Botanica Pacifica. A journal of plant science and conservation. 2026. 15(1): 183–189
DOI: 10.17581/bp.2025.15114

VEGETATION CLASSIFICATION

Unique plant communities of ancient weathering crusts of the Southern Urals steppe zone (Russia)

Yaroslav M. Golovanov*, Sergey M. Yamalov, Maria V. Lebedeva & Larisa M. Abramova

Yaroslav M. Golovanov *
e-mail: ymalovsm@mail.ru

Sergey M. Yamalov
e-mail: jaro1986@mail.ru

Maria V. Lebedeva
e-mail: lebedevamv@mail.ru

Larisa M. Abramova
e-mail: abramova57lm@yandex.ru

South-Ural Botanical Garden-Institute of the Ufa Federal Scientific Center RAS, Ufa, Russia

* corresponding author

Manuscript received: 01.07.2025
Review completed: 10.03.2026
Accepted for publication: 03.04.2026
Published online: 07.04.2026

ABSTRACT

The article presents the research data on the vegetation of specific habitats in the Southern Urals – ancient variegated weathering crusts located in the south-eastern regions of the Orenburg Region and the adjacent territories of the Republic of Bashkortostan. Being specific geological and morphological formations, they determine the growth of a rare and in many aspects unique complex of halophytic, petrophytic-steppe and steppe plant species. Within the alliance Artemisio pauciflorae–Camphorosmion monspeliacae Karpov 2001, the order Artemisietalia pauciflorae Golub et Karpov in Golub et al. 2005 and the class Festuco–Puccinellietea Soó ex Vicherek 1973, the association Psathyrostacho juncei–Anabasietum cretaceae **ass. nov.** was described for the first time. The association is typical for clayey, saline upland or slope habitats with a high proportion of rubble. The article highlights a high conservation significance of the association communities as the cenoses featuring a large number of rare and protected plant species, which make up 24 % of the total coenoflora composition. Some types of communities are located on the eastern edge of their range. It is probable that such specific habitats are northern analogues of hamadas, rubble, rocky deserts of North Africa and Central Asia.

Keywords: ancient weathering crusts, vegetation, Southern Urals, class Festuco–Puccinellietea

РЕЗЮМЕ

Голованов Я.М., Ямалов С.М., Лебедева М.В., Абрамова Л.М. Уникальные растительные сообщества древних кор выветривания степной зоны Южного Урала (Россия). Приведены результаты исследований растительности специфических местообитаний Южного Урала – древних пестроцветных кор выветривания, расположенных в юго-восточных районах Оренбургской области и прилегающих территорий Республики Башкортостан. Являясь специфическими геолого-морфологическими образованиями, они обуславливают произрастание редкого и во многом уникального комплекса галофитных, петрофитно-степных и степных видов растений. В рамках союза Artemisio pauciflorae–Camphorosmion monspeliacae Karpov 2001, порядка Artemisietalia pauciflorae Golub et Karpov in Golub et al. 2005, класса Festuco–Puccinellietea Soó ex Vicherek 1973 впервые для науки была описана Psathyrostacho juncei–Anabasietum cretaceae **ass. nov.** Ассоциация характерна для глинистых, засоленных плакорных либо склоновых местообитаний с высокой долей щебня. Отмечена высокая природоохранная значимость сообществ ассоциации, как ценозов с участием большого числа редких и нуждающихся в охране видов растений, которые составляют 24 % от общего состава ценофлоры. Некоторые виды сообществ находятся на восточном краю своего ареала. Вероятно, подобные специфические местообитания являются северными аналогами гаммады – щебнистых, каменистых пустынь Северной Африки и Средней Азии.

Ключевые слова: коры выветривания, растительность, Южный Урал, класс Festuco–Puccinellietea

The vegetation cover of the steppe zone in the Southern Urals and adjacent territories exhibits considerable heterogeneity, attributed both to the region's climatic features and to the diversity of edaphic conditions across habitats. The complex geological structure of the Bashkir and, in particular, the Orenburg Trans-Urals is reflected in the variety of soil-forming materials. Alongside Quaternary yellow-brown clays and clay loams, as well as proluvial, lacustrine-alluvial, and eluvial deposits, diverse ancient weathering crusts of igneous and metamorphic rocks are widespread. These often serve as the parent material for solonetz-type soils. Most researchers agree that favorable conditions for the formation of weathering crusts occurred from the mid-Triassic to the late Oligocene inclusive. The specific age of weathering crusts in individual regions is associated with the tectonic differentiation of large structural forms, the formation of depressions, and the burial of certain areas under discrete strata (Gutsaki & Gudoshnikov 1969, Prutkov 1999).

Ancient weathering crusts are heterogeneous in mechanical composition and are characterized by wide variation in physical properties. Most are described as loose and porous,

with low volumetric swell and better water permeability compared to other soil-forming rocks. They also differ significantly from other parent materials in the Trans-Urals in their superior water adsorption capacity. A typical soil type in these areas is low-sodium and residual-sodium steppe solonetzes (Prutkov 1999).

Characterized by specific geochemical properties (e.g., salinization, high content of rubble), such habitats serve as refuges for unique plant communities comprising halophytic, steppe, and petrophytic-steppe species. Despite the relatively thorough study of herbaceous vegetation in the southern steppe zone of the Southern Urals (Karpov & Yuritsyna 2006, Golovanov et al. 2021, Korolyuk et al. 2022), the distinctive vegetation of weathering crusts remains unexplored. The lack of data on these habitats is primarily due to their rarity in the Trans-Urals region within the zone of bunchgrass–feathergrass steppes, their small spatial extent, and their location in sparsely populated and hard-to-reach areas bordering the Republic of Kazakhstan.

This paper presents research data on the diversity of plant communities on weathering crusts at six locations in the Republic of Bashkortostan and Orenburg Region.

MATERIAL AND METHODS

Study area

According to the physical-geographical zoning (Russkin et al. 1993), the main localities of ancient weathering crusts are situated within the Trans-Ural (Ural-Tobolsk) High Plain and the Turgay Elevated Province. The predominant soils are southern chernozems; dark chestnut solonetzic soils are widespread in the south and east. The soil cover is thin and solonetzic. Solonetzes are common. Annual precipitation ranges from 300 to 340 mm, decreasing to 260–280 mm in the easternmost areas. The day degree temperatures are approximately 2500–2700°C. The surface runoff rate declines eastward from 1.5 l/s to 0.5 l/s per 1 km² (Chibilev et al. 2009). The study area is part of the Trans-Volga–Kazakhstan steppe province in the Black Sea–Kazakhstan steppe region.

The studies were carried out in 2021–2023 in the Southern Urals (the Republic of Bashkortostan and Orenburg Region). In this work, we used 25 complete relevés of new communities in the region.

The abundance of species was assessed using the Braun-Blanquet scale (Mirkin & Naumova 1998). Classification followed the Braun-Blanquet method (Braun-Blanquet 1964, Westhoff & Maarel 1978). For synoptic tables, a scale of persistence in percent was applied. The TURBOVEG (Hennekens 1995) and JUICE 7.1 (Tichý 2002) software packages were used for storage and initial processing of the relevés. The description and naming of new associations followed the International Code of Phytosociological Nomenclature, 4th edition (Theurillat et al. 2021).

The names of higher syntaxa are given according to Mucina et al. (2016). Diagnostic combinations of classes are provided in accordance with the aforementioned source, as well as with the regional prodromus (Yamalov et al. 2012).

To compare the floristic composition of the communities on ancient weathering crusts with adjacent vegetation types, a data set was compiled using literature references and materials from the South Ural non-forest vegetation database (GIVD id 00-RU-006) (Yamalov et al. 2012). For 47 relevés of individual syntaxa, a hierarchical cluster analysis using Ward's linkage method (Ward 1963) was performed, with the Bray-Curtis index (Bray & Curtis 1957) as a measure of similarity. The total sample size comprised 350 relevés.

The conservation significance of plant communities is characterized according to the assessment criteria proposed by the Ufa geobotanical school (Martynenko et al. 2015).

RESULTS

We determined the syntaxonomic affiliation of the studied communities based on the results of a hierarchical cluster analysis of relevés of the vegetation on ancient weathering crusts and summary descriptions of adjacent vegetation types in the southern Orenburg Region (Fig. 1). The sample includes data on the vegetation of saline and desertified habitats, Cretaceous outcrops, and zonal variants of steppes.

As a result of the analysis, the bulk of the collected data presented in the diagram was clearly divided into two groups. The first group (clusters A, B) encompasses the most mesophilic coenoses, representing intracontinental dry meadow, steppe, and semi-desert communities on saline and solonetz soils of the class Festuco–Puccinellietea (alliances Plantagini salsae–Artemision santonici Lysenko et Mucina in Lysenko et al. 2011 and Festuco valesiacae–Limonion gmelinii Mirkin in Golub et V. Solomakha 1988).

The second group (clusters C, D, E, F, G, H) is formed by more xerophilic communities belonging to different classes of steppe zone vegetation. The communities of weathering crusts described by us (cluster D) also belong to this group and converge at the lower branching levels with the coenoses of the alliance Artemisio pauciflorae–Camphorosmion monspeliacae Karpov 2001, class Festuco–Puccinellietea. The floristic similarity of the communities with the desertified steppe coenoses of the order Agropyretalia desertorum Korolyuk et Laktionov 2021, class Artemisietea lerchianae, is also reflected in the cluster analysis diagram. Based on the analysis results, which indicate the independence of the weathering crust communities, we distinguish a separate association Psathyrostacho juncei–Anabasietum cretaceae **ass. nov.** within the alliance Artemisio pauciflorae–Camphorosmion monspeliacae, order Artemisietalia pauciflorae Golub et Karpov in Golub et al. 2005, class Festuco–Puccinellietea. A detailed description of the association is presented below.

Ass. Psathyrostacho juncei–Anabasietum cretaceae (Table 1, Fig. 2)

Holotypus: Table. 1, relevé 11: Russian Federation, Orenburg Region, Yasnensky District: 7 km N settl. Akzharskoye (51.16908ºN 59.40267ºE), 2021.06.06., author – Ya.M. Golovanov.

Diagnostic species: *Anabasis cretacea*, *Psathyrostachys juncea*, *Silene fruticulosa*.

Composition and structure: The coenoflora is dominated by the halophytic species of the alliance Artemisio pauciflorae–Camphorosmion monspeliacae and the class Festuco–Puccinellietea (*Artemisia nitrosa*, *Atriplex*

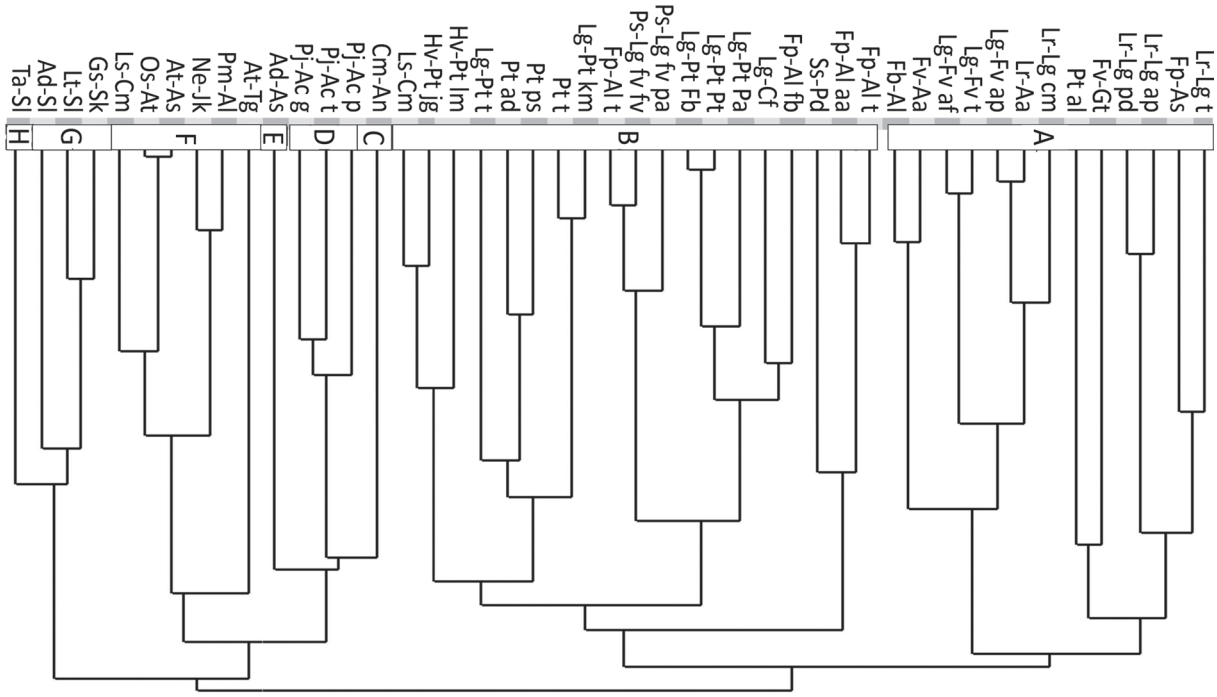

Figure 1 Cluster analysis of adjacent community types in the south of the steppe zone of the Southern Urals (Ward's method, Euclidean distance). Vegetation classes: **A**, **B**, **C**, **D** – class Festuco–Puccinellietea Soó ex Vicherek 1973 (Karpov & Yuritczina 2008); **E** – class Artemisietea lerchianae Golub 1994 (Golovanov et al. 2020); **G**, **F** – class Anabasietea cretaceae Golovanov in Golovanov et al. 2021 + class Festuco–Brometea Br.-Bl. et Tx. ex Soó 1947 (Golovanov et al., 2021); **H** – class Festuco–Brometea (Korolyuk, 2017, phytocoenoteca of the Southern Urals). Associations and variants. **Hv-Pt** – Halimiono verruciferae–Puccinellietum tenuissimae (Karpov et Mirkin 1985) Karpov et Yuritsyna 2006 (**lm**, **jg** – subassociations); **Fb-Al** – Festuco beckeri–Artemisietum lerchianae Karpov, Lysenko, Golub 2006; **Fp-Al** – Festuco pratensis–Artemisietum lerchianae Karpov et al. 2003 ex Yuritsyna et Karpov 2006 (**aa**, **fb**, **t** – subassociations); **Fp-As** – Festuco pseudovinae–Artemisietum santonicae Karpov et al. 2003 ex Yuritsyna et Karpov 2006; **Lr-Lg** – Leymo ramosi–Limonietum gmelinii Karpov et al. 2003 ex Yuritsyna et Karpov 2006 (**t**, **ap**, **pd**, **cm** – subassociations); **Lg-Cf** – Limonio gmelinii–Caraganetum fruticosae Karpov et Mirkin 1985; **Lg-Fv** – Limonio gmelinii–Festucetum valesiacae Karpov et al. 2003 ex Yuritsyna et Karpov 2006 (**t**, **af**, **ap** – subassociations); **Lg-Gt** – Festuco valesiacae–Galatelletum tataricae Karpov, Lysenko, Yuritsyna 2006; **Lr-Aa** – Karpov, Lysenko, Golub 2006; **Lg-Pt** – Limonio gmelinii–Puccinellietum tenuissimae Karpov et Mirkin 1985 (**pa**, **pt**, **fb**, **km**, **t** – subassociations); **Ls-Cm** – Limonio suffruticosi–Camphorosmetum monspeliacae Karpov et Mirkin 1985; **Ps-Lg** – Plantagini salsae–Limonietum gmelinii Karpov 1985 (**t**, **fv pa**, **fv fv** – subassociations, variants); **Pt** – Puccinellietum tenuissimae Karpov et Mirkin 1985 (**al**, **t**, **ps**, **ad** – subassociations); **Ss-Pd** – Stemmacantho serratuloidis–Puccinellietum dolicholepidis Karpov et al. 2003 ex Yuritsyna et Karpov 2006; **Cm-An** – Camphorosmo monspeliacae–Artemisietum nitrosae Lysenko et al. 2013; **Pj-Ac** – Psathyrostacho juncei–Anabasietum cretaceae (**p**, **t**, **g** – variants); **Ad-Al** – Agropyro desertori–Artemisietum lessingianae Golovanov et al. 2021; **Pm-Al** – Psephello marschallianae–Artemisietum lerchianae Golovanov et al., 2021; **Ne-Jk** – Nanophytono erinacei–Jurinetum kirghisori Golovanov et al., 2021; **Os-At** – Onosmo simplicissimae–Anthemietum trotzkianae Golovanov et al., 2021; **At-As** – Anthemido trotzkianae–Artemisietum salsoloidis Golovanov et al. 2021; **At-Tg** – Anthemido trotzkianae–Thymetum guberlinensis Golovanov et al., 2021; **Gs-Sk** – Galatello subglabrae–Stipetum korshinskyi Toman 1969; **Ad-Sl** – Astragalo stenoceratis–Stipetum lessingianae Korolyuk 2007; **Lt-Sl** – Lynosyrido tataricae–Stipetum lessingianae Toman 1969; **Ta-Sl** – Tanaceto achilleifolii–Stipetum lessingianae Lysenko et Kalmykova in Mucina et al. 2016.

cana, *Bassia prostrata*, *Camphorosma monspeliaca*, *Frankenia hirsuta*, *Limonium gmelinii*). A distinctive feature of these communities is the presence of the petrophytic-steppe species of the class Festuco–Brometea (*Astragalus tenuifolius*, *Lomelosia isetensis*, *Seseli ledebourii*), as well as the species of other vegetation classes associated with rock outcrops (*Anthemis trotzkiana*, *Artemisia salsoloides*, *Gypsophila rupestris*, *Matthiola superba*), especially in heavily detrital slope habitats. On more flattened slopes, cenoses feature the species of solonetzic steppes of the order Tanaceto achilleifolii–Stipetalia lessingianae (*Galatella tatarica*, *Stipa lessingiana*, *S. sareptana*, *Tanacetum achilleifolium*).

The grass layer is 5–20 cm in height. The communities of the association are mostly sparse. The cover varies from 10 to 80 % within the area of 25–100 m^2. The number of species per site varies from 7 to 26 (14 on average).

Ecology. The communities of the association are distributed over rubble, saline habitats, often occupying the sides of small hills of various exposures with a slope of 1 to 15 degrees. The rubble content varies from 5 to 95 %.

Distribution. Mainly within the eastern regions of the Orenburg Region. Locally, they occur in the south-eastern regions of Bashkortostan in the areas where the relief exposes ancient weathering crusts (Fig. 4). Similar cenoses can probably be observed in Kazakhstan, as well.

The diversity of communities within the association is expressed in three variants: typica, Plantago salsa, Galatella tatarica.

Variant typica (Table 1, col. 12–17)
The communities of the variant are characterized by the predominance of *Anabasis cretacea* in the grass stand. They occupy flattened habitats. The grass layer is 5–10 cm high. The communities of the association are sparse, the cover varies from 20 to 30 % within the area of 10–100 m^2. The number of species on the site varies from 7 to 12 (9 on average).

Variant Plantago salsa (Table 1, col. 1–10)
Diagnostic species of the variant: *Anthemis trotzkiana*, *Asparagus inderiensis*, *Echinops ruthenicus*, *Lomelosia isetensis*, *Matthio-*

Table 1. Characterizing table of association Psathyrostacho juncei–Anabasietum cretaceae

Relevé area, m²	25	100	100	64	100	64	25	100	100	25		25	100	100	64	25	64	10		100	100	100	100	100	100	100	100					
Total cover, %	10	15	20	15	15	20	20	15	25	20		20	30	30	20	20	30	20		50	30	50	30	35	60	50	80					
Average height herbs, sm	10	5	10	8	5	10	10	5	10	15		5	5	10	5	5	7	5		15	5	20	15	10	10	20	25					
Cover bare rock, %	90	70	80	90	80	95	95	80	90	90		60	60	90	15	15	10	15		15	5	20	15	10	10	20	25					
Aspect	NE	N	NE	SW	N	W	W	SW	-	SE		-	-	-	-	-	-	-		SE	S	NW	-	-	-	W	S					
Slope	5	5	5	1	3	2	2	2	-	2		-	-	-	-	-	-	-		15	5	10	-	-	-	10	5					
Number of species	15	15	19	16	19	12	10	17	12	15		8	7	9	10	10	11	12		26	16	19	12	11	13	20	21					
Ordinal number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		**11***	**12**	**13**	**14**	**15**	**16**	**17**		**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**					
Diagnostic species of the ass. Psathyrostacho juncei–Anabasietum cretaceae																																
Anabasis cretacea **Ac**	1	1	2	1	+	1	1	1	2	1	100	2	2	2	2	3	3	2	100	+	+	2	1	1	+	2	+	100					
Psathyrostachys juncea	+	r	+	r	r	r	+	r	+	+	100	r	r	+	r	·	+	+	86	r	·	2	r	r	+	+	+	88					
Silene fruticulosa	·	+	r	+	r	·	·	r	+	·	90	+	·	2	·	·	·	·	29	·	·	·	1	·	·	1	2	38					
Diagnostic species of the var. Plantago salsa																																
Plantago salsa **F-P**	+	+	r	+	r	+	1	+	+	1	100	·	·	·	·	·	·	+	14	r	·	·	r	·	·	·	·	25					
Lomelosia isetensis **F-B**	1	+	2	1	+	1	1	r	·	·	80	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	r	25					
Matthiola superba	+	r	+	·	+	+	+	r	·	·	70	·	·	1	·	·	·	·	14	·	·	·	·	·	·	·	·	·					
Saussurea turgaiensis	+	·	·	r	1	+	r	+	·	+	70	·	·	·	·	·	·	·	·	r	·	·	·	·	·	·	·	13					
Seseli glabratum **Ac**	+	r	r	+	+	·	+	+	·	·	70	·	·	+	·	·	·	·	14	·	·	r	·	·	·	·	·	13					
Seseli eriocephalum	+	r	+	·	·	+	·	r	·	1	60	·	·	·	·	·	·	·	·	·	r	·	·	·	·	·	·	13					
Thymus kirgisorum **F-B**	·	+	+	r	r	·	·	r	·	·	50	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·					
Anthemis trotzkiana **Ac**	+	+	+	+	r	·	·	·	·	·	50	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·					
Nanophyton erinaceum **Kf**	+	r	r	·	r	·	r	·	·	·	50	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·					
Asparagus inderiensis	·	·	·	·	r	+	·	r	r	+	50	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·						
Echinops ruthenicus **F-B**	·	·	·	·	r	r	·	r	·	r	40	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·						
Diagnostic species of the var. Galatella tatarica																																
Galatella tatarica **F-B (T-S)**	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	r	r	r	r	+	+	+	100					
Echinops ritro subsp. *meyeri* **Ac**	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	r	+	r	r	·	·	r	75					
Tanacetum achilleifolium **F-B (T-S)**	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	+	r	·	+	+	63					
Takhtajaniantha austriaca **F-B**	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+	·	·	r	·	+	r	63					
Stipa lessingiana **F-B (T-S)**	·	·	·	·	·	·	·	r	·	·	10	·	·	·	·	·	·	·	·	r	·	+	+	r	·	·	·	50					
Stipa sareptana **F-B (T-S)**	·	·	·	·	·	·	·	·	r	·	10	·	·	·	·	·	·	·	·	+	+	r	·	·	·	r	·	50					
Artemisia lessingiana	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	14	·	·	+	1	+	·	+	·	50					
A. lerchiana **Al**	·	·	·	·	·	·	·	·	+	·	10	·	·	·	·	·	·	·	·	r	·	·	·	·	1	r	1	50					
Seseli ledebourii **F-B**	·	·	·	r	·	·	·	·	·	·	10	·	·	·	·	·	·	·	·	+	+	·	r	·	·	·	r	50					
Koeleria pyramidata **F-B**	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	14	·	·	r	+	·	·	+	+	50					
Gypsophila rupestris	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	·	·	·	·	·	1	2	38					
Allium delicatulum	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	·	14	r	r	·	·	·	r	·	·	38					
Diagnostic species of the ord. Artemisietalia pauciflorae and the all. Artemisio pauciflorae–Camphorosmion monspeliacae																																
Limonium suffruticosum	+	·	r	+	r	+	+	r	+	+	90	r	·	·	1	2	+	·	57	·	·	·	·	1	·	·	·	13					
Camphorosma monspeliaca	·	·	·	·	·	·	·	·	+	+	20	r	+	1	r	+	+	1	100	r	+	+	1	2	2	+	·	88					
Atriplex cana	+	+	r	·	·	·	·	+	+	+	60	1	2	+	·	·	·	·	43	·	·	·	·	·	+	·	+	25					
Bassia prostrata	+	·	·	·	·	·	·	·	·	·	10	·	·	1	1	1	+	·	57	+	+	+	·	·	+	·	·	50					
Diagnostic species of the class Festuco–Puccinellietea																																
Artemisia nitrosa	·	·	r	+	r	·	+	+	·	+	60	+	1	·	·	1	+	+	71	1	+	·	·	·	·	·	·	25					
Limonium gmelinii	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	r	·	r	43	·	·	+	·	·	·	·	·	13					
Frankenia hirsuta	+	·	r	·	·	·	·	·	·	+	30	·	r	·	·	·	·	·	14	·	·	·	·	·	·	·	·	·					
Puccinellia distans	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	1	·	29	·	·	·	·	·	·	·	+	13					
Diagnostic species of the ord. Agropyretalia desertorum of the class Artemisietea lerchianae																																
Agropyron desertorum	·	·	r	r	r	·	·	·	·	·	30	·	·	·	·	·	·	·	·	+	r	+	·	·	+	+	+	75					
Diagnostic species of the class Kalidietea foliati Mirkin et al. ex Rukhlenko 2012																																
Atriplex verrucifera	·	·	·	·	·	·	·	·	·	+	10	·	·	·	r	r	r	r	57	·	·	·	·	·	·	·	r	13					
Diagnostic species of the class Anabasietea cretaceae																																
Artemisia salsoloides	+	+	r	+	+	+	·	+	·	+	80	·	·	·	·	·	·	·	·	3	2	·	·	·	·	·	·	25					
Diagnostic species of the class Festuco–Brometea (including petrophytic variants)																																
Astragalus tenuifolius	·	·	·	+	·	1	·	·	+	+	40	·	·	·	·	·	·	·	·	r	+	r	·	·	·	·	·	38					
Festuca valesiaca s.l.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	·	+	29	·	·	r	·	·	+	·	r	38					
Orostachys spinosa	·	·	r	·	r	·	·	·	·	·	20	·	·	·	·	·	·	·	·	r	·	·	·	·	r	·	·	25					
Other species																																
Allium saxatile	·	·	·	r	·	·	·	·	·	·	10	·	·	·	·	·	·	+	14	·	·	·	·	·	·	+	·	13					
Poa bulbosa s.l.	·	·	·	·	·	·	·	·	·	·	·	r	·	·	r	·	·	·	29	·	·	·	·	·	·	2	+	25					

Note. Species with low constancy: *Allium flavescens* 25 (+); *Anabasis salsa* 9 (r); *Artemisia austriaca* 17 (+), 24 (r); *A. commutata* 17 (r); *Atraphaxis frutescens* 20 (+); *Atriplex patens* 16 (r); *Grubovia sedoides* 14 (r), 15 (+); *Chorispora tenella* 16 (r); *Ephedra distachya* 20 (+), 23 (+); *Eremogone koriniana* 18 (r), 19 (r); *Eremopyrum triticeum* 14 (r); *Ferula tatarica* 24 (+); *Galatella villosa* 22 (r); *Helichrysum arenarium* 18 (r), 25 (+); *Koeleria sclerophylla* 2 (r), 3 (r); *Lepidium coronopifolium* 23 (+), 24 (+); *Nitraria sibirica* 18 (r); *Odontarrhena tortuosa* 2 (r); *Onosma simplicissima* 18 (r); *Polygala wolfgangiana* 5 (r); *Puccinellia tenuissima* 11 (r), 12 (+); *Serratula cardunculus* 20 (+); *Spiraea hypericifolia* 18 (r); *Stipa korshinskyi* 18 (+), 19 (+); *Trinia muricata* 24 (r), 25 (+).

Localization of relevés: **Orenburg Oblast**. *Yasnensky district*: 7 km N settl. Akzharskoye, 2021.06.06. 1 – 51.16443ºN 59.40435ºE, 2 – 51.16319ºN 59.40880ºE, 3 – 51.16442ºN 59.40429ºE, 4 – 51.16373ºN 59.41001ºE, 5 – 51.16330ºN 59.40958ºE, 6 – 51.163120ºN 59.40879ºE, 7 – 51.16312ºN 59.40879ºE, 8 – 51.16127ºN 59.40873ºE, 9 – 51.16127ºN 59.40873ºE, 11 – 51.16908ºN 59.40267ºE. *Adamovsky district*: 10 km SE settl. Komsomolskoye. 2023.06.10. 10 – 51.43240ºN 60.73240ºE, 18 – 51.48763ºN 60.702720ºE, 19 – 51.48714ºN 60.70290ºE, 23 – 51.43720ºN 60.73297ºE, 24 – 51.48714ºN 60.69911ºE, 25 – 51.487147ºN 60.699113ºE. *Dombarovsky district*: 14 km SW settl. Karaganda, 2021.06.04. 12, 13 – 50.59018ºN 59.68302ºE, 17 – 50.59355ºN 58.68121ºE. *Novoorsky district*: 8 km NNE settl. Karaganka, 2023.06.09. 14 – 51.44196ºN 59.45634ºE, 20 – 51.44458ºN 59.45615ºE, 21 – 51.44778ºN 59.45481ºE, 22 – 51.44883ºN 59.45615ºE. **Republic of Bashkortostan**. *Khaibullinsky district*: 2023.06.08. 15 – 51.86987ºN 58.38940ºE, 16 – 51.87211ºN 58.39236ºE.

Autors of relevés: 1, 4, 6, 7, 11, 17 – Golovanov Ya.M.; 2, 3, 5, 8, 9, 12-15 – Yamalov S.M.; 10, 16, 18 -25 – Lebedeva M.V.

F-P – Festuco–Puccinellietea, F-B – Festuco–Brometea, F-B (T-S) – Tanaceto achilleifolii–Stipetalia lessingianae, Ac – Anabasietea cretaceae, Kf – Kalidietea foliati, Al – Artemisietea lerchianae.

* – Nomenclature type of association **Psathyrostacho juncei–Anabasietum cretaceae ass. nov.**

Figure 2 Appearance of new association Psathyrostacho juncei–Anabasietum cretaceae

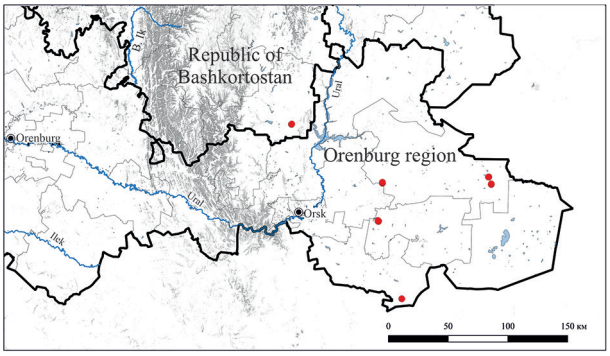

Figure 3 Localities of the association Psathyrostacho juncei–Anabasietum cretaceae (red dots)

Table 2. Rare component of floristic composition of the association Psathyrostacho juncei–Anabasietum cretaceae

Species	Rarity and category		
	Geltman (2024)	Belov (2019)	Martynenko (2021)
Anthemis trotzkiana	3 (VU, III)	1	·
Anabasis cretacea	·	3	1 (CR, I)
Artemisia salsoloides	·	1	3 (LC, III)
Gypsophila rupestris	·	3	1 (CR, I)
Helichrysum arenarium	·	3	3 (NT, III)
Koeleria sclerophylla	·	1	5 (LC, III)
Allium flavescens	·	·	2 (VU, II)
Silene fruticulosa	·	·	1 (CR, I)
Stipa korshinskyi	·	·	3 (LC, III)
S. lessingiana	·	·	3 (LC, III)
S. sareptana	·	·	3 (NT, III)
Anabasis salsa	·	3	·
Matthiola superba	·	3	·
Nanophyton erinaceum	·	3	·
Saussurea turgaiensis	·	3	·
Seseli eriocephalum	·	3	·

Rarity status: 0 – probably extinct species; 1 – endangered species; 2 – species declining in number and/or distribution; 3 – rare species, taxa with naturally low frequency, occurring in geographically confined areas; 5 – restoring and recovering species.

The category of extinction status that characterizes their condition in the natural habitat: CR – Critically Endangered; VU – Vulnerable; NT – Near Threatened; LC – Least Concern.

Category of degree and priority of the environmental protection measures, taken and planned: priority I – immediate adoption of comprehensive measures is required, including the development and implementation of a conservation strategy and/or a program for the restoration (reintroduction) of plants and fungi; priority II – it is necessary to implement one or more special measures to preserve plants and fungi; priority III – general measures provided by regulatory legal acts are sufficient.

la superba, *Nanophyton erinaceum*, *Plantago salsa*, *Saussurea turgaiensis*, *Seseli eriocephalum*, *S. glabratum*, *Thymus kirgisorum*. Cenoses of the variant are typical for gentle hillock slopes of various exposures with highly rubble soils. This promotes the growth of petrophytic-steppe species together with typical halophytes.

Variant Galatella tatarica (Table 1, col. 18–25)

Diagnostic species of the variant: *Artemisia lerchiana*, *A. lessingiana*, *Allium delicatulum*, *Echinops ritro* subsp. *meyeri*, *Galatella tatarica*, *Gypsophila rupestris*, *Koeleria pyramidata*, *Stipa lessingiana*, *S. sareptana*, *Seseli ledebourii*, *Takhtajaniantha austriaca*, *Tanacetum achilleifolium*. Cenoses of the variant are typical mainly for flattened habitats, less common for gentle hillock slopes, the soils are less detrital. This promotes the growth of species characteristic of dry solonetzic steppes of the order Tanaceto achilleifolii–Stipetalia lessingianae, as well as of the order Agropyretalia desertorum, the class Artemisietea lerchianae. In this case, the share of petrophytes decreases.

The cenoses of the association Psathyrostacho juncei–Anabasietum cretaceae are characterized by high conservation significance. The composition of the association communities features 16 rare and endangered plant species enlisted in regional and federal Red Books (Table 2). The species from the Red Book of the Orenburg Region (Belov 2019) are characterized by the greatest representation – 11 species in total, 3 species of which – *Anthemis trotzkiana*, *Artemisia salsoloides* and *Koeleria sclerophylla* possess the rarity status 1. At the same time, 10 species were identified as enlisted in the Red Book of the Republic of Bashkortostan (Martynenko 2021), 3 of which – *Anabasis cretacea*, *Gypsophila rupestris*, *Silene fruticulosa* possess the rarity status 1. Thus, the locations of *Anabasis cretacea* in the Republic of Bashkortostan are associated exclusively with the cenoses of the association under study. *Gypsophila rupestris* and *Silene fruticulosa* are rare and are located at the northern boundary of the range. Considering the ranges of the mentioned rare plant species, it should be emphasized that *Anabasis cretacea*, *Anthemis trotzkiana*, the species mainly confined to the cretaceous outcrops, and *Artemisia salsoloides*, a species of a wider range of rocky habitats, in places of ancient weathering crust outcrops, are located at the easternmost boundary of their range both in the Southern Urals and, for *Anthemis trotzkiana* and *Artemisia salsoloides*, in the Russian Federation on the whole. Other rare species also demonstrate confinement to similar habitats: *Saussurea turgaiensis* and *Seseli eriocephalum*.

According to the system of conservation significance criteria (Martynenko et al. 2015), provided for the Southern Urals, the communities of the association Psathyrostacho juncei–Anabasietum cretaceae got the following scores: floristic significance (F = 9), phytosociological value (B = 9), distribution (S = 8), naturalness (N = 4), area reduction (D = 2), recoverability (N = 3), protection category (C = 35) – the highest, protection provision (P = 2). The obtained results show that the studied weathering crust communities of the association Psathyrostacho juncei–Anabasietum cretaceae have high conservation significance both in the territory of individual entities in the region and for the Southern Urals as a whole. This fact once again emphasizes the uniqueness of the communities under consideration.

CONCLUSIONS

Being specific geological and morphological formations, ancient variegated weathering crusts provide for the growth of a rare and in many aspects unique complex of halophytic, petrophytic-steppe and steppe plant species. Within the alliance Artemisio pauciflorae–Camphorosmion monspeliacae, the order Artemisietalia pauciflorae and the class Festuco–Puccinellietea, the association Psathyrostachyo juncei–Anabasietum cretaceae was described for the first time in science. The association is typical of clayey, saline upland or slope habitats with a high proportion of rubble. The uniqueness of the association's coenoflora is manifested in the combination of species from three groups of arid-zone vegetation: steppe and semi-desert communities on saline and solonetz soils of the class Festuco–Puccinellietea, steppe species of zonal dry steppes of the class Festuco–Brometea, and species of desertified steppes of the class Artemisietea lerchianae. Within the association, three variants – typica, Plantago salsa and Galatella tatarica – differing in the edaphic conditions of specific habitats, are distinguished. The range of the association covers mostly the eastern regions of Orenburg Region, with its northern border penetrating into the southeast of the Republic of Bashkortostan. The high conservation significance of weathering crust communities, as coenoses comprising a large number of rare and protected plant species (24 % of the total coenoflora of the association), is emphasized. Some species of the communities are located at the eastern edge of their range. Probably, such specific habitats represent northern analogues of hamadas, rubble, and rocky deserts of North Africa and Central Asia.

ACKNOWLEDGEMENTS

This work was carried out on the topic "Biodiversity of plant resources of Russia: status, dynamics, ecology of species and communities, gene pool conservation, problems of introduction, reproduction and sustainable use" within the framework of a State assignment of the South Ural Branch, Ufa Federal Research Center, Russian Academy of Sciences, project no № FMRS-2025-0018.

LITERATURE CITED

Belov, V.S. (ed.) 2019. *The Red Book of the Orenburg Region: Rare and endangered species of animals, plants and fungi. 2nd ed.* Mir, Voronezh, 488 pp. (in Russian). [Красная книга Оренбургской области: Редкие и находящиеся под угрозой исчезновения виды животных, растений и грибов. 2-е изд. / отв. ред. В.С. Белов. Воронеж: Мир. 488 с.].

Braun-Blanquet, J. 1964. *Pflanzensociologie. Grundzuge der Vegetationskunde. 3 Aufl.* Springer Verlag, Wien, New York, 865 pp.

Bray, J.R. & J.T. Curtis 1957. An ordination of the upland forest of the Southern Wisconsin. *Ecological Monographs* 27(4):325–349.

Chibilev, A.A., V.M. Pavleichik & A.A. Chibilev 2009. *Natural heritage of the Orenburg Region: Specially protected natural areas*. Dimur Publ., UrO RAS, Orenburg, 328 pp. (in Russian). [Чибилев А.А., Павлейчик В.М., Чибилев А.А. Природное наследие Оренбургской области: особо охраняемые природные территории. Оренбург: УрО РАН, Печатный дом «Димур», 328 с.].

Geltman, D.V. (ed.) 2024. *The Red Book of the Russian Federation. Plants and fungi. 2-nd official edition*. VNII Ecologiya, Moscow, 944 pp. (in Russian). [Красная книга Российской Федерации. Растения и грибы. 2-е официальное издание / отв. ред. Д.В. Гельтман. Москва: ВНИИ «Экология». 944 с.].

Golovanov, Ya.M., S.M. Yamalov & M.V. Lebedeva 2020. Some extrazonal desert communities in the vegetation cover of the Orenburg region and adjacent territories of the Republic of Kazakhstan. *Vestnik Orenburgskogo gosudarstvennogo pedagogicheskogo universiteta. Elektronnyi nauchnyi zhurnal* 4(36):124–133 (in Russian). [Голованов Я.М., Ямалов С.М., Лебедева М.В. 2020. Некоторые экстразональные сообщества пустынь в растительном покрове Оренбургской области и прилегающих территорий республики Казахстан // Вестник Оренбургского государственного педагогического университета. Электронный научный журнал. № 4(36). С. 124–133].

Golovanov, Ya.M., S.M. Yamalov, M.V. Lebedeva & A.Yu. Korolyuk 2021. Vegetation of chalk outcrops of Sub-Ural Plateau and adjacent territories. *Rastitel'nost' Rossii* 40:3–42 (in Russian). [Голованов Я.М., Ямалов С.М., Лебедева М.В., Королюк А.Ю., Абрамова Л.М., Дулепова Н.А. 2021. Растительность меловых обнажений Подуральского плато и сопредельных территорий // Растительность России. № 40. С. 3–42].

Gutsaki, V.A. & V.V. Gudoshnikov 1969. History of formation and mineralogical composition of weathering crusts of the Orsk Urals and Trans-Urals region. In: *Weathering crusts of the Urals and Trans-Ural region* (A.P. Sigov, ed.), pp. 45–61, Izdatel'stvo Saratovskogo universiteta, Saratov. (in Russian). [Гуцаки В.А., Гудошников В.В. 1969. История формирования и минералогический состав кор выветривания Орского Урала и Зауралья // Коры выветривания Урала и Зауралья / под ред. А.П. Сигова. Саратов: Изд-во Саратовского университета. С. 45–61].

Karpov, D.N. & N.A. Yuritsyna 2006. *Vegetation of saline soils of the Southern Urals and adjacent territories*. Institute of Ecology of the Volga Basin RAS, Togliatti, 124 pp. (in Russian). [Карпов Д.Н., Юрицына Н.А. 2006. Растительность засоленных почв Южного Урала и сопредельных территорий. Тольятти: ИЭВБ РАН. 124 с.].

Korolyuk, A.Yu. 2017. Steppes of Northern Kazakhstan – syntaxonomical revision. *Rastitel'nost' Rossii* 30:61–77 (in Russian). [Королюк А.Ю. 2017. Степи Северного Казахстана – синтаксономическая ревизия // Растительность России. № 30. С. 61–77].

Korolyuk, A.Yu., S.M. Yamalov, M.V. Lebedeva, Ya.M. Golovanov, N.A. Dulepova & N.V. Zolotareva 2022. Syntaxonomy of xeropetrophytic vegetation of Southern Urals: alliance Elytrigion pruiniferae all. nov. *Rastitel'nost' Rossii* 43:88–115 (in Russian). [Королюк А.Ю., Ямалов С.М., Лебедева М.В., Голованов Я.М., Дулепова Н.А., Золотарева Н.В. 2022. Синтаксономия ксеропетрофитной растительности Южного Урала: союз Elytrigion pruiniferae all. nov. // Растительность России. № 43. С. 88–115].

Martynenko, V.B. (ed.) 2021. *The Red Book of the Republic of Bashkortostan. Vol. 1: Plants and fungi. 3rd ed.* Studio Online, Moscow, 392 pp. (In Russian). [Красная книга Республики Башкортостан. Том. 1: Растения и грибы. 3-е изд. / под ред. В.Б. Мартыненко. Москва: Студия онлайн. 392 с.].

Martynenko, V.B., B.M. Mirkin, E.Z. Baisheva, A.A. Muldashev, L.G. Naumova, P.S. Shirokikh & S.M. Yamalov

2015. Green books: concepts, experience, prospects. *Uspekhi sovremennoi biologii* 135(1):40–51 (in Russian). [Мартыненко В.Б., Миркин Б.М., Баишева Э.З., Муллдашев А.А., Наумова Л.Г., Широких П.С., Ямалов С.М. 2015. Зеленые книги: концепции, опыт, перспективы // Успехи современной биологии. Т. 135, № 1. С. 40–51].

Mirkin, B.M. & L.G. Naumova 1998. *Vegetation science (history and present state of the basic concepts)*. Gilem, Ufa, 413 pp. (in Russian). [Миркин Б.М., Наумова Л.Г. 1998. Наука о растительности (история и современное состояние основных концепций). Уфа: Гилем. 413 с.].

Mucina, L., H. Bültmann, K. Dierßen, J.P. Theurillat, J. Dengler, A. Carni, K. Šumberová, T. Raus, R. Di Pietro, ... & L. Tichý 2016. Vegetation of Europe: hierarchical floristic classification system of plant, bryophyte, lichen, and algal communities. *Applied Vegetation Science* 19 (Suppl. 1):3–264.

Prutkov, A.M. 1999. Physical and water-physical properties of chernozem solonts of steppe Orenburg Trans-Urals on ancient weathering crusts. *Voprosy stepevedeniya* 1:44–47 (in Russian). [Прутков А.М. 1999. Физические и водно-физические свойства черноземных солонцов степных Оренбургского Зауралья на древних корах выветривания // Вопросы степеведения. № 1. С. 44–47].

Russkin, G.A. et al. (eds) 1993. *Atlas of the Orenburg Region*. Roskartografiya, Moscow, 40 pp. (in Russian). [Атлас Оренбургской области / под ред. Г.А. Русскина и др. Москва: Роскартография. 40 с.].

Theurillat, J-P., W. Willner, F. Fernández-González, H. Bültmann, A. Čarni, D. Gigante, L. Mucina & H. Weber 2021. International Code of Phytosociological Nomenclature. 4th edition. *Applied Vegetation Science* 24:12491.

Tichý, L. 2002. JUICE, software for vegetation classification. *Journal of Vegetation Science* 13(3):451–453.

Ward, J.H. 1963. Hierarchical grouping to optimize an objective function. *Journal of the American Statistical Association* 58(301):236–244.

Yamalov, S.M., V.B. Martynenko, L.M. Abramova, V.B. Golub, E.Z. Baisheva & A.V. Bayanov. 2012. *Prodromus of plant communities of the Republic of Bashkortostan*. Gilem, Ufa, 100 pp. (in Russian). [Ямалов С.М., Мартыненко В.Б., Абрамова Л.М., Голуб В.Б., Баишева Э.З., Баянов А.В. 2012. Продромус растительных сообществ Республики Башкортостан. Уфа: Гилем. 100 с.].

Yamalov, S., A. Muldashev, A. Bayanov, T. Jirnova, A. Solomesch 2012. Database Meadows and Steppes of South Ural. *Biodiversity and Ecology* 4:291.