Classification of dry land and ocean landscapes

E A Pozachenyuk¹*

¹ V. I. Vernadsky Crimean Federal University, Simferopol, 4 Ac. Vernadsky av., the Russian Federation

*pozachenyuk@gmail.com

Abstract. The paper presents the elaborated unified classification of the landscapes of different spheres: dry land (terrigene), oceanic, river, lake (aquatic); subterranean and mud flow, and also natural and anthropogenic. The landscape is viewed as a three-dimensional geosystem at all the taxonomic levels. At the level of the division the three-dimensionality is manifested by the formation of the landscape levels of the continents and oceans. The paper distinguishes the landscape levels of the dry land (hydromorphic, foothills, middle mountain, and highland) as well as of the ocean landscape (shelf, mainland slope, ocean bed, oceanic trenches). The following taxa are the basis for the classification: the landscape sphere – the environment contacts (atmo-, litho-, hydrosphere); order – the prevailing system generating component: liquid or solid; divisions – landscape levels of the continents and oceans; section – the differences at the level of landscape (geographic) zones; family – the degree of the illumination; class – morphostructural megarelief; subclass – morphostructural macrorelief; type – zonal differences; genus – morphology and the relief genesis (genetical landscape type); subgenus – lithology of the surface deposits; kind – the similarity of the prevailing countries. Each taxon considers the degree of the anthropogenic landscape transformation.

1. Introduction

The science differs from other types of human activities, first of all, by the systematization and formalization of the knowledge about the reality. The landscape has become the integrating conception of the XXI century by right [1]. At the same time many regulations in the Landscape Science remain poorly systematized and formalized. Partially this is explained by the complexity of the geosystems, which are studied by the Landscape Science.

Landscape Science as a separate science gave rise in the end of XIX – the beginning of XX centuries due to the works of Z. Passarg, V.V. Dokuchaev, L.S. Berg. The term itself “landscape science” (landschaftkunde) was introduced by O. Opel (in 1884) and I. Wimmer (in 1885). Marine landscape science came into existence half a century later [2]. But the ideas of marine landscapes emerge and were realized a bit earlier due to the works of S. A. Zernov and K. M. Deryugin (1913), L. S. Berg (1925), N. A, Solntsev (1948), S. P. Khromov (1949), B. B. Polynov (1952), S. V. Kalesnik (1955), F. N. Mil’kov (1967, 1970), D. L. Armand (1975) et al.

Originally sea landscapes and the science about them were considered to be a constituent of the classical Landscape Science. The idea of the landscapes of the dry land and sea being analogous was laid as the foundation in the works of S.P. Khromov [3], who asserted that the landscape of the sea was quite similar to the landscape of the dry land according to its unity and interaction of its constituent elements, as well as in the works of F. N. Mil’kov [4, 5], V. I. Lymarev [2] et al. Further,
the Sea Landscape Science singled out into an independent science, and nowadays it develops independently of the classical Landscape Science.

In Landscape Science more often the classifications of the dry land landscapes and the sea landscape are elaborated separately. The works of F. N. Mil’kov [4, 5], V.A. Nikolaev [6], A.G. Isachenko [7, 8] et al. are dedicated to the classification of the dry land landscapes.

The issues of the sea landscapes typification are considered in the works of V.I. Lymarev (1978), K.M. Petrova (1989), V.A. Alekseeva (1990), B.V. Preobrazhensky (2000), A.A. Pasynkov (2012), L.A. Pasynkova (2008) et al.

One of the first attempts of the unified typification of the landscapes were the works of F.N. Mil’kov [4, 5], V.A. Nikolaev [6]. But these works mostly presented the classification of the dry land landscapes, the sea landscapes were presented only at the level of divisions or classes. In the regional aspect, the unified classification for the ground and underwater landscapes of Shkot Island (Peter the Great Gulf) was elaborated [9].

The unanimity of the theoretical and methodological approaches to the study of the landscapes of the dry land and oceans is necessary when organizing the nature management of the dry land as well as of the sea; it is especially indispensable for the research of the coastal zones. At the same time more and more parts of the dry land and sea landscapes are transformed by the people, and the anthropogenic landscapes are being formed; it is sensible to include them into the unified landscapes’ classification.

Modern adaptive [10] or co-adaptive [11] paradigm of nature management consists in such a territory organization, at which the region would function as an integral stable system in which an economic subsystem harmonizes with the natural one according to the principle of the natural landscape components’ compatibility [11]; and also is based on this unity, on the one hand, and on the other hand, it includes a human into the landscape’s components.

That is why the task of elaborating the integrated landscapes’ classification of the landscape sphere, including the landscapes of the dry land, oceans, rivers, lakes, mud flows and subterranean landscapes is topical. The classification has to reflect the natural and anthropogenic landscapes.

2. Problem statement
The objective of the research is the elaboration of a unified classification of landscapes of the landscape sphere: dry land, oceanic, subterranean, river, lake, mud flow, and also natural and anthropogenic.

The novelty of the research consists in the fact that the landscape classification is based on the understanding of the landscape sphere’s integrity; and the dry land and oceanic landscapes, natural and anthropogenic are considered as one system. For the first time the classification of the landscapes of the landscape sphere which unites all the landscapes (dry land, oceanic, subterranean, river, lake, mud flow, natural and anthropogenic) is elaborated.

3. Methodology and methods
At present it is difficult not to acknowledge the unity and integrity of the landscape sphere the doctrine of which was worked out by F.N. Mil’kov [4]. The integrity of the landscape sphere first of all is manifested by the fact that the processes, combining the elements of the landscape sphere, are going on in the strict subordination to the general nature’s laws. The main regularities, according to which the landscape sphere develops, are aimed at preserving its unity and integrity; maintenance of the balances: geophysical, geochemical, dynamic, ecological, etc.; preservation of the landscape and biological diversity; maintenance of the atmospheric air’ stable composition and preservation of the habitat of all the living, etc.

In agreement with the understanding of the landscape sphere integrity it is logical to ascertain that it is necessary to single out all the landscapes of the dry land in ocean in the unified system. At the same time on the dry land there are other water landscapes: of rivers, lakes; mud flow’s landscapes which were formed in the conditions of the river flow and consisting of the mixture of water, rock fragments
and other inclusions. Also subterranean landscapes of karstic vesicles exist (N.A. Gvozdetsky [12] and G.A. Amelichev [13, 14] et al.). It is still not known to which taxonomic rank ice landscapes should belong, as ice landscapes are in all the geographical zones both on the dry land and in the ocean. The existing classifications do not include anthropogenic landscapes despite the fact that separate classifications of anthropogenic landscapes have been elaborated [5] et al.

The landscape is a three-dimensional geosystem: it has the length, the width and the height. It is reasonable to consider this property when making the classification.

The methodological basis of the work is the regularities of the systematic approach about the integrity, systemacy and unity of the landscape sphere, its role in the maintenance of the balances of the landscape sphere and the geographical cover; regulations on the general interconnection of the landscapes in the landscape sphere, its functions, aimed at maintaining the stability and biosystem homeostasis, maintenance and preservation of the conditions for the vital functions of the living substance, etc.

The general methodological basis for the research was system-synergetic, landscape, geological approaches with the application of the research methods’ complex, including general philosophical: analysis, synthesis, induction, deduction, analogy, axiomatization, formalization, and abstracting; general and specific scientific methods: cartographical, historical, ecological, comparative.

4. Main part

To work out the unified classification of the landscapes of the landscape sphere it is reasonable to show that the landscapes of the dry land and sea are analogous as they consist of the same components, but having different system-generating functions. The difference is that in the landscapes of the World Ocean the system-generating role of the components is redistributed in comparison with the dry land landscapes: the hydrosphere conditionally functions as the atmosphere; the atmosphere substance is present in the form of gases, dissolved in the sea water; the living substance has specific marine forms; the “liquid soil” is formed – the solution of the humus acids’ complex (see Table 1).

Table 1. The components of the dry land and ocean landscapes.

| Landscape subsystems | Blocks of components | Landscape components of the dry land | Landscape components of the ocean |
|----------------------|----------------------|-------------------------------------|----------------------------------|
| Natural              | abiotic              | mountain rock                       | mountain rock                    |
|                      | landscape gases      |                                     | landscape gases                  |
|                      | water solutions      |                                     | water solutions                  |
|                      | bioinert             | soil                                | “liquid soil” – the solution of   |
|                      |                      |                                     | humic acids complex              |
|                      | biotic               | ecosystems (flora and fauna)        | ecosystems (flora and fauna)     |
| Economic             | anthropogenic        | population and technical substance  | technical substance              |

Undoubtedly, some landscapes both of the dry land and ocean do not have soils; differ in their ecosystems, including anaerobic conditions (which exist not only in the marine environment, but on the surface, too); they also differ in the composition of the landscape gases, which unlike the constant composition of the atmospheric air, vary in such wide ranges that the ideas of landscape sphere discontinuity and non-identity of the dry land and sea landscapes arise. In this regard the propositions of G.E. Grishankov [15] about complete and incomplete landscape complexes not only explain the existence of the landscapes in which all the components were not able to form, but also confirm the possibility of the integrated approach to the study of the landscapes of the dry land and sea. A.A. Pasynkov [16], classifying the underwater landscapes of the Sea of Azov and the Black Sea basin, took the propositions of G.E. Grishankov [15] about complete and incomplete landscape
complexes as the basis for singling out the taxa, having mentioned that the idea of sea landscapes typification of F.N. Mil’kov [4] is not suitable for the Black Sea and the Sea of Azov.

The main thing uniting the landscapes of the dry land and ocean is the interconnection and interdependence of the geosystem components, this leads to the formation of integral geosystems, i.e. landscapes. It is important that in all the landscapes there is a living substance including the anaerobic conditions.

According to F.N. Mil’kov [4], the divisions of the landscapes are marked out by the criterion – the combination of the environments (lithosphere + hydrosphere + atmosphere). But, as it is seen in Figure 1, the same combination is not sustained when singling out the divisions. If the division is an integrated taxonomic level, the criterion for its singling out has also to be integrated. The integrated criterion is not also followed when singling out the classes. The shelf is divided into two classes, but the shelf as an integrated system is not marked out, while the mainland slope, ocean bed and trenches are singled out as integrated systems.

Figure 1. The fragment of the typological classification of the sea landscapes according to Mil’kov F. N. [4].

The author of the paper offers the typological classification of the landscapes of the dry land and oceans, which has the following distinctive features:
1. It is based on the integrity of the landscape sphere.
2. In the unified classification it unites all the landscapes of the landscape sphere:
   a. dry land;
   b. oceanic;
   c. subterranean;
   d. river;
   e. lake;
   f. mud flow;
   g. natural and anthropogenic.
3. It considers the landscapes as three-dimensional geosystems.
4. It is based on the integrity of the classification – lower taxonomic units are united with the higher ones.
5. Ice landscapes are not singled out into a special division (unlike F.N. Mil’kov did), but are considered as one of the landscape’s state.

The criteria of taxonomic units’ classification are presented in Table 2.
Table 2. The criteria and examples of the typological classification of the landscape of the landscape sphere.

| Taxon | The basis for division (criterion) | Examples of the oceanic landscapes | Examples of the dry land landscapes |
|-------|-----------------------------------|------------------------------------|------------------------------------|
| Order | System-forming component: liquid or solid | Oceanic | Territorial |
| Landscape levels of the continents and oceans | Shelf, mainland slope, ocean bed, deep water trenches | Hydromorphic, placor, foothills, middle mountainous, highland |
| Differences at the level of landscape (geographical) zones | Arctic, Antarctic, subarctic, subantarctic, moderate (northern and southern), subtropical (northern and southern), tropical, subequatorial (northern and southern), equatorial. |
| Degree of illumination | Euphotic (Epipelagic), bathyal (pelagian), abyssal (abyssal), hadal zone. | Amphibian: Surface-littoral, river, lake, mud flow |
| Morphostructura1 megarelief | Oceanic plateau; middle mountain ridges; abyssal plains, abyssal trenches | Plain, mountainous |
| Morphostructura1 macrolief | Plane abyssal plains, abyssal plains, trenches, troughs, island arches | Low-lying, elevated, high plains. Low, middle, high and highest mountains |
| Zonal differences | Forest, forest-steppe, steppe, semidesert, desert of the moderate latitudes |
| Morphology and relief genesis (genetic landscape type) | Sloping erosive-accumulative plain, buried paleodeltas, steeply inclined armored structural-denudation sloping surface of Lomonosov underwater massif | Accumulative non-drained lowlands; seaside pebbles terraces; abrasive-denudation rib plains, structural-denudation watershed plateau |
| Lithology of the surface depositions | Clayey slits, volcanic slits, sandy, detritus, shell rock | Loamy, sandy, crushed rock, stony |
| Similarity of dominating countries | Sloping erosion-accumulative plain of the continent’s sloop on the buried paleodelta depositions | Structural denudation-accumulative gently sloping plateau with stippa – sheep fescue steppes on the middle loamy black earth. |

We will scrutinize in details the division singling out – landscapes’ levels of continents and oceans, grounded by E. G. Grishankov [17]. Landscape levels are planetary geomorphologic formations, relatively homogeneous in the character of the relief [17]. G.E. Grishankov singles out the following landscape levels for the landscapes of the dry land: hydromorphic, placor, foothills, middle mountains.
and highlands. As for the ocean, for the first time the attempt of singling out landscape levels is made: shelf, mainland slope, ocean bed, oceanic trenches (see Table 3).

**Table 3. The landscape levels of the World Ocean.**

| Landscape levels of the World Ocean | Depth | Geological and geomorphologic characteristics | Illumination | Ecological criterion (living substance) |
|------------------------------------|-------|-----------------------------------------------|--------------|----------------------------------------|
| Shelf                              | 100-200 m, sometimes 500-1,500 | Evened area of the underwater edge of the mainland (coastal platform) | Euphotic zone (illumination) | Epipelagic |
| Mainland slope                     | 200 – 3,000 | Transitional sloping area of the underwater edge of the mainland, located between the shelf and the foot of the mainland, being contiguous with the ocean bed | Bathyal zone (twilight) | Pelagian |
| Ocean bed                          | 3,000 – 6,000 | Planetary morphostructure, corresponding to the oceanic platforms with the typical oceanic Earth crust and calm tectonic regime | Abyssal zone | Abyssal |
| Ocean trench                       | 6,000-11,022 (10.994) | A deep and long hollow on the bottom of the ocean, being formed by the extrusion of the Earth crust under another oceanic or continental crust | Abyssal zone | Hadal zone |

Typological classification of the landscapes of the dry land and ocean is presented in Figure 2.
Figure 2. The typological classification of the landscapes of the dry land and ocean.
5. Conclusions
1. The similarity of the components of the dry land and oceanic landscapes according to the interaction between their constituting components is determined.

2. The landscapes of different landscape spheres are presented in the unified typological classification: dry land, oceanic, subterranean, river, lake, mud flow, and also natural and anthropogenic.

3. The ice landscapes are not singled out into a special taxon, but are considered as one of the landscape state.

4. The landscape is viewed as a three-dimensional geosystem at all the taxonomic levels. At the level of the division the three-dimensionality is manifested by the formation of the landscape levels of the continents and oceans. The ocean landscape levels are distinguished: shelf, mainland slope, ocean bed, oceanic trenches.

5. The following taxa are the basis for the classification: the landscape sphere – the environment contacts (atmo-, litho-, hydrosphere); order – the prevailing system generating component: liquid or solid; divisions – landscape levels of the continents and oceans; section – the differences at the level of landscape (geographic) zones; family – the degree of the illumination; class – morphostructural megarelief; subclass – morphostructural macrorelief; type – zonal differences; genus – morphology and the relief genesis (genetical landscape type); subgenus – lithology of the surface deposits; kind – the similarity of the prevailing countries. Each taxon considers the degree of the anthropogenic landscape transformation.

6. Each taxon takes into consideration the degree of anthropogenic transformation of the landscape.

7. The classification unity – lower taxonomic units are united with higher ones.

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