Linking Wine Culture and Geoheritage—Missing Opportunities at European UNESCO World Heritage Sites and in UNESCO Global Geoparks? A Survey of Web-Based Resources

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Abstract

Vine cultivation is strongly dependent on local terrain conditions, including geology, landforms and soils. This offers an opportunity to develop interpretation and geo-education that would holistically relate wine culture to abiotic environment. Wine-related cultural landscapes inscribed on the UNESCO World Heritage List and those UNESCO Global Geoparks, where wine production is an important economic activity or leaves a distinctive imprint on the landscape, are particularly suited to emphasize local geoheritage in this specific context. We analyzed official web-based resources of UNESCO World Heritage Committee, UNESCO Global Geoparks programme, individual World Heritage properties and individual global geoparks to evaluate whether causal relationships between geoheritage, geodiversity and wine culture are indicated at all, and if so, how they are presented and linked to geotourism and geo-education. Our analysis involved 14 World Heritage properties and 38 global geoparks, all located in Europe. General observation is that given web-based information alone, the theme is insufficiently explored and poorly communicated to the public, although more recent nomination dossiers for World Heritage contain extensive presentations of abiotic environment. These are, however, not very likely to be consulted by the general public. In global geoparks, wine culture is mainly presented as a sustainable local activity, with local wine as one of brand products, whereas geoheritage context is seldom considered in depth. Growing interest in wine tourism and increasing appreciation of the value of cultural landscapes provide a good background to develop geo-interpretation and thereby to raise awareness of geoheritage matters.

Keywords Viticulture · Cultural landscape · Terroir · Geotourism · Geo-education

Introduction

Raising adequate awareness of geoheritage is a persistent challenge and various ways are currently explored, from enhancing visitors' experience via technology-based means of re-creating geological evolution, through increasing engagement while visiting geosites (e.g. storytelling, guided tours, geocaching, quests) (Cayla and Martin 2018; Macadam 2018; Pica et al. 2018; Zecha and Regelous 2018), to

exploration of multiple links between geology, landforms and culture (Panizza and Piacente 2009; Gordon 2018a; Reynard and Giusti 2018). The latter is based on the premise that teaching and learning are more effective if 'unknown' is related to 'known', and in geo-education, it is assumed that various aspects of cultural heritage are more familiar and better comprehended by the general public than the history of the Earth. Thus, they may provide a good starting point to develop geo-stories (Reynard and Giusti 2018). Examples of this approach include teaching about rocks through the examination of historical buildings (e.g. De Wever et al. 2017; Gordon 2018b), using mining heritage as an opportunity to explain distant geological evolution (e.g. Rybár et al. 2017), relating folk tales to real-life geological events (Lanza and Negrete 2007; Piccardi and Masse 2007), focus on cultural landmarks and history of scientific exploration by famous persons (e.g. tracing journeys and scientific inquiries by Johann Wolfgang Goethe – Coratza and Panizza 2017) or interpretation of

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cultural landscapes and how they are underpinned by rocks, soils and landform configurations (e.g. Migoń and Latocha 2013). Panizza (2001) went as far as to define a geomorphosite in terms of its cultural connotations, which was probably a step too far and not universally accepted, but it is evident that local cultural legacy may constitute a significant added value for geosites, as reflected in multiple evaluation templates (Reynard et al. 2007, 2016; Kubalíková 2013; Štrba et al. 2018).

Wine production is a human activity that is both firmly embedded in the long-term cultural history of the mankind and exploits the natural environment in sustainable way, taking advantage of favourable soil conditions, derived in turn from weathering of the underlying rocks, topography and local climate, all accounted for in the overarching term ‘terroir’ (Van Leeuwen and Seguin 2006; Dougherty 2012). These two aspects converge in specific cultural landscapes, created through centuries-long modifications of natural conditions to ensure successful vine cultivation. Among them are terraced landscapes in steep terrains, which give unmistakable identity to specific regions, especially in the Mediterranean Europe (Harea and Eplenyi 2017; Myga-Piątek and Rahmonov 2018). But whereas the cultural dimension of vine growing and wine consumption is familiar to many people and may be considered ‘known’, the relationships to the environment are less realized and perhaps mostly in relation to climate rather than geology and geomorphology. Thus, the wide interest in wine culture may be seen as an opportunity to develop geo-educational activities, focused on comprehensive exploration of linkages between rocks, soils, landforms and topoclimate, raising thereby awareness in geoheritage matters and geosystem services.

This paper seeks an answer to the question if and how these opportunities are explored in Europe, at two types of areas bearing UNESCO label in recognition of their global significance. The first are UNESCO World Heritage properties, inscribed as cultural landscapes related to wine production. These inscriptions explicitly highlight long-term mutual relationships between abiotic environment and human activities, which have resulted in the origin of unique, visually appealing sceneries. The second group is constituted by UNESCO Global Geoparks, whose development strategy should emphasize a holistic view of the environment, with the crucial role of geological factors (in a broad sense, including geomorphology) underpinning biotic world and cultural history, and focus on communicating this view to the general public (www.unesco.org/new/en/natural-sciences/environment/earth-sciences/unesco-global-geoparks/top-10-focus-areas/). Thus, UNESCO Global Geoparks are particularly suited (indeed, expected to do so) to explore various nature–culture interactions in their activities. However, we do not analyze the current state of all interpretation available at these properties, but limit ourselves to information provided by web-based resources maintained or endorsed by these two types of

properties. Thus, our approach to the research questions formulated above is through the examination of information packages about the relevant localities. We are aware that various local sources and activities may also emphasize the relationships between wine culture and terroir, but we are primarily interested to see what can be learnt by a potential visitor in an increasingly digitized world, who consults a limited but the most obvious range of resources, which are the properties’ websites. They are also virtual gateways to the territories and therefore, their role in geotourism is not to dismiss (Lehto et al. 2006; Widawski et al. 2018; Rozenkiewicz et al. 2020).

Approach and Data Sources

In the first step, properties for detailed analysis were selected. Regarding UNESCO World Heritage, we analyzed all properties inscribed in recognition of an outstanding value of wine landscapes and vine cultivation history and traditions. Fourteen such properties in total are on the World Heritage List, with dates of inscription ranging from 1997 to 2019. To select relevant UNESCO Global Geoparks, our initial analysis included all geoparks located to the south of 51° N latitude, where thermal conditions are theoretically suitable for vine growth. However, considering that vine does not grow well if temperatures become too high or too low in certain periods of the year and precipitation is too high/low (annual precipitation in the range of 400–600 mm is regarded optimal, with the crucial role of spring rainfall to support plant growth) (Jones et al. 2012), some geoparks were excluded based on the assumption that wine production, even if present, plays a marginal role in local economy. Consequently, we did not take into account geoparks located predominantly at high elevations (e.g. Adamello Brenta, Molina and Alto Tajo) and in very dry areas (e.g. Cabo de Gata – Nijar). This decision was supported by an examination of accessible sources of information (see below), which did not reveal any references to wine production in these areas. This preselection resulted in identification of 38 UNESCO Global Geoparks in Europe, which may have vineyards on their territories and might explore linkages between wine industry and Earth resources. Ongoing climate change and global warming, coupled with the introduction of various hybrid variants of vine, has recently led to setting up of vineyards even further to the north than 51° N, but these are generally small, experimental plots and have not been inventoried for this study. Likewise, we do not consider aspiring geoparks, although our findings and recommendations may be valid for at least some of these.

In the second step, we turned to information resources available for the preselected UNESCO World Heritage properties and UNESCO Global Geoparks, to examine their contents. However, we limited ourselves to resources authorized by the respective organizations, as our aim was to investigate whether

the links between geology, landscape and wine are realized by the property' managers, decision-makers and governing bodies. For UNESCO World Heritage, the World Heritage Committee website (whc.unesco.org) was the prime source of information and we searched for references to geology and landforms in both website-hosted statements and nomination documents, if these were available. For UNESCO Global Geoparks, we analyzed short statements containing geoparks' auto-presentation on the UGG website (www.unesco.org/new/en/natural-sciences/environment/earth-sciences/unesco-global-geoparks/) and the content of websites of individual geoparks. Within the latter, attention was paid not only to relationships between geology, landscape and wine culture, but also to geotourism and geo-educational activities focused on the geoscientific context of wine.

UNESCO World Heritage Properties

Criteria and Outstanding Universal Value

The World Heritage Convention, agreed in 1972 and implemented in practice since 1978, when first inscriptions on the World Heritage List were approved, has the notion of outstanding universal value (OUV) as central. It is defined as 'cultural and/or natural significance which is so exceptional as to transcend national boundaries and to be of common importance for present and future generations of all humanity' (Operational Guidelines... 2019; par. 49) and specific criteria have been established to inform the process of nominating and inscribing properties as World Heritage sites. These are defined in Operational Guidelines... (2019) and categorized into two groups, relevant to cultural properties (no. (i) to (vi)) and natural properties (no. (vii) to (x)), respectively. Among them, criterion no. (viii) relates explicitly to geoheritage, requiring nominated properties 'to be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features', whereas the practice tells that criterion no. (vii), which emphasizes superlative natural phenomena and scenic beauty, also applies and many important geoheritage areas across the world received recognition on the basis of criterion no. (vii) rather than no. (viii). Moreover, high-class geology and geomorphological landscapes occur within properties inscribed for their ecological and conservation values, as well as within cultural properties of various kind (Migoñ 2018, 2021). This reflects the position, debatable in specific cases, that abiotic environment may provide important underpinning to biological or cultural heritage, but does not represent OUV itself.

This awareness of geodiversity and geoheritage values intersects with the notion of cultural landscapes, which are

understood as embracing a diversity of interactions between humankind and natural environment, reflecting specific techniques of sustainable land use and adopting to the characteristics and limits of the natural environment, as well as specific spiritual relations to nature (Mitchell et al. 2009). The most relevant criterion for cultural properties is no. (v), specified as the requirement that properties have 'to be an outstanding example of a traditional human settlement, land-use, or sea-use which is representative of a culture (or cultures), or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change'. The key phrases are 'traditional land-use' and 'interaction with the environment', which may and usually do include some kind of soft environmental engineering to ensure efficient and sustainable use of natural resources, including rock type, soils and relief. Criterion no. (v) may be used in conjunction with other criteria for cultural properties, emphasizing human creativity (i), milestones in architectural and technological developments, as well as landscape design (ii), testimony to a cultural tradition or civilization (iii), the presence of buildings or landscapes illustrating significant stages in the human history (iv) and association with living traditions, ideas and artistic works (vi). However, some cultural landscapes centred around wine production have not been inscribed using criterion no. (v), but the other ones.

Representation

As of early 2021, fourteen UNESCO World Heritage properties are directly related to viticulture traditions and include landform ensembles that were anthropogenically modified to allow vine growing and wine production. All of them are cultural properties, although specific criteria used to support the inscription vary from site to site (Table 1; Fig. 1). They constitute 1.2% of the total number of World Heritage sites (1121 in total) and 1.5% of all cultural properties (869 in total). Inscriptions took place since the year 1997, so relatively late in the history of World Heritage Convention. Seven countries are represented, all European, with France having the highest number of properties (4), followed by Italy (3) and Portugal (2). Austria, Germany, Hungary and Switzerland have one property each within their territories, whereas one property is transboundary (Austria/Hungary). Among the criteria, no. (v) was used most often—10 times, followed by criteria no. (iv)—8 times and no. (iii)—7 times. One potentially relevant property is located outside Europe. It is 'Palestine: Land of Olives and Vines – Cultural Landscape of Southern Jerusalem, Battir' (inscribed in 2014), but the examination of the nomination file reveals that the focus is clearly on olive economy and oil production, and there is no wine production at present. It is useful to add that wine culture has been also acknowledged within UNESCO Intangible Cultural Heritage List and is represented by three inscriptions.

Table 1 Characteristics of wine-related cultural landscapes inscribed on UNESCO World Heritage List. Excerpts from Outstanding universal value statements are taken from the website of World Heritage Committee (whc.unesco.org). Part of property name in bold font is used in the text

	Name of the site	Year of inscription	Country	Property in ha	Criteria	Outstanding universal value	Geology	Landforms
1.	Portovenere, Cinque Terre , and the Islands (Palmaria, Tino and Tinetto)	1997	Italy	4689	II, IV, V	The jagged, steep coastal landscape has over centuries been intensively developed with stone-walled terraces for the growing of vines and olive trees.	Sandstones, siltstones, claystones (Palaeogene)	Very steep coastal slopes, cliffs, V-shaped valleys
2.	Jurisdiction of Saint Emilion	1999	France	7487	III, IV	Viticulture was introduced to this fertile region of Aquitaine by the Romans, and intensified in the Middle Ages. (...) It is an exceptional landscape devoted entirely to wine growing, with many fine historic monuments in its towns and villages.	Limestones, sands, silts and clays (Tertiary); alluvial sediments (Quaternary)	Low-lying plateau, alluvial valley floor of Dordogne river
3.	The Loire Valley between Sully-sur-Loire and Chalonnes	2000	France	86,021	I, II, IV	The Loire Valley is an outstanding cultural landscape of great beauty, containing historic towns and villages (...), and cultivated lands formed by many centuries of interaction between their population and the physical environment (...).	Sandstones, calcareous deposits (Palaeogene); alluvial sediments (Quaternary)	Bluffs along the river, fluvial terraces, floodplain
4.	Wachau Cultural Landscape	2000	Austria	18,387	II, IV	The Wachau is (...) a landscape of high visual quality. It preserves in an intact and visible form many traces—in terms of architecture (...), urban design (...), and agricultural use, principally for the cultivation of vines—of its evolution since prehistoric times.	Crystalline basement (gneiss, quartzite), loess	Danube gorge, steep valley sides, loess-covered slopes and upland
5.	Fertő/Neusiedlersee Cultural Landscape	2001	Hungary/Austria	68,369	V	The Fertő/Neusiedler Lake area has been the meeting place of different cultures for eight millennia. This is graphically demonstrated by its varied landscape, the result of an evolutionary symbiosis between human activity and the physical environment.	Sands, clays, limestones (Miocene); lake deposits (Holocene)	Lacustrine plain and low-angle slopes
6.	Alto Douro Wine Region	2001	Portugal	24,600	III, IV, V	Wine has been produced by traditional landholders in the Alto Douro region for some 2000 years. (...) This long tradition of viticulture has produced a cultural landscape of outstanding beauty that reflects its technological, social and economic evolution.	Schist, phyllite	Steep sides of the Douro valley, deeply incised into a rolling upland
7.	Upper Middle Rhine Valley	2002	Germany	27,250	II, IV, V	The 65 km stretch of the Middle Rhine Valley, with its castles, historic towns and vineyards, graphically illustrates the long history of human involvement with a dramatic and varied natural landscape. (...)	Slate	Rhine gorge, steep valley sides
8.	Tokaj Wine Region Historic Cultural Landscape	2002	Hungary	13,255	III, V	The cultural landscape of Tokaj graphically demonstrates the long tradition of wine production in this region of	Rhyolite tuff, dacite, loess	Volcanic cones, loess-mantled uplands and gentle slopes

Table 1 (continued)

Name of the site	Year of inscription	Country	Property in ha	Criteria	Outstanding universal value	Geology	Landforms
9. Landscape of Pico Island Vineyards	2004	Portugal	987	II, V	low hills and river valleys. The intricate pattern of vineyards, farms, villages and small towns, with their historic networks of deep wine cellars, illustrates every facet of the production of the famous Tokaj wines (...). The [site] (...) consists of a remarkable pattern of spaced-out, long linear walls running inland from, and parallel to, the rocky shore. The walls were built to protect the thousands of small, contiguous, rectangular plots (currais) from wind and sea-water. Evidence of this viniculture, whose origins date back to the 15th century, is manifest in the extraordinary assembly of the fields (...).	Basalt lava flows	Structural, lava-supported benches
10. Lavaux Vineyard Terraces	2007	Switzerland	898	III, IV, V	The Lavaux Vineyard Terraces (...), cover the lower slopes of the mountainside between the villages and the lake. (...) It is an outstanding example of a centuries-long interaction between people and their environment, developed to optimize local resources so as to produce a highly valued wine that has always been important to the economy.	Alpine Molasse (conglomerates, sandstones, claystones)	Stepped, rock resistance-controlled slopes
11. Vineyard Landscape of Piedmont : Langhe-Roero and Monferrato	2014	Italy	10,789	III, V	This landscape covers five distinct wine-growing areas with outstanding landscapes and the Castle of Cavour, an emblematic name both in the development of vineyards and in Italian history. It (...) encompasses the whole range of technical and economic processes relating to the wine growing and winemaking that has characterized the region for centuries.	Sandstones, clays, conglomerates (Miocene Molasse)	Low, gently sloping hills, locally deeper valleys
12. The Climats, terroirs of Burgundy	2015	France	13,219	III, V	The climats are precisely delimited vineyard parcels (...). They differ from one another due to specific natural conditions (geology and exposure) as well as vine types and have been shaped by human cultivation. (...) The site is an outstanding example of grape cultivation and wine production developed since the High Middle Ages.	Quaternary slope deposits on limestone and sandstone	Lower slopes of a fault-generated escarpment
13. Champagne Hillsides, Houses and Cellars	2015	France	1102	III, IV, VI	The property encompasses sites where the method of producing sparkling wines was developed on the principle of secondary fermentation in	Chalk (Cretaceous)	Rolling upland, low-to moderate-angle lower slopes of a cuesta front, valley floor

Table 1 (continued)

Name of the site	Year of inscription	Country	Property in ha	Criteria	Outstanding universal value	Geology	Landforms
14. Le Colline del Prosecco di Conegliano e Valdobbiadene (Prosecco Hills)	2019	Italy	20,334	V	the bottle (...) These three components—the supply basin formed by the historic hillsides, the production sites (with their underground cellars) and the sales and distribution centres (the Champagne Houses)—illustrate the entire champagne production process. (...) The property includes part of the wine-growing landscape of the Prosecco wine production area. The landscape is characterized by 'hogback' hills, <i>ciglioni</i> —small plots of vines on narrow grassy terraces—forests, small villages and farmland. (...) Since the 17th century, the use of <i>ciglioni</i> has created a particular chequerboard landscape consisting of rows of vines parallel and vertical to the slopes. (...)	Sedimentary clastic rocks: conglomerates, marls, flysch (Miocene)	Parallel hogback ridges, with steep slopes and intervening corridors

One is related to traditional way of making and storing wine in Georgia, another one concerns vine growing culture in Pantelleria (Italy) with its clear scenic landscape dimension and the third one is the annual wine festival in Vevey (Switzerland).

Geological settings of the winescape-related UNESCO World Heritage properties are diverse and include volcanic, sedimentary and metamorphic bedrock of various ages (Table 1). Both ancient (Miocene – Tokaj) and recent (Pico) volcanic rocks support viticulture, with the latter being so young that very little soil has developed upon basaltic lava flows and indigenous techniques of planting vine evolved in this soilless environment. In the circum-alpine area, wine landscapes of Lavaux, Piedmont and Prosecco Hills are associated with clastic sedimentary sequences (Molasse) of Miocene age, with vineyards preferably set upon finer-grained variants (sandstones, siltstone) rather than coarse conglomerates. Finer-grained clastic and calcareous sediments occur in lowland wine regions of Aquitaine (St-Emilion), along the Loire valley and around Fertö/Neusiedlersee. Metamorphic basement is represented by schists (Alto Duero), slates (Rhine Valley) and gneiss (Wachau). Loess- and colluvium-mantled lower slopes provide the geological background for vine cultivation at Mt. Tokaj, Wachau and Climats in Burgundy. In most cases, however, soil resources were either scarce due to type of weathering or were prone to severe erosion due to high erodibility (loess). Therefore, terracing and construction of dividing walls made of stone and locally reinforced by plants are a unifying theme, irrespective of local geology.

Wine landscapes were set within various larger-scale landform ensembles, ranging from steep slopes to low-relief areas. The former are represented by river gorges (water gaps), exemplified by Wachau, Alto Duero and Upper Middle Rhine Valley, where steepness of the terrain required extensive terracing of valley slopes to make cultivation feasible (Fig. 2). Likewise, very steep slopes typify the Prosecco Hills and Lavaux, both located in the foreland of the Alps and composed of heterolithic Molasse series, ranging in lithological composition from conglomerates to clays. In both places, terracing was necessary as the average slope inclination exceeds 20°. At Lavaux, terrace construction took advantage of natural hillslope morphology, which in turn reflects local geological relationships (Reynard and Estoppey 2021). The steepest sections are built of coarse conglomerates, which support cliffs and crags up to 10–15 m high and these are unsuitable for any cultivation. However, they are separated by less inclined (although still fairly steep) slope sections on sandstone and claystone bedrock. These sections were divided into parcels and strips, buttressing walls were built, whereas conglomerate cliffs, artificially reinforced to ensure higher stability, provided first-order divisions (Fig. 3). Extremely steep are coastal slopes in Cinque Terre, where extensive terracing was involved too. However, harsh working conditions and high incidence of devastating mass movements led to widespread abandonment of vineyard plots and it is estimated that more than 80% of terraced fields are no longer maintained and in use (Brandolini 2017).

Moderate relief characterizes the vineyard landscapes of Piedmont in Italy and along the Dijon – Beaune fault-generated escarpment in Burgundy. At the Tokaj Wine Region, Historic Cultural Landscape vineyards occur on low-angle ($<10^\circ$) lower slopes underlain mainly by rhyolitic tuff of Middle to Late Miocene age, including the characteristic landmark of Mt. Tokaj itself, built of pyroxene dacite (Szepesi et al. 2017). Their footslopes are covered by loess, favouring viticulture. Vineyards at the World Heritage property in Champagne occupy rather gentle lower slopes of a cuesta front underlain by soft chalk and partly a floodplain, as does the winescape around St-Emilion. The setting of vineyards around Neusiedlersee is similar, although they are mostly located in the buffer zone, occupying higher ground. Both the floodplain and higher valley bluffs are used for

viticulture along the Loire river. A narrow coastal strip, with near-level morphology reflecting the original relief of lava flows, is used for traditional vine growing on the Pico Island.

UNESCO Global Geoparks

Following the criteria presented earlier, 38 European geoparks—members of the UNESCO Global Geoparks network—were considered in the analysis. Expectedly, most of these geoparks are present in the circum-Mediterranean zone and only a few occur further to the north. Representation by country is very uneven, which reflects the diverse number of geoparks in particular countries (Fig. 1). Spain (9 geoparks), Italy (7) and France (6) are most represented, followed by Greece and Portugal (4

Fig. 1 Location of UNESCO World Heritage properties and UNESCO Global Geoparks analyzed in this paper. Global geoparks. Portugal: 1 – Azores, 2 – Arouca, 3 – Terras de Cavaleiros, 4 – Naturtejo da Meseta Meridional; Spain: 5 – El Hierro, 6 – Lanzarote and Chinijo Islands, 7 – Granada; 8 – Sierras Subbéticas, 9 – Sierra Norte de Sevilla, 10 – Villuercas Ibores Jara, 11 – Courel, 12 – Orizans, 13 – Central Catalunya, 14 – Causses du Quercy, 15 – Monts d’Ardèche, 16 – Luberon, 17 – Massif des Bauges, 18 – Beaujolais, 19 – Chablais; Germany: 20 – Bergstrasse-Odenwald; Italy: 21 – Sesia Val Grande, 22

– Beigua, 23 – Alpi Apuani, 24 – Tuscan Mining Geopark, 25 – Cilento, Vallo di Diano and Alburni, 26 – Pollino, 27 – Madonie, 28 – Rocca di Cerere; Croatia: 29 – Vis Archipelago, 30 – Papuk; Austria/Slovenia: 31 – Karawanken/Karavanke; Hungary: 32 – Bakony-Balaton; Hungary/Slovakia: 33 – Novohrad-Nógrád; Greece: 34 – Chelmos Vouraikos, 35 – Psiloritis, 36 – Sitia, 37 – Lesvos Island; Cyprus: 38 – Troodos. Note that names of UNESCO World Heritage properties are given in abbreviated form

each). Two geoparks occur in Croatia and Hungary (including a transboundary one with Slovakia), whereas Austria/Slovenia (transboundary one), Cyprus and Germany have one geopark each. Among these 38 geoparks, 29 are in mainland Europe and nine are located on islands or their parts. Within the latter, six geoparks are on Mediterranean islands and the remaining three were established on Atlantic islands.

In terms of geological/geotectonic setting, nearly two-thirds of the total number of geoparks are within the Alpine orogenic system that includes the Betic Mountains (2), the Pyrenees (2), the Alps (5), the Apennines and their prolongation to Sicily (7), the Dinarides (2), the Hellenides (4) and the Taurides (1). Twelve geoparks encompass the Variscan basement and its sedimentary cover, situated to the north of the Alpine chain or, in the case of Hungarian geoparks, within it. Three geoparks are located on volcanic islands in the Atlantic Ocean, related to ongoing hotspot activity. Given that geoparks occupy large areas, much larger in extent than UNESCO World Heritage properties, and in the majority of cases they include very diverse lithologies, their general characterization in terms of lithology does not seem feasible and meaningful in the context of this analysis. However, sedimentary clastic and carbonate rocks of Mesozoic age seem to predominate, whereas volcanic rocks may have more localized occurrence within the geoparks, but they distinctively influence landforms patterns.

Geoparks selected for the analysis vary in terms of general relief and specific landforms included into their territories. Climatic constraints on vine cultivation preclude representation of high-mountain terrains and even if high-elevation ridges are included into specific geoparks, wine industry is concentrated at lower elevations, in the foothills, within valley tracts, in mountain piedmont zones and intramontane depressions. However, local relief differences can still be considerable, requiring special adaptations to specific site conditions. Thus, most vine-growing areas belong to the category of medium- to low-altitude mountains, including those of volcanic origin, but dissected uplands and plains are represented as well. A general observation is that European UNESCO Global Geoparks collectively represent a variety of geological and geomorphological settings, allowing for exploration of various links between terroir and wine culture (Fig. 4).

Evaluation

UNESCO World Heritage Properties

Examination of web-based resources presented in the introductory part of the paper demonstrates that relationships

Fig. 2 Vineyard landscapes at UNESCO World Heritage properties: **a, b** Wachau (Austria), **c, d** Upper Middle Rhine Valley (Germany). Note largely abandoned small plots on a terraced steep slate slope in **d**

Fig. 3 Adjustment of spatial pattern of vineyard plots in Lavaux to geology and landforms: vertical slope sections are in coarse conglomerates (foreground, right), intervening less inclined slope sections in sandstones and mudstones allow for cultivation

between abiotic environment and wine culture are rather poorly addressed, and in many cases, they are not explored at all (Table 2). This is particularly evident in the summary statements of outstanding universal value, since these relationships are alluded to at only two World Heritage properties (out of 14) and even there, without going into any specific linkages. Thus, the OUV statement for The Climats in Burgundy emphasizes that individual vineyard parcels ‘differ from one another due to specific natural conditions (geology and exposure) as well as vine types and have been shaped by human cultivation’, whereas in the case of Prosecco Hills ‘The landscape is characterized by ‘hogback’ hills, ciglioni – small plots of vines on narrow grassy terraces – forests, small villages and farmland. For centuries, this rugged terrain has been shaped and adapted by man’. Whereas OUV statements are by necessity very brief and not suitable to explore complex causal linkages between various characteristics of the properties, longer descriptions of OUV available from the World Heritage Committee website offer better opportunities. Nevertheless, except one, in no other case are such linkages presented in more detail, whether in general description part or integrity part. The exception is Tokaj Wine Region, where ‘The unique combination of topographic, environmental and climatic conditions (...), with its volcanic slopes, wetlands creating a special microclimate that favours the apparition of the ‘noble rote’ (*Botrytis cinerea*), as well as the surrounding oak-woods have long been recognized as outstandingly favourable for grape cultivation and specialized wine production. All these features have enabled the development of vineyards, farms, villages, small towns and historic networks of wine cellars carved by hand into mostly volcanic rocks, which are the most characteristic structures in Tokaj’. Thus, two aspects are emphasized,

one related to complex geology—landforms—soils interrelationships and another one to specific rock properties, which allowed for extensive excavations of subterranean chambers for wine storage. These two themes also indicated for Champagne Hillsides, House and Cellars, where ancient chalk quarries were enlarged to serve as storage rooms. Less exposed are terroir conditions at Cinque Terre, Climats in Burgundy and Prosecco Hills, whereas for the remaining nine properties they were entirely ignored.

A different picture, however, emerges from the critical analysis of nomination files. Abiotic environment as a complex factor underpinning wine culture and wine cultural landscapes is elaborately presented in four dossiers (two from Italy, one from France and one from Switzerland), whereas more superficial evaluation of its significance can be found in another six dossiers. Thus, in three cases only geodiversity–wine linkages remained overlooked (Loire Valley, Wachau, Fertö/Neusiedlersee) and one nomination file is not available (Cinque Terre). All these three nominations were prepared in the late 1990s and inscriptions took place in 2000–2001. Since that time, terroir conditions have apparently been better realized and in four out of five most recent nominations, geology, landforms, soils and climate have been extensively presented.

A final group of resources examined were websites of specific World Heritage properties, linked to the official World Heritage Committee website. It seems that only eight properties maintain their own websites and the only one where the terroir is presented in more detail is the Loire Valley (although in French only). In three other cases, presentation is rather sketchy, whereas four properties do not provide any easily accessible information. Of particular note is the website of Lavaux Vineyard Terraces, where the lack of information

contrasts with an extensive coverage of the theme in the nomination dossier.

General observations emerging from this evaluation are as follows. First, the theme is insufficiently explored and poorly communicated to the public. Consequently, the crucial role of terroir and specific evident instances of geological or geomorphological underpinning will likely remain neglected and possibly misunderstood. Second, as time went by, the situation improved and the more recent nomination files contain extensive presentations of abiotic environment. However, this positive trend is only partially reflected in OUV descriptions, which concentrate on scenic aspects of wine landscapes, land use patterns, traditions and historical architecture. Third, nomination files are good resources to learn about geological and geomorphological conditions of vine cultivation, but they are not necessarily user-friendly. Specialist language (in some cases, presentation in French instead of English, although allowed by the World Heritage Committee) and difficult navigation limit their usefulness.

UNESCO Global Geoparks

Within the total of 38 geoparks considered in this study, viticulture is mentioned in only eight descriptive characteristics presented on the official website of UNESCO Global Geoparks programme (Troodos, Beaujolais, Chablais, Massif des Bauges, Monts d'Ardèche, Sesia Val Grande, Azores, Origens) (Table 3). Half of them is located in France, confirming strong connection with wine culture typical for this country, and one each in Cyprus, Italy, Portugal and Spain. In addition, although winemaking traditions are not specifically emphasized in the introductory description of

Lanzarote and Chinijo Islands, the cover image shows the indigenous winescape, with shallow hollows dug to plant vine, surrounded by crescentic walls built from the local volcanic stone. These specific constructions aim to protect vine against strong offshore winds and prevent aeolian soil erosion.

For most of these geoparks, information about local wine culture is contained only within the 'Sustaining local communities' part of the web-based presentation (Troodos, Chablais, Monts d'Ardèche, Azores, Sesia Val Grande and Origens). Thus, regional wine and viticulture are mainly seen as one of sources of income for the local communities, consistent with the idea of sustainable development championed in geoparks, rather than as an example of close connection between abiotic environment and human activities. Two exceptions are French geoparks of Beaujolais and Massif des Bauges, for which linkages between geology, landforms and wine are more explicitly mentioned. The descriptive characteristics of Beaujolais geopark, most clearly associated with winemaking due to its world-famous *Beaujolais nouveau* wines, includes the following statement: '[Geopark is] renowned worldwide for its wines and the territory benefits from an exceptional geological diversity that has been shaped over nearly 500 million years. (...) Mont Brouilly is one of the most emblematic sites of the Beaujolais UNESCO Global Geopark. Rising in the heart of the wine-growing coast, Mont Brouilly is witness to the long and tumultuous geological history of Beaujolais. This geosite offers spectacular panoramas and a sustainable layout to discover its geology, history and legends, the vineyards and forests of Beaujolais'. For the Massif des Bauges geopark, a comparable statement holds that 'In the Massif des Bauges UNESCO Global Geopark, geotourism concerns not only

Fig. 4 Vineyards cover lower and middle slopes of volcanic Mt. Badacsony in the Bakony-Balaton UNESCO Global Geopark

Table 2 Coverage of environment—wine culture relationships at UNESCO World Heritage properties (‘–’ – absent, ‘+/-’ – mentioned at very general level, ‘+’ – more elaborately presented). For website addresses, see the reference list

	OUV statement	OUV description	Nomination file	WH property website	Remarks regarding nomination file
Cinque Terre	–	+/-	n/a	+/-	
St. Emilion	–	–	+/-	+/-	Terroir mentioned, but at elementary level
Loire Valley	–	–	–	+	
Wachau	–	–	–	–	
Fertő/Neusiedlersee	–	–	–	–	Linkages emphasized but not explored in any detail
Alto Duero	–	–	+/-	n/a	Focus on landscape, with scant coverage of geology and soils
Upper Middle Rhine Valley	–	–	+/-	–	Remarks on hillslope shapes, geology poorly covered
Tokaj	–	+	+/-	n/a	Basic level of presentation, brief mention of tuff mechanical properties as favouring cellar excavation
Pico	–	–	+/-	n/a	Landform configuration and thermal properties of basalt mentioned
Lavaux	–	–	+	–	Very comprehensive description of geology and landforms in nomination file
Piedmont	–	–	+	n/a	Extensive coverage of abiotic environment in nomination file, both as a summary and for individual components
Burgundy	+/-	+/-	+	n/a	Good coverage of geology and landforms in nomination file
Champagne	–	+/-	+/-	+/-	Specific properties of chalk emphasized (soils, easy excavation for cellars)
Prosecco Hills	+/-	+/-	+	n/a	Extensive coverage of abiotic environment, focus on landforms, water resources and climate

geology, but also closely linked themes. For example, local wine producers have long been aware that the quality and originality of their wines are due to the area’s soils and exposures’. In the description of various activities in the geopark, the role of winemakers as guides of specialist field trips focused on exploration of relationships between terroir and wine is emphasized.

Much more information about local wine culture can be found on the official websites of particular geoparks, although it is still dominated by presentation of wine as one of local products. Thus, local wine is considered a brand product within a ‘Geo-food’ project coordinated by a geopark (e.g. ‘geo-wine’ in Naturtejo in Portugal) or is emphasized as a product offered by local vineyards, which hold a distinction of being partners of geoparks (‘geo-partners’). Among famous wines specifically listed as products of geoparks are Commandaria from Troodos (‘Cyprus sweet white wine famous from ancient time’), Grašavina from Papuk and Plavac mali from Vis Archipelago, both in Croatia, French AOP Cahors from Causses du Quercy, AOP ‘vins de Savoie’ from Massif des Bauges and the Chatus from Monts d’Ardèche, or Italian Gattinara from Sesia Val Grande. Some wine producers include geo-motifs on labels of their wines, be they related to geology (e.g. fossils from sedimentary rocks exposed in Origenes) or geomorphology (e.g. winescapes in volcanic terrains of Lanzarote and Chinijo). The sale names of the wines themselves may also indicate geological origins of the terrain, as shown by Terras de Lava, Magma and

Basalto wines from Azores, or Volcanic Malvasia from Lanzarote. In specific cases, the labels or accompanying flyers inform about geological history of an area and specific features of wine derived from soil characteristics.

In several geoparks, vine cultivation is a novelty, recently introduced or re-introduced after decades of abandonment of vineyards. In Alpi Apuani, an experimental vineyard was established at an altitude of 850 m a.s.l. and the wine is labelled as ‘Mountain wine’. According to geopark authorities, viticulture at this elevation is now possible due to ongoing climate warming, and given current trends of climate change it may be hypothesized that traditional climate-related altitude limits for winemaking will be exceeded over larger areas, providing an opportunity to begin vine cultivation in new areas. Another example of this adjustment to environmental change is setting up of a vineyard and winery in the village of Sittersdorf in Karawanken in Austria, where vines were grown in medieval times, as confirmed by the presence of grape motif in the coat of arms, but not continued in subsequent centuries coincident with the Little Ice Age. Nowadays, an annual wine festival in Sittersdorf is among mass events promoted by the geopark.

A few geopark websites provide brief information about characteristic wine-related landscapes. For example, the occurrence of steep mountain slopes that were terraced to provide space for cultivation is highlighted for Courel Mountains and El Hierro (Spain), as well as for Monts d’Ardèche. From the

Table 3 Overview of information about relationships between wine culture, geodiversity and geoheritage contained in official web-based resources about UNESCO Global Geoparks ('+' – mentioned, '–' – absent; specific themes indicated if relevant). For website addresses, see the reference list

	Name of the geopark	Country	Information on official UNESCO website		Information on geopark's own website		
			'Celebrating Earth Heritage' part	'Sustaining local communities' part	Wine as local product	Wine cultural landscape	Wine and geo-resources
1.	Karawanken /Karavanke	Austria/Slovenia	–	–	Rebirth of old tradition (on small scale)	–	–
2.	Papuk	Croatia	–	–	Kutjevo wine cellars	–	–
3.	Vis Archipelago	Croatia	–	–	+	Dry stone terraces landscape	–
4.	Troodos	Cyprus	–	+	+	Vineyards scattered across the area	–
5.	Beaujolais	France	+	+	+	Plains and hillsides	Relation between wine and soil
6.	Causses du Quercy	France	–	–	+	–	–
7.	Chablais	France	–	+	+	–	–
8.	Luberon	France	–	–	+	–	–
9.	Massif des Bauges	France	+	+	+	–	Geo-wine tourism
10.	Monts d'Ardèche	France	–	+	+	Dry stone terraces landscape	–
11.	Bergstrasse-Odenwald	Germany	–	–	+	–	'Wine and Rock' thematic trail
12.	Chelmos Vouraikos	Greece	–	–	+	–	–
13.	Lesvos Island	Greece	–	–	+	–	Geo-wine tourism
14.	Psiloritis	Greece	–	–	+	–	–
15.	Sitia	Greece	–	–	–	–	–
16.	Bakony-Balaton	Hungary	–	–	+	–	–
17.	Novohrad-Nógrád	Hungary /Slovakia	–	–	–	–	–
18.	Alpi Apuani	Italy	–	–	New project 'Mountain wine'	–	–
19.	Beigua	Italy	–	–	+	–	–
20.	Cilento, Vallo di Diano and Alburni	Italy	–	–	Idea of slow wine	–	–
21.	Madonie (Sicily)	Italy	–	–	–	–	–
22.	Pollino	Italy	–	–	–	–	–
23.	Rocca di Cerere	Italy	–	–	–	–	–
24.	Sesia Val Grande	Italy	–	+	+	–	–
25.	Tuscan Mining Geopark	Italy	–	–	–	–	–
26.	Azores	Portugal	–	+	+	Viticulture landscape of Pico Island	–
27.	Arouca	Portugal	–	–	+	–	–
28.	Naturtejo da Meseta Meridional	Portugal	–	–	+	–	–
29.	Terras de Cavaleiros	Portugal	–	–	+	–	+

Table 3 (continued)

Name of the geopark	Country	Information on official UNESCO website		Information on geopark's own website		
		'Celebrating Earth Heritage' part	'Sustaining local communities' part	Wine as local product	Wine cultural landscape	Wine and geo-resources
30. Courel Mountains	Spain	—	—	+	Ribeira Sacra region—wine terraces on very steep slopes	—
31. El Hierro	Spain	—	—	—	—	—
32. Granada	Spain	—	—	+	—	Geo-wine tourism
33. Central Catalonia	Spain	—	—	+	Small plots of vines surrounded by forest	—
34. Lanzarote and Chinijo Islands	Spain	Not in text, but wine landscape shown on cover photo	—	+	Wine landscape of La Geria	Geo-wine tourism
35. Origenes	Spain	—	+	+	High-mountain vineyards	Wine production in 12 th C stone vats
36. Sierra Norte de Sevilla	Spain	—	—	—	—	—
37. Sierras Subbéticas	Spain	—	—	—	—	—
38. Villuercas Ibores Jara	Spain	—	—	+	—	—

Central Catalonia geopark (Spain) website, one can learn about Roman origins of viticulture and the widespread presence of dry stone terraces. The Abadal winery, an official partner of the geopark, is distinctive through its 'small plots of vines surrounded by forest'. An anthropogenic wine landscape is also characteristic for Vis Archipelago. An imprint of vine cultivation on the physical landscape is also emphasized in volcanic geoparks of Azores and Lanzarote and Chinijo Islands. In the latter, a description of La Geria geosite informs that 'in addition to its geological value, also enjoys a landscape derived from popular use for agriculture in Lanzarote, where grapevines and other fruits are grown in holes dug in the lapilli'.

Information about tailored guided tours that explore linkages between geology and wine is rarely provided on the official websites of geoparks. Relevant offers are available for Beaujolais, Massif des Bauges (in French only), Bergstrasse-Odenwald (Germany), Granada and Origenes (Spain). In Bergstrasse-Odenwald, one can follow a specialist 'Wine and Rock' trail, available with a guide, but also suitable for individual visits, helped by leaflets prepared separately for adults and children (Weber 2018). Guided tours include wine tasting. Beaujolais promotes the Hameau Dubœuf oenological park that consists of a museum and gardens, promising that 'as you go through the museum, you'll gaze at the unique site that focuses on the relations between the vineyard and the soil'.

However, other website resources such as social media and wine-focused websites—not feasible to be explored

systematically for all geoparks—suggest that specialist trips centred around the geology and wine theme are organized in other geoparks as well. Examples include the Novohrad Wine Route and Tuff Cellar Route in the Slovak part of Novohrad-Nógrád and guided tours available in Lesvos Island (Greece), but this information is missing on official geopark websites.

Discussion

The last few decades have seen three parallel developments: (1) rapid growth of geotourism (Dowling 2011), both in terms of new tourist products available to tourists as well as increasing popularity of geoheritage destinations, including geoparks (Štrba et al. 2020); (2) increasing interest in wine tourism (López-Guzmán et al. 2014; Karagiannis and Metaxas 2020); and (3) increasing awareness of the value of cultural landscapes, which are now considered heritage worth conserving (Lugeri et al. 2011; Taylor and Lennon 2011). Among the latter are cultural landscapes of outstanding universal value and global significance, hence fulfilling the criteria to become UNESCO World Heritage properties. These circumstances, taken in conjunction, create an opportunity to strengthen links between geoheritage awareness and wine-related cultural heritage, both tangible (cultural landscapes) and intangible (region-specific winemaking traditions). UNESCO World Heritage properties and UNESCO

Global Geoparks seem to be particularly suited to explore these links, capitalizing upon international significance of wine-related cultural heritage, geoheritage or both. However, an important comment here is that these two UNESCO-branded properties have different aims and hence, explorations of possible linkages will have to follow different paths. Whereas the primary aim of UNESCO World Heritage properties is ensure safeguarding of inherited values and conservation remains a priority, UNESCO Global Geoparks focus on sustainable local development (Frey 2021), geotourism and geo-education towards increasing awareness of geoheritage and geodiversity. Implications of these different overarching goals are at least threefold. First, any tourism-oriented activities undertaken at UNESCO World Heritage sites, including the development of facilities, have to comply with long-term conservation strategies, whereas in geoparks there seems to be more freedom in creating geo-products. Second, interpretation trajectories are likely to be different. Human activities and their landscape effects are an obvious starting point at UNESCO World Heritage properties, leading to a question what factors proved decisive for the development of wine culture in this particular place. By contrast, in geoparks, interpretation is built around and upon geological and landform characteristics, following the ABC concept, where abiotic factors underpin the cultural environment (Dowling 2013; Pásková et al. 2021). Here, winemaking process is presented as one among the ways to use available geo-resources. Third, these different priorities may be reflected in dissimilar profiles of visitors, their expectations and levels of a priori knowledge. Various studies have shown that profiles of tourists primarily interested in cultural heritage sites (e.g. Huh et al. 2006; Poria et al. 2013; Adie and Hall 2017; Menor-Campos et al. 2020), involved in enotourism (Mitchell et al. 2002; Carlsen 2004; Tassiopoulos et al. 2004; Lameiras et al. 2016) and visiting geosites (Dowling 2011; Vasiljević et al. 2018; Allan and Shavanddasht 2019; Rivero et al. 2019), are markedly different. For example, as a consequence of focus on geo-education, geoparks are visited by both individual tourists, including those with specific interest in Earth heritage already developed, and school groups and families. Logically, given these different target groups at different properties, the range of activities aimed at discovering the relationships between terroir and wine culture should be wide and diverse (Table 4).

Nevertheless, our website information analysis shows that these relationships are insufficiently explored, at least from the perspective of tourists and within easiest-to-find web-based resources, which are official websites of both UNESCO-endorsed programmes and websites of particular World Heritage properties and geoparks (acknowledging that these relationships may be much more effectively presented in reality). Within these, cultural, aesthetic and economic aspects are evidently given more emphasis. Most comprehensively are they presented in nomination dossiers for World Heritage

status, although the depth of coverage varies and, in general, the more recent are the documents, the more insightful they are regarding the links between local geology, environment and wine culture. However, this in-depth treatment does not translate into specific emphasis on the underpinning role of geo-factors in the OUV statements and justifications, save a few examples. Likewise, official websites of particular properties address these linkages rather superficially (if at all), although again, exceptions exist. On the other hand, the availability of well-presented cases in nomination files provides a good background for future development of educational packages and tourist products developed by various local stakeholders, where these causal relationships could be further explored. Nomination files are freely accessible to everyone through the UNESCO World Heritage website, but some are difficult to navigate through because of dispersal of relevant information within a dossier and/or a too general table of contents. Nevertheless, they may provide a good starting point to develop interpretation of factors behind wine culture at particular localities, to be presented in a way accessible to both general public and interested geotourists. Of particular note is an opportunity to combine two perspectives, from the surface that would directly focus on attributes of the terroir (soils, land configuration, geographical setting, microclimate), and from underground, allowing one to examine the rocks more closely. The latter is offered by extensive subterranean wine storage facilities present at some properties, such as Tokaj Wine Region and Champagne Hillside Houses and Cellars.

In the specific context of web resources maintained by UNESCO Global Geoparks, wine is typically highlighted as one of local products or a branded geo-product. In addition, vineyards holding the status of a certified partner of a geoparks are promoted. This is consistent and in full agreement with the fundamental premises of UNESCO Global Geoparks, which aim to support economic development at the local level (Zouros 2008; Rodrigues et al. 2020), but is insufficient if contrasted with the holistic vision of geoparks, where geo-education should not be limited to various aspects of distant geological history, but include multi-aspect human use of complex Earth resources as well. Building new tourist products, based on simultaneous acquaintance with local terroir and wine culture, might be a way to engage more visitors in geoheritage and geodiversity matters, even if their interest in geosciences is initially marginal. This is because the theme of wine production and consumption is perceived as less technical and easier to understand than geology and geomorphology. Moreover, proper exploration of these linkages should emphasize that geology is all but one abiotic factor contributing to the characteristics of terroir. It is mutually linked with surface landforms and processes, hydrological and topoclimatic conditions, illustrating the 'one Earth' view, with all cause-and-effect linkages. Equally important is the extent and nature of human interventions to make the land

suitable for vine cultivation—usually adjusted to natural terrain conditions, but also based on collective experience accumulated through centuries of land use and management. Speaking about ‘geology and wine’ is to simplify the actual relationships, which are much more complex.

Another aspect is better understanding of local wine product and its possible implications. Both winescapes protected within UNESCO World Heritage properties and particularly those present within UNESCO Global Geoparks are often located in marginal, hilly to mountainous areas, which suffer from various socio-economic problems (Lourenço-Gomes et al. 2015). These include adverse conditions for local winemaking, which requires more labour expenditure than in lowland settings and hence results in higher production costs (Nicolosi et al. 2016). It has been demonstrated that increasing knowledge of local conditions translates into higher level of acceptance of higher sale prices among potential buyers, whereas good memories contribute to a sense of loyalty to particular brands (Dodd and Beverland 2001; Alant and Bruwer 2004; Howley and van Westering 2008; Dawson et al. 2011), which may be capitalized by producers of these brand products in geoparks. Higher revenues from sales of geopark-endorsed products may in turn increase the level of support for geopark among the entrepreneurs.

The development of geoheritage-oriented wine tourism, to be holistic and scientifically sound, may first require education of the winemakers themselves, whose understanding of geology may be intuitive and limited to certain specific themes rather than it is science-based and sufficiently broad. This could be challenging, but is a key ingredient of the success in geo-education. Another challenge is to reconcile tourist visitations and the rhythm of work at vineyards (Hall et al. 2009; Koch et al. 2013; Mazurkiewicz-Pizło 2014; Mazurkiewicz-Pizło and Pizło 2018;

Pijet-Migoń and Królikowska 2020). The peak tourist season and the peak of work often overlap, meaning limited availability of winemakers to guide the visitors, although this may not be an issue at large wineries which may have dedicated visitor centres and guided tours on offer. On the other hand, this temporal overlap may be used as an opportunity to engage visitors in the winemaking process and hence, indirectly, to facilitate better understanding of factors behind successful viticulture.

Conclusions

Winemaking is a human activity that is related to Earth resources in multiple ways. They are encapsulated under the term ‘terroir’, which can be resolved into a range of geo-factors, such as bedrock and its susceptibility to weathering, soils and their characteristics, geomorphological setting, which may reflect both the underlying geology and various exogenous forces, local hydrological conditions, and micro- and topoclimate. Causal relationships between these abiotic factors and wine production have long been appreciated by winemakers, but seem to be relatively seldom used as an opportunity to build customized geotourist products and to develop geo-educational activities. This contrasts with widespread emphasis on cultural imprints on winescapes, their cultural significance and aesthetic values, including those recognized at the global scale as of outstanding universal value. This imbalance appears clearly in the basic web-available resources examined for the purpose of this study. Our survey showed that geodiversity and geoheritage values of vine-growing areas within UNESCO World Heritage properties and UNESCO Global Geoparks are often insufficiently addressed, at least from the perspective of prospective tourists who would consult easiest-to-find web-available information.

Table 4 Means to show relationships between geo-resources and wine culture practiced in European geoparks—members of UNESCO Global Geoparks network

Products and activities	Examples
‘Geo’-wines (name, labels and flyers with information about geology and terroir)	Naturtejo, Origenes, Lanzarote and Chinijo Islands, Azores, Causses du Quercy, Luberon
Wine tasting with special commentaries	Lesvos Island, Beaujolais, Massif des Bauges, Bergstrasse-Odenwald
Guided tours	Beaujolais, Massif des Bauges, Granada, Origenes, Bergstrasse-Odenwald, Lesvos Island
Visits to wine cellars	Novohrad-Nógrád, Papuk
Thematic trails	Bergstrasse-Odenwald, Beaujolais, Massif des Bauges
Alternative sightseeing (e.g. games, questing, geocaching)	Bergstrasse-Odenwald
Information panels, exhibitions, dedicated visitor centres, museums of wine	Beaujolais, Massif des Bauges, Azores, Lanzarote and Chinijo, Origenes
Special events and festivals during grape harvesting	Karavanken, Beaujolais, Massif des Bauges
Special events (e.g. conferences, festivals) outside geoparks	Event GoVolcanic*—promoting wines of the volcanic regions all over the world

*<https://2019.govolcanic.com>

Examination of these resources has revealed that very few properties emphasize these linkages, even if they are comprehensively explored in specialist studies such as nomination files for UNESCO World Heritage properties. Within UNESCO Global Geoparks, wine is typically presented as one of local products of a geopark and only a handful of geoparks underlines wine culture as an emanation of local and regional geo-factors on their websites and in promotional materials. However, we are aware that systematic field survey of these various properties and proposals addressed to tourists on-site may reveal a different picture and, at least in some areas, a better state of integration between geodiversity and cultural factors.

Opportunities to use traditions of wine production to develop geotourist products and to increase visitors' awareness in geoheritage and geodiversity matters should not be neglected. First, this would be a logical step from something familiar (wine) to less familiar (environmental resources), which is an acknowledged way to make people more engaged and apprehensive. Second, relationships between abiotic factors and wine culture are multiple, so that both complex terrain evaluation is possible and insights into deeper geology can be provided while visiting underground cellars, often dug in specific rock types. Growing interest in wine tourism observed worldwide can certainly be used to promote geoheritage, especially in areas already recognized for their international value such as wine-related UNESCO World Heritage properties and UNESCO Global Geoparks in the vine-growing belt.

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