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ORIGINAL ARTICLE

An Assessment Method for Urban Geoheritage as a Model for Environmental Awareness and Geotourism (Segovia, Spain)

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Abstract

The City Council of Segovia, as part of the Second Environmental Education Strategy of the Autonomous Region of Castile & Leon (Spain), together with the Geological Survey of Spain (Instituto Geológico y Minero de España, IGME), has developed a research project to implement the management of urban geoheritage in the Department of the Environment, with the integration of other council departments. Top ten areas, called ELIGES (Spanish acronym for Areas with Geosites for Environmental Education in the city of Segovia, Spain), have been selected from the 94 geosites previously identified for this city. The assessment method was developed specifically with the idea of using geoheritage for environmental education and geotourism at the local level. The assessment criteria used were (1) Value for environmental education (Ved); (2) Scientific value (Vsc); (3) Tourism value (Vtr); (4) Safety and accessibility (Vsa); (5) Conservation and site sustainability (Vcs) and (6) Value of the geosite's environmental information for geotourism (Vti). These criteria have been assessed for the 94 geosites in the city of Segovia, each of which in turn includes four subcriteria to minimise subjectivity in the decision-making process. Environmental challenges transmitted by the ELIGES are global change and climate change (sea level, temperature changes and extreme storms), geohazards (mainly floods, landslides and rockfalls), groundwater contamination, extinction of species, impacts caused by the exploitation of raw materials, degradation of rocks by pollution in monuments, the harmful and damaging effects of naturally occurring radon on human health

Highlights

- A method is proposed to assess urban geoheritage based on 6 main objective criteria to select the top ten areas in the city that have geosites for environmental education and geotourism.
- This method has been applied to the 94 urban geosites of Segovia, from which 10 key areas called ELIGES (Spanish acronym for 'Areas with Geosites for Environmental education in the city Segovia') have been selected.
- The City Council of Segovia has taken on the responsibility for managing the conservation of their local geoheritage and has launched a dissemination plan that includes placing QR codes on outcrops, a web page with all the pertinent information and the publication of a handbook (in Spanish and English) and brochures. It has also integrated them into its own environmental education programme.
- This method and this real experience can be reproduced in other cities with recognised urban geoheritage. This demonstrates the effectiveness of the transfer of scientific knowledge and geoheritage management at the municipal level.
- When urban geoheritage is managed by public administrations based on scientific criteria, it generates benefits for our society (economic, ecosystem, public health), favours gender equality and promotes the participation of people with disabilities and the resilience of citizens to climate change and sustainable development goals (UNESCO 2017).

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and recommendations for collecting and trading movable geological heritage. Understanding the city's geological past and present through environmental education and geotourism using ELIGES makes all stakeholders more resilient when tackling important issues in our society such as global change and its effects on the urban ecosystem and people.

Keywords Assessment · Geotourism · Environmental education · Inventory · Urban geoheritage

Introduction

Geoheritage is a constituent and inseparable element of natural heritage, and it possesses scientific, aesthetic, landscape, economic, and intrinsic values that must be preserved and transmitted to future generations (IUCN resolution WCC-2012-Res-048). Research carried out over the last decades on the regulation and public use of geoheritage has taken place mostly in Natural Protected Areas, UNESCO Global Geoparks and in other rural areas (e.g., Gordon et al. 2018; Brilha 2018). However, geoheritage located in urban areas has received much less attention by research teams and, particularly, much less real management and protection by local administrations.

Urban geoheritage has a great potential due to its easy accessibility in protected public areas, better accommodation and mobility for visitors and, most importantly, a higher population density (including schoolchildren) compared to remote natural areas. Urban geoheritage can be defined as the entity of unique geological elements, geological processes and geological outcrops in urban territories and close to cities that are important to modern society because of their scientific, educational and touristic value (Habibi et al. 2018). Urban protected areas are distinctive in two fundamental ways (Trzyna et al. 2008, 2014): they offer experiences in nature to the large number of people who live near them, and they build urban constituencies for nature conservation. Many cities have had experiences on their urban geoheritage published during the last decades, e.g., Madrid (Díaz-Martínez and García-Pardo 1988), Alicante (Alfaro et al. 2004), Curitiba (Liccardo et al. 2008, 2012), Lisbon (Rodrigues et al. 2011), Segovia (Díez-Herrero and Vegas 2011), Rio de Janeiro (Mansur and Soares da Silva 2011), Burgos (Fernández 2012), Salvador de Bahía (Liccardo et al. 2012), Turin (Borghi et al. 2014), São Paulo City (Del Lama et al. 2015), Rome (Del Monte et al. 2013; Pica et al. 2015, 2016), Mexico City (Palacio-Prieto 2015), Oslo (Erikstad et al. 2018), Belgrade (Petrović et al. 2017), Pruszków (Górska-Zabielska and Zabielski 2017), Brno (Kubalíková et al. 2017), Shiraz (Habibi et al. 2018), Hefei (Kong et al. 2020), among others.

Most geotourism activities in cities include marking georoutes or trails with signs and the selection and assessment of accessible geosites in the urban environment, such as museums, rocks and fossils on building facades and monuments, outcrops in parks and gardens, rock gardens, etc. However, at this moment, no methodology has been developed that selects urban geosites specifically for environmental education, which is included in the 2021 and 2030 agendas of many municipalities, especially in Europe. There are many experiences in the educational use of geosites in the formal Geology and Earth Sciences curricula, but it can also be an important ally in environmental education efforts and, specifically, to communicate the environmental challenges of our time. Geosites have a great potential for environmental education in sensitive key areas such as climate change, geohazards, pollution and groundwater, responsible consumption and production and reduction of inequalities according to the 2030 Agenda for Sustainable Development of United Nations (United Nations 2015). Environmental education and nature conservation have developed a mutually beneficial relationship. Environmental education raises awareness of actions to protect the environment, supporting the process of defining standards and regulations through communication and participation. Additionally, it enables the implementation and effectiveness of the initiatives adopted through outreach and training (Stapp 1969; Tilbury 1995; Chawla and Flanders Cushing 2007).

Since 1989, the province of Segovia has been a pioneer in Spain in geoheritage research, inventory, protection and outreach activities (Díez-Herrero 1991; Vegas 2000; De las Rivas 2006) and particularly at the urban scale (Díez-Herrero and Vegas 2011; Díez-Herrero et al. 2011; Vegas and Díez-Herrero 2018). A new step for Segovia's urban geoheritage is a new methodological development for assessing this heritage that contributes to increase the knowledge, interpretation and awareness of its protection in the city, while highlighting the importance of sustainability and the use of geoheritage for education and tourism, as expressed in the *2nd Castile & Leon Environmental Education Strategy* (2016-2020). This *2nd strategy* was approved by Agreement 35/2016 of 9 June 2016 of the Castile & Leon Regional Government and is the reference document to promote environmental education in this Autonomous Region. It consists of eight strategic guidelines focused on seven stakeholder groups and has 10 general objectives and 18 specific objectives that are embodied in 87 lines of action. This *2nd strategy* sought to involve stakeholders in its implementation and to maximise the use of available resources. Among other new developments, the *2nd Strategy* establishes 12 indicators for monitoring and assessment. This new methodological approach for geoheritage in the city of Segovia is included in General Objective A.I. 'To offer of a consistent and reliable educational action by the public authorities," and, within it, develops Specific

Objective 3: 'To develop specific programmes for environmental education,' which includes Action Line 3.2: 'To further the knowledge and interpretation of geological heritage, highlighting the importance of its sustainable use and its potential for tourism and education'.

Assessment is also one of the essential methodological phases for conducting geoheritage inventories (e.g., Brilha 2016; García-Cortés et al. 2019). According to these authors, the main aims of geoheritage assessment are (i) to establish a geosite ranking based on standardised scientific criteria; (ii) to establish the conservation status of the geosites; (iii) to estimate their potential use (scientific, educational and touristic) and (iv) to prioritise management of geosites. Some papers have refined and applied the assessment criteria to specific areas, to highlight the geosites that best meet specific objectives, such as geotourism in UNESCO Global Geoparks or National Parks (Suzuki and Takagi 2018; Ballesteros et al. 2019). Nevertheless, the criteria of these methodologies usually include only the scientific, educational (formal education) and touristic value. Aspects related to geoheritage use for environmental education, or taking into account people with disabilities, are very rarely included.

The aim of this paper is to assess the urban geoheritage of the city of Segovia, combining classic criteria such as scientific value and state of conservation, with other new ones such as the potential for environmental education and urban geotourism, in addition to safety issues for all users visiting the geosite and accessibility for people with disabilities. All these results are extremely useful for the local administration (municipal government) that is responsible for this heritage when it comes to highlighting and prioritising actions for its conservation and public use. With the methodology proposed herein, council departments involved in the management of urban geoheritage have a new tool for environmental awareness and geotourism, which can be easily adapted to other cities and territories.

Materials and Methods

Study Case

Segovia is a small city in the central part of Spain, with 51,683 inhabitants (official data from 2018), and is part of the autonomous region of Castile & Leon (Fig. 1, up). It is located at an average altitude of 1005 m a.s.l., in the northern side of the Guadarrama Mountains (Spanish Central Range) and close to the Duero Cenozoic sedimentary basin. Located just 100 km north of Madrid, Segovia is full of ancient history. The remains of the first settlers in the surrounding area date back to 45,000 years BP (Álvarez-Alonso et al. 2016). Its historical significance as a Celtiberian population, a Roman town and a mediaeval village-city that acted as the administrative seat of a vast territory, has given it an impressive historical, cultural and artistic legacy (Barrio et al. 1987). Due to its architectural and artistic heritage and the magnificent state of conservation, the Roman Aqueduct and the old city of Segovia were declared a UNESCO World Heritage Site in 1985.

The geological setting of Segovia comprises the rocks and structures of the three main geological domains of the Iberian Peninsula (Gibbons and Moreno 2002; Vera 2004; Fig. 1, down):

- The Iberian Massif is a part of the Variscan Orogen, which is represented by Proterozoic-Palaeozoic metamorphic rocks (mainly gneisses and minor marble and calc-silicate rocks) and Carboniferous granitoids (monzogranites, granodiorites and leucogranites).
- The Alpine basin and range, in particular the western prolongation of the Castilian Branch of the Mesozoic Iberian Basin, are represented by sedimentary siliciclastic rocks (quartzarenites, siltstones and shales) and marine carbonate sequences (dolostones, limestones, marls and sandstones) of Upper Cretaceous age.
- The Cenozoic basin, namely, the central-southern part of the sedimentary Duero basin, includes conglomerates, sandstones, gravels, limestones, sands and clays, ranging in age from Palaeocene to the Holocene (i.e., Cenozoic).

Geoheritage Research and Management Background

The creation of the geoheritage inventory of the province of Segovia began in the 1980s, as a local response to the official national initiative launched at the end of the period 1975–1980 by the former government organisation ICONA (Institute for Nature Conservation) and the Geological Survey of Spain (Instituto Geológico y Minero de España –IGME- in Spanish). It was publicly presented in 1991 during the *2nd Earth Meetings* (Segovia; hosted by INICE, Institute for Scientific and Ecological Research) and partially published in the journal *LITOS* (Díez-Herrero 1991). It consisted of a list of 94 geosites, with their location on a map and their categories of geological interest (petrological, structural, stratigraphic, mineralogical, and so on). Two years before, in 1989, the Segovia Association of Amateur Mineralogists (acronym ASAM) announced the first 'Daniel de Cortázar Award', a national competition on Geological Sites of Scientific and Educational Interest. The award was later discontinued as the jury opted to withhold the prizes established for the first edition. However, it can be considered one of the pioneering initiatives at the national and even international level regarding the use of geoheritage for educational purposes.

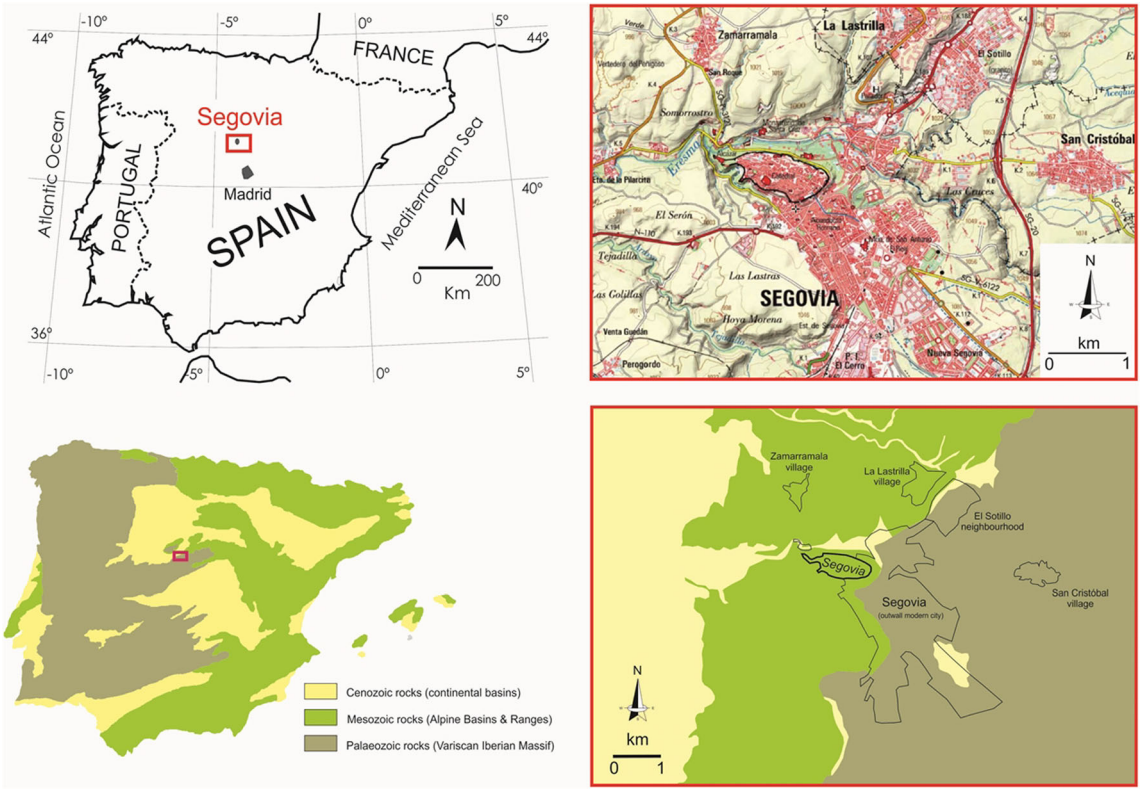

Fig. 1 Geographical (up) and geological (down) setting of the city of Segovia, within the framework of the Iberian Peninsula

New geosites have subsequently been added to the inventory and their values assessed, reaching a total of 142 (Vegas 2000), for which the development of a management and conservation plan was proposed and presented at the *3rd International ProGEO Symposium on the Conservation of Geological Heritage* (Díez-Herrero and Vegas 1999). In parallel, significant progress has been made in the assessment and hierarchisation of geosites using standardised methodologies (Brilha 2016; García-Cortés et al. 2019). This quantitative assessment of geosites, along with a review of the actions for heritage management carried out to date, was published in a book summarising the work done within the framework of the '11th Caja Segovia Environment Awards' (Vegas 2000).

The most significant initiative for geoconservation in Segovia was the development of the 'Guidelines for the urban and landscape planning of Segovia and its surrounding area' (Spanish acronym: DOTSE) set forth by the Castile & Leon Regional Government, involving the review and expansion of the geoheritage inventory corresponding to the southern and western third of the province of Segovia. This catalogue was uploaded to a digital map so that it can be managed using a geographic information system (GIS, ArcView by ESRI), associating it with each georeferenced geosite in the area (such as points or polygons, according to their spatial dimension at a scale of 1:50.000) and a data base (Santos et al. 2001, 2006; De las Rivas 2006). The spatial scope of the DOTSE was subsequently redefined, and the catalogue was expanded from a total of 36 geosites, containing their exact location, and protected by specific regulation (Junta de Castilla y Leon 2005). It was later published and distributed to the participating local authorities (De las Rivas 2006).

As regards the municipal scope for the city of Segovia, in addition to the geosites included in the provincial catalogues mentioned above, it is worth noting the first publication of the sites and areas of geological and hydrological interest for the 'Environmental diagnose of the abiotic physical environment (Gea and hydrosphere)' as part of the local Agenda 21. A new and detailed catalogue of the municipal district was then compiled as part of the review of the General Regulation for Urban Planning (GUOP) for Segovia, containing 85 geosites, where four of them are collections of minerals, rocks and fossils (movable geoheritage). It contains a database describing the names, properties (singular or interesting geological features) and location (UTM coordinates taken with a GPS receiver and a map at a scale of 1:25.000, with an accuracy of ± 20 m), arranged by type of geological interest, an assessment based on standardised criteria, and concludes with technical recommendations for their protection, conservation and potential use. The catalogue was later published to coincide with the 'General Regulation for Urban Planning –PGOU in Spanish' (Ayuntamiento de Segovia 2005).

Methodology for Urban Geoheritage Assessment

The methodology herein applied for the inventory of urban geoheritage uses a semi-quantitative assessment of the geosites previously identified for the city of Segovia that was adapted and extended based on the original proposal of Suzuki and Takagi (2018). This methodology is outlined in Fig. 2, from source data to results, using numerical analysis and GIS mapping. Regarding the data sources, the inventory of urban geosites comes from the list of 97 geosites previously identified for the city in Díez-Herrero and Vegas (2011), plus another 14 geosites identified after 2011. All of the geosites identified in Segovia are representative of the 16 local geological frameworks according to the global chronostratigraphic scale, which includes rocks, minerals, fossils, soils, sedimentary and tectonic structures, stratigraphycal sections, morphologies and hydrogeology that are relevant for understanding the geological evolution of Segovia's urban area (Table 1). The classification of the urban territory in these geological frameworks is the first step in identifying these geosites, following the methodology of the Global Geosites Project (Wimbledon et al. 1999) adapted here to a local scale.

A first semi-quantitative assessment was made of all of these aspects in the 94 geosites identified, specifically designed for public use, whether for environmental education or for geotourism. The assessment was based on the methodology developed by Suzuki and Takagi (2018) for the 'Evaluation of geosite for sustainable planning and management in geotourism', which includes six main criteria and three subcriteria that are key factors for managing geoheritage for its use in tourism. Following this method of six criteria, we have added a fourth subcriteria to each one proposed by these authors, adapting the criteria to the urban scale and to the various stakeholders that interact in Segovia (Table 2). These new subcriteria emphasise the issues of environmental education, geoconservation, security and special accessibility conditions for all end users (citizens, students and visitors, including people with disabilities).

A key question was defined in detail, which represents the potential users of environmental education and geotourism in

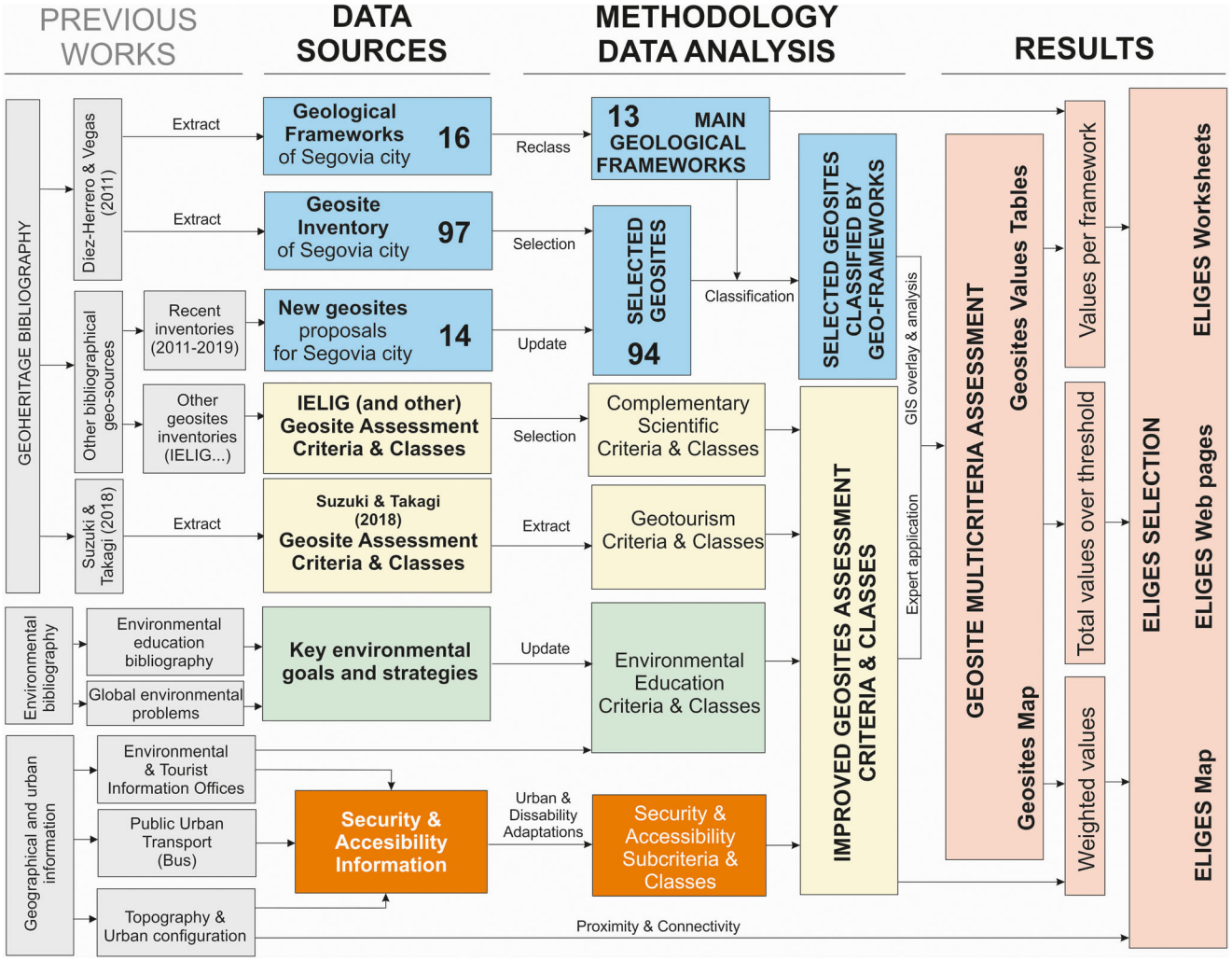

Fig. 2 Methodological general scheme of this study, from data sources and previous works, to the final results

Table 1 Main geological frameworks (GFW) in the city of Segovia that were previously identified to select the geosites that are representative of its urban geology

GFW for the city of Segovia		Number of geosites		GFW ID
ID (2011)	Denomination	Díez-Herrero and Vegas (2011)	This work	
1	Metamorphic rocks from the Iberian massif	6	6	1
2	Carboniferous igneous rocks from the Iberian massif	5	5	2
3	Sandstones and shales from Late Cretaceous transitional sedimentary environments	6	6	3
4	Sedimentary rocks from Late Cretaceous intertidal environments	6	6	4
5	Carbonate marine rocks from the Late Cretaceous period	7	10	5
6	Continental rocks and sediments from the Cenozoic period	5	5	6
7	Tectonic structures from Variscan and Alpine orogenies	6	6	7
8	Mineral sites	4	4	8
9	Mesozoic and Cenozoic palaeontological sites	6	6	9
10	Fluvial and karstic geomorphological features	18	18	10
11	Movable geological heritage: museums and collections	4	4	11
12	Ornamental rocks in buildings and streets	6	-	
13	Soil profiles	4	4	12
14	Natural springs	7	-	
15	Surface hydric elements: lakes and singular river reaches	6	-	
16	Hydrogeology	1	14	13
	Total	97	**94**	

the city that have also been considered during the design of the assessment method. The main end users are students of primary, secondary and university education, families in their leisure time, visitors and different groups of people with disabilities. Segovia had 2 million visitors in 2019, out of which 54.07% were national and 45.93% were international (data from the Tourism Office available at http://turismodesegovia.com).

Those six criteria have been assessed for each geosite in the city of Segovia, each of which in turn includes four subcriteria to minimise the subjectivity of experts. This methodology, which is very common and the most widely accepted in all the studies on geoheritage (García-Cortés et al. 2019, and references herein), is characterised by a semi-quantitative assessment of the subcriteria, consisting of a score from 1 (the lowest possible value for each criterion) to 4 (the highest). Scores 2 and 3 represent intermediate situations.

Additionally, other sources of bibliographic and mapping information have been used (see Fig. 2), both to document the scientific value of the geosites and to identify the key goals in environmental education and the geographical location of urban transport infrastructures, interpretation centres and information offices. Likewise, aspects of topographical anfractuosity and spatial distribution have been used to analyse accessibility and geohazards that can affect geosites and their public use. MS Excel has been used for the analyses because of its basic descriptive statistical analysis capabilities, and a geographic information system (ArcGIS by ESRI Geosystems) was applied for the spatial analysis of the results. In addition, it has been necessary to carry out field work in the geosites to update the data on the observation, danger, security and accessibility conditions for all types of people and availability of public transport.

The final aim of this assessment is the selection, as a requirement of the City Council, of 10 key sets of geosites that combine the best choice for their use in environmental education and offer a high value for urban geotourism due to their intrinsic value. These key areas of selected geosites, which we denominated ELIGES (acronym in Spanish of 'Areas of Geosites for Environmental education in the city of Segovia), show some of the global and environmental challenges and have the best accessibility conditions and interpretation tools available. For this final selection of the 10 ELIGES, the results of the total assessment of the geosites, their spatial locations and the weighting of the result have been combined so that 13 of the original 16 geological frameworks are represented.

Results and Discussion

Table 3 and Fig. 3 show the basic descriptive statistical values and the frequency histograms of the values adopted by the 94 geosites for the different 6 assessment criteria, in the total evaluation.

Table 2 Main assessment criteria and their identifiers (ID) for the geosites in the city of Segovia for environmental education and urban geotourism

ID	Criteria *Subcriteria*	Scoring			
Ved	Value for environmental education	1	2	3	4
Ved1	Understanding of geological history	Difficult, even with a geoguide	Understandable with an explanation from a geoguide	Understandable with information sources (panels, brochures, etc.)	Easy to understand without additional information sources
Ved2	Representativeness	None, only for scientific use	Low	Moderate, but not the best geosite in the city	High, the best geosite in the city
Ved3	Understanding of information available on geosites (panels, brochures, website)	No information available	Complicated or inadequate information	Easy to understand but not related	Understandable
Ved4	Flexibility for educational use	Low	Moderate	High	Very high
Vsc	Scientific value	1	2	3	4
Vsc1	Research significance	Low	Moderate	High, > 5 scientific publications	Very high, (national and international)
Vsc2	Clarity and non-obsolescence of the scientific story on interpretative panels, guidebooks, etc.	Low or no scientific content, or it is obsolete	Partially explained, but not specific to the geosite	Explained, but incomplete or not updated	Clearly explained, updated and specific
Vsc3	Rarity in Segovia city	Not rare	Moderate, at least five geosites	Rare, fewer than five geosites	Very rare, only one geosite
Vsc4	Representativeness within Segovia's geological frameworks	Not representative	Moderate, one geological framework	High, more than one geological framework	Very high, the most representative
Vtr	Tourism value	1	2	3	4
Vtr1	Aesthetic/emotional value or iconic site	Low	Moderate, amplitude of relief or rock colours	High, amplitude of relief, rock colours and presence of water	Very high, iconic landscape or emotional links to citizens
Vtr2	Other natural and cultural values	None	Present but not relevant	Present	Important and well-known
Vtr3	Other tourist attractions in the vicinity	None	Not relevant to attract tourism	Present but outside the guided visits (Discover Segovia programme)	Exist, included in official tourist routes (Segovia Tourist Board)
Vtr4	Proximity to tourist offices (walking)	Far, > 1 h	Close, > 30 min	Very close, > 15 min	< 5 min
Vsa	Safety and accessibility	1	2	3	4
Vsa1	Geosite safety conditions and route leading to it	Relatively dangerous (includes escarpments or sites with natural hazards)	Moderate risk of danger, reduced space for large groups, etc.	Relatively safe: parks, gardens or open spaces, without nearby traffic	Safe: located in open spaces without traffic, flat area and with no natural hazards
Vsa2	Walking time between environmental interpretation centres to geosites	> 1 h	> 30 min	> 15 min	< 15 min
Vsa3	Walking time from the closest bus stop to the geosite	> 30 min	> 15 min	> 5 min	Right beside the bus stop
Vsa4	Accessibility to the geosite for people with physical and intellectual disabilities	Not accessible to any disabled segment	Only accessible to people with intellectual disabilities	Accessible to people with intellectual and physical disabilities, but assisted by carers	Perfectly accessible to any disabled segment

Table 2 (continued)

ID	Criteria *Subcriteria*	Scoring			
Ved	Value for environmental education	1	2	3	4
Vcs	Conservation and site sustainability	1	2	3	4
Vcs1	Current geosite state of conservation	Low: the geological values of the geosite are not preserved	Partially conserved: some elements of the geosite are not preserved	Moderately conserved: all the geological elements can be recognised	Well conserved: geosite is entirely well-preserved
Vcs2	Legal protection	Not protected	Existing plans for protection, but with a general scope, not specifically for geoheritage values	Partially protected: recognised in the GUOP, but for other values (biodiversity or cultural)	Protected due to its geoheritage value (SNI or geosite included in the GUOP)
Vcs3	Natural geosite sustainability	Difficult to preserve, intense natural active processes or vegetation coverage	Damaged by mid-term natural processes (return periods of > 10 yr)	Affected by natural disaster or vegetation cover with return periods > 100 yr	With no incidence of natural processes that could affect its conservation
Vcs4	Anthropic impacts	Constant and direct anthropic impacts	Damaged by medium-term anthropic activities (over 10 yr)	Exceptional anthropic impact with a frequency of over 100 yr	No incidence of anthropic activities that affect its conservation
Vti	Geosite environmental information for geotourism	1	2	3	4
Vti1	Interpretive panels installed in the geosite	No interpretive panels	Limited information. Panels have high risk of vandalism or deterioration	Yes, but only moderately useful for environmental education	Yes and they provide useful information for environmental education
Vti2	Geosite information on the Internet, in brochures and guidebooks	No information	Information on websites or printed	Information both on the Internet and printed	Wide outreach resources specialising in environmental interpretation
Vti3	International character of the environmental information (in different languages)	No information	1 language only (Spanish)	2 languages (Spanish and English) or in Braille	> 2 languages or guides speak > 2 languages (including sign language)
Vti4	Values and attitudes for the geoconservation	No value or attitude	Vague references	Recommendations and prohibitions	Clear and explicit values and attitudes for geoconservation

Table 3 Basic descriptive statistical parameters for the 94 selected geosites in the city of Segovia for environmental education and urban geotourism, according to different criteria and subcriteria

ID	Criteria Subcriteria	Basic descriptive statistics				
		Max	Min	Mode	Mean	Variance
Ved	Value for environmental education	16	5	11	10.8	5.2
Ved1	Easy understanding of geological history	4	1	3	2.7	0.4
Ved2	Representativeness	4	2	3	3.1	0.5
Ved3	Easy understanding at geosites	4	1	1	2.1	1.0
Ved4	Flexibility for educational use	4	1	3	2.9	0.6
Vsc	Scientific value	16	4	8	8.4	6.5
Vsc1	Research significance	4	1	1	1.6	0.5
Vsc2	Clarity and non-obsolescence	4	1	1	1.9	0.8
Vsc3	Rarity in the city of Segovia	4	1	3	2.3	0.7
Vsc4	Representativeness	4	1	2	2.6	0.7
Vtr	Tourism value	16	4	8	9.3	9.6
Vtr1	Aesthetic/emotional value or iconic site	4	1	2	2.5	0.9
Vtr2	Other natural and cultural values	4	1	4	2.8	1.3
Vtr3	Other tourist attractions in the vicinity	4	1	1	2.1	1.4
Vtr4	Proximity to tourist offices	4	1	1	2.0	1.1
Vsa	Safety and accessibility	15	4	11	8.7	8.7
Vsa1	Geosite's safety conditions	4	1	1	2.1	1.4
Vsa2	Walking time to interpret. centres	4	1	2	2.2	1.1
Vsa3	Walking time from the closest bus stop	4	1	3	2.5	1.0
Vsa4	Accessibility to geosites for disabilities	4	1	1	1.8	1.0
Vcs	Conservation and site sustainability	15	5	9	10.4	7.7
Vcs1	Current geosite's state of conservation	4	1	2	2.8	0.9
Vcs2	Legal protection	4	1	3	2.7	1.2
Vcs3	Natural geosite sustainability	4	1	2	2.5	1.0
Vcs4	Anthropic impacts	4	1	2	2.4	0.8
Vti	Environmental information for geotourism	13	4	6	6.7	3.6
Vti1	Interpretive panels installed in the geosite	4	1	1	1.2	0.3
Vti2	Geosite information on the Internet …	4	1	2	2.4	0.6
Vti3	International environmental information	4	1	2	1.8	0.3
Vti4	Values and attitudes for geoconservation	4	1	1	1.3	0.3
Vto	Total assessment	82	34	47	54.3	116.1

The criteria that register the highest maximum values in the 94 selected urban geosites are those related to the environmental education (Ved), scientific (Vsc) and tourism (Vtr) assessment, while the lowest maximums are recorded in the assessment of environmental information for geotourism (Vti). This scheme is repeated for minimum values, with the highest minimums in the assessment for environmental education (Ved) and conservation and sustainability (Vcs) and lower in the rest of the criteria. Modal values are located differently depending on the criterion, which can be mostly biassed towards the upper part of the range (Ved, Vsa, Vcs), centred on the middle part (Vsc, Vto) or slightly directed towards the bottom (Vti, Vtr). The mean values follow the same pattern, being similar to the modal values for some criteria (Ved, Vsc, Vti) and very different for others (Vtr, Vsa), which of course are the ones with the highest variance values. The bar diagrams present a basically unimodal (Ved, Vsc) or slightly bimodal (Vcs) pattern, with a symmetrical Gaussian bell shape (Ved, Vcs) or some asymmetry with the indicated biases (Vsa).

All these results are robust and relatively easy to interpret. The selection of a sample of 94 geosites from the complete inventory (111 geosites) was carried out with scientific and informative criteria, so the geosites with low value had already been discarded, raising the maximum, minimum and mean values of several criteria (Ved, Vsc, Vtr). Furthermore, the sample is large enough (94 elements) for intermediate values to predominate, and there are only a few geosites with high relative scores. However, despite the fact that Segovia has a long history in conservation and enhancement of this geoheritage, accessibility is inadequate, and specific material for environmental education is lacking. The evaluations in these criteria are thus lower as a whole

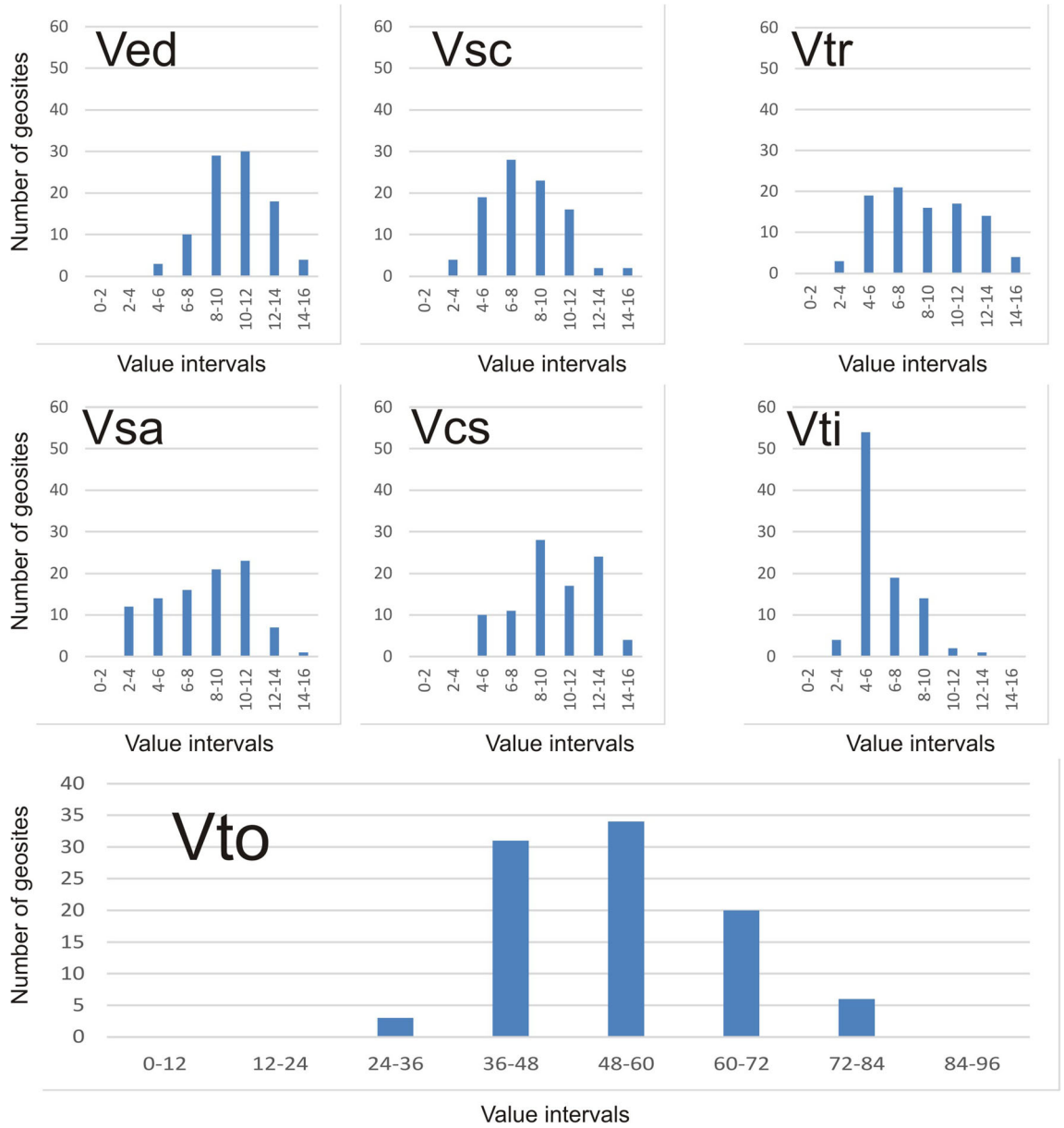

Fig. 3 Bar diagrams of the values adopted by the 94 geosites of Segovia for the six assessment criteria: Value for environmental education (Ved), Scientific value (Vsc), Tourism value (Vtr), Safety and accessibility (Vsa), Conservation and site sustainability (Vcs) and Value of the geosite's environmental information for geotourism (Vti) and for the total assessment set (Vto)

(Vti, Vsa) or present greater disparity between the different geosites in their use in tourism, conservation and sustainability (Vtr, Vsa). Bivariate analyses have been carried out to estimate the correlation of the values between the different criteria, especially those of potential use (scientific, geotouristic and environmental) (Fig. 4).

Figure 4 shows that the best linear correlation occurs between the values for the scientific criterion (Vsc) and the values for the environmental education criterion (Ved), although with a relatively low correlation factor ($R^2 = 0.4291$). This is followed by the correlation between the values for the environmental education criterion (Ved) versus the information for geotourism ($R^2 = 0.3394$ for the linear correlation and $R^2 = 0.342$ for the exponential). The lowest correlation occurs between the values of the tourism criterion (Vtr) versus environmental education (Ved), with a $R^2 = 0.1$. From these results, it is evident that there is not a good correlation between the different evaluation criteria of the geosites, because some of them may present very high values for public use by tourists, but very low for other stakeholders. Regarding the distribution of the assessments within the different geological frameworks, Table 4 shows the basic descriptive statistical values and the number of geosites in each framework that exceed a certain total value threshold.

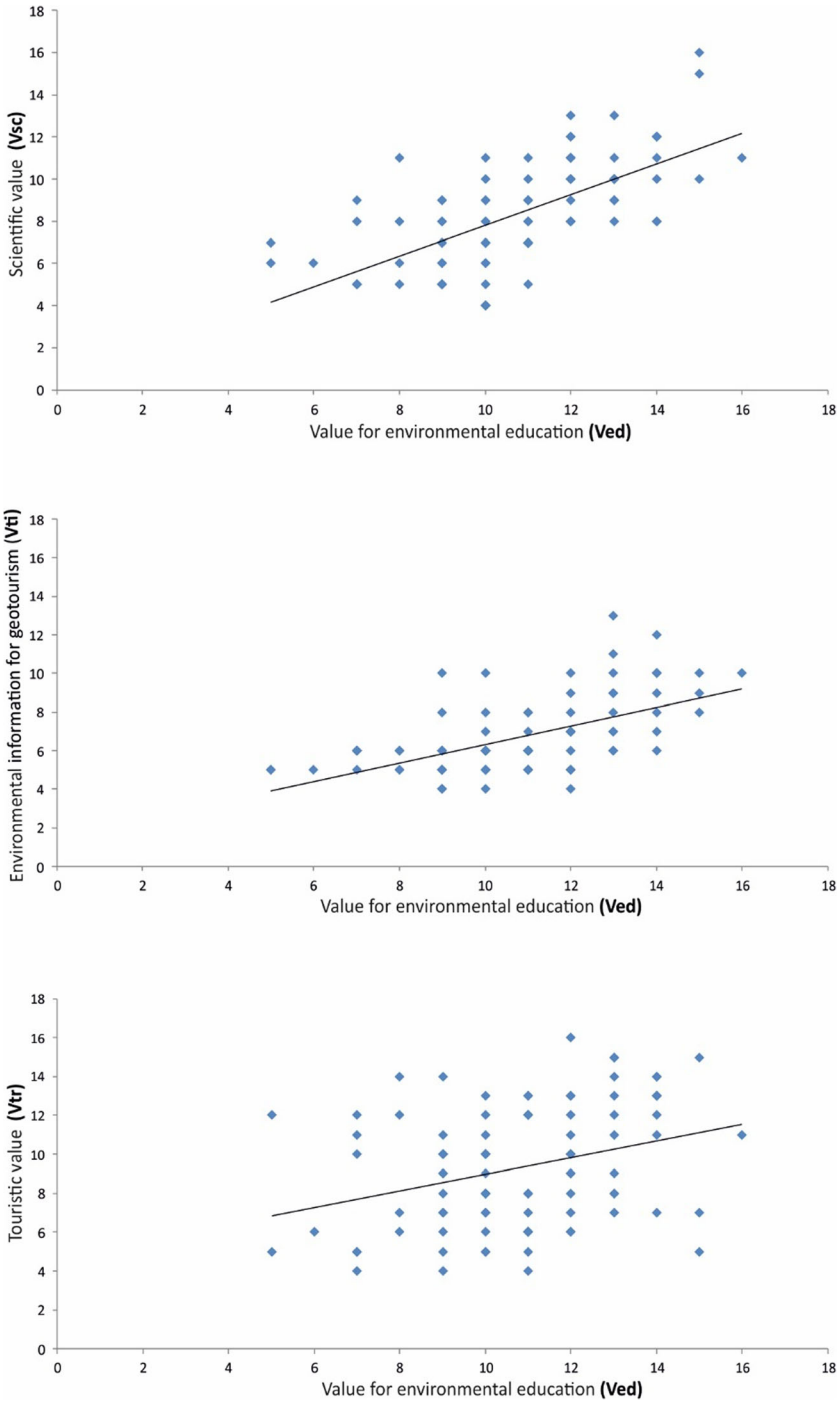

Fig. 4 Bivariate graphs showing values of the criteria for scientific and geotouristic use in environmental education for the 94 urban geosites of Segovia

Movable geoheritage (collections and museums with minerals, rocks and fossils) is the geological framework that presents the highest maximum, minimum and average value. These sites have high intrinsic, scientific and tourist value, as they are located in central areas, accessible to the public and well-communicated. By contrast, the soil profiles have the lowest mean and maximum value, followed by mineral sites, Cenozoic continental sedimentary rock outcrops and metamorphic rocks. The greatest variances occur precisely in some of these geological frameworks with the lowest global valuations (Cenozoic sedimentary rocks, mineral sites or hydrogeological elements), and they also show a greater diversity within these frameworks.

The final selection of the 10 ELIGES was made by combining the geosites with the highest values within each of the 13 geological frameworks (numbers in bold and underlined in Table 4). This makes it easy for practically all the frameworks of Segovia to be represented (except for the soil profiles due to

Table 4 Basic descriptive statistical values of the geosites of each of the 13 geological frameworks of Segovia. The number of geosites whose total assessment exceeds a certain threshold of points is indicated for each geological framework (bold and underlined numbers)

Geological framework		Geosite statistics				Number of geosites over … points								
Number	Name	Max	min	Mean	Var	40	45	50	55	60	65	70	75	80
1	Metamorphic rocks	58	37	46.8	41.1	5	4	2	**1**					
2	Igneous rocks	76	54	65.8	78.6	5	5	5	4	3	3	**2**	1	
3	Transitional sediments	53	40	47.7	16.9	6	5	**3**						
4	Intertidal sediments	72	45	61.3	100.9	6	6	5	4	4	**4**	1		
5	Carbonate marine rocks	68	52	60.0	22.8	10	10	10	8	5	**2**			
6	Cenozoic continental rocks	68	34	46.8	152.6	3	2	2	1	1	**1**			
7	Tectonic structures	66	40	51.5	82.9	6	4	3	2	1	**1**			
8	Mineral deposits	62	36	44.5	106.8	2	1	1	1	**1**				
9	Palaeontological sites	65	44	52.3	56.2	6	5	2	2	2	**1**			
10	Geomorphological features	73	47	56.1	65.7	18	18	13	9	6	**3**	2		
11	Movable geoheritage	82	65	71.5	40.3	4	4	4	4	4	4	2	1	**1**
12	Soil profiles	50	36	43.5	25.3	3	2	1						
13	Hydrogeology	74	41	52.3	106.8	14	11	8	5	2	2	**2**		

their low global values), and it takes into account the criteria of proximity and spatial grouping of these sites (Table 5 and Figs. 5 and 6).

For each of these 10 ELIGES, the value of the six main criteria used in this methodology has been graphically represented in accordance with Suzuki and Takagi (2018). Each graph represents an ELIGES, and the different coloured hexagons represent the different geosites and the values for the criteria (Fig. 7). The ELIGES with more than one geosite achieve higher total values for each criterion because each geosite contributes to the total value. The 10 ELIGES bring together almost a third of the geosites evaluated in Segovia (31 out of a total of 94). The ELIGES that contains the most geosites is La Fuencisla with 7, while there are 3 ELIGES that contain a single geosite. The diversity of geological frameworks represented is greater in two ELIGES (01 Alonso Lake and 08 La Fuencisla), with five frameworks represented in each of them, while again three ELIGES are only representative of a single framework. For all these reasons, the City Council has named the Alonso lake park as the 'Segovia Urban Geodiversity Interpretation Centre'.

The methodology used in this work has a series of limitations and strengths that should be considered when interpreting the results and extrapolating them to other cities. First, it is necessary to start based on geoheritage inventories that have already been carried out. The available inventories

Table 5 Geosites included in each ELIGES according to the methodology detailed in this work. ELIGES include the assessed geosites with the highest value and representativeness within the geological frameworks of the city of Segovia

Geosite sets (ELIGES)		ID of geosites included in the ELIGES	Represented geological frameworks
Number	ELIGES name		
01	Alonso lake	1, 11, 35, 41, 93	1, 2, 7, 8, 13
02	Día Sanz Square	7	2
03	Los Molinos trail	8, 9, 53, 94	2, 10, 13
04	El Terminillo	13, 23	3, 5
05	San Cebrián gate	18	4
06	San Juan street	21	4
07	Clamores valley	24, 67, 86, 87	5, 10, 13
08	La Fuencisla	25, 34, 49, 64, 65, 82, 95	5, 6, 9, 10, 13
09	Tejadilla caves	28, 38, 45, 47, 60	5, 7, 9, 10
10	Collection of Artillery Academy	68	11
	TOTAL	**31/94**	**12/13**

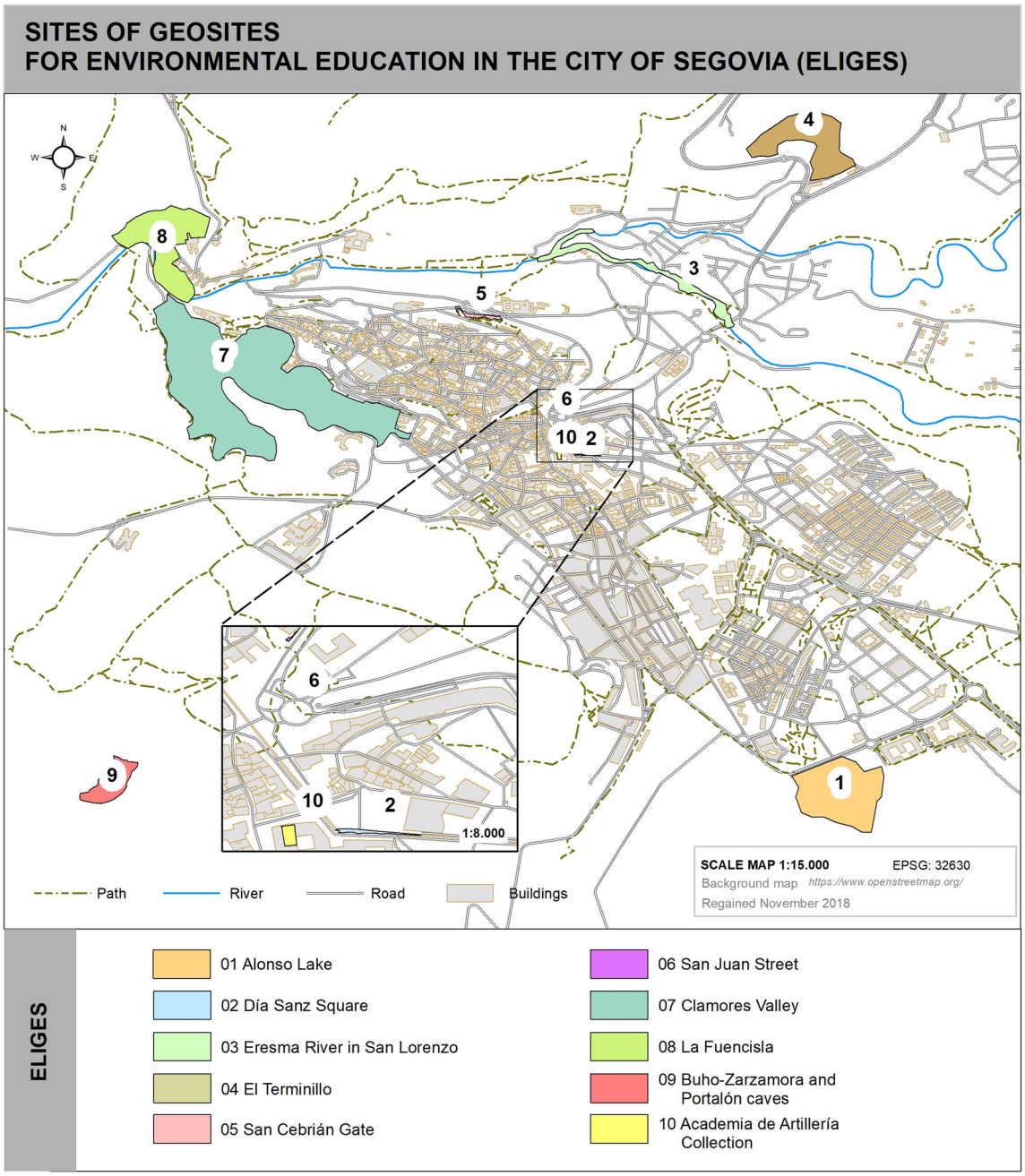

Fig. 5 Map with the spatial distribution of the 10 ELIGES of the city of Segovia

may not have an assessment of each geosite, or they may have been conducted using other methodologies, such as those of Díez-Herrero and Vegas (2011) and other precedents. This could introduce some subjectivity to the assessment, and the results could be biassed. For example, geoheritage inventories tend to include only geosites with high scientific and tourist value. They may only catalogue the most valuable and unique sites, as occurred in Segovia with the collection of minerals, rocks and fossils of the Artillery Academy (ELIGES 10), and leave out others of less relative value, such as other collections of minerals and fossils that have been put together by individuals. If this is the case, the distribution of values is initially skewed towards the upper part of the value range. This subjectivity can be minimised using standardised assessment methods and other local inventories. Since the assessment in Segovia is semi-quantitative, there is a certain subjectivity in the assignment of values to each criterion and the limits of class intervals, which can introduce uncertainty in the results. For example, the distance from geosites to urban transport stops or tourist offices is based on standard walking time, which could be readjusted for each user group according to age, motor capacity, time of the year (season), group size,

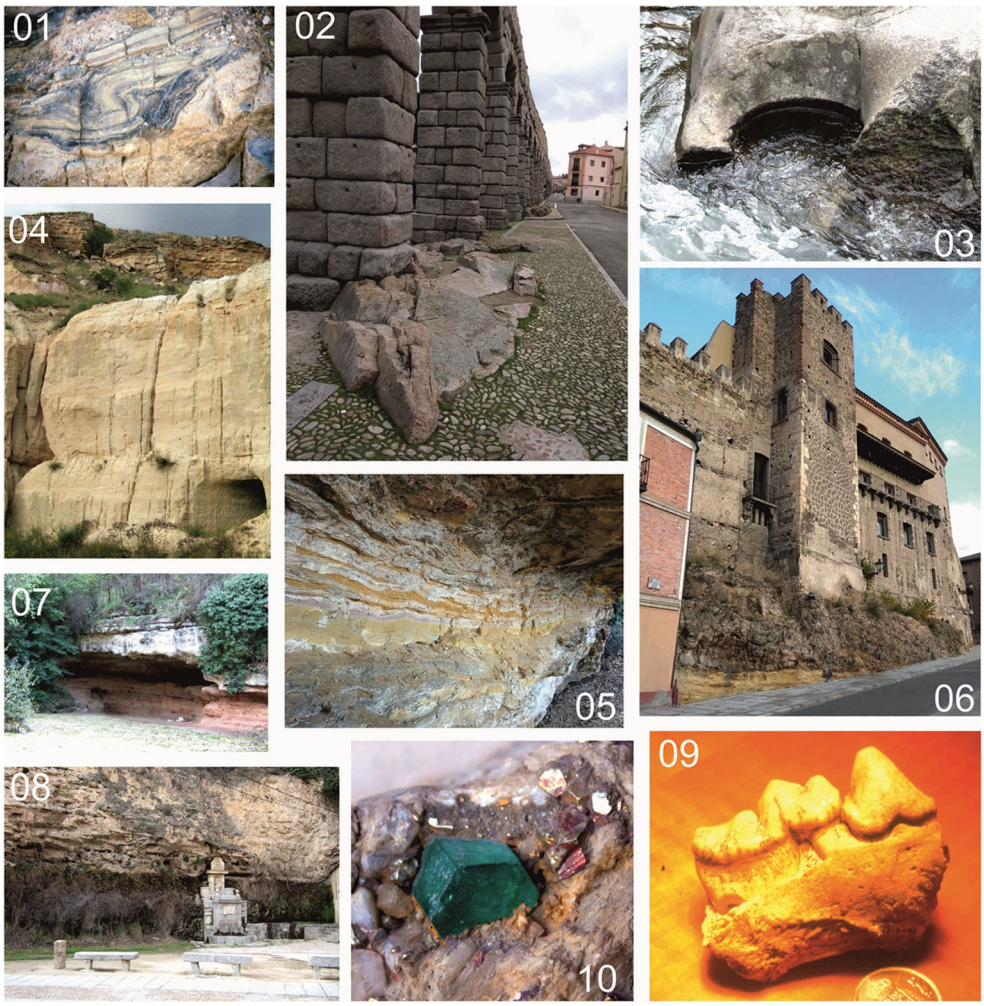

Fig. 6 Images of the 10 ELIGES of the city of Segovia referred to in Table 5 and Fig. 5. ELIGES short names: 01, Alonso Lake; 02, Día Sanz Square; 03, Los Molinos Trail in the Eresma River ; 04, El Terminillo; 05, San Cebrián Gate; 06, San Juan Street; 07, Clamores Valley; 08, La Fuencisla; 09, Buho, Zarzamora and Portalón caves; 10, Collection of Artillery Academy

etc. These values could introduce a bias with respect to the final results, but they are considered robust as they have been used in 94 geosites of very diverse geological interest and are discriminative. The total and partial values obtained in the assessment for the different geosites evaluated suggest that the method is perfectly reproducible by other specialists in geoheritage, with very similar results. This means that the method is replicable and scientifically valid and can be used in other cities by taking into consideration the appropriate modifications, since none of the criteria or subcriteria are specific for the city studied here.

The results obtained have made it possible to rank the 94 geosites of Segovia and select those that best meet the proposed objectives. The very large sample population of geosites (close to one hundred) available in this case has allowed statistical analyses to be significant. This high number of elements allows us to validate the assessment method for the urban geoheritage of the city of Segovia.

The 10 ELIGES designations are directly applied by the Department of the Environment in the Segovia City Council to design and create environmental education activities featuring Segovia's geoheritage (Table 6). A website has been designed (in Spanish and English language; https://www.segovia.es/educaPatriGeo/ELIGES/), containing worksheets for teachers, including the ELIGES location, geological setting, general description, main characteristics and values, the best time of year for visits, recommended educational level, graphic information sources, bibliography, location of bus stops, interpretation centres and tourist information offices and other upcoming ELIGES. The City Council has organised the production of flyers of each ELIGES, in printed and digital format available on the web, to be distributed to users of environmental education programmes, educational centres and the Segovia tourism office.

Conclusions

The research and management of urban geoheritage by the City Council of Segovia is a novel case worldwide, as it has been fully implemented and applied by a local government. The methodological design and protocols have been tested,

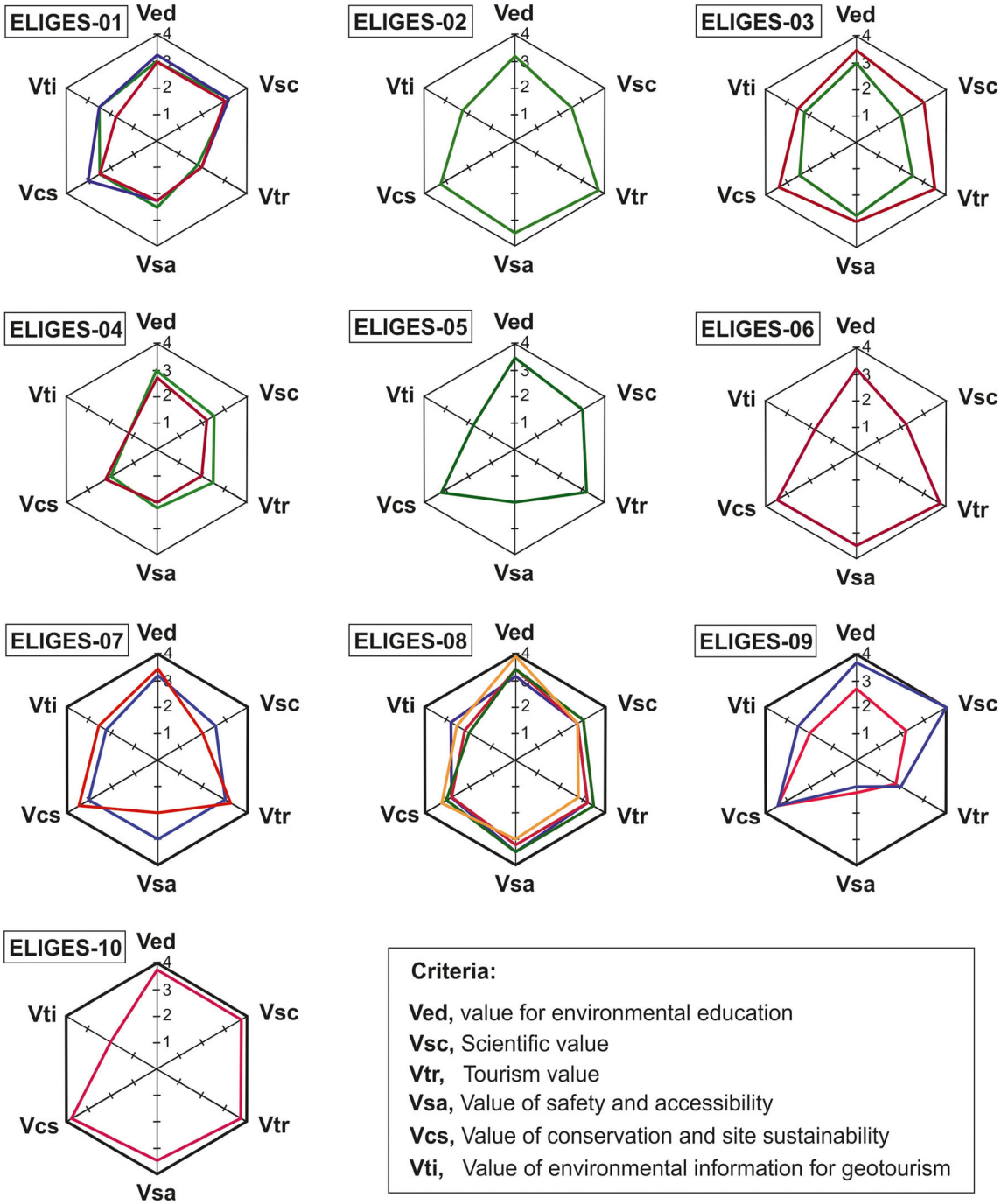

Fig. 7 Hexagonal graphs with the assessment of the 10 ELIGES according to the six criteria detailed in this methodology, and that include the representation of all the geosites they contain. ELIGES 01, 03, 07, 08 and 09 are composed by more than three geosites, but some of them have the same values, and several polygons coincide in projection

proving that it is a model that can be replicated in other cities with geoheritage inventory. Urban geoheritage is an opportunity for local administrations to contribute to nature conservation and above all to use geosites for environmental education and sustainable geotourism.

Six scientific criteria have been used for the assessment of 94 geosites adapted to the urban scale. The objectives were previously established and agreed upon, and all the stakeholders involved in their use and management at the municipal level have been considered. These criteria were Value for environmental education (Ved), Scientific value (Vsc), Tourism value (Vtr), Safety and accessibility (Vsa), Conservation and site sustainability (Vcs) and Geosite environmental information for geotourism (Vti). The 10 ELIGES (Spanish acronym for 'Areas of Geosites for Environmental education in the city of Segovia') chosen from the 94 geosites

Table 6 Environmental challenges and sustainable development goals (SDG) identified for each ELIGES in Segovia

Environmental challenges		ELIGES									
		1	2	3	4	5	6	7	8	9	10
Climate change and global change						●	●	●	●	●	
Variations in global sea level						●	●	●	●		
Environmental impact of mining		●			●						●
Geohazards	Landslides	●			●	●		●	●		
	Floods			●				●	●		
	Radon gas		●	●							
Water pollution		●		●					●		
Stone degradation in monuments			●				●		●		
Geoconservation				●						●	●
Species extinction									●	●	●

evaluated with this method were those that achieved the highest total score in the six criteria and those that are most representative of Segovia's 13 geological frameworks.

These ELIGES have been integrated into environmental education and geotourism programmes developed by the City Council and offer answers to many key questions about the environment. These include issues such as the exploitation of non-renewable mineral raw materials, the benefits and impacts produced on landscape and water resources, as well as the influence of climate change and global warming, and how the increase in temperature on Earth affects the variation of sea level; the extinction and distribution of species over time; geohazards such as landslides, rockfalls and floods, and how to analyse them to prevent disasters and catastrophes. Hence, by looking at the importance of nature conservation and the restoration of degraded areas, the ELIGES implemented at a local scale are an opportunity for people to reflect on nature conservation, environmental education and geotourism.

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Availability of data and material Available in http://www.segovia.es/educaPatriGeo/ELIGES/index.html

Code availability Not applicable

Author contribution Both authors contribute with fieldwork, method design, assessment of geosites, data processing and statistics, interpretation of results and conclusions.

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Declarations

Competing interests The authors declare that they have no competing interests.

References

Alfaro P, Andreu JM, Estévez A, López-Arcos M, Martín I, Martín-Martín M, Tent-Manclús JE (2004) Patrimonio geológico urbano de Alicante. In: Guillén-Mondéjar F, Del Ramo, J (eds) El Patrimonio Geológico: Cultura, Turismo y Medio Ambiente, pp 59–66

Álvarez-Alonso D, de Andrés-Herrero M, Díez-Herrero A, Medialdea A, Rojo-Hernández J (2016) Neanderthal settlement in central Iberia: geo-archaeological research in the Abrigo del Molino site, MIS 3 (Segovia, Iberian Peninsula). Quat Int 474:85–97

Ayuntamiento de Segovia (2005) Plan General de Ordenación Urbana de Segovia. Revisión. Environmental Book, 274 pp, In: http://www.segovia.es

Ballesteros D, Fernández-Martínez E, Carcavilla L, Jiménez-Sánchez M (2019) Karst cave geoheritage in protected areas: characterisation and proposals of management of deep caves in the Picos de Europa National Park (Spain). Geoheritage 11:1919–1939. https://doi.org/10.1007/s12371-019-00416-8

Barrio M, Cortón MT, García A, Pérez V, Santamaría JM, Zamora A (1987) Historia de Segovia. Obra Cultural. Caja de Ahorros y Monte de Piedad de Segovia, Segovia 313 pp

Borghi A, d'Atri A, Martire L, Castelli D, Costa E, Dino G, Favero Longo SE, Ferrando S, Gallo LM, Giardino M, Groppo C, Piervittori R, Rolfo F, Rossetti P, Vaggelli G (2014) Fragments of the Western Alpine chain as historic ornamental stones in Turin (Italy): enhancement of urban geological heritage through geotourism. Geoheritage 6:41–55

Brilha J (2016) Inventory and quantitative assessment of geosites and geodiversity sites: a review. Geoheritage 8:119–134. https://doi.org/10.1007/s12371-014-0139-3

Brilha J (2018) Geoheritage and geoparks. In: Reynard E, Brilha J (eds) Geoheritage: Assessment, Protection, and Management. Elsevier, pp 323–339

Chawla L, Flanders Cushing D (2007) Education for strategic environmental behavior. Environ Educ Res 13:437–452. https://doi.org/10.1080/13504620701581539

de Castilla y Leon J (2005) Decreto 74/2005, de 20 de octubre, por el que se aprueban las Directrices de Ordenación de Ámbito Subregional de Segovia y Entorno. Consejería de Fomento Boletín Oficial de Castilla y León 207:18351–18375

De las Rivas JL(Coord) (2006) DOTSE. Directrices de Ordenación de Ámbito Subregional de Segovia y Entorno. Ed Consejería de Fomento, Junta de Castilla y León, Salamanca, 91 pp + Planos de Ordenación formato. ISBN: 84-9718-352-5

Del Lama E, de La Corte Bacci D, Martins L, da Motta Garcia MG, Kazumi Dehira L (2015) Urban geotourism and the old centre of São Paulo City, Brazil. Geoheritage 7:147–164

Del Monte M, Fredi P, Pica A, Vergari F (2013) Geosites within Rome City center (Italy): a mixture of cultural and geomorphological heritage. Geogr Fis Din Quat 36:241–257

Díaz-Martínez E, García-Pardo B (1988) Aprovechamiento pedagógico de las rocas ornamentales de las estaciones del Metro de Madrid. Henares, Revista de Geología 2:277–283

Díez-Herrero A (1991) Puntos de Interés Geológico de la Provincia de Segovia. Litos 6:31–33

Díez-Herrero A, Vegas J (1999) The geological heritage in the province of Segovia (Spain); proposals for its management and conservation. In: Barettino D, Vallejo M, Gallego E (eds) Towards the balanced management and Conservation of the Geological Heritage in the New Millenium. Instituto Geológico y Minero de España & Sociedad Geológica de España, Madrid, pp 433–438

Díez-Herrero A, Vegas J (2011) De roca a roca. Descubre el patrimonio geológico de la ciudad de Segovia. Ed Concejalía de Turismo, Ayuntamiento de Segovia, Segovia, 95pp.

Erikstad L, Nakrem HA, Markussen JA (2018) Protected geosites in an urban area of Norway, inventories, values, and management. Geoheritage 10:219–229

Fernández E (Coord) (2012) Geoturismo en la ciudad de Burgos. *Una guía de geologíaurbana para todos los públicos.* Instituto Municipal de Cultura. Ed Ayuntamiento de Burgos.

García-Cortés A, Vegas J, Carcavilla, L, Díaz-Martínez, E (2019) Conceptual base and methodology of the Spanish Inventory of Sites of Geological Interest (IELIG). Ed Instituto Geológico y Minero de España, 102 pp, ISBN: 978-84-9138-092-4

Gibbons W, Moreno T (2002) The geology of Spain. The Geological Society of London, London. https://doi.org/10.1144/GOSPP

Gordon JE, Crofts R, Díaz-Martínez E (2018) Geoheritage conservation and environmental policies: retrospect and prospect. In: Reynard E, Brilha J (eds) Geoheritage: Assessment, Protection, and Management. Elsevier, Amsterdam, pp 213–236

Górska-Zabielska M, Zabielski R (2017) Potential values of urban geotourism development in a small polish town (Pruszków, Central Mazovia, Poland). Quaestiones Geographicae 36(3):75–86

Habibi T, Ponedelnik AA, Yashalova NN, Ruban DA (2018) Urban geoheritage complexity: evidence of a unique natural resource from Shiraz city in Iran. Res Policy 59:85–94. https://doi.org/10.1016/j.resourpol.2018.06.002

Kong W, Li Y, Chen M, Peng Y, Wang D, Chen L (2020) Urban geoheritage sites under strong anthropogenic pressure: example from the Chaohu Lake Region, Hefei China. Geoheritage 12. https://doi.org/10.1007/s12371-020-00490-3

Kubalíková L, Kirchner K, Bajer A (2017) Secondary geodiversity and its potential for urban geotourism: a case study from Brno City, Czech Republic. Quaestiones Geographicae 36(3):65–73

Liccardo A, Piekarz G, Salamuni E (2008) Geoturismo em Curitiba. Mineropar Ed, Curitiba

Liccardo A, Mantesso-Neto V, Piekarz G (2012) Geoturismo urbano educação e cultura. Anu Inst Geocienc 35(1):133–141

Mansur KL, Soares da Silva A (2011) Society's Response: assessment of the performance of the "Caminhos Geológicos" ("Geological Paths") Project, State of Rio de Janeiro, Brazil. Geoheritage 3:27–39. https://doi.org/10.1007/s12371-010-0029-2

Palacio-Prieto JL (2015) Geoheritage within Cities: urban geosites in Mexico City. Geoheritage 7(4):365–373

Petrović MD, Lukić DM, Radovanović M, Vujko A, Gajić T, Vuković D (2017) "Urban geosites" as an alternative geotourism destination - evidence from Belgrade. Open Geosciences 9:442–456

Pica A, Vergari F, Fredi P, Del Monte M (2015) The Aeterna Urbs geomorphological heritage (Rome, Italy). Geoheritage 8:31–42. https://doi.org/10.1007/s12371-015-0150-3

Pica A, Grangier L, Reynard E, Kaiser C, Del Monte M (2016) GeoguideRome, urban geotourism offer powered by mobile application technology. Geophys Res Abstr 18:EGU2016–EGU2941

Rodrigues ML, Machado CR, Freire E (2011) Geotourism routes in urban areas: a preliminary approach to the Lisbon geoheritage survey. GeoJournal of Tourism and Geosites 8(2):281–294

Santos L, Martín-Duque JF, De las Rivas Sanz JL, Díez-Herrero A (2001) Orientación fisiográfica en la formulación de las Directrices de Ordenación Territorial de Segovia y su Entorno. In: III Congreso Internacional de Ordenación del Territorio. Política Regional, Urbanismo y Medio Ambiente, FUNDICOT (Asociación Interprofesional de Ordenación del Territorio). Gijón (Asturias), pp 1068-1070

Santos L, Martín JF, Díez A (2006) Aspectos geomorfológicos en las Directrices de Ordenación Territorial de Segovia y Entorno (DOTSE). In: Pérez Alberti A, López Bedoya J (eds) Geomorfología y territorio, Actas de la IX Reunión Nacional de Geomorfología, Santiago de Compostela, vol 171. Ed Universidade de Santiago de Compostela, Cursos y Congresos, Santiago de Compostela, pp 945–961

Stapp WB (1969) The concept of environmental education. Environ Educ 1:30–31. https://doi.org/10.1080/00139254.1969.10801479

Suzuki DA, Takagi H (2018) Evaluation of geosite for sustainable planning and management in geotourism. Geoheritage 10:123–135

Tilbury D (1995) Environmental education for sustainability: defining the new focus of environmental education in the 1990s. Environ Educ Res 1(2):195–212. https://doi.org/10.1080/1350462950010206

Trzyna T, Edmiston JT, Hyman G, McNeely JA, Menezes PC, Myrdal B, Phillips A, other members of the IUCN WCPA Urban Specialist Group (2008) Urban Protected Areas. IUCN WCPA's Best Practice Protected Area Guidelines Series 22:128 pp

Trzyna T, Edmiston JT, Hyman G, McNeely JA, da Cunha P, Menezes E, Myrdal B, Phillips A, other members of the IUCN WCPA Urban Specialist Group (2014) *Urban Protected Areas: Profiles and best practice guidelines.* Best Practice Protected Area Guidelines Series 22, Gland, Switzerland: IUCN. xiv + 110 pp

UNESCO (2017) Education for sustainable development goals learning objectives. http://www.unesco.org/open-access/termsuse-ccbysa-en

United Nations (2015) Transforming our world: the 2030 Agenda for Sustainable Development. Resolution adopted by the General Assembly on 25 September 2015. http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

Vegas J (2000) El patrimonio geológico de la provincia de Segovia: geodiversidad y geoconservación. Colección Naturaleza y Medio Ambiente, 26th edn. Caja Segovia, Segovia 69 pp

Vegas J, Díez-Herrero A (2018) Best practice guidelines for the use of the geoheritage in the city of Segovia. A sustainable model for environmental awareness and urban geotourism. Ayuntamiento de Segovia, Segovia 120 pp

Vera JA (ed) (2004) Geología de España. Ed SGE-IGME, Madrid 683 pp

Wimbledon WAP, Andersen S, Cleal CJ, Cowie JW, Erikstad L, Gonggrijp GP, Johansson CE, Karis LO, Suominen V (1999) Geological World Heritage: GEOSITES - a global comparative site inventory to enable prioritisation for conservation. Memorie Descrittive della Carta Geologica d'Italia 56:45–60

Díez-Herrero A, Vegas J, Peña-González B, Herrero-Ayuso AS, Lucía-Atance R., Santos Borreguero C de (2011) Geoturismo en la ciudad de Segovia: complemento y alternativa al turismo rural. In: Fernández-Martínez E, Castaño de Luis R (eds) Avances y retos en la conservación del Patrimonio Geológico en España. Actas de la IX Reunión Nacional de la Comisión de Patrimonio Geológico (Sociedad Geológica de España). Ed Universidad de León. pp 104-108