THE SECOND DANISH PAMIR EXPEDITION

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The translation has been revised and corrected by Dr. W. G. Smith, of the College of Agriculture, Edinburgh, who has assisted also in proof-reading. I would offer Dr. Smith my sincere thanks for his valuable assistance without which it would hardly have been possible to find correct English equivalents for Danish botanical terms.

A Russian edition is under preparation.

The author.

THE SECOND DANISH PAMIR EXPEDITION

CONDUCTED

BY

O. OLUFSEN
LIEUTENANT OF THE DANISH ARMY

STUDIES ON THE VEGETATION OF THE TRANSCASPIAN LOWLANDS

BY

OVE PAULSEN
MEMBER OF THE EXPEDITION

WITH 79 FIGURES AND A MAP

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OVE PAULSEN

STUDIES ON THE VEGETATION OF THE TRANSCASPIAN LOWLANDS

CONTENTS.

INTRODUCTION.

The second Danish Pamir Expedition initiated and conducted by Professor O. Olufsen, at that time lieutenant in the Danish army, left Copenhagen in March 1898. After an unavoidable delay at St. Petersburg the expedition proceeded by rail southwards through Russia, then by steamer across the Caspian and on the 23rd of April we, for the first time, set foot on Asiatic soil in Krasnowodsk.

The expedition spent a couple of months in the Transcaspian lowlands visiting Tshardshui, Buchara, Samarkand, Tashkent, Kokand, Andidshan and Osh, generally travelling by rail. In the middle of June we left Osh and went to Pamir, whence we returned in April 1899. The spring and summer of 1899 were passed in Ferghana and the Transcaspian lowlands, most of the time in Buchara and Chiwa. The journey to Chiwa was made by boat from Tshardshui down the Amu Darya (Oxus) and botanically this was one of the most interesting parts of the journey, as it afforded a good opportunity of studying the deserts of the river banks and the «Gallery forests.» The Chiwa journey lasted from the middle of June till the end of August when we returned to Tshardshui. Here I was fortunate enough to make the acquaintance of Mr. V. Palezkij, inspector of the plantations along the Transcaspian railroad, who with the greatest kindness showed me these plantations.

From Tshardshui we returned westward to the Caspian Sea. September and October were spent in Persia, whence the expedition returned, through Russia, to Copenhagen, where we arrived in November 1899.

The systematic part of the botanical results of this journey have been published from time to time as the examination of the separate families was completed.[1])

This memoir is the first part of the biological section of the botanical results of the expedition, and includes the vegetation of the lowlands.

As the expedition never remained long in one place, there was not much opportunity for thorough investigation of the desert in any locality, so that this memoir is the result of observations in many parts most of which were only examined for a short time. Physiognomy therefore occupies a prominent place in this description of a type of vegetation which in detail would constitute an extensive research. It is to be hoped that detailed investigations, such as those made at the desert laboratory in Tuczon (Arizona) or similar to FITTING'S researches in the Sahara will also be made in the Transcaspian desert, so characteristic and worthy of careful examination.

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[1]) These publications are located as follows: Videnskabelige Meddelelser fra den naturhistoriske Forening i Kbhvn. 1901 — Caryophyllaceae, Ranunculaceae; in the same periodical for 1903 — Cruciferae, Umbelliferae, Valerianaceae, Compositae, Gramineae, Potamogetonaceae, Chenopodiaceae; Botanisk Tidsskrift Vol. 26 — Pteridophyta, Gnetaceae, Cupressaceae, Lemnaceae, Typhaceae, Juncaginaceae, Alismaceae, Typhaceae, Juncaginaceae, Alismaceae, Liliaceae, Convallariaceae, Amaryllidaceae, Iridaceae, Juncaceae, Orchidaceae, Salicaceae, Cupuliferae, Urticaceae, Cannabaceae, Polygonaceae; in Botanisk Tidsskrift Vol. 27 — Amarantaceae, Phytolaccaceae, Berberidaceae, Ceratophyllaceae, Papaveraceae, Fumariaceae, Resedaceae, Violaceae, Frankeniaceae, Tamaricaceae, Euphorbiaceae, Oxalidaceae, Linaceae, Geraniaceae, Balsaminaceae, Malvaceae, Rutaceae, Zygophyllaceae. Polygalaceae, Ampelidaceae, Rhamnaceae, Thymelaeaceae, Elaeagnaceae, Saxifragaceae, Ribesiaceae, Hamamelidaceae, Rosaceae, Lythraceae, Oenotheraceae, Haloragidaceae, Myrtaceae, Loranthaceae, Primulaceae, Convolvulaceae, Solanaceae, Plantaginaceae, Bignoniaceae, Apocynaceae, Asclepiadaceae, Rubiaceae, Caprifoliaceae, Dipsacaceae, Scrophulariaceae, Borraginiaceae; Botanisk Tidsskrift Vol. 28 — Fungi, Cyperaceae, Labiatae; Bulletin de l'Herbier Boissier VI — Papilionaceae; Botanisk Tidsskrift Vol. 29 — Additions and Corrections.

SECTION I. TRANSCASPIA AND ITS NATURAL CONDITIONS

CHAPTER I

Situation and Boundaries of the Region examined.

The great tract of lowlands, a southern extension of the West-Siberian plain, stretching from the Caspian Sea to the country round Lake Balchash, and having as its southern boundary the mountains of northern Persia, the Thianshan and Ala-tau and which is in open communication with the south of Russia, to the north-west, through the plains north of the Caspian Sea, cannot strictly be designated as belonging to those portions of the continent which are without drainage to the sea. The »Duab« or »country with two streams« traversed by the two great rivers Amu and Syr, both flowing into the Aral Sea, is of the type designated by Richthofen as a peripheral region, that is a region whose waters are carried by rivers to the sea, or to remnants of sea which are now lakes. Richthofen's Central Asia, on the contrary, includes the areas in the interior of Asia which are devoid of any drainage to the sea. Here the wind is the principal geological agent, and all the products of chemical or mechanical disintegration remain in the country; they are only moved from one place to another, filling up the hollows and thus imparting a monotonous aspect to the country. While, as Richthofen remarks, the movement in Central Asia is centripetal, it is centrifugal in the peripheral regions,

— here water is the principal agent as it continually carries away the products of erosion by the rivers.

As regards Turkestan[1]), MUSHKETOW maintains, contrary to RICHTHOFEN, that this part is very similar to Central Asia proper. It is without drainage to the sea and the eolian or windborne deposits are the most important feature. The rivers in the lowlands have no effluence, and can therefore only be local agents in transportation. Moreover there is a very close geological affinity, deposits from the Cretaceous and Tertiary periods stretching, almost without interruption, from Hanhai into Turkestan, not only through the ravine of Dsungaria but also more to the south. Hanhai and Turkestan have been covered by the same Tertiary sea.

MUSHKETOW therefore, for the present at any rate, rejects RICHTHOFEN'S definition of Central Asia and designates as Asia-Media the regions that are without drainage to the open sea and amongst these Turkestan. (l. c. p. 11).

Turkestan or the Turkestanian Basin, called by ROMANOWSKI the Turanian Plain, is defined by MUSHKETOW as follows: It stretches from the Mugodshar mountains and Usturt in the west to Tsungei Alatau, Thianshan and Pamir in the east, from Kopetdagh and the Chorassan mountains in the south, to Tarbagatai and Tjingistau in the north-east and in the north to the watershed between this area and the rivers running into the Irtish. (See the map appended to this memoir). The mountain range Karatau divides the area into two parts: the north-eastern Balchash Basin which is not dealt with here except as regards the distribution of plants, and the Aral Basin or the Turanian Basin proper.

This latter is the subject of the present contribution, but not to the full extent of the limits given above. In view of the botanical investigations, it is advisable to fix the northern boundary in this memoir at about 46 ° N. Lat. This line passes through the northern part of the Aral Sea and thus cuts off the whole territory of the Kirghiz Steppe. The

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[1]) Mushketow also discards East Turkestan as name of a geographical area on the ground that it belongs to the Central region of Asia (L. c. p. 13).

northern part of this is a Stipa-steppe which I prefer to omit, as I have not seen it, and it does not occur farther south. The southern part is a desert in the sense employed in this memoir, (see chap. 5) with its northern boundary, according to TANFILJEW, (1903, pp. 386, 388) extending from the southern end of the Mugodshar Mts. to the town of Uralsk, and which, in a more or less changed form (the "Kalmyk Steppe") extends westwards to the foot of the Jergeni Mts.[1]) But this northern desert must be far less warm or less dry (perhaps both) than the deserts south of the Aral Sea. We are led to this conclusion because *Hippophaë rhamnoides, Salix repens, Koeleria glauca, Elymus arenarius, Populus tremula, Amygdalus nana, Rhamnus cathartica* and several other plants (see SAWITSH p. 224) occur here near their southern limit on the plain, although several of them *e. g. Hippophaë* and *Amygdalus* are again found in the mountains to the south (Compare BORSZCZOW cited later p. 29, point 1,3) The list of plants given later (chap. 12) would convey a less striking picture of the character of the desert if these plants were included in it, and for this reason I have excluded the Kirghiz Steppe; moreover, as already stated, the expedition did not explore it.

What name then can be given to the territory, delineated as above, and whose vegetation is the subject of our memoir?

The area from the Caspian Sea and far into China is generally designated "Turkestan" and, even if in accordance with MUSHKETOW, we limit it to the lowlands west and north of the mountains, it will still include the Balchash Basin and the Kirghiz Steppe which we wish to exclude. The same

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[1]) According to BEKÉTOFF (1886) and PATSCHOSKIJ (1892) the Jergeni Mts. form the boundary between European and Asiatic vegetation, the former is the steppe of southern Russia, for the most part under cultivation, the latter is a desert, the «Aralocaspian steppe», as PATSCHOSKIJ terms it. According to RADDE (1899), the Jergeni forms the boundary between better humus soil (4—7 per ct.) towards the west and poor humus soil (under 2 per ct.) towards the east. Finally, according to WOEIKOFF (Hann III p. 194) the Jergeni Mts. coincide with part of the eastern limit of Russia's regular summer rains, which is evidently the cause underlying the contrast between vegetation and soils.

argument applies to the name "Turan" which covers MUSHKETOW's „Turkestan". The "Aral-Basin" would better designate our territory, but this name also includes the Kirghiz Steppe. The designation Transcaspian Plain or Lowlands or briefly Transcaspia has finally been selected as most appropriate. The same name has been used to indicate an administrative unit of the Russian empire, the government Transcaspia, which extended almost to the Amu Darya, to the borders of the vassal state of Buchara.

In thus designating my territory Transcaspia it should be emphasised that though to the east it stretches to Kara Tau, I do not use this name as defining a geographical area, but only as a name for a territory the borders of which I have determined myself, and which lies beyond the Caspian Sea.

CHAPTER 2

Features of the Geology of Transcaspia.

Turkestan and Central Asia are supposed to have been covered by the sea during the Cretaceous and Tertiary periods, and even on the mountains at a height of 11,000 feet, Tertiary deposits have been found (MUSHKETOW).

This sea receded from Hanhai earlier than from the plain of Turkestan, and of this country the eastern part was the first part to become dry. During the Miocene period the brackish Sarmatian inland sea connected the Aral, the Caspian and the Black Sea (KARPINSKI). At a later period, probably contemporaneous with the great Scandinavian glacial period and when there was much water from the melting ice, there existed a sea (the Aralo-Caspian Basin) which filled the depressions now occupied by the Caspian Sea and the Aral Sea, connecting them by a narrow straight (KARPINSKI, SJÖGREN).

Almost all the lowlands of Turkestan (95 per ct. according to MUSHKETOW) are thus covered with deposits from the Cretaceous and Tertiary periods. Through these, islands of

older rocks emerge, for instance Tamdi-Tau, Bukan-Tau, Sultan Uis Dagh, now isolated mountainous masses consisting of various slates and crystalline rocks which as a result of greater denudation are now more cut up than the rocks of Thianshan.

The deposits from the Cretaceous and Tertiary periods are of great thickness, attaining 5000 feet in Ferghana for instance. They consist of diverse coloured strata of marl, limestone, ferruginous sandstones, gypsum, clay &c. They are not identical everywhere but change according to the nearness of the mountains: At the foot of the mountains, marginal deposits are found, such as shelly limestones, conglomerates, clay with gypsum and rock-salt, while, out on the flat land, sand and clay are found deposited in deeper water (ROMANOWSKI, MUSHKETOW).

The Tertiary deposits, however, are rarely visible, as they are almost everywhere covered by newer deposits partly derived from them. Of these the most important are: the moving sands, the Aralo-Caspian deposits and the loess.

Deserts of moving sand cover, according to RODSEWITCH, about 88 per ct. of the lowland. The sand is of varied origin. In the northern part it is derived from old Aralian sea-coast dunes and is white or grey. As this sand originates from the old Aralo-Caspian Basin, it has much the same distribution as the Aralo-Caspian deposits mentioned below.

Throughout the rest of the moving-sand territory, the dunes ("Barchans") are genuine inland deposits which owe their origin purely to the wind. The wind carries off everything available, all that mechanical disintegration provides for it. Thus the Aralian dunes, the Aralo-Caspian deposits and the older rocks contribute to the formation of the "Barchans". Illustrations of the effects of the levelling process will be found in BERG. — The Barchans are of a dirty yellow colour, they have the shape of a crescent, generally quite regular. The convex part faces the wind, the inclination of the surface is here 6—16°, while on the lee side it is 30—38° (MUSHKETOW). The crest is a sharp and regular line, which from the highest point curves downwards and away from the wind. How the crescent shape is produced has been ex-

plained by MIDDENDORFF, WALTHER (p. 122) and SOLGER (p. 149). In contrast to the dunes of western Europe, the barchans do not owe their occurrence to the sand having at first found shelter behind some obstacle, but they take that form which offers least resistance to the wind, hence they must be regarded as gigantic wave-lines in the sand. Good pictures of barchans may be seen in BESSEY.

Other forms of sand landscapes are dealt with in the chapter on the formation of the sand desert.

The Aralocaspian formations which originated in the post-pliocene Aralocaspian Basin consist of sandy clays deposited on the bottom of the basin. The area of the older sea was considerably larger than that of the present lakes; thus, its eastern part extended down both sides of the isolated mountains Bukan Tau and Sultan Uis Dagh so that these occupied a peninsula in the sea. As the sea dried up, many smaller lakes were left.

Loess, as is well known, is a calcareous loam intersected by innumerable irregular veins which often contain roots of plants. "Ein Leichenfeld von unzählbaren Generationen von Gräsern", as RICHTHOFEN puts it (I, p. 71). Loess is now generally regarded as an eolian deposit derived from dust-drift, since the finest material shifted by the wind — if not taken right away — must sooner or later come to rest either in water or on a fixed "steppe", because the wind would carry it away again from any other place (RICHTHOFEN I, p. 98). In the first case the material will go to form stratified deposits on the sea-bottom, in the latter it will form land-loess which is not stratified.

In Turkestan Loess may attain a great thickness, according to ROMANOWSKI up to 1500 feet. It occurs more especially in the south-eastern, southern and eastern parts of the territory, but also occurs in patches in other places (MUSHKETOW).

Like all areas without drainage to the sea, the Transcaspian plains are rich in salts, since if the products of disintegration and chemical weathering cannot be taken out of the country, they must remain. Most of the Russian authors known to me are of opinion that the salts origin-

ate from the old sea as the result of evaporation. But I am rather of the opinion of ANIKIN that the salts are mainly due to the constantly continued chemical weathering.

Chlorides and sulphates occur most frequently both in the soil of the desert and in the salt-lakes. These two groups of salts are often found separate, so that some lakes have mainly sodium chloride in solution, while others have mainly compounds of sodium and magnesium sulphates. The latter are called bitter-lakes. ANIKIN explains the difference in the following way. The wind assorts the material which has been crystallized out through evaporation. The common salt crystallizes out first and as a firm mass, then the sulphates crystallize later above this in loose powdery masses which later, when left dry, are carried off by wind, the firmer masses of sodium chloride being left as a coherent deposit.

In a supplement to MIDDENDORFF's memoir on Ferghana, SCHMIDT gives a number of salt-analyses from which the following are selected:

1. Kara-Tjubé, salt-desert. Crystalline Powder with glauber-salt, gypsum, bitter-salt and clay: —

Salts soluble in water: 74,2045 per ct.

including:	Na_2SO_4	62,4234	per ct.
	$CaSo_4$	8,5121	—
	$MgSO_4$	3,1500	—
	Al_2O_3	6,9351	—

2. Mojan. Efflorescence upon limestone: —

Salts soluble in water: 21,661 per ct.

including:	NaCl	2,742	per ct.
	Na_2SO_4	11,287	—
	$CaSO_4$	6,977	—
	$CaCO_3$	47,447	—

3. Kokan. Jany Kurgan. Salt crust on dry plant stems: —

Salts soluble in water: 49,0787 per ct.
including: Na_2SO_4 44,8090 per ct.
$CaSO_4$ 3,2232 —
$MgSO_4$ 1,2510 —
$CaCO_3$ 4,7170 —
NaCl 0,2891 —

4. Margilan. Alty Aryk. Snow-white salt-desert —

Salts soluble in water: 26,6792 per ct.
including: Na_2SO_3 9,4161 per ct.
$CaSO_4$ 10,1121 —
$MgSO_4$ 6,8053 —
$CaCO_3$ 5,9624 —
NaCl 0,1236 —

Radde (1899 p. 22) gives the following analysis of a "Ssor", salt-patch in the desert: —

Na_2SO_4 85,50 per ct.
NaCl 8 —
$MgSO_4$ 3,50 —
$CaSO_4$ 0,68 —

In the following the samples were collected by me and analysed by Mr. Wöhlk, chemist:

1. Salt on the earth in a desert near Buchara.
A greyish-white, amorphous, flocculent, dusty powder consisting of: —

Na_2SO_4
with $CaSO_4$, about 6 per ct.
and NaCl, trace.

2. Rough firm saline crust from the same place: —
Salts soluble in water:

$CaSO_4$, ab. 8,9 per ct.
Na_2SO_4 - 5,4 —
$MgSO_4$ - 44,7 —
NaCl - 41,0 —

3. Pure white salt around the lake Jugur Kul, Chiwa. July 15th 1899: —

NaCl
with $MgSO_4$, ab. 3,7 per ct.
and $MgCl_2$, - 1,4 —

4. In the same place. Salt around and encrusting the base of Salicornia plants: —

$MgSO_4$, ab. 21,50 per ct.
NaCl, - 76,9 —
Na_2SO_4, - 1,6 —

5. Salt from a dried-up water-hole near Chodsheli, Chiwa. July 26th 1899. A salt-cake consisting of six strata of colourless crystals lying one above another, and corresponding somewhat to the mineral Astrakanit: —

NaCl, ab. 0,50 per ct.
$MgSO_4$ - 36,7 —
Na_2SO_4, - 41,5 —
Water - 31,3 —
(including carbonate of Mg or Na).

As will be seen, gypsum, glauber-salts, magnesium sulphate, carbonate of lime and common salt are the most frequent salts. Their mode of occurence will be dealt with later, especially in the chapter on salt-deserts.

CHAPTER 3

General Aspects of the Climate of Transcaspia.

The climate is continental, the winter is cold and the summer very hot. Kasalinsk has an annual range of almost 90° Centig. (+ 48° C. summer-maximum, — 40° C. winter-minimum) (Schwarz p. 576). The precipitation is slight.

The winter is not very long, as a rule there is frost, not of long duration, but hard. In 1886 Tashkent had 89 frosty

days, Petro Alexandrowsk 127 (SCHWARZ p. 561). January is the coldest month, and FICKER gives as the absolute minima for 10 years, — 28°,4 and — 28°,1 C. for Petro Alexandrowsk and Tashkent respectively. On the other hand, the temperature may rise to + 20° C. in January. — Snow is not rare, but it seldom lies long on the ground.

Spring comes quickly, commencing at the end of February, and it is comparatively warm; April is warmer than October. In May the average temperature is over 20° C. July is the hottest month, with absolute maxima for 10 years, according to FICKER, 43°,4 C. and 42°,1 C. for Petro Alexandrowsk and Tashkent. In Merw 44°,4 C. has been recorded, and in Namangan (Ferghana) as much as 47°,6 C. (MUSHKETOW). The atmosphere is clear and nightly radiation strong, so that the temperature varies greatly as can be seen from the maxima and minima given in Table 1. The daily variations in temperature are also very great, but as the Russian meteorological stations do not record maximum temperatures, except the temperatures at 1 p. m., no definite figures can be given. At Tashkent in the years 1900—1902 the difference between the minima and the 1 p. m. readings varied from 11,4 to 20,0, but the maximum occurs later in the day than 1 p. m. RADDE (1899) records from the sand-desert a variation of temperature of 36° in 24 hours, while CAPUS (p. 20) gives up to 40°, and OBRUTSHEW (quoted by RADDE) records the following temperatures for the month of March in the sand-desert: At 6 a. m., 3°; 9 a. m., 20°; 1 p. m., 28° C.

At Tachta on the Murghab river near the northern border of Afghanistan, the following temperatures were observed on June 23rd (RADDE 1899 p. 151):

6	a. m.,	in shade	25,°5,	in the sun	34° C.
8	—	—»—	29,°5,	—»—	
11	—	—»—	40,°	—»—	50° -
3	p. m. (?)	—»—	43,°	—»—	54° -

SCHWARZ (p. 559) gives the monthly and yearly amplitudes for a number of stations.

The amount of cloud is greatest during the winter (December—January) and least in summer (August). Buchara has 180 bright days per annum; at Petro Alexandrowsk, for instance, the average number of bright days is 17 in June, 22 in July, 25 in August, 23 in September and 18 in October (FICKER p. 554), and other places have about the same number. An overcast sky is rare during the summer; thus Petro Alexandrowsk has the low average of about 4 days during the five months June—October, and Tashkent about 8 days when the sky is overcast.

Calm days predominate, and from the records of KERSNOWSKIJ (p. 108) I have calculated that at Petro Alexandrowsk, 27 per ct. of all the observations for the year (which are made 3 times daily) showed calm. During the summer months it was 29 per ct. — The prevailing winds come from the N. and N. E., they average 37 per ct. for the whole year and 41 per ct. for the summer months. Less frequently the winds blow from the E. and N. W., while winds from the S, S. E. and S. W. together total at Petro Alexandrowsk only 5 p. ct. during the summer months. The prevailing N. and N. E. winds are moreover the strongest, yet only rarely do they attain any great strength; they are also the most constant, and blow especially during spring and summer being accompanied by bright weather, a cloudless sky and dry air. They are dry in themselves, and as they travel from colder to warmer zones they yield no precipitation, but cause evaporation (MUSHKETOW).

The precipation is slight. In contrast to southern Russia which has summer rain, the precipitation maximum occurs here during the winter or the spring (HANN III p. 192). The winter snow must be of great importance to the vegetation, and as late as April in many places rain cannot be termed rare. July and August are exceedingly dry, in Merw it has not rained at all during these months for four years. When greater quantities of rain fall it is as a few heavy downpours, not continuous rain. The number of rainy days is therefore small, which is of great importance to the plants, because extreme conditions are the result.

The relative humidity is given by FICKER, from a yearly average for all the stations, as 61 per ct. In Table 1 will be found the averages for each month at 3 different times of the day. It must be remembered, however, that these figures are taken on an oasis where the degree of saturation must be greater than in the desert. OLUFSEN records (1901 pp. 12—13) from various places (Merw, Buchara, Kona Urgentsh) relative humidities of 13—19 per ct.

On account of the heat and dryness in Transcaspia during summer it is natural that evaporation must be very great. According to SEMENOW (p. 128) evaporation is 3 times greater than precipitation in Tashkent and Samarkand, 4 times in Ferghana, 24 times in Nukus, and 270 times in Petro Alexandrowsk. Nukus and Petro Alexandrowsk lie south of the Aral Sea not far apart, and obviously local influences have to be reckoned with here.

The figures in Table 2 show the amount of evaporation and its relation to precipitation. For the daily evaporation per month we find amongst others a table in MUSHKETOW p. 508 taken from STELLING, and another in SCHWARZ p. 572.

As a result of the evaporation being much greater than the precipitation, the country is becoming drier and drier. SCHWARZ (p. 578) proves that the Syr Darya, the Aral Sea and other lakes are continually decreasing. According to some calculations the Aral Sea sinks 7 metres, according to others 4,2 metres in the course of a century, and SCHWARZ is of opinion that Turkestan is in process of being irretrievably ruined on account of scarcity of water. Buchara is already on the verge of ruin because Samarkand, which lies higher up the Serafshan river, uses all the water available.

BORSZCZOW is also of opinion that the drying up of Transcaspia is increasing, while BAER has come to the conclusion that there is now a condition of balance. As regards the Aral Sea, BERG points out (1908 p. 374), that the water-level is changing, and that at the present time it is rising after a minimum in 1880.

Comments on Table 1. This table gives meteorological data from three stations: Tashkent (comparatively cold and

moist), Petro Alexandrowsk which is situated near Chiwa south of the Aral Sea (drier and colder during winter, but warmer during summer), and Askhabad to the north of the

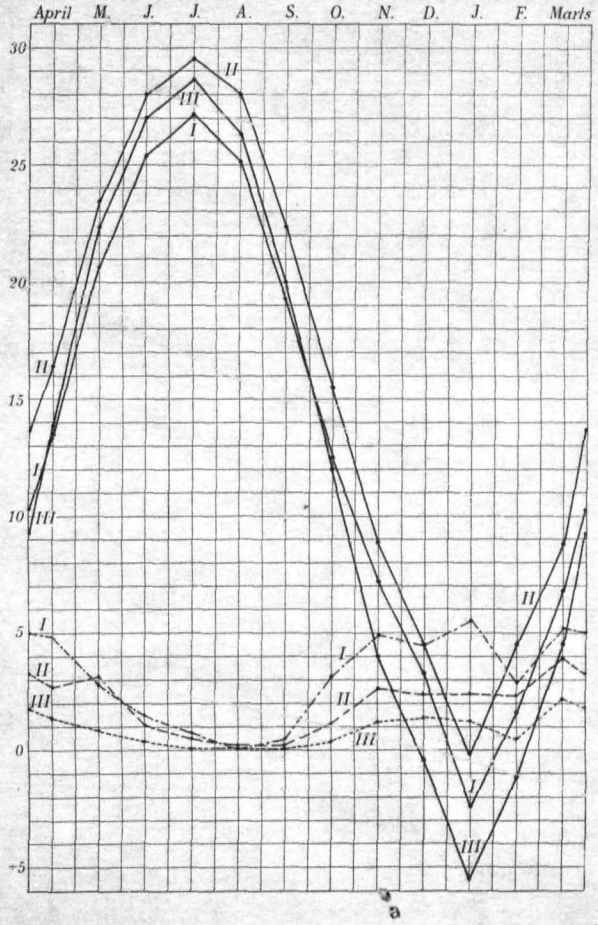

Fig. 1. Hydrothermals for three stations in Transcaspia, viz.: I. Tashkent, II Askhabad, III Petro Alexandrowsk. The ordinary lines are temperature-curves, and the figures to the left express degrees Centigrade. The dotted lines give the precipitation in centimetres. (Constructed after the method of RAUNKJÆR (1905, 1907).

mountains bordering Persia (very hot and dry). The temperature and precipitation of these stations are moreover marked out in curves in the manner indicated by RAUNKJÆR (fig. 1).

The table is prepared from the annual volumes (1897—1906) of «Annales de l'Observatoire physique central de St. Pétersbourg», especially from «Résumés mensuels et annuels». The observations were made every day at 7 a. m., 1 p. m. and 9 p. m. The maximum averages given are the mean of the highest readings at 1 p. m., and are therefore too low because that hour is not the hottest part of the day. The minimum averages on the contrary are the mean of real minima; they are not given for Petro Alexandrowsk.

The figures on the whole correspond with those given by FICKER for another decade.

Brackets round a figure indicate that it is not the mean of 10 years' observations, but only of 7—9 years' on account of gaps in the series of observations.

Within a territory of the size of Transcaspia there are of course meteorological differences, the extent of which may be seen by reference to the great «Atlas climatologique», wher ethey are charted. We need only point out here that the area south of the Aral Sea has the least precipitation and that from this centre there is an increase on all sides. As defined by KÖPPEN this area has a true rain-less climate, the rain-probability being under 0,20. Petro-Alexandrowsk has 0,13, Askhahad 0,33, Tashkent 0,36.

Further details are unnecessary as I do not know the vegetative conditions intimately enough to be able to correlate the climatic differences with them.

The «light-climate» of Aralocaspia is characterized by the large number of cloudless days. WIESNER mentions (quoting from HANN) that in the Kirghiz Steppe there are 170 cloudless days per annum. The foliage of the plants is here aphotometric, that is it has no fixed position in relation to the light; or it is only in the lowest degree photometric, having a fixed position to the light (WIESNER p. 62). This is in the main correct, yet plants occur which turn their leaves in accordance with the light, for example *Glycyrrhiza* and *Smirnowia*.

Table 1. 1897—1906.

	Tashkent 41° 20′ N. Lat. 69° 18′ E. Long. 478 metres above sea-level.								Askhabad 37° 57′ N. Lat. 58° 23′ E. Long. 226 m. a. s.-l.					Petro Alexandrowsk 41° 28′ N. Lat. 61° 05′ E. Long. 85 m. a. s.-l.			
	Average temp. (Centigrade)	temp. max. average	temp. min. abs. average	total precipitation mm. average	number of days with precipitation (average)	Relative humidity. 7 a. m.	1 p. m.	9 p. m.	average temp. (Centigr.)	temp. max. average	temp. min. abs. average	total precipitation mm. average	number of days with precipitation (average)	average temp (Centigr.)	temp. max. average	total precipitation mm. average	number of days with precipitation (average)
January....	— 2,3	12,3	— 20,5	57,4	10,5	82	62	84	— 0,2	15,7	— 15,0	25,0	9,1	— 5,5	6,7	(13,0)	(3,3)
February ..	1,6	15,8	— 13,7	28,3	7,8	80	58	82	4,5	19,5	(— 8,2)	23,3	7,6	— 1,1	13,5	(5,2)	(2,4)
March	6,8	22,0	— 8,7	51,8	11,8	78	55	77	8,9	26,5	— 4,4	40.0	10,1	4,6	22,8	(21,7)	(4,0)
April.....	13,5	28,9	— 0,8	49,2	9,3	71	46	72	16,3	33,1	2,9	28,0	6.2	13,9	30,7	14,1	(3,2)
May.....	20,6	34,5	6,4	28,2	6,5	65	41	67	23,4	38,3	(10,5)	32,1	7,4	22,5	36,4	(8,5)	(1,7)
June	25,4	37,4	9,8	16,3	4,0	60	35	58	28,0	40,6	(14,1)	11,1	2,6	27,0	39,6	5,9	(2,0)
July.....	27,2	38,4	12,1	8,3	1,7	59	33	53	29,7	41,7	(16,8)	4,7	1,5	28,7	40,3	0,8	(0,4)
August.....	25,2	37,1	9,8	0,5	0,4	61	33	55	28,0	40,4	(14,4)	1,8	0,7	26,4	39,5	0,7	(0,3)
September .	19,3	34,5	4,7	3,8	1,1	67	36	64	22,3	37,7	7,2	1,5	1,0	20,0	36,0	0,9	(0,4)
October....	12,6	29,7	— 2,3	31,5	5,2	76	42	73	15,6	32,3	0,8	12,0	3,6	12,0	28,0	4,0	(1,6)
November..	7,2	23,8	— 5,6	48,7	8,6	81	57	82	8,9	26,9	(— 3,0)	25,6	8,3	4,0	20,0	(12,3)	(3,4)
December..	3,2	17,5	— 9,8	44,7	10,9	82	64	83	4,6	20,8	(— 7,4)	23,6	9,7	— 0,4	12,1	(14,2)	(3,0)
Year	13,4	38,8	— 21,0	368,7	77,8	72	47	71	15,8	42,4	(— 17,1)	227,2	67,8	12,7	41,1	(91,5)	(26,3)

Table 2.

Amount of evaporation and precipitation for St. Petersburg and two stations in Transcaspia. After BRITZKE Table 8.

	January	February	March	April	May	June	July	August	September	October	November	December	Year
St. Petersburg (average of 20 years' observations)													
evaporation, mm.	4	5	10	24	44	63	63	46	31	18	8	4	320
precipitation, mm.	22	22	23	23	42	47	66	66	50	43	36	31	470
Tashkent (average of 14 years' observations)													
evaporation, mm.	29	39	87	97	146	198	215	201	139	88	57	43	1339
precipitation, mm.	41	40	66	55	17	4	1	2	4	21	22	56	328
Sultan Bend S. E. of Merw (average of 2 years' observations)													
evaporation, mm.	35	52	104	194	302	459	526	466	296	157	109	64	2764
precipitation, mm.	36	28	22	19	21	0	0	0	1	9	8	36	176

SECTION II. THE VEGETATION OF THE TRANSCASPIAN LOWLANDS

CHAPTER 4

Earlier Literature.

The botanical literature on the Transcaspian lowlands is already large. During the first half of last century, Russian naturalists began to examine this country which was up till then, at least as regards natural history, an unknown land, and since then numerous memoirs have been published. Since the Russian occupation of these vast areas, they have

been examined by many naturalists; but the papers containing the results of the journeys are scattered throughout different periodicals, mostly Russian and often very difficult of access. More especially during the later decades when it has become a national feature to write in Russian, it is very hard for anyone in western Europe to study Russian literature. The publications on the botanical conditions of the Transcaspian lowlands are — so far as we can ascertain — mainly taxonomic, lists of plants and descriptions of new species. There now exists a large amount of systematic material which in recent years is gradually becoming arranged into consecutive floras, mainly through the works of FEDTSCHENKO.

Very few descriptions of the vegetation exist, still less any attempts at ecological treatment. What I have had access to will be dealt with in this account, and Russian authors, inaccessible to most people, will be reported in greater detail than those who have written in the languages of western Europe.

BASINER'S journey through the Kirghiz steppe to Chiwa. This account dates from 1848. He travelled from Orenburg to Chiwa, and he gives many lists of plants as well as brief descriptions of the vegetation, and other botanical remarks. The greater part of the territory where he travelled does not belong to the areas dealt with in this work. BASINER describes the «steppe» between Orenburg and Usturt with its three regions: The grass region, the transitional region and the region of *Chenopodiaceae* of which the first is the most northern, the last the most southern region. The region of *Chenopodiaceae* is evidently closely related to the desert ot the south, such as we deal with later on. Frequently the soil is devoid of plants, yet in places a considerable number of plants were found, but these form «keine heitere Hülle, sondern höchstens ein dunkles Trauergewandt». The most common plants are: *Salsola brachiata, clavifolia, crassa, Kali, Anabasis aphylla, Brachylepis salsa* and Artemisia *(Artemisia fragrans)*. The number of *Chenopodiaceae* increase towards the south and many individuals of a species were often found in masses together.

The plateau of Usturt which lies between the Aral Sea and the Caspian is divided by BASINER into four vegetation-regions: the Clay-region, the Sand-region, the Marl-region and the Salt-region. The first named embraces the greater part of the plateau, is dry and bare with a scattered vegetation. During spring many annuals are in bloom especially *Cruciferae* and bulbous plants (*Allium* and *Tulipa*); during autumn hardly anything but scattered perennial *Chenopodiaceae* are found: Saxaul, *Anabasis aphylla, Salsola glauca, Arbuscula, crassa, rigida, Brachylepis salsa* and the polygonaceous *Atraphaxis spinosa.*

The Sand-region consists of scattered sand-hills (dunes) The vegetation is richer than on the clay, as the sand retains the moisture better. The most common plant is *Pterococcus aphyllus (= Calligonum Pallasii)*, next comes *Tamarix gallica*, and of annuals we find recorded *Salsola Kali, Horaninowia ulicina, Corispermum laxiflorum* and *Asperula Danilewskiana.*

The substratum of the Marl-region is looser than clay, but more compact than the sand. It occurs especially in crevices between rocks and other similar places on the eastern slope of the plateau; the vegetation is comparatively rich, BASINER gives a long list of plants which are found during autumn. This contains some annuals (*Cruciferae*), and many herbaceous perennials, undershrubs and bushes such as: *Peganum Harmala, Astragalus*-species, *Alhagi Camelorum, Tamarix, Artemisiae, Chenopodiaceae, Atraphaxis.*

The vegetation of the Salt-region is chiefly found round the coast of the Aral Sea, both on marl and on moving sands. The most important plants are: *Frankenia intermedia, Zygophyllum Fabago, Lycium ruthenicum, Saussurea crassifolia, Salsola ericoides, Schoberia (= Suœda) microphylla, Halocnemum strobilaceum, Halostachys caspica, Atriplex laciniatus,* and on sandy soil: *Clematis orientalis, Mulgedium tataricum, Cynanchum acutum, Phelipaea salsa.*

BASINER also describes thickets on the river sides with tamarisks, willows and poplars, and a wood of Saxaul, which took three hours to traverse. The height of the trees was 15 to 20 feet and the diameter of the stems 8 inches or more. The year-rings were very narrow, 200—260 being

counted. The wood is brittle, for which reason providence has not furnished this tree with leaves, for if leaves were present a slight gust of wind would break the stem.

The next account from the lowlands of Transcaspia is ALEXANDER LEHMANN's "Reise nach Buchara und Samarkand". In the years 1841—1842 LEHMANN, in the capacity of naturalist, accompanied a Russian envoy to the Emir of Buchara, but he died shortly after his return to Russia. The very large collections of plants made by him were examined and described by AL. BUNGE, and this book is still a standard work. Lehmann's notes on the journey were published in 1852, after revision by G. v. HELMERSEN. The account contains occasional remarks on the scenery of the country, and short lists of plants from different localities, but one feels that the material has not been revised by one who knows the country from personal observation; it lacks those comprehensive comments, which convey a general view to the mind of the reader and make of the work a connected whole.

The next work to be dealt with is BORSZCZOW's Russian memoir: "Contribution to the Geography of Plants in the Aralo-Caspian countries" (1861)[1]. This begins with a short topographical-geological survey of the country. In the introduction to the phytogeographical part of the work we find the following remarks:

> "The flora of the Aralo-Caspian countries is only partly the flora of the steppes; to a great extent it is a desert-flora, characterised by the prevalence of bushes and undershrubs with herbs growing below, or by the almost exclusive occurrence of the first-named. This is the first physiognomical feature of the region we are dealing with.
>
> The second characteristic is the general poverty of the plant-covering. The vegetation develops with the greatest difficulty — one might say reluctantly — on a soil containing an abundance of salts, which is continually scorched by the merciless rays of the sun and only rarely refreshed by a light rain. It does not cover the area uni-

[1]) BORSZCZOW's "Ueber die Natur des Aralo-Caspischen Flachlandes" (1860) contains an orographical description of the area.

formly, but appears in oases, between which stretch large tracts of quite bare soil. Even in the north-western part which has a more favourable situation and climate, and where the flora is more steppe-like in character, we look in vain for the luxuriant growth of the herbaceous plant forms which are a characteristic of the steppes of southern Russia and southern Siberia. It is not found here. The immediate neighbourhood of the vast burning deserts which occupy almost three-fourths of the whole area, and the insufficiency of the precipitation (!) have too great an influence on the climate, moreover the soil itself possesses too few of the conditions which are necessary to produce a luxuriant vegetation. The herb-covered steppe, the only refuge for the nomad and his numberless cattle, is here only a dry Stipa Steppe whose vegetation forms hardly anywhere a thick carpet; only in the river-valleys (and frequently not even there) do we find a somewhat richer development.

Here, as throughout the whole of Aralo-Caspia, it is a few specially characteristic forms which prevail, they repeat themselves continually so that the country has a very monotonous appearance. Other species are only subordinate to these. Where the character of the soil changes, these predominant species sometimes change very quickly and give place to others which in turn prevail until the soil changes again. This monotony and this repetition of certain species over vast areas is the third characteristic of the vegetation of the Aralo-Caspian countries. It is no doubt a direct consequence of the uniformity of the climate, which again is mainly dependent on the slight vertical relief of the surface.

A fourth characteristic of the flora is the unfamiliar appearance of many of the plant-forms[1]). As soon as the Ural is crossed, a different zone of vegetation is entered upon, where the plants differ greatly from those living in the same latitude, but in areas with a different geographical location, a different relief and different soil. Even

[1]) *Great poverty in Cryptogams is also a characteristic.* (B.'s remark.)

the flora of the right bank of the Ural between Uralsk and Orsk differs in many ways from the flora of the left bank. On the right bank we find for instance frequently: *Arabis pendula*, *Adenophora liliifolia*, *Tilia parvifolia*, *Prunus Chamaecerasus*, some *Verbascum* species, *Urtica dioica* and *U. urens*, *Senecio vulgaris* and many others, but they disappear totally on the left bank of the river and never appear again[1]). The unique character of the flora is still more strongly expressed in the heart of the country, south of 49° N. Lat. Plant-forms such as Saxaul (*Haloxylon Ammodendron*) Kara-Djusgjon (*Calligonum*-species), the unfamiliar poplars *Populus diversifolia* and *P. pruinosa*, Kujan-Sujok (*Ammodendron Sieversii*, *A. Karelini*) and the species of *Chenopodiaceae*, *Papilionaceae*, *Cruciferae* &c. are all unique in appearance and structure, and could only be developed under special conditions of climate and soil. In the Aralo-Caspian lands, the soil in particular has such a great influence on the vegetation that a change of soil — other conditions remaining the same — often alters the physiognomy totally and almost abruptly without any gradual transitions. This change is most evident in the moving sand deserts, where the depressions between the sand-hills are mainly covered by salt-swamps or by a loose clayey bottom permeated with salts. The vegetation on the sand-hills is varied and highly characteristic, but its spe-

[1]) Borzszcow comments on this in more detail in another place ("Ueber die Natur d. Aralo-Casp. Flachlandes", p. 272, Anm.): on approaching the steppe, the tree-vegetation disappears, poplars, elms, limes, birches, willows, *Prunus Chamaecerasus* and *P. Padus;* instead of *Salix fragilis* and *S. viminalis* so common in the Ural we have here *S. pallida* and *S. Wilhelmsiana* and "sogar die, im Ganzen, dem Grassteppen-Gebiete angehörigen Sträucher: *Caragana frutescens*, *Spiraea crenata* u. *hypericifolia* und *Amygdalus nana* kommen südlich von Ural nur gruppenweise und selten vor" *Stipa pennata* is replaced by *S. capillata* and *S. Lessingiana*. A great many plants disappear altogether (*Delphinium*, *Arabis*, *Trifolium*, *Fragaria*, *Scabiosa*, *Senecio*, *Urtica*, *Poa*, *Aira* &c.) The Ural is a line of demarcation between the grass and forest region on one side, and the "true steppe" on the other.

The change in the soil and vegetation south of Tshagan and the steppe-mountains was, however, previously pointed out by Pallas (1776, p. 310).

cies suddenly disappear at the margins of the depressions and all that is left is a meagre flora, frequently reduced to two or three *Chenopodiaceae*, such as *Brachylepis salsa*, *Anabasis aphylla*, species which are uniformly distributed throughout the whole area.

These changes in the soil-conditions are mainly responsible for the variations in the general physiognomy of the vegetation. They also bring into prominence certain plant-forms which may be observed over considerable areas and which furnish the features characteristic of the areas or sub-floras into which the Aralo-Caspian countries may be divided.

There are five of these areas:

1) The Stipa-steppe
2) The Clay-deserts
3) The Salt-deserts
4) The Moving-sand-deserts
5) The river Serafshan."

The following is a summary of Borszczow's description of these areas.

1) The area of the Stipa Steppe is the most northern, and extends from its southern boundary at the Mugodshar mountains and the rivers Tshit-Irgis and Turgai, towards the N. E. where it merges into the grass steppes of the southern part of the Tobolsk government. The Stipa Steppe thus lies outside of the area under consideration in this work. The surface of the steppe is almost everywhere undulating. Forests do not occur, but here and there are groves mainly consisting of poplars and willows. The most prevalent plant is *Stipa capillata*, then follows *Festuca ovina*. Besides these a number of species are recorded: *Amygdalus nana*, *Spiraea*-species, *Ulmus campestris*, *Caragana frutescens*, Poplars, Willows, *Betula and Alnus*, *Ranunculaceae*, *Dianthus* and *Silene*, *Eryngium*, *Trinia*, *Compositae* (*Cirsium acaule*, *Jurinea*, *Saussurea*, *Echinops*), also *Tulipa*, *Iris*, *Allium* and *Carex*. About 10 per ct. of the

total species (551) are trees and shrubs; the proportion of biennials and perennials to annuals is 1 : 0,31.

For each area Borszczow gives statistics which show for a number of families the proportion of species in the given area as compared with the whole country examined by him. After so many years of further research in these countries, his figures must be far from correct, but as they have a certain interest, the figures for a few selected families are given. In the area of the Stipa Steppe were found:

57	per ct. of the	Ranunculaceae	of the whole area.
47	—»—	Cruciferae	—»—
41,8	—»—	Papilionaceae	—»—
50,5	—»—	Compositae	—»—
28,7	—»—	Salsolaceae	—»—
74	—»—	Cyperaceae	—»—
58,9	—»—	Gramineae	—»—

The Stipa Steppe is rather monotonous in character and resembles in many ways the steppes of the adjacent western governments. It is by no means always a fertile grass-steppe, more often it is dry, clayey and poor, and the farther south one goes the more frequent do large bare patches of clay become.

Borszczow distinguishes three floras included in the Stipa Steppe: the grass-steppe, the stone-steppe (Mugodshar and its slopes) and the clay-stone-steppe. This last flora embraces, especially in its southern part, many species characteristic of the clay and salt deserts.

2) The area of the Clay Desert stretches, according to Borszczow, between the Caspian Sea and the Aral Sea (Usturt), and again to the north and east of the Aral Sea. The surface is an undulating plain, generally of higher elevation than the soil of salt-deserts and moving-sands. The soil consists of pure compact clay and loose or compact clayey or sandy marls. Almost everywhere the soil is permeated with salts, and salt-swamps are not uncommon. The resemblance to the steppes of southern Russia seen in parts of the Stipa-steppe has disappeared here. The vegetation is

characterized by few, but exceedingly characteristic plant forms, and a terrible monotony. — Of the plants (329 species) in this formation, 10,63 per ct. are shrubs. The proportion of perennials and biennials to annuals is 1:0,7.

Borszczow's percentages for the families already named are as follows for the area of the clay-desert:

29,6	per ct. of	Ranunculaceae	of the whole area.
40,9	—»—	Cruciferae	—»—
17,09	—»—	Papilionaceae	—»—
23	—»—	Compositae	—»—
49	—»—	Salsolaceae	—»—
26	—»—	Cyperaceae	—»—
23	—»—	Gramineae	—»—

The most frequent species are *Artemisia fragrans* and *A. monogyna;* these alone cover large tracts and present a most melancholy picture. They are frequently accompanied by *Salsola crassa*, *S. lanata*, *Brachylepis (Anabasis) salsa* and *Anabasis tatarica*, sometimes with Saxaul (*Haloxylon Ammodendron*), and *Ferula persica*, *Rheum caspicum* and *Calligonum Calliphysa*.

"The occurrence of these (the three last-named species) is so closely correlated with the soils of this area that it is possible with the aid of only a few specimens to determine with great certainty the character and physiognomy of the sub-flora from which they are taken."

The plants mentioned are almost the only ones to be found in the clay-deserts after the second half of April when the sun becomes very powerful. In spring the flora is richer, during the flowering season of species of *Alyssum*, *Megacarpaea*, *Tauscheria*, *Euclidium*, *Matthiola*, *Chorispora*, *Echinospermum*, *Onosma*, *Phelipaea*, *Allium (A. caspicum)*, *Tulipa patens*, and *Rhinopetalum Karelini*. These plants are the "spring decorations of the desert flora", but unfortunately they are too quickly lost again. A richer vegetation of roses with *Spiraea* and *Elaeagnus* occurs in the deep ravines on the margin of the Usturt.

3) The area of the Salt-deserts stretches over a very

large expanse at the north-east end of the Caspian Sea, but smaller stretches are found interspersed in other territories. The surface is a perfectly level plain covered with innumerable salt-lakes with here and there sand-hills. The soil is a compact clay often hard as stone, or loose marl with a mixture of chalk, permeated to a considerable depth with salts.

The vegetation is exceedingly poor and uniform. Out of 170 species, characteristic for the salt-deserts, 63 are *Chenopodiaceae*, 17 per ct. are trees or shrubs (a very high proportion); perennials and biennials are to annuals as 1 : 1,3

In spite of uniformity, the physiognomy of the evergreen salt-swamps has a much less desolate appearance than the clay-deserts.

"Here (in the salt-deserts) the vegetation tries, as it were, to make up for uniformity by its characteristic forms and by constant freshness and unusual tints. Enormous salt-swamps, pale green during the spring, turn by degrees yellowish and finally light-yellow, as the burning heat comes on, and again during the early days of autumn the colours turn to pink, scarlet and purple. Simultaneously the young green of the new branches shows forth and the four colours blend in the most charming way. It is difficult to imagine the effect of such a picture especially at sunrise or sunset, and one must see it to realize its beauty."

The salt-deserts contain: —

7,68	per ct of the	Ranunculaceae	of the whole area
10,84	—»—	Cruciferae	—»—
7,68	—»—	Papilionaceae	—»—
8,4	—»—	Compositae	—»—
58,3	—»—	Salsolaceae	—»—
3,7	—»—	Cyperaceae	—»—
16	—»—	Gramineae	—»—

It will be seen that the Salsolaceae predominate here.

Borszczow gives as the most common amongst them: *Ceratocarpus arenarius, Kalidium foliatum, K. arabicum, Halocnemum strobilaceum, Salicornia herbacea, Schoberia* (*Suaeda*)

baccifera, S. salsa, Salsola clavifolia, Ofaiston monandrum, Halimocnemis villosa, H. sclerosperma, H. glauca, Halogeton glomeratus, Anabasis aphylla, A. brachiata, Brachylepis (*Anabasis*) *salsa, Halostachys caspica.* Another important species is *Zygophyllum Eichwaldii.*

4. The area of the Moving-Sands.

This stretches mainly south-east and east from the Aral Sea. The vegetation is more luxuriant than in the other areas, and is at the same time more interesting and richer in rare and strange plant-forms. In spring it looks quite like a garden. The dunes are covered with bushes of *Calligonum, Halimodendron*, Saxaul, *Tamarix, Salsola* etc. Some of these are also present in other formations, but reach here their fullest development, "so that this territory may justly be termed the forest of the desert-flora".[1])

Of the 501 species of Phanerogams characteristic for the sand-flora, 16,16 per ct. are trees and shrubs. The proportion of perennials and biennials to annuals is as 1 : 0,75. 235 species belong exclusively to the dunes. The sand-flora includes:

26,9	per ct. of	Ranunculaceae	of thew hole area.
54,21	—»—	Cruciferae	—»—
63	—»—	Papilionaceae	—»—
65	—»—	Compositae	—»—
61	—»—	Salsolaceae	—»—
10	—»—	Cyperaceae	—»—
28	—»—	Gramineae	—»—

In addition to *Cruciferae* and *Papilionaceae*, *Borragineae* and *Polygonaceae* are also plentiful. Borszczow mentions amongst the Cruciferae: *Dontostemon* (several species) *Streptoloma, Spirorhynchus, Pachypterygium, Cithareloma, Lachno-*

[1]) This simile has justly been contradicted by Korschinsky and Tanfiljew. Yet Lipsky (1911) is of the opinion that some large tracts of Saxaul — but only of this — may rightly be named forests, the trees being big and thick and giving a considerable amount of ground-litter.

loma, Chartoloma and Octoceras; the *Papilionaceae* include *Ammodendron, Halimodendron, Ammothamnus, Eremosparton, Alhagi* and *Astragalus.* As representatives of other families we may mention: *Heliotropium, Echinospermum, Calligonum* (17 species) various Umbelliferae (*Dorema, Ferula* etc.), and Compositae (*Artemisia, Echinops, Cousinia, Microlonchus, Scorzonera, Streptorhamphus,* etc.). The *Salsolaceae* are represented by much the same species as in the salt-deserts, but they are more luxuriantly developed; noteworthy are *Alexandra Lehmanni, Caroxylon* (*Salsola*) *hispidulum, C. subaphyllum, Eurotia Eversmanniana.* Smaller families are also represented by a number of species: *Zygophyllaceae, Rutaceae, Tamaricaceae, Gnetaceae* (*Ephedra*), and of Monocotytedons the following may be named: *Biarum, Tulipa, Merendera, Gagea, Heleocharis.*

4) The area of the Serafshan River.

Lying as this does in the mountainous regions along the upper courses of the river, it is outside of our area and need not be considered.

Following on the introductory description just summarised, Borszczow then deals with the families of plants with respect to the distribution of genera and species. This analysis occupies the greater part of his work and leads him to the following general conclusions:

"1. The majority of the commoner plants of Central Russia with a distribution west of the Caspian Sea extending to Trans-Caucasia, have as their southern limit of distribution east of the Caspian Sea in Aralo-Caspia, the parallel of $51^1/_2{}^0$ N. lat.

2. When these forms occur farther east in Siberia, the boundary limiting their area of uninterrupted distribution lies outside of Aralo-Caspia and always north of $51^1/_2{}^0$ N. lat.

3. Most of the typical steppe-plants met with in southern Russia and distributed towards the west from the Caspian to the foot of the Caucasus, attain their southern limit in Aralo-Caspia at the parallel of 49^0 N. lat., and their eastern boundary at the meridian of the Mugodshar

range (77° E. long., Ferro, ab. 60° E. long., Greenw.) thus they do not overstep that part of the area of Stipa which we have termed the Grass-steppe. If these plants occur farther east, their limit of uninterrupted distribution is a line generally extending towards the north along the western slopes of the Mudgodshar Mts.; from the north end (50½° N. lat.) of these the line strikes eastwards round the basin in which the middle and lower courses of the rivers Irgis, Ulkojak and Turgai are situated. They may of course be met with as isolated outposts south of this latitude, but never farther south than 49° N. lat.

4. The more southern plant-forms, characteristic both for Persia and Aralo-Caspia. do not occur in our flora of the present time further north than 47° N. lat.

5. The more eastern forms, met with in Altaian Siberia and Dsungaria, are rarely met with further west than 78° E. long. F. (ab. 60° W. Greenw.)

6. In the case of a great many south-eastern forms, the lower course of the Syr-Daria (45°—46° lat.) is the northern boundary, and the meridian of the eastern shore of the Aral Sea (70° E. long. F., ab. 62° Greenw.) forms the western boundary.

7. The areas east of the Aral sea must be considered as the centre of distribution for tree-like forms of the families of the *Salsolaceae, Polygonaceae* (*Calligoneae*) and *Papilionaceae.*

8. The flora of the Aralo-Caspian countries as known to us at the present time is relatively new in origin, and most of its plant-forms have probably distributed themselves over these parts of Asia within very recent times; presumably they came mainly from the east and south, to a less degree from west and north, so that from these directions they have not penetrated so far. This flora is the gathering ground for forms occurring in the steppes of South Russia, the Altaian Siberia and Persia. The original plant-forms indigenous to the area are evidently limited to: *Salsolaceae*, the tree-like *Polygonaceae, Nitrariaceae, Zygophyllaceae* and some species of *Tamaricaceae, Papilionaceae* and *Cruciferae.*

9. When we take into consideration how the sheets of water and the river-systems are drying up[1]) while the dryness of the climate increases, it may almost be regarded as certain that the western and northern forms will ere long cease to reproduce themselves successfully in the Aralo-Caspian countries, and that forms already found there will begin to die out. On the other hand, it is beyond doubt that the southern and south-eastern desert-forms will continue to extend their zone towards the north and the west as a result of the environment. Saxaul, *Elaeagnus hortensis* and some others are at present migrating towards the north, whereas species such as *Populus nigra* and *P. alba* are disappearing from the southern latitudes where they occurred; this proves, that this period is already drawing near."

Borszczow's memoir ends with some brief notes on the Cryptogams which, on the whole, are not specially important. *Parmelia esculenta* occurs sporadically in the deserts along with a few *Lycoperdaceae.*

In spite of its antiquity, Borszczow's work has been dealt with at considerable length because, on the whole, it conveys an interesting picture of the Aralo-Caspian countries. The relation of the flora to that of the surrounding areas is especially well defined, hence I have included the Stipa-steppe, which otherwise does not come within the scope of this work. As far as I know, Borszczow's work is the only one that treats the flora of Aralo-Caspia from that point of view, but it may be that other important works have been overlooked on account of the inaccessibility of Russian literature.

The next work known to me in this connection is: A. A. Antonow: "On the Plant-formations of the Transcaspian territory"[2]) 1892.

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[1]) According to Baer (1855), the phase of drying up is now past and a condition of stability has long ago set in. Comp. Schwarz and Berg, above page 14.

[2]) "Territory" is here given as the translation for "oblast". In Borszczow, "area" is given; this author uses it as corresponding to Antonow's "formation." Antonow himself uses the word "formation."

ANTONOW travelled in these parts from April 18th to June 27th in 1889, so that, as he states, he has not seen the flowering season of early spring, nor the late bloom of perennial plants.

ANTONOW has six formations:

1. The flora of the Clay(or loess) Desert-plains.
2. The flora of the Riverside Thickets.
3. The Loess-steppe.
4. The Sand-desert.
5. The Promontory or Stone-steppe.
6. The Mountain or Rock-flora.

1. The formation of the Clay-Deserts is the most prevalent and has the greatest extension of all. The soil has a level surface and is formed by loess which is soft and greasy in its crude form, and hard as stone when dry. When very dry it cracks into 4—5-angled polygons and the surface peels off. This soil may occur as the subsoil for other formations.

The flora is poor and monotonous, this formation being the domain of the *Chenopodiaceae*. Saxaul (*Haloxylon Ammodendron*) is the most important of these, it is here a low, twisted bush, no higher than an Arshin (about 0,7 metre); *Salsola*, *Suaeda* and *Halimocnemis* are also mentioned. The plants stand far apart from each other.—Where the moisture-conditions are more favourable, the plants are more abundant and stronger, for instance near water-holes or saline places or on the more retentive sands of the dunes.

The saline places ("Takyr" and "Ssor") are mentioned as a sub-formation, but no details are given by which they can be differentiated.

2. The Riverside Thickets. Along the rivers on the narrow strips of land which are continually moist, *Tamarix*, Poplars (*Populus euphratica*, *pruinosa*), Willows, *Lycium turcomanicum*, *Phragmites*, etc. grow, often accompanied by the creepers *Cynanchum acutum* and *Apocynum sibiricum* (= *A. venetum*). They form a thick and often impenetrable living fence along the banks of the river, — a luxuriant vegetation, the poplars

sometimes reaching the height of 5 Sashen (about $10^1/_2$ metres) with a stem diameter of half an Arshin (about 0,35 metre). The poplars often grow along with reeds on low islands, which are covered at high water. The tamarisks grow smaller a few fathoms away from the river and become mixed with salsolaceous plants which enjoy the moisture, but even at a distance of two to three Versts (about 1 kilom.) into the desert stunted tamarisks may still be seen.

The vegetation of the river sides contains no flora of herbaceous plants and in this respect it differs from the alluvial forests in Russia, where *Populus nigra* takes the place of *P. euphratica*. ANTONOW is, however, of opinion that the term forest should not be used for this formation, because it only appears in strips along the rivers and has so to speak only one dimension. In my opinion this remark is not quite correct, for in some places at least the vegetation in question has a considerable width, for instance in a deserted river-bed where the conditions of moisture are good.

Where a river bends sharply or has changed its bed, "Starizi" are often formed, enclosed backwaters where bushes and rushes grow, and "other herbaceous forms" occur around the stagnant water. In this connection, large "swamp-lakes", are also mentioned which are frequently formed in the plains by the snow-water in spring. Round these grow salsolaceous plants, but the occurrence of reeds and *Tamarix* makes it reasonable to include these places as riverside thickets. — Such thickets are often extensive, the haunts of wild boars and numerous birds, but as a rule uninhabited by man, hence ANTONOW calls them "biological oases."

3. The formation of the Loess-steppe is found on the same type of soil as the clay-desert, but with more abundant moisture; it occurs most frequently at the foot of mountains. It is rich both as regards species and individuals. As a type of vegetation it corresponds to the steppes of Southern Russia, but differs in its floristic composition. (Yet ANTONOW tells us later that no carpet of vegetation is formed, which is an important difference between this and the Russian steppe). As in southern Russia, *Caragana* and *Prunus* grow near streams, so here *Tamarix* is found, and in both countries tall herb-

aceous perennials rise above the lower, brightly coloured ground-vegetation. The following herbaceous perennials are given for the asiatic steppe: *Eremurus*, *Eremostachys*, *Astragalus*, *Cousinia*, *Centaurea* and several Umbelliferae.

4. The Sand-desert occupying about half the area of Transcaspia is the most recent geological formation. Its flora is very rich, and during the best season, April and May, it looks like a luxuriant garden. The plants include shrubs also annual and perennial herbs, but the shrubs are the most characteristic. This rich and extensive "flora or formation" has more definite limits than the others, its plants are dependent on the sand and do not migrate to other soils. The plants of the loess-deserts and the riverside thickets may intermingle or pass out on to the sand, but sand-plants are never found on loess soil. Saxaul grows both on loess and sand, nay thrives even better on the latter especially on "Ssor" covered by sand, but bushes like *Calligonum* or *Ammodendron* we look for in vain on the clay plain.

Antonow mentions as the most typical sand-bushes: *Calligonum*, *Ephedra*, *Ammodendron*, *Eremosparton*, *Salsola Arbuscula*, *Astragalus dendroides*, *Haloxylon Ammodendron*. — These bushes attain a heigth of $1^1/_2$—3 Arshin (about 1—2,10 metres), sometimes under specially favourable conditions they may be 2 Sashen high (about 4,2 metres). The stems are short and bent, with a low and richly branched crown. The leafage is very poor. The root-system in several of them is strongly developed. In Saxaul and *Calligonum*, radical branches may be seen on the surface between the dunes giving rise to new shoots and creeping sometimes for a distance of 5—7 Sashen (about 10,5—14,7 metres), so that these bushes play an important part in binding the sand. Still more important in this way are: *Aristida pungens* (0,7—1 metre high) which grows as a rule on the tops of the dunes, and *Carex physodes* which frequents more sheltered places among the dunes, and there weaves the sand together with its tangled roots. These two he calls the "conqueror and regent" of the sand-desert.

The following are given as representatives of the remaining herbaceous vegetation: *Delphinium camptocarpum*, *Hypecoum pendulum*, *Roemeria refracta*, *Malcolmia africana*, *Spiro-*

rhynchus sabulosus, Astragalus sp., Erodium oxyrrhynchum, Alhagi camelorum, Senecio coronopifolius, less frequent are *Dorema Ammoniacum, Sphaerophysa sp., Rheum sp.*

5. The Promontory-or Stone-steppe is found on hard conglomerate soil at the foot of mountains, between these and the loess-steppe. It is an *Artemisia*-steppe, *A. nutans* being the principal plant. Amongst other species found are: *Stipa orientalis, Papaver pavoninum, Cruciferae, Caryophyllaceae, Astragalus, Umbelliferae (Zosimia, Ferula), Compositae (Centaurea ovina, pulchella, Balsamita, solstitialis, Cousinia turcomanica, dichotoma, lyrata, Achillea santolina), Labiatae, Liliaceae,* grasses and others. *Ulmus nuda* and occasionally the shrub *Zygophyllum eurypterum* occur by the streams.

6. The mountain-flora does not come within the scope of this review.

Next to be considered is the work of S. Korshinsky: "Sketches of the Vegetation of Turkestan" (1896), the first section of which deals with Transcaspia.

The "normal type" of sand-desert, the most extensive and continuous, is Korshinsky considers, "flat or undulating areas of sand" consisting of loose but not drifting sand, and covered by a meagre, yet comparatively rich and rather varied vegetation. Its most characteristic feature is that it consists chiefly of ligneous species: *Haloxylon Ammodendron, Salsola Arbuscula, Calligonum, Ephedra, Ammodendron Karelini, Eremosparton, Astragalus Ammodendron* etc. In the spring many herbaceous plants also occur, most of them growing isolated and not forming a carpet. A few species like *Carex physodes* and *Capsella elliptica,* are sometimes so luxuriant and dense that a green sward or something approaching one is formed. In the autumn the herbs have disappeared, and one finds then perennial species of *Salsola,* little bushes covered with handsome, multicoloured fruits.

The sandy parts are not so bare as one might imagine, Korshinsky says, so that there is really no reason why they should be called deserts. In spring, at least, the soil holds water at a few centimetres depth, and he adds: "I am of opinion that the sharply defined xerophytic character of the vegetation is not so much a consequence of the dryness of

the soil but results rather from the dryness of the atmosphere, especially the strongly heated lower layers of the air, combined with the direct effect of the sun's rays, and the reflection of these from the hot bare yellowish-grey sandy soil."

KORSHINSKY regards the vegetation of ligneous plants described above as specially characteristic for the sand-desert, and he is also of opinion that this is the original vegetation which formerly covered the whole area of sand. The change from fixed to moving sands is, he thinks, due mainly, perhaps exclusively, to the action of man. As soon as roads and inhabited places are left behind, we find the sands more level and covered with the trees and shrubs just named. The nomads are mainly responsible for the extermination of trees and bushes, as they cut them down for firewood and their cattle eat and tread down the vegetation. As it is now we find perfectly lifeless areas, occupied by the high, crescent-shaped "Barchans" devoid of plants. The transition to this is seen in the stage where most of the herbaceous plants have disappeared, and isolated trees and bushes occur with *Aristida pennata* and *A. pungens* still holding their ground.

Even in the barren desert, some vegetation may still be found in places where water from melting snows or river floods has collected in the hollows and deposited finer particles of earth which bind the sand together. In addition to numerous typical sand-plants, many of the more showy herbs grow here such as *Ceratocephalus falcatus*, *Euclidium syriacum*, *Umbelliferae*, *Koelpinia linearis* and many others; KORSHINSKY (p. 7) gives a long list of them.

A further step in this direction in seen in the "Takyr", flats or depressions covered by water after rain. The water evaporates rapidly leaving a greasy soil, which when dry becomes very hard and cracks, salts frequently crystallising out. "Takyr" are almost always devoid of plants.

At the foot of Kopet-Dagh lies a narrow strip of cultivated land which towards the north is bordered by the desert. It is watered by streams coming from the mountains, but they are few in number and carry little water, so that large patches are left uncultivated among the fields In these uncultivated parts the desert plants are mixed with weeds of

cultivation and with species originating from the neighbouring mountains. Noteworthy amongst the desert species are: *Alhagi Camelorum, Salsolaceae, Zygophyllum* and *Peganum Harmala;* the mountain plants are represented by *Leontice Leontopodium, Glaucium luteum* and *Carex stenophylla*, while the plants which frequent the neighbourhood of cultivated land are mainly *Cruciferae* and *Papaveraceae (Roemeria)*; and often *Hordeum murinum, Spinacia tetrandra, Arnebia cornuta*, etc.

From the south-eastern part of Transcaspia, on the borders of Afghanistan, KORSHINSKY describes the vegetation at the foot of the Paropamisus chain. Here the landscape is undulating ("Badchis") with a sandy, but rarely a loose surface. The lower, more gently sloping parts of the "Badchis" have a vegetation which Korshinsky calls "sand-steppe". It consists "exclusively of herbaceous plants or undershrubs which, according to the relief of the locality or to variations in dryness of the soil, stand more or less scattered, but always singly so that they do not form a green sward." This picture recalls the steppes on the black-soils in the south of Russia. Just as *Stipa pennata* is there, so *Stipa barbata* is here in Asia the characteristic plant. Moreover there are several species of *Convolvulus, Onobrychis, Ranunculaceae, Acanthophyllum, Aegilops*, etc., and in the most southern part *Dorema* and *Ferula.*

The higher parts of the "Badchis" have a different vegetation to some extent characterised by other plants, such as *Amygdalus horrida* and *Pistacia vera.* This vegetation cannot be regarded as belonging to the lowlands, and so need not to be further detailed.

KORSHINSKY also gives a short description of the river sides with their thickets of *Phragmites* and poplars, especially *P. euphratica.* The irrigation of the cultivated land is also noted, and the plants cultivated there. His interesting work will be referred to again later.

RADDE'S memoir. "Transkaspien und Nord-Chorassan" (1899) also contains many valuable statements about the vegetation.

He describes the hoof-shaped "Barchans" devoid of vegetation so that the landscape looks like a stormy but frozen

sea, and the more rounded sand-hills ("Hügelsand") "like a smooth sea with a swell on". On the crests grow *Halimodendron*, *Ammodendron*, Saxaul and Tamarisks, while the hollows between them are covered by *Capsella elliptica*. The "sand-steppe" he likens to an almost calm sea which in spring bears a rich bloom of *Capsella elliptica*, *Rheum caspicum*, *Calligonum*, *Atraphaxis*, *Lycium*, *Zygophyllum*, *Nitraria*, *Poa bulbosa*, *Bromus tectorum*, *Avena sterilis*, *Hordeum murinum*, *Stipa barbata*. — RADDE also describes the sand mounds in the north-western parts of the territory; here in the valleys and on the slopes of the mounds, Saxaul attains its greatest development, while *Ammodendron Sieversii* prefers the loose soil of the crests.

The leafless desert shrubs occur almost exclusively where the sand is in motion; on old-established sand-hills we find for instance *Prosopis Stephaniana*, *Heliotropium dasycarpum*, *Delphinium camptocarpum*, species of *Artemisia* and *Cousinia*. — Only plants with tubers or deep running roots keep green long, the rest are quickly scorched.

RADDE'S opinion is that the relatively luxuriant "sand-steppe" is the last stage, and that the moving sand will, if left to itself, gradually become covered with vegetation and then the country will in time become level.

RADDE'S long account of his travels contains many other descriptive notes on vegetation, but it is unnecessary to enter into further detail here as the work is easily accessible and other references will be made to it later.

The description of Asiatic Russia by M. P. DE SEMENOV (1900) also gives the more important features of the vegetation of Turkestan. He describes the trees of the sand-deserts, *Haloxylon*, *Salsola*, *Calligonum* etc. ("des arbres sans ombre, sans fraîcheur et sans vie") and records their importance in binding the sand. There is also an account of the vegetation of the clay-deserts of *Artemisia*, *Salsolaceae*, *Zygophyllum* and large *Umbelliferae* with their short-lived flowering period in spring, of the chenopodiaceous vegetation of the "salt-steppe" with its seasonal changes of colour and the dense thickets of poplars and reeds on the river-banks. The work also contains a number of geological, meteorological, and other

observations. His classification of the sand-deserts will be referred to later.

The Petersburg Forestry Journal (1901) contains an important article by W. PALEZKIJ on "Sand-binding on the Mid-Asiatic Railroad", and a later contribution has appeared in the Russian Forestry Journal (1908 nos. 31 and 32). The author has for many years superintended the operations for the protection of the Transcaspian railroad against sand-drift, — and in 1899 I had the pleasure of visiting parts of this undertaking under his able guidance.

The paper begins with description of the features of the different landscapes and the dune-formations, the dangers arising from sand, and the different ways in which the drift may block the railroad.

The most effective means of settling the sand-drift is to encourage vegetation; artificial means such as the planting of green turf and reeds are also resorted to. Trees are planted extensively along the railroad in belts 425 to 530 metres wide. Later on these spread naturally and have in some places reached a width of 2—3 kilometres.

The natural conditions of the sand-deserts are extraordinary, he says. It does not rain from May till November, and the precipitation during winter and spring is insignificant. Ground-water containing bitter-salt, moving sands and the broiling heat of summer are other impediments to a luxuriant vegetation. In combating the sand it is therefore necessary to select local plants acclimatised to the conditions, and sufficiently aggressive to establish themselves. Experiments with introduced plants are, however, also made. The principal species used for planting are: Saxaul *(Haloxylon Ammodendron)*, *Salsola Arbuscula*, *Ammodendron Conollyi*, *Eremosparton aphyllum*, *Salsola subaphylla*, *Smirnowia turkestana*, *Astragalus paucijugus* and *A. Ammodendron*, *Aristida pennata*, *Carex physodes* and various species of *Calligonum*. Short notes on their properties are given which we shall refer to later on.

Nurseries have been established in which stocks are raised for transplanting. As the desert plants often have very long roots which would be damaged by transplanting, the nursery

at Farab is located in a place where the ground-water is only about 1 metre down, and 0,7 m. during summer when the water is high in the Amu Darya. The roots on an average do not exceed 0,7 metre (1 Arshin) in this place. The conditions of precipitation and heat render it advisable to sow in the autumn, and before sowing the "seeds" are placed 10 or 15 days in moist sand, then into the soil loosened to a depth of about 30 centimetres. If *Calligonum* is to be sown in spring, the fruits must be kept over winter in moist sand, and the seed-beds are covered with straw as the seedlings are injured by late frosts. — After sowing all that is necessary is to weed the beds and to break up any salt-crusts which may appear, or to strew the soil with clean sand, which prevents the formation of salt-crusts. No watering is done except during abnormally dry seasons, since watering is generally harmful. The seedlings are thinned out, and in the autumn when a year old, they have grown to a height of from 0,35 to 1,4 metres (1/2—2 Arshin) (The author does not mention which species). The seedlings vary considerably, and this PALEZKIJ considers to be due to differences in the salinity of the soil which interferes with growth. Development is also dependent on the depth to which the soil is loosened, and where this depth is great the plants may attain a height of 2 metres. The distance between the seedlings is also important, greater space giving larger plants.

The separation of the seedlings takes place in the autumn — except Saxaul which is very susceptible to frost, — and from January to March the transplanting takes place. The seedlings are planted in rows at right angles to the prevailing direction of the wind, and it is highly important to select the right species for the different places. Thus low places with ground-water at a depth of 1—1,5 metres are more suitable for Tamarisks, and where the subsoil is clayey *Salsola Arbuscula* thrives well. A subsoil consisting of lime and clay is specially favourable to Saxaul, while on pure shifting sand *Ammodendron* and *Aristida* and to some extent *Calligonum* grow readily. The success of the planting is dependent among other things upon the winter precipitation. During the first year, the plants are protected, and if the

sand has been carried away, the roots are covered in with sand over which a layer of clay is spread. On an average about half the plants are successful, but the gaps are filled up by a second planting.

It is of the greatest importance for the natural seeding of trees and bushes that many herbaceous plants should grow on the sand; if these are absent, then many seeds of *Aristida pennata* and *Alhagi Camelorum* are sown. The herbaceous plants retain the fruits of the trees and protect the seedlings during their growth.

We have here only referred to those parts of PALEZKIJ's work which deal with the vegetation.

G. J. TANFILJEW in the second Russian edition of WARMING's "Plantesamfund" (Oecology of Plants) (translated by GENKEL, St. Petersburg 1903) gives a survey of the vegetation of Russia. The chapter dealing with deserts is of special interest to us. Desert and Steppe are closely related in the following respects: both are at the present time devoid of trees, they are not leached by running water and the soil is rich in dissolved salts, especially carbonates but also sulphates and chlorides.

In the steppe, however, carbonate of lime is dominant, and the more soluble salts do not attain the same concentration as in the desert. The steppe-vegetation is therefore richer, forming a more or less thick carpet all the year round, and the decomposing vegetable matter gives a dark colour to the upper layers of the soil (for instance in the Tjernosem). In the deserts the carpet of vegetation is either absent altogether or is present only in early spring; during summer and autumn the earth is bare or only sparsely covered with woody stems or dead shoots. No green-sward is present and no dark humus is formed, but dissolved salts are abundant and often crystallize out on the surface.

The Semi-Desert (Loess-desert) is related to both steppe and desert. It resembles the desert in that it lacks the dark surface-layer of humus and the perennial sward of plants, while it has the high salinity of the loess. On the other hand, the luxuriant spring-vegetation is like the steppe, the loess of which is identical with that of the semi-desert.

TANFILJEW gives a short description of the different parts of the Russian desert-territory which almost completely encircles the Caspian Sea.

1. The Calmuck Steppe between the rivers Manitsh and Volga and the Jergeni Mountains. The soil is here mainly clayey, and sparsely covered with species of *Artemisia*, *Achillea*, *Alyssum minimum*, *Lepidium perfoliatum*, *Triticum*, *Poa bulbosa*, *Ceratocarpus*, *Astragalus*, *Alhagi*, *Zygophyllum*, *Anabasis* etc. In sandy tracts the plants include *Elymus sabulosus*, *Calamagrostis Epigejos*, *Euphorbia Gerardiana*, *Agriophyllum* and *Calligonum Pallasii*; in salt-swamps are *Tamarix* and *Salsolaceae*.

2. The Kirghiz Steppe (Inner Horde) between the Volga and the Ural. The soil is saline clay with here and there moving-sands. The northern parts are the most fertile and include depressions with Tjernosem and true steppe-plants; here for instance are seen *Stipa capillata* and *Lessingiana*, *Koeleria cristata*, *Silene viscosa* and *Otites*, *Phlomis tuberosa* and *pungens*. etc., while the ordinary chenopodiaceous vegetation may be found on the neighbouring saline clay soil. Farther south the vegetation is poorer and in the sandy areas *Pulsatilla*, *Tribulus*, *Cytisus biflorus*, *Astragalus*, *Amygdalus nana*, *Thymus odoratissimus*, etc., are replaced by *Elymus sabulosus*, *Stipa*, *Poa bulbosa*, *Carex stenophylla* and *physodes*. Some of the latter are also found on the more northern sand areas, but are reported to be less prominent there. On the clay areas species of *Artemisia* are dominant. Low hills of gypsum have a characteristic vegetation (*Matthiola tatarica*, *Eremostachys tuberosa*, *Fritillaria gibbosa*, etc.).

3. East of the Ural river, TANFILJEW gives as the approximate northern limit of the desert, a line from Uralsk through Ulu Uil, the southern end of the Mugodshar mountains, the town of Irgis (Ft. Uralsk) to the southern spurs of the Ulutau mountains. North of this line lies the Stipa-steppe, which in TANFILJEW's phytogeographical map of the Russian empire is also included in the desert. South of the Stipa steppes there is a salt clay-desert which occupies the peninsula of Mangishlak, the Usturt plateau and the area

between the lower course of Syr Darya, the river Tshu, the northern shore of Lake Balchash and the upper Irtish.

The Stipa-steppe and the Clay-desert have already been referred to in our summary of Borszczow's memoir which is also followed by Tanfiljew.

4. The Sand-Deserts in Transcaspia are described as by Borszczow and Korshinsky.

In Tanfiljews treatise: "Die südrussischen Steppen" (1906), the difference between desert and steppe is again emphasized.

The Russian memoir by A. Rodsewitch: "The Tree-Vegetation of Transcaspia" (1896), is known to me only through a summary by Lipsky in "Contributions from the Botanical Garden in Tiflis", 1902.

Of about 500 species found in Transcaspia, nearly half belong to the desert-flora; of these 17 per ct. are trees and 57 per ct. perennials. The characteristics of the desert-plants are: a strongly developed root-system, sclerenchyma in the stems, the radical branches encased in a siliceous coat, and the leaves poorly developed. The most important sand-plants are: *Haloxylon Ammodendron, Tamarix gallica* (?), *Alhagi camelorum, Aeluropus repens, Salsola subaphylla, Populus diversifolia (euphratica), Ephedra, Eremosparton aphyllum, Aristida pungens var. pennata, Ammodendron Karelini, Calligonum* and *Salsola Arbuscula.*

So far as I know these are all the available memoirs which deal with the vegetation of the Transcaspian lowlands. If all have not been included, I hope that nothing of great importance is left out. Descriptions in general works on plant-geography have been omitted since they must necessarily be compiled from the original works.

CHAPTER 5.

Classification of Formations.

On a lovely sunny day in April 1898 the expedition saw the brown mountains of Asia rising above the Caspian Sea. The mountains near Krasnowodsk on the eastern shore of

the Caspian are not beautiful, but low, round and arid-looking, they appear, as if scorched by the intense sunshine. No green was to be seen anywhere. It was delightful to get ashore and to glean our first impressions of nature in Asia. Plants were there on the mountains, although rather scattered; *Gagea*, *Tetradiclis*, *Arnebia* are here with many others, these are representative of three important forms of desert life: Geophytes, Halophytes and Annual Spring-Plants. There is scarcely time to observe more as the train soon starts eastwards and we bid the sea farewell for a long time to come. We pass through and across brown stony hills and flats with scattered bluish grey or green tufts of plants, foot-high Umbellifers and low leafless bushes. Then the sun sets. Next morning brings the finest sight we ever saw, the earth is covered with flowers, glowing poppies and tulips, green grass and Irises and many other flowers. Great flocks of birds soar in the air, and camels graze among the cupola-like "kibitkas" of the Turkomans. Towards the north the view is open, but to the south the low slaty heights of the Kopet Dagh on the Persian border, obstruct the view.

We enjoyed this beautiful scene all day. Next day all was changed, for now the train speeds through the awe-inspiring waste of the sand-desert. It is as RADDE has said, a stormy sea frozen into stillness; enormous ocean-waves without motion, only the foam on the crests is active, it is the sand rising in clouds like smoke. As far as the eye can reach all is greyish-brown sand. Not a plant! Yes there is one, a grass on the top of a dune, its coarse leaves lashed by the wind. More come into view and then we look curiously at the Switch-plants. They stand in the loose sand which is whirled round them and their slender leafless branches are driven before the wind. In reality there are several species but they are all alike switches or rather small leafless birch brooms, and they are leafless, or look so at first sight.

Then the train passes the Oxus or Amu Darya whose brown water coming from the Pamirs flows below us while we slowly cross the long bridge, which extends to 3 kilometres.

The river banks are occupied by poplars and immense tufts of grass (*Erianthus*).

East of the Amu Darya we are on the desert of shifting sand again, and then the large oasis of Buchara is reached. The sun is shining on green fields, tall poplars and brown clay houses. This is our first camping place.

During these past days we have while traversing them acquired a preliminary knowledge of three of the greater plant formations of Transcaspia, namely the Clay-desert, the Sand-desert and the Riverside Thickets. The first we have seen in its luxuriant spring aspect characterized mainly by short-lived annuals; the second, seen at its worst, is distinguished by the exceptionally severe conditions under which only a few, specially equipped plants are able to live; the third is a fringing or gallery-forest ("Galleriewald") rigidly limited to the banks of the river.

It is the object of this contribution to describe these and other formations more closely. First, however, it will be necessary to consider the plant-formations of Transcaspia recognised by earlier writers and to explain our choice of names used to designate the formations in the following pages:

In the Caspian Depression-territory — extending from the southern limit of the forest in European Russia to the Caucasus and the border-mountains of Persia —, GRISEBACH recognises three formations, namely Grass-steppe, Sand-steppe and Salt-steppe (I p. 455). The first of these has a soil with humus and is the south Russian steppe which does not come within the scope of this work. Under Salt-steppe he records a series of other "formations" (p. 461) between which, however, he does not distinguish sharply. The following three are noteworthy: 1) Dry Clay-steppe with a few Saxauls, annual *Chenopodiaceae* or *Artemisia fragrans* or *Anabasis aphylla*, 2) More moist steppe with bushes of social *Salsolaceae* and Tamarisks, 3) Salt-swamps.

BORSZCZOW distinguishes 3 "areas" (see p. 24), namely Salt-desert, Clay-desert and Moving-sand-desert besides two, which lie outside our area. Finally ANTONOW has in addition to "Mountain-Flora", five formations namely Loess-

desert, Loess-steppe, Promontory or Stone-steppe, Sand-desert and the riverside thickets.

Of the authors named, BORSZCZOW, as already stated, does not use the word formation, and ANTONOW, who uses it, defines it as a "natural plant-group". GRISEBACH's definition of formation is well known (1838): A group of plants having a definite physiognomic character, and characterised by a single social species or by several species which although differently organised, yet have some feature in common.

Though there is disagreement between the concept of formation held by these authors and the concept maintained in the following pages, it is in this case of no vital importance. In Transcaspia the natural conditions are so uniform, and the boundaries so distinct, at any rate between the more important formations (those observed on our first railroad journey), that there is very little probability of any misunderstanding.

The formations to be described by us are regarded as plant-communities, belonging to certain growth-forms — always the same within the same formation — and these are determined by and adapted to common conditions. This is the same conception as WARMING has (1909 p. 140). On practical grounds the conditions of soil will be employed in the following descriptions as the principal basis of classification.

The Transcaspian formations or "areas", described by different authors are given in the following table arranged in order to show their relationship. In the column to the right will be found those formations which I regard as necessary for distinction.

GRISEBACH	BORSZCZOW "Territories"	ANTONOW	PAULSEN
Salt-steppe	Salt-desert		Salt-desert
		Loess-desert	
	Clay-desert	Loess-steppe	Clay-desert
		Stone-steppe	Stone-desert
Sand-Steppe	Moving-sand-desert	Sand-desert	Sand-desert
		Riverside Thickets	Riverside Thickets

It will be understood that the Salt-desert is regarded by BORSZCZOW and PAULSEN as a part of ANTONOW's Loess-desert of which another part together withe Loess-steppe is referred to Clay-desert. The salt-desert of BORSZCZOW is not however the same as that of PAULSEN.

The vegetation of the lowlands of Transcaspia is in my opinion, to be classified under the following natural formations:

1. Salt-desert corresponding to parts of ANTONOW's Loess-desert.
2. Clay-desert corresponding to ANTONOW's Loess-steppe and parts of his Loess-desert.
3. Stone-desert. Under this heading are placed not only deserts with stony soil, but also the small, scattered groups of mountains.
4. Sand-desert.
5. The Riverside Thickets.

The outstanding features of the formations are sufficiently indicated by the above titles.

The principal factor which determines the formations is the amount of water. The riversides and the salt-deserts have the moister soil, the clay-desert has the driest, in the physiological sense at least. The physical constitution of the soil also plays a great part especially all that is involved in the difference between sand and clay. Beyond these the life-conditions of the plants in the different formations are still very obscure.

To the natural formations one should add the tilled soil, the formation of cultivation, which in this work is left out of consideration. It only amounts to 2 per ct. of the total area (SCHWARTZ p. 576).

In selecting names for the formations I have avoided the word Steppe. Like SCHIMPER, KRASSNOW (1899) and TANFILJEW (1903, 1905), I prefer to recognise grass-steppe alone as Steppe (see p. 41). Carbonate of lime is here the dominant salt, the vegetation is on the whole uniform all the year round and has produced a surface layer of dark soil. The desert, on the contrary, is an open formation on soil which

has not been greatly transformed by the vegetation, and which is rich in sulphates and chlorides.

The vegetation provides a further difference between the steppes of southern Russia and the Transcaspian deserts. Without entering into details on the vegetation of the steppes, we may take for instance GRUNER's description (p. 106) which states that during summer and autumn a large proportion of non-xerophilous or only slightly xerophilous plants appear (*Melilotus*, *Marrubium*, *Teucrium*, *Chenopodium*, &c.). In Transcaspia the summer and autumn types of vegetation are quite distinct, as will appear from the following chapters.

The same has been pointed out by KRASSNOW (1899), namely that the plants of the desert have a special organisation which enables them to endure the severe drought. (He says this without any reservation although the ephemeral plants might well be taken as exceptions.) Steppes on the contrary are covered by a grassy vegetation not specially adapted to droughts, and therefore liable to be scorched. As a further disparity between desert and steppe, KRASSNOW points out that the former cannot produce crops except with the aid of irrigation whereas the steppe can. Both are devoid of forests.

It seems moreover to be of importance that trees are absent from the steppes (the grass-steppes), while the desert-vegetation in a considerable degree is characterised by trees and bushes. This was also pointed out by GRISEBACH (1872, I, p. 400). His view was, that desert is not a scientific definition but means "uninhabitable places", and, as already stated (p. 45), he included all formations under "steppe". His opinion is that the different forms of steppe are not caused by climatic conditions but originate in the soil. Where there is clay near the surface the water from precipitation does not penetrate deeply so that grasses and herbaceous perennials can live, and we find a grass-steppe. But where sand stones and rocks attract the water to greater depths, we have a desert, which is richer in ligneous plants than the grass-steppe, because their roots go down deeper. In the desert the surface consists of permeable strata.

Apart from the fact that the desert is certainly depen-

dent upon the climate and not upon the soil, and that its surface in many places consists of impermeable clay, the reasoning of GRISEBACH has a great amount of truth. KOSTYTSCHEFF, ISMAILSKY and KRASSNOW independently point out the same circumstance in the Russian steppes, that the absence of tree-growth (among other things) is caused by the surface layer of the soil not permitting the water to penetrate into the depths. With reference to Transcaspia, ROMANOWSKI states (p. 56) that in layers of gravel under the loess, water is found and is widely diffused under the soil. This may be rain or snow absorbed through sand[1]), or it may originate from rivers which have sunk into the sand. "Consequently the sand-steppes of Túran cannot be said to be absolutely waterless."

Here then we have probably the reason — or one of the reasons — why the desert has trees, the steppe none. The presence or absence of trees taken along with the relation of the water to the soil, seem to me so important, that they, together with the climatic conditions and the conditions of the soils, must be regarded as distinguishing characters between steppe and desert.

For my own part I regard the steppe (grass-steppe) as mainly a closed plant-formation (or group of formations) occurring on soil rich in humus without excess of sulphates and chlorides, and with a comparatively moist surface-soil; the vegetation consists of herbaceous perennials, undershrubs and annuals while trees and bushes are wanting.

The soil of the desert, on the contrary, is devoid of humus or very poor in humus, and contains many sulphates and chlorides. The subsoil is (always?) better supplied with water than the surface. The formations are very open and they frequently include trees and bushes.

This attempt to explain the terms steppe and desert may not lead to any sharp distinction between the two, so much the less

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[1]) In this connection it may be pointed out that the steppes of southern Russia have their maximum precipitation in summer so that the water will evaporate quicker than in Transcaspia where maximum occurs between winter and spring. O. P.

as it is mainly based on studies in South Russia and Transcaspia. But the distinction between steppe (grass-steppe) on the one hand and desert on the other, seems easier to apply than the one maintained by most authors, for instance WARMING and VAHL. Phytogeographical literature defines so many different kinds of steppe — Meadow-steppe, Grass-steppe, Vermuth-steppe, Salt-steppe, Sand-steppe, Bush-steppe and even such types as Orchard-steppe poor in grass, Tree-steppe, Steppe-forest &c. (ENGLER 1910) — that it is hard to see what they have in common except that all are more or less xerophilous formations.

What SCHIMPER, KRASSNOW and TANFILJEW have termed steppe, is not an extreme xerophilous formation. The Sand-steppe ("die Sandpuszte", ADAMOVIC p. 320, WOENIG) belongs to the steppe type, but differs from the "Sand-steppes" described from Transcaspia which are deserts. Steppes, according to the definition given here, do not occur in Transcaspia at all.

CHAPTER 6

Formation of the Salt-Deserts.

Under this heading are classed localities where the plants grow on soil so saline that the salt crystallizes out as a layer covering the surface. The conditions which render this possible are: 1) the presence of salts in solution, 2) facilities for the solution reaching the surface. It is essential for this that the underground water-table is not located at too great a depth. It is usual therefore to find salt-deserts in depressions. The constant evaporation from the surface causes the salts to crystallize out, and a fresh solution diffuses constantly from below. Where the soil is loess, this upward diffusion takes place rather easily on account of the capillary structure.

"Ssor" is the name given by the natives to wet saline flats. They are often found among dunes and are said to be generally flooded during winter and spring. A "Ssor" is not a very pleasant sight (fig. 2). The ground is flat and white like

snow so that in the strong sunlight it is dazzling to the eyes. Very often this is all that is to be seen, one can walk hundreds of paces without finding a plant. In some places the salt crackles under the feet, in other places the soil is soft to the tread because under the salts, it is moist or wet. One slips frequently on the greasy greenish-brown clay. In such a place the water-table may be barely 1 metre below the surface.

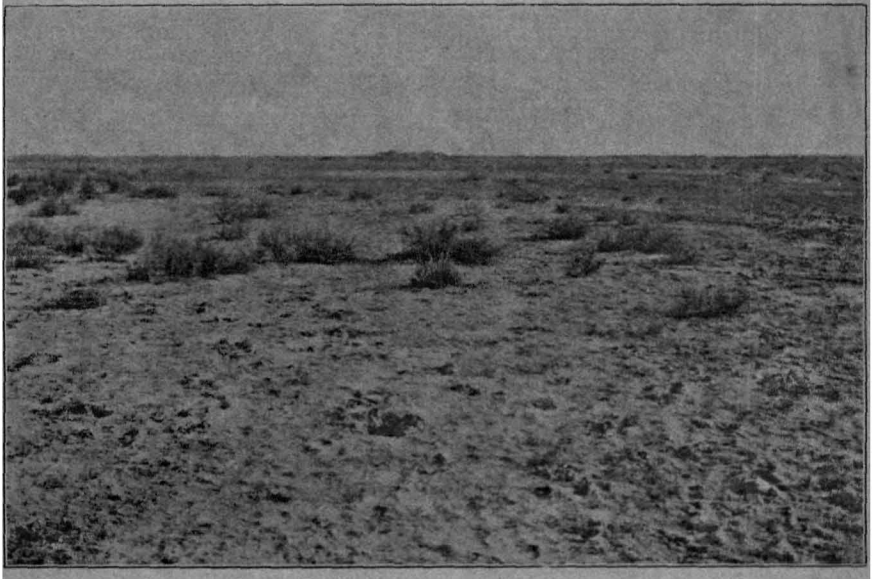

Fig. 2. "Ssor" (Salt-desert) near Buchara. The ground is white with salt and occupied by scattered *Aeluropus littoralis* and *Halostachys caspica* (the bushes). Month of May.

In small depressions the soil is brown, because here it is so wet that the salts are kept permanently in solution. Also on small elevations the soil may be brown and only coated with a thin, granular, hard incrustation. Towards summer the salt in some places becomes dry and dusty.

The salts are mainly sulphates especially of sodium and magnesium, but there is also gypsum and common salt[1]) Crystals of gypsum are sometimes found in the earth.

[1]) See above p. 9.

The vegetation is exceedingly scanty. At long intervals small stunted bushes of *Halostachys caspica* may be seen, a leafless dwarf-bush with assimilating shoots like those of *Salicornia*.

Halocnemum strobilaceum, a small bush, distinguished by its globular dwarf-shoots, has a similar appearance. Also *Lycium ruthenicum* is a bush with fleshy cylindrical leaves; like the other two it scarcely attains the height of one foot on this wet saline soil, but under favourable circumstances it may become many times larger. (See for instance the chapter on the riverside thickets).

A number of annual species are also characteristic for the salt-desert, or may be found there. The more important of these are: *Salicornia herbacea, Halopeplis pygmaea* (this has exceedingly succulent, thick and almost globular leaves), *Suæda setigera, arcuata, corniculata* etc., *Bienertia cycloptera, Halogeton glomeratus, Statice leptostachya* and *spicata*, species of *Salsola*, (*S. crassa, obtusifolia* etc.) and *Halimocnemis* which, however, usually occurs more frequently on somewhat drier soil. The same holds good for *Frankenia pulverulenta* and the prostrate undershrub *Frankenia hirsuta*, also for *Anabasis*, some species of which are herbaceous perennials, some undershrubs, and all with leafless assimilating shoots. Other herbaceous perennials are *Statice otolepis* with broad leaves arranged in rosettes, and *Aeluropus littoralis*, a prostrate bluish-grey grass.

My experience is that *Aeluropus, Halostachys, Halocnemum* and *Salicornia* are the species most frequently met with on "Ssor". On one occasion near Chodsheli (in July) I found *Phragmites communis* in a locality of this kind. The soil was moist and brown at the depth of a few centimetres, but the surface was dry, white and dusty with salts. The *Phragmites* plants were small, and with surface-runners as when the species grows on wet sand in the north of Europe, but these runners did not exceed 30 cm. in length. *Tamarix* bushes, half a metre high, were growing scattered along with *Phragmites*.

The species mentioned above are all Halophytes. Most of them are Chenopodiaceae and belong to the succulent,

leafless or leaf-bearing type, with the exception of *Aeluropus*, *Statice*, *Phragmites* and the salt-excreting Frankenias and Tamarisks. Their internal structure is dealt with in chapter 13.

Most of the species are annuals and all are summer-plants, none being ephemeral spring-plants. The annual Statices *(S. leptostachya* and *spicata)* are probably not very long-lived, but on this point I have no definite observations.

As regards the natural development of "Ssor", I can only say that on one occasion I observed that sand from the neighbouring sand-desert had drifted across the salt-flats, and sheltering behind plants of Salicornia had formed miniature sand-dunes. If this sand remains long enough it will become permeated by the moisture coming from below, and the salt incrustation must form over it. In this way the surface may be raised a little. This process does not seem, however, to play any great part, because I have always found clay under the salt incrustation, but further examination might perhaps reveal the presence of sand.

That the barrenness of the salt-desert is due to the want of fresh water alone, was illustrated by a striking example seen near Buchara. Here in May 1898, two parallel ditches were dug through a snow-white salt-desert, and the excavated material was made into a mound between them, so that the mound and the double ditch surrounded a square piece of of ground. The inner ditch was connected by a long straight ditch with the irrigation system of some tilled fields in the neighbourhood. The piece of ground enclosed by the mound and the ditches was perfectly green, *Aeluropus littoralis* having spread so luxuriantly that it almost formed a carpet of vegetation and so dense that it almost suppressed all the other halophytes, only a very few *Halostachys* being left.

Outside the outer ditch the ground was white with salt and covered with scattered *Halostachys caspica* and *Aeluropus* (fig. 3).

The peasants told me that the enclosed piece of ground was made into a field this year, that it had only once been irrigated (through the long straight ditch) and that in the autumn they intended to sow it with wheat. MIDDENDORFF,

however, maintains (l. c. p. 123) that saline soil must be washed for two winters before it is fit to be tilled.

Batpak or Batkak, according to CHOROSHKIN (cited by MUSKETOW p. 655), must be closely related to Ssor. These are swampy depressions with efflorescent salts, and they are nearly always found by salt-lakes and may be partly covered by water. It must be areas of this kind which BORSZCZOW

Fig. 3. To the left Salt-desert with scattered *Halostachys caspica*. The soil to the right of the mound has been irrigated once and is covered with a thick growth of *Aeluropus littoralis*. Near Buchara in May.

has described as "Salt-deserts" and whose brilliancy of colour he admires so much. ANTONOW's "Swamp-lakes" must also be of this same type.

If the above assumptions are correct, Batpak must be more swampy than Ssor. Only near Chiwa have I seen salt-swamps which can be classed in this category. These are small, shallow, stinking salt-lakes, surrounded by a snowy-white salt-steppe which is flat or slightly undulating. The salt-plain is similar to the Ssor described above, and has large tracts without any plants, but in most of the depressions are found fresh green groups of *Salicornia* or *Halimocnemis*.