Feddes Repertorium **102** (1991) 1–2, 137–150 Berlin, Februar 1991

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Vegetation description of mud volcanoes of Crimea

With 6 Tables

Summary

The paper presents results of studying vegetation on the mud volcanic formations of the Kerch peninsula (Crimea). Three types of mud-volcanic structures differing by activity and position in relief have been singled out. A number of new syntaxa from the classes Thero-Suaedetea VICHEREK 73, Festuco-Puccinellietea SOÓ 68, Festuco-Brometea BR.-BL. et TX. 43 have been stated. Status of vegetation units on the succession trend has been determined.

Zusammenfassung

In dieser Arbeit werden Untersuchungsergebnisse zur Vegetation auf den Schlammvulkanen der Halbinsel Kertsch (Krim) mitgeteilt. Es können drei Schlammvulkan-Typen ausgeschieden werden, die sich durch ihre Aktivität und ihre Position im Relief unterscheiden. Etliche Syntaxa der Klassen Thero-Suaedetea VICHEREK 73, Festuco-Puccinellietea SOÓ 68, Festuco-Brometea BR.-BL. et TX. 43 werden ausgeschieden. Der Status der Vegetationseinheiten im Ablauf des Trends wird bestimmt.

Introduction

Formation of plant communities on surface of mud volcanoes proceeds under extreme conditions. At eruptions certain plant individuals and perish or undergo effects of water-soluble salts and petroleum products which are contained in erupted materials. So, the succession trend and rate depend on the surface age, chemical composition and thickness of the formed substrate, rate of its desalinizations and intoxication under concrete landscape-climatic conditions.

General characteristic of mud-volcanic landscape

The mud-volcanic formations differ by location (ground, submerged, insular, buried), by modern activity (active, "extinct") and by relief (mud volcanoes, hills, graffins, craters, calderas of subsidence, mud-volcanic flows and covers) which to more or less extent is broken up with hollows, ravines and gullies, cut up by suffosion channels or cut off by landslides. The mud volcanoes gravitate towards oil-gas fields and volcanic provinces, they occur in various landscape-climatic zones. They are known to be in Italy, Romania, Pakistan, India, Myanmar (Burma), Indonesia, Japan, Venezuela, Colombia, Mexico, USA, Iceland and other countries. In the Soviet Union the mud volcanoes are typical in Azerbaijan, in Kerch and Taman peninsulas, Turkmenistan and Sakhalin (SHNIUKOV et al. 1986; YAKUBOV & ALIEV 1978). Differences in location, activity, chemical composition of eruption products, in morphology and age of mud-volcanic relief, climate and landscape they are found determine variety of ecological conditions and plant communities.

Vegetation of the mud volcanoes, undoubtedly, is a phenomenon from the viewpoint

of genesis and syntaxonomic state. It has not been studied yet practically from the stand point of ecologo-floristic classification. Separate descriptions of species composition of phytocoenoses of mud volcanoes in the Kerch peninsula are found in works by E. V. WULFF (1929), E. V. SHIFFERS (1929), V. F. IVANOV et al. (1989). Some informations on vegetation of the mud-volcanic formations in Azerbaijan are presented in papers by B. A. KLOPOTOVSKY (1949) and D. A. LILIENBERG (1962). In foreign scientific literature the floristic composition of plants near mud griffins of Andaman Islands, Indian Ocean, was described (SRIVASTAVA 1962).

Vegetation of mud-volcanic landscapes of the Crimea is represented by communities of the following classes: Thero-Suaedetea VICHEREK 73, Festuco-Puccinellietea Soó 68, Festuco-Brometea BR.-BL. et TX. 43, Crypsidetea aculeata VICHEREK 73, Phragmitetea TX. et PREISING 42. Phytocoenoses of two latter classes are found locally in sites of higher humidity and will not be considered here. The syntaxa of the class Thero-Suaedetea VICHEREK 73, order Thero-Suaedetalia BR.-BL. et DE BOLOS 57 emend. BEEFTINK 62, alliance Thero-Camphorosmion (BILIK 63) VICHEREK 73 are attached to pioneer habitats forming on fresh mud-volcanic flows. Communities of the class Festuco-Puccinellietea Soó 68 are integrated with subsequent stages of the succession and those of Festuco-Brometea BR.-BL. et TX. 43 are background and the final stage of the succession series on old and ancient surfaces of mud-volcanic origin.

Ecological conditions of vegetation formation on mud volcanoes of the Crimea

The mud volcanoes give off gaseous, liquid and solid eruption products. In volcanic gases methane and carbon dioxide prevail. Alkalic chloride-hydrocarbonate-sodium and hydrocarbonate-chloride-sodium waters with mineralization of 8–23 g/l are main types of volcanic waters. Higher contents of iodine, bromine, boron, mercury, lithium and potassium have been stated in them. Petroleum is not infrequent. Solid products of mud-volcanic eruptions are represented by volcanic breccias and pelites in which clay-silty particles prevail. They usually have viscous or liquid-fluid consistency and spread down the slopes in a thick or thin layer, respectively.

Salts and toxic substances are concentrated near the eruption centres, particularly in superficial horizons of young volcanic sediments and in microhollows where solonchaks are formed. During stormy eruptions they are dispersed with mud-volcanic flows few hundred metres from craters. Under warm, droughty climatic conditions, with annual precipitation of 300 to 400 mm, wash-out of water-soluble salts and toxic substances from the volcanic deposits proceed very slow.

The mud volcanoes of the Crimea, by their activity, morphology and ecologic conditions, are divided into three types: 1 – Djau-Tepé, 2 – Bulganak and 3 – Siuyurtash. Activity decreases from first to third type and proper volcanic constructions are changed with volcanic and then griffin fields, which show fading of the mud-volcanic activity.

In active volcanoes of the Djau-Tepé type eruptions occur through craters with diameter 10–40 m, on an average once every 40–50 years and frequently they proceed in a violent, catastrophic way. The eruptions can be accompanied by explosions and ignition of gases with spouts of cold or warm mud of few dozen metres high, cracks and sinking of surface. At stormy eruptions flows of volcanic breccia of viscous fluid consistency with volume of 100–200 thousand m^3 are formed spreading to 500 m far from the crater, when dried, they retain steep borders forming small-hilly microrelief of surface. Considerable viscosity and abundance of mud-volcanic "lava" determine morphology of the volcanoes. They look like cup-shaped hills or truncated cones with relative height of 11 m. Their slopes with steepness of 5–30° are disjointed with hollows, ravines, gullies and gorges which form radial-centripedal pattern in plan. Considerable steepness of surface and erosion disjunction promote leaching of volcanic salts from breccia. The radial pattern of asynchronous mud-volcanic flows and erosion forms (drains) determined the radialblade structure of plant cover.

Mud volcanoes of the Bulganak type have numerous dispersed eruption centres. They are fields of volcanoes and griffins craters of which practically always discharge gas and small

quantity of mud. Due to constant unloading of gas pressure of the hearth, there are no catastrophic eruptions in such volcanoes. Prolonged phase of quiet development is changed with a short-termed, unsignificant eruption which effects on nearby landscapes.

Volcano hills of the Bulganak type belong to two morphological types. Former ones look like gentle shield-shaped hillocks slightly raising over bottoms of kettles (calderas of sinking). Craters of the hills with diameter of 10 – 20 m are filled with liquid mud, at which outpouring very thin flows are formed. The second type of the hills is cone-shaped with height of 3 – 5 m. They usually are set on the flat-topped hills formed with volcanic breccias and give off mud of viscous-flow consistency. It forms short flows at eruptions or lens-shaped covers up to 0.5 m thick.

Bulganak and Tarkhan knoll fields belong to the type of mud volcanoes under consideration. In range of the former the knolls Tsentralnaya, Obruchev, Tishchenko, Andrusov, Abikha, Pavlov, Vernadsky and Oldenburgsky are singled out. At most considerable eruptions 0.5 – 1 thousand cubic meters of mud flow out of crater lakes. Only once, in 1926, at eruption of Andrusov knoll formation of mud-volcanic cover with volume of about 10,000 m^3 was observed (TURLEY 1930).

Poor activity of volcanoes of the Bulganak type, abundance of local eruption centres and slight surface slopes determine slight influence of mud-volcanic eruptions on vegetation and significant effects of water-soluble salts and toxic substances which are accumulated near the eruption centres and redistributed from here mainly with superficial flow along microdepressions and talwegs of erosion forms. In this connection, in the structure of plant cover concentric and radial-blade elements are combined.

Mud volcanoes of the Siuyurtash type belong to fading formations. As a matter of fact, they are griffin fields. They have an appearance of flat-topped hills composed with a volcanic breccia, on these hills there are few griffins giving off gas quietly. Liquid or thick mud, sometimes mixed with petroleum, pulses in crater-like depressions with diameter 0.1 – 0.3 m and practically flows not off. Some griffins are stopped up eventually and disappear, and new ones form beside. Their eruptions are not known and their traces in modern relief are not seen. So salts and toxic substances accumulated in microdepressions aroupd griffins on poorly drained slope surface of the griffin field influence mainly on plants growth. This determines spotty-concentric structure of plant cover. Siuyurtash, Vladislavovka, Nassyr and some other mud volcanoes are in the described stage of fading development.

Vegetation syntaxonomy of mud volcanoes

Studies of vegetation were carried out in the Kerch peninsula where there are more than 20 active and "fading" (fossile) mud volcanoes. When describing the phytocoenoses and classifying the vegetation methodical approaches by J. BRAUN-BLANQUET (WESTHOFF & MAAREL 1978) supplement with recommendations from the Code of Phytosociological Nomenclatures (BARKMAN et al. 1988) have been used.

The class Thero-Suadetea VICHEREK 73. Within limits of the class two new associations have been stated: Lepidietum crassifoliae and Petrosimonio-Artemisietum santonicae, phytocoenoses of which represent pioneer plant aggregations assimilating new forming substrate on surfaces of mud-volcanic formations. Communities of the association Lepidietum crassifoliae are noted on surfaces of fresh flows of volcanic pelites flowing out of crater lakes and griffins of Bulganak type volcanoes. Mineralization of their mud is very high, water *p*H of samples collected near crater of the Oldenburgsky volcano was 10.4. However, the volcanic mud ran out desalinize gradually, its mineralization reduces and when *p*H reaches 10.14 first plants of *Lepidium crassifolia* from the subassociation Lepidietum crassifoliae typicum appear (Table 1, Descript. 1 – 5).

Communities of second subass. Lepidietum crassifoliae petrosimonietosum oppositifoliae (Table 1, Descr. 6 – 10) are adapted to the griffins surrounding crater lakes of Bulganak and Tarkhan volcanic fields. They are in the locations where eruption products do not get rather long time and the substrate had enough time for desalinization (*p*H 9.8 – 9.3). Near the crater lakes communities of the association Lepidie-

Table 1
Lepidietum crassifoliae ass. nov.

Subassociations	typicum					constancy by subas-sociation	petrosimonietosum					constancy by subas-sociation	constancy by asso-ciation
Description area, m^2	40	25	12	4	12		50	16	12	25	10		
Coverage, %	2	4	5	2	8		35	30	40	35	50		
No. species	2	1	1	2	1		9	11	13	7	8		
No. of description	1	2	3	4	5		6	7	8	9	10		
Typical species of Thero-Suaedetea + Thero-Suadetalia													
Suaeda confusa	1	.	.	.	.	I	1	1	.	.	1	III	II
Suaeda prostrata	.	.	.	.	.		1	.	1	1	.	III	II
Typical species of Thero-Camphorosmion													
Camphorosma monspeliaca	.	.	.	1	.	I	1	1	1	1	1	V	III
Typical species of Lepidietum crassifoliae													
Lepidium crassifolia	1	5	3	3	3	V^{1-5}	3	1	1	3	1	V^{1-3}	V^{1-5}
Differential species of the subassociation													
Petrosimonia oppositifolia	.	.	.	.	.		1	1	1	1	1	V	III
Puccinellia fominii	.	.	.	.	.		2	4	4	2	2	V^{2-4}	III
Other species													
Limonium gmelenii	.	.	.	.	.		.	.	1	1	1	III	II
Artemisia santonica	.	.	.	.	.		.	1	1	1	.	III	II
Cerastium glutinosum	.	.	.	.	.		.	1	1	.	1	III	II
Hamilione verrucifera	.	.	.	.	.		1	.	.	.	1	II	I
Poa bulbosa	.	.	.	.	.		.	1	1	.	.	II	I

In addition, there occurred separately: *Salsola soda* (6), *Erophila verna* (7), *Palimbia salsa* (6), *Ranunculus trachyceras* (7), *Bromus squarrosus* (7), *Vicia lathyroides* (8), *Anthemis cotula* (8), *Scorzonera laciniata* (8), *Lepidium campestre* (8).

Localization of the descriptions: the Bulganak volcanic field: volcano of Oldenburgsky (1, 6); volcano Tsentralnaya (2, 7); volcano of Vernadsky (3, 8); the Tarkhan volcanic field: griffins of the Great Tarkhan (5, 9); griffins of the Small Tarkhan (10); volcano of Trubetskoi (4).

Nomenclature types: Descr. 4. The Small-Tarkhan volcanic field, volcano of Trubetskoi, 26. 5. 84, author KORZHENEVSKY, V. V. Descr. 8. The Bulganak volcanic field, volcano of Vernadsky, 31. 05. 87, authors KORZHENEVSKY, V. V., KLIUKIN, A. A.

Table 2
Petrosimonio-Artemisietum santonicae ass. nov.

Subassociations	atriplicetosum					constancy by subassociation	puccinellietosum					constancy by subassociation	constancy by association
Description area, m²	9	9	4	12	12		25	9	12	9	10		
Coverage, %	12	10	35	30	30		30	25	20	35	40		
Number of species	8	10	9	9	8		6	7	11	6	5		
Description number	1	2	3	4	5		6	7	8	9	10		
Typical species of Thero-Suaedetea + Thero-Suaedetalia													
Suaeda confusa	3	2	1	2	3	V¹⁻³	1	1	.	1	1	IV	V¹⁻³
Suada prostrata	.	1	.	.	1	II	.	1	.	.	.	I	I
Typical species of Thero-Camphorosmion													
Camphorosma monspeliaca	1	1	.	1	1	IV	1	1	1	2	1	V¹⁻²	
Typical species of Petrosimonio-Artemisietum santonicae													
Artemisia santonica	2	3	1	1	1	V¹⁻³	1	1	1	1	1	V	V
Petrosimonia brachiata	1	2	4	1	1	V¹⁻⁴	1	1	.	1	1	IV	V
Differential species of the subassociation													
Atriplex calotheca	1	3	1	1	1	V¹⁻³	.	.	.	.	.		III
Atriplex tatarica	1	1	1	.	1	IV	.	.	.	.	.		III
Puccinellia fominii	.	.	1	.	1	II	3	1	3	2	2	V¹⁻³	IV¹⁻³
Other species													
Limonium gmelenii	.	.	1	1	.	II	1	.	1	1	.	III	III
Salsola soda	1	1	1	1	.	IV	.	1	.	.	.	I	III
Salsola tragus	.	1	.	1	1	III	.	.	.	.	.		II
Petrosimonia triandra	1	1	.	1	.	III	.	.	.	.	.		II

Besides, there occurred separately: *Petrosimonia oppositifolia* (3), *Goniolimon tataricum* (8), *Bromus japonicus* (8), *Cerastium glutinosum* (8), *Erophila verna* (8), *Halimione verrucifera* (8), *Polygonum salsugineum* (8).

Localization of the descriptions: the mud volcano Djardjava (1, 2), the mud volcano Djau-Tepé (3, 4), the Bulganak volcanic field – volcano of Andrusov (5), Nassyr mud volcano (6, 9), Siuyurtash mud volcano (7, 8, 10).

Nomenclature types: Descr. 3, mud volcano Djau-Tepé (vill. Vulkanovka), 03. 09. 83, author KORZHENEVSKY, V. V.; Descr. 8, the mud volcano Siuyurtashsky, 14. 05. 82, author KORZHENEVSKY, V. V.

Table 3
Artemisio tauricae-Valerianetum tuberosae ass. nov.

Subassociation	halimionetosum					constancy
Description area, m²	12	10	4	9	12	by association
Coverage, %	80	85	80	75	70	subassociation
Number of species	33	29	21	20	16	
Description no.	1	2	3	4	5	
Typical species of Festuco-Puccinellietea + Artemisio-Festucetalia						
Taraxacum bessarabicum	1	.	.	1	.	II
Artemisia sântonica	.	1	.	1	1	III
Scorzonera laciniata	2	1	1	1	.	IV[1-2]
Festuca valesiaca ssp. *pseudodalmatica*	1	1	1	.	1	IV
Puccinellia fominii	3	3	5	5	5	V[3-5]
Typical species of Festucion pseudovinae						
Limonium mejeri	3	3	3	2	2	V[2-3]
Ranunculus pedatus	1	1	1	1	1	V
Trifolium parviflorum	1	1	1	1	.	IV
Typical species of the association						
Artemisia taurica	3	3	2	2	1	V[1-3]
Valeriana tuberosa	1	1	1	1	1	V
Polygonum salsugineum	1	.	1	1	.	III
Myosurus minimus	1	1	1	.	1	IV
Myosotis ramosissima	1	.	1	1	.	III
Differential species of the subassociation						
Halimione verrucifera	1	1	2	1	1	V[1-2]
Veronica verna	1	1	1	1	1	V
Petrosimonia triandra	.	1	1	1	1	IV
Holosteum umbellatum	1	1	2	1	.	IV[1-2]
Cerastium tauricum	2	1	1	1	1	V[1-2]
Other species						
Poa bulbosa	3	3	3	2	1	V[1-3]
Agropyron desertorum	1	1	2	1	.	IV[1-2]
Muscarimia muscari	1	.	1	1	.	III
Erophila verna	1	1	1	.	.	III
Salsola soda	.	.	1	.	1	II
Vicia lathyroides	1	1	.	.	.	II
Geranium dissectum	1	1	.	.	.	II
Bromus japonicus ssp. *anatolicus*	1	1	.	.	.	II
Trifolium campestre	1	1	.	.	.	II
Chamomilla tzvelevii	1	1	.	.	.	II
Vicia tetrasperma	1	1	.	.	.	II
Hordeum geniculatum	1	1	.	.	.	II

Besides, the following species were occurred separately: *Ventenata dubia* (1), *Allium albiflorum* (1), *Koeleria cristata* (1), *Valerianella carinata* (1), *Lathyrus aphaca* (1), *L. nissolia* (1), *Vicia amphicarpa* (2), *Ranunculus oxyspermum* (2), *Ferula orientalis* (2), *Camphorosma monspeliaca* (2), *Bromus mollis* (4), *Lepidium campestre* (5), *Crinitaria villosa* (5).

Localization of the descriptions: the Bulganak volcanic field: 1–5 m east of Pavlov volcano, 2–10 m west of the volcano of Vernadsky, 3–40 m south of the Oldenburgsky volcano; the Small Tarkhan volcanic field: 4–15 m north of the Trubetskoi volcano, 5 – the Large Turkhan volcanic field.

The nomenclature type: Descr. 2, the Bulganak volcanic field (vill. Bondarenkovo, the Kerch peninsula), 31. 05. 87, authors KORZHENEVSKY V. V., KLIUKIN A. A.

tum crassifoliae petrosimonietosum oppositifolii represent the second stage on the succession trend in range of Bulganak type of the mud-volcanic formations.

Communities of the association Petrosimonio-Artemisietum santonicae are attached to the mud-volcanic formations of types Djau-Tepé and Siuyurtash. The association includes two subassociations. First one – Petrosimonio-Artemisietum santonicae atriplicetosum (Table 2, Descr. 1 – 5) is typical for young covers on volcanoes of the Djau-Tepé type. Formation of the pioneer aggregation starts after 3 – 5 years, when as a result of precipitation effects, desalinization of the upper centimeters of the mud-volcanic breccia occurs onto which diaspores come from surrounding sites and more or less favourable conditions are created. It is evident from the floristic composition that species of Chenopodiaceae prevail and a group of spring annuals with shallow root system is the main biomorph. This syntaxon exists on an average 30 – 35 years.

Phytocoenoses of the subass. Petrosimonio-Artemisietum santonicae puccinellietosum (Table 2, Descr. 6 – 10) are conjugated with superficial deposits of the mud-volcanic breccia of "fading" volcanoes of Siuyurtash type. The substrate here is strongly salinized on the whole profile and impregnated considerably with petroleum products which hamper entry and filtration of rain waters. This limits desalinization process and, thereby, wider distribution of plants.

Class Festuco-Puccinellietea Soó 68. Within this class a new alliance and three associations are described. Communities of the association Artemisio tauricae-Valerianetum tuberosae (Table 3, Descr. 1 – 5) are attached to lowest sites of the Bulganak and Tarkhan volcanic fields where superficial waters carry down water-soluble salts washed out from volcanic pelites. The substrate is characterized by alkaline reaction, high contents of Ca, Mg and soda. Habitats of the association's communities are run with water only during short humid periods being dried strongly in rest time. Existence duration of the subassociation Artemisio tauricae-Valerianetum tuberosae halemonietosum is determined by habitat stability.

Within structure of the class Festuco-Puccinellietea Soó 68 and the order Artemisio-Festucetalia pseudovinae Soó 68 a new alliance Camphorosmo-Agropyrion desertorii (Tables 4, 5) has been singled out whose syntaxa phytocoenoses are conjugated with initially salinized clayey and clay-silty rocks and occur not only in mud-volcanic landscapes, but in badlands of south-east Crimea, too. On the moistening gradient (within the class) plant communities of this alliance are most xerophyte phytocoenoses typical for arid areas of USSR south and, except of Crimea, probably occur in Azerbaidjan.

The alliance includes two associations of which Thero-Eremopyretum is a model for the alliance. Age of the substrate on which the association's communities are developed exceeds 35 years. The association consists of two subassociations. Their surface age and substrate transformation which correlates to it are different. Communities of the subassociation Thero-Eremopyretum typicum (Table 4, Descr. 1 – 5) are attached to surfaces of the mud-volcanic flows whose age does not exceed 70 years. Phytocoenoses of the subassociation Thero-Emeropyretum feruletosum (Table 4, Descr. 6 – 10) occur on flows of the mud-volcanic breccia with age of 70 – 75 years. Both subassociations are typical for the mud-volcanic formations of the Djau-Tepé type.

Second association in the alliance Camphorosmo-Agropyrion desertorii is Meliloti-Elytrigietum repensii (Table 5) which represents phytocoenoses being under conditions of persistent stress caused by slope erosion and aggravated with cattle grazing. If one proceeds from age of the eruption products, then the plant cover should transit at the succession trend to climax stage, the association Ferulo-Artemisietum tauricae is an integral expression of it (this association will be discussed later). However, due to ever effects of slope processes this takes no place.

The ass. Meliloti-Elytrigietum repensii includes three subassociations. The first one – Meliloti-Elytrigietum repensii typicum (Table 5, Descr. 1 – 5) characterizes communities attached to talwegs of numerous ravines and gorges breaking down radially old and ancient slopes of volcanoes of the Djau-Tepé type. Owing to the fact that temporary water streams run periodically along the talwegs, erosion and accumulation of water-soluble salts washed out

Table 4
Thero-Eremopyretum ass. nov.

Subassociations	typicum					constancy by subas-sociation	feruletosum					constancy by subas-sociation	constancy by subas-sociation
Description area, m^2	12	16	16	16	12		12	16	16	14	16		
Coverage, %	25	35	30	60	70		40	30	55	30	60		
Number of species	12	12	13	16	22		26	16	20	17	20		
Description No.	1	2	3	4	5		6	7	8	9	10		
Typical species of Festuco-Puccinellietea + Artemisio-Festucetalia													
Taraxacum bessarabicum	.	1	.	.	1	II	1	1	.	.	1	III	III
Artemisia santonica	1	2	1	.	.	III	4	1	2	2	3	V^{1-4}	IV^{1-4}
Scorzonera lacinata	1	1	1	2	1	V^{1-2}	1	.	1	.	.	II	IV^{1-2}
Festuca valesiaca ssp. *pseudodalmatica*	.	1	1	.	1	III	1	1	1	1	.	IV	IV
Puccinellia fominii	2	2	2	1	.	V^{1-2}	2	2	2	2	2	V^{2}	V^{1-2}
Typical species of Camphorosmo-Agropyrion desertorii													
Camphorosma monspeliaca	3	2	3	3	2	V^{2-3}	4	4	4	4	4	V^{4}	V^{2-4}
Salsola soda	.	1	1	1	1	IV	1	1	1	1	1	V	V
Agropyron desertorum	1	1	1	1	2	V^{1-2}	1	1	2	1	2	V^{1-2}	V^{1-2}
Typical species of the association													
Eremopyron orientale	2	1	2	3	2	V^{1-3}	1	1	1	1	1	V	V^{1-3}
Petrosimonia triandra	1	1	.	1	1	IV	1	1	1	.	1	IV	IV
Ventenata dubia	1	.	1	.	1	III	.	1	1	.	1	III	III
Differential species of the subassociation													
Erophila verna	.	.	.	.	.		1	1	1	1	1	V	III
Ferula orientalis	.	.	.	.	.		1	1	1	1	1	V	III
Holosteum umbellatum	.	.	.	.	.		1	1	1	1	1	V	III
Cerastium tauricum	.	.	.	.	.		1	1	1	1	1	V	III
Other species													
Limonium mejeri	1	.	.	1	1	III	1	1	1	1	1	V	IV
Poa bulbosa	1	1	1	1	2	V^{1-2}	4	.	.	2	1	III	IV^{1-4}
Vicia lathyroides	.	.	.	1	1	II	1	.	1	1	.	III	III
Artemisia taurica	.	.	.	3	1	II	.	1	.	1	1	III	III
Atriplex colotheca	1	.	1	.	1	III	.	.	.	.	.		II
Bromus japonicus ssp. *anatolicus*	.	1	.	1	1	III	1	1	1	.	.	III	III
Cardaria draba	1	.	1	.	1	III	.	.	.	.	.		II

Veronica arvensis	.	.	.	1	1	II	1	.	1	.	.	II	II
Turgenia latifolia	.	.	1	.	1	II	.	.	.	.	.		I
Medicago minima	.	.	.	1	.	I	.	.	1	.	.	I	I
Alyssum hirsutum	.	.	.	.	1	I	1	.	.	.	.	I	I
Polygonum salsugineum	.	.	.	.	.		.	.	.	1	1	II	I
Trifolium parviflorum	.	.	.	1	.	I	1	.	1	.	1	III	II

In addition, the following species occurred separately: *Erysimum diffusum* (5), *Ceratocephala testiculata* (5), *Trifolium campestre* (6), *Allium albiflorum* (6), *Plantago lanceolata* (6), *Trigonella monspeliaca* (6), *Koeleria cristata* (6), *Galium tenuisissimum* (6), *Myosotis ramosissima* (6), *Tragopogon dasyrhynchus* (6), *Valerianella carinata* (6), *Crepis micrantha* (9), *Petrosimonia brachiata* (10), *Atriplex nitens* (10).

Localization of the descriptions: 1, 2, 3, 6, 7, 8, 9, 10 – the mud volcano Djau-Tepé (vill. Vulkanovka); 4, 5 – the mud volcano Djardjava (town of Kerch).

Nomenclature types: Descr. 4 – the mud volcano Djardjava, flow 3 1930, 02. 06. 87, author KORZHENEVSKY V. V.; Descr. 8 – the mud volcano Djau-Tepé, south-west slope (108 m), flow 1914, 03. 09. 83, author KORZHENEVSKY V. V.

from the upper mud-volcanic deposits are observed here.

The subass. Meliloti-Elytrigietum repensii alopecuretosum (Table 5, Descr. 6–10) unites phytocoenoses of slopes of gorges and ravines. Spurtous wash-out, floating ground and creeps manifest themselves here with different intensity. Amongst syntaxa of the association, in that discussed highest species saturation is noted, conditioned by wide variation of microrelief forms and microclimatic parameters conjugated with it.

The subass. Meliloti-Elytrigietum repensii serratuletosum (Table 5, Descr. 11–15) includes plant communities spread on deluvio-proluvial tails formed at the foot of mud-volcanic hills, in outfalls of ravines and gorges. Slight steepness of the tails surface accompanies poor accumulation of clay-silty products of wash-out, redistribution of water-soluble salts and their concentration in local depressions which results in mosaic structure of plant cover.

The class Festuco-Brometea BR.-BL. et TX. 43 is represented by a new alliance and a standard association. The alliance Artemisio tauricae-Festucion (Table 6) unites syntaxa communities of which are placed on clays of the Maikop series wide-spread in the Kerch peninsula. In the concrete case, the association Ferulo-Artemisietum tauricae (Table 6, Descr. 1–5) is climax one on substrates of old and ancient mud-volcanic deposits. Its phytocoenoses are wide-spread within the manifestation field of both modern and ancient volcanism. In this connection, it is of great importance for indication research and at mapping territories.

Thus, the hierarchic structure of syntaxa of mud-volcanic landscape of the Kerch peninsula is as follows:

Class Thero-Suadetea VICHEREK 73
- Order Thero-Suadetalia BR.-BL. et DE BOLOS 57 emend. BEEFTING 62
  - Alliance Thero-Camphorosmion (BILIK 63) VICHEREK 73
    - Ass. Lepidietum crassifoliae ass. nov.
      - Subass. L.c. typicum subass. nov.
      - l.c. petrosimonietosum oppositifolii subass. nov.
    - Ass. Petrosimonio-Artemisietum santonicae ass. nov.
      - Subass. P.-A.s. atriplicetosum subass. nov.

Table 5
Meliloti-Elytrigietum repensii ass. nov.

Subassociations	typicum					const. by subassociation
Description area, m²	12	16	16	20	25	
Coverage, %	65	60	60	65	70	
Number of species	10	10	10	10	9	
Description no.	1	2	3	4	5	
Typical species of Festuco-Puccinellietea + Artemisio-Festucetalia						
Taraxacum bessarabicum	.	.	.	1	.	I
Artemisia santonica	.	1	1	.	.	II
Scorzonera laciniata	1	1	1	1	.	IV
Festuca valesiaca ssp. *pseudodalmatica*	1	.	.	.	1	II
Puccinellia fominii	.	.	.	.	1	I
Typical species of Camphorosmo-Agropyrion desertorii						
Agropyron desertorum	1	1	1	.	1	IV
Camphorosma monspeliaca	.	1	1	1	.	III
Salsola soda	1	.	.	1	1	III
Malabajla graveolens	1	.	1	1	1	IV
Typical species of the association						
Elytrigia repens	3	3	2	3	2	V^{2-3}
Cardaria draba	1	1	.	1	1	IV
Taraxacum erythrospermum	.	1	1	1	.	III
Melilotus neapolitanus	1	1	1	.	1	IV
Differential species of the subassociations						
Phlomis tuberosa	.	.	.	.	.	
Scorzonera cana	.	.	.	.	.	
Alopecurus myosuroides	.	.	.	.	.	
Convolvulus arvensis	.	.	.	.	.	
Linum euxinum	.	.	.	.	.	
Centaurea diffusa	.	.	.	.	.	
Serratula erucifolia	.	.	.	.	.	
Palimbia salsa	.	.	.	.	.	
Ballota nigra	.	.	.	.	.	
Other species						
Poa bulbosa	.	.	.	.	.	
Limonium mejeri	1	2	1	1	1	V^{1-2}
Bromus squarrosus ssp. *japonicus*	.	.	.	.	.	
Eryngium campestre	.	.	.	.	.	
Atriplex calotheca	1	1	1	1	.	IV
Plantago lanceolata	.	.	.	.	.	
Artemisia taurica	.	.	.	.	.	
Vicia tetrasperma	.	.	.	.	.	
Allium albiflorum	.	.	.	.	.	
Erophila verna	.	.	.	.	.	
Alyssum hirsutum	.	.	.	.	.	
Crepis ramosissima	.	.	.	.	.	
Medicago minima	.	.	.	.	.	
Consolida paniculata	.	.	.	.	.	
Falcaria vulgaris	.	.	.	.	.	
Valeriana tuberosa	.	.	.	.	.	
Polygonatum salsugineum	.	.	.	.	.	
Eremopyron orientale	.	.	.	.	.	
Ranunculus oxyspermum	.	.	.	.	.	

Besides, the following species occurred separately: *Verbascum thapsiforme* (7), *Anthemis cotula* (7), *Alyssum turkestanicum* *Carduus uncinatus* (8).

– the mud volcano Djau-Tepé (vill. Vulkanovka); 8 – the Siuyurtash mud volcano; 10 – the Small-Tarkhan volcanic

Nomenclature types: Descr. 4, the mud volcano Djau-Tepé, eastern slope, 08. 06. 85, authors KORZHENEVSKY V. V., Descr. 13, the mud volcano Djau-Tepé, lower part of slope of the Gorge Kriva, 08. 06. 85, authors KORZHENEVSKY V. V.,

alopecuretosum					const. by subassociation	serratuletosum					const. by subassociation	const. by association
12	12	16	12	16		25	16	12	16	16		
75	80	60	75	75		55	60	65	70	55		
32	37	22	20	20		24	21	22	24	26		
6	7	8	9	10		11	12	13	14	15		
.	1	1	.	.	II	.	.	.	.	.	I	II
2	1	2	3	3	V^{1-3}	3	2	1	1	3	V^{1-3}	IV^{1-3}
1	1	1	1	2	V^{1-2}	.	.	.	1	.	I	IV^{1-2}
4	3	4	1	1	V^{1-4}	3	2	2	2	2	V^{2-3}	IV^{1-4}
1	1	.	1	2	IV^{1-2}	.	1	1	.	.	II	III
3	3	3	2	2	V^{2-3}	2	3	3	3	4	V^{2-4}	V^{1-4}
1	1	1	2	2	V^{1-2}	1	2	2	2	3	V^{1-3}	V^{1-3}
1	1	.	1	.	III	1	.	.	1	.	II	III
1	1	1	1	1	V	1	1	1	1	1	V	V
1	1	3	2	1	V^{1-3}	2	1	1	1	1	V^{1-2}	V^{1-3}
1	3	.	1	1	IV^{1-3}	2	1	1	1	1	V^{1-2}	V^{1-3}
1	.	1	1	.	III	1	1	1	1	1	V	IV
1	1	2	1	1	V^{1-2}	1	1	1	1	1	V	V^{1-2}
1	1	1	.	1	IV	.	.	.	.	.		II
1	1	1	1	1	V	.	.	.	.	.		II
1	1	1	1	1	V	.	.	.	.	.		II
1	1	.	1	1	IV	.	.	.	.	.		II
1	.	1	.	.	II	1	2	2	2	1	V^{1-2}	
.	.	.	.	.		1	1	1	1	1	V	II
1	1	.	.	.	II	1	1	1	1	1	V	III
.	.	.	.	.		1	1	1	1	1	V	II
.	2	.	.	.	I	1	1	1	1	1	IV	II
2	1	2	3	3	V^{1-3}	3	2	1	1	3	V^{1-3}	IV^{1-3}
1	1	1	1	1	V	1	1	1	1	1	V	V
1	1	1	1	1	V	1	1	1	1	1	V	IV
.	1	.	.	.	I	1	1	1	1	1	V	III
1	2	.	.	.	II	.	.	1	1	1	III	III
1	1	1	1	1	V	2	2	2	2	1	V^{1-2}	IV^{1-2}
1	.	.	.	.	I	1	1	.	.	1	III	II
.	.	1	1	1	III	1	1	1	1	1	V	III
1	1	.	.	.	II	.	.	.	.	.		I
1	1	.	.	.	II	.	.	.	.	.		I
1	1	.	.	.	II	.	.	.	.	.		I
1	1	.	.	.	II	.	.	.	.	.		I
.	.	.	.	.		.	.	.	1	1	II	I
1	1	.	.	.	II	.	.	.	.	.		I
1	1	.	.	.	II	.	.	.	.	.		I
1	1	.	.	.	II	.	.	.	.	.		I
.	1	.	.	.	I	1	.	.	.	1	II	I
.	.	.	1	2	II	.	.	.	.	.		I
.	.	.	.	.		1	.	.	.	1	II	I

(7), *Senecio vernalis* (7), *Tulipa biebersteinii* (6), *Rhagadiolus stellatus* (8), *Lagoseris sancta* (7), *Cerastium tauricum* (8),

Localization of the descriptions: 1, 2, 9, 12 – the Bulganak volcanic field (vill. Bondarenkovo); 3, 4, 5, 6, 7, 11, 13, 15 field; 12 – the mud volcano Djardjava (town of Kerch).

KLIUKIN A. A.; Descr. 8, the mud volcano Djau-Tepé, western slope, 08. 06. 85, authors KORZHENEVSKY V. V., KLIUKIN A. A.; KLIUKIN A. A.

Table 6
Ferulo-Artemisietum tauricae ass. nov.

Subassociation	typicum					constancy by subassociation and association
Description area, m^2	12	16	16	16	16	
Coverage, %	80	85	95	80	90	
Number of species	32	33	43	28	30	
Description no.	1	2	3	4	5	
Typical species of Festuco-Brometea + Festucetalia						
Poa bulbosa	3	2	2	1	2	V^{1-3}
Stipa capillata	1	2	1	1	1	V^{1-2}
Erophila verna	2	1	2	2	1	V^{1-2}
Ventenata dubia	2	1	1	.	1	IV^{1-2}
Poa angustifolia	1	1	.	1	.	III
Critaria villosa	1	3	.	1	.	III
Eryngium campestre	1	1	1	.	.	III
Bromus mollis	.	1	.	.	.	I
Cruciata pedemontana	.	.	1	.	1	II
Plantago lanceolata	.	.	1	.	.	I
Achillea setacea	1	.	1	.	1	III
Typical species of Artemisio tauricae-Festucion						
Festuca valesiaca	4	3	5	4	4	V^{3-5}
Myosotis ramosissima	1	1	2	1	1	V^{1-2}
Sceleranthus polycarpos	2	2	2	1	1	V^{1-2}
Erodium cicutarium	1	1	1	1	1	V
Linum euxinum	1	1	.	2	1	IV^{1-2}
Trigonella monspeliaca	1	1	1	1	1	V
Colchicum ancerense	.	1	1	1	1	IV
Typical species of the association						
Artemisia taurica	3	3	2	2	3	V^{2-3}
Ferula orientalis	3	2	1	1	3	V^{1-3}
Valeriana tuberosa	1	.	2	1	1	IV^{1-2}
Koeleria cristata	1	1	3	1	1	V^{1-3}
Vicia tetrasperma	1	.	2	1	1	IV^{1-2}
Valerianella costata	1	.	1	.	1	III
Other species						
Agropyron desertorum	.	1	.	3	2	III
Ranunculus pedatus	.	1	.	1	.	II
Veronica arvensis	1	1	.	.	.	II
Limonium mejeri	2	1	1	2	2	V^{1-2}
Cerastium tauricum	1	.	1	.	1	III
Trifolium parviflorum	.	.	2	.	1	II
Scorzonera laciniata	1	2	.	1	2	IV^{1-2}
Lepidium campestre	.	1	1	.	.	II
Veronica verna	.	.	1	1	1	III
Vicia angustifolia	.	.	1	.	1	II
Holosteum umbellatum	1	1	1	1	.	IV
Elytrigia repens	1	1	1	.	.	III
Trifolium scabrum	2	1	.	.	.	II
Trifolium campestre	1	.	1	1	2	IV^{1-2}
Galium tenuissimum	1	2	2	2	1	V^{1-2}
Myosurus minimus	.	1	.	.	1	II
Cardaria draba	.	.	1	1	.	II
Saxifraga tridactylites	.	.	.	1	1	II

P.-A.s. puccinellietosum subass. nov.
Class Festuco-Puccinellietea Soó 68
Order Artemisio-Festucetalia pseudovinae Soó 68
Alliance Festucion pseudovinae Soó 68 em. VICHEREK 73
Ass. Artemisio tauricae-Valerianetum tuberosae ass. nov.
Subass. A.t.-V.t. typicum subass. nov.
Alliance Camphorosmo-Agropyrion desertorii all. nov.
Ass. Thero-Eremopyretum ass. nov.
Subass. T.-E. typicum subass. nov.
T.-E. feruletosum subass. nov.
Ass. Meliloti-Elytrigietum repensii ass. nov.
Subass. M.-E.r. typicum subass. nov.
M.-E.r. alopecuretosum subass. nov.
M.-E.r. serratuletosum subass. nov.

Class Festuco-Brometea BR.-BL. et TX. 43
Order Festucetalia valesiacae BR.-BL. et TX. 43
Alliance Artemisio tauricae-Festucion all. nov.
Ass. Ferulo-Artemisietum tauricae ass. nov.
Subass. F.-A.t. typicum subass. nov.

The established syntaxa of the mud-volcanic formations of the Kerch peninsula are substantiated ecologically, conjugated with relief elements and kept within the scheme of succession connections which completes this paper.

Age of surface			
Young	Lepidietum crassifoliae typicum	Petrosimonio-Artemisietum santonicae atriplicetosum	Petrosimonio-Artemisietum santonicae puccinellietosum
	Lepidietum crassifoliae petrosimonietosum	Thero-Eremopyretum typicum	
		Thero-Eremopyretum feruletosum	
	Artemisio tauricae-Valerianetum tuberosae	Meliloti-Elytrigietum repensii	Meliloti-Elytrigietum repensii
Old	Ferulo-Artemisietum tauricae	Ferulo-Artemisietum tauricae	Ferulo-Artemisietum tauricae
Type of the mudvolcanic formation	Bulganak	Djau-Tepé	Siuyurtash

◀

Besides, the following species occurred separately: *Hordeum geniculatum* (1), *Polygonum salsugineum* (1), *Vicia lathyroides* (1), *Muscarimia muscari* (1), *Trifolium arvense* (2), *Medicago romanica* (2), *Potentilla recta* (2), *Tulipa biflora* (2), *Lagoseris sancta* (3), *Lamium amplexicaule* (3), *Lathyrus nissolia* (3), *Taraxacum erythrospermum* (3), *Anthemis cotula* (3), *Bromopsis cappadocica* (3), *Thaeniatherum asperum* (3), *Kohlrauschia prolifera* (3), *Carduus uncinatus* (3), *Falcaria vulgaris* (3), *Camphorosma monspeliaca* (5), *Sedum caespitosum* (5), *Halimione verrucifera* (5), *Vicia hirsuta* (5), *Erysimum repandum* (5).

Localization of the descriptions: 1, 2 – environs of the Bulganak volcanic field (vill. Bondarenkovo); 3 – environs of the Small-Tarkhan volcanic field; 4, 5 – environs of the Large Tarkhan Field.

Nomenclature type: Descr. 2, slopes of the Bulganak hollow (vill. Bondarenkovo), 01. 06. 87, author KORZHENEVSKY V. V.

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Manuscript received: March, 26th, 1990.