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Geographic itinerary with augmented reality through the natural landscape in the Arribes del Duero of Zamora (Castile and Leon, Spain)

I. INTRODUCTION

The geographical itinerary is a practice with great roots in the didactics of geography since in the last quarter of the nineteenth century, within the Free Institution of Education, Giner de los Ríos and Bartolomé Cossío revealed its usefulness applying this resource to the knowledge of the landscape of the Sierra de Guadarrama (ORTEGA, 2001).

Consolidated this pedagogical application in the first half of the twentieth century with geographers or naturalists of the class of Dantín Cereceda, Carandell Pericay, and Vidal Box, today there is an abundant and solvent bibliography of a theoretical and practical character (HERNANDO, 1979; GÓMEZ ORTIZ, 1985; GARCÍA RUIZ, 1993; SANCHEZ, 1995; PIÑEIRO, 1997; BLACKSMITH, 2001; GARCÍA DE LA VEGA, 2012; GAITE BROWN, 2013). Therefore, its value as a beneficial teaching resource in the teaching-learning process at any of the educational levels remains indisputable, as it allows the motivation of learning, the acquisition of knowledge, and the creation of values and sensitivity in favour of the landscape among students (GARCÍA DE LA VEGA, 2004).

More recent is the prominence that geographical itineraries are acquiring as territorial tourist resources linked to natural heritage (POBLETE and Others, 2014). In this process, information and communication technologies (ICTs) have great significance, facilitating the development of new forms of knowledge and dissemination: interpretive panels with QR codes, audio-routes, virtual tours, and various geolocation and augmented reality

applications that allow from a mobile device access to added content (OLAY and Others, 2019; BLESSED and Others, 2020). Not surprisingly, the European Landscape Convention itself (Council of Europe, 2000) considers the important role that landscape plays as a favourable resource for economic activity and may even contribute to job creation.

Regarding the landscape of the Arribes del Duero, its geographical discovery was carried out by one of the most outstanding writers of the so-called Generation of '98: D. Miguel de Unamuno (1864-1936). Through hiking practice, Unamuno revealed the geographic nature of the Arribes del Duero landscape.

Currently, there are endless proposals for geographical routes through the Arribes del Duero, materialized in guides of nature or travel (CORRALES and Others, 1991; RODRIGUEZ, 1994; MARTIN, 1995; HOUSES, 1998; SANZ AND DOMINGUEZ, 1999; CALZÓN, 2000) and on marked hiking trails with interpretive brochures available in tourist offices and on the internet (Path GR 14 or Camino Natural Senda del Duero and other PR Trails). However, from a scientific perspective, hiking proposals are very scarce. They are restricted to concrete initiatives developed by university centres —case of the Geología held in Zamora in 2017 with an associated Geology (ANTON and Others, 2017)— and foundations such as Natural Heritage of Castile and Leon through the numerous guided tours offered during the holiday periods from the Casas del Parque.

This framework presents a geographical itinerary that aims to offer any person or institution concerned with the interpretative keys of the natural landscape. In addition,

augmented reality is used as a tool for the explanation of the landscape, making available to teachers, students, territorial agents, and visitors the geographical knowledge necessary to understand, value, and enjoy the natural landscape of the Arribes del Duero in the province of Zamora.

II. STUDY AREA

Arribes del Duero is a protected natural area (natural park since 2002) nestled in the western edge of the Spanish-Speaking region, between the provinces of Zamora and Salamanca. Its name refers to the imposing slashes opened by the Douro River on its international stretch, where it profiles a majestic natural border of 120 km in length between Spain and Portugal. As with the Spanish margin, the Portuguese bank of the river gorge, located in the district of Braganza – is legally preserved under the name of Parque Natural do Douro Internacional (1998). Together, a total of 191,255 ha has been protected – 106,105 ha in the Spanish part and 85,150 in Portuguese— which in turn have been included since 2015 in a cross-border protected natural macro-space: the Iberian Plateau Biosphere Reserve (1,132,607 ha).

The landscape originality of the Arribes del Duero Natural Park is determined by the cut up to 400 m high that form the Douro River and its main tributaries – Esla, Tormes, Uces, Huebra, Agueda, among other minors. On its way to the Atlantic, this great river course must have saved the sharp vertical step that separates its tertiary basin from the Portuguese coast where it flows. The hardness of the materials in this portion of the Paleozoic basement - the so-called Zamorano-Salamanca peneplain - led the river to look for points of structural weakness, that is, the fracture lines through which the channel was embedded until forming a narrow, deep, and prolonged gorge with steep slopes (ARENILLAS AND SÁENZ, 1987). From this unique geomorphological configuration are derived exceptional climatic conditions, materialized in a softening of the thermal regime – short and mild winters together with long and hot summers, with a wide annual period free of frost – that contrasts with the extreme cold of the plains of Castile and Leon (CALONGE, 1990).

The landscape of the Arribes del Duero can be considered as a “natural” landscape or at least “of natural dominant”, because of the little modification imposed by human action or because it is currently contingent on natural dynamics (MILLER AND TORT, 2018). Large sections of the river gorge are delimited as a Limited

Use Zone (ZUL) in the Natural Resources Management Plan (PORN), due to the high quality of the natural environment, whose characteristics allow only very moderate public use. Other sectors of the gorge with terraced crops and the rest of the surface of the protected area that extends through the peneplain integrate traditional agricultural uses and an attempt is made to make them compatible with natural dynamics (*BOLETÍN OFICIAL DE CASTILLA Y LEÓN*, 2001).

III. METHOD AND MATERIALS

The methodology used in the preparation of this geographical itinerary was divided into three phases. In the first, the selection, characterization and assessment of those places and elements of the space that have a greater degree of representativeness and natural singularity from the landscape point of view was carried out. In the next one, the points that present the best observation and accessibility conditions were set at each stop and several complementary routes were drawn. In the last one, the scientific information for the geographic interpretation of the natural landscape was prepared through the texts that make up the results of this article and the materials incorporated into the augmented reality computer application.

The first phase focused on the geographical study of the natural landscape oriented to the inventory and evaluation of landscapes with natural interest. This part of the work was based on previous research carried out by the authors themselves in the field of geomorphology (MARINO and Others, 2017a, 2018a and 2019), biogeography (MARINO and Others, 2017b; MARINO, 2020) and integrated landscape (MARINO and Others, 2020). Specifically, within a representative sector (6,000 ha) of the Arribes del Duero Natural Park located in the Sayago region of Zamora, the following works were carried out:

- 1) the analysis of the natural landscape and its physical, biotic, and anthropic components.
- 2) the cartographic representation of the natural landscape (scale 1: 25,000) from the combination of its geomorphological and phytogeographic elements.
- 3) the identification and classification of the natural landscape units in hierarchical levels (sets, types, and units).
- 4) the inventory of natural places (large sites) and elements (reduced points) of landscape interest according to criteria of representativeness (places

or characteristic elements) and singularity (places or special elements).

- 5) the elaboration of a descriptive sheet with the fundamental features of each place and natural element of scenic interest (organization, dynamics, visual perception and main and secondary interests), as well as information regarding its use and management (cultural content, accessibility, degree of interest, state of conservation, current uses, communications, infrastructures, impacts and legal situation).
- 6) the evaluation of places and elements from a triple perspective: intrinsic or scientific values (morphogenesis, landforms, geomorphological dynamics, lithology, geological structure, plant diversity, floristic richness, tree cover, maturity and ecological function), added or cultural (landscape and aesthetic scaling consideration, heritage elements, cultural aspects, historical phases of use and occupation, pedagogical resources and levels, scientific significance and representativeness and, finally, tourism potential and contents) and of use and management (accessibility, fragility, vulnerability, the intensity of use, risk of degradation, impacts, observation conditions, limits of acceptable change, services and equipment and economic potential).

With the results obtained in this preliminary phase, a set of materials was available under which the itinerary was carefully planned. Thus, the places and natural elements recognized as sites or points of scenic interest were established as stops on the route. In each one of them, the evaluation of values such as accessibility, observation conditions or the landscape and aesthetic scaling consideration allowed objectively to select the best observation points, prioritizing, in any case, the road access over the pedestrian. Also, the identification and hierarchical classification of the natural landscape in 2 sets, 6 types and 32 landscape units allowed to build a sequential argument of geographical interpretation of the natural landscape applied to the itinerary. In this way, the first two stops serve to introduce the visitor to each of the two large landscape ensembles, that is, the river gorge first and the penepain later, while the rest of the stops are dedicated monographically to each one. of the types of landscape: erosive plains, residual reliefs, tertiary terraces, boulders, alluvial plains and gorges and ravines. The basic units of the natural landscape with the greatest interest at each stop were taken into consideration for their

proposal as complementary walking tours to the itinerary. In some cases, it was possible to make them coincide with Short Route (PR) trails that have signalling marks, which undoubtedly facilitates access. In others, it was not possible, although they are equally simple and safe routes. In any case, in all of them, the same measures, advice and recommendations that the practice of hiking requires should be taken.

Finally, the scientific information was selected for its interpretation and adaptation to the augmented reality computer application, to motivate and facilitate learning through interactive participation. The contents that have been prepared are openly available to any user on the Internet portal of the Territorial Observatory of the Department of Geography of the University of Oviedo (www.observatoriodelterritorio.es). Specifically, the materials can be displayed online through any electronic device with an internet connection. They are classified by stops and the information available is very diverse, from the most practical (geographical coordinates of the observation point, access to it, the interest of the stop, indications on complementary pedestrian routes) to the most scientific (organization, dynamics, and visual perception of the landscape), passing through the other related to the uses that may also be attractive to the visitor (cultural content, uses, infrastructures, services and equipment). Apart from all this information of a textual nature, synthesized in cards, different graphic material is included. These are maps that combine the most important natural elements in the landscape and detailed photographs of the most relevant landscape aspects, with the corresponding interpretive texts in both cases. Besides, to enrich all these contents, various computer techniques were also used to create interactive resources. One of them was the realization of spherical views generated with the 3DVista Virtual Tour software (from 360° photos taken with the Samsung Gear camera), which allowed integrating all the information mentioned above. Another was the use of digital elevation models (DEM) or surface models (MDS) constructed from IGN LIDAR data and processed with LasTools, Saga GIS and QuantumGIS software. Access to all this extended information can be done in two different ways. The first is done through markers (tracking images), through hyperlinks that are activated with QR (Quick Response) codes or with images or 3D objects detected by a sensor (camera) that link to the web page where they are hosted. The second uses sensors integrated into mobile devices (mainly GPS) for its activation. The great advantage of this system is that it enables self-guidance through open-air spaces while offering additional infor-

mation based on the user's position. In any case, in the explanatory texts of each of the stops on the itinerary, the link to all the virtual resources generated has been inserted, so they are also at the service of the review's readers.

IV. RESULTS

The itinerary developed runs along different roads between the towns of Miranda do Douro and Pinilla de Fermoselle for 50 km (Fig. 2). Of the eight proposed stops, five have direct access to the observation point: the Torregamones de Sayago arrivals from the Miranda do Douro Cathedral (stop 1), the Badilla plains from kilometre 20 + 350 m from the road ZA-P-2222 (stop 2), the Fariza mountain ranges from kilometre 1 + 300 m from the ZA-L-2218 road (stop 4), the Fornillos de Fermoselle barreros from kilometre 5 + 200 m from the ZA-P-2221 road (stop 7) and the Pinilla de Fermoselle arrivals from the Peña del Cura viewpoint (stop 8). The three remaining stops require an approach on foot to the observation point, in all cases of short walks: the arrivals of Cozcurrita from the Las Barrancas viewpoint (500 m on foot to stop 3), the arrivals of Mámoles from Cueto viewpoint (1 km on foot to stop 5) and the valleys and baroque valleys of Palazuelo de Sayago from Teso del Cuerno (2.2 km on foot to stop 6). Therefore, the itinerary is designed to be done in one day.

If you choose to do the complementary walking routes planned at each of the stops, it is necessary to have at least a second day. Each stop has at least one small additional route, if not three, for a total of twelve. Not necessarily all routes start from the same observation point, although they do so from a place where the vehicle can be properly parked. In the same way, in all cases, these are short journeys, comprised between the five and a half kilometres of the longest path —round trip to Cornicabral del Carrascón (terebinth trees)— and the kilometre of the shortest —round trip to Teso de la Calera—. However, by proposing such a high number of routes, by virtue of the formidable variety and unique landscape of the territory through which the itinerary passes, the total number of walking kilometres amounts to thirty-nine.

Therefore, it is advisable to distribute the walks equitably throughout the days —two to three would be the most appropriate— and according to the order established to follow the interpretive storyline (Table II).

The itinerary begins by focusing on the fluvial gorge opened by the Douro River, a landform that acts as a true trigger for the rest of the geographical factors that intervene in the natural landscape. Explaining its geomorphological configuration by observing its significance in the landscape is the primary objective of the inaugural stop. In this sense, the great fluvial cut that gives rise to the granite wall of the Peña del Dos constitutes, without a doubt, one of the most impressive pictures of all that can be seen in the Zamoran arribes. Added to this is the possibility of frontally admiring the sublime landscape —from the medieval quarter of Miranda— and then ascending —following the first of the proposed pedestrian routes— from the dam to Peña Gazón and peering over the Peña del Dos itself abyss. A second complementary tour aims to understand the derived topoclimatic peculiarities that give shelter to the gall oak groves, one of the most peculiar units of the landscape of the arribes.

After this first contact with the throat, it is necessary to know the great morphostructural unit in which it is carved, that is, the peneplain. Understanding this landscape of stepped surfaces because of extensive erosion processes is now the purpose. The plant landscape, strongly anthropized —a circular route through the Las Chanas pastureland is suggested— becomes the pretext for introducing questions about uses and uses into the discourse. After these first two introductory stops to the two large landscape groups, the scale of analysis is amplified to know in detail the types of landscape associated with secondary gullies, quartzite sierros, tertiary terraces, alluvial plains, and granite boulders. Thus, there are stops in which the mere contemplation of the landscape from strategic enclaves can be complemented with small itineraries that allow reaching the maximum level of detail, when entering the most unique landscape tesserae from the geomorphological point of view (tesos, hills, bornhardts, boulders, waterfalls) and biogeographic (holm oak forest, juniper forest, terebinth trees, cork oak forest, and ash forest).