





Geotourism as a Basis for Conserving Soils of Beligerative Complexes

Roman Malyk¹^a, Andriy Kyrylchuk¹^b, Ihor Kasiyanyk²^c and Petro Boltaniuk³^d

¹Ivan Franko National University of Lviv, 79000, University str. 1, Lviv, Ukraine

²Ivan Ogienko National University of Kamianets-Podilskyi, 32301, Ogienko str. 61, Kamianets-Podilskyi, Ukraine

³Kamianets-Podilskyi State Historical Museum-Reserve, Ukraine


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Abstract: In this article geotourism is considered as a basis for use and conservation of soils of beligerative landscape complexes. The viability of geotouristic use of such soils has been proven through the disclosure of the format and forms of its development. Effective types of formats and forms of geotouristic use of the studied soils are determined. Field and laboratory on-line master classes of interaction with the soil have been developed and experimentally implemented in practice. The integration of soil information into geotours has been done to increase its adaptability, nonlinearity and interactivity. To assess the effectiveness of the geotour, statistical calculations and anonymous questionnaires were conducted. The results of the introduction of the soil component to the geotour were used in the development and implementation of the grant project given by the Ukrainian Cultural Foundation. Geotourism use of soils of beligerative landscapes is an effective means of its conservation with economic development at the same time. In geotour the soil of the beligerative complex plays the role of the primary link of natural-anthropogenic interaction and is a clear demonstration of its historical result. Studies of buried soils of beligerative complexes allow to recreate paleogeographic conditions, reconstruct paleolandscapes, draw conclusions about the climate of the past and on this basis to predict future climate change.


1 INTRODUCTION


Topicality. Nowadays geotourism is one of the effective tools that provides theoretical and practical justification for the effective use of lithological, hydrological and biogenic components of the beligerative landscape. Soils, as its object, are considered indirectly as a background component due to the difficulty of their popular demonstration. At the same time, as a geotourism resource, they have a special scientific and educational potential because they reflect the relationship and interaction of inanimate (geological basis) and living nature (biosphere). The "memory" of the soil contains information about the events of both natural change and the people's cultural impact in the past (Targulyan, 1978). Soil serves as a sensitive indicator

of changes in the landscape in which it develops, operates and evolves. Its features and properties reflect the history of development and evolution of the nature of a particular area (Pozniak, 2008). The study of soils, in particular beligerative complexes, is promising, as the appearance of specific structures is usually clearly dated, so it is possible to objectively establish the time frame of object under study creation. At the same time, it gives grounds to characterize the conditions and factors that emerged during the formation and operation of these structures and contributed to the conservation of soil horizons that existed at that time. Given these features, information about the soils during the implementation of the geotour "History of Kamyanskyi rocks" significantly strengthens it. At the same time, it can be the basis for the development, implementation and

^a <https://orcid.org/0000-0001-7132-3817>

^b <https://orcid.org/0000-0002-3700-3331>

^c <https://orcid.org/0000-0003-2612-7969>

^d <https://orcid.org/0000-0002-3751-6532>

application of a highly specialized geotourism product focused directly on learning soil component of the beligerative landscape.

The purpose of the study is to demonstrate the viability of geotourism use of soils of beligerative landscapes as an effective means of conserving them simultaneously with economic development (with Kamyanets-Podilskyi State Historical Reserve Museum as an example).

To achieve this goal, it is necessary to solve the following tasks: to find an effective format and forms of geotourism use of soils of the beligerative complex and information about their parameters; to optimize the format of the organization of the reference geotour "History of Kamyanets rocks" by integrating information about the soils of the beligerative complex within the route; to develop and experimentally implement on the basis of its own soil research a geotourism product - geotour, where the soils of the beligerative landscape complex of Kamyanets-Podilskyi State Historical Reserve Museum are the main cognitive object; to substantiate the prospects of geotourism use of soils from the standpoint of economic development and conservation.

The object of research is geotourism as a universal form of soil conservation of the beligerative landscape complex of Kamyanets-Podilskyi State Historical Reserve Museum

The subject of research is the soil component of the beligerative landscape as a cognitive component of geotour interactivity.

To study the viability of geotourism use of soils of the beligerative landscape of Kamyanets-Podilskyi State Historical Reserve Museum as an effective means of their conservation and economic development, the following scientific methods were used: cartographic (route planning), system (development of geotour as an adaptive multicomponent multifunctional system), statistical (calculation of the results of the introduction of new formats and forms of geotour).

2 RECENT RESEARCH AND PUBLICATIONS ANALYSIS

Analysis of recent publications shows that the issue of soil popularization in tourism as a geocomponent of beligerative landscapes and natural landscapes in general is insufficiently studied and requires the use of new non-standard research methods and forms of implementation. Geotourism as a basis for the

conservation of such soils in scientific publications is not considered at all.

The aspect of popularization of uniqueness and protection of soils of beligerative complexes is considered in the works of S. P. Pozniak (2008), J.M. Matviyishyna and Y.M. Dmytruk. In particular, the monograph "Soils of Trajan's Wall: ecological and genetic analysis" by Y. M. Dmytruk, J. M. Matviyishyna, I. I. Slyusarchuk is devoted to Holocene soils of beligerative complexes of ancient shafts and mounds, where its ecological and genetic features are studied in detail (Dmytruk, Matviyishyna 2008). Studies of the conditions for the effective development of geotourism are covered in the works of V. P. Grytsenko (Grytsenko, 2016; Grytsenko, 2018). Features of the functioning of geoparks are considered in the works of Y. V. Zinko, A. B. Bogutskyi (Bogutsky, 2018). Problems of application of specialized information about geocomponents of landscapes in the organization of geotours are considered in detail in the publication "Geological information on tourist natural sites, its significance and interpretation for a wide range of tourists" by N.O. Fedoronchuk. Regional conditions for the organization of geotours within the Podilskyi region and the territory of the "Podilskyi Tovtry" National Park were covered in the works of G. V. Chernyuk, Y. Y. Vitvitsky. (Vitivitsky, 2020). Problems of problems of geotourism potential are considered by Turkish scientists (Bahadır & Veşik, 2021). Soil micromorphology as a tool for the reconstruction of paleoclimatic indicators is considered in the scientific publications of Longhi, Trombino, Guglielmin. (Longhi et al., 2021).

3 RESEARCH MATERIALS

The city of Kamyanets-Podilskyi has a unique soil cover, geological structures, flora and fauna. The beligerative complex of the Kamyanets-Podilskyi Fortress in combination with the Smotrych canyon forms the landscape of the city. These components are of limited use to ensure tourist attractiveness, although they have significant aesthetic, cognitive and resource potential and can be involved in practical applications. Accordingly, supplementing the tourist image of the city with a natural component is necessary.

Geotourism is a universal form of economic use of natural resources without their direct consumption, which provides the possibility of multiple use of the resource with its economic conversion and the necessary preservation of the original features

(Bahadır & VeIşik, 2021). A striking example of effective geotour is the "History of Kamyanets rocks", the route of which has been operating since 2019 and is a reference for our study area. Its main object is the nature of the lithological components of the Smotrych river valley, the soil component is considered indirectly as a background component.

Experimental inclusion of soils of a beligerative complex within a route as similar or even alternative object of a geotour was not carried out earlier. This inclusion is appropriate because the soil component of the beligerative landscape is extremely representative due to the configuration of the route at different hypsometric levels, and within different landscape taxons of beligerative structures. The soil of the beligerative complex plays the role of the primary link of natural-anthropogenic interaction in geotour and is a clear demonstration of its historical result. Learning the soil will make geotour more adaptive and nonlinear, diversify the forms of on-line interaction of consumers with nature and ensure the conservation of the soil as a natural resource of the beligerative landscape.

Beligerative landscape complex within the geotour route "History of Kamyanets rocks", according to G. I. Denysyk, is a long-term self-regulating military-fortification beligerative landscape complex of sloping type, located over the canyon of the Smotrych river valley. The total area is about 4.5 hectares (Denysyk, 2017). Information parameters about the soils of the beligerative complex of the Kamyanets-Podilskyi State Historical Reserve Museum, which were used to introduce the soil component to the geotour, are based on the results of our own soil and ecological research, which began in 2019 and are still ongoing. We have laid down 4 key areas within the beligerative structures, which differ in functional purpose and period of formation. When choosing the location of the sections, the following were used: plan-scheme of the territory of the reserve museum "Kamyanets-Podilskyi State Historical Reserve Museum" (scale 1:1000); large-scale topographic map (scale 1:10000); materials on geomorphology, geological and tectonic structure, hydrogeology and historical and local lore archival materials of the reserve museum. The system of indices proposed by academician O. N. Sokolovskiy with additions proposed by S. P. Poznyak and A. A. Kyrylchuk in combination with the classification developed by M. M. Stroganova was used to denote genetic horizons (Stroganova, 1992). The color of

genetic horizons was determined by the Mansell scale (Mansell, 1994).

Soils within the research area and the route of the reference geotour are represented by natural and anthropogenic soils - urborendzins and construct soils. Studies show that they have specific morphological, micromorphological and physicochemical characteristics and are unique natural and anthropogenic formations. Horizons that have many exclusively individual features (color, structure, density, presence of artifacts, etc.), depending on the reasons, conditions and time of their formation, are buried in the profile of these soils due to anthropogenic influence. A specific feature of the morphology of the studied soils is the presence of urban horizons (U) with a significant number of anthropogenic artifacts that fall into natural genetic horizons as well because of anthropogenic impact. Quilting of soils with floors, foundations, or floors of fortifications is quite common. Sometimes there are layers that consist entirely of building material.

Significant vertical and horizontal variability of morphological elements of the soil is characteristic of construct soils. Urban soils are characterized by the presence in the profile of buried, mostly humus [H] horizons of natural anthropogenic origin, buried fragments of zonal soil types and buried soils of the Black Forest and Trypillia culture. Artifacts (from Latin *Ars*, art, *facere*, to make), represented by fragments of bricks, ceramics, glass, processed stones, coal, etc., are an important visual information resource for geotour and provide an opportunity to form consumer's ideas about evolution, history and ways of using the territory. The most representative in terms of the morphology of construct soils is the anthropogenic outcrop wall with buried soils and urban horizons, located in the northeastern part of the Kamyanets-Podilskyi State Historical Reserve Museum at a distance of 10 meters east of the casemate crossing from the Rozhanka tower to the Vigilant tower. Geograph The surface is turfed. Vegetation within the outcrop is meadow-steppe, represented by dominants: *amaranthuscaudatus*, *phleumpratense*, *dáctylisglomeráta*; subdominants: *amaranthusretro flexus*, *malvasylvestris*, *bgerteroaicana*, *stellariamedia*, *hyoscýamusníge*; petrophyte *auriniasaxatilis*; *rudiralom artemisiavulgaris*.ic coordinates are 48° 40' 26.13" of northern latitude and 26° 33' 45.62" of eastern longitude (Fig. 2).

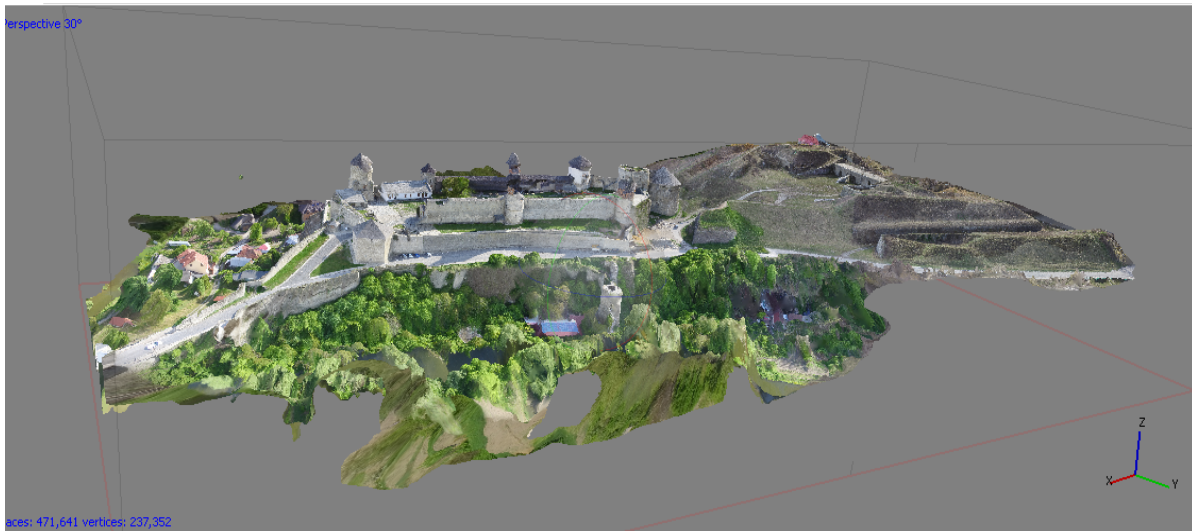


Figure 1: 3D model of the Kamyanets-Podilskiy State Historical Reserve Museum beligerative landscape complex (designed by the authors).

The outcrop consists of 19 natural and anthropogenic horizons and bulk layers with a thickness of 770cm without underlying rock.



Figure 2: Visual demonstration of soil morphology with an example of anthropogenic outcrop wall with buried soils and urban horizons within the key point of the route.

In general, it includes: modern soil - construct soil of 0-115cm; buried sod soil of 115-220cm; buried construct soil of 220-345cm; fragment of buried zonal

soil type of 345-385cm; fragment of buried zonal soil of 420-455cm; a fragment of the buried soil of the Black Forest culture of 525-590cm; buried soil of Trypillia culture of 590-710cm respectively.

Accordingly, the abovementioned unique features of this outcrop make it an ideal means of demonstrating the relationship between geological and social history of their interaction and complementarity.

The soil is a mirror in which all the conditions and factors of the functioning of the landscape are reflected. Climate information is recorded in the soil, both directly through morphological features (structure, color, particle size and mineralogical composition) of buried horizons, and indirectly through cultural and organic inclusions. Such soil outcrops are unique records of weather conditions of the past. Their research at different levels of soil mass organization allows to reproduce paleogeographic conditions, reconstruct paleolandscapes, draw conclusions about the climate of the past and predict future climate change in the study area.

The lithological structure as the leading object of geotour includes rich fossils of the upper Silurian (S2) in the Malynovets series as part of the Koniv horizon (Holoskiv and Shutniv subhorizons) and Zvykliv horizon (Sokilskyi subhorizon). There is a good outcrop and easy access near the Kamyanets fortress.

Soil as an object of geotour does not work without the correct format and forms of learning. Therefore, we have a problem of their development and implementation in the experimental modification of the reference geotour, the result of which is the next geotour.

The tour is focused on explaining the processes of formation of Smotrytch canyon from the formation of sediments in which it is laid, to the development of modern landscapes. Basic cognitive principles on which the explanation of complex phenomena and processes is based are as follows – interpretation, analogy and on-line learning. For its implementation it is convenient to use actual visual information about the soil cover or its mechanical (physico-chemical) features in form of a master class.

Fossils in the structure of the Silurian sediments are the most powerful cognitive tool and the leading object of geotour. They are available for inspection directly in the outcrops at the locations within the route, and due to erosion processes can be accumulated in the debris.

Fossil groups are clearly grouped by lithological formations: Goloskiv subhorizon - eurypterids, Shutnivetskyi subhorizon - corals, stromatopores, crinoids, mosses; Sokilskyi subhorizon - brachiopods, trilobites, gastropods, orthoceratids. Such a grouping is due to the peculiarities of sedimentation from the depth of the reservoir where the formation was formed. An on-line fossil search (fossil hunting) is used to reveal them, and an interpretation with typical images of the Middle Ages is used to establish cognitive value as landscape forms such a sensory-emotional background with fortress (Fig. 3). The route passes through various destinations and infrastructure equipment (sidewalks, roadsides and local sections of roads, trails and sites of used quarries). It includes also three main lithological locations, one introductory-explanatory and a point for organizing a master class.

The geotour route is built on the ring principle, in which starting point is the initial and the final one. The most convenient one in our case is the location between the entrance to the fortress and the car park along the northern bastion, but there are safety restrictions and tour participants must be moved to a technically safe area. The area between the fortress and the bastion, where the anthropogenic outcrop wall is located, meets the requirements of the safe zone. By means of this outcrop we demonstrate the features of stay and movement within the route while illustrating safety measures, possibility of interpretation of the principle of stratification sequence of construct soils, revealing the information potential of the soil about historical events and features of landscapes of the past.

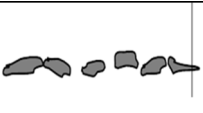





Figure 3: Advanced interpretation stand of the route "History of Kamyanets rocks"/(in the vulgar tongue).

An effective form of soil learning in geotour is an on-line master class that can be implemented in the field and in-house conditions, depending on the course of geotour. The adaptability of master classes increases the stability of geotour and promotes its parallelism and nonlinearity. The field is a master class on determining the particle size distribution of the soil by organoleptic method. The work is carried out with previously prepared soil samples similar in granulometric composition to the soils of the beligerative complex. Participants conduct assessment of the particle size distribution of the soil according to standard criteria for field determination (Table 1).

Table 1: Typical indicators for field determination of particle size distribution by organoleptic method.

Particle size distribution	Diagnostic features	Morphology of the sample during testing
1	2	3
Sand	When moistened, a fluid mass of "sand-spit" is formed. Does not twist into a cord.
Loamy sand	Non-plastic mass. Forms cord prototype.

Light loam	Slightly plastic mass. Forms a cord that easily breaks into pieces.	
Medium loam	Plastic mass. When twisted, it forms a solid cord, which disintegrates when bent into a ring.	
Heavy loam	Well-defined plastic mass. When twisting easily forms a cord. In case of bending in the ring cracks are formed on its outer side.	
Clay	Good plastic sticky mass. The cord is easily bent into a ring without cracks.	

During the master class, participants with the help of organoleptics through their own experience of interaction with the soil gain a tactile understanding of the formation of soil deposits, which are the result of many natural and social processes. First experience with the morphology of the samples during the tests gives participants a clear confirmation of the valuable material on the interaction of soil mass, lithological basis and fortifications of the beligerative complex.

In-house master class is a work with samples to determine the mechanical composition or slides of soils in the laboratory, which reveals to participants its new characteristics and creates spectacular emotional impressions (Fig. 4).



Figure 4: Work to determine the mechanical composition of the soil in the laboratory.

Reference samples are slides in the form of sections with intact soil structure made in the grinding laboratory of the M.P. Semenenko Institute of Geochemistry, Mineralogy and Ore Formation at the National Academy of Sciences of Ukraine. Micromorphology provides a large amount of

objective information about the conditions of soil formation, soil origin, intensity and ratio of the processes that form them, physical condition and material composition.

Working with a microscope in the laboratory allows to observe at the microscopic level the intact microstructure of soil deposits (Fig. 3a.), various forms of remains of carbonate skeletons of ancient fossilized organisms from dolomitized limestone in several layers of soil (Fig. 3b-d.), the influence of microorganisms on the weathering of soil-forming rock in the soil mass (Fig. 3e-f), anthropogenic inclusions, traces of life of ancient cultures, in particular, Trypillia, in the form of carbonaceous remains of plants confined to the cavity space in the buried horizons of paleosoil (Fig. 3g), microscopic structure of soil minerals and new Learning the composition of the soil of the beligerative complex at the microscopic level will form a holistic view of the participants about the direct role of soil in archiving landscape information and translating it into a geological record. This form of interaction between the participants and the soil will effectively contribute to the understanding of its uniqueness and the importance of conservation, which, in turn, is a significant impetus to the popularization of soil among the population and its protection by law (Longhi, Trombino, Guglielmin 2021).

To define the effectiveness of these forms of geotourism activities within the project "History of Kamyanets rocks" (2021) test groups of different ages, gender and social composition were polled.

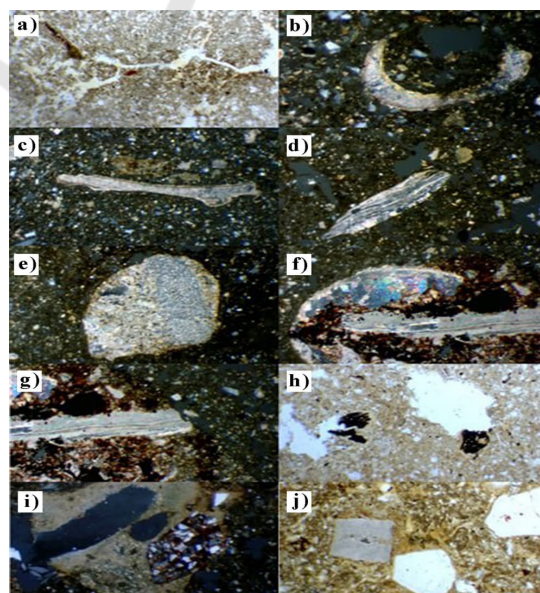


Figure 5: Micromorphology of samples of laboratory master class.

A total of 587 people (14 groups) were involved. To assess the effectiveness of the participants an anonymous survey was conducted after the geotour. The questionnaire included the following: "Which natural object best preserves the memory of historical events?" and rating one (5-point grade) - "Did you like the work in the master class?" (It was unpleasant; I didn't like it; I don't know; It was interesting; I want something else). Respectively, 434 (72%) participants answered the first question with "land" or "soil", in the case of the second – 27 (1), 59 (2), 75 (3), 189 (4), 237 (5). It is worth noting that the highest score (5) in the case of a rating question was given exclusively by participants under the age of 10.

The results of the introduction of the soil component to the geotour were used in the development and implementation of the grant project "Project № 4REG11-03434 Terra Podolica 2021" given by the Ukrainian Cultural Foundation.

4 SUMMARIES

Based on the study the following was found: geotourism use of soils of beligerative landscapes is an effective means of its conservation with economic development at the same time. The viability of geotourism is in its form of economic use of the soil of the beligerative complex without direct consumption, providing the possibility of multiple use of the resource and its economic conversion with the necessary conservation of natural features. This form of soil development is the basis for its promotion among the population and encourages the introduction of additional protection measures;

soils within the study area are unique natural and anthropogenic formations and are represented by urban land and construct soils. Studies show that they have specific morphological, micromorphological and physicochemical features;

studies of buried soils of beligerative complexes at different levels of soil mass organization allow to reproduce paleogeographic conditions, reconstruct paleolandscapes, draw conclusions about the climate of the past and predict future climate change based on this

soil as an object of geotour does not work without the correct format and forms of learning;

an effective format of geotourism use of soils of the beligerative complex is an adapted reference geotour, expanded by the soil component;

effective forms of soil characteristics learning are on-line master classes with development and

experimental implementation of its field and in-house parts;

integration of soil information into geotour makes it more adaptive, nonlinear, diversifies forms of on-line consumer interaction with nature and ensures the soil conservation as a natural resource of the beligerative landscape;

in geotour the soil of the beligerative complex plays the role of the primary link of natural-anthropogenic interaction and is a clear demonstration of its historical result.

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