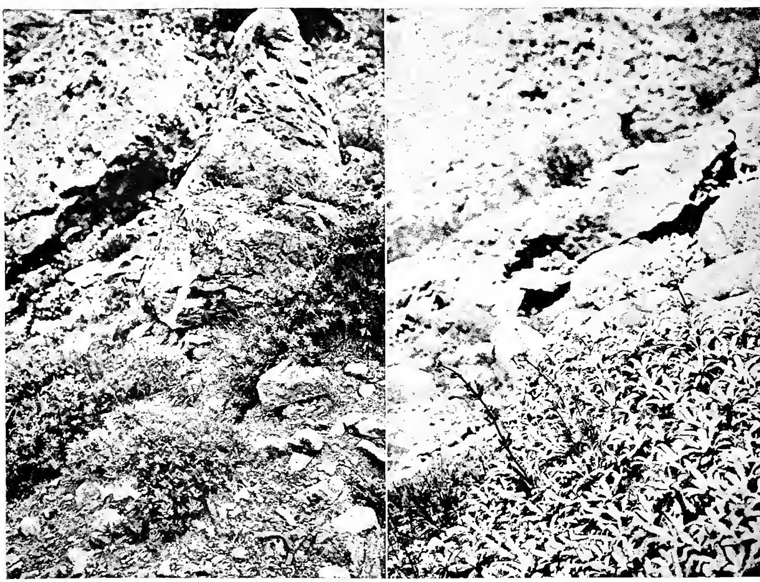


Fig. 59. A mountain road in Daghestan. (Sovfoto)

Fig. 60. Lake Sevan on the Armenian Plateau. (Bolshaya Sovetskaya Entsiklopedia. Vol. 30: 459)

Fig. 61. The flat summit of the Yaila, the main range of the Crimean mountains. (*Vegetationsbilder*. Vol. 17; part 1; plate 4)

However, on the northern slope of Babugan-Yaila, at an elevation of 1250 to 1350 m., Poplavskaya (1925) discovered a peculiar, crooked, "subalpine" form of beech—evidence that this is the upper boundary of its distribution.[13] In the western Transcaucasus, north of Abkhaziya, beech is found from the seacoast to an elevation of 1400 m., where it is replaced by fir; in the form of a shrub, however, beech extends into the subalpine meadows, up to an elevation of 2100 m. It would be possible for fir or spruce to grow on the Yaila also, but they are not found here. Scotch pine may have had a wide distribution on the Yaila at one time. But the Yaila cannot have been covered with continuous forest, because, as we have pointed out, on the unforested areas of the Yaila the soils are mountain chernozems and chernozemlike mountain-meadow soils, which do not develop under forest.

The upper northern slope of the Yaila is covered by beech and hornbeam forests (Fig. 66), in which there are stands of Scotch and Crimean pine. The thoroughly investigated forests of the Crimean game preserve (which lies on the northern slope of Babugan-Yaila) occupy a belt between 550 and 1250 to 1350 m. above sea level. Beech grows here predominantly in pure stands; sometimes there is a small admixture of hornbeam, ash, linden, Scotch elm, and individual yew trees. There are many beeches, centuries old, which measure several arms'-lengths in circumference. The pure beech forest contains no undergrowth; during the first half of May there blooms here a plant which is characteristic of the Crimean beech forest—the five-leaved toothwort (*Dentaria quinquefolia*). In the vicinity of the game preserve an aborescent juniper (*Juniperus foetidissima*) grows in small quantity; this species is almost nonexistent on the south coast.

But most remarkable of all is the presence in the preserve of the European white birch (*Betula verrucosa*),[14] which is not consistent with the general appearance of the flora of the Crimean mountains.[15] It grows here on the northern, steep slopes, at an elevation of 1000 to 1200 m., forming the second layer society in the Scotch pine stands. Individual aspens (*Populus tremula*) are found here also occasionally. The herbaceous

[13] According to Wulff, the appearance of the beech here in the form of a bush is due to the grazing of stock.

[14] G. I. Poplavskaya, "O bereze v Krymu" (The Birch in the Crimea), *Zhurn. Russk. botan. obshch.* (Journal of the Russian Botanical Society), XIII, 1928, pp. 65–92.

[15] This circumstance astonished the observant Pushkin. In a letter to Delwig from Mikhailovsk in December, 1824, the great poet writes: "We rode across the mountains (at Kikeneiz), and the first object which astonished me was the birch, northern birch. My heart contracted; I began to yearn for my beloved north, although I was still in the Taurida, still among poplars and grapevines."

plants in these pine forests, which also contain birch, include a series of northern forest plants, such as the side-bells pyrola (*Pyrola secunda*), creeping rattlesnake plantain (*Goodyera repens*), and stone bramble (*Rubus saxatilis*); but there are also some plants peculiar to the Yaila, such as the above-mentioned Crimean "edelweiss," the Altay violet, and the sedge *Carex humilis*. The birch appears to be a relict of the same cold period to which the Yaila subalpine plants which we have mentioned belong. At Bakhchisaray, in the Paleolithic site which apparently belongs to the epoch of the last glaciation, birch charcoal is found in large quantity.

Below the beech zone the terrain drops sharply in elevation, beginning approximately at the boundary between the Jurassic and the Cretaceous deposits. On the northern slope there lie forests of oak (*Quercus* of the *sessiliflora* [*petraea*] group) and oriental hornbeam (*Carpinus orientalis*), among which grow filbert, aspen, pear, maple, ash, euonymus, and others. In the west, beginning from about Bakhchisaray, there is Crimean pine.

Below the zone of oak forests lies forest steppe, which extends to the north somewhat beyond a line from Simferopol to Karasubazar; that is, up to the third ridge. Here there grow, chiefly, oak, pear, smoothleaf elm (*Ulmus campestris* or *U. foliacea* [*U. carpinifolia*]), and shrubs; these small woods are called *dubki*. At one time they were well developed in the neighborhood of Simferopol, where their remains are still preserved.[16] Here *dubki* lie along the southern slope of the third ridge and the northern slope of the second ridge. The soils under the *dubki* are poor calcareous chernozems which have been subjected to slight degradation, or forest soils, also calcareous, due to the calcareous character of the parent materials. The vegetation consists of the more southern oaks (*Quercus pubescens, Q. sessiliflora* [*Q. petraea*]) and the English oak (*Q. pedunculata* [*Q. robur*]), hawthorn (*Crataegus monogyna*), sloe (*Prunus spinosa*), pear (*Pyrus communis, P. elaeagnifolia*), checkertree mountain ash (*P. torminalis* [*Sorbus torminalis*]), filbert, smoothleaf elm, common smoke tree (*Rhus cotinus* [*Cotinus coggygria*]), dogwood, and sweetbrier rose. The herbaceous vegetation of the *dubki* belongs partly to the forest steppe, partly to the steppe. In spring the fernleaf peony (*Paeonia tenuifolia*) and spring adonis (*Adonis vernalis*) predominate; they form an almost continuous cover in the glades.

[16] T. Tsyrina, "Livenskie *dubki*" (The Liven *Dubki*), *Zap. Krym. obshch. yest.* (Report of the Crimean Nature Society), VIII (1925), Simferopol, 1926. S. A. Dzevanovsky, "Osminskie *dubki*" (The Osminsk *Dubki*), *ibid.* (22 km. northeast of Simferopol).

Sevastopol *raion* also has a forest-steppe character. The soils of this region constitute a transition from forest soils with a dark humus horizon to chestnut soils. In Sevastopol *raion* there are found, in addition, red-brown clays overlying limestones (for example, at Khersonese), on which are formed soils of the steppe chestnut type (Prasolov).

Fauna

The fauna of mountain Crimea, and particularly of the south coast, contains many unique features, and, like the vegetation, includes a series of Mediterranean forms. There are no endemic mammalian forms (neither species, nor subspecies) in the Crimea, but the absence of a series of forest forms, like the squirrel, bear, wild cat, dormouse, and wild boar, is conspicuous. During the Paleolithic period, however, the bear and the wild boar inhabited the Crimea. In the Crimean preserve there are red deer (*Cervus elaphus*)—the same form as in the Carpathians—and roebuck (*Capreolus capreolus*). The hypothesis has been advanced that the deer may have been introduced here by man; however, remains of the deer (and also of the roebuck) have been discovered by Byalynitsky-Birulya in the Crimean Paleolithic beds. In the mountains there are wolf (now almost exterminated), fox, badger, Crimean weasel (*Mustela nivalis nikolskii*),[17] and beech marten (*Mustela foina* [*Martes foina*]). The hare [*Lepus europaeus*] inhabits both the mountains and the steppe.[18] The Crimea is poor in birds. The absence of black grouse, rock partridge, and most woodpeckers is striking. Many common species of birds occur in the Crimea in special Crimean forms; such, for example, are the jay (*Garrulus glandarius iphigenia*)—very characteristic for the mountain forest—goldfinch, rock bunting, azure tit, and others. The presence in mountain Crimea of several forest birds should be noted; these include the crossbill (*Loxia curvirostra caucasica*) and the siskin (*Spinus spinus*). There are some bird subspecies which are found also in the Caucasus. The Crimean starling (*Sturnus vulgaris purpurascens*), native to the northern foothills and steppes, is found also in Asia Minor. The lizards on the south coast include the endemic Crimean sand gecko (*Gymnodactylus danilewskii*), closely related to the Balkan *G. kotschyi*, and also several Mediterranean forms (among them the mountain lizard *Lacerta saxicola*). The Crimean lizard (*L. taurica*) is found on the Balkan Peninsula, as well as in the Crimea. The green lizard (*L. viridis*)

[17] It is found also in the Crimean steppe, as well as in the adjoining steppes of the continent.

[18] In the caves at Simferopol, in the Quaternary deposits, bones of the hare *Lepus timidus* have been found.

and the slowworm (*Anguis fragilis*) are absent in the Crimea. The large apod lizard, or glass snake, *Ophisaurus apus,* is also found on the south coast. In the mountains, the leopard snake (*Elaphe situla*) and the smooth snake (*Coronella austriaca*) are common. The large but entirely harmless yellow-bellied European whip snake (*Coluber jugularis caspius*) is found both in the mountains and on the steppe. The amphibians include the crested newt, tree frog (*Hyla arborea*), river frog (*Rana ridibunda*), and green toad. But the grass frog (*R. temporaria*) and moor frog (*R. arvalis*), toad [*Bombinator*], and small common newt are absent here. There are few fresh-water fish; these include river trout, minnows [*Phoxinus phoxinus* and *Leuciscus cephalus*], and the cyprinid barbel.

Among the invertebrates of the Crimea there are many unique forms. The streams (for example, the Uchan-Su) are inhabited by a fresh-water crab (*Telphusa fluviatilis* [*Potamon* (*potamon*) *edulis*]). Under the rocks may be found the large dark-green centipede (*Scolopendra cingulata*); there are some chilopods (*Scutigera coleoptrata*), solpugids, and the Crimean scorpion (*Euscorpius tauricus*), which is found from Sevastopol to Sudak and is common under the rocks; in the forests are found the oriental cockroach (*Stylopyga orientalis spontanea* [*Blatta orientalis*]) and some endemic cockroaches (*Aphlebia adusta,* and others). The praying mantis (*Mantis religiosa*) and the empusa (*Empusa tricornis*) may be mentioned also. The vineyards are ravaged by grasshoppers —Crimean apterous locusts (*Isophya taurica*). Embioptera (*Embia taurica*) are peculiar; they are small insects which have spinning-glands on their front legs. The cicada (*Cicada plebeia,* a Mediterranean form characteristic of the south coast); the mimetic butterfly, *Libythaea celtis;* the satyrid butterfly, *Satyrus euxinus,* endemic in Ai-Petri; and the blue-violet carabid beetle, *Procerus scabrosus tauricus* (related to the *P. scabrosus* of the Balkans and Asia Minor, and often found in gardens), are among the other insects. The longicorn beetle, *Rosalia alpina,* appears occasionally in the beech forests. Of the land mollusks of mountain Crimea, many are endemic; the closest relatives of the Crimean mollusks are found among Mediterranean forms, particularly those of Asia Minor.[19]

In caves, in the Quaternary deposits[20] which belong to the Paleolithic

[19] I. Puzanov, "Materialy k poznaniyu nazemnykh mollyuskov Kryma" (Materials Concerning the Land Mollusks of the Crimea), *Byull. Mosk. obshch. ispyt. prir.* (Bulletin of the Moscow Society for Natural Research), otd. biol. (Biological Section), 1928.

[20] A. A. Byalynitsky-Birulya, *Priroda* (Nature), 1928, No. 11. *Byull. Kom. po izuchen. chetvertichnovo perioda* (Bulletin of the Committee for the Study of the Quaternary Period), No. 1, 1929, table on p. 34.

period, a numerous extinct mammalian fauna has been found: woolly rhinoceros (*Rhinoceros tichorhinus*); mammoth (*Elephas primigenius*), cave hyena (*Hyaena spelaea*); cave bear (*Ursus spelaeus*); brown bear (*U. arctos*); lion (*Felis leo*); wild cat (*F. silvestris*); lynx (*F. lynx* [*Lynx lynx*]); wolf; dog; arctic fox (*Alopex lagopus*); corsac fox (*Vulpes corsak*); common fox (*V. vulpes*); reindeer; saiga antelope (*Saiga saiga* [*S. tatarica*]); wild boar; ox (*Bos* sp.); gigantic deer; red deer; a large sheep which resembles the mountain sheep [*Ovis ammon*], in a cave on a summit of the Yaila; a small sheep which resembles the mountain sheep [*O. vignei*], in the same place, and also in Simferopol and Sevastopol *raions*; a goat (*Capra*), found in a cave on a summit of the Yaila;[21] beaver; wild ass (*Equus hemionus?*); horse; hamster (*Cricetus cricetus*); jerboa (*Allactaga jaculus* [*A. major*]); suslik (*Citellus rufescens?*); and others. From an examination of this fauna, Byalynitsky-Birulya (1929) reached the conclusion that during the Paleolithic period the Crimea was connected with the continent by a wide strip of dry land. The combination of forest and steppe forms is worth noting. Thus, in the layer which belongs to the Lower Aurignacian epoch, there are found the remains of arctic fox, reindeer, and beaver, side by side with the remains of suslik, jerboa, corsac fox, saiga antelope, and horse. Here also are found the remains of red deer, ox, wild boar, hyena, and others. Of the birds in the Paleolithic strata of the Crimea, A. Ya. Tugarinov found the willow ptarmigan, black grouse, and chough (*Pyrrhocorax pyrrhocorax*).

The origin of the flora and fauna of the Crimea. The flora and fauna of mountain Crimea are characterized by the following features: (1) the absence of the usual series of forest forms, (2) the presence of species foreign to the Black Sea steppes and native to the Balkan Peninsula and Asia Minor, (3) the presence of a series of endemic species (that is, species native only to mountain Crimea), and (4) the presence of Mediterranean forms.

In order to explain these features, we must recall the geological history of mountain Crimea. The Crimean mountains were dry land even during the Cretaceous period. During the Lower Tertiary period, the land mass grew considerably larger. There is reason to believe that during the Upper Tertiary period, and perhaps even during the Quaternary, the Crimea constituted a land mass connected with Asia Minor and the Balkan Peninsula, and probably with the northern part of the western Transcaucasus along the line from Feodosia to Anapa. This land mass

[21] V. Gromova, *Doklady Akad. nauk* (Reports of the Academy of Sciences), 1935, IV, No. 1–2.

was inhabited by a Mediterranean fauna and covered with a Mediterranean flora.[22] On the other hand, during the Quaternary period, as we have seen, this land mass was connected with the present region of the Black Sea steppes. In this manner, during the glacial period, northern forms were able to penetrate into the Crimea from the north.

[22] Concerning the origin of the flora of the Crimea, see E. V. Wulff, in *Zap. Krym. obshch. yest.* (Report of the Crimean Nature Society), IX (1926).

XII · The Ural Range

Relief

THE Ural range is divided provisionally as follows:

(1) The *North* Ural range, from Konstantinov Kamen (elevation 450 m., lat. 68°29′ N) to Mount Isherim (elevation 980 m., lat. 61°04′ N), which lies south of the upper course of the Pechora. The highest point of the North Urals (and also of the entire Ural range) is Mount Narodnaya, in lat. 65° N, which rises 1885 m. in elevation.[1] Formerly Mount Telpos-Iz was considered the highest point; this peak, which reaches an elevation of only 1685 m., lies farther south, in the upper course of the Shchugor River (a tributary of the Pechora), in lat. 63°55′ N. To the south of Mount Sablya (elevation 1650 m., south of lat. 65° N), the range consists of two chains, of which the eastern serves as the divide. In the North Urals, remains of the old peneplain are well represented at elevations of about 800 m. and about 1000 m.[2] During recent years, on Mount Sablya (Fig. 67) and Mount Narodnaya, and in some other places, small glaciers have been found. The largest of these, Hoffman's Glacier, on Mount Sablya, is only 1 km. long.

Some authorities consider that the Ural glaciers are remains of the Quaternary ice sheet. However, according to S. V. Kalesnik,[3] they are contemporary formations. Except for Hoffman's Glacier, all of the glaciers consist of *névé ice,* and persist because of the orographic conditions —the presence of deep cirque basins. Traces of ancient glaciation are, however, very distinct in the North Urals; they may be found approxi-

[1] A. N. Aleshkov, "Ural" (The Urals), *Trudy lednik. eksp.* (Proceedings of the Glacial Expedition), IV, 1935, p. 13.

[2] V. A. Varsonofyeva, "Geomorfologicheskie nablyudeniya na Sev. Urale" (Geomorphological Observations in the North Urals), *Izv. Geogr. obshch.* (Report of the Geographical Society), Vol. 64, 1932.

[3] S. V. Kalesnik, *Gornie lednikovie raiony S.S.S.R.* (Glacial Mountain Regions of the U.S.S.R.), Leningrad, 1937, Gidromet. izd-vo. (Hydrometric Publication), pp. 13–14.

mately as far south as lat. 60° N. During the glacial period the ice sheet descended from the Urals both to the west into the Pechora basin, and to the east into the Ob basin.

The Pai-Khoy ridge extends southeast from Yugorsky Strait, in the direction of the Ural range; it is composed of crystalline schists and sedimentary strata from the Silurian to the Artinsk, but predominantly Devonian. While its mean elevation is about 300 m., individual peaks reach an elevation of 450 m. Vaigach Island (composed of Devonian deposits) and Novaya Zemlya are a continuation of the Pai-Khoy ridge to the northwest, beyond Yugorsky Strait. Although the Pai-Khoy is separated from the northern end of the Urals by 50 km. of tundra, geologically it is an integral part of this range.

(2) The *Central* Ural range extends from Mount Isherim (lat. 61°04′ N) to Mount Yurma (lat. 55°25′ N; that is, north of the parallel of Zlatoust), and reaches an elevation of 1045 m. In the southern part of the North Urals, the range divides into several chains. The water-divide ridge of the Central Urals is called Poyasovoy Kamen; on this ridge lies the highest point of the Central Urals, Konzhakovsk Kamen (elevation 1595 m.). In the southern part of the Central Urals the passes are very low; the railroad from Perm to Sverdlovsk crosses the Urals at an elevation of only 410 m.; near Sverdlovsk the Urals drop still lower, to 300 m. Here, opposite the Ufa Plateau, the arc of the Urals is convex to the east. Farther south, the Urals rise in elevation again.

(3) The *South* Ural range extends from Mount Yurma to the middle course of the Ural River, where it lies roughly along lat. 52° N. The highest point of the South Urals is Yaman-Tau, which reaches an elevation of 1646 m. The water-divide range of the South Urals is called the Ural-Tau; it lies to the east, and reaches only 950 m. in elevation, while the Yurma chain and its prolongations, the Taganay (elevation 1220 m.) and Urenga (elevation 1275 m.), which lie farther west, are higher in elevation. Remains of an old peneplain are found in the South as well as in the Central and North Urals. South of the Belaya River the Urals lose the characteristics of a range and become a high plain (640 to 420 m.), composed of dislocated Devonian and some Carboniferous strata dissected by deep valleys. The water-divide chain of the Urals is lower in elevation than the chains which adjoin it to the west and east. In the Central Urals the water-divide chain is transected by the Chusovaya River, which has its source on the eastern slope.

The Ural range does not rise as high as the snow line except at the few points mentioned above. In some years, however, the snow does not melt in the sheltered valleys of the Yaman-Tau and Iremel (elevation 1600 m.).

There is a great difference between the western and eastern slopes of the Urals. While the western slope, which has foothills, is gentle, the eastern slope drops abruptly to the West Siberian Lowland.

A so-called "rolling" (*uvalistaya*) strip, composed chiefly of igneous rocks (porphyrites and others) and fragments of strongly dislocated Paleozoic deposits, adjoins the eastern slope of the Ural range approximately south of lat. 62° N. The eastern edge of this strip lies at an absolute elevation of 180 to 190 m.; east of this line the West Siberian Lowland begins. The *uvalistaya* strip has a sharply rolling relief; the hills do not lie in straight ridges, but are scattered at random. A good view of this type of relief may be had from Kachkanar peak (elevation 881 m.). Absolute elevations here vary between 210 and 250 m., and only a few isolated peaks slightly exceed 400 m.

The valleys of many of the rivers on the western slope of the South Ural range follow a very characteristic pattern: the Inzer (a tributary of the Belaya), the Belaya (a tributary of the Kama), the Sakmara (a tributary of the Ural), the Ural—all flow at first in longitudinal valleys from north to south, and then turn sharply to the west, to cut across the ranges. Chernyshev held that in the case of these rivers erosion took place simultaneously with mountain-forming processes; the rivers are older than the mountains, and as the mountains have been uplifted, the rivers have cut deeper and deeper into them. But now students take into account the fact that at the points where the rivers turn to the west, there is a drop in the axes of the folds; the folds are broken into a series of beadlike sections, and the rivers flow along the depressions between these sections.

The eastern slope of the Central Ural range abounds in lakes. They are particularly numerous between Sverdlovsk and Chelyabinsk; these lakes include Itkul, Irtyash, Uvildy (depth, 28 m.), Argazi, and Turgoyak (depth, 34 m.).

The Urals are composed of Paleozoic, predominantly marine, deposits, from the Cambrian to the Permian.[4] The region of the central axis is built of various metamorphic rocks, related partly to the pre-Cambrian, partly to the Lower Paleozoic period. The Ural-Tau water-divide range is composed of these rocks. On the east the Urals are bordered by marine Tertiary deposits (Eocene and Oligocene), under which may be traced the Ural folds which were abraded during the transgressions of Mesozoic

[4] Geological map of the Urals, 1:1,000,000, Leningrad, 1931.

and Tertiary seas. On the west the Urals are bordered by Permian-Carboniferous and Permian deposits.

The Ural range is asymmetrical. In its structure six north-south belts may be distinguished. From west to east, these belts are composed of: (1) sedimentary Paleozoic strata (Permian, Carboniferous, and Devonian) and quartzites (possibly of Silurian age); (2) crystalline schists, which were mentioned above; (3) thick intrusive basic rocks—a zone of gabbro, underlain by platinum-bearing sections of dunite; this strip is characteristic of the northern half of the Urals; the South Urals contain no gabbro zone, and here, of the deep-lying basic rocks, serpentines predominate; (4) igneous rocks and their tuffs, and also schists, which date from Upper Silurian to Lower Carboniferous; (5) granites and gneisses on the eastern slope; (6) metamorphic Paleozoic deposits, transected by igneous rocks (diabases, porphyrites, and porphyries), and partly covered by the horizontal Upper Cretaceous and Lower Tertiary sediments of the West Siberian Lowland.

The most intensive folding took place in the Urals at the *end of the Carboniferous period* (Nalivkin, 1933). The formation of the Urals basically came to an end at the close of the Paleozoic, and all the periods which followed have been periods of denudation. According to Nalivkin, at the end of the Tertiary period and during the Quaternary, the Urals, which had become a peneplain, were uplifted. No traces of alpine folding appear in the Urals. Thrusts, which took place during the Mesozoic period, are very important in the structure (Arkhangelsky, 1934).

Like other ancient mountains, the Urals abound in mineral resources. These include iron ores (magnetite and limonite), copper, vein and alluvial gold, platinum, aluminum (bauxite), chromite, nickel and manganese ores, precious stones, rock salt and deposits of other salts, coal, and asbestos.

Climate

Because of the vast north-south extent of the Ural range (over 2500 km.), its climates are extremely varied. On the north the range extends almost to the coast of the Arctic Ocean and is covered with tundra; on the south, along the middle course of the Ural River, the steppe extends into the range. The Urals have a noticeable effect upon the climates of the slopes which adjoin them to the west and to the east. Since moisture-bearing west winds prevail in the Urals, precipitation is much more abundant on the western than on the eastern slope, particularly in autumn and winter; as a result, the depth of the snow cover in the West

Urals Foreland is much greater than in the Trans-Urals. Precipitation is 150 mm. greater on the western than on the eastern side of the central part of the range. In the central part of the range the annual precipitation is 600 mm., or even more (Biser, in lat. 58½° N, at an elevation of 471 m., has 683 mm.). North of lat. 61° N, the amount of precipitation decreases; a similar decrease appears also south of Zlatoust (55° N). Relative humidity and cloudiness are greater to the west of the range than to the east of it.

At the Ivanovsk mine (elevation 856 m., in lat. 55° N), temperature inversion is observed in winter; that is, the temperature increases with elevation; from December to March it is warmer (or no colder) here than in Zlatoust, which lies 400 m. lower. The mean July temperature at the Ivanovsk mine, however, is 14.7° C., while in Zlatoust it is 16.0° C. In general, temperature inversion is very common in the South Urals, and, as we shall see, it has an effect on the distribution of vegetation.

Vegetation [5]

The North Urals. The northern extreme of the Urals is covered with tundra, from the foot of the mountains to the summit. At the source of the Kara in lat. 68° N, Hoffman found feeble small larch trees growing. In lat. 67° N, the upper limit of the forest on the eastern slope lies at 300 m. It is interesting that in the region of the Sob River (opposite Salegard, formerly Obdorsk), the base of the Urals and the foothills are only lightly forested, while in the central range, according to Gorodkov, the forests are well developed; Siberian larch, which grows at the upper boundary of the forest, reaches 20 m. in height; Siberian spruce (*Picea excelsa obovata* [*P. obovata*]) and birch (*Betula tortuosa*) are common. The upper boundary of the forest is composed of thickets of scrub Manchurian alder (*Alnus fruticosa*), which form a subalpine belt. In the Sob valley the elevation of more or less continuous larch forests on the southern slopes is 210 m., but stunted larches among the alder thickets occur as high as 310 m., while individual specimens of much deformed larch, together with alder bushes, are found along the southern slopes up to an elevation of 400 m. Thus, on the North Ural range the zones of vegetation are reversed; there is tundra below, and forest higher up —apparently a result of the temperature inversion.

Above the subalpine belt in the arctic Urals (in the Sob River basin), moss tundras predominate on the gentle slopes covered with silt, while

[5] B. N. Gorodkov, M. M. Ilin, I. M. Krasheninnikov in the publication, *Priroda Urala* (Natural Features of the Urals), Sverdlovsk, 1936.

on the rocky and sandy areas there are lichen tundras (with reindeer moss and other lichens).

On the flat passes and water divides near the Arctic Circle, forests disappear at 260 m.; tree vegetation is absent on the western slope of the Urals in these places, and in general the spring reawakening of plant life is delayed on this slope by about two weeks.

In the northern part of the North Urals, larch predominates among the tree species. According to Sochava, the larch grows here on very diverse substrata and under widely divergent geographic conditions: on granites, on crystalline schists, and on gabbro; on sandy loams, on peaty soils, and so forth. It grows both in the river valleys and at the upper boundary of the forest. But in the southern part of the North Urals the larch begins to gravitate toward the boundary of the forest.

In the region of the upper course of the Shchugor and Telpos ridge (lat. 63°–64° N),[6] four vertical zones may be distinguished in the vegetation of the North Ural range. Beginning at the bottom, these are:

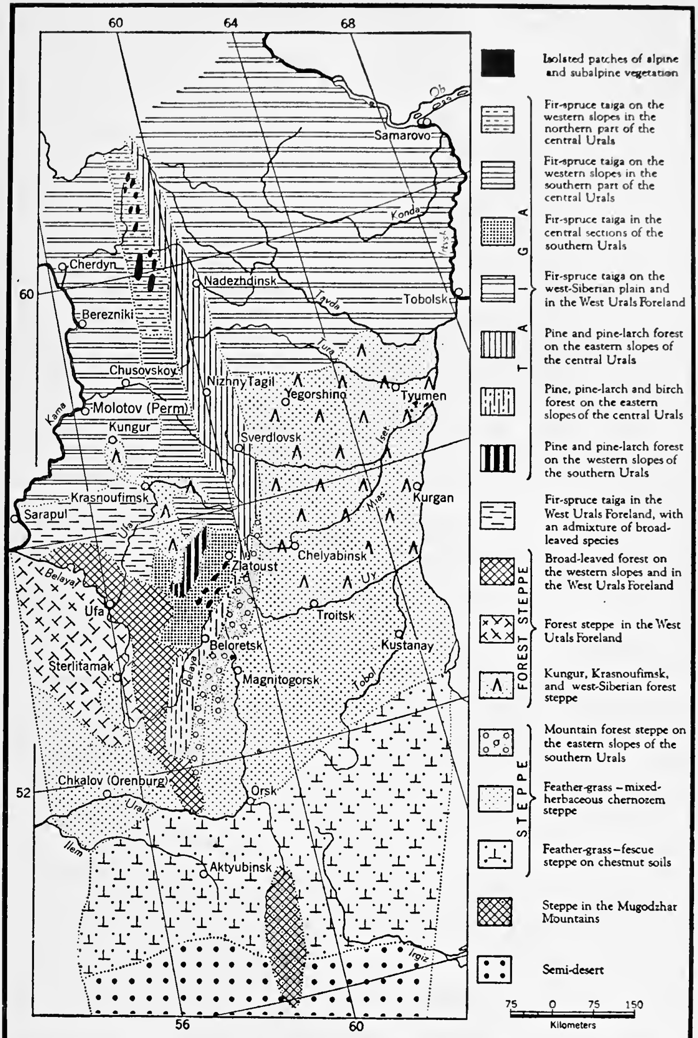
(1) A zone of mossy coniferous forest, which extends up to an elevation of 400 to 450 m. Here Siberian spruce predominates. In addition there is always fir, Siberian stone pine, and birch. Neither pine nor aspen occurs. Spruce-bilberry groves are most widespread; on rich and moist soils they are replaced by fir-bilberry groves. The spruce does not grow tall, usually 12 to 15 m., and the density of the stand in the spruce forests is not very great.

(2) At an elevation of 500 to 700 m. lies a meadow-forest zone. Open herbaceous coppices of birch (*Betula tortuosa*), with an admixture of fir, sometimes spruce, and in a few places Siberian larch, alternate with small glades. These coppices form the upper boundary of the forest. In the more northern parts of the Urals this zone is represented by a strip of subalpine larch forests.

(3) Above the meadow-forest zone lies a zone of dwarf arctic birch (*Betula nana*). The moss cover of the birch groves consists of either hypnum or sphagnum mosses, or of haircap moss (*Polytrichum*).

(4) Finally, still higher lie mountain tundras which contain moss, moss with lichen, and lichen growing among stones. Sometimes dryad (*Dryas octopetala*) grows here in great numbers. In some places there are alpine glades, on which European bistort (*Polygonum bistorta*),

[6] V. B. Sochava, "V istokakh rek Shchugora i Severnoy Sosvy" (In the Sources of the Shchugor and the Northern Sosva Rivers), *Izv. Geogr. obshch.* (Report of the Geographical Society), LXV, No. 6, 1933, pp. 565–583.



MAP 10. Vegetation of the central and southern Urals and the West Urals Foreland (I. M. Krasheninnikov, 1936).

false hellebore (*Veratrum lobelianum*), geranium (*Geranium albiflorum*), and grasses predominate.

In lat. 62° N, according to N. I. Kuznetsov (1887), the boundary of the forest consists of birch. Here, and somewhat south (in the upper course of the Lozva), the alpine zone begins at 730 m. and occupies the water-divide heights in an almost uninterrupted belt.

The Central Urals. On Konzhakovsk Kamen (south of lat. 60° N),[7] the alpine zone begins at 950 to 1000 m. There are very few mountain forms among the flowering plants of this zone. Arctic forms predominate, such as alpine meadow rue (*Thalictrum alpinum*), snowy buttercup (*Ranunculus nivalis*), and arctic diapensia (*Diapensia lapponica*). The dryad is common here also; however, it extends below the upper boundary of the forest as well. The upper boundary of the subalpine zone consists of stunted groves of spruce and fir. Below these stunted groves lies a narrow strip of birch groves (*Betula tortuosa*); the low birches, 5 to 6 m. tall, form coppices which alternate with meadows; here and there are found patches of larch forest. Still lower, at an elevation of about 800 m., lies a strip of stunted coniferous woods of spruce and fir, with an admixture of birch and occasionally of Siberian stone pine.

In the Central Urals the alpine zone is represented by islands on the summits of the high mountains; the rest of the range, foothills, and lowland are covered with a fir-spruce forest, with spruce predominating, and with an admixture of birch, aspen, and pine (Fig. 68). On the dry water-divide plateaus and on the summits of the slopes there grow green-moss spruce groves, which locally are called *parma.* After fires and felling, the coniferous forests are replaced by birch groves and aspen groves.

Beginning in the latitude of Sverdlovsk (56°50′ N, elevation 292 m.), the Ural range constitutes an island of forest rising amid forest steppe.

The South Urals.[8] As far south as lat. 52° N (that is, north of the latitude of Orenburg), the South Ural range is covered with forest, beginning at an elevation of 700 m. and rising up to 1600 m. South of lat.

[7] K. N. Igoshina, "Vysokogornaya rastitelnost Srednevo Urala" (The High-Mountain Vegetation of the Central Urals), *Zhurn. Russk. botan. obshch.* (Journal of the Russian Botanical Society), XVI, 1931, pp. 3–62.

[8] I. M. Krasheninnikov and M. M. Ilin, *Geobotanichesky ocherk gornoy chasti Sterlitamakskovo kantona Bashkirskoy resp.* (Geobotanical Sketch of the Mountainous Part of the Sterlitamak Canton of the Bashkir Republic), Leningrad, 1926, p. 56, Bashk. kom, zeml. (Bashkir Agricultural Committee); I. M. Krasheninnikov, *Iz istorii razvitiya landshaftov Yuzhnovo Urala* (The History of the Development of the Landscapes of the South Urals), Leningrad, 1927, p. 28, with a diagram, izd. Bashk. kom. zeml. (publication of the Bashkir Agricultural Committee).

52° N, however, forest steppe predominates on the South Urals. The highest peaks—Iremel, Zigalga, Yaman-Tau—are unforested.

In the South Urals fir-spruce forests appear only in the northern part; farther south, pine-larch forests predominate.

The vertical zonation of vegetation in the South Urals is as follows: The low foothills of the western slope are covered with broad-leaved forests, which grow on more or less degraded chernozems. Scotch-elm and linden forests predominate; sometimes the Scotch elm (*Ulmus scabra or U. montana* [*U. glabra*]) predominates; there is some maple; less frequently, Russian elm and oak; and occasionally, birch and aspen. The following plants are characteristic for the herbaceous cover of these relatively moist forests: male fern (*Dryopteris filix-mas*), sweet woodruff (*Asperula odorata*), European wild ginger (*Asarum europaeum*), Easter-bell starwort (*Stellaria holostea*), bishop's-goutweed (*Aegopodium podagraria*), and others. The soils of the high foothills (up to 1100 m. in elevation) are predominantly of a podzolic type; as Krasheninnikov points out, the valleys here, as a result of temperature inversion, have a more continental climate, and contain pine groves with birch, while the slopes, which have a milder climate, are covered with linden forests of the type described above. On the summits of the higher ranges (of the foothills) lie park-land pine and larch groves surrounded by glades.

The highest principal ranges of the South Urals are covered with pine-larch forests or fir-spruce taiga, in some places with an admixture of larch, pine, and birch, and a few specimens of broad-leaved species. There are occasional broad-leaved forests.

A few of the highest points of the South Urals rise above the limits of forest vegetation. Such is Iremel (elevation 1600 m.); here the subalpine zone is represented by park-land spruce groves, in which the spruce grows in scattered coppices amid tall meadow herbage.[9] At the upper boundary of its distribution, the spruce grows in stunted groves; occasionally among the spruces there are clumps of fir. The table-flat summit of Iremel is covered with spotty mountain "tundra," developed on areas thickly covered with rock fragments; clayey patches, barren of vegetation, occupy about a third of the surface.

The Ural-Tau water-divide range, only 950 m. in elevation, is covered with pine-larch forests, in which individual specimens of broad-leaved species are found.

[9] L. Tyulina, *Iz vysokogornoy oblasti Yuzhnovo Urala, Ocherki po fitosotsiologii i fitogeografii* (The High-Mountain Region of the Southern Urals, Sketches on Phytosociology and Phytogeography), izd. "Novaya Derevnya" (publication of "The New Village"), Moscow, 1929, pp. 345–359.

Larch extends south beyond the Belaya River almost as far as the Sakmara River (lat. 52° N).

The eastern slope of the Ural range, which faces Asia, is distinguished sharply from the western slope. On the eastern slope broad-leaved species are absent, and birch forest steppe, which is peculiar to western Siberia (see above, pp. 81–82), characterizes the landscape.

Fauna

The fauna of the Ural range is varied; tundra animals appear in the north, steppe animals in the south. In the taiga on the eastern slope of the Ural range, along the Lozva and beyond the Sosva, there is sable; it appears also on the western slope, in the upper course of the Shchugor. North of the Tagilsk Urals, the marten is of economic importance. A hundred years ago the red deer still ranged as far south as the upper reaches of the Sakmara River, that is, approximately as far as lat. 53° N. Today the reindeer ranges about to this same latitude; in winter it may be found occasionally in the pine groves. Other animals include the roebuck, elk, bear, squirrel, flying squirrel, chipmunk, capercaillie, black grouse, and hazel grouse.[10]

The roebuck is common in the South and Central Urals. In the Central Urals there is lynx, and in the northern part of the Central Urals, glutton. Bear and squirrel are numerous. Reindeer are raised only north of lat. 60° N in the Urals.

The birds include the Ural capercaillie (*Tetrao urogallus uralensis*), which inhabits the forests of the South Urals; in the Central Urals it is replaced by the common capercaillie (*T. urogallus*). The presence in the South Urals of the willow ptarmigan (*Lagopus lagopus*) is worth noting; this bird, like the Ural capercaillie, is native also to the pine-grove islands of southwestern Siberia. Pallas (1769) found this bird in the Guberlinsk Mountains.

Characteristic of the birch groves of the subalpine zone are accentors —the black-throated accentor (*Prunella atrogularis*) and the mountain accentor (*P. montanella*); the latter is native also to the Altay and the Tian Shan. In the same birch groves the willow ptarmigan (*Lagopus lagopus*) nests also.

The following birds are native to the alpine zone: the North Ural

[10] S. V. Kirikov, "Ekologiya fauny pozvonochnykh Preduralya i Zauralya na yikh yuzhnoy razgranichitelnoy linii" (Ecology of the Vertebrate Fauna of the West Urals Foreland and the Trans-Urals along Their Southern Line of Demarcation), *Zool. zhurn.* (Zoological Journal), XIV, 1935; XV, 1936.

tundra ptarmigan (*Lagopus mutus komensis*), the Lapland longspur (*Calcarius lapponicus*), and the golden plover (*Pluvialis apricarius*)—all typical representatives of the tundra.[11]

In the spruce and Siberian-stone-pine forests of the North Urals, Siberian passerines are common: the bluetail (*Janthia cyanura* [*Tarsiger cyanurus*], of the thrush family), Eversmann's warbler (*Phylloscopus borealis*), and the black-throated thrush (*Turdus atrogularis*). The capercaillie also is native to these forests.

The Siberian four-toed salamander (*Hynobius keyserlingi*) inhabits the vicinity of Sverdlovsk; it extends as far north as lat. 60° N.

The following salmonids are characteristic among the fish of the Ural range: the grayling; brown trout (*Hucho taimen*), native to the basins of the Kama and the Ural, and also the Ob; the Siberian whitefish (*Stenodus leucichthys*), which comes up from the Caspian Sea to the basin of the Ufa River (on the eastern slope, a closely related form, the *nelma* [*S. leucichthys nelma*], is represented); in the upper course of the Pechora, the true or Atlantic salmon (*Salmo salar*) is found; at one time numerous Caspian brown trout (S. *trutta caspius*) used to enter the Kama from the Caspian Sea, but today they are found only very seldom in the Ufa basin. A coregonid, the *sig*, breeds in Lake Turgoyak.

It was formerly believed that the Ural range constituted a sharp zoogeographical and phytogeographical boundary. More detailed investigations have shown that this is not the case. Nevertheless, it must be noted that there is indeed a whole series of species which do not cross the Urals. Thus, a number of Siberian birds, which inhabit the North Urals, are distributed no farther west than the Ural range; these include, for example, the black-throated thrush (*Turdus atrogularis*), the pin-tailed snipe (*Capella stenura*), some accentors, and others.[12] Of the fish, the minnows [*Leuciscus cephalus* and *Aspius aspius*], roach, catfish, pikeperch, and many others are not found east of the Ural range.

[11] L. A. Portenko, *Fauna ptits vnepolyarnoy chasti Severnovo Urala* (Bird Fauna of the Nonpolar Part of the North Urals), Leningrad, 1937, izd. Akad. nauk (publication of the Academy of Sciences).

[12] *Ibid.*

XIII · The Altay

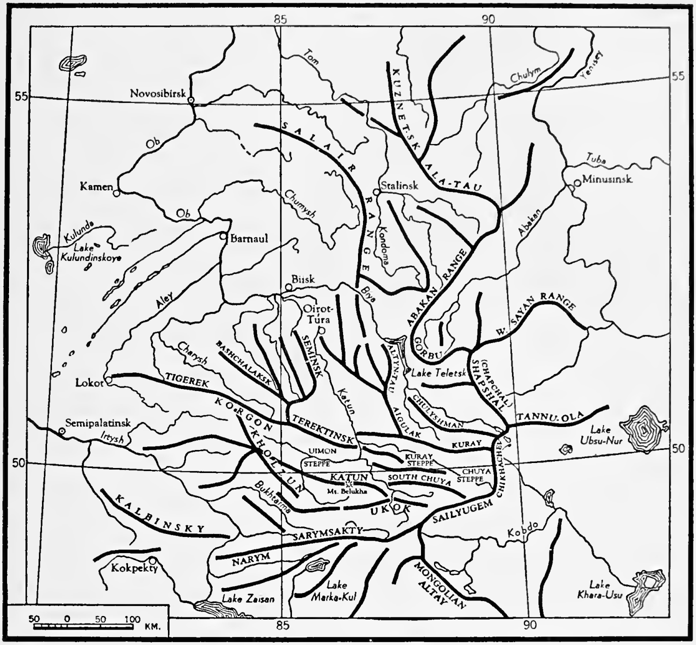
Relief

THE mountain system of the Altay may be divided provisionally into four main water-divide ranges: (1) the South Altay, (2) the Inner Altay, (3) the East Altay, and (4) the Mongolian Altay. The last, which lies between the Black Irtysh and Kobdo rivers, falls within Mongolia. On the north the Altay is separated from the Biya steppe by a declivity several hundred meters in elevation. This boundary has a tectonic significance (see below).

(1) The *South,* or *Great Altay,* the western end of which is called the Narym range, separates the waters of the Black Irtysh and Lake Zaisan from the Bukhtarma River system; it branches off from the Tabyn-Bogdo-Ola massif, which reaches an elevation of 4500 m. in Kiityn peak. The highest point of the South Altay, Mount Kirey, has an elevation of 3790 m. The Ukok Plateau, which lies at an elevation of 2200 to 2300 m., adjoins the Tabyn-Bogdo-Ola massif. The elevation of the Narym range drops from 3200 to 3000 m. in the east, to 1500 to 1200 m. in the west. On the southern slope lies Lake Marka-Kul, 27 m. deep; its elevation is 1484 m.

(2) The *Inner Altay.* The highest ranges of the Inner Altay are the Katun *belki* (snow-capped mountains) and their direct continuation to the east, the Chuya *belki;* they are separated by the Argut River (a right tributary of the Katun). The mean elevation of the Katun *belki* is about 3000 m.; they are covered throughout by everlasting snows (Fig. 69); almost in the middle of the range lies its highest point (and that of the entire Russian Altay), Mount Belukha, 4540 m. in elevation (Fig. 70). The transverse valley of the Katun River (Fig. 71) separates the western end of the Katun *belki* from the Kholzun range, which serves as the divide between the Bukhtarma and the Katun basin; the Kholzun range reaches elevations of 2200 to 2400 m.

(3) The *East Altay* is composed of a system of ranges which lie on the water divide between the Ob and the Yenisey river systems. It begins in the south with the Sailyugem range, which lies on the boundary with China (Mongolia) and serves as the water divide between the river sys-



MAP 11. Altay ranges.

tems of the Ob (Argut, Chuya, Bashkaus, Chulyshman) and the Kobdo. The Sailyugem range, like the South Altay, originates in the Kiityn massif, and its highest elevation exceeds 3600 m. Shapshal (Chapchal) Pass, 3177 m. in elevation, near the peak of the same name, may be regarded as the northern end of this range.[1] The Gorbu range, which lies along the eastern shore of picturesque and deep Lake Teletsk (elevation about

[1] V. Obruchev (1915, p. 36) proposes that the name Sailyugem be retained for the southern part of the range, which extends latitudinally, and that the range from Tashanty Pass to the plateau of Lake Dzhuvlu-Kul be called the Chikhachev range.

450 m.; depth, 325 m.),[2] belongs to the Sailyugem system. On maps, mountains which reach 2438 m. in the south usually appear to the northeast of Lake Teletsk, along the left bank of the Abakan River. However, the most recent investigations of Bazhenov (1930) show that no independent range does exist here. Actually, situated along the upper course of the Abakan River, these mountains constitute a connection between the southern end of the Kuznetsk Ala-Tau, on the one hand, and the western end of the West Sayans, on the other.

The Altay is composed of Cambrian rocks and metamorphic schists of the Cambrian-Silurian, Silurian, and Devonian periods. Marine Lower Carboniferous deposits are found only in the southwestern, or so-called Rudny (Ore) Altay, which borders upon the Irtysh. There are extensive intrusions of granite. Following the Lower Carboniferous in the Rudny Altay, and the Upper Devonian (and in some places the Middle Devonian) in the remaining Altay, a continental period set in.[3] Metamorphic schists, predominantly green and intensely dislocated, occupy tremendous areas in the Altay proper (that is, not in the Rudny Altay). The principal ranges of the Altay (the Katun, Chuya, and others) are composed of these rocks. The metamorphic series of the Altay apparently belongs to the Lower Silurian.

The Altay is a mountain system in which folding took place during two different epochs: the Rudny Altay, and also the Kalbinsky range and the Tarbagatay, were formed by folding which took place during the Upper Paleozoic (Variscan) period, while the Altay proper was subjected to the most intense folding during the Lower Paleozoic (Caledonian) period. Folding in the Rudny Altay ended presumably at the end of the Paleozoic and the beginning of the Mesozoic; the orientation of this folding is northwest. It was accompanied by two large faults which are also oriented northwest; these faults form the boundaries of the Rudny Altay.

The long duration of the continental period which existed throughout the Altay following the Lower Carboniferous (and in many places from

[2] Concerning Lake Teletsk, see *Issledovaniya ozer S.S.S.R.* (Survey of the Lakes of the U.S.S.R.), izd. Gidrol. inst. (publication of the Hydrological Institute), No. 3, 1933, with a map of the lake, No. 7, 1934.

[3] V. P. Nekhoroshev, "Materialy dlya geologii Gornovo Altaya" (Materials on the Geology of Mountain Altay), *Trudy Geol. razved. Obyed.* (Proceedings of the Geological Survey Society), No. 177, 1932, p. 111, with a map. "Geologichesky ocherk Altaya" (Geological Sketch of the Altay), *Ocherki po geologii Sibiri* (Sketches on the Geology of Siberia), izd. Akad. nauk (publication of the Academy of Sciences), 1932, p. 46, with a map, bibliography.

an even earlier date), led to the peneplanation of the Altay, which did not exist as a mountain system during the Tertiary period. At the end of the Tertiary and the beginning of the Quaternary, extensive faulting took place, forming the Altay as it exists today (Nekhoroshev, 1932). This faulting broke the foundations of the ancient Altay once more, but this time in new directions. The Altay became a mountain country again, but now it was composed of ranges in the form of plateaus of varying elevation. The disruptive tectonic lines which created the present Altay have, in general, an east-west orientation (on Lake Teletsk, also north-south). The tectonic line which forms the northern boundary of the Altay in the Ob steppe south of Biisk, is very distinct; this line, which appears in sharp relief, is marked by the presence of the Belokurikhinsk hot springs. Nekhoroshev is inclined to attribute the formation of this line, and also of Lake Teletsk, to disruptive dislocations which took place during the interglacial period.

In the contemporary relief of the Altay, the predominance of more or less wide plateaus, sometimes half worn away by erosion, is characteristic. But the previously existing flat surfaces of the plateaus may be discerned even in the highest and narrowest surfaces, those most intensely dissected by erosion (such as the Katun and South-Chuya and North-Chuya *belki*). Many of these watershed plateaus are so flat that bogs appear on their surfaces. From such watersheds the streams drain at first with a barely perceptible gradient; then, as they draw farther away from the water divides, the flow becomes more rapid, and the rivers cut deep gorges; near the points where the streams empty into the main rivers, they flow along narrow gorges, or precipitate themselves over waterfalls. Sometimes the difference between the purely erosional valleys and the valleys which lie in grabens is very sharp. The latter are wide and sometimes have a rather dry climate (for example, the Kan "steppe," the Chuya "steppe," and others). Most erosional valleys, on the other hand, are narrow, sometimes having the appearance of gorges, such, for example, as the completely impassable gorge of the lower Argut. The Katun *belki* drop steeply to the valley of the middle Katun River. The ascent along the gorges of the lateral ranges leads to a high, rolling plateau, 1800 to 2500 m. in elevation. The eastern part of this range (or the South-Chuya range), viewed from the north, from the Chuya steppe (elevation 1700 m.), reveals even more sharply the characteristics of a plateau. We see before us a level or gently rolling plateau, dissected by several river valleys, and reaching 2400 to 2600 m. in elevation; peaks (Iiktu and others), which lie in a straight line and reach 3000 to 4200 m. in elevation, rise above the plateau. Apparently, states Obruchev,[4] this was formerly a higher surface, such as is found in the Katun *belki;* it is now much worn down by erosion.

Deep in the mountains lie the famous Rakhmanovsk hot springs. They are situated on the southern slope of the Katun *belki,* in the basin of the Bukhtarma, at an elevation of 1725 m. Their temperature is about 40° C. (Fig. 72).

The snow line in the South Altay lies at an elevation of 2600 to 3000 m.; in the dry East Altay, at 3000 m. In the Katun and Chuya *belki,* on the southern side of the main chain, it lies at 2600 to 3000 m.; on the northern side, at 2400 to 2600 m.

The most intense contemporary glaciation of the Central Altay is found in the Katun and Chuya *belki.* Six large glaciers descend from Belukha (Fig. 70); of these the Berelsk, 8.5 km. long, reaches down to an elevation of 1950 m. In the South Altay, according to Reznichenko, there are about a hundred glaciers, chiefly of the cirque type; the longest, Bas-Bukhtarminsk, from which the Bukhtarma River takes its source, is 6 km. in length and descends to an elevation of 2450 m. The total area of glaciation in the Russian Altay is only 450 sq. km., a much smaller area than in the Tian Shan. But in the Tabyn-Bogdo-Ola massif, on the side which faces Mongolia, Sapozhnikov discovered extensive glaciation; one glacier, the Potanin, is 20 km. long.

During the glacial period the glaciers reached their greatest development in the same places as they do today. The Altay was subjected to at least two glaciations, of which the first was the more intense. At that time the glaciers descended far down along the valleys, as far as the country at the foot of the Altay. The ancient Bukhtarma glacier reached 150 km. in length, and descended to an elevation of 730 m. The Ukok Plateau at one time was covered by a continuous ice sheet.

In the Rudny Altay there are many polymetallic deposits, which contain zinc, lead, copper, silver, and gold.

Climate

In the Altay dry south and southwest winds prevail in winter, moist northwest and west winds in summer. For this reason the maximum precipitation in the Altay comes in summer, in July and August. (In some places a secondary maximum is observed in the latter half of

[4] V. A. Obruchev, "Altaiskie etyudy, II" (Studies on the Altay, II), *Zemlevedenie* (Agriculture), 1915, Bk. 3.

autumn.) The greatest annual precipitation recorded at average elevations in the Altay is about 1000 mm.[5] The western Altay has relatively abundant precipitation, more than 500 mm. per year at Zmeinogorsk, but its western outskirts are subject to the drying influence of the surrounding steppes, and have less than 400 mm. at Loktevskoye. The fault basins of the central Altay, such as the Uimonsk (on the Katun) and Chuya steppes, are distinguished by extreme dryness. The southern Altay is also dry; Altaiskaya stanitsa, which lies at an elevation of 1000 m., receives only 378 mm. of precipitation per year; the Ukok Plateau (elevation 2400 m.), only 280 mm. On the plateau there are found traces of ancient irrigation canals.

The high steppe plateaus surrounded by mountains undergo very low temperatures in winter. Thus, in the Chuya steppe (at Kosh-Agach, elevation 1700 m.) temperatures as low as − 48° C. are recorded, while the mean January temperature is − 31° C. The snow cover here is very thin, reaching only 7 cm.; as a result, permanent ground frost appears even at a depth of 1 m. Winter temperature inversion is widespread in the Altay; at the Zyryanovsk mine in the Bukhtarma basin (elevation 450 m., lat. 49¾° N) the mean February temperature is − 22.3° C., while in Altaiskaya stanitsa, which lies 550 m. higher, February is almost 10° C. warmer (− 12.5° C.). One explanation for this condition is that the cold waves which invade from the north do not penetrate beyond the outskirts of the mountains. The Altay in winter constitutes a kind of warm island between the cold regions of Siberia and Central Asia. Cloudiness in the Altay is greatest in autumn, least at the end of winter and the beginning of spring.

Soils

As one ascends into the mountains from the lowlands between Barnaul and Semipalatinsk, the following soils appear in succession: chernozems, rich chernozems, gray forest soils, podzolic soils, and, finally, mountain-meadow soils. Ascending from the Zaisan basin, light-chestnut soils appear first; somewhat higher, stony dark-chestnut soils; then mountain chernozems; still higher, podzolic soils; and, finally, mountain-meadow soils. On the north and northwest the Altay is bordered by degraded chernozems. In the southern Altay, south of lat. 44° N, there are

[5] There is evidence that in the mountains in the region of the Ridder mine, at an elevation of about 2000 m., the annual precipitation is greater than 2000 mm., while in the valley of the Ulba River (a tributary of the Irtysh at Ustkamennogorsk), at an elevation of 600 m., the annual precipitation is only 600 to 800 mm.

chestnut soils in the lower zone (for example, at Onguday on the Ursula, a tributary of the Katun); often they are slightly solonized. Along the Bukhtarma and the Naryn, chernozems and chernozemlike soils are developed. North of lat. 51° N, chernozemlike, or, more exactly, meadow-steppe soils, are widespread. Under the forests are found podzolic soils and degraded clay loams. At the upper limit of vegetation lies mountain tundra—tundra which contains lichen, moss, or lichen among stones, and which is studded profusely with dryad.

Vegetation

"In the Altay," states Sapozhnikov,[6] "we find typical steppes, often rising to a considerable elevation; expanses of taiga, peculiar to a more northern section of Siberia; light larch forest; and, finally, vast alpine meadows, similar to the meadows of the Caucasus and Switzerland, with a slight suggestion of tundra." As distinguished from the Caucasus and the Tian Shan, broad-leaved species are absent in the Altay. Linden is found only in the Kuznetsk Ala-Tau.

In the Altay the following vertical zones may be distinguished:

Steppes adjoin the Altay to the northwest, west, and south. They are perfectly suitable for agriculture, which extends up into the mountains somewhat above 1000 m. Along the borders of the mountains the steppe reaches up to elevations of 350 to 600 m., where it is replaced by forest. Prominent in the steppes of the foothills, in addition to grasses, are shrubs: spiraea, honeysuckle, sweetbrier rose, pea shrub [*Caragana* sp.], and Russian almond (*Amygdalus nana*). Closer to the mountains the vegetation takes on a meadow character.

A somewhat different type of mountain steppe is developed, often at elevations of 1000 meters and more, along the broad, open valleys. The high steppes of the eastern Altay (the Chuya steppe, at an elevation of 1700 to 1800 m., and the Kuray steppe, which lies along the course of the Chuya River below the Chuya steppe, at an elevation of 1500 m.) are more like the stony steppes of neighboring Mongolia. Astragali (*Astragalus brevifolius* and *A. dilutus*) and other stunted legumes, grasses, *polyns*, and halophytes are particularly characteristic for these steppes. On the Ukok Plateau (elevation 2400 m.), where skeletal chestnut soils are developed, the vegetation cover consists of *polyns* and cinquefoil (*Potentilla*), crested wheat grass (*Agropyron cristatum*), and others, while closer to the mountains, side by side with steppe plants, there

[6] V. V. Sapozhnikov, *Katun i yeyo istoki* (The Katun and Its Sources), Tomsk, 1901.

appear alpine plants: common edelweiss (*Leontopodium alpinum*),[7] alpine poppy (*Papaver alpinum*), and others. Several glaciers descend to the plateau along its border; the glaciers end at 2500 to 2600 m., appearing in close proximity to the dry steppe.

The *forest zone* of the Altay on the side of the western and southern steppes begins at an elevation of 350 m. In the northeast, however, beyond the Kuznetsk *chern* (fir forests), the forest zone adjoins the Siberian taiga. The upper boundary of this zone lies at 2000 to 2400 m. Deciduous species (birch, aspen, mountain ash, and bird cherry) are of secondary importance. The conifers in the Altay include Siberian larch, which appears as the predominant species; Siberian stone pine, fir, and spruce. Pine appears up to an elevation of 700 m.; in the mountains it does not form the pure stands which are characteristic of this tree. Usually it grows here in admixture with birch, aspen, and, higher up, with larch. In this pine zone there appears one mountain shrub—the Dahurian rhododendron (*Rhododendron dauricum*), a very beautiful plant with a multitude of pink-violet flowers. Sometimes it grows quite tall; thus, on the shore of Lake Teletsk, Sapozhnikov saw Dahurian rhododendrons up to 4 m. tall, with stems as thick as a man's hand. This shrub grows at elevations up to 1800 m. The herbaceous vegetation in the pine zone is like that in the forest glades of the Siberian taiga: anemone (*Anemone altaica* and *A. caerulea* [*A. nemorosa caerulea*]), spreading pasqueflower (*Pulsatilla patens* [*A. patens*]), peony (*Paeonia anomala*), lily (*Lilium martagon*), iris (*Iris ruthenica*), and others.

Larch begins to appear before the upper boundary of pine is reached, above 700 m.; it grows in pure stands (Fig. 73). This most characteristic tree in the mountain forest of the Altay, prefers not too steep, moderately moist slopes in the open valleys. In the open country which is referred to as steppe, the larch settles only along the mountain slopes and in narrow belts along the rivers. It grows up to an elevation of 2000 m. and higher, and often forms the upper limit of the forest.

The north-facing slopes are much more extensively forested than those which face south; all the valleys of the Katun *belki* which face north are heavily forested, while on the south-facing slopes there are coppices only in the shadier places. Among other factors which bring about this condition are the prevailing south and southwest winds: "In addition to their drying effect, they also promote the accumulation of winter snows on the northern side, which is protected from winds"

[7] However, in the Alps the edelweiss is not associated exclusively with the alpine zone.

(Sapozhnikov). On the south-facing slopes even when tree vegetation does appear, it is represented by the less hydrophytic larches.

"The mountain larch forest characteristically seldom forms dense thickets; more often it resembles a light park with glades, usually filled with shrubs and herbaceous plants" (Sapozhnikov). Of the shrubs in the larch forest, various species of spiraea (*Spiraea*) form dense, almost impassable thickets; they grow in admixture with raspberry, elder, European cranberry-bush viburnum, sweetbrier rose, honeysuckle, currant, hawthorn, barberry, and pea shrub [*Caragana* sp.]. "The forest glades among the larches are richly covered with meadows which contain bright flowers; *Iris ruthenica* blooms here in such numbers that the air is saturated with the odor of violets; gold-beard iris (*I. flavissima*) is found less frequently; globeflowers (*Trollius asiaticus* and *T. altaicus*), which replace the golden-yellow adonis (*Adonis sibiricus*), produce red blooms everywhere; whole glades of forget-me-nots (*Myosotis sylvatica*), yellow pea vine (*Orobus luteus* [*Lathyrus luteus*]), blue gentian, and a great many others add their colors to this carpet. And the trees are twined with alpine clematis (*Atragene sibirica* [*Clematis alpina sibirica*]), with its pendant masses of white flowers" (Sapozhnikov).

In the narrower and more moist valleys, larch grows in admixture with *chern* species (Siberian stone pine, fir, and spruce). Here herbaceous plants reach gigantic dimensions, forming a tall stand which in some places rises as high as the head of a man on horseback. Here are found the enormous Japanese bee larkspur (*Delphinium elatum*), monkshood (*Aconitum excelsum* and *A. krylovii*), burnet (*Sanguisorba alpina*), fireweed (*Epilobium angustifolium, Ptarmica alpina*), pedicularis (*Pedicularis proboscidea*), two large umbellifers (*Bupleurum aureum, Archangelica decurrens* [*Angelica*]), and others. At an elevation of 1400 m. birch disappears; higher up, aspen; still higher, about a hundred meters below the timber line, fir and spruce. The upper limit of the forest on the wetter slopes consists of Siberian stone pine; on the drier slopes, of larch. In the Chuya *belki* this boundary reaches elevations of 2200 to 2465 m.

The upper limit of the forest lies at a somewhat higher elevation as one moves from north to south and from west to east. In the west it reaches 2000 m.; in the east, 2400 m. Forest grows reluctantly on the high plateaus. Thus, the Ukok Plateau (elevation 2400 m.) is unforested, while in the adjoining valleys there is forest at elevations 100 to 180 m. higher. The explanation lies in the cold and almost snowless winters on the plateaus. The transitional zone between the forest and the alpine meadows is occupied by a belt of stunted shrubs; it consists of dwarf arctic birch (*Betula nana*) and various dwarf willows. The dwarf arctic birch, which usually grows half as tall as a man, is very characteristic for the Altay. In addition there are cotoneaster (*Cotoneaster uniflora*), honeysuckle (*Lonicera hispida*) with bright red berries, currant (*Ribes fragrans var. infracanum*) with brownish-black berries and strongly scented leaves, black crowberry, and juniper.

From 2000 to 2400 m. to 2800 to 3000 m. lies the *region of alpine meadows,* variegated by a mass of flowers. Here there is an abundance of Altay columbine (*Aquilegia glandulosa*); Altay violet (*Viola altaica*), with large yellow and blue flowers of different shades; white narcissus anemone (*Anemone narcissiflora*) and white *Callianthemum rutaefolium* (also of the buttercup family); pink and yellow pedicularis; blue gentian; and golden-yellow buttercup (*Ranunculus altaicus*), which raises its stems from under the snow.

The alpine meadows, as they ascend, tend to resemble the alpine tundra. In the Terektin range (which reaches as far as the left bank of the Katun), lichens predominate at elevations of 2000 to 2500 m. There are thickets of shrub ground birch (*Betula rotundifolia*) and dryad. Under the small birches, mosses prevail. In the vicinity of the snowy patches there are herbaceous glades, which merge in some places into bogs with peat mosses, sheathed cotton sedge, and sedges.

Fauna

Judging by its fauna, the southeastern Altay (the Ukok Plateau, Chuya steppe, Chulyshman Plateau) is a continuation of northwestern Mongolia. The northeastern Altay (the basin of the Abakan and to some extent Lake Teletsk) is inhabited by fauna of the East Siberian taiga.

The mammals include the bear; sable; Trans-Baikal polecat [*Putorius eversmanni michnoi*]; badger; lynx; along the Argut and the Chuya, snow leopard (*Leopardus uncia* [*Felis uncia*]); northern dhole; Mongolian seren (*Gazella gutturosa* [*G.* (*Procapra*) *gutturosa*]); in the Chuya steppe, ibex (Fig. 74); in the Chuya *belki*, along the Chuya River, in the Chuya steppe, and along the upper Chulyshman, mountain sheep (*Ovis ammon*); red deer (*Cervus elaphus canadensis n. sibiricus* [*C. elaphus sibiricus*]); occasionally, reindeer; musk deer; alpine and Mongolian mouse hare (*Ochotona alpina, O. pricei* [*O. pallasii pricei*]); varying hare; on the Chuya steppe, Altay and Tian Shan bobac and Mongolian bobac (*Marmota baibacina* and *M. sibirica*); suslik (*Citellus eversmanni*); Altay mole; and others.

The birds include the Altay snow pheasant (*Tetraogallus altaicus*);

grouse—the willow ptarmigan (*Lagopus lagopus*), tundra ptarmigan (*L. mutus rupestris*), European partridge (*Perdix perdix*), and bearded partridge (*P. daurica* [*P. barbata*]); in the Chuya steppe, the Chinese goose (*Cygnopsis cygnoides*) and Indian goose (*Eulabeia indica* [*Eulabes indica*]); black grouse; capercaillie; Swinhoe's snipe (*Capella megala*); pin-tailed snipe (*C. stenura*); solitary snipe (*C. solitaria*); the common daw (northwestern Altay) and Dahurian jackdaw (*Colaeus dahuricus*, Chuya steppe); Siberian jay (*Perisoreus infaustus*); nutcracker (*Nucifraga caryocatactes macrorhynca*), which feeds on the seeds of the Siberian stone pine and spruce; chough (*Pyrrhocorax pyrrhocorax*); alpine chough (*P. graculus*); Altay finch (*Fringillauda altaica*); and the black-throated and redheaded thrushes.

Among the birds as among the mammals, there are Mongolian elements. Thus, the Chuya steppe contains the Mongolian brambling (*Montifringilla davidiana potanini*), wheatear (*Saxicola insignis*), Mongolian rock sparrow (*Petronia petronia mongolica*), and others.

As for the fish, the mountain streams abound in salmonids: brown trout (*Hucho taimen*); *lenok* trout, or *uskuch* (*Brachymystax lenok*); arctic grayling (*Thymallus arcticus*); and, in the Chuya, the Mongolian cyprinid, *osman* (*Oreoleuciscus*). In Lake Teletsk a fish of economic importance is the *sig* (a form of *Coregonus lavaretus*), there mistakenly called herring.

Kuznetsk Ala-Tau

In all likelihood the Kuznetsk Ala-Tau is the northern continuation of the Gorbu range. It extends from NW to SE, and is bordered on the east by the Minusinsk basin, and on the west by the Kuznetsk coal-bearing basin, noted for its huge reserves of coal. The central, highest part of the Kuznetsk Ala-Tau reaches absolute elevations of 1000 to 2100 m. Along the line of the Siberian railroad, the Kuznetsk Ala-Tau merges gradually into rolling plains. The range is not a single mountain chain with clearly defined orientation, but "consists of irregular remnant massifs ('horsts') of ancient folded mountain systems, bordered on all sides by large faults."[8] On the east the outlying spurs of the Kuznetsk Ala-Tau are rooted deep in the Minusinsk basin.

The Kuznetsk Ala-Tau is composed of a thick series of crystalline limestones, chiefly of the Cambrian period, overlain by a series of green-

[8] Ya. S. Edelstein, "Gidrogeologichesky ocherk Minusinskovo kraya" (Hydrogeological Sketch of Minusinsk *Kray*), *Trudy Geol.-razved. obyed.* (Proceedings of the Geological Survey Society), No. 145, 1931.

ish or greenish-gray sandstones, shales, limestones, and tuffs, no younger than Lower Silurian. Both these series, which underwent powerful folding during the Lower Paleozoic (Caledonian) period, are cut by volcanic intrusives. The above-mentioned strata are overlain unconformably by Devonian strata (Edelstein).

The present configuration of the Kuznetsk Ala-Tau is not related at all to the bearing of the Paleozoic folds. The Kuznetsk Ala-Tau owes its present form to dislocations caused by faulting. Today there are no glaciers in the Kuznetsk Ala-Tau, but the southern mountain summits are covered with snow almost throughout the summer. During the glacial period there were many glaciers here.

As for the vegetative cover of the Kuznetsk Ala-Tau, the following zones may be distinguished: [9] (1) mountain-fir and Siberian-stone-pine and spruce taiga in the north, (2) mixed fir and aspen forests in the south, and (3) an alpine region of bald summits. In the taiga region there is a strongly developed moss cover, which is absent or poorly represented in the fir-aspen forests. In the latter, on burned-over sites, tall herbaceous meadows develop. In some places in the region of fir-aspen forests, entire slopes are occupied by lindens, which reach great dimensions. The herbaceous cover of these linden forests contains many relict forms; some of these are peculiar to the broad-leaved forests of Europe, while others are found in similar forests in the Far East. The linden forests of the Kuznetsk Ala-Tau are regarded as relicts of the Upper Tertiary or interglacial periods.

The Kuznetsk basin lies between the Kuznetsk Ala-Tau and the Salair ridge (elevation 600 m.). Throughout the entire length of the basin flows the Tom River, which together with its tributaries gives the basin a well developed river network. Although the basin has an undulating relief, the local differences in elevation between the river bottoms and the interfluves between them seldom exceed 100 m. The formation of the Kuznetsk basin is related to the formation of the mountain ranges along its edges during the Lower Paleozoic period; folding in these ridges was accompanied by a simultaneous subsidence of the area which lay between them. At the beginning of the Devonian, both the Kuznetsk Ala-Tau and the Salair existed in the form of islands and peninsulas in the vast Ural-Siberian sea. Along the edges of this sea volcanic eruptions took place. From the Lower Carboniferous on, the connection between the Kuznetsk basin and the open sea became weaker, and the basin

[9] V. V. Reverdatto, *Trudy Obshchestva izucheniya Tomskovo kraya* (Proceedings of the Society for the Study of Tomsk *Kray*), I, 1927.

changed gradually into a lake. Conditions on the shores of this lake became favorable for the development of a sumptuous vegetation. Enormous waterlogged forests of arborescent ferns—*Sigillaria, Lepidodendron, Calamites, Araucarites,* and others—grew here; these forests provided the material for the formation of thick deposits of coal. In the south, in the basin of the Telbes River lies the Telbes iron-ore region.[10]

Both the interstream areas and the ancient river terraces of the Kuznetsk basin are covered in many places by material which has the characteristics of loesslike clay loams. At a depth of 80 to 100 cm. from the surface these clay loams become calcareous. On these materials are developed more or less typical chernozems, degraded chernozems, and forest soils. Near the mountains the soils merge into podzolic soils. In vegetation the Kuznetsk basin is birch forest steppe, although at present few forests remain. Mixed-herbaceous meadow steppe predominates.

[10] V. I. Yavorsky and P. I. Butov, "Kuznetsky kamennougolny bassein" (The Kuznetsk Coal Basin), *Trudy* (Proceedings), Geol. kom. (Geological Committee), No. 177, 1927, p. 222, with map.

XIV · The Sayans

THE Sayan system forms a rough arc, convex on the north. On the west it borders on the Altay, while on the east, between the southern end of Lake Baikal and Lake Kosogol in Mongolia, it adjoins the Khamar-Daban system of the Trans-Baikal region.

Relief

The Sayan Mountains are divided into the western and eastern ranges. As we shall see, at one time a distinct geological history was attributed to each. The West and East Sayans meet in the mountain knot which lies at the northernmost point of the above-mentioned arc; here, in long. 96° E, lie the sources of the Kazyr River, which flows west and is part of the Yenisey basin, and the Uda River, which is part of the upper Tunguska basin and flows in the opposite direction. At the point where the West and East Sayans meet, the elevations reach 3000 m. The West Sayan ranges lie SW–NE and WSW–ENE, the East Sayan ranges, SE–NW.

The *West Sayans*[1] begin east of Lake Teletsk, at the sources of the Bolshoy Abakan (a left tributary of the Yenisey), where the Sayans join the Altay. From here the main Sayan range extends northeast toward the Bolshoy rapids of the Yenisey, which lie between the mouths of the Kemchik and the Kantigir (left tributaries of the Yenisey). Almost throughout its entire extent the main Sayan range is composed of granite. In the western, or Abakan section, individual peaks reach 2800 to 2900 m. in elevation, extending above the limits of tree growth. East of the Yenisey the main range has not been investigated thoroughly. In the basin of the upper Us River (a right tributary of the Yenisey) the

[1] I. K. Bazhenov, "Zapadny Sayan" (The West Sayans), *Ocherki po geologii Sibiri* (Sketches on the Geology of Siberia), izd. Akad. nauk (publication of the Academy of Sciences), 1934, p. 137, with map, bibliography.

range is called the Yergaki; farther up, as far as the upper reaches of the Kazyr River, it is called the Yergak-Targok-Taiga. East of the Yenisey the range decreases in elevation, descending generally to 1800 to 1600 m., in some places below the timber line; but in other places it reaches 2100 m. (in the Yergaki range). A series of ranges which run almost north and south branch from the western part of the main range to the north; these ranges are not very long, but sometimes reach a considerable elevation (2920 m.), no lower than the main range.

At one time the axial (main) range of the West Sayans was considered the range which lies along the boundary of the Tuva People's Republic, that is, the Sabinsky range, across which lies the border pass of Shabin-Daban (elevation 2060 m.). The Sabinsky range lies north of the Sayan range, along the left side of the upper Kantigir (a left tributary of the Yenisey). According to Bazhenov, the Sabinsky range is part of the Dzhebash range, which extends from the upper reaches of the streams of the basin of the Dzhebash River (a right tributary of the Abakan), northeast toward the Yenisey, but not reaching as far as the Yenisey. The main Sayan range has been drawn also along the Kemchik range, which branches from the Sayan range proper and extends southeast to the Yenisey, crossing it at the natural boundary of the Kemchik-Bom. Beyond the Yenisey, to the east, the Kemchik range is called the Kurtushibinsk range; this frontier range, formerly regarded as the main Sayan range, adjoins the Yergak-Targok-Taiga range in the upper reaches of the Us River, and here reaches 2100 m. in elevation. Much is still obscure regarding the orography of the West Sayans.

The crest of the Sayans usually does not have the form of a ridge. Seen from an elevation, it appears to be a dissected plateau from which there usually protrude rounded, domelike, bald summits, that is, summits which rise above the timber line (Fig. 75).[2] Postoyev states (1932), describing the western end of the West Sayans,

> In some places, when the river valleys are out of sight, one seems to be in a rather gently rolling country, and only when one stands before a deep valley gorge does one get a conception of the degree to which the relief is dissected. This impression is promoted by the remains of the old peneplain in the form of flat, plateaulike areas, which lie at an elevation of about 2000 m.

All of these features suggest that the Sayans were formed on the site of a peneplain, which subsequently was lifted to a considerable elevation by mountain-forming processes. At present this peneplain has been

[2] But where the bare summits and ranges are cut by cirques, they have pointed peaks and ridges.

Fig. 62. Harvesting grapes on the southern slopes of the Yaila near Alushta. (Sovfoto)

Fig. 63. Juniper (*Juniperus excelsa*) on the south coast of the Crimea. (*Vegetationsbilder*. Vol. 17; part 1; plate 1)

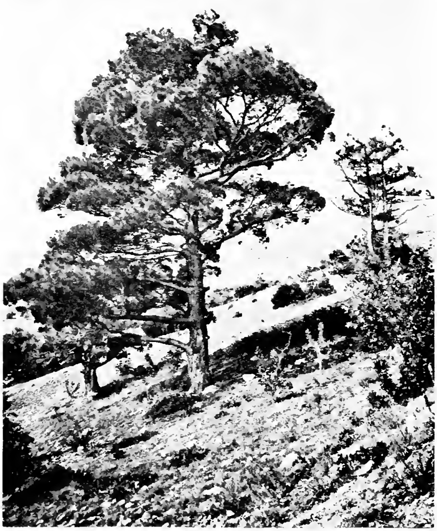


Fig. 64. Crimean form of the Aleppo pine (*Pinus pityusa stankewitschi* [*P. halepensis pityusa stankewitschi*]) and juniper (*Juniperus excelsa*) on the south coast of the Crimea at Sudak. (*Vegetationsbilder*. Vol. 17; part 1; plate 3)

Fig. 65. Crimean pine (*Pinus laricio pallasiana* [*P. nigra poiretiana*]) on the southern slopes of the Yaila. (*Vegetationsbilder*. Vol. 17; part 1; plate 2)

Fig. 66. Beech forest on the northern slope of the Yaila. (*Vegetationsbilder*. Vol. 17; part 1; plate 3)

Fig. 67. The Northern Urals. Subalpine landscape on Mt. Sablya. (*Vegetationsbilder*. Vol. 5; part 3; plate 21)

Fig. 68. Coniferous forest on the slopes of Mt. Kvasya in Sverdlovsk *oblast.* (*Sovfoto*)

Fig. 69. The Inner Altay. Lake Verkhne-Multinsk and the Katun *belki* (snow-capped mountains). (Sovetskaya Sibirskaya Entsiklopedia. Vol. 1: 63)

Fig. 70. Mt. Belukha, the highest peak in the Soviet Altay. View from the east with Men-su Glacier in the foreground. (Sovetskaya Sibirskaya Entsiklopedia. Vol. 1: 63)

Fig. 71. The Katun River near Toguz-Kan in the Inner Altay. (Sovetskaya Sibirskaya Entsiklopedia. Vol. 1: 63)

Fig. 72. Lake Rakhmanovsk in the Altay. Near the lake are hot springs of the same name. (*Aziatskaya Rossiya*. Vol. 1: 401)

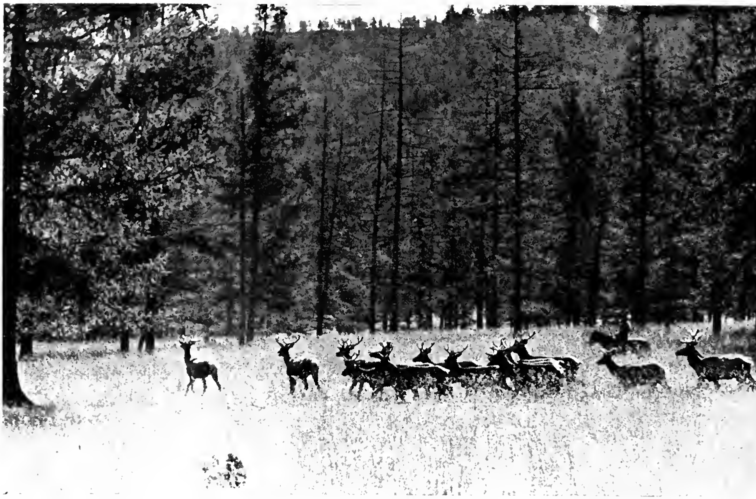


Fig. 73. Larch stand and reindeer on a state farm in the Altay (Oirot autonomous *oblast*). (Sovfoto)

Fig. 74. Altay ibex. The park-like character of the valley bottom is characteristic of the dry valleys of the Altay. (Sovfoto)

preserved in only a few places. As in the case of the Altay, the formation of a peneplain on the site of the West Sayans took place during the Mesozoic and Tertiary periods. In the middle or at the end of the Tertiary period, faulting and uplifts took place here; they gave rise to the contemporary West Sayans.

The West Sayans are composed fundamentally of a thick series of greenish or green-gray crystalline schists. This series, which until recently was considered pre-Cambrian, is classified now as definitely Lower Silurian, because of the nature of the fauna remains that are found here. The crystalline schists are intensely dislocated; the folding took place between the Devonian and the Silurian (that is, during the Caledonian period, particularly during the Epiisk phase). During the Lower Devonian period the sea apparently covered part of the West Sayans. (Indications of marine deposits have been found, for example, in the Us basin.) Opinions differ regarding what took place during the Middle Devonian, but, in any case, after the Middle Devonian the sea retreated from the West Sayans. Following this retreat, a long continental period ensued.

There are no glaciers at present in the West Sayans, but traces of Quaternary glaciation are very numerous, in the form of moraines, cirques, glacial lakes, U-shaped valleys, and so forth. The snow line during the glacial period lay approximately at the present timber line. Some authorities acknowledge two glaciations in the West Sayans, others only one.

Areas strewn with talus—*kurums*—are very characteristic for the Sayans (especially the East Sayans) and the Kuznetsk Ala-Tau. In some places the *kurums* cover the flat ranges and summits; sometimes they descend in wide rock flows into the upper reaches of the valleys. These "rivers" of rock are often covered with taiga, while under the rocks, which creep slowly downward, streams of water may flow. *Kurums* are products of the mechanical weathering of the bedrock under the influence of temperature fluctuation. According to Edelstein, the formation of *kurums* took place predominantly during the first half of the Quaternary period, when the climate was more severe and the forest vegetation did not rise so high into the mountains as it does today. It is difficult to believe that the *kurums* could have been formed under taiga, with which they are often covered today.

The Yenisey cuts through the West Sayans in a deep and narrow valley with numerous rapids. In the region of the Bolshoy rapids the Yenisey is only 55 m. wide. Often the sides of the valley rise hundreds of meters above the river; sometimes bald summits approach very close to the river. The tributaries which enter the main river in this section often flow in deep gorges.

The *Minusinsk basin.*[3] Between the northern slope of the West Sayans on the south and southeast, the Abakan range and the southern Kuznetsk Ala-Tau on the west, and the outlying spurs of the East Sayans on the northeast, lies the Minusinsk basin, crossed approximately in the middle by the Yenisey. Its lower portions, along the Yenisey, lie at 250 to 300 m.; its borders lie at 400 to 600 m., and, in some places, even higher. A part of the basin, between the Yenisey, the Abakan, and the foot of the West Sayans, bears the name *Koibalsk steppe.* On the north the Minusinsk basin is enclosed by mountain ridges, which are transected by the Yenisey and which form the uniting link between the Kuznetsk Ala-Tau and the East Sayans; the Bateni range, which crosses the Yenisey at Bateni village, is such a ridge (Edelstein, 1931).

In the literature, the name Minusinsk basin often designates the entire territory of the former Minusinsk *uyezd* (district). But this conception, as Edelstein (1931) has pointed out, is mistaken. Within this area there are several isolated sections of undisturbed sedimentary Paleozoic deposits, which are separated from one another by strips of metamorphic and igneous rocks. Only the southernmost area, within which lies Minusinsk, has the form of a basin, and Edelstein suggests that the name "Minusinsk basin" be restricted to that area.

The floor of this basin is composed of Devonian and some terrestrial Lower Carboniferous and Permian deposits, which occur in the central part of the basin in relatively undisturbed condition, in some places horizontally. Along the periphery, closer to the West Sayans and the Kuznetsk Ala-Tau, they are more noticeably dislocated; the dislocations here are chiefly of the thrust type. But even in the bottom of the basin there are some areas where the Devonian and Carboniferous strata were subjected to violent dislocations which gave rise to folds having a northwest trend.[4]

Within the Minusinsk basin, loesses and loesslike clay loams, usually associated with the river valleys, are rather widespread. Thus, more or

[3] Ya. S. Edelstein, "Gidrogeologichesky ocherk Minusinskovo kraya" (Hydrogeological Sketch of Minusinsk *Kray*), *Trudy Geol.-razved. obyed.* (Proceedings of the Geological Survey Society), No. 145, 1931; "Geomorfologichesky ocherk Minusinskovo kraya" (Geomorphological Sketch of Minusinsk *Kray*), *Trudy Inst. fiz. geogr.* (Proceedings of the Institute of Physical Geography), No. 22, 1936.

[4] Ya. S. Edelstein, "Geologichesky ocherk Minusinskoy kotloviny" (Geological Sketch of the Minusinsk Basin), *Ocherki po geologii Sibiri* (Sketches on the Geology of Siberia), izd. Akad. nauk (publication of the Academy of Sciences), 1932.

less typical loesses are developed on the terraces which lie above the flood plain of the Yenisey and its tributaries, the Abakan, the Tuba, and others. But in the region of Minusinsk these strata occupy the interstream spaces as well.

The *East Sayan system*[5] begins on the left bank of the Yenisey above Krasnoyarsk, near the mouth of the Mana River (a right-bank tributary), and extends southeast from there, to the area between lakes Baikal and Kosogol. There, in the region of the Tunka graben, which is occupied by the Irkut valley, the East Sayans join the mountain system of the Trans-Baikal.

The East Sayans are higher than the West, and contain several glaciers. The East Sayans reach their highest point north of Kosogol, at the sources of the left tributaries of the Angara (the Oka and the Irkut), where Mount Munku-Sardyk rises to an elevation of 3490 m. Several glaciers come down from this peak (Fig. 76). The valley of the Irkut River separates the main East Sayan range from the Tunka *belki* which lie to the north and have an elevation of up to 2400 m. North of the Tunka *belki* and parallel with them lie the higher Kitoy *belki* (elevation 2900 m.).

In the region where the East Sayans meet the West Sayans, in the longitude of the Biryusa and the Kazyr (tributaries of the Uda), the elevations reach 3000 m. From this mountain knot, at the juncture with the West Sayans, a chain extends WNW toward the Yenisey; this chain serves as the water divide between the basins of the Kan and the Mana on the one hand, and the Tuba on the other. It consists of a series of massifs: in the upper reaches of the Kan River, the Kan *belki* (elevation 2162 m.); west of the upper Mana River, the Mana *belki* (mean elevation 1500 to 1550 m.; some elevations up to 1800 m.). Part of the East Sayan system is the Kizir-Kazyr range, which forms the water divide between the Kizir and the Kazyr rivers, tributaries of the Tuba River, itself a right-bank tributary of the Yenisey which empties into that river in the Minusinsk basin. This range reaches an elevation of 2676 m. in Mount Edelstein; on the slopes of the range, traces of two glaciations appear very distinctly.[6]

The relief of the East Sayans consists of mountain massifs with flat summits above which low domelike bald peaks rise in some places. As

[5] I. A. Molchanov, "Vostochny Sayan" (The East Sayans), *Ocherki po geologii Sibiri* (Sketches on the Geology of Siberia), izd. Akad. nauk (publication of the Academy of Sciences), 1934, p. 83, with map, bibliography.

[6] A. G. Vologdin, "Kizir-Kazyrsky raion" (Kizir-Kazyr *Raion*), *Trudy Geol.-razved. upr.* (Proceedings of the Geological Survey Board), No. 92, 1931.

Molchanov points out, the elevation of the original peneplain decreases from the center of the Sayans to the periphery; in the center the peneplain lies at 2300 to 2400 m. and even 3000 m., while on the periphery it is lower. The summits of the bald peaks are sometimes flat; the ranges, therefore, have the character of plateaus. The peneplain surfaces have been preserved much better in the East Sayans than in the West. In places where the East Sayans were subjected to more intense glaciation (as in the Tunka and Kitoy *belki,* and in the Kizir-Kazyr range), they assume an alpine relief: pointed peaks with jagged ridges.

The East Sayans are composed of crystalline schists and crystalline limestones of unknown age, and extensive Cambrian strata. Marine Devonian strata have a limited extent in the East Sayans. In the greater part of the East Sayans a continental period followed the Devonian. On terrestrial Tertiary deposits may be found basalt crusts, sometimes lying on the summits of the bald peaks (for example, on Mount Ospinsk, elevation 2900 m.); this indicates that the East Sayans were uplifted relatively recently. The basalt flows, in any case, took place after the surface of the peneplain had been formed. The flatness of the Sayans, thus, has no relation to the lava crusts.

Suess attributed the formation of the East Sayans to the original uplift of Asia. He argued that folding took place here during the pre-Cambrian period, and that since the beginning of the Paleozoic the region of the East Sayans has not been covered by sea. But we have seen already that the East Sayans were submerged by a sea during the Cambrian period, while intensive folding took place here during the Lower Paleozoic (Caledonian) period. Toward the middle of the Tertiary period the region of the East Sayans constituted a peneplain. During the second half of the Tertiary period, dislocations caused by faulting took place, which gave rise to the contemporary relief of the East Sayans. Even before the uplifting of the Sayans, mighty basalt flows began; they continued, according to I. A. Molchanov, even into the glacial period.

The Sayans were subjected to glaciation repeatedly. In the Irkut valley traces of two glaciations may be seen; during the epoch of the more intense glaciation, an ice sheet descended here to an elevation of 815 m.; this glacier left a terminal moraine. Traces of ancient glaciation are found also in many other places. At present, glaciation in the East Sayans is very slight. In addition to Munku-Sardyk, small glaciers are found in a few places, some of them in the Kizir-Kazyr range. In the Kizir valley there are very distinct evidences of two glaciations, which may be traced down to an elevation of 450 m.

The following mineral resources are found in the Sayans: gold (particularly in the East Sayans), iron ores, and others. Graphite has been discovered in Mount Botogol (elevation 2308 m.) in the East Sayans north of Lake Kosogol; the graphite was formed here as a result of the action of syenite magma on richly carbonated sedimentary strata, which are thought to be of pre-Cambrian age. The only beds of nephrite in the Soviet Union are found in the Kitoy and Tunka *belki.*

Climate

The Minusinsk basin has hot summers and cold winters. In summer the temperature reaches 40° C.; in winter, there are frosts of − 50° C. The hot summer permits the cultivation of watermelons and melons in the Minusinsk forest steppe.

Little is known about the climate of the Sayans. Southwest and west winds prevail, which is shown by the shape of the trees. In describing the West Sayans, Tugarinov (1925) writes:

> The Siberian stone pine rises highest of all into the mountains, losing, however, the characteristics of a tree and turning into a crooked creeping shrub. Its recumbent branches and trunk find shelter behind rocks and crags, on the sides away from the prevailing winds. Wherever we may go on the mountain peaks throughout the high-mountain region, we can be certain always from the appearance of the trees that the prevailing winds here are south and southwest. The last of the erect Siberian stone pines are completely devoid of branches on the side toward the prevailing winds; only those branches on the leeward side survive; often on the windward side even the bark is absent.

Precipitation in the Sayans comes predominantly in the summer; it is at a minimum in winter. In the lowlands, for example, at Minusinsk (elevation 250 m.), in the Minusinsk basin, or at Usinskoye village (elevation 666 m.) in the Us River basin, the mean annual precipitation is less than 300 mm. On the southern slope of the West Sayans, which rise from the Us basin, 1220 mm. fell during one year at Buiba (elevation 1111 m.).[7] So little snow falls in the Minusinsk basin that often it is possible to ride in wheeled vehicles all winter long, and stock may be kept on pasture throughout the winter. In the mountains, however, the thickness of the snow cover is considerable, in some places as much as 2.5 m. In the East Sayans, as one goes south and southeast, the total

[7] S. P. Suslov, "Materialy po fiz.-geogr. landshaftam Zap. Sayana i yevo predgory" (Materials Concerning the Physical-Geographical Landscapes of the West Sayans and Their Foothills), *Trudy Inst. fiz. geogr. Akad. nauk* (Proceedings of the Institute of Physical Geography of the Academy of Sciences), XVIII, 1936, pp. 49, 50.

annual precipitation decreases; the amount of winter precipitation decreases particularly rapidly; the percentage of summer precipitation, however, increases. In these trends the climate approaches that of Mongolia. At Mondy station (elevation 1310 m., lat. 51°42′ N), which lies on the upper course of the Irkut River, the mean temperature for July is 15.7° C., for January, − 20.9° C.; precipitation amounts to about 300 mm. annually, with 70 per cent coming in summer. Cloudiness decreases southward (toward Mongolia): in the north the mean annual figure is 60 to 55 per cent; in the south, 45 per cent. Cloudiness decreases southward particularly rapidly in winter. In the west cloudiness is distributed almost evenly throughout the seasons; in the east the winter is distinguished by clear skies, while the summer is cloudy (Mondy: cloudiness in February, 20 per cent; in July, 62 per cent).

Vegetation

In the Minusinsk basin, west of the Yenisey, there is grassy steppe vegetation consisting predominantly of capillary feather grass, the fescue grass *Diplachne squarrosa,* and koeleria. On the slopes the grasses grow in admixture with *polyn.* Dark-chestnut soils and southern chernozems predominate. In the steppe east of the Yenisey there are occasional pine groves growing on sands, and birch groves growing on degraded chernozems and podzolic soils. The steppe sections are occupied by chernozems, developed on deep, calcareous, loesslike clay loams. In general the part of the basin east of the Yenisey is forest steppe. On the salinized soils thickets of iris (*Iris biglumis* [*I. ensata*]) are common.

In the West Sayans the foothills are covered with chernozem steppes, which on the south-facing slopes extend as high as 400 m. On the north-facing slopes the chernozems are degraded and there are many forests. Above 600 m. the soils are podzolic. In the foothills there are pine groves and birch groves; this vegetation is supposed to have appeared as a result of the destruction of the taiga by man.

Higher up lies continuous taiga of Siberian stone pine, fir, spruce, larch, pine, and birch (European white birch and pubescent birch). In some places Siberian stone pine predominates; in others, fir. The undergrowth contains mountain ash, bird cherry, alder, honeysuckle, and juniper. Occasionally (for example, along the Ana River, a tributary of the Abakan), almost pure larch forests are found. At 1600 to 2000 m. forest vegetation disappears; the boundary of the forest consists of Siberian stone pine. In the subalpine zone the presence of Manchurian alder (*Alnus fruticosa*) is characteristic. The alpine zone contains meadows developed partly on meadow soils, partly on peat-bog soils. Here, as in the taiga, rhododendron (*Rhododendron chrysanthum*) and bergenia may be found. On areas covered with talus, there are many lichens and mosses.

The Us basin, drained by the Us River (a tributary of the Yenisey), is bounded on the north by the Mirsk range. The floor of this basin lies at an elevation of about 700 m. Here soils of a podzolic type alternate with chernozemlike soils; in appearance the basin belongs to the mountain forest steppe. The north-facing slopes are covered with spruce-larch and larch forests; the south-facing slopes are steppes, on which pinnate feather grass is common.[8] Winter in the Us River basin is very severe (the mean January temperature is $-29°$ C.); the summer is warm (the mean July temperature is 17° C.), so that the sowing of grains is possible.

The vegetation of the East Sayans, in general, has the same appearance as that of the West Sayans. In the foothills, up to an elevation of 1000 m., pines and larches grow; higher up, taiga of fir with Siberian stone pine, or of Siberian stone pine, fir, and spruce, predominates. The deciduous trees include the birch, Mongolian poplar (*Populus suaveolens*), and aspen. At the timber line the forest consists of Siberian stone pine and sometimes larch. In the Belaya River basin, the upper limit of Siberian stone pine lies at 1800 m.[9] In the lower sections of the mountains, there are moss-grown Siberian-stone-pine groves with a continuous moss carpet; at an elevation of about 1200 m. the moss is replaced by a dense undergrowth of rhododendron (*Rhododendron chrysanthum*), or *kashkara*, as it is called here. In other places (such as Oka *kray*) Siberian-stone-pine and larch forests with a dense reindeer-moss cover lie below the Siberian-stone-pine zone; here the Soyot reindeer breeders graze their herds; sometimes Siberian stone pine predominates, sometimes larch. On the north-facing slopes, particularly near regions of permanent ground frost, there is larch taiga with a continuous reindeer-moss cover. Here there is much tundra rhododendron (*Rhododendron parvifolium*), black crowberry, and bog bilberry. There is no pine at all in Oka *kray*.[10]

[8] Suslov, *op. cit.*

[9] V. A. Povarnitsyn, "Lesa i lesovozobnovlenie v basseine r. Beloy v Vostochnykh Sayanakh" (Forests and Forest Renewal in the Basin of the Belaya River in the East Sayans), *Trudy Sov. po izuch. proizv. sil, Akad. nauk* (Proceedings of the Council for the Study of Productive Forces, Academy of Sciences), 1934, p. 43.

[10] M. I. Nazarov, "Ocherk rastitelnosti Okinskovo kraya v Vostochnom Sayane" (Sketch of the Vegetation of Oka *Kray* in the East Sayans), *Izv. Gos. geogr. obshch.* (Report of the State Geographical Society), 1935, pp. 54–86.

In the region of the Tunka mountains there are only 300 to 400 mm. of precipitation. For this reason the vegetation has a xerophytic character. Pure stands of pine and Siberian larch are common.

On the banks of the Irkut there are tall spruce stands in some places, clumps of poplars in others, and willows and Siberian pea shrub (*Caragana arborescens*) in still others. The north-facing slopes of the range are covered either with larch or spruce-fir forest, while in the gorges there are pure stands of Siberian stone pine. Pine forests in the Irkut valley extend no higher than 800 m.; at higher elevations larch predominates. In addition, in the undergrowth of the larch forest on the dry slopes, there is Dahurian rhododendron, while on the moist slopes there is a carpet of sphagnum and hypnum mosses, with occasional thickets of ledum. The timber line lies at 1800 to 2000 m.; here the forest consists usually of larch and occasionally of Siberian stone pine; however, individual trees are found as high as 2100 to 2300 m. Higher up (2000 to 2400 m.) lies a belt of shrubs composed of ground birch (*Betula rotundifolia*), rhododendron, willow (*Salix vestita*), shag-spine pea shrub (*Caragana jubata*), Manchurian alder (*Alnus fruticosa*), currant (*Ribes graveolens*), and alpine spiraea (*Spiraea alpina*) (V. Komarov). Subalpine tall herbaceous meadows and alpine meadows are poorly represented. High-mountain "tundra," chiefly of lichen, predominates. Near the region of everlasting snows may be found leather bergenia (*Bergenia crassifolia*), Altay violet (*Viola altaica*), Altay gentian (*Gentiana altaica*), and others.

Fauna

In the foothills of the Sayans, extensive areas are covered with birch groves. Here are found black grouse (*Lyrurus tetrix*), willow ptarmigan, varying hare (*Lepus timidus*), fox, wolf, European polecat (*Putorius eversmanni*), ermine, weasel, and roebuck. Steppe forms are found in the Minusinsk basin; for example, the Dzhungarian hamster (*Phodopus songorus*), short-tailed vole (*Lagurus lagurus*), sheld duck (*Tadorna tadorna*), ruddy sheldrake (*T. ferruginea* [*Casarca ferruginea*]), Siberian bustard (*Otis tarda dybowskii*), bearded partridge (*Perdix daurica* [*P. barbata*]), and others.

In the Siberian-stone-pine taiga of the West Sayan range live ermine, weasel, kolinsky, varying hare, Sayan forest lemming (*Myopus schisticolor saianicus*), elk, red deer (*Cervus elaphus canadensis sibiricus* [*C. elaphus sibiricus*]), reindeer (*Rangifer tarandus*), bear, glutton, sable, lynx, musk deer, squirrel, alpine mouse hare (*Ochotona alpina*), chipmunk (*Eutamias asiaticus* [*E. sibiricus*]), flying squirrel (*Pteromys volans*), mole, and others. In winter the hazel grouse, capercaillie, woodpecker, linnit, bullfinch, coal tit, tit, nuthatch, jay, nutcracker, Siberian jay, waxwing, rough-legged buzzard (*Archibuteo pallidus* [*Buteo lagopus pallidus*]), snowy owl (*Nyctea nyctea*), and goshawk are found in the taiga.

The alpine zone lies at 2100 m. and higher. In summer this zone contains many ungulates: reindeer, musk deer, Asiatic ibex (*Capra sibirica*), and sometimes elk and red deer. In summer there are also bear and northern dhole. The ungulates descend into the forest zone for the winter, and only the musk deer remains somewhat above the edge of the forest.

The birds of the alpine zone in summer include the tundra ptarmigan (*Lagopus mutus*), water pipit (*Anthus spinoletta blackistoni*), willow warbler (*Acanthopneuste borealis*), black-throated diver (*Colymbus arcticus* [*Gavia arcticus*]), Altay snow pheasant (*Tetraogallus altaicus*), and others. In winter they include the snowy owl, rough-legged Siberian buzzard, and Ural owl.[11]

The Sayans are rich in economically valuable animals. Sable is still rather numerous in the Siberian-stone-pine groves.[12] In the mountain taiga the Manchurian reed deer (*izyubr,* or *maral*) is very widespread; it is hunted for its horns and skins. Elk is found predominantly in the East Sayans. Roebuck is widespread. The musk deer is very common, and is hunted chiefly for musk. Above the boundary of the forest and even above the alpine meadows, along the rocky plateaulike *belki,* covered with mosses and lichens (such, for example, as the Kan or Mana *belki*), there is wild reindeer. In fall, with the coming of snow, it descends into the forest zone; the reindeer is hunted by the northern dhole (*chikalka*), common wolf, lynx, and glutton, as well as by man. On the southern slopes of the West Sayans there is some ibex. In the taiga there are many bears. Squirrels, which are of great economic importance, are very widespread. There is considerable ermine, which follows the sable, squirrel, and Manchurian red deer in importance. The domestic form of the reindeer is found in the Sayans among the Karagasses and the forest Soyots. The region inhabited by the reindeer in the Sayans is isolated completely from the more northern regions of its distribution.

[11] *Sayansky promyslovo-okhotnichy raion* (The Sayan Commercial-Hunting Region), Petrograd, 1921, Chap. III.
[12] *Ibid.,* p. 145

The Sayan deer is used exclusively as a riding and pack animal, and is never used in harness.[13]

The birds, in addition to those mentioned above, include the following: Swinhoe's snipe (*Capella megala*); solitary snipe (*C. solitaria*); pin-tailed snipe (*C. stenura*); bearded partridge; needle-tailed swift (*Chaetura caudacuta*), the tail feathers of which terminate in spines; Siberian swift (*Apus pacificus*); and the red-throated and black-throated thrushes (*Turdus ruficollis* and *T. atrogularis*).

The caterpillar of the Siberian or Siberian-stone-pine dendrolimus (*Dendrolimus sibiricus*) does great damage to the pine groves of the East Sayans, while the fir forests suffer severely from the larvae of the taiga longicorn beetle, *Monochamus urusovi.*

[13] *Ibid.*, p. 145.

XV · Lake Baikal and the Trans-Baikal Region

Relief

IN its relief the Trans-Baikal region is a continuation of the East Sayans. Neither the East Sayans nor the Trans-Baikal mountains consist of elevations in the form of ranges with clearly expressed crests; instead, these mountains have the appearance of flat and wide watershed plateaus, dissected by erosion into dome-shaped peaks and rounded ridges. There are few peaks which stand out individually. The view from any of the passes is a series of flat massifs, overgrown with forests, separated from one another by wide and deep valleys. Topographic maps lead one to expect to find folded mountain ridges in the Trans-Baikal region. But actually the picture is quite different. The ranges of this region, composed predominantly of dislocated massive crystalline strata and crystalline schists, have a generally ENE–WSW orientation; but the dip of the strata which compose them is often different. This is explained by the fact that after the folding processes (which took place during the Lower Paleozoic period) had ended, the mountain country was vigorously eroded, becoming a peneplain; subsequently, as Obruchev has explained, differential vertical movements formed alternating zones of subsidence (grabens) and uplift (horsts); it is the latter which constitute the present ranges.

Of the ranges of the Trans-Baikal, the Yablonovy is well known; roughly speaking, it forms the water divide between the Arctic Ocean and the Amur. This is strictly true only of its southwestern part, where the range serves as the water divide between the Khilok (a tributary of the Selenga) and the Ingoda (which, together with the Onon, forms the Shilka); but where it extends as far as the upper course of the Chita River, the Yablonovy range lies on the water divide between the Vitim River and its tributary, the Karenga; in this region it no longer constitutes the water divide between the basins of the Lena and the Amur. The highest point of the Yablonovy range is Mount Saranakan (elevation 1610 m.), 65 km. NNE of the city of Chita. Obruchev (1914) describes the southwestern part of the range as follows:

> As seen from the valley of the Khilok River, the Yablonovy range appears to be of very inconsiderable elevation. The gentle northwestern slope rises quite imperceptibly to the main water divide, which appears from a distance to be either an almost completely flat divide, or a chain of flattened hills. . . . The water-divide ridge constitutes a plain of varying width, covered with dense forest, and slightly dissected by wide saddles which are occupied by bogs. The tributaries of both the Khilok (Baikal basin) and the Ingoda (Amur basin) often have their sources in these bogs.

At the point where the railroad crosses the Yablonovy range, the pass is 1050 to 1070 m. in elevation. The heights on either side of the Khilok rise only 105 to 125 m. above the river; those along the Ingoda, 305 to 325 m.; thus, the eastern slope is steeper. On the pass there is found a bed of post-Tertiary lacustrine deposits.

The highest point of the entire Trans-Baikal region, Mount Sokhondo, is composed of dacite,[1] and reaches an elevation of 2540 m. The main peak of Sokhondo is completely flat, covered with large fragments of dacite, and has terracelike slopes. Tree vegetation in the form of sparse stands of Japanese stone pine and larch rises up to 2000 m. On Sokhondo there are distinct traces of ancient glaciation in the form of moraines and cirques. This bald summit in the upper reaches of the Ingoda River lies not far from the Mongolian border, in the Borshchovochny range, which extends northeast from here. The passes across this range lie at an average elevation of 950 m., while the peaks reach 1100 m. Beyond the point where the Onon River crosses it, the Borshchovochny range lies along the right bank of the Shilka.

Northwest from the Yablonovy range spreads the gently rolling Vitim Plateau, covered with bogs and a continuous larch forest, and drained by the Vitim River. It is composed chiefly of granites, granite-gneisses, and gneiss-granites. In the center of the plateau there are basalts and basalt lavas up to 20 m. in thickness; these igneous products came from several small volcanoes, now extinct, as high as 160 m. in relative elevation. The rivers have worn canyon-shaped courses through the igneous rocks. The absolute elevation of the plateau is 850 to 1450 m.; elevations of 1000 to 1350 m. predominate.

In the basin of the Patom River (which empties into the Lena from

[1] Dacite is an igneous rock of porphyritic structure.

the right, above Olekminsk) lies a mountain country, which Kropotkin calls the Patom Upland. In structure this land is a continuation of the northern Trans-Baikal region; it is composed of granites and metamorphic rocks. The mean elevation of the upland is 850 to 1050 m. On the north, toward the Lena, the upland descends to the Central Siberian Plateau in a 400 to 500 m. escarpment. The boundary of the upland, in general outline, reflects the arc of the Lena River between the mouths of the Vitim and the Patom. The Patom Upland is characterized by the absence of clearly defined ranges and the relatively uniform height of all the more important individual peaks. The highest point of the upland is Mount Longdor (elevation 1956 m.).

The country between the Vitim and the Olekma is rich in gold.

Western Trans-Baikal, the Vitim Plateau, and the Patom Upland, according to Suess, are part of the system which he believes comprises the original uplift of Asia; all of these regions are composed of archean strata which were folded during the pre-Cambrian period; they have not been covered by sea since the Cambrian period. However, at present there is reason to believe that a sea did exist here during the Lower Paleozoic period, and that intensive folding took place here during the Caledonian (Lower Paleozoic) period.

Eastern Trans-Baikal belongs to the region of Mesozoic folding. Here folded marine deposits—Paleozoic, Triassic, and Jurassic—have been found. The general trend of the folds of the Mesozoic deposits is to the northeast, while the folds are inclined to the northwest. Less intense folding took place here during the Tertiary period as well.

The water-filled basins include Lake Baikal, the most remarkable lake in the world. If Baikal were placed in its latitude on the map of Europe, it would extend approximately from Moscow to Kursk, but the climate of its shores, as will be seen below, is much more severe than in corresponding latitudes in Europe. Baikal is the deepest lake on earth, the deepest depression on any continent. Its greatest depth is 1741 m.; its average depth, about 700 m. Since the mean elevation of the surface of Baikal is 453 m., the bottom of the deepest part of this lake is almost 1300 m. below sea level. When we consider that the mountains on the shores of Baikal reach about 2000 m. in absolute elevation (for example, the Barguzinsk Mountains), the contrast in the relief of the earth's crust in this region is even more remarkable. From what has been said, it is clear that the Baikal basin can have originated only by tectonic means. After the Silurian, the region occupied by Baikal today was no longer covered by sea. The Baikal depression was formed by subsidences, analogous to the subsidences (grabens) in which the Trans-Baikal region is so rich. These subsidences took place no later than the middle of the Tertiary period. Corroborative evidence is found in the character of the contemporary fauna of Baikal, which includes many ancient forms, as well as in the presence on the southern shore of Baikal of Middle Tertiary lacustrine deposits which contain remains of fresh-water mollusks; among the latter there are gastropods, which resemble the contemporary Baikal *Baicalia* (see below).

The temperature of the water in the open lake in summer is very low; the mean temperature of the water in August, which is the warmest month, is 9° C. Along the shores in summer, the temperature of the water rises to 15° C., and in some places even to 19° C. Baikal freezes very late, not until the beginning of January (Fig. 77); this late freezing is explained by the slow rate at which very large masses of water are cooled; the violent storms which take place in autumn also have an effect. Up to the middle of May, Baikal is covered by a deep layer of ice, the thickness of which reaches 1.25 m. At great depths the temperature of the water in Baikal is constant, slightly over 3° C.

The character of the temperature regime of the surface waters of Baikal exerts a tremendous influence on the climate of its shores. Summer in the Baikal area is cool, while the winter is milder than in the interior of the country, at a distance from the lake. In short, Lake Baikal has the effect of making the climate less continental; in July the mean temperature is 5° C. cooler on the shores of the lake than at a distance from the lake; in December, on the other hand, it is 10° C. warmer on the lake than at a distance from it (see Table 24, p. 306).

The water in Lake Baikal is as clear as ocean water; transparency up to 40 m. has been observed. In Baikal, in addition to stationary waves, or "seiches," which are typical in all lakes, there are also tides, although these are of negligible amplitude.

The fauna of Baikal is extremely rich and abounds in endemic forms. It is ancient and unique. The basins which surround Baikal contain the usual Siberian fauna, which is found even in the bays (*sors*) of Baikal. But as soon as we move into Baikal itself, it is as though a new world opens before us, in the form of a fauna so unique that I have designated it (1916) as belonging to a separate (Baikal) subregion of the circumpolar region. The fauna of Baikal includes the Baikal hair seal (*nerpa, Phoca sibirica*), which is related closely, on the one hand, to the ringed seal of the Arctic Ocean (*P. hispida*), and, on the other, to the Caspian hair seal. The fish include the viviparous Baikal "oilfish" (*Comephorus*), a representative of a family native only to Baikal; another closely related family, Cottocomephoridae, the Baikal representatives of which are called *bychki,* is also endemic in this lake. The Baikal whitefish (*Coregonus autumnalis migratorius*) is of great economic importance. Mollusks are represented in Baikal by more than eighty species; there are two endemic families of gastropods (Benedictiidae and Baicaliidae), which, like the two above-mentioned fish families, are typical fresh-water families. The Baikal mollusks bear some resemblance to the mollusks of the Upper Tertiary salt-water deposits of southeastern Europe, and also to the mollusks living at present in Lake Okhrid (on the Balkan Peninsula) and in some parts of the Caspian. It is worth noting that the mollusk genus *Baicalia* appears in the Lower Cretaceous fresh-water deposits of the Trans-Baikal region.

Baikal is particularly rich in amphipods (Gammaridae), of which more than two hundred species are known here. The worms include a small, many-bristled worm of the genus *Manayunkia,* representatives of which are distributed extensively in the fresh and salt waters of the Northern Hemisphere. Some of the invertebrates found in Baikal have very close relatives in the tropics and subtropics (for example, the leech *Torix baicalensis,* the bryozoan *Hislopia baicalensis,* and the fresh-water copepod *Harpacticella inopinata*).

In the Tertiary deposits on the shores of Baikal, fresh-water bivalve mollusks have been discovered; they are found today in the Amur and in China (E. Rammelmeyer). As for the origin of the Baikal fauna, the hypothesis has been advanced that it had its beginnings in the sea, but I maintain the view that the fauna of this lake is of ancient fresh-water origin.[2] The endemic fauna of Baikal consists of two elements: (1) Ancient forms, developed in Baikal itself, from roots of which nothing more is known, during the course of its long geological existence (for example, sponges of the Baikal family Lubomirskiidae, several sparsely bristled worms, several mollusks, fish of the two above-mentioned endemic families, and others). Relatives of these forms are found nowhere among present-day fresh-water or marine fauna; but some of them are found in fossil condition, for example, the above-mentioned *Baicalia.* (2) Remains (relicts) of Upper Tertiary fresh-water fauna, which inhab-

[2] For details and bibliography see L. S. Berg, *Klimat i zhizn* (Climate and Life), Moscow, 1922, pp. 28–53; also "O predpolagayemykh morskikh elementakh v faune i flore Baikala" (Concerning the Supposed Marine Elements in the Fauna and Flora of Baikal), *Izv. Akad. nauk* (Report of the Academy of Sciences), 1934; "Yuzhnie elementy v faune Baikala" (Southern Elements in the Fauna of Baikal), *Uchen. zap. Lgr. univ.* (Scientific Report of Leningrad University), No. 17, 1937.

ited Siberia and possibly adjoining parts of Central Asia (as well as North America and eastern Europe). Finally, we must note that several genera which at one time were considered endemic in Baikal, have been discovered subsequently in the fresh waters of Siberia and even Europe.

Climate

The climate of the Baikal and Trans-Baikal regions is unique, and is affected by a number of different factors. The climate of the Siberian taiga is found here, adjacent to the climate of the Mongolian steppe; in addition, Lake Baikal exercises a strong influence. The climate of Mongolia is distinguished by sharp differences in the quantity of summer

Table 23

CLIMATE OF THE BAIKAL AND TRANS-BAIKAL REGIONS

METEOROLOGICAL STATION	LATITUDE (°N)	ELEVATION ABOVE SEA LEVEL (M.)	PRECIPITATION PER YEAR (MM.)	TEMPERATURE (°C.)	
				July	January
Barguzin	53½	490	260	19.0	−26.6
Ulan-Ude (formerly Verkhneudinsk)	51¾	509	204	20.0	−26.0
Selenginsk	51	570	162	20.0	−25.9
Troitskosavsk	50⅓	758	280	19.9	−23.1
Nerchinsk	52	485	283	20.7	−32.5

and winter precipitation; as much as 75 per cent of the total annual precipitation may occur in summer, while in winter there is only 2 to 3 per cent, or even less. This type of rainfall distribution is found also in the southern Trans-Baikal. There is not much precipitation in the Trans-Baikal and the Baikal regions, the average being about 300 mm. per year, and in some places even less. On Olkhon Island (in Baikal) there are only 169 mm., so that the Buryats (the inhabitants of Olkhon) have to irrigate their meadows; irrigation is used also in the valley of the Barguzin River. A large part of the shore of Baikal southwest of Olkhon is covered by dry steppe; here and there lie salt lakes, surrounded by solonchaks which bear halophytic vegetation. But in the southwestern part of the region there is considerable precipitation; in Mysovaya there are 515 mm., while in Pereyemnaya there are over 600 mm.

The southern Trans-Baikal lies in the same latitude as Kiev and Kharkov and even farther south, and the summer is generally warm, in spite of the relatively high elevation above sea level (500 to 800 m.). The winter, however, is severe.

The maximum precipitation comes in July; the minimum, in February. At Selenginsk three-fourths (74 per cent) of the total annual precipitation comes in summer, only 3 per cent in winter. There is very little snow; at its greatest depth, the snow cover in winter at Ulan-Ude reaches only 17 cm.; at Troitskosavsk, 13 cm.; and at Olovyannaya, only 2 cm. As a result of the negligible snow cover, the subsoils freeze hard, and permanent ground frost is extensive; near Mogzon station (lat. 51°43′ N) the depth of the permanently frozen layer reaches 67 m.; this depth, of course, is the extreme. In summer the subsoil thaws to an average depth of 3 m. Because of the negligible snow cover in this region, there is almost no high water in spring.

Winter in the Trans-Baikal (as also in Yakutiya) is characterized by clear skies and calm. The cloudiest month is July; the clearest months, January and February. In general, however, there is little cloudiness; the mean annual figure for Ulan-Ude is 53 per cent; for Troitskosavsk, 47 per cent; and for Nerchinsk, 39 per cent (July and August there have 53 per cent; January, 19 per cent). In general no part of the U.S.S.R., nor even of Central Asia, has such clear winter skies as the Trans-Baikal. The duration of insolation is very great; in Akatuy it is 72 per cent of the duration possible annually. In March the sun shines here 85 per cent of the number of hours possible; in July, 59 per cent; there are only 23 days during the year when the sky is covered with clouds all day long.

A region of very high pressure covers the Trans-Baikal in winter. The isobars (in January, atmospheric pressures—converted to sea level—are 775 to 773 mm.), which generally extend from north to south, are disposed so that the pressure decreases from west to east and from south to north. (Over the Okhotsk and Bering seas the pressure is low.) For this reason winds with a western component prevail in winter; they range from northwest to west. In summer, on the other hand, the pressure is low over the Trans-Baikal, and the isobars are disposed so that in July, for example, north and northeast winds prevail; in June and August, northwest winds.

Baikal, as we have said, exerts a pronounced influence on the climate of the surrounding area, not only in summer and autumn, but also in the latter half of the winter, when the lake is covered with ice. For illustration we present the annual course of atmospheric temperature at Listvenichnoye, which lies on the shore of Baikal, and at Ulan-Ude (formerly Verkhneudinsk), which lies in the same latitude (51°50′ N), but at some distance from the eastern shore. (The data are for the period 1896–1905.)

Table 24

TEMPERATURES AT LISTVENICHNOYE AND ULAN-UDE (°C.)

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
Listvenichnoye	−15.4	−15.7	−10.1	−1.0	5.0	10.1	12.7	13.9	8.7	1.5	−5.3	−11.9	−0.6
Ulan-Ude	−25.7	−21.2	−11.8	0.5	8.5	17.0	19.7	16.9	8.8	−0.6	−12.5	−22.3	−1.9

In January and December at Listvenichnoye it is 10° C. warmer than at Ulan-Ude; but in June and July on the shore of the lake it is 7° C. cooler than at a distance from the shore. The highest temperatures at Listvenichnoye occur not in July, but in August; the lowest temperatures, not in January, but in February; this lag in temperature maximum and minimum is found generally in a marine climate. The annual temperature range at Listvenichnoye is only 29.6° C., while at Ulan-Ude it is 45.4° C.

Vegetation

The Trans-Baikal is unique in that here the Siberian taiga lies adjacent to the Mongolian steppes. In the depressions the steppe extends far to the north—as far as Baikal (Olkhon Island and neighboring places), the Upper Angara, and the Barguzin. In the mountains the taiga stretches from Siberia far to the south, as far as the upper reaches of the Onon and the Ingoda, where it protrudes into the dry steppes of Mongolia. This intermixture of two elements may be traced in the climate, the soils, the vegetation, and the fauna.

In the Trans-Baikal there are two large zones of steppe and forest steppe; these are the Selenginsk on the west, and the Nerchinsk on the east. At elevations of approximately 500 to 900 to 1000 m. there are steppes; from 900 to 1000 m. up to 1200 m. there is forest steppe; higher up there is mountain taiga, which rises in the south to elevations of 1700 to 1900 m. The steppe and forest, naturally, extend higher up into the mountains in the southern Trans-Baikal than in the north; in the north the forest ends in some places at 1200 m. The subalpine zone extends up to 1900 to 2200 m., where it is replaced by the alpine zone. Agriculture does not extend beyond 900 to 1100 m.

The steppe and forest-steppe zones. In addition to the two large steppe zones mentioned above, steppe elements may be found still farther to the north, in the basin of the upper Angara. Here, in some places on the southern slopes, soils are developed which resemble steppe soils and which are covered with steppe vegetation—fescue, koeleria, feather grass, steppe sedge, and others; on the north-facing slopes there are larch and pine-larch forests; on the wetter slopes and in the valley bottoms, growing on podzolic soils, there are numerous Japanese-stone-pine stands, some pure, some with an admixture of fir and larch.

In the basin of the Barguzin there are chestnut soils, on which are found *polyn* and feather-grass steppes; of the feather grasses, the capillary feather grass predominates. There are some solonetz soils also. The mountains, however, are covered with forest—on the northern slopes, larch, on the southern slopes, pine. Between latitudes 52½° N and 53½° N, at an elevation of about 950 m., lie the Yeravinsk steppes, which have slightly podzolic, dark soils.

Farther south, at a lower elevation, lie the Nerchinsk steppes, or, more exactly, forest steppes; they lie at an elevation of 620 to 690 m. (The mountains here reach 850 m. in elevation.) The steppe areas are covered with meadow-steppe soils with sharply distinct carbonate horizons beginning at a depth of 30 cm. and extending to 1.5 to 2.5 m. Several types of steppe may be distinguished here, according to vegetation: steppe covered chiefly by wheat grass (*Agropyron pseudagropyron*), which is a very valuable fodder crop; mixed-herbaceous steppe, on which narrowleaf clematis (*Clematis angustifolia*) predominates; steppe on which the day lily (*Hemerocallis graminea* [*H. minor*]—Liliaceae) is most prominent; and other types. In the Nerchinsk steppes columnar solonetz soils are widespread. The floors of the deep valleys contain solonchaks. In some places there are thickets of birches and willows.

In the southeastern corner of the Trans-Baikal, through which the railroad passes into Manchuria, typical *polyn* steppes are developed on chestnut soils. They stretch from the land-locked Tarey lakes on the west to the Argun River on the east. This is one of the northernmost outposts of the Mongolian steppes. Farther north, 50 to 70 km. from the border, and also westward, along the Onon and the Selenga, steppe is found only in separate islands, which are part of the forest-steppe complex, while in the western Trans-Baikal, steppe sections are found only in the depressions. Between the Tarey lakes and the Argun River the steppe rises also into the low ranges which are found here; the lowlands, or *pads*, however, are covered with solonchak meadows.

Grassy steppes on chestnut and forest-steppe soils are widespread in the western Trans-Baikal, in the basin of the Selenga and its tributaries, the Khilok, Chikoy, and Dzhida. In this region the elevations are distributed as follows: [3]

[3] L. I. Prasolov, Yuzhnoye Zabaikalye, "Pochvenno-geografichesky ocherk" (The Southern Trans-Baikal Region: a Sketch of the Soil-Geography), *Mat. Kom. po issled. resp.* (Materials of the Commission for the Study of the Republics), izd. Akad. nauk (publication of the Academy of Sciences), No. 12, 1927, p. 131.

Table 25

ELEVATIONS IN THE WESTERN TRANS-BAIKAL REGION

OROGRAPHIC ELEMENTS	ELEVATIONS (M.)
Main valleys	500 to 600
Secondary valleys	600 to 800
Passes across the ranges	900 to 1000
Summits of the ranges	1000 to 1200

The Burin-Khan hills (elevation 1640 m.), which lie between the Dzhida and the Temnik,[4] are covered, up to an elevation of 800 to 900 m., with dry grassy steppe on dark-chestnut soils and southern chernozems. The summits of the hillocks in this steppe stand out because of the predominance on them of Siberian tansy (*Tanacetum sibiricum*). Higher up, on the shady slopes, coppices of larch appear; this forest steppe lies at 900 to 1200 m. At an elevation of 1200 to 1300 m. there is a birch-larch forest. The flat summit of the Burin-Khan is covered with a mossy taiga of larch, spruce, and Japanese stone pine.

Considerable tracts in the region between Selenginsk and Troitskosavsk are covered by sands which represent alluvial post-Tertiary deposits, sorted during the dry postglacial epoch. Loesslike sandy loams are found here also. The sands are covered (or were covered until recently) with pine groves, which in some places alternate with sections of steppe covered with sandy-loam chestnut soils. Therefore, this region must be classified with the forest steppe, which descends very low here, below 600 m. in absolute elevation. Trans-Baikal pine groves are distinguished from European pine groves by the abundant undergrowth of Dahurian rhododendron and the profusion of orchids.

Besides pine groves in the Trans-Baikal forest steppe, there are small birch woods and also larch and birch-larch woods.

The mountain taiga. As one ascends, the pine groves, as well as the birch and aspen, disappear gradually, and larch begins to predominate, in some places together with Japanese stone pine; on the high ranges, Japanese stone pine occasionally predominates. On Sokhondo, Japanese stone pine ascends to an elevation of 2000 m.

As we have said, the taiga in the southern Trans-Baikal begins at 1200 m. But this is true only in general; there are exceptions. Thus, around Lake Baikal the taiga usually extends down to the elevation of the lake; for example, on the northwest slopes of Khamar-Daban,

[4] One branch of the Temnik River empties into the Selenga, the other into Lake Gusinoye.

Japanese stone pine grows on the shore of the lake itself (although there are steppes on Baikal also, for example, on Olkhon Island).

But in the northern Trans-Baikal the taiga often ends at 1200 m. Thus, in the basin of the Tungir River (a right tributary of the Olekma, lat. 54° to 55° N), according to Sukachev,[5] forests of Dahurian larch predominate, with an undergrowth of Dahurian rhododendron, which reaches 2.5 m. in height; sometimes the undergrowth contains the shrubby Middendorff's birch (*Betula middendorffii*), which grows 2 m. tall. The herbaceous cover consists mostly of cowberry and crystal tea ledum (*Ledum palustre*). On the sandy soils and clay loams there is pine; very rarely there is Siberian spruce. The Asiatic white birch (*Betula platyphylla*) is not numerous, nor does it extend far up the slopes; occasionally there are Erman's birch (*B. ermani*), aspen, Mongolian poplar, and bird cherry; mountain ash extends as far as the timber line. At an elevation of 1200 to 1300 m. the taiga ends; it is replaced by Japanese stone pine (*Pinus pumila*), characteristic for the subalpine strip; this pine grows 2 to 3 m. tall here, and forms almost impassable thickets. The above-mentioned shrubby Middendorff's birch appears here also, together with the Japanese stone pine. Two other plants which grow here are the characteristic East Siberian ericaceous alpine plant, *Cassiope ericoides*, and the alpine ptarmiganberry (*Arctostaphylos alpina* [*Arctous alpinus*]). Above the zone of Japanese-stone-pine groves lies the alpine zone of bald summits, with many lichens, as well as some of the higher plants: alpine ptarmiganberry, ledum, cowberry, black crowberry, an arctic species of diapensia (Diapensiaceae), *severny zlak* ("northern grass"), alpine sweet grass (*Hierochloë alpina*), rhododendron (*Rhododendron chrysanthum*), Japanese stone pine, and shrub birch. Here, as is usually true throughout the Trans-Baikal (but not, for example, in the Altay), there is no belt of wet meadows in the alpine zone.

In the region of Mount Sokhondo, in the southern Trans-Baikal, there are larch forests with Japanese stone pine at lower elevations; there are also some pine, birch, and aspen. Tree vegetation extends up to 2000 m. Under the taiga the soils are slightly podzolic. Higher up lies a subalpine shrub belt of Japanese stone pine, East Siberian dwarf birch (*Betula exilis*), rhododendron (*Rhododendron chrysanthum*), and juni-

[5] V. N. Sukachev, "Rastitelnost verkhney chasti basseina r. Tungira Olekminskovo okr. Yakutskoy obl." (Vegetation of the Upper Part of the Tungir River Basin in Olekminsk *Okrug* of Yakutsk *Oblast*), *Trudy Amursk. eksp.* (Proceedings of the Amur Expedition), No. 16, botan. issled. (Botanical Survey), 1910 g., Vol. 1, St. Petersburg, 1912, p. 286. Formerly these localities did not belong to the administrative unit of the Trans-Baikal.

per (*Juniperus davurica*). Below the rock-strewn summits there are glades, which bear a variegated carpet of dicotyledons; such glades are rare in the Trans-Baikal.

Fauna

The fauna of the Trans-Baikal displays the same intermixture of steppe and taiga forms as does the vegetation. In the steppe and forest-steppe areas the suslik (*Citellus eversmanni* and *C. dauricus*), Mongolian bobac (the marmot *Marmota sibirica*), jerboa (*Allactaga saltator mongolica* [*A. sibirica mongolica*]), Dahurian hamster (*Cricetulus furunculus* [*C. barabensis*]), Siberian red-backed mouse (*Evotomys rutilus* [*Clethrionomys rutilus*]), various species of meadow mice of the genus *Microtus*, Dahurian burrowing rat (*Myospalax dybowski*), and hare (*Lepus tolai*) are common. Many Mongolian birds nest here: the sheld duck (*Tadorna tadorna*), ruddy sheldrake (*T. ferruginea* [*Casarca ferruginea*]), Indian goose (*Anser indicus*), saker falcon (*Falco cherrug*), demoiselle crane (*Anthropoides virgo*), Siberian bustard (*Otis tarda dybowskii*), avocet (*Recurvirostra avocetta*), Mongolian lark (*Melanocorypha mongolica*), and others.

The Trans-Baikal taiga contains bear, sable, glutton, wolf, northern dhole, lynx, squirrel, flying squirrel (*Pteromys volans*), birch mouse (*Sicista montana* [*S. betulina montana*]), mountain sheep, roebuck, Manchurian red deer, elk, and reindeer (*Rangifer angustirostris* [*R. tarandus angustirostris*]). There are many East Siberian taiga birds.

The rose finch (*Carpodacus roseus*) and the pine grosbeak (*Pinicola enucleator*) are characteristic of the Japanese-stone-pine thickets in the Trans-Baikal; in fact, they are characteristic of eastern Siberia in general.

The tundra ptarmigan (*Lagopus mutus*), dotterel (*Eudromias morinellus*), and horned lark (*Eremophila alpestris flava* [*Otocoris alpestris flava*]), nest in the alpine zone. A remarkable shore bird, the Polynesian tattler (*Heteractites incana brevipes* [*Heteroscelus brevipes*]), nests in the Baikal area; the nearest relative of this bird nests in Alaska. The rock thrush (*Monticola saxatilis turkestanica*) nests on the rocky precipices of the northern Baikal area; this bird, which is native to dry and warm countries (for example, the Crimea), is undoubtedly a relict of the xerothermic period.

The amphibians of the Trans-Baikal (Nerchinsk, Troitskosavsk) include the Asiatic tree frog (*Hyla stepheni*).

XVI · Mountains of Northeastern Siberia

THIS region includes the Verkhoyansk, Chersky, and Kolyma (Gydan) ranges, and the heights of Chukotsk National *okrug*.

Relief

During recent years considerable changes have taken place in our conceptions of the Verkhoyansk system, which lies east of the middle and lower course of the Lena. Suess, in agreement with Maidel, held that the Verkhoyansk range merges on the southeast into the Kolyma range, which lies along the northern shore of the Sea of Okhotsk. But the most recent investigations have shown [1] that to the east of Okhotsk (village) there is no continuous latitudinal range. (Maidel continued the Kolyma Mountains far to the west, while in fact they do not extend west of the Yama River, which empties into the Sea of Okhotsk at Yamsk.)

Tectonically the Verkhoyansk range appears to be a continuation of the Dzhugdzhur (Aldan) range, which lies along the western shore of the Sea of Okhotsk.

The Verkhoyansk system includes the Verkhoyansk range; the Tas-Kystabyt range, which lies west of the Chersky range; the Chersky range; and several other elevations in Northeast Asia. The development of dislocated Triassic marine sediments is common to all of these ranges. The folding took place roughly from east to west.

The Verkhoyansk range lies on the water divide between the Lena, the Yana, and a part of the Indigirka. To the north it extends as far as the Arctic Ocean, and to the south as far as the Suantar River, which lies in the basin of the upper reaches of the Indigirka.

[1] S. Obruchev, "Kolymsko-indigirsky kray, Geograf. i geolog. ocherk" (Kolyma-Indigirka *Kray,* Geographical and Geological Sketch), *Trudy Soveta po izuch. proizv. sil,* ser. yakut. (Proceedings of the Council for the Study of Productive Forces, Yakutian Series), No. 1, 1931, with map. U. A. Bilibin, "O khrebtakh severo-vostoka Azii" (Concerning the Ranges of Northeastern Asia), *Problemy sov. geologii* (Problems in Soviet Geology), 1935, No. 12, pp. 1079–1085.

Bilibin (1935) draws the Verkhoyansk range as far south as the lower course of the Yudoma River (a tributary of the Maya). Here, to the east of that part of the Aldan which flows from south to north, lie mountain chains with individual peaks up to 1800 m. in elevation; these chains are composed of Lower Paleozoic limestones, and, like the strata of which they are composed, are oriented in a northeast direction. Bilibin calls these chains the Setta-Daban.

In the south, in the region of the upper Indigirka, the elevations of the range reach 2500 m.; in the region of the road from Yakutsk to Verkhoyansk, 2000 m.; the range decreases in elevation to the north. The Verkhoyansk range belongs to the category of folded ranges; it is composed predominantly of a thick series of shales and sandstones ("the Verkhoyansk complex") of Upper Carboniferous, Permian, Triassic, and Jurassic age. There are no extensive Lower Paleozoic deposits in the Verkhoyansk range. The last of the folding movements which gave rise to the range took place at the end of the Triassic and the beginning of the Jurassic.[2] During the Middle Jurassic the sea withdrew from the region of the range. The presence of terraces 300 to 350 m. above the valley bottoms (A. Grigoryev, 1926) indicates that an uplift took place during the post-Tertiary period.

Vanyushin (1937) points out that the Verkhoyansk range, in the region between the Vilyuy and the Aldan rivers, must be considered not as a folded range, but as an uplifted peneplain, that is, a range of the massif type. The summits of many of the mountains have the character of a plain, so that they present the appearance of table mountains; in general, long chains are absent, but there are many large elevations which consist of flat, undissected plateaus.

> Looking down at the district from the high mountains, a picture typical for the Verkhoyansk region unfolds before the observer: as far as the eye can reach, there lie numerous separate, chaotically disposed, sandstone-shale mountains of the table type, approximately of the same height; they have gentle contours in the basin of the Yana River, and sharper relief in the direction of the Lena basin.

According to this observer, S. S. Vanyushin, the region of the Verkhoyansk range constituted a peneplain, which was uplifted during the Upper Tertiary period, and then dissected by river erosion.[3]

[2] N. P. Kheraskov, "Skhema tektoniki Verkhoyanskoy skladchatoy zony" (Scheme of the Tectonics of the Verkhoyansk Folded Region), *Problemy sov. geologii* (Problems in Soviet Geology), 1935, No. 4, pp. 368–382.

[3] S. S. Vanyushin, "Fiziko-geografichesky ocherk zapadno-verkhoyanskovo rudnovo raiona" (Physical-Geographical Sketch of the West-Verkhoyansk Mining Region), *Izv. Geogr. obshch.* (Report of the Geographical Society), Vol. 69, 1937, pp. 783–788.

The range bears traces of no less than two glaciations. On the Aldan slope glaciers of the alpine type descended at one time as far as the Aldan valley.

In the upper Indigirka region lies the Oimekon Plateau, which does not exceed 1500 m. in elevation. It is noted for its low winter temperatures, which rival those of Verkhoyansk.

The Chersky range (or Ulakhan-Chistay), which consists of several parallel chains, cuts across the upper course of the Indigirka and the Kolyma. The Chersky range is little known, and Bilibin doubts even that it exists as a separate orographic entity, maintaining that, at least in the southern part, it is not a folded range, but a "vast upland consisting of elevations of approximately uniform height, composed of sedimentary rocks, among which rise individual granite massifs." In any case, in the region where it crosses the Indigirka, the range, or upland, or plateau—whatever it may be called in this place—reaches elevations of 2000 to 2500 m., and perhaps even higher. Both the Kolyma and the Indigirka cut the range at right angles in narrow gorges, or "rift" valleys. The rift valley of the Indigirka, which passes through the highest part of the range, is particularly majestic; here the valley floor lies 1500 to 2000 m. below the summit of the range. Part of the range extends beyond the Kolyma onto the Pacific slope, in the direction of the Sea of Okhotsk. Along the Pacific the mountain ranges usually lie parallel to the contour of the shore, but in this place the Triassic folds lie SSE–NNW, while the shore trends east and west.

The Chersky range consists fundamentally of the same thick folded series of rocks (the Verkhoyansk complex) as the Verkhoyansk range; on the north it joins chains which consist predominantly of Paleozoic deposits; in both formations granite intrusions, which compose the highest parts of the chains, are very common.

Bilibin is inclined to call these Paleozoic chains a range, pointing out that they are equivalent to the Tomus-Khay, or Garmychan range, which lies in the basins of the rivers Moma (a right tributary of the Indigirka) and Yasachnaya (a left tributary of the Kolyma). The Garmychan range continues west across the Moma basin along the left bank of the Indigirka, and merges into the Tas-Khayakhtakh range,[4] which lies on the watershed between the Indigirka and the Yana. At any rate, the geological structure of the Tas-Khayakhtakh range is related very closely to the structure of the Paleozoic chains of the Chersky range; granites are very extensive in both formations.

[4] Concerning this range, see V. A. Fedortsev, *Izv. Gos. geogr. obshch.* (Report of the State Geographical Society), 1935, No. 5, p. 592.

During the glacial period a tremendous ice sheet covered the Chersky range. In the region where the Indigirka cuts through the range, glaciers descended to an elevation of 400 m., as is evident from the presence of moraines at this elevation. Some of the glaciers were over 150 km. long.

Between the Kolyma (Fig. 78) and its right tributary, the Omolon, lies the Yukagirsk Plateau, which has an elevation of 300 to 800 m. It is composed chiefly of horizontal Triassic deposits.

Along the shore of the Sea of Okhotsk, northeast from the Yama River (which empties into the Sea of Okhotsk at Yamsk), lies the Kolyma, or Gydan range, which has an average elevation of 1500 to 1600 m. in the upper course of the Omolon River. The Kolyma (Gydan) range does not reach as far north as the basin of the Bolshoy Anyuy River, a right tributary of the Kolyma. Traces of former glaciation have been discovered in this range.

On the watershed between the Anadyr and the rivers of the Arctic Ocean basin lies the Anadyr range, with elevations over 2000 m.[5] On the northern shore of Kresta Bay lies Mount Matachingay (elevation about 2800 m.),[6] the highest point in Chukotsk National *okrug;* it rises sharply above the surrounding heights, which do not exceed 450 to 600 m. Matachingay may be a volcano—andesites and liparites have been found at its foot. In the vicinity of Matachingay traces of former glaciation are very distinct.

From the Parapolsky Dol (which divides Kamchatka from the continent) the Koryak range extends to the northeast. The elevations do not exceed 1500 m.

We must keep in mind that traces of ancient glaciation in northeastern Siberia are found only in the mountains. As in Alaska, there were no glaciers in the lowlands. This fact is corroborated not only by geomorphological data, but also by evidence from the fields of botanical and zoological geography.

Climate

Very little is known of the climate of the mountains of Northeast Siberia, because there are no meteorological stations in the mountains. However, the following data deserve mention. In the southern foothills of the Verkhoyansk range, at an elevation of 1020 m., in lat. 64° N, lies

[5] S. Obruchev, "Orograficheskу ocherk Chukotskovo okruga" (Orographic Sketch of Chukotsk *Okrug*), *Trudy Arktich. inst.* (Proceedings of the Arctic Institute), LIV, 1936.

[6] According to Litke (1828), the elevation of Matachingay is 2625 m.

the Mangazeisk silver-lead deposit (formerly the Semenovsk mine), where meteorological observations, conducted during the course of one year (1917–1918),[7] showed that a large-scale inversion of temperature takes place in winter. In January it is comparatively warm, the mean temperature being − 29° C., while in Verkhoyansk it is − 50° C., and in Yakutsk, − 43° C. The mean July temperature is only 8.3° C. There was very little precipitation during that year, only 163 mm. (a maximum in August, 44 mm.). In the upper reaches of the Indigirka, on the Oimekon Plateau, very low winter temperatures (lower than − 60° C.) have been recorded during recent years.

Vegetation

In the Verkhoyansk range the Dahurian larch predominates. In the foothill river valleys it is accompanied by Mongolian poplar; in some places on sandy soils there grow small pine woods. In the mountains on the southern slope, the larch is accompanied sporadically by birch; and in the valleys, on the podzolic soils which lie above the flood plain, by Siberian spruce. Along the streams and brooks there are small woods of Mongolian poplar, willow, larch, and individual spruces. The larch forest along the road from Yakutsk to Verkhoyansk rises to an elevation of 950 m., while individual larches occur even 100 m. higher. Above this lies wooded tundra of recumbent birches (*Betula middendorffii* and *B. subtilis*), recumbent Japanese stone pine, and a series of flowering herbaceous plants. The pass lies here at an elevation of 1420 m.[8] On the northern slope of the Verkhoyansk range there is no spruce. To the east, along the passes in the Indigirka basin, larch forests occur up to an elevation of 1400 m.[9] In the Chersky range near the Arctic Circle, on the Indigirka River, the timber line lies at an elevation of 650 m. As in the Verkhoyansk range, there is some Erman's birch (*Betula ermani*) in the Chersky range.

East of the Kolyma basin the mountains are unforested, with this ex-

[7] V. B. Shostakovich, "Materialy po klimatu Yakutskoy A.S.S.R." (Materials Concerning the Climate of the Yakutsk A.S.S.R.), *Mat. Yakut. kom.* (Materials of the Yakutian Commission), VI, 1927.

[8] A. Birkenhof, in the publication *Lesnie resursy Yakutii* (Forest Resources of Yakutiya), "Yakutskaya A.S.S.R." (The Yakutian A.S.S.R.), No. 3, izd. Akad. nauk (publication of the Academy of Sciences), 1932, p. 14.

[9] S. N. Nedrigailov, *Mat. Kom. po izucheniyu Yakutii* (Materials of the Commission for the Study of Yakutiya), XII, 1928, pp. 356–361. According to Chersky (1893), on the northeastern slope of the Verkhoyansk range, in lat. 63° N, the forest extends up to 1730 m.; I have pointed out the improbability of this figure in *Osnovy klimatologii* (Principles of Climatology), 1927, p. 255.

ception: along the upper course of the Anadyr and the middle course of its tributary, the Main, there are larch forests.

The northernmost outposts of forest in northeastern Siberia are along the right (northern) tributaries of the Maly Anyuy (a tributary of the Kolyma); here Dahurian larch is found in lat. 69° N. In the upper reaches of the Bolshoy and Maly Anyuy rivers, the larch, as has been pointed out, extends into the basin of the Anadyr, but it has spread only along the upper course, as far south as lat. 65° N.

Along the river valleys of Anadyr *kray*, beyond the boundary of continuous forests, are scattered small woods of Mongolian poplar (*Populus suaveolens*) and the relict Korean willow (*Salix macrolepis*); here and there on the elevated portions of the valleys there are small islands of white birch (*Betula cajanderi*). In the valley of the Anadyr, Japanese stone pine (*Pinus pumila*) is widespread; there is Japanese stone pine lower down also, next to the flood plain, as well as on the hills and on the mountain slopes; in some places it forms vast impassable thickets (L. Portenko).

At one time, apparently during the xerothermic period, forests occupied a greater extent in Anadyr *kray*, but today they have been replaced by tundra or wooded tundra.

In the Verkhoyansk and Kolyma (Gydan) ranges, as in the adjoining lowlands, forests of Dahurian larch, with an undergrowth of Japanese stone pine, predominate. Poplar and willows grow in the valleys. In the mountains of the Anadyr and Penzhina basins, a subalpine type of vegetation is widespread; it takes the form of Japanese-stone-pine groves with Manchurian alder (*Alnus fruticosa*) and shrubby Middendorff's birch (*Betula middendorffii*), and with a great many lichens. On the Chukotsk Peninsula and in the Anadyr range, lichen tundras and areas covered with talus predominate.

Fauna

The fauna of the mountains of northeastern Siberia has been little studied. The mammals include the mountain sheep (*Ovis nivicola*), which is found as far as Chukotsk National *okrug*;[10] musk deer; black-capped bobac (*Marmota camtschatica bungei*), which is associated with the high-mountain tundra; and Kolyma suslik (*Citellus eversmanni buxtoni*), which does not ascend high into the mountains and is not found in the Verkhoyansk range. Another animal found here is the lemminglike

[10] According to the Luoravetlans, at one time the mountain sheep extended as far as Cape Dezhnev.

mountain vole (*Arvicola lemmina* [*Aschizomys lemminus*]). The suslik and bobac go into hibernation during the cold period of the year, which lasts eight to nine months, and sleep in the permanently frozen subsoil. The presence of steppe rodents (suslik and bobac) so far north and up in the mountains is curious. The squirrel, fox, and ermine are very common in the mountain forests. In the Verkhoyansk range the Amur lemming (*Lemmus amurensis*) has been found; apparently, it descended from the mountains of eastern Siberia into the Amur basin during the glacial period. Among the birds of economic importance, the capercaillie (*Tetrao parvirostris*) and the hazel grouse (*Tetrastes bonasia*) are common. Other typical birds which nest in the mountains include the harlequin duck, mountain-tundra ptarmigan, Polynesian tattler (*Heteractitis incana brevipes* [*Heteroscelus brevipes*]), and Mongolian plover (*Aegialitis mongolus* [*Charadrius mongolus*]). The nutcracker (*Nucifraga caryocatactes macrorhynca*) is common in the thickets of Japanese stone pine, where it feeds on the pine nuts. The tundra ptarmigan (*Lagopus mutus*) inhabits the rock-strewn areas overgrown with lichens.

The great knot (*Erolia tenuirostris*)[11] nests in the alpine zone of the mountains of Anadyr *kray*, at an elevation of 500 to 600 m.

[11] L. A. Portenko, "Ornitogeograficheskie sootnosheniya na krainem severo-vostoke Palearktiki v svyazi s osobennostyami landshafta" (Ornithogeographical correlations in the Extreme Northeast of the Palearctic, in Relation to the Landscape Features), *Pamyati M. A. Menzbira* (In Honor of M. A. Menzbier), Moscow, 1937, izd. Akad. nauk (publication of the Academy of Sciences), p. 395.

XVII · Mountains of the Far East

(THE AMUR BASIN)

THIS CHAPTER DEALS with the Amur basin, except for the Shilka and Argun basins, which are described in Chapter XV.

Relief

Geographers at one time pictured the Stanovoy range, which they drew from the Trans-Baikal to Bering Strait, as lying on the watershed between the Arctic and the Pacific oceans. This conception originated in the first half of the seventeenth century, when the Cossacks from Yakutsk penetrated across the mountains to the Sea of Okhotsk in one direction, and in the other, into the Amur basin, at the point where the Zeya empties into the Amur and where Blagoveshchensk stands today (Poyarkov in 1644). But this conception is inadmissible, first of all, because the outlying spurs of the Chersky range (pp. 313–314), which extend as far as the northern shore of the Sea of Okhotsk, cross the expanse of the conjectural Stanovoy range at a right angle. Furthermore, as Kropotkin wrote, back in 1875, "there does not exist any single range—either high or low, either steep or flat—which lies along the watershed between the waters of the Pacific and the Arctic oceans." Kropotkin referred to the region of the upper Olekma. The most recent investigations confirm anew Kropotkin's conception, concerning not only the upper reaches of the Olekma, but also, to the best of our knowledge, the region as far as the upper reaches of the Zeya, as well. The rivers of the Lena and Amur basins do not have their source in a water-divide range, but originate on a rather high plateau bordered on the north and south by ranges across which rivers force their way either toward the Lena or toward the Amur. The border range which faces the Lena basin is usually called the Stanovoy, but it does not have any significance as a water divide.

The Stanovoy range in the upper reaches of the Zeya was explored by Prokhorov in 1911. The watershed between the Zeya and the Lena basins is a plateau, lying at an absolute elevation of 1300 to 1450 m. and covered with lakes and low ridges. On the north and on the south this plateau is bordered by mountain chains. The highest chain, which, as we have said, may be called the Stanovoy range, lies on the north. It is interesting to note that the rivers of the Lena basin have their source not on the northern slope of this chain (that is, not in the Stanovoy range), but at the foot of its *southern* slope; they cut across the chain transversely. The elevations of the main chain of the Stanovoy range, which drops sharply to the north, reach 2000 to 2500 m. The southern, secondary chain is much lower; the peaks here do not exceed 1400 m. in elevation.

Today the name Stanovoy is given to the system of ranges which lie between the upper reaches of the Aldan River and its tributary the Maya. The structure and tectonic history of the Stanovoy range are the same as those of the northern Trans-Baikal and the Olekma-Vitim mountain country, and the principal folding in all of these regions is attributed to the Lower Paleozoic.

To the west the Stanovoy merges into the system of chains which are known as the Olekma-Baikal system.[1] This system, which extends from the upper reaches of the Aldan to the northern end of Lake Baikal, is composed of two ranges: the eastern, which lies between the big rapids on the Olekma in lat. 57° N and the region in which the Muya empties into the Vitim, is the Udokan range; west of the Vitim lies the other range—the South-Muya. The Olekma-Baikal system lies approximately east-northeast. The elevations in this system reach 2000 m.; elevations of 2800 m. and more have been reported in the Udokan range, but these figures are not reliable. In the Udokan and neighboring ranges there are distinct traces of glaciation.[2] At the eastern end of the Udokan range, in the region where it approaches the Olekma River, it joins the north-eastern end of the Yablonovy range; this mountain country is strongly dissected.

According to V. Obruchev, the Olekma-Baikal range is part of the Stanovoy system, but I do not agree. The Stanovoy range was under-

[1] For details see L. S. Berg, Uchenie zap. Mosk. univ. (Scientific Report of Moscow University), (Geography), 1936, p. 62.

[2] A. A. Arsenyev, "K geomorfologii Olekmo-Vitimskoy gornoy strany" (Concerning the Geomorphology of the Olekma-Vitim Mountain Country), *Byull. Mosk. obshch. isp. prir.* (Bulletin of the Moscow Society for Natural Research), otd. geol. (Geological Section), XV, 1937, pp. 422–431.

stood originally to be a range lying at least approximately in the region of the watershed between the Lena and the Amur; the Olekma-Baikal range, however, belongs entirely to the Lena system.[3]

The Bureya range, or the Little Khingan, begins in the upper reaches of the Selemdzha, crosses the upper course of the Bureya, and then extends toward the Amur, with the Bureya on its right side. In the north this range reaches elevations over 2000 m.[4] In addition to deep-lying igneous and metamorphic rocks, it contains undisturbed Paleozoic, as well as Mesozoic rocks. Where the Bureya Mountains cross the Amur, the river flows through a narrow gorge, which has sheer cliffs in some places.

Between the Ussuri River and the lower Amur on the west, and the Sea of Japan and Tatar Strait on the east, lies the Sikhote-Alin mountain system, consisting of a series of ranges extending in a northeast-southwest direction. In the south the Sikhote-Alin extends as far as Vladivostok. It does not follow that the highest range of the Sikhote-Alin lies on the water divide between the Sea of Japan, on the one hand, and the Ussuri and the Amur, on the other; the sources of the rivers of both these basins often extend to the opposite slope.

According to the character of the seacoast, the eastern slope of the Sikhote-Alin may be divided into two strikingly different sections. The southern, from Peter the Great Bay to Olga Bay, is strongly dissected, and has many indentations. The northern, from Olga Bay to DeCastries Bay, has undissected shores; here, with the exception of Sovetskaya Gavan, there is not one bay. The explanation for these differences in the coast line lies in the fact that to the north of Olga Bay the shore lies parallel to the chains of the Sikhote-Alin, while to the south the shore line cuts across the mountain chains at a right angle, to form Posyet, Amur, Ussuri, and other bays, as well as a number of islands (Putyatin, Askold, Russky, and others).

Individual peaks almost reach (in the south, northeast of Suchan) or somewhat exceed (in the north, in lat. 48½° N) 1900 m.[5] The mean elevation of the peaks is 650 to 850 m.

At the extreme south, in Suchan *raion*, the highest peaks only slightly

[3] See Berg, *op. cit.*

[4] S. L. Kushev, "K geomorfologii Bureinskovo khrebta" (Concerning the Geomorphology of the Bureya Range), *Amgun-Selemdzhinskaya eksp.* (Amgun-Selemdzha Expedition), I, 1934, izd. Akad. nauk (publication of the Academy of Sciences).

[5] The highest point is Mount Komarov (elevation 1940 m.), in the upper reaches of the Kopi River (A. Yemelyanov, *Izv. Dalne-Vostochnovo filiala Akad. nauk* [Report of the Far Eastern Branch of the Academy of Sciences], 1937).

Fig. 75. The Western Sayans from the Little Abakan pass. (Sovetskaya Sibirskaya Entsiklopedia. Vol. 2: 63)

Fig. 76. Munku-Sardyk Glacier and Mt. Munku-Sardyk in the Eastern Sayans. (Sovetskaya Sibirskaya Entsiklopedia. Vol. 1: 200)

Fig. 77. Lake Baikal in November. The steep shore at Malie Koty. (Sovetskaya Sibirskaya Entsiklopedia. Vol. 1: 200)

Fig. 78. The Kolyma River in its upper reaches. (Sovetskaya Sibirskaya Entsiklopedia. Vol. 2: 855)

Fig. 79. Kronotsk volcano on Kamchatka. (Bolshaya Sovetskaya Entsiklopedia. Vol. 18: 207)

Fig. 80. Primeval stand of birch (*Betula ermani*) in Kamchatka. (*Vegetationsbilder*. Vol. 23; part 1/2; plate 8)

Fig. 81. *Angelica ursina* in a well drained valley meadow in Kamchatka. (*Vegetationsbilder*. Vol. 23; part 1/2; plate 5)

exceed 1300 m. The range is built of igneous, metamorphic, and sedimentary Paleozoic rocks. There are also basalt fields which form table mountains. The extrusion of these basalts took place at different periods; there are some pre-Tertiary basalts, but there are also some which were extruded during the Quaternary period. Along the borders Carboniferous, Triassic, and Jurassic deposits have been found; these, however, are not a part of the structure of the range itself. The Sikhote-Alin is a folded range, formed by folding which began during the Lower Cretaceous period. In Suchan rich deposits of coal are being worked; they underlie the Nikansk series (Upper Cretaceous to Lower Jurassic). At Tetyukhe (north of Olga Bay) there is a lead-zinc deposit, which lies in the form of a lens along the boundary between the porphyry and the limestones (probably Triassic). Terraces containing the shells of mollusks which still inhabit the Sea of Japan are found on the shore of that sea; they indicate that a shifting of the coast line has taken place.

Climate

Little is known about the climate of the mountains of the Far East. The monsoon type of climate is clearly in evidence (see above, pp. 60–62). Moist and cool winds from the sea prevail in summer and dry and cold winds from the land in winter. Thus, at Vladivostok, in summer, SE and S winds prevail; in winter, N, NW, and NE winds. The temperature is lowered severely when the ice melts in the Sea of Okhotsk. At Ayan, which lies on the shore of the Sea of Okhotsk only slightly north of the parallel of Moscow, the warmest month, August, has a mean temperature of only 12.6° C. (that is, 6° C. cooler than the warmest month in Moscow). As a result of the cool summer and the proximity to the ocean, forest vegetation does not rise high up into the mountains of the Far East; on the side of the Sikhote-Alin which faces the ocean, north of lat. 44° N, elevations over 1200 to 1300 m. are usually unforested. On the other hand, because of the sparsity of winter precipitation, there are no glaciers in the mountains of the Far East (with the exception of Kamchatka, which will be discussed below).

Soils

Slightly podzolic stony soils predominate, with patches of peat-bog soils among the crags and in the areas covered with talus. In the north of Amur *oblast,* on the above-mentioned (pp. 318–319) watershed plateau of the Stanovoy range, at an elevation of 1300 to 1500 m., bog and half-bog soils predominate; on these there grow thickets of rough bluejoint reed grass (*Calamagrostis langsdorfii* [*C. canadensis scabra*]). Here also in some places there are half-bog podzolic soils, covered with forests of Dahurian larch, with an undergrowth of Japanese stone pine and shrubby Middendorff's birch (*Betula middendorffii*).

Under the broad-leaved forests of Ussuri *kray*, the podzolic horizon has a gray-yellow color, as do the podzolic soils of the warm-temperate regions of Europe.

Vegetation

The forest vegetation of the Far East consists of three types: (1) The East Siberian vegetation consists predominantly of Dahurian larch. (2) The arctic, or so-called Okhotsk vegetation is characterized by Yeddo spruce, Erman's birch, Khingan fir, and some Dahurian larch;.the shores of the Sea of Okhotsk and the lower reaches of the Amur are part of the region in which this vegetation is developed. (3) Finally, along the middle course of the Amur, in the Ussuri basin, and in the southern Sikhote-Alin there is found a third type of vegetation, the Manchurian, which is characterized by a profusion of broad-leaved species (oak, maples, ash, lindens, and others), a great many southern shrubs, Korean pine, and a number of vines.

In the southern Sikhote-Alin all three types of vegetation are found: at lower elevations, the Manchurian type, which in the extreme south on the south-facing slopes extends no higher than 750 to 1000 m.; higher up, the Okhotsk type; and still higher, the Siberian taiga of Dahurian larch.

While the Manchurian element, particularly oak, makes it appearance, as we have said earlier (pp. 63–64), even east of the confluence of the Shilka and the Argun, it reaches considerable development only to the east of the Bureya River.

In the Bureya range the Okhotsk type of forest predominates in the north; the Manchurian type in the south. In the northern part of the range, forests of Dahurian larch and Yeddo spruce predominate; the latter is found in the river valleys and also at the timber line, where it grows in the subalpine coppices together with Japanese stone pine and rhododendron; there is also some Erman's birch (*Betula ermani*). The Asiatic white birch (*B. platyphylla*) is found throughout. Yeddo spruce (*Picea jezoensis*) is an ancient type, related to one of the spruces found on the Balkan Peninsula; it grows in northern Japan, Korea, Manchuria, in the Amur basin, on the Okhotsk coast, on Sakhalin, and in Kamchatka.

At not very high elevations in the mountains, along the banks of streams, there is Khingan fir (*Abies nephrolepis*) (Sochava, 1934).

In the southern part of the Bureya range, the forests have an entirely different appearance. Here on the eastern slope the following vegetation may be seen: [6] At lower elevations, at the foot of the range, lie mixed-herbaceous and shrub meadows, on which there are individual Mongolian oak and Dahurian birch trees; the shrubs are lespedeza and Siberian filbert. Higher up, on the southern slopes, there is park-land forest of Mongolian oak [*Quercus mongolica*], Amur linden, and Dahurian birch, with an undergrowth of the two shrubs mentioned above, together with Dahurian rose (*Rosa davurica*). There is also some Amur grape (*Vitis amurensis*). In the lower and middle belts of the mountains grow Korean-pine and broad-leaved forests composed of a great variety of trees and shrubs. The following species are found here: Korean pine (*Pinus koraiensis*); Amur linden (*Tilia cordata amurensis* [*T. amurensis*]); Manchurian ash (*Fraxinus mandshurica*); Khingan fir; Mongolian oak [*Quercus mongolica*]; mono maple (*Acer mono*), very closely related to the European Norway maple; maackia (*Maackia amurensis*), a papilionaceous shrub; Amur lilac (*Syringa amurensis*); and Amur cork tree (*Phellodendron amurense*—Rutaceae). The undergrowth is very profuse, consisting of Manchurian filbert, honeysuckle, euonymus, aralia (*Aralia mandshurica*), "wild pepper" (*Eleutherococcus senticosus* [*Acanthopanax senticosus*]—Araliaceae), and many other species. The trees and shrubs are twined with vines, which include Amur grape, Chinese magnolia vine (*Schizandra chinensis*), and kolomikta actinidia (*Actinidia kolomikta*). The Chinese magnolia vine, which belongs to the magnolia family, got its Russian name, *limmonik,* from the lemon odor emitted by its bark; this plant is a Japanese-Chinese form, which extends about as far north as the grape. The actinidia, which bears the local name of *kishmish,* or "raisin," is also a vine (Dilleniaceae); *A. kolomikta* rises rather high up into the mountains; its fruits are used for making compote or jam.

Somewhat farther north, these Korean-pine and broad-leaved forests of the Bureya range contain Yeddo spruce and Khingan fir. At elevations of 600 to 900 m. lie spruce-fir forests of the Okhotsk type.

It is interesting to note that the river valleys, into which the cold air

[6] V. P. Bayanova, "Medonosnie rasteniya Birobidzhana" (Melliferous Plants of Birobidzhan), *Trudy Dalne-Vostochnovo filiala Akad. nauk* (Proceedings of the Far Eastern Branch of the Academy of Sciences), I, 1935, pp. 411–417.

descends, contain larch forests, which extend into this area from the northern part of the Bureya range.

The flood plains have forests which differ little in composition from the Korean-pine and broad-leaved forests. Here the Manchurian walnut (*Juglans mandshurica*) begins to appear.

Along the Amur the Korean-pine and broad-leaved forests extend approximately as far as lat. 50° N; they reach up to 300 m. in elevation. The Korean pine, however, extends somewhat farther north, as far as the basin of the Garin River.

In the southern part of the Sikhote-Alin,[7] Manchurian vegetation is well represented; however, it does not ascend high up in the mountains. At the extreme south, in Suchan *raion,* the vertical limits of the distribution of some representatives of the Manchurian flora are as follows (I. Shishkin, 1923):

Table 26

Distribution of Manchurian Flora in the Southern Sikhote-Alin

Species	Limits of Distribution (m.)	
	Northern Slopes	Southern Slopes
Korean pine (*Pinus koraiensis*)	930	1160
Oak (*Quercus mongolica*)	450	970
Maple (*Acer pseudo-sieboldianum*)	530	970
Filbert (*Corylus mandshurica* [*C sieboldiana mandshurica*])	585	840
Grape (*Vitis amurensis*)	. . .	840
Maackia (*Maackia amurensis*)	. . .	690
Chinese magnolia vine (*Schizandra chinensis*)	415	605

As a result of felling and fires, the mixed forests which contain Korean pine turn into deciduous forests, often with spiny aralia (*Aralia mandshurica*) predominating.

The vertical vegetation belts of the Sikhote-Alin, beginning at the bottom, are as follows:

(1) In the southern Sikhote-Alin there are three types of Korean-pine and broad-leaved forests:

a) Oak and Korean-pine and broad-leaved forests. The fundamental forest-forming species here are the Mongolian oak [*Quercus mongolica*],

[7] D. P. Vorobyev, "Rastitelny pokrov yuzhnovo Sikhote-Alinya" (The Vegetation Cover of the Southern Sikhote-Alin), *Trudy Dalne-Vostochnovo filiala Akad. nauk* (Proceedings of the Far Eastern Branch of the Academy of Sciences), I, 1935, pp. 287–372.

Dahurian birch (*Betula davurica*), and Korean pine (*Pinus koraiensis*), which reaches tremendous dimensions. As a result of felling and fires, this type of forest turns into oak groves and shrub thickets, chiefly of Siberian filbert and lespedeza; the latter shrub is one of the chief mellifers of this area.

b) Along the mountain slopes grow Korean-pine and broad-leaved forests. The first layer society contains the gigantic Manchurian fir (*Abies holophylla*), which grows as tall as the Korean pine. This fir, native to South Ussuri *kray*, Manchuria, and Korea, is not found in the mountains above 300 to 400 m. In addition to Korean pine and fir, the first layer society contains birch (*Betula costata*), Scotch elm (*Ulmus montana heterophylla* [*U. glabra*]), kalopanax (*Kalopanax ricinifolia*), Amur linden, mono maple (*Acer mono*), and, occasionally, cork tree and enormous Mongolian oak trees. The second layer society consists of Manchurian linden, hornbeam, maples, mazzard cherry, and Amur lilac; sometimes there is Japanese yew (*Taxus cuspidata*), related very closely to the European species. The undergrowth is very rich in shrubs —Manchurian filbert, "wild pepper," jasmine, various species of honeysuckle, euonymus, currant, and others. This forest contains many grapevines, Chinese magnolia vine, and actinidia. In addition to the above-mentioned actinidia (*Actinidia kolomikta*), another species is found here which grows only in South Ussuri *kray;* this is *A. arguta,* the largest of the Ussuri vines, which has stems up to 16 cm. in diameter; its fruits are eaten. The herbaceous cover contains many ferns. An epiphytic fern, the linear polypody (*Polypodium lineare*), which is distributed from Japan and China to the Tian Shan, is often found growing on the tree trunks.

c) Korean-pine and broad-leaved forests with an admixture of Yeddo spruce, and with birch [*Betula costata*], Amur linden, maple (*Acer mono*), Manchurian linden, and Scotch elm (*Ulmus montana heterophylla* [*U. glabra*]) predominating, are found in the first layer society. The second layer society contains maples, hornbeam, Miyama cherry (*Cerasus maximowiczi* [*Prunus maximowiczi*]), maackia (*Maackia amurensis*), and Khingan fir; among the vines, actinidia is common, and there is some Chinese magnolia vine and grape; the undergrowth contains Manchurian filbert, "wild pepper" (*Eleutherococcus senticosus* [*Acanthopanax senticosus*]), aralia (*Aralia mandshurica*), currant, and jasmine. In the upper parts of the valleys, Yeddo spruce and Khingan fir assume a great significance; Amur cork tree (*Phellodendron amurense*) and Manchurian walnut (*Juglans mandshurica*) appear. These forests rise to about 600 m. in the south. Farther north, in addition to Yeddo spruce this type of forest also contains Siberian spruce, and there is a great deal of Manchurian ash (*Fraxinus mandshurica*).

In the extreme south of the Sikhote-Alin, in the Korean-pine and broad-leaved forests, there is Korean Siberian spruce (*Picea excelsa obovata n. koraiensis* [*P. obovata koraiensis*]), closely related to the Siberian spruce.

(2) Higher up in the mountains, the Manchurian type of vegetation (broad-leaved forests with Korean pine) is replaced by Okhotsk fir and spruce forests of Yeddo spruce, accompanied in the second layer society by Khingan fir (*Abies nephrolepis*) and Erman's birch (*Betula ermani*). In the southern Sikhote-Alin Yeddo spruce and Khingan fir grow as far as the upper limit of forest vegetation, but are found also in the valleys along the middle courses of the rivers; in the north, however, they descend as far as the seacoast. As distinguished from the Manchurian forest, the Okhotsk type contains a vigorous moss cover. Although forests of this type are found even in the extreme south of the Sikhote-Alin, they predominate in the northern part, north of the Samarga River, and also in the lower reaches of the Amur. In this type of forest vines are either completely absent or (as in the south) rare.

(3) Still higher appears the East Siberian type of vegetation—high-mountain forest of Dahurian larch. It is represented by the same types as are found in the Trans-Baikal: (*a*) with an undergrowth of Japanese stone pine, (*b*) with an undergrowth of shrubby Middendorff's birch, and (*c*) with an undergrowth of ericaceous undershrubs, among which the chief element is not the common crystal tea ledum, as in the Trans-Baikal, but the silvery ledum (*Ledum hypoleucum*). After fires, the larch is replaced by Japanese white birch (*Betula japonica* [*B. platyphylla japonica*]).

(4) In the subalpine zone there are stunted groves of creeping Japanese stone pine and golden rhododendron. There are occasional coppices of Erman's birch.

(5) On the bald summits and in areas covered with talus, lichens (reindeer moss) predominate, among which grow many ericaceous plants: ledum, cowberry, cassiope, rhododendron, and others. There are also dryads, and stunted groves which contain the same species as the subalpine strip. Finally, there is microbiota, the coniferous *Microbiota decussata* [*Thuja orientalis*?], which resembles the juniper; this shrub or small tree, which grows up to 5 m. tall, is native to the upper zones of the mountains—above 500 m. and as high as 1550 m.; it belongs to a genus which is endemic in the Sikhote-Alin.

It is worth noting that in the valleys of the Sikhote-Alin the broad-leaved Manchurian forest contains an admixture of Yeddo and Siberian spruce, species which are native to the zone which lies *above* the broad-leaved forests. The valleys of the rivers which empty into the sea contain characteristic park-land flood-plain forests of Japanese poplar (*Populus maximowiczi*), which grows tremendously tall—as tall as 45 m. In these forests there are a great many species of deciduous trees and shrubs. In some places, lying along the border of the flood plain, there are long and narrow thickets of the singular Korean willow, *Salix* (*Chosenia*) *macrolepis.*

On the eastern slope of the Sikhote-Alin, between lat. 43° and 44½° N, and from the seacoast up to an elevation of 1100 m., there grows the peculiar Korean Dahurian larch (*Larix olgensis* [*L. gmelini olgensis*]), which does not extend as far as the timber line.

Fauna

The southern Sikhote-Alin contains a number of Manchurian animal forms which do not ascend high into the mountains. These include the Japanese deer (*Cervus nippon* [*Sika nippon*]), which is found between Olga Bay, the Iman River, and Lake Khanka, as well as in the adjoining parts of Manchuria and Korea; in the southern part of the Primorye this deer is bred for its antlers, which are sold in China. Among the other animals are the Himalayan black bear (*Selenarctos tibetanus ussuricus*), native also to the Bureya range and Japan; Ussuri elk; Amur goral (*Nemorhaedus goral*); yellow-throated marten (*Martes flavigula* [*M.* (*Lamprogale*) *flavigula borealis*]); and Amur badger (*Meles amurensis* [*M. leptorhynchus amurensis*]); the sable and musk deer are Siberian forms found here.

The Siberian spruce grouse (*Falcipennis falcipennis*), a member of the grouse family, closely related to the North American *Canace canadensis* [*Canachites canadensis canace*], is associated with the region of Okhotsk flora, and particularly with the forests of Yeddo spruce.

Siberian forms predominate in the northern ranges.

XVIII · Sakhalin[1]

THE island of Sakhalin, over 950 km. in length, lies approximately between the latitudes of Tula and Odessa. Only the northern half of the island, from lat. 50° N, belongs to the U.S.S.R.[*]

It will be recalled that during the first half of the last century, Sakhalin was considered a peninsula, connected with the continent south of the mouth of the Amur River. However, two hundred years before that time, it was known to Russians that Sakhalin was an island. Thus, in the curious "Account of the Great River Amur, Which Divides the Russian Settlement from the Chinese," a document drawn up during the last half of the seventeenth century (before 1689), we find the following statement:

> One of the mouths of the famous great river Amur, which is mountainous and forested, empties into the ocean, and *opposite that mouth there is a great island;* and on that island live many foreigners, the *Gilyak peoples.* Their yurts are of hewn wood, and they wear clothes made of sable and fox and animal skins, and ride on dog-drawn sledges in winter, and in summer on the water in boats, and they keep from 500 to 1000 dogs in their settlements; they subsist on all kinds of animals and fish.[2]

Without any doubt it was Sakhalin which was being described.

Opposite Cape Lazareva, Sakhalin is separated from the continent by a strait only 7.5 km. wide. This strait is named after Nevelsky, who discovered it in 1849.

[1] D. V. Sokolov and N. N. Tikhonovich, *Sakhalin (priroda, naselenie, bogatstva)* (Sakhalin [Natural Features, Population, Resources]), Moscow, 1925, p. 126, with map.

[*] The entire island is, of course, now Soviet, the southern half having been occupied by Soviet forces in August, 1945. Berg describes the northern half of the island only.—Tr.

[2] See A. Titov, *Sibir v XVII veke* (Siberia in the Seventeenth Century), Moscow, 1890, p. 110.

Relief

From the Japanese boundary almost as far as lat. 51° N, mountain ranges lie along each coast; from lat. 51° to 51½° N, the ranges decrease in elevation and recede somewhat from the shore; finally, still farther north, there are areas of lowland up to 30 km. wide along the shore, and the height of the mountains diminishes still further, exposing this part of the island to cold winds from the Sea of Okhotsk. The eastern range, which is higher in elevation, in the south (lat. 50½° N) reaches 2013 m. in Mount Nevelsky; this is the highest elevation on Sakhalin. The western range is called the Kamyshevy range, after the thickets of bamboo (locally known as *kamysh*); in the south it reaches elevations of 1022 m. The northern tip of Sakhalin, which is called Schmidt Peninsula (in honor of the scholar F. B. Schmidt, who explored Sakhalin), reaches elevations of 708 m.

South of lat. 52° N, in the middle of the island (as also in the middle of Kamchatka), lies a lowland, drained by the Tym River in the north and the Poronay in the south. This lowland, bordered on the east and west by mountains, is from 5 to 30 km. wide, and up to 150 m. in elevation. As it is sheltered from winds, it has a relatively more continental climate than the coasts, and is better suited for agriculture than any other part of the region.

Wide lagoons, separated from the ocean by long and narrow sand spits, and kept fresh by the rivers which empty into them, are very characteristic of the eastern coast. These lagoons are comparable to the Frisches Haff, Kurisches Haff, and other lagoons of the Baltic Sea. They afford easy and safe communication for tens of kilometers. Steamers are able to enter some of them.

The structure of Sakhalin includes igneous rocks (syenites, diabases, andesites, porphyries, and basalts, but no granites); metamorphic rocks of Paleozoic age; and, finally, Cretaceous, Tertiary, and post-Pliocene sedimentary deposits. Among the Cretaceous deposits, black or dark-gray argillaceous shales predominate. The Tertiary deposits are developed predominantly in the western range, in the northern part of the eastern range, and on Schmidt Peninsula.

The deposits of the Tertiary, and to some extent also of the Cretaceous system, are very rich in coal of excellent quality. The greatest coal-bearing regions are the western coast, the central lowland, and, finally, the eastern strip (west of the region of oil-bearing deposits). In some places in the

Tertiary deposits on the eastern coast there are oil beds; these are found occasionally also on the western coast.

Post-Tertiary marine deposits, developed up to elevations of 60 to 120 m., and in some places, on the western coast, up to 275 m. (Krishtofovich), form distinct terraces (usually four) along the shores.

All of the Tertiary and Cretaceous deposits of Sakhalin are strongly dislocated; folding was accompanied by radial displacements. The chief epoch of mountain-formation was during the period between the Pliocene and the beginning of the post-Tertiary marine transgression, the deposits of which lie horizontally or nearly so. Before the post-Tertiary transgression, Sakhalin was connected with the continent in the region of Nevelsky Strait. No traces of glaciation have been discovered on Sakhalin.

Climate

The climate of Sakhalin is more severe than might be expected from the position of the island. The summer is cool and the winter cold; the explanation lies in the cold winds—in summer, south, southeast, and east, blowing from the cold sea; in winter, northwest, that is, from the region of the Siberian anticyclone. The eastern coast has a more severe climate than the western. The climate is milder in the central lowland. Although frosts of almost − 50° C. occur here in winter, in summer the temperature rises to over 30° C. In spring there is a period of drought, while in summer and autumn there are monsoon rains. At the beginning of June, the summer is in full swing in the central lowland, while along the eastern and northwestern coast there is snow until July, when the scant vegetation is just beginning to come to life on the permanently frozen soil (Krasyuk, 1927).

Winter on Sakhalin is long, bitter, and windy. All of these factors are adverse to the cultivation of winter grains, but spring wheat yields an excellent harvest in the central lowland.

The climate in the interior of the island and along the coast may be compared by examination of the mean monthly temperatures for Aleksandrovsk and Kirovskoye, which lie in the same latitude (Table 27, p. 331). The data show that the summer temperature is almost the same in both localities, while the winter is somewhat milder on the coast. Precipitation is greatest in summer and autumn, when the moist sea monsoon blows, and least in winter. The number of days with precipitation is great. Snow remains in the mountains until the middle of August, but there are no everlasting snows. The mean annual figure for cloudiness on

Table 27

CLIMATE OF ALEKSANDROVSK AND KIROVSKOYE, ON SAKHALIN

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
Aleksandrovsk * temperature (°C.)	−19.1	−15.6	−9.6	−0.2	5.2	10.8	15.5	16.2	12.0	4.1	−5.6	−13.9	0.0
Kirovskoye village † temperature (°C.)	−23.4	−18.4	−11.2	−0.9	5.3	11.4	16.2	15.7	10.9	2.0	−8.8	−18.4	−1.6
Precipitation (mm.)	17	14	23	31	35	46	70	87	88	81	41	33	566

* On the west coast, lat. 50° 54′ N, absolute elevation 16 m., 1881–1915.

† On the Tym River, lat. 50° 44′ N, absolute elevation 125 m.; temperature, 1881–1915; precipitation, 1886–1904.

Sakhalin is about the same as on the shores of the Gulf of Finland, 60 to 65 per cent, but its seasonal distribution is entirely different. On Sakhalin cloudiness is greatest in summer, least in winter and spring; cloudy days are most numerous in summer, clear days, in winter; this distribution is a result of the monsoon climate.

The Sakhalin coast is famous for its fogs, which often last for weeks at a time. As one ascends into the mountains, the fogs disappear; fogs are few also in the central part of the island. On the eastern coast the most persistent fogs occur in May, June, and July; fogs are uncommon in winter.

Permanent ground frost is very widespread, although not continuous. The rivers on Sakhalin are covered with ice from the beginning of December to the middle of April. The open sea does not freeze along the eastern coast or in the southern part of Tatar Strait; but near the shores and in the bays along the eastern coast there is ice. The Amur estuary and the Gulf of Sakhalin also freeze annually.

High water in the rivers occurs three times a year—in spring, due to the melting of snows in the valleys; somewhat later, due to the melting of mountain snows; and, finally, in the latter half of the summer, due to rains.

Soils

The soils of Sakhalin belong to the podzolic, bog, and alluvial types. Alluvial soils developed in the central lowland are very fertile. They have a clay-loam texture and granular structure, and contain 6 to 8 per cent humus and a great deal of phosphorus. "Apparently," says Krasyuk, "annually over a long period of time masses of salmonid species died along the river banks and were covered with silt; as they decayed, they enriched the soil with humus, phosphorus, and nitrogen, thereby contributing to the richness of the alluvial soils."[3] These soils yield an excellent wheat harvest. On the alluvial soils in the Tym valley there are tall herbaceous meadows (with scattered clumps of birch) or spruce-fir forests.

Vegetation

The flora of Sakhalin belongs, in general, to the Okhotsk type, but includes also a certain admixture of Manchurian elements, which increase in number as one moves south. But even in the northern part of the island, we find in the west such plants as the Mongolian oak [*Quercus mongolica*], *ukurundu* maple [*Acer caudatum ukurunduense*?], Manchurian ash, elm, "wild pepper" [*Acanthopanax senticosus*], and others. The presence of bamboo, which grows only in the western range, is very characteristic.

Like the opposite shore of Tatar Strait, Sakhalin lies in the taiga zone. Spruce-fir forest predominates, often with an admixture of birch. All of the foothills and mountains are covered with these forests, which grow on podzolized clays or clay loams. The spruce belongs to two species—Yeddo (*Picea jezoensis*) and Sakhalin (*P. glehni*); the latter, native also to Hokkaido and the southern Kurile Islands, has a bark which resembles the bark of the fir. The Sakhalin fir (*Abies sachalinensis*), which has the same distribution as the Sakhalin spruce, is related rather closely to the Khingan fir. Spruce predominates in the first layer of the forests; fir, in the second. In localities which have more favorable climatic conditions, spruce and fir are accompanied by aspen, birch, elm, ash, maple, willow, poplar, and even oak. Japanese white birch (*Betula japonica* [*B. platyphylla japonica*]) grows in the lowlands and in the foothills, while in the mountains there is Erman's birch, which will be discussed below.

On poor soils and on peat bogs there is Dahurian larch (*Larix dahurica* [*L. gmelini*]), which takes the place of pine here. In the valley of the Poronay, on sandy ridges, grow larch forests of the pine-grove type; they have a ground cover of reindeer moss. In addition to larch, these groves contain birch, and also Japanese stone pine (*Pinus pumila*). Deer

[3] A. A. Krasyuk, "Selskokhozyaistvenny promysel na Sakhaline v svyazi s pochvennymi usloviyami" (Agriculture on Sakhalin and Its Relation to Soil Conditions), *Soobshch. Otd. pochvoved.* (Report of the Soil Science Section), No. 2, Leningrad, 1927, p. 56, with map.

often graze in these larch groves. Larch forests are widespread along both the western and eastern shores, below the zone of the spruce-fir taiga. There are many larch forests on Schmidt Peninsula. In some places, where the seacoast is higher in elevation, the larch forest extends down to the very sea, but on low-lying shores the larch forest merges gradually into "tundra," passing through a stage of puny dwarf larches. "Tundras" are developed both on the eastern coast and in the region of the Amur estuary, as well as along the upper course of the Poronay River. On the sandy coasts there is dry "tundra," covered with lichens and bushes of birch, alder, Japanese stone pine, sweetbrier rose, and others. In the north, on mossy peat bogs with permanently frozen subsoil, there lies a tundra covered with peat mounds and very similar to the typical tundras of northern latitudes; here grow ledum, leather leaf, bog bilberry, cranberry, cloudberry, sundew, sheathed cotton sedge, and sedges.

In the flood plains the herbaceous plants reach a tremendous height—3 to 4 m. Such tall herbaceous stands consist of the groundsel *Senecio cannabifolia,* which is called nettle here, because of its resemblance to that plant; Kamchatka meadowsweet; Japanese butterbur, or *lopukha* (*Petasites japonicus*); Sakhalin knotweed (*Polygonum sachalinense*); reed grass; fern; and others. In the river flood plains, *yelans* are numerous —plantations of willow, poplar, Mongolian poplar (*Populus suaveolens*), Asiatic smoothleaf elm (*Ulmus foliacea propinqua* [*U. carpinifolia*]), and Manchurian ash; among the willows the Korean willow (*Salix macrolepis*) is distinguished for its size. The river valleys contain, in addition, Manchurian alder (*Alnus hirsuta*), hawthorn, elder, bird cherry, and mountain ash. The older flood plains, which are not subject to inundation, are covered with mixed forests.

On the cut-over or burned-over areas grow Japanese-white-birch groves (*Betula japonica* [*B. platyphylla japonica*]) containing alder or larch. With the passage of time these forests change into spruce-fir or larch forests.

As one ascends into the mountains on the western coast, Erman's birch (*Betula ermani*) and Kurile bamboo (*Sasa kurilensis,* locally called *kamysh*) appear in the spruce-fir forests. Western Sakhalin is the only place in the U.S.S.R. where bamboo grows in its wild form. In some places the bamboo forms dense and tall thickets which are difficult to penetrate. Both bamboo and Erman's birch are absent in the eastern range. Still higher lies a belt of Japanese stone pine (*Pinus pumila*), and, finally, an alpine belt. The Japanese stone pine is widespread not only in the mountains, but also along the coasts, where it forms thickets sometimes impassable except with the aid of an ax.

Fauna

The fauna, like the flora, is an admixture of Manchurian, Siberian, and Okhotsk elements. Of the mammals, there is an abundance of bear, glutton, lynx, sable, squirrel, chipmunk, flying squirrel, fox, wolf, and hare. The reindeer belongs to the Okhotsk-Kamchatka form. The birds include the Siberian spruce grouse (*Falcipennis falcipennis*), a member of the grouse family; this bird is a representative of the Okhotsk fauna; it has been mentioned previously (p. 327).

Of the lizards there is the common lizard (*Lacerta vivipara*). The frogs include the Siberian *Rana amurensis*, native to the mound bogs which contain ledum and cloudberry. In the rivers pink salmon and chum are numerous. The Sakhalin pike belongs to the Amur form (*Esox reicherti*). Among the fresh-water mussels on Sakhalin are (according to V. I. Zhadin): cristaria (*Cristaria plicata*), a large Manchurian form, native also to the Amur basin, Japan, and China; the Sakhalin fresh-water pearl mussel *Margaritana sachalinensis;* and Bering's anodonta (*Anodonta beringiana*); the last two forms belong to the category of Okhotsk fauna.

XIX · Kamchatka

KAMCHATKA lies between lats. 60° and 51° N, that is, approximately between the latitudes of Leningrad and Kiev; but its natural features are entirely different. Kamchatka is the only place in the U.S.S.R. where there are active volcanoes at the present time.

Relief

In the middle of the peninsula, there lie two parallel ranges extending SSW–NNE, and separated by a depression in which flows the Kamchatka River. The same type of structure—two ranges with a depression between them—is found also farther north in Anadyr *kray,* as well as in Sakhalin, in Alaska, and along the western coast of North America. The western range of Kamchatka, sometimes called the central range, reaches an elevation of 3660 m. in the Belaya or Ichinsk volcano. This is the only volcano active today in the central range; its crater always smokes. The central range is composed of phyllites and crystalline schists, which are overlain by sandstones and shales, perhaps of Paleozoic age; higher up there are volcanic rocks, apparently of Mesozoic age; the western boundary of this series is overlain by dislocated Tertiary strata.

Between the central range and the Sea of Okhotsk lies an unforested region (in the literature it is often called a tundra), which rises to an elevation of 600 to 750 m. Its structure includes dislocated marine Pliocene and some Upper Cretaceous deposits.

On the western side of the peninsula there is not a single active volcano, but there are some fifteen old extinct volcanoes and andesitic laccoliths.

Between the eastern range and the coast of the Bering Sea, there are eighteen volcanoes active at the present time, of which the most interesting will be mentioned here. Beginning at the south, 30 km. northeast of Petropavlovsk, there is the Avacha volcano (elevation 2725 m.), which erupted last in 1926. In 1927 this volcano emitted ash, and in subsequent years it has emitted vapors and gases, chiefly sulphurous gas and hydrogen sulphide, but also some hydrogen chloride. Avacha has a structure like Vesuvius, but is twice as high. The lavas of Avacha belong chiefly to the andesitic type.[1]

The Kronotsk volcano, 3730 m. in elevation, situated on the shore of a deep lake (depth, 128 m.) of the same name, has been considered extinct; but in 1922 a blackish smoke was observed near the summit (Fig. 79).

Klyuchevsk volcano, 4860 m. in elevation, in the lower reaches of the Kamchatka River, is the highest point on the entire peninsula and one of the most grandiose volcanoes on earth; it surpasses Mont Blanc in elevation. It has erupted repeatedly, the last time in 1931. According to legend, somewhat before the coming of the Russians (1696) a violent eruption took place, in the course of which the lava reached as far as the Kamchatka River at Klyuchi village, 32 km. away from the crater. Usually above the summit smoke billows in the form of gigantic cabbage heads, sometimes rising two or more kilometers above the crater; from within these clouds of smoke, ashes and stones often rain down on the slopes of the volcano. The crater, into which investigators descended in 1935, has a diameter of 250 to 300 m. and a depth of 50 m. As the party descended into the crater, they saw

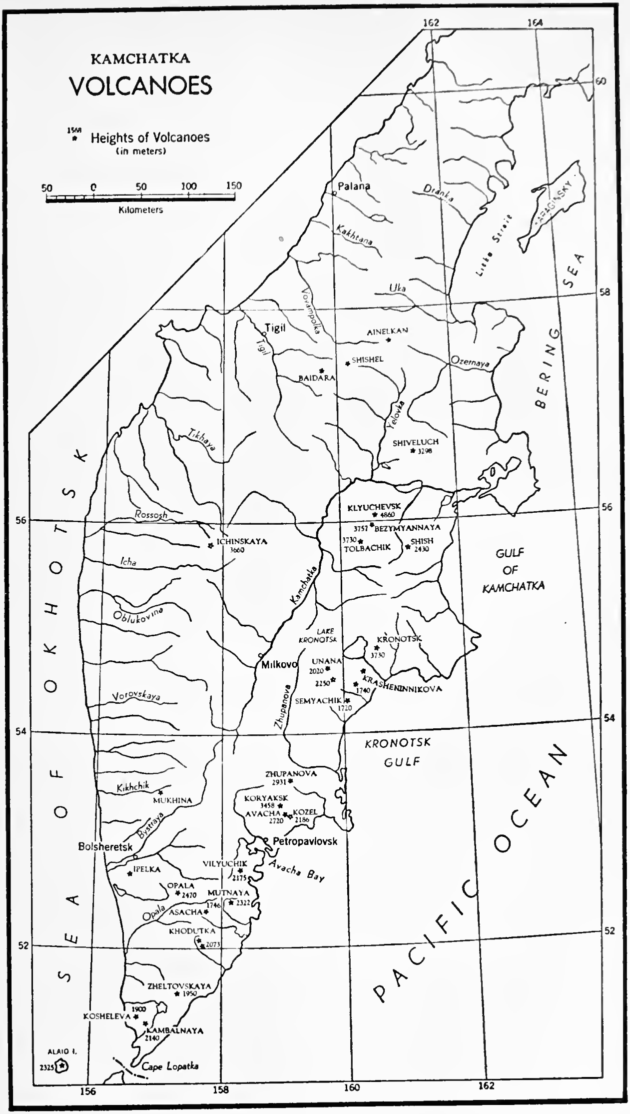
> clouds of ash and stones, many of them a bright iridescent red color, which rose in a fan 200 to 300 m. high and fell back with a crash. Dark gray smoke enveloped the crater continually. The strong odor of the sulphurous gas and hydrogen chloride irritated the nose and throat. Within the crater reigned twilight gloom and darkness, which made the bright color of the incandescent rocks stand out more sharply and brightly. Crashing and rumbling shook the whole basin of the crater. At about 4:00 P.M., while we were inside the crater, a particularly powerful explosion took place: a gigantic cloud rose and began to inundate the whole basin of the crater with a hail of incandescent rocks.[2]

Finally, the northernmost active volcano of Kamchatka is Shiveluch (elevation 3300 m., lat. 56°39′ N), of which the most recent eruption took place in 1928; there are six glaciers on Shiveluch.

Where the peninsula joins the mainland, from Korf Bay in the Bering Sea (in lat. 60° N), to Penzhinskaya Bay in the Sea of Okhotsk, there lies a low plateau, the Parapolsky Dol, 155 m. in elevation. This plateau

[1] A. N. Zavaritsky, *Problemy sov. geologii* (Problems in Soviet Geology), 1935, No. 12.

[2] *Izv. Geogr. obshch.* (Report of the Geographical Society), Vol. 69, 1937, p. 973.



MAP 12. Volcanoes of Kamchatka.

is covered with tundra. At the eastern edge, 40 km. from the coast of the Bering Sea, lies a low unforested range, 940 m. in elevation, composed of andesites; it is a continuation of the central range of Kamchatka. Farther to the northeast, it rises in elevation and merges into the Koryak range.

As in other volcanic regions, there are many hot springs on Kamchatka, for example, the Paratunsk at Petropavlovsk. The Nalychevsk hot springs, which lie between the Avacha and Zhupanovsk volcanoes, are noteworthy. The water in these springs has a temperature of 72° C. The springs, which emerge from andesitic lava beds, are very rich in boron and arsenic; they deposit large quantities of arsenious travertine (Zavaritsky).

There are some deep lakes. For example, Lake Kurilsk, which lies in the south, is 306 m. deep; it is surrounded on all sides by extinct volcanoes.

During the Quaternary period, mountain glaciers had a somewhat greater development than today, but the ice cover was not continuous.

Climate [3]

Because of the length of Kamchatka from north to south, its climate naturally varies. The southern tip, Cape Lopatka (lat. 50°57′ N) lies approximately in the same latitude as Saratov.

In winter a low-pressure area prevails over Kamchatka; the pressure decreases from the western coast of the Sea of Okhotsk to the western coast of the Bering Sea, and from north to south. Accordingly, northwest and north winds prevail in winter at Petropavlovsk. In summer, however, a high-pressure area lies over Kamchatka, and the pressure increases from the western coast of the Sea of Okhotsk to the western coast of the Bering Sea, and from north to south. For this reason, southeast, east, and south winds prevail in summer at Petropavlovsk. In short, a shift of winds of monsoon character occurs. In the interior of the peninsula the climate is much more continental than along its coasts. The west coast, which is under the influence of the cold Sea of Okhotsk, is characterized by a much more severe climate than the east coast. Petropavlovsk, which lies in the same latitude as Orel (lat. 53° N), has a marine climate: a cool summer and a rather mild winter; the mean temperature of the warmest month, August, is 12.5° C.; the mean temperature of the coldest month, February, is − 10.2° C.; thus, the annual range is only

[3] V. A. Vlasov, *O klimate Kamchatki, Kamchatskaya ekspeditsiya Ryabushinskovo* (The Climate of Kamchatka, Ryabushinsky Expedition into Kamchatka), met. otd. (Meteorological Section), No. 1, Moscow, 1916.

about 23° C., which is relatively small. In the interior of the peninsula the summer is warmer and the winter colder; in Klyuchi, which lies 3½° farther north than Petropavlovsk, the annual range is greater than 31° C. (The warmest month is July, and the coldest month, January, as in continental climates.) During the day, in August, the thermometer in Petropavlovsk rises to about 16° C. (the mean daily maximum); in Klyuchi, in July, it reaches 18° C. Absolute maxima in the valley of the Kamchatka River reach higher than 30° C.; absolute minima, – 50° C. The vegetative period, during which the mean diurnal temperature is greater than 5° C., generally lasts from the end of May or the first days of June to the first days of October; in the central part of the peninsula it begins earlier, in the middle of May. The central part of Kamchatka is relatively better suited for agriculture.[4] Cloudiness on the coast, particularly on the western coast, is great, and reaches its maximum (as is generally true in monsoon regions) in summer; its minimum comes in winter. In the interior of the country, there is less cloudiness. The annual cloudiness at Petropavlovsk is 60 per cent; in July, 73 per cent; in December, 53 per cent. In summer along the coasts there are many fogs; in Petropavlovsk one out of every two days in July has fog; in Bolsheretsk fogs are even more frequent. In winter, however, there are almost no fogs along the coasts. In the interior of the country, it is the other way around; in Klyuchi (absolute elevation 30 m.) and in Milkovo (absolute elevation 150 m.), there are almost no fogs in summer.

Fogs and cloudiness prevail up to elevations of 1500 m., at least along the west coast. Higher up, the climate is drier; there is evidence of this fact in the presence here of the suslik and bobac.

At Petropavlovsk, on the east coast, there is much precipitation; the annual total is 821 mm. Most of it comes from August to October, the least in January. In winter there is much snowfall; often it accounts for more than half the total annual precipitation. On the west coast, however, where dry west winds blow in winter from the region of the Siberian maximum, the winters have little snow; in Bolsheretsk (lat. 52¾° N), in 1910, only 17 per cent of the total annual precipitation (450 mm.) fell in the form of snow. There is also relatively little precipitation in the valley of the Kamchatka River; at Milkovo the precipitation totals about 350 mm. per year. Thunderstorms are a rare phenomenon on Kam-

[4] S. U. Lipshits and U. A. Liverovsky, *Pochvenno-botanicheskie issledovaniya i problema selskovo khozyaistva v tsentralnoy chasti doliny r. Kamchatki* (Studies of Soils and Flora and the Problem of Agriculture in the Central Part of the Kamchatka River Valley), Moscow, 1937, p. 220, with a map of Kamchatka, izd. Akad. nauk (publication of the Academy of Sciences).

chatka. At Petropavlovsk 189 mm. of precipitation fell in one day in October;[5] showers of such magnitude have not been recorded in other parts of Kamchatka.

In northern Kamchatka there is permanent ground frost.

Soils

The soils of Kamchatka belong to the podzolic, sodded-meadow, and bog types. The sodded-meadow soils, which are developed on the old alluvium of the second and third terraces of the Kamchatka River, are the most fertile; these soils are covered with meadows and thin forests of white birch.

Vegetation [6]

The flora of Kamchatka is poor. There are only 800 to 850 species. The reason for this paucity is believed to be the lack of contact between the peninsula and neighboring districts. On Kamchatka there are relatively few composite and papilionaceous plants (with the exception of the genera *Oxytropis* and *Astragalus*).

With the exception of the valley of the middle Kamchatka River and the poorly drained western coast, Kamchatka is covered with mountain vegetation of the Okhotsk type. There are no forests here like those of the Siberian taiga. The characteristic tree is Erman's or mountain birch (*Betula ermani*), which has a gray or reddish bark and a thick bushy crown; it grows in thin, parklike stands (Fig. 80). Birch coppices alternate with glades of tall herbage. Along the eastern coast the shore is covered with Erman's birch, together with groves of Japanese stone pine, alder, and mountain ash, typical of the subalpine zone. In the central part of the peninsula, Erman's birch rises into the mountains to an elevation of 600 to 750 m., but along the coast, only to 300 m. or lower.

Amid the undergrowth in the Erman's-birch forests (and in other places, as well), sweetberry honeysuckle (*Lonicera edulis*) is common; its dark-blue edible fruits are gathered in large quantities by the local population at the end of July and in August.

At lower elevations in the valley of the Kamchatka River there is no

[5] P. I. Koloskov, "Klimatichesky ocherk poluostrova Kamchatki" (Climatic Sketch of the Kamchatka Peninsula), *Izv. Dalnevostochnovo geofiz. inst.* (Report of the Far Eastern Geophysical Institute) No. II (IX), 1932, p. 138.

[6] V. L. Komarov, *Puteshestvie po Kamchatke v 1908–1909 gg., Kamchatskaya eksp. Ryabushinskovo* (Journey Along the Kamchatka in the Years 1908–1909, Ryabushinsky Expedition into Kamchatka), botan. otd. (Botanical Section), No. 1, Moscow, 1912.

Erman's birch; here grow forests of Dahurian larch, and coppices of Yeddo spruce and Japanese white birch (*Betula japonica* [*B. platyphylla japonica*]). As one ascends into the mountains, the first tree to disappear is the spruce, and then the larch and white birch; then there appears Erman's birch, which rises, as we have said, to an elevation of 600 to 750 m. Above the Erman's birch in the mountains of Central Kamchatka, lies a vigorously developed belt of shrub thickets, sometimes completely impassable, of Japanese stone pine (*Pinus pumila*), alder (*Alnus kamtschatica*), and Siberian mountain ash (*Sorbus sambucifolia*). These thickets are very characteristic for Kamchatka in general. At an elevation of 1000 m. alpine tundras and meadows begin; the presence of ericaceous plants is characteristic for the tundras. Alpine plants are found even along the coast in Kamchatka.

In the river valleys there grow forests of willow and Mongolian poplar. The willows include the Korean willow, *Salix* (*Chosenia*) *macrolepis*. Of the true willows, the Sakhalin willow (*Salix sachalinensis*) predominates.[7] In the valley forests Manchurian alder (*Alnus hirsuta*) is common. The riparian meadows are covered chiefly with rough bluejoint reed grass (*Calamagrostis langsdorffii* [*C. canadensis scabra*]), sedges, and meadow pea vine (*Lathyrus pratensis*).

A typical plant in the dry meadows among the coppices of Erman's birch is the umbellifer *Angelica ursina*, which grows to a considerable height (Fig. 81). Another large umbellifer is the cow parsnip (*Heracleum lanatum* or *H. dulce*), up to 4.5 m. high and 12 cm. in diameter; the Itelmen people (Kamchadals) used it for sweetening, and the Russians formerly distilled vodka out of it. In the valleys on fertile arable soils, there are large thickets of Kamchatka meadowsweet (*Filipendula kamtschatica*), a herbaceous plant which grows 2 m. high in one month; at one time its roots were stored for the winter. The Kamchatka fritillary (*Fritillaria kamtschatcensis*), with large purple flowers, is widespread in the birch forests, on the meadows, and among the shrubs, as far as the alpine belt. The bulbs of this plant, which are rich in starch and sugar, are cooked and eaten by the local population; in taste, the bulbs resemble chestnuts. Mice accumulate stores of Kamchatka fritillary bulbs for the winter. On fertile soils in the flood-plain forests, there is Kamchatka nettle (*Urtica platyphylla*), which sometimes grows as tall as a man; at one time fishnets and fabrics were made from its fiber.

[7] N. V. Pavlov and P. N. Chizhikov, *Prirodnie usloviya i problemy zemledeliya na yuge Bolsheretskovo raiona Kamchatki* (Natural Conditions and Problems of Agriculture in the South Part of Bolsheretsk *Raion* of Kamchatka), Moscow, 1937, p. 125, izd. Akad. nauk (publication of the Academy of Sciences).

Near the hot springs there is found a whole series of relict, more characteristically southern plants, native to Sakhalin, Japan, Korea, and Manchuria. Often in March, while snow lies all around, the bog violet (*Viola repens*) bursts into bloom.

On the eastern coast of Kamchatka, near the mouth of the Semyachik River, there is a grove of fir (*Abies gracilis*) related very closely to the Sakhalin fir. On the slopes of Shiveluch volcano grow groves of Kamchatka spruce, related very closely to the Yeddo spruce.

In conclusion we present the vertical sequence of vegetation on the western coast (according to N. V. Pavlov):

Forest belt, 0 to 550 m.
- Sphagnum bogs
- Thickets of black crowberry (*Empetrum nigrum*)
- Mixed-herbaceous meadows
- Tall-herbaceous meadows (*ushkha*)
- Forests of Erman's birch

Shrub belt, 500 to 800 m.
- Japanese stone pine
- Alder groves (*Alnus kamtschatica*)

Alpine belt, 800 to 1400 m.
- Dry mountain tundras
- Alpine meadows
- Alpine glades

Fauna

The fauna of Kamchatka is not rich; it has a rather insular character. In the mountains up to 1000 m., there are mountain sheep (*Ovis nivicola*), which are found all the way to the extreme south of the peninsula. There are many bear and fox, and some black-capped bobac (*Marmota camtschatica*) and Kamchatka suslik (*Citellus eversmanni stejnegeri*). Wild reindeer (*Rangifer tarandus phylarchus*), of the same form as is found on Sakhalin and on the Amur, are encountered. There is a large sable, but its fur is of little value. Elk is absent. The tree squirrel (*Sciurus vulgaris*) has appeared only recently on Kamchatka, particularly in Tigil *raion*, where there were none in 1910.[8]

There are few birds on Kamchatka, fewer than 200 species. Only aquatic birds are well represented: ducks, which are found in great numbers, geese, shore birds, gulls, cormorants, and guillemots. Starlings, creepers, kingfishers, pigeons, water rails, cranes, and others are com-

[8] *Otchet* Kamchatskovo okr. revol. kom. I. Kamchatskomu syezdu sovetov (Report of the Kamchatka *Okrug* Revolutionary Committee to the First Kamchatka Congress of Soviets), Petropavlovsk, 1928, pp. 43–44.

pletely absent; there are no black grouse, hazel grouse, or Siberian jays. Some common Siberian forest birds form special subspecies on Kamchatka; for example, the capercaillie, the pied and the three-toed woodpeckers, and the bullfinch.

The amphibians include the Siberian four-toed salamander (*Hynobius keyserlingi*).

Kamchatka is very poor in true fresh-water fish; the Amur grayling is the only one known. However, there are many anadromous salmonids, which belong to the North Pacific genus *Oncorhynchus*, an Okhotsk form, analogous to Erman's birch and Yeddo spruce. To this genus belong the king salmon, red salmon, chum, pink salmon, and silver salmon, which are of great economic importance in Kamchatka. Here is found also the true salmon (*Salmo*), which is not found in Siberia and which reappears in the North Pacific, in Kamchatka, and in North America, after an interval. Together with the salmonids, seal penetrates into the Kamchatka River; it goes as far as Kozyrevka, 200 km. up the river from its mouth.

The fresh-water mollusks include the fresh-water pearl mussel *Margaritana middendorffii*, from which the inhabitants of Golygin village used to obtain a fairly good pearl. The pearl mussel is not found in Siberia except in Kamchatka, the Amur basin, and Sakhalin.

The Commander Islands[9]

The Commander Islands, which lie east of Kamchatka, approximately in lat. 55° N, consist of two islands, Bering and Medny. The former was discovered on November 4, 1741, by the famous navigator Bering; the latter, in the same year, by Steller, a companion of Bering. The islands are separated from Kamchatka by tremendous depths (about 5000 m.), and from the Aleutians by considerable, but lesser depths. In some places the coast descends to the sea in vertical precipices. The islands are composed of volcanic rocks (andesitic tuffs, basalts, and others). Bering Island rises to an elevation of 670 m.; Medny to an elevation of 590 m. The age of the tuffs is Upper Oligocene or Lower Miocene. Medny Island was named for the copper contained in the igneous rocks.[*]

The climate of the islands is marine, humid, cool, and foggy. The

[9] E. K. Suvorov, *Komandorskie ostrova i pushnoy promysel na nikh* (The Commander Islands and the Fur Industry on Them), St. Petersburg, 1912, p. 324. L. S. Berg, *Otkrytie Kamchatki i ekspeditsii Beringa* (The Discovery of Kamchatka and Bering's Expeditions), Leningrad, 1935, izd. Arkt. inst. (publication of the Arctic Institute), pp. 278–308.

[*] The Russian word for copper is *med*.—Tr.

winter is mild; the coldest month, February or March, has a mean temperature of − 3° or − 4° C. The summer is cool; the warmest month, August, has a mean temperature of 10° to 11° C.—this in a latitude south of that of Moscow. Storms are very frequent on the islands. "At times there are such bitterly strong winds on this island [Bering Island] that a man can hardly remain standing on his feet," wrote Khitrov, a companion of Bering. Precipitation amounts to about 500 mm. per year.

The islands are unforested and covered with tundra—the southernmost outpost of this type of vegetation in the Northern Hemisphere. In some places in the valleys there are thickets of willow, mountain ash, and Erman's birch (*Betula ermani*), which grow as tall as a man, or a little taller.

The islands are inhabited by arctic fox, while on the coast there are marine animals: the sea otter (*Enhydra lutris*), incorrectly called sea beaver; Steller's sea lion (*Eumetopias jubatus*), a member of the eared seal family; and northern fur seal (*Arctocephalus ursinus* [*Callorhinus ursinus*]), of the same family. During the time of Bering the sea around the islands abounded in Steller's sea cow (*Rhytina stelleri* [*Hydrodamalis stelleri*]), which was exterminated completely by about 1770.

XX · Mountains of the Arctic

IN this chapter we will examine that part of the Arctic which belongs to the region which I have called (1930) the ice region; in this region the mean temperature of the warmest month is approximately 0° C. Precipitation as a rule falls in the form of snow. To this region belong Franz Josef Land, the northern part of Novaya Zemlya, Severnaya Zemlya (North Land), and Bennett Island. That part of the Arctic which is occupied by tundra has been described already (p. 2 ff.).

Franz Josef Land[1]

This archipelago, which was discovered in 1873 by the Austrian expedition of Payer and Weyprecht, and became a part of the U.S.S.R. in 1926, lies approximately between lat. 80° and 82° N. It is thus the northernmost territory of the U.S.S.R. The area of Franz Josef Land, including 800 islands, is about one-third the size of Spitzbergen. The largest two islands lie on the western border of the archipelago. Aleksandra Land, the westernmost of the two, is low-lying. In 1928 a geophysical station was built on Hooker Island (one of the southern islands) by the Institute for the Study of the North (now the Arctic Institute).

Almost all the islands consist of low plateaus covered by continental glaciers. Approximately 97 per cent of the archipelago is covered with ice. The highest elevations rise over 900 m.

The islands are composed of Middle and Upper Jurassic marine deposits, and are covered with basalt crusts up to 20 m. thick. In some

[1] "Zemlya Frantsa-Iosifa" (Franz Josef Land), *Trudy Inst. po izuch. Severa* (Proceedings of the Institute for the Study of the North), No. 47, 1930 (articles by V. U. Wiese and R. L. Samoilovich). V. K. Esipov, *Zemlya Frantsa-Iosifa* (Franz Josef Land), Archangel, 1935, p. 74 (bibliography). T. N. Spizharsky, "Oledenenie i geomorfologiya" (Glaciation and Geomorphology), *Trudy Arkt. inst.* (Proceedings of the Arctic Institute), XLI, 1936. "Geologicheskoye stroyenie Zemli Frantsa-Iosifa" (Geological Structure of Franz Josef Land), *Trudy Arkt. inst.* (Proceedings of the Arctic Institute), LXXVI, 1937.

places the lavas are overlain by terrestrial Lower Cretaceous deposits which contain remains of vegetation; here and there they contain beds of lignite; these deposits also are covered with basalt crusts. After the Upper Jurassic sea retreated, the archipelago became a land mass. The basalt extrusions took place during the Lower Cretaceous period; there were several of them, which explains the alternation of basalt crusts with sedimentary deposits which contain flora.

During the Quaternary period, powerful faulting took place in the region of Franz Josef Land; these dislocations divided the land mass which existed on the site of the archipelago into numerous islands. Evidence of the subsidences which took place here is found in the fact that the straits which divide the islands are very deep in some places, sometimes as much as 500 m. deeper than surrounding parts of the Barents Sea (Spizharsky). Along the shores, at elevations up to 30 m., as many as four levels of terraces are well developed.

Lying so high in the Arctic, the archipelago naturally has a very severe climate. The annual course of temperatures during the years 1932–1936 at Tikhy Bay in lat. 80°20′ N, was as follows:[2]

Table 28

Temperature in Tikhy Bay, 1932–1936 (in °C.)

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
−18.7	−19.3	−22.3	−16.9	−7.9	−1.0	1.3	0.8	−2.6	−8.9	−14.0	−16.9

The annual course of temperatures on Franz Josef Land, as in the high Arctic in general, is characterized by a rather even temperature throughout the winter, although in some years a sharp rise in December and January may be observed (for example, in 1929, December was 5.5° C. warmer than November). At one time this phenomenon was explained as the effect of the relatively warm ocean water, which raises the temperature of the air through the ice cover. But a more correct explanation may be that it is due to warm air currents from the south.[3] It is true that at Tikhy Bay in December, 1929, SE, S, and E winds prevailed, while in November the winds were E, N, and SE, and in March 1930, N, E, and NE. In general, however, the winter is relatively mild, as compared

[2] Z. A. Ryazantseva, "Novaya Zemlya i Zemlya Frantsa-Iosifa" (Novaya Zemlya and Franz Josef Land), *Trudy Arkt. inst.* (Proceedings of the Arctic Institute), Vol. 79, 1937, p. 37.

[3] E. Lir, "K voprosu o prichine 'bezyadernykh' zim" (Concerning the Reason for Mild Winters), *Met. vestn.* (Meteorological Herald), 1934, Nos. 4–7, pp. 107–117.

with the winter on the mainland of northeastern Asia, which lies much farther south. However, the wind velocity in winter may reach 40 m. per second. During some years the number of stormy days (when the wind velocity exceeded 20 m. per second) has been as high as 10 in January.[4]

On individual days in summer the temperature in the south of the archipelago may reach 12° C. (for example, in 1904). The number of days without frost in July at Tikhy Bay is only 8; the annual total is 19. Cloudiness is very great, being least in March, and greatest in August and September.

The measurement of precipitation in the Arctic is very unreliable, but on the basis of data from snow surveys, the approximate annual total of precipitation on Hooker Island is estimated at 300 mm. Fogs, as in general in the Arctic, predominate in summer.

The vegetation of the archipelago, which is covered in considerable part by an ice sheet, is naturally very poor. Only about forty species of arctic flowering plants are known: buttercup, saxifrages, arctic poppy, scurvy weed, *Draba, Cerastium,* and several grasses. In the south in some places there is polar willow (*Salix polaris*). Lichens are far more numerous; there are about a hundred species.

On the islands there are as many as thirty species of birds. The dovekie, or little auk (*Alle alle*), the most numerous of the birds here; Mandt's guillemot (*Cepphus mandti*); the large glaucous gull (*Larus hyperboreus*); the kittiwake (*Rissa tridactyla*); Brünnich's murre (*Uria lomvia*); the fulmar (*Fulmarus glacialis*); and the ivory gull (*Pagophila eburnea*) nest in tremendous colonies ("bazaars") on the steep shores. There are some tundra ptarmigan (*Lagopus mutus*). The kittiwake and murre nest only in the south of the archipelago. The ivory gull sometimes forms bazaars on the rocks, sometimes nests on flat surfaces. The mammals include the polar bear, and, occasionally, the arctic fox, which feeds on birds and their eggs. Of the marine mammals, the walrus, bearded seal [*Erignathus barbatus barbatus*?], and seal are of economic importance.

To the west of Franz Josef archipelago, in lat. 80° N and long. 37° E, lies the small island of Victoria, the western boundary of the arctic possessions of the U.S.S.R. It is about 7 km. long, and is covered completely with a layer of ice about 100 m. thick. Judging from the pebbles, which consist of Upper Carboniferous limestone, this island, in structure, is related closely to the Northeast Land of Spitzbergen.[5]

[4] E. Shishakova, *Klimat i pogoda* (Climate and Weather), 1932, pp. 143–144.
[5] M. V. Klenova, "Ostrov Viktoriya" (Victoria Island), *Arctica*, III, 1935.

Northern Novaya Zemlya

Novaya Zemlya has been discussed to some extent already (p. 10). The northern island, approximately north of lat. 75° N, is part of the ice region. The northern tip of the island lies in lat. 77° N. The sparse vegetation and fauna are concentrated along the shores. The island was crossed in 1913, in lat. 76° N (from Pankratyev Peninsula). The surface of the ice sheet here reaches 913 m. above sea level; on April 4, on the highest point, the temperature was − 18° C.; a light NNW wind was blowing, the sun was shining, and in general the weather was excellent; throughout the day, hoarfrost was deposited on the surface of the ice in tremendous quantity: the layer of freshly deposited hoarfrost was 3 cm. deep. On the return journey, on April 22, it was calm, rain was falling, and there was a dense fog; the temperature was + 1° C.[6] Meteorological observations at the northern tip of Novaya Zemlya (Cape Zhelaniya, 1931–1936) show the following mean temperatures: [7]

Table 29

Temperature at Cape Zhelaniya, 1931–1936 (in °C.)

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
−18.4	−17.8	−21.4	−15.3	−7.3	−1.2	1.7	2.1	−0.1	−4.2	−12.1	−17.1

Here, as on Franz Josef Land, there are equable temperatures in the middle of winter, and February is warmer than either January or March.

In January temperatures of − 50° C. have been recorded here.

Polygonal soils are widespread.

On the shore of Russkaya Gavan, in lat. 76°14′ N, only 25 flowering plants have been enumerated. They include the arctic draba, saxifrages, poppy, buttercup, and dwarf polar willow (*Salix polaris*). The first to appear in the spring of 1933 was the twinleaf saxifrage (*Saxifraga oppositifolia*); its green leaflets were visible at the end of May. At the end of June, the vegetation began to blossom; some species (*Cerastium alpinum*) continued to bloom until the last days of September, when the soil had become frozen already.[8]

In lat. 76° N on the western coast, 70 species of flowering plants and over 200 lichens have been collected. The vegetation is particularly rich in places which are fertilized by birds.[9]

[6] V. U. Wiese, *Zap. po gidrogr.* (Hydrographic Report), XLIX, 1925, pp. 63–74.

[7] S. E. Ryazantseva, *op. cit.*

[8] L. I. Zubkov, *Arctica*, III, 1935.

[9] North of latitude 75° N, there are only 80 species of flowering plants. See A. I. Tolmachev, "Obzor flory Novoy Zemli" (Survey of the Flora of Novaya Zemlya), *Arctica*, IV, 1936, pp. 143–174.

The shores of Novaya Zemlya, to the extreme north, contain many bird bazaars. The bird which appears here in largest numbers is Brünnich's murre (*Uria lomvia*); but north of lat. 75° N, there are also bazaars where the guillemot (*Cepphus mandti*), kittiwake (*Rissa tridactyla*), dovekie (*Alle alle*), and fulmar (*Fulmarus glacialis*) nest. Reindeer are found as far as the northern tip of Novaya Zemlya.[10]

Severnaya Zemlya (North Land)

Severnaya Zemlya was discovered in 1913 by Captain Vilkitsky. But as early as 1869 Tretyakov had written as follows concerning the vicinity of Cape Chelyuskin: "We have heard often that in the sea there is another land, from which the arctic fox and polar bear come. Perhaps there are islands which stretch, in the form of an archipelago, from Novaya Zemlya to Severo-Vostochny (North-East) Cape."[11] In the years 1930–1932 Severnaya Zemlya was charted and explored by the geologist Urvantsev.[12]

The Severnaya Zemlya archipelago, which lies approximately between lats. 78° and 81° N, is situated opposite Cape Chelyuskin, from which it is separated by Vilkitsky Strait. Bordering the Kara Sea on the east, the archipelago consists of four large islands and many small ones, with a total area of 36,712 sq. km. The largest island, October Revolution Island, has rocky, steep eastern shores and low western shores, indented by bays. The highest elevation on the island (and in the whole archipelago) is 675 m. A considerable part of the area of the archipelago (about 42 per cent) is covered with ice, which does not exceed 200 to 250 m. in thickness. According to Urvantsev, the present glaciation is a vestige of an ancient, much thicker ice sheet. There are traces of two phases of glaciation, separated by the boreal marine transgression. Judging from the shells which have been found, this transgression reached an absolute elevation of 70 m.; judging from the elevation of the terraces, it reached 90 to 100 m. During the postglacial period another transgression took place, up to an elevation of 15 to 25 m. At present an uplift of the land mass is taking place. The archipelago is composed of metamorphic schists, igneous rocks, and Paleozoic Quaternary deposits. All of the pre-Quater-

[10] L. I. Zubkov, "Dikie oleni Novoy Zemli" (Wild Deer of Novaya Zemlya), *Trudy Arkt. inst.* (Proceedings of the Arctic Institute), XXII, 1935, pp. 55–60.

[11] *Zap. Geograf. obshch. po obshch. geogr.* (Report of the Geographical Society Concerned with Social Geography), II, 1869, p. 231.

[12] N. N. Urvantsev, *Severnaya Zemlya* (North Land), Leningrad, 1933, p. 29, with map, izd. Arkt. inst. (publication of the Arctic Institute), *Dva goda na Severnoy Zemle* (Two Years on Severnaya Zemlya), Leningrad, 1935, izd. Glavn. upr. Sevmorputi (publication of the Board of the Northern Sea Route), p. 364, with map.

nary deposits have been intricately dislocated. Severnaya Zemlya attained its present features as a result of faulting which took place during the Tertiary and Quaternary periods. Until recently Severnaya Zemlya was connected with Taimyr, from which it became separated as a result of subsidences, which probably took place during the postglacial epoch (Urvantsev).

The climate of the archipelago is very severe. Data on the temperature of the islands which lie to the west of October Revolution Island (in lat. 79½° N), and, for comparison, observations on Cape Chelyuskin (lat. 77°43′ N), are illustrative of the climate of the southern part of the archipelago:

Table 30

TEMPERATURE IN THE SEVERNAYA ZEMLYA ARCHIPELAGO (IN °C.)

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Islands which lie west of October Revolution Island*	−26.4	−23.7	−27.3	−21.8	−9.7	−1.5	0.8	0.4	−2.4	−10.4	−19.8	−26.4
Cape Chelyuskin †	−25.5	−22.6	−25.7	−20.9	−15.2	−1.7	1.2	0.1	−5.3	−10.0	−25.0	−30.8

* October, 1930, to August, 1934. I. L. Rusinova and M. A. Davydova, "Meteorologicheskie nablyudeniya Severozemelskoy ekspeditsii 1930–1932 gg." (Meteorological Observations of the Severnaya Zemlya Expedition, 1930–1932), *Trudy Arkt. inst.* (Proceedings of the Arctic Institute), LV, 1936, p. 28.

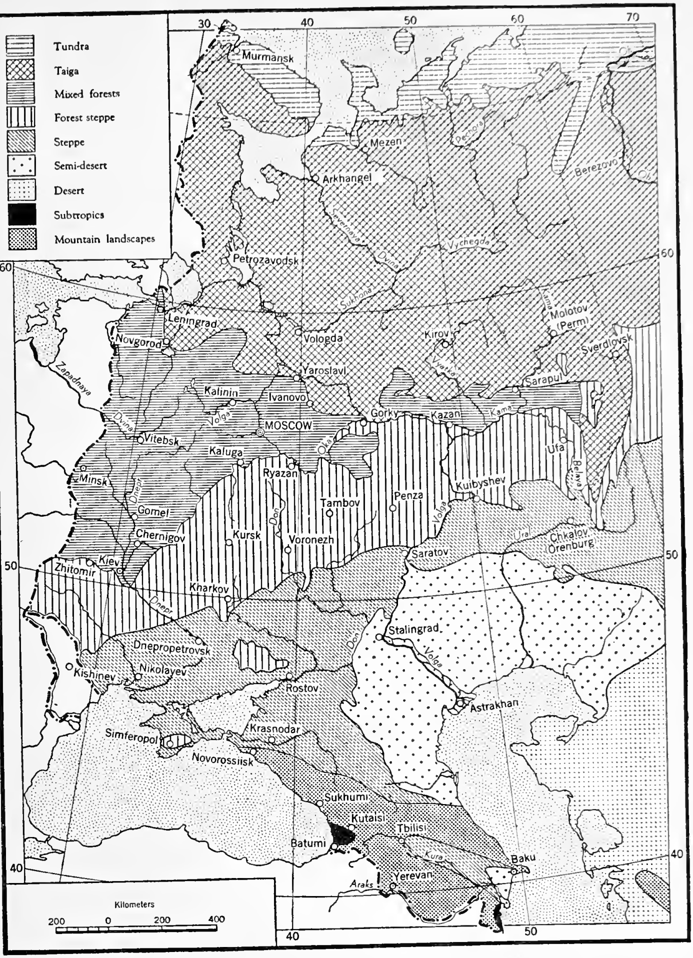
† October, 1932, to August, 1934. B. Richter, *Sovetsky Sever* (The Soviet Arctic), Moscow, 1935, No. 3–4, p. 126.

Here, as on Franz Josef Land, a rise in temperature is observed in the middle of winter, in February.

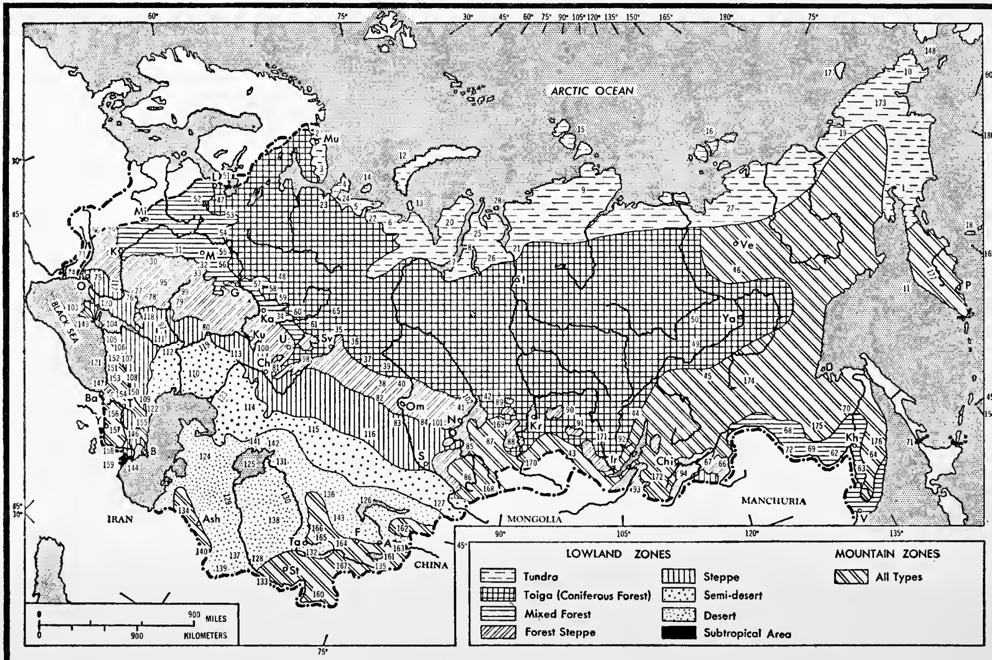
The lowest temperature recorded on Severnaya Zemlya for the period indicated is − 47°C.; the highest, less than 5° C. Cloudiness is greatest in August, least in March. The annual precipitation must be about 150 mm. The snow cover disappears at the end of June or the beginning of July. The wind velocity is relatively small; it is greatest in September (7.4 m. per second), least in April and December (4.9 m. per second). In general, this area has an arctic and marine variety of East Siberian climate.

Bennett Island, discovered in 1881 by the American Lieutenant De Long on the yacht *Jeannette,* lies north of New Siberia Island in the New Siberian archipelago. It is composed of the same horizontal Cambrian deposits and basalts as the Central Siberian Plateau, and reaches 450 m. in elevation. There is a glacier in the interior of the island.

Wrangel Island is part of the region of arctic tundras. In climate, the island approaches that of the ice region; the mean temperature in July is 2.4° C. There are no glaciers, even though the elevation on the island reaches 755 m.



MAP 13. Landscape zones of the European part of the U.S.S.R.



MAP 14. Landscape zones of the U.S.S.R.

Cities Used for General Orientation (Letters)

A	Alma-Ata
Ash	Ashkhabad
B	Baku
Ba	Batumi
Ch	Chkalov
Chi	Chita
F	Frunze
G	Gorky
I	Igarka
Ir	Irkutsk
K	Kiev
Ka	Kazan
Kh	Khabarovsk
Kr	Krasnoyarsk
Ku	Kuibyshev
L	Leningrad
M	Moscow
Mi	Minsk
Mu	Murmansk
N	Novosibirsk
O	Odessa
Om	Omsk
P	Petropavlovsk (Kamchatka)
S	Semipalatinsk
St	Stalinabad
Sv	Sverdlovsk
T	Tbilisi
Ta	Tashkent
U	Ufa
V	Vladivostok
Ve	Verkhoyansk
Y	Yerevan
Ya	Yakutsk

Other Points Mentioned in Text (Numbers)

Tundra

1. Parapolsky Dol (Vale)
2. Kola Inlet
3. Ponoy River
4. Kanin Peninsula
5. Malozemelskaya Tundra
6. Bolshezemelskaya Tundra
7. Gulf of Ob
8. Taz Bay
9. Taimyr Peninsula and Tundra
10. Chukotsk Peninsula and Tundra
11. Kamchatka Peninsula
12. Novaya Zemlya
13. Vaigach Island
14. Kolguyev Island
15. Severnaya Zemlya
16. New Siberian Islands
17. Wrangel Island
18. Komandorskie Islands
19. Tundra east of Kolyma River
20. Yamal Peninsula
21. Yenisey River
22. Pechora River
23. Mezen
24. Cheshskaya Bay
25. Gydan Peninsula
26. West Siberian Tundra
27. Yakut Tundra
28. Dickson Island

Forest Zone

29. Zhitomir
30. Karachev
31. Kaluga
32. Oka River
33. Ryazan
34. Belaya, Vyatka, and Kama rivers
35. Tagil River
36. Irbit
37. Tyumen
38. Ishim River
39. Ishim
40. Tara
41. Kolyvan
42. Tomsk
43. Sayan Mountains
44. Baikal Range
45. Mts. of northern Trans-Baikalia
46. Verkhoyansk Range
47. Leningrad Oblast
48. Kirov Oblast
49. Lena River
50. Vilyuy River
51. Karelian Isthmus
52. Novgorod
53. Tikhvin Canal
54. Bezhetsk
55. Yaroslavl
56. Ivanoyo
57. Sanchursk
58. Yaransk
59. Urzhum
60. Sarapul
61. Kungur
62. Amur River
63. Ussuri River
64. Primorye
65. Molotov Oblast
66. Argun River
67. Shilka River
68. Zeya River
69. Bureya River
70. Komsomolsk
71. La Pérouse Strait
72. Blagoveshchensk

Forest Steppe Zone

73. Beletsk Steppe
74. Bessarabia
75. Ingul River
76. Kremenchug
77. Poltava
78. Kharkov
79. Voronezh
80. Saratov
81. Troitsk
82. Petropavlovsk (Kazakhstan)
83. Irtysh River
84. Lake Chany
85. Barnaul
86. Altay Mountains
87. Kuznetsk Area, Kuznetsk Basin
88. Minusinsk Area
89. Achinsk Area
90. Kansk Area
91. Tulun Area
92. Verkholensk Area
93. Selenga Area, Selenga Steppe
94. Nerchinsk Area, Nerchinsk Steppe
95. Kursk (south of which lie the Streletsk and Kazakh steppes)
96. Podolia
97. Don River
98. Southern Ural Mountains
99. Voronezh River
100. Buzuluk Pine Woods
101. Kulundinsk Steppe
102. Ob River

Steppe Zone

103. Crimean Mountains and Peninsula
104. Sea of Azov
105. Kuban River
106. Krasnodar
107. Labinskaya
108. Pystigorsk
109. Grozny
110. Caspian Lowland
111. Nizhne-Chirskayx
112. Stalingrad
113. Uralsk
114. Temir
115. Turgay
116. Akmolinsk
117. Dnepr River
118. Severny (N.) Donets River
119. Volga River
120. Askaniya-Nova Steppe Preserve

Zone of the Semidesert

121. Caucasus or Great Caucasus Mountains
122. Sulak River
123. Ural River
124. Ust-Urt Plateau
125. Aral Sea
126. Lake Balkhash
127. Lake Zaisan

Desert Zone

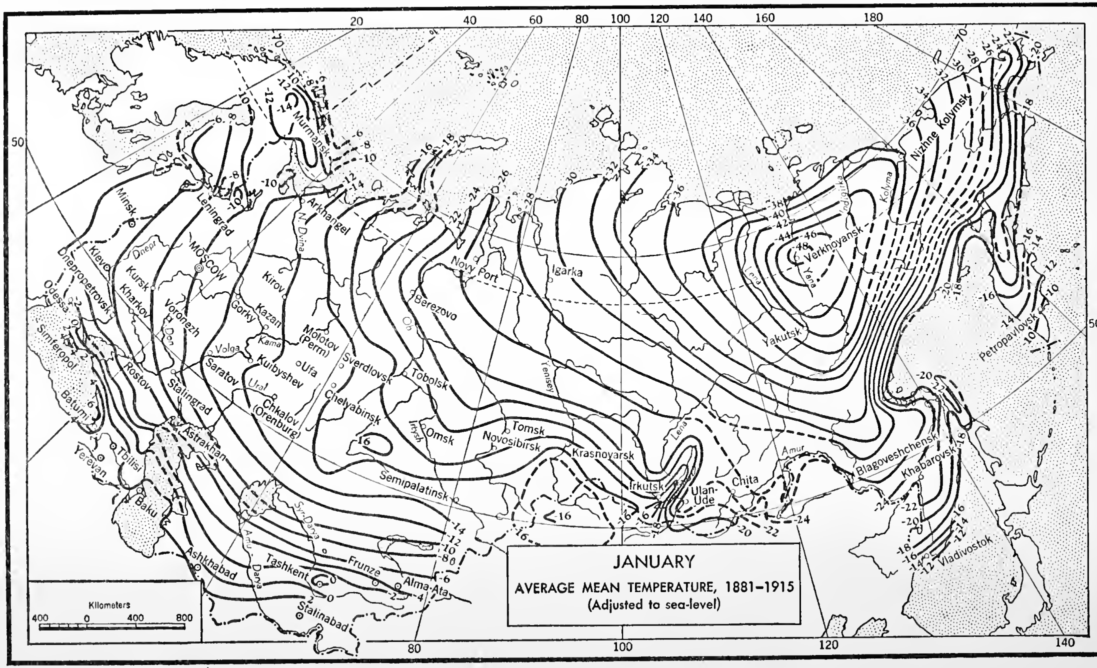
128. Kerki
129. Amu-Darya (river)
130. Syr-Darya (river)
131. Kazalinsk
132. Khodzhent or Leninabad
133. Termez
134. Kopet-Dagh (mts.)
135. Tian Shan (mts.)
136. Bedpak-Dala Plateau
137. Kara-Kum (desert)
138. Kyzyl-Kum (desert)
139. Murgab River
140. Tedzhen River
141. Bolshie Barsuki (desert)
142. Malie Barsuki (desert)
143. Muyun-Kum (desert)

Subtropical Zone

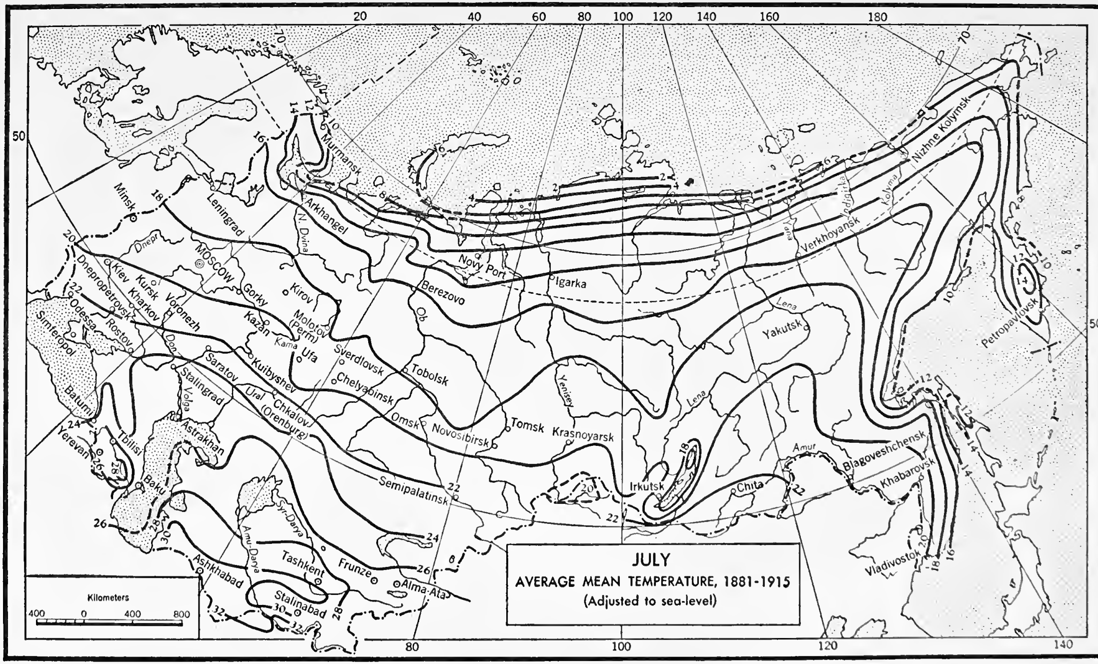
144. Lenkoran Coastal Lowland
145. Rion River
146. Kura River and Shirak, Karayazy and Shirvan steppes
147. Colchian Lowland

Mountain Zone

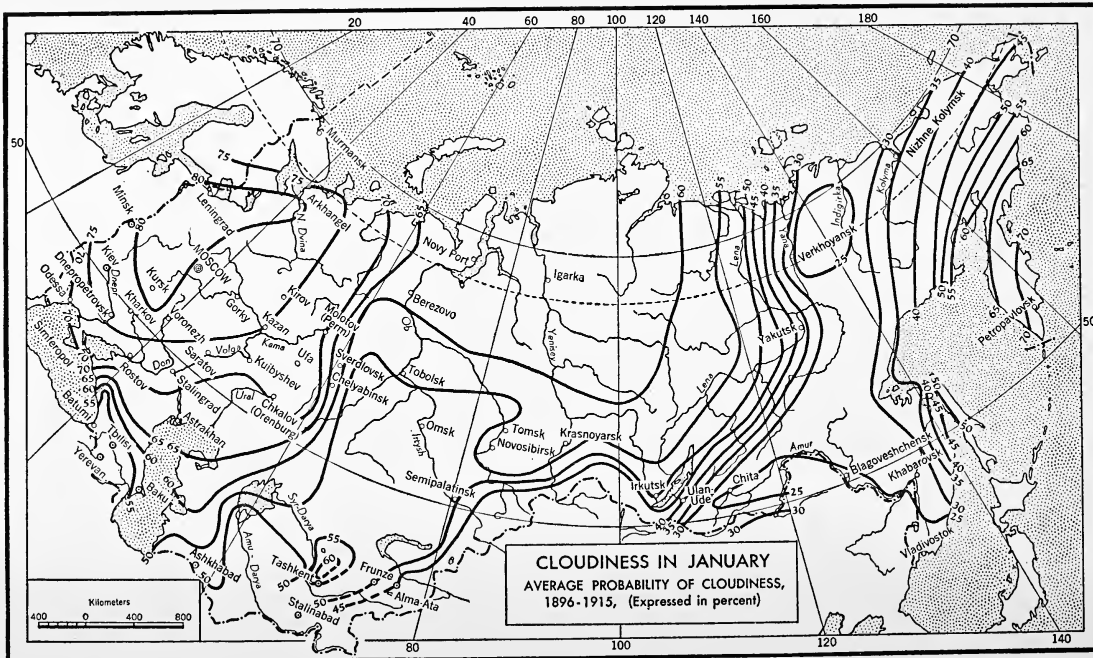
148. Bering Strait
149. Yaila (highland)
150. Stavropol Upland
151. Laba and Belaya rivers and Caucasus Preserve
152. Maikop
153. Teberda
154. South Osetia
155. Daghestan
156. Armenian Plateau
157. Lake Sevan
158. Araks River
159. Talysh Range
160. Pamir Mountains
161. Issyk-Kul (lake)
162. Dzhungarian Ala-Tau (mts.)
163. Trans-Ili Ala-Tau (mts.)
164. Kirgiz Range
165. Chatkal Range
166. Talas Range
167. Fergana Range
168. Chuya Steppe and Kuray Steppe
169. Kuznetsk Ala-Tau (mts.)
170. Us Basin
171. Baikal Region
172. Trans-Baikal Region
173. Anadyr Range
174. Stanovoy Range
175. Bureya Range
176. Sikhote-Alin (mts.)
177. Valley of the Kamchatka River



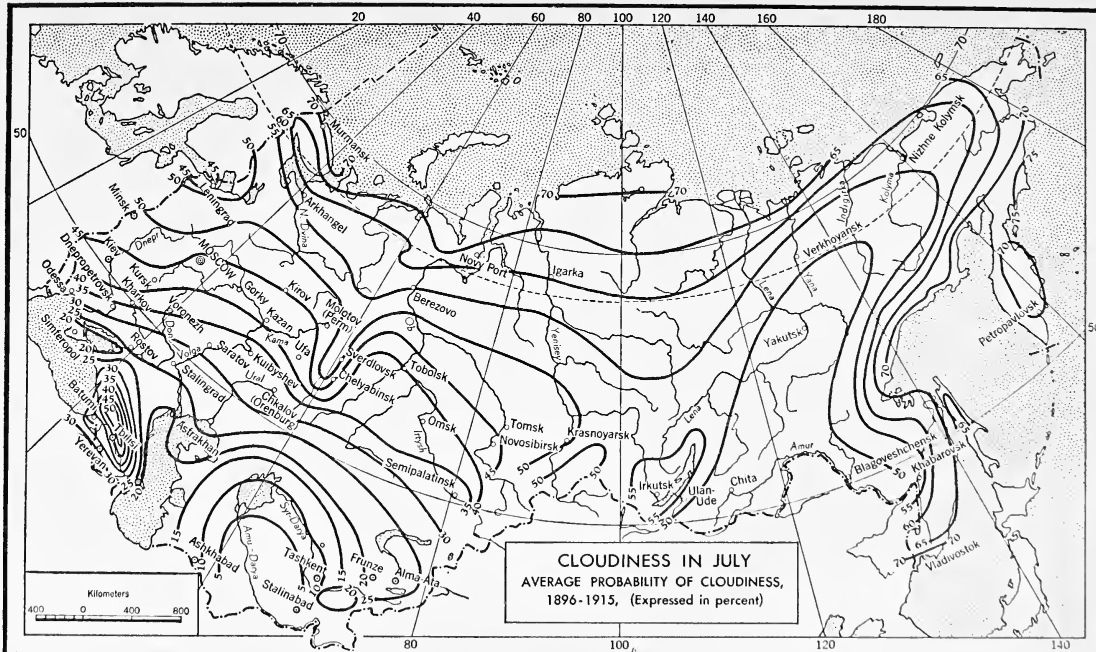
MAP 15. Average mean temperature, January, 1881–1915 (Climatological Atlas, 1933).



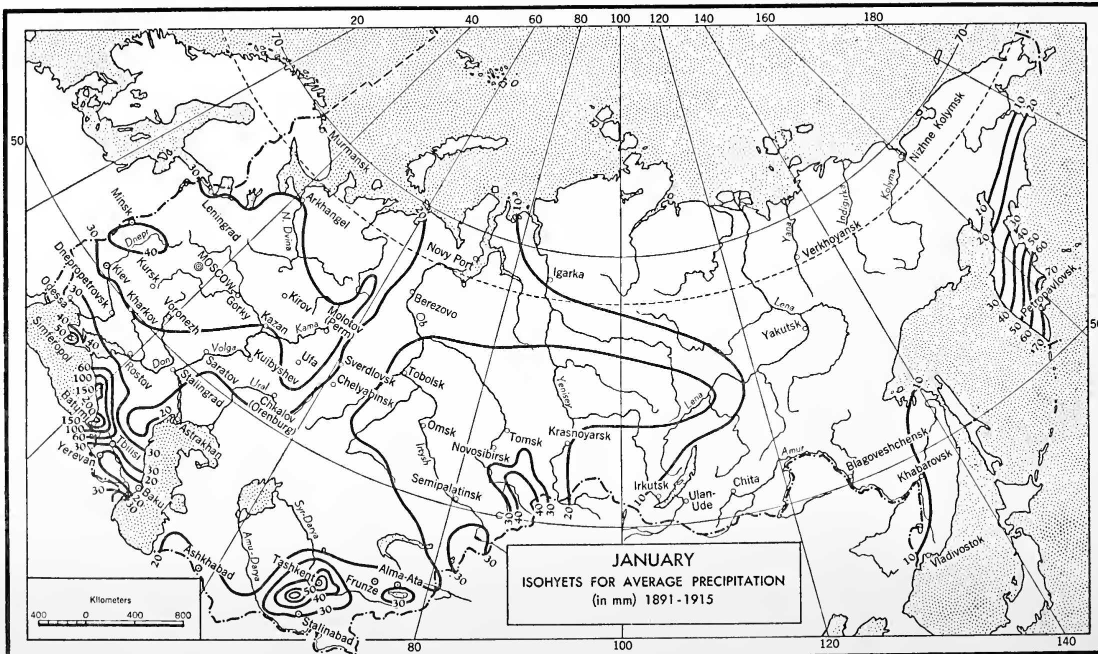
MAP 16. Average mean temperature, July, 1881–1915 (Climatological Atlas, 1933).



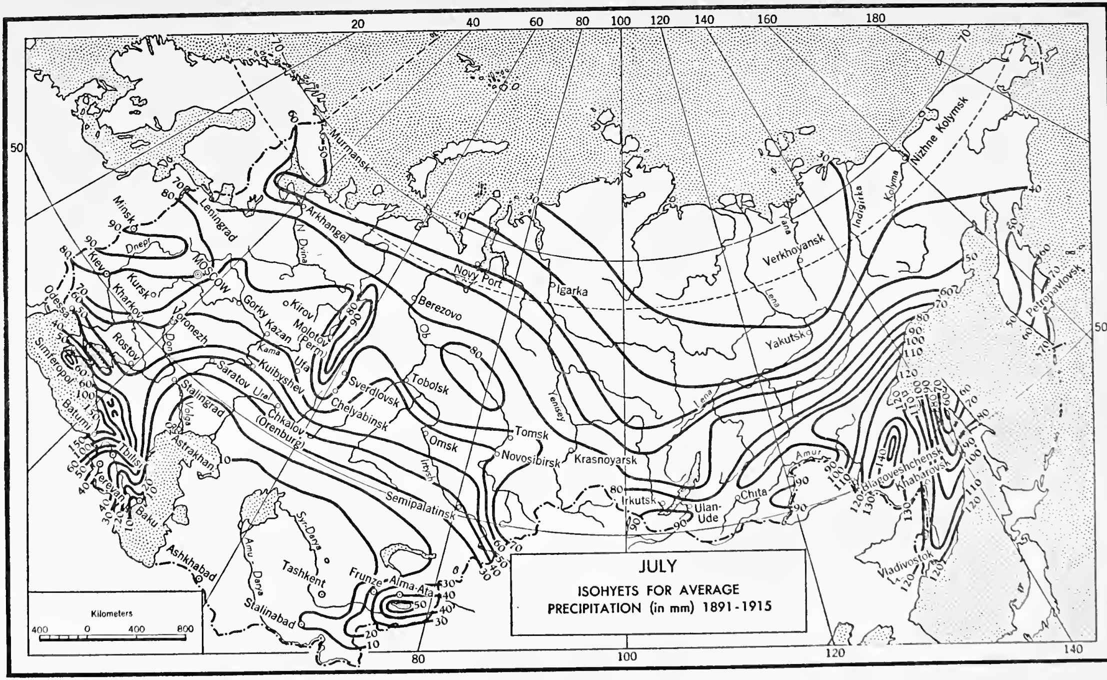
MAP 17. Cloudiness, January, 1896–1915 (Climatological Atlas, 1933).



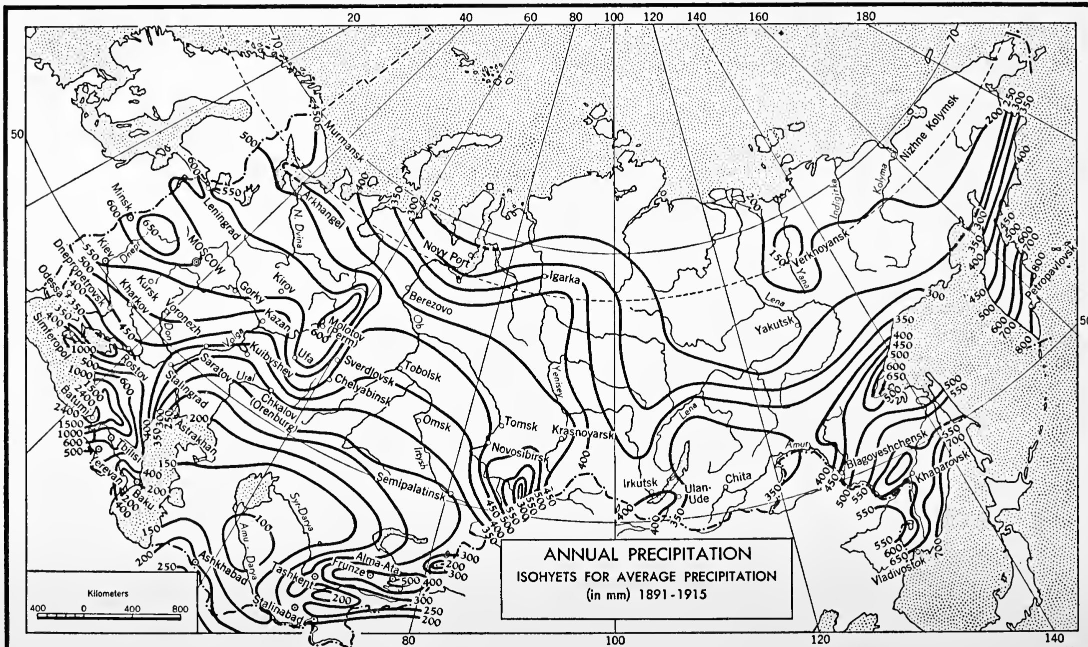
MAP 18. Cloudiness, July, 1896–1915 (Climatological Atlas, 1933).



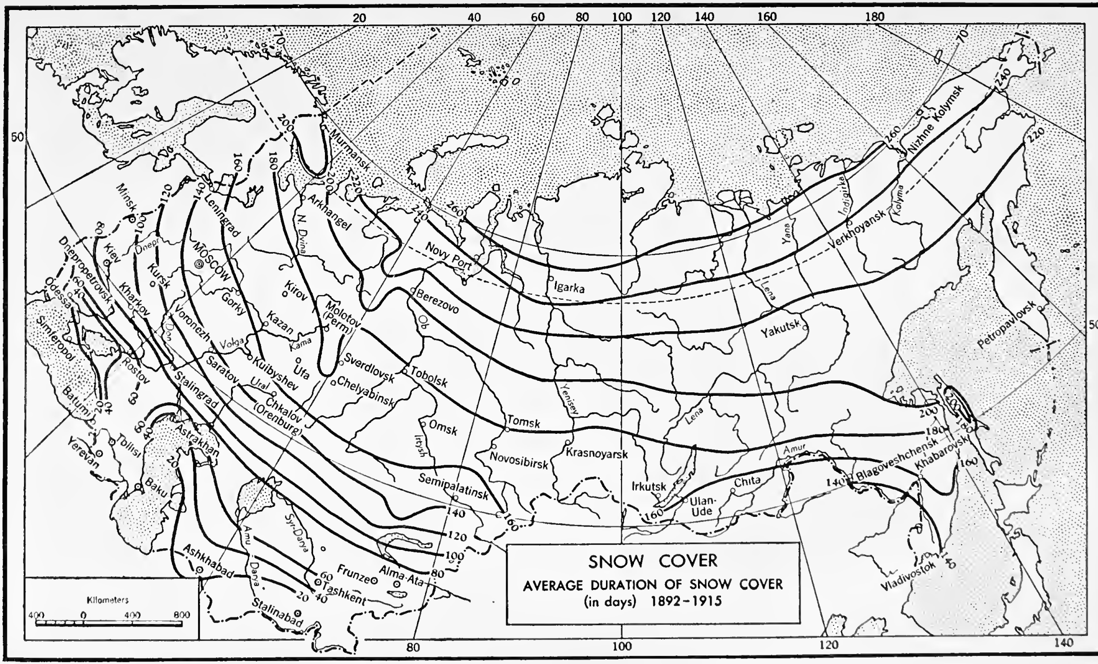
MAP 19. Average precipitation (in mm.), January, 1891–1915 (Climatological Atlas, 1933).



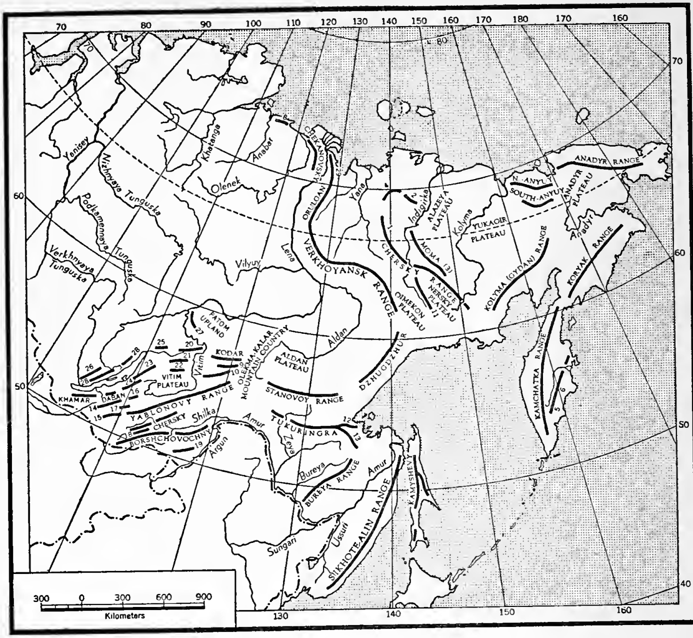
MAP 20. Average precipitation (in mm.), July, 1891–1915 (Climatological Atlas, 1933).



MAP 21. Average annual precipitation (in mm.), 1891–1915 (Climatological Atlas, 1933).



MAP 22. Average duration of snow cover (in days), 1892–1915 (Climatological Atlas, 1933).



MAP 23. Mountain ranges of Eastern Siberia and the Far East.

1—Tas-Khayakhtakh range; 2—Poluosny range; 3—Moma (Garmychan) range; 4—Kyun-Tas range; 5—Ganalsk-peak range; 6—Balaginsk range; 7—Kum-Roch range; 8—Pronchishchev range; 9—Udokan range; 10—Kalar range; 11—Tas-Kystabyt range; 12—Dzhagda range; 13—Yam-Alin range; 14—Tsagan-Daban range; 15—Malkhansk range; 16—Khudunsk range; 17—Tsagan-Zhurzhey range; 18—Dahurian range; 19—Nerchinsk range; 20—Delyun-Uransk range; 21—North-Muya range; 22—South-Muya range; 23—Barguzin range; 24—Ulan-Burgasy range; 25—Upper-Angara range; 26—Onotsk range; 27—Kropotkin range; 28—Primorsk (Maritime) range.

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Glossary

ABSOLUTE ELEVATION. Elevation above sea level.

ALLUVIAL SOILS. Azonal group of soils, developed from transported and relatively recently deposited material (alluvium) characterized by a weak modification (or none) of the original material by soil-forming processes.

ALLUVIUM. Fine material, such as sand, mud, or other sediments deposited on land by streams.

ANTICLINE. An upfold or arch of stratified rock in which the beds or layers dip in opposite directions from the crest.

ANTICYCLONE. The system of winds that belongs to and encircles a region of maximum barometric pressure. The winds circulate around the center clockwise.

AWN. A bristlelike appendage of plants, especially occurring on the glumes of grasses.

BARKHAN. Isolated sand dune in the form of a lunar crescent. The windward slope is convex; the horns point down-wind.

BASIC ROCKS. Rocks poor in silica; opposed to acid.

BEDROCK. The solid rock underlying soils and other superficial formations.

BELKI (Russian). Snow-capped mountains.

BOBAC. A marmot of eastern Europe and Asia.

BOG SOILS. An intrazonal group of soils with a mucky or peaty surface soil underlain by peat, developed under swamp or marsh types of vegetation, mostly in a humid or subhumid climate.

BOR (Russian). A pine grove growing on sandy soil.

CARYOPSIS. A one-celled, one-seeded, superior fruit, with pericarp united to the seed; the fruit of cereals.

CHERNOZEM SOILS. Azonal group of soils having a deep, dark-colored to nearly black surface horizon, rich in organic matter, which grades below into lighter-colored soil and finally into a layer of lime accumulation; developed under tall and mixed grasses in a temperate to cool subhumid climate. From the Russian for "black earth."

CIRQUE. A deep, steep-walled, amphitheatral recess in a mountain, caused by glacial erosion. The glacial cirque is so distinctive a geomorphic form that it is identified by a specific word in many languages, thus: *kar, corrie, cwm, botn, caldare, oule, zanoga.* These foreign terms are occasionally used in English when the reference is to the occurrence of glacial cirques in the places where these words are used.

Cyclone. The system of winds that accompanies and surrounds any considerable region of minimum barometric pressure. The winds circulate around the center counterclockwise.

Degradation. Change of one soil type to a more highly leached one.

Degraded Chernozem. A zonal group of soils having a very dark brown to black surface horizon underlain by a dark- to light-gray leached horizon which rests upon a brown horizon; developed in the region between chernozem and podzolic soils, where the forest vegetation has encroached upon grassland.

Detritus. A heterogeneous mass of fragments of stone or earth.

Dhole. A fierce wild dog of Asia, of houndlike form, of a deep bay color, with small erect ears and a bushy tail. It hunts in packs and will attack even the tiger.

Dicotyledon. Plant of the class denoted by their possession of two cotyledons, or seed lobes.

Diluvium. Material of any sort deposited in one place after having been moved from another; drift.

Drumlin. An oval hill of glacial drift, normally compact and unstratified, usually with its longer axis parallel to the movement of the ice responsible for its deposition.

Eluvial. See "eluviation."

Eluviation. The movement of soil material from one place to another within the soil, in solution or in suspension, when there is an excess of rainfall over evaporation. Horizons that have lost material through eluviation are referred to as eluvial and those that have received material as illuvial. The term refers especially to the movement of colloids, whereas leaching refers to the complete removal of material in solution.

Endemic. Indigenous or native to a restricted locality; confined naturally to a certain limited area or region; opposed to exotic.

Epeirogenic. Of, pertaining to, or designating, continent-making movements of the earth's crust, or the rising or sinking of vast areas.

Epiphytes. Plants which germinate on other plants and grow without obtaining nourishment at the cost of the substance of the host.

Escape. A cultivated plant found growing as though wild, dispersed by any agency.

Esker. A sinuous ridge of glacial sand and gravel, deposited by a stream flowing beneath, in, or upon the glacier, and left as a ridge after the melting of the enclosing ice; serpentine kame, os.

Extrusive Rocks. Igneous rocks produced from lavas which reach the surface of the earth before they consolidate.

Fault. A fracture in the earth's crust accompanied by a displacement of one side of the fracture with respect to the other and in a direction parallel to the fracture.

Flood Plain. The nearly flat surface subject to overflow along stream courses.

Fluvioglacial. Deposited or accomplished by streams from glacier ice.

Foehn. A warm, dry wind blowing down a mountain side onto the valleys and plains beyond; the chinook is a warm, dry foehnlike wind that descends the Rocky Mountains.

Fossorial. Fitted for digging or burrowing, as the legs of certain insects.

Geosyncline. A great downward flexure of the earth's crust.

Glavny (Russian). Main.

Gleization. A general term for the process of soil formation leading to the development, under the influence of excessive moistening, of a glei (gley) horizon in the lower part of the solum. A soil horizon in which the material ordinarily is bluish gray or olive gray, more or less sticky, compact, and often structureless, is called a glei (gley) horizon and is developed under the influence of excessive moistening.

Gley. See "gleization."

Glint (Russian). An escarpment in the Baltic region.

Glume. The chaffy two-ranked members of the inflorescence of grasses and similar plants.

Graben. A block of the earth's surface that is depressed in relation to the surrounding rock units. The topographic basin that results from graben faulting is a rift, or rift valley.

Grasses. Annual or perennial, mostly herbaceous plants, family Gramineae.

Half-bog Soils. An intrazonal group of soils with mucky or peaty surface soil underlain by gray mineral soil; developed largely under swamp-forest type of vegetation, mostly in a humid or subhumid climate.

Halophyte. A plant which grows on saline soil. Halo is from the Greek for "salt."

Hamate. Hooked at the tip.

Herb. A plant that dies to the ground each year, or at least that does not become woody. It may be annual, biennial, or perennial.

Horst. A block of the earth's surface bounded by faults and lifted above its surroundings; opposed to graben.

Humus. The well decomposed, more or less stable part of the organic matter of the soil.

Hydrophyte. A plant which grows in water or in saturated soil.

Igneous Rock. A rock produced through the cooling of melted mineral material.

Illuvial. See "eluviation."

Interfluve. The higher land separating adjacent stream valleys.

Intrazonal Soil. Any of the great groups of soils with more or less well developed soil characteristics that reflect the dominating influence of some local factor of relief, parent material, or age over the normal effect of the climate and vegetation.

Intrusive Rocks. Igneous rocks produced from magmas that have consolidated below the earth's surface; plutonic rocks.

Kame. A short irregular ridge, hill, or hillock of stratified glacial drift.

Karst. A limestone plateau on the eastern coast of the Adriatic, marked by sinks, or karst holes, interspersed with abrupt ridges and irregular protuberant rocks, and by caverns and underground streams; any region characterized by similar topography.

KIANG. A large Tibetan wild ass (*Equus hemionus*), somewhat resembling a horse.

KRAY (Russian). An administrative unit in the R.S.F.S.R. and the Ukraine, formed along lines of economic characteristics, which supersedes both the *raion* congresses of soviets of the rural districts and the soviets of the small cities. See "*oblast.*"

KURGAN (Russian). An accumulation of earth, of rounded, generally symmetrical form, often more or less elliptical in horizontal section; tumulus, or barrow.

LACCOLITH. An intrusive mass of igneous rock completely surrounded by strata which it has upheaved to form an arch or domical bulging.

LACUSTRINE DEPOSITS. Materials deposited by lake waters.

LAYER SOCIETY. A plant community within an association which results from the tendency of various species of smaller size than the dominant life form to display their foliage at more or less definite levels. Thus, horizontal vegetative strata, the product of a process of adaptation and selection in which light is a dominant factor.

LEACHING. Removal of materials in solution.

LEGUME. A simple, usually dry pod, splitting along the back into two valves or parts; the fruit of any leguminous plant.

LOESS. An unstratified deposit of loam, ranging to clay at the one extreme and to fine sand at the other, usually of a buff or yellowish-brown color.

MAQUIS. Evergreen transition zone between steppe and forest in the Mediterranean region, the species being characteristic of the adjoining forest; mostly of taller scrubs.

MASSIF. The dominant, central mass of a mountain ridge more or less defined by longitudinal or transverse valleys; a diastrophic block, or any isolated central independent mass; a thickly-wooded hillside or a cluster of trees such as obscures all view beyond it.

MELKOSOPOCHNIK (Russian). Region of low hillocks and declivities with gentle slopes, believed to have been formed as a result of erosion under continental conditions.

METAMORPHIC ROCK. A rock the constitution of which has undergone pronounced alteration. Such changes are generally effected by the combined action of pressure, heat, and water, frequently resulting in a more compact and more highly crystalline condition of the rock. Gneiss, schist, and marble are common examples.

MINERAL SOIL. A general term used in reference to any soil composed chiefly of mineral matter.

MONOCLINAL. Having a single oblique inclination.

MONSOON. A wind that blows steadily along the Asiatic coast of the Pacific over an extent of about 40° lat., in winter from the northeast (dry monsoon), in summer more violently from the southwest (wet monsoon). Hence, any wind that alternates annually in direction and force; a trade-wind.

MORAINE. An accumulation of earth, stones, and so forth, carried and finally deposited by a glacier.

MOUSE HARE. A pika.

Mud Volcano. An orifice in the earth from which gas or vapor issues, either through a pool of mud, or with the ejection of mud, which accumulates in a conical mound.

"Mushroom" Rocks. Rock formations, characteristic of desert landscapes, which have been shaped by the cutting away of all projecting masses near their bases, due to the restriction of the more effective tools of erosion to the layer of air just above the ground.

Mycotrophic. Obtaining food by association with a fungus.

Névé. The partially compacted granular snow forming the surface part of the upper end of a glacier; firn.

Niche. A faintly etched amphitheater on the slope of a mountain, sometimes produced by the hollowing action of snowdrifts.

Oblast (Russian). The terms *oblast* and *kray* are applied indiscriminately, according to local usage. But strictly speaking, an *oblast* is a newly established administrative district containing no autonomous area. Where an autonomous area peopled mainly by a national minority exists as an enclave within the district, the proper term is *kray*. The North Caucasian *kray*, for example, contains as many as seven autonomous areas.

Okrug (Russian). In the early days of the Soviet Union there was a tier of councils, in addition to the divisions of *oblast* or *kray* and *raion*, termed the *okrug* soviet, for an area roughly corresponding to that of the old *volost* (rural district), in which both village soviets and city soviets were represented. This division was found inconvenient. It was decided by the Central Committee of the Communist Party by a decree of July 6, 1930, to "liquidate" the *okrugs* and to conclude by October 1, 1930. The decision was ratified by the Sixteenth Party Congress. But, in the vast area of the U.S.S.R., such changes take time to become universal. In 1934 there were still functioning twenty-two *okrugs*.

Organic Soil. A general term used in reference to any soil the solid part of which is predominantly organic matter.

Panicle. A loose flower cluster.

Parent Materials. The unconsolidated mass from which the soil profile develops.

Parent Rock. The rock from which parent materials of soils are formed.

Peat. Unconsolidated soil material consisting largely of undecomposed or slightly decomposed organic matter accumulated under conditions of excessive moisture.

Petiole. The footstalk of a leaf.

Pinnate. With leaflets arranged along each side of a common petiole.

Podzol Soils. A zonal group of soils having an organic mat and a very thin organic-mineral layer above a gray leached layer, which rests upon an alluvial dark-brown horizon, developed under coniferous or mixed forest, or under heath vegetation in a temperate to cold moist climate. Iron oxide and alumina, and sometimes organic matter, have been removed from the *A* and deposited in the *B* horizon. From the Russian for "like ash" or "near ash."

Podolization. A general term referring to that process (or those processes) by which soils are depleted of bases, become acid, and have developed eluvial *A* horizons (surface layers of removal) and illuvial *B* horizons (lower horizons of accumulation). Specifically the term refers to the process by which a podzol is developed, including the more rapid removal of iron and alumina than of silica, from the surface horizons, but it is also used to include similar processes operative in the formation of certain other soils of humid regions.

POLYN (Russian). Species of *Artemisia.* In *Standardized Plant Names* (see Translator's Bibliography), species of *Artemisia* growing in the western United States are called "sagebrush," while those growing in the Old World are called "wormwood." However, this usage is not accepted by all authorities in this country. For this reason it was decided to retain the Russian word *polyn* throughout this translation.

RAION (Russian). An area, formed mainly on lines of economic production, comprising a number of adjacent villages and hamlets, together with such small cities and urban settlements as are found in the area. The geographical extent and population of the *raion* differ from place to place according to local circumstances, and may be varied from time to time by decrees of any superior authority. It may thus comprise any number of villages, from a few dozen to many score, with half a dozen times as many dependent hamlets, with or without one or more cities and urban settlements.

RELATIVE ELEVATION. Elevation in local relief.

RELICT, *adj.* Left behind in a process of change; *n.* a living remnant of an otherwise extinct type of plants or animals.

RHACHIS. The axis of an inflorescence or compound leaf or frond.

RHIZOME. Rootstock or dorsiventral stem, of rootlike appearance, prostrate on or under ground, sending off rootlets, the apex progressively sending up stems or leaves.

RIFT VALLEY. See "graben."

ROCHE MOUTONNÉE. A knob of rock produced by the erosive action of glaciers; it has a gently inclined, striated and grooved, smoothed, or even polished slope on the end against which the glacier impinged; the long axis is oriented in the direction of the ice motion; the lee end is steep, and has a rough, hackly surface.

SAXAUL. A singular tree (*Anabasis ammodendron* and other species) without leaves, its thin boughs without branches, the stem growing in zigzag curves to the height of fifteen feet or more. It is common in western Asia.

SEDIMENTARY ROCK. A rock composed of particles deposited from suspension in water. The chief groups of sedimentary rocks are (1) conglomerates (from gravels), (2) sandstones (from sands), (3) shales (from clays), and (4) limestones (from calcium carbonate deposits); but there are many intermediate types.

SEICHE. An oscillation of the surface of a lake or landlocked sea, varying in period from a few minutes to several hours. It is thought to be initiated chiefly by local variations in atmospheric pressure, and perpetuated by the oscillations of the water surface, after the inequalities of atmospheric pressure have disappeared.

SESSILE. Without a stem or stalk.

SESQUIOXIDE. A binary compound of oxygen and a metal in the proportion of three to two. The two oxides, alumina (Al_2O_3) and iron oxide (Fe_2O_3) are the only two oxides in soils, in any considerable quantity, in which the elements are present in the ratio of two to three, or one to one-and-a-half; hence the term "sesquioxide."

SHIBLYAK (Russian). Transition community between steppe and forest; such communities have arisen on the deforested soil of the Balkan Peninsula; they are composed of species which are not characteristic of forest; *sibljak*.

SIEROZEM SOILS. A zonal group of soils having a brownish-gray surface horizon that grades through lighter-colored material into a layer of carbonate accumulation and frequently into a hardpan layer, developed under mixed shrub vegetation in a temperate to cool arid climate. From the Russian for "gray earth."

SINKS. Funnel-shaped depressions dissolved from the surface of rock about the caverns of limestone formations.

SKELETAL SOILS. An azonal group of soils having no clearly expressed soil morphology and consisting of a freshly and imperfectly weathered mass of rock fragments; largely confined to steeply sloping land; lithosols.

SOIL. The natural medium for the growth of land plants on the surface of the earth. A natural body on the surface of the earth in which plants grow, composed of organic and mineral materials.

SOLOD SOILS. An intrazonal group of soils having a thin surface layer of brown friable soil above a gray leached horizon which rests upon a brown or dark-brown horizon; developed under shrubs, grasses, or mixed grasses and trees, usually in a semiarid or subhumid climate. From the Russian for "salt."

SOLONCHAK SOILS. An intrazonal group of soils having a high concentration of soluble salts; usually light colored; without characteristic structural form; developed under salt-loving grass or shrub vegetation mostly in arid, semiarid, or subhumid climate. From the Russian for "salt."

SOLONETZ SOILS. An intrazonal group of soils having a variable surface horizon of friable soil underlain by dark hard soil, ordinarily with columnar structure; usually highly alkaline; developed under grass or shrub vegetation, mostly in a subhumid or semiarid climate. From the Russian for "salt."

SOLONIZED SOIL. A soil which is affected by a process which ultimately leads to the formation of a solonetz. According to the extent of modification of the original material by such a process, one may recognize a weakly solonized, a moderately solonized, and a strongly solonized soil. The highest degree of solonization is represented by the fully developed or "mature" solonetz. The most conspicuous characteristic of solonization is the development of a dark-colored impervious clayey *B* horizon or layer immediately below the surface soil. Thus, a solonized soil is a weakly or imperfectly developed solonetz.

SOLUM. The upper part of the soil profile, above the parent material, in which the processes of soil formation are taking place.

STANITSA. A Cossack village or commune.

SUBSOIL. Roughly, that part of the solum below plow depth.

SUSLIK. A ground squirrel (*Citellus*) of northeastern Europe and northwestern Asia.

SYNCLINE. A downward flexure in folded rocks, formed by strata dipping toward a common line or plane; a trough.

TAKYR (Russian). The flat-floored bottom of an undrained desert basin, becoming at times a shallow lake, which, on evaporation, may leave a deposit of salt or gypsum; playa, salt pan.

TALUS. Fragments of rock and soil material collected at the foot of cliffs or steep slopes, chiefly as a result of gravitational forces.

TARPAN (Russian). A small feral horse (*Equus gmelini*) of the steppes of Russia and Central Asia, dun-colored and with a short mane.

TECTONIC. Designating the rock structures and external forms resulting from the deformation of the earth's crust.

THERMOPHILE. An organism growing at a high temperature.

THRUST. A compressive tangential stress in the earth's crust or the effect of such stress. Thrust faults are faults produced by horizontal compression, in which the vertical displacement of one block relative to the other is incidental to the horizontal shortening of the mass as a whole.

TRAP. Any of various dark-colored, fine-grained, igneous rocks. Gabbro and diabase are often called trap rock.

TUFF (TUFA). A rock composed of the finer kinds of volcanic detritus, usually more or less stratified and in various states of consolidation. There are many varieties. Tufa applies to similar rocks, but more especially to a kind of porous rock formed as a deposit from springs or streams; usually applied to calcareous deposits (travertine) in the phrase, "calcareous tufa."

UNDERSHRUB. A low shrub; a low woody plant, whether growing beneath trees or in open ground; a subshrub.

URMAN (Russian). A dense coniferous forest with fir predominating.

VODORAZDELNY (Russian). *adj.* Watershed.

XEROPHILOUS. Drought-resistant or drought-tolerant; able to withstand the absence or scarcity of moisture, as a desert plant.

XEROPHYTE. A plant which can subsist with a small amount of moisture, as a desert plant.

ZONAL SOIL. Any one of the great groups of soils having well developed soil characteristics that reflect the influence of the active factors of soil genesis —climate and living organisms, chiefly vegetation.

Russian Transliteration Table

(Based on the new Russian orthography)

This scheme is designed for the convenience of readers who do not know Russian. It is intended primarily for the rendering of personal and place names—mostly nouns in the nominative case.

The aim is to produce words as "normal" in appearance as possible, without the use of diacritical marks, superscripts or apostrophes, but at the same time to approximate the sounds of the Russian words, so that if spoken by an educated American they would easily be identified by a Russian.

Names which are a part of English cultural tradition, such as Moscow, Archangel, Tolstoy, Tchaikovsky, are given in their customary English spelling.

Extended phrases or entire sentences involving verb forms and case endings, which occur in footnotes for the convenience of students who know Russian, are given in a somewhat more complex transliteration which is reversible.

Russian			*English*	
А	а		*a*	
Б	б		*b*	
В	в		*v*	
Г	г		*g*	except in genitive singular where it is *v*, as in Tolstovo.
Д	д		*d*	
Е	е	(1)	*ye*	when initial, and after ь, ъ, and all vowels, except ы, и: Yekaterina, Izdanie, Nikolayev.
		(2)	*e*	elsewhere, as in Lenin, Vera, Pero.
Ё	ё		*yo*	but after ж and ш = *o*.
Ж	ж		*zh*	
З	з		*z*	
И	и		*i*	but after ь = *yi*, as in Ilyich.
Й	й		*y*	in terminal diphthongs, but *i* medially, as in May, Kochubey, Kiy, Tolstoy, but Khoz*yai*stvo.
К	к		*k*	
Л	л		*l*	

Russian		*English*	
М	м	*m*	
Н	н	*n*	
О	о	*o*	
П	п	*p*	
Р	р	*r*	
С	с	*s*	
Т	т	*t*	
У	у	*u*	
Ф	ф	*f*	
Х	х	*kh* as in	Kharkov.
Ц	ц	*ts*	Tsargrad.
Ч	ч	*ch*	Chapayev, Vaigach.
Ш	ш	*sh*	Shakhta.
Щ	щ	*shch*	Shchedrin.
Ъ	ъ	Omit	
Ы	ы	*y*	Mys, Tsaritsyn.
Ь	ь	Omit	
Э	э	*e*	Ermitazh.
Ю	ю	*yu*	
Я	я	*ya*	

Adjectival Endings

Singular	ЫЙ,	ИЙ	ый,	ий	both simply *y*, as in Dostoyevsky, Grozny.
Plural	ЫЕ,	ИЕ	ые,	ие	both simply *ie*.

The English letter *y* serves both as vowel and as consonant (as it does in English): (1) as a vowel *within* words, as in Mys, Tsaritsyn, and also (2) as an adjectival terminal vowel, as in Khoroshy, Razumovsky, May, Kochubey, Tolstoy, and (3) with consonantal force to soften vowels, as in Istoriya, Bratya, Yug.

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KEEP CARD IN POCKET