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Inventory and Enhancement of Geological Heritage in the Ouzoud Syncline (M'Goun UNESCO Geopark, Central High Atlas, Morocco): First Step for Promoting Geotourism and Sustainable Development

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Abstract: The Ouzoud syncline, in central Morocco, is one of the kingdom's wealthiest areas of natural and cultural heritage. This syncline has significant potential for geotourism development; it contains the Ouzoud waterfalls, one of the most coveted tourist attractions, which are part of the geosites listed in the M'Goun Unesco Geopark. The abundance of resurgences, waterfalls, travertine, caves, magmatic rocks, exceptional geomorphological forms, and fascinating panoramic views make this territory a suitable tourist destination for excursions, hiking and climbing, and a good support for understanding the geological history of the central High Atlas (CHA) of Morocco and paleoclimate changes. The dense and diversified vegetation cover offers a habitat for various animals (magot monkeys, bats, birds), which attracts more nature-loving tourists. This exceptional geo-biodiversity and cultural wealth (traditional mills and the Zaouïa of Tanaghmelt) that may constitute a lever for local socio-economic development remain unknown to the public and not well exploited by managers. Hence, this study attempted to inventory and assess interest sites for providing a database that help decision-makers in in territorial planning and geoheritage conservation and promotion. Thus, about twenty highly attractive geosites were inventoried, eight of which (the most important ones) were selected for evaluation using the Reynard et al. (2016) methodology. This approach considers the scientific value, the additional values, and the use and management values of sites. Such promotion can popularise the geosciences and create income-generating activities, which will improve the economic situation of the local population

Keywords: geoheritage; Ouzoud syncline; geotourism; inventory; assessment; geopark

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1. Introduction

In recent years, several attempts to enhance and protect geoheritage have emerged in several countries around the world [1–8] and particularly in Morocco [9–16]. Geological heritage refers to all geological features and objects (rocks, minerals, geomorphological and geological forms, fossils) or sites, sometimes culturally important, which offer an overview of the history of the earth and testify to the climatic changes or the tectonic evolution of the earth's crust [17,18]. The smallest unit of these systems is called a Geosite, a site of interest that allows the exploitation of geological features for geotourism and geodidactic purposes [19,20]. A site can only be considered as a geosite if it combines several interests at the same time, including the scientific value that is considered central. This makes sites more susceptible to being promoted for geotourism purposes and preserved against natural and anthropic threats. In Morocco, few efforts have been undertaken to enhance the geoheritage, a large part of which is still unknown and under-exploited by managers. This low level of valorisation can be attributed to managers

and visitors who are unaware of geological heritage and who are primarily concerned with aesthetics while ignoring the scientific and educational aspects of geological items. This work aims to fill this gap by highlighting the geological heritage of Ouzoud syncline through an inventory supported by a quantitative assessment to provide a database that would help decision-makers in any development project of local tourism. The choice of this syncline is explained by its particular characteristics that make it a territory of considerable tourist attraction: it contains the Ouzoud waterfalls, a site of international interest listed in the M'Goun Unesco geopark with good tourist infrastructure.

2. Geographical and Geological Setting

Geographically, the Ouzoud syncline belongs to the Beni Mellal- Khenifra region, to the Azilal province, and more precisely, to the rural commune of Ait Taguella (Figure 1a and b). It has a Mediterranean climate with wet winters and dry summers [21]. This territory is peopled by Amazigh Berber tribes whose main economic activities are agriculture, livestock and tourism. The vegetation cover consisted of cedar, holm oak, juniper, euphorbia, acacia, aromatic and medicinal plants, which offer favourable fauna habitat for several species such as the magot monkey, bats, and various bird species [22]. This is the reason why this area has been classified as a Site of Ecological and Biological Interest (SEBI).

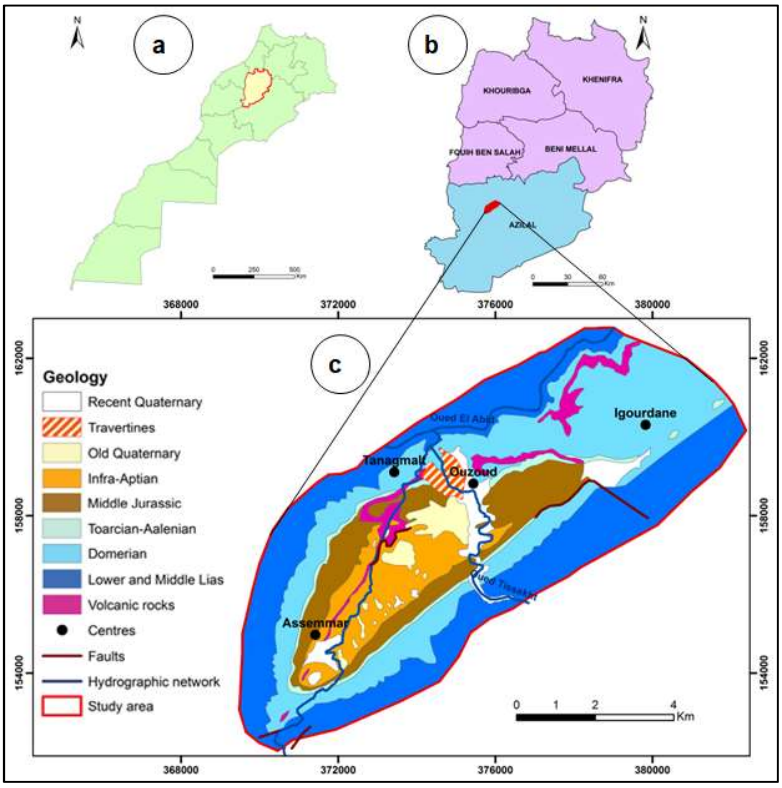


Figure 1. (**a**) Geographical situation of Beni Mellal-Khenifra region in the centre of Morocco; (**b**) Geographical situation of the study area in Beni Mellal-Khenifra region; (**c**) Geological map of study area extracted from geological map of Afourer 1/100000 and Azilal 1/100000.

Geologically, the Ouzoud syncline is one of the central High Atlas' synclines whose implementation is linked to differential subsidence and brittle tectonics of the Middle and Upper Jurassic [23]. It is a small basin, oriented North-East South-West (Figure 1 **c**), and located south of the Ait Attab syncline. It has the form of a more or less folded plateau occupied, in its majority, by marine Jurassic limestones (Ait Boulli, Jbel Rat, Aganane and Bine El Ouidane group) which alternate with continental red formations (Azilal and Iouaridene). This succession of transgressive and regressive mega-sequences thus attests

to a great change in the deposit environments. In addition, the syncline presents two types of magmatic rock deposits, notably doleritic sills and basaltic flows of 124 ± 2 Ma age (24), as well as quaternary deposits, the most important of which are the travertine concretions.

3. Materials and Methods

Recently, several attempts to inventory and valorise geosites have emerged by applying different methodologies that all agree on the importance of scientific value [5,7,25,26]. The inventory of geosites in the Ouzoud syncline began with a bibliographical study to highlight the study area's main geological and geomorphological characteristics. Then a series of field visits were carried out to collect information used in selecting and evaluating potential sites; these data are represented in the form of a data sheet including general data, description, morphogenesis and synthesis. Sites representative of the regional geology and geomorphology and having significant scientific value, are selected for quantitative assessment.

In this study, we chose to evaluate these geosites by the method of Reynard et al. (2016) because of its simplicity and relevance; it is based on the justification of geosites through the appreciation of their scientific, aesthetic, ecological and cultural values. The scientific value is evaluated based on four criteria: integrity, representativeness, rarity and palaeogeographical interest, each of these criteria is scored from 0 to 1 (a step of 0.25). Thus, the scientific value equals the arithmetic average of the four criteria mentioned above. The additional values are based on three values: ecological, aesthetic and cultural, highlighting the close link between the geosite and its environment [7]. Ecological value is assessed based on two criteria: ecological impact and protection status, while aesthetic value is assessed based on two values: viewpoint and structure. Cultural value is associated with the criterion of the highest value, be it religious, historical, artistic, literary, geohistorical or economic [7]. The assessment also includes a diagnosis of the current state of site protection, specifying the possible impacts and threats to propose protection measures that will ensure the sustainability of this heritage. This diagnosis also describes certain parameters about safety, accessibility, tourist infrastructures, the natural environment and development to promote these heritage assets better.

4. Results

4.1. Presentation of the Selected Geosites

The inventory of the geological heritage in the study area reveals the existence of over twenty potential sites, from which the most representative ones are chosen to illustrate the remarkable geodiversity of the syncline (Figure 2). Table 1 presents the geological characteristics of the selected sites.

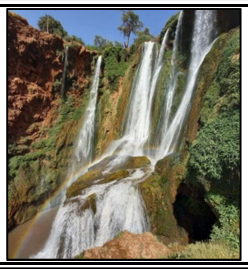
4.2 Assessment of the Scientific and Additional Values of Selected Geosites

The inventory of geosites in the Ouzoud syncline is carried out in two phases. The first one includes selected potential sites through the analysis of geological and topographical maps and an in-depth bibliographical study. The next step is to confirm the scientific, educational and geotourism interests of potential sites through the organisation of field visits and consulting experts. Thus, eight geosites of scientific interest were selected for the quantitative assessment using the Reynard et al. (2016) methodology.

The quantitative assessment results revealed a high scientific value (average of 0.83) (Table 2) for all selected geosites because they are relatively preserved, unique, and representative of the regional geomorphology. These geosites also showed high palaeogeographic value, which testifies to a long geological history from the Lias to the recent quaternary. The site of Ouzoud waterfalls seems to be the most valuable of the syncline; it has the highest scientific value score due to its representativeness of fluvial and karstic processes, the splendour of its unique well-preserved outcrops and its exceptional biodiversity. It should be noted that this site is part of the M'Goun Unesco Geopark and is

also named a SBEI. The Ouzoud basaltic flows have the lowest score (0.69) due to their damaged condition caused by rock extraction activities.

Table 1. Geological characteristics of the selected gesites.

Name (code)	Main features	Photos
The dolerite sill of Ouzoud (OUZmag001)	The Ouzoud sill is located in the North-East, 3 km from the centre of Ouzoud. It is a greenish dolerite layer of Lower Cretaceous age [27] which intrudes the massifs limestones of the Dogger. It extends over a distance of 3.5 km and has a texture that tends to be microlitic with phenocrysts of olivine and pyroxene [28]. The same sill intersects the chocolate marls of the Aalenian-Toarcian and the last benches of the Domerian towards the west [28]. This site constitutes an educational station which can be used to teach magmatism process and stratigraphic principles.	
Ouzoud waterfalls (OUZhyd002)	The Ouzoud waterfalls are falls that occur when the Oued Tissakht crosses the Bajocian limestone cliffs, the most spectacular fall is about 110 m high at the bottom of a chasm covered with beautiful travertine concretions. This picturesque landscape constitutes an internationally known tourist attraction; it is one of the geosites of the M'Goun Unesco Geopark and a SEBI. At the top of the waterfalls, tourists can visit small grain mills that rotate by exploiting the speed of waterfalls. In some places, the speed of the river current has carved Giant's kettle in the limestone bedrock, forming basins that overflow into each other.	
The Ouzoud travertines (OUZKar003)	Important travertine stripping on the limestone cliffs dominates the Ouzoud waterfalls and along the Oued Tissakht. These concretions result from the precipitation of calcium carbonates dissolved in the river water following the degassing of C02 in the open air [29]. These changes in the physico-chemical parameters of water are closely related to hydrogeological, morphological, bioclimatic and anthropogenic conditions. The Ouzoud travertine's, particularly the oldest ones, have yielded beautiful leaf, root and twig imprints of various sizes that can characterise the Plio-quaternary ecological, climatic and hydrological paleoenvironment of the study area.	
The estuary of Oued Tissakht (OUZflu004)	The estuary of the Oued Tissakht is located only 3km from the Ouzoud waterfalls. This Tissakht watercourse descends quickly among limestone cliff of about fifteen meters high, covered with travertine. The rapid flow between these structures forms a turbulent eddy that joins the Oued El Abid, thus digging beautiful cavities of different sizes, known locally as the Ouzoud caves. These structures give this site an undeniable aesthetic interest.	
The Oued El Abid Gorges (OUZGeo005)	The Oued El Abid Gorges, located 7 km NNW of the Ouzoud waterfalls, are exceptional geomorphological forms carved out of the massive Lias limestone by the Oued El Abid, forming a very deep valley that exceeds 100 m. This river has succeeded over centuries of erosive events to shape a stratigraphic column from the Domerian to the Upper Jurassic. The caves lining the gorge provide habitat for monkeys, birds, and bats. This site attracts hundreds of hikers annually to enjoy unique and admirable landscapes.	
Azilal Fmintruded by the Tanaghmelt sill (OUZmag006)	About 800 m west of Tanaghmelt, we find a particular geological structure; it is a doleritic sill that cuts the reddish-brown marls of the Azilal Fm, leaving traces of contact metamorphism [28, 24]. The Azilal Fm is underlain by Domerian marine limestone; this transition from carbonate to terrigenous sedimentation is considered a good benchmark of marine regression. In addition to this geological wealth, the site contains an ancient religious building called the Zaouïa of Tanaghmelt that accumulated an impressive religious heritage dating back to the 7th century.	
The basaltic flows of Ouzoud (OUZmag007)	The basaltic flows of Ouzoud are located west of the syncline; they are associated with the upper part of the Iouaridene Fm, which corresponds to the second magmatic outpouring B2 of the Lower Cretaceous [24]. These flows, of 10 m thickness, present reddish grey facies, with vacuolated surfaces of prismatic structure at the top. Unfortunately, these magmatic rocks are being excessively exploited as building materials, which risks destroying this magmatic heritage.	
Ouzoud springs (OUZkar008)	Ouzoud springs are karstic resurgences; there are 22 of them, which gush out through a complex karstic system formed by carbonates of the Lias. Underground waters from these springs feed the Oued Tissakht and give rise to a favourable environment for developing diversified freshwater fauna (fish, gastropods, crabs, and insects). This geosite has constituted for a long time a favourite tourist destination to practice bivouac and camping within a picturesque, soft, and calm landscape.	

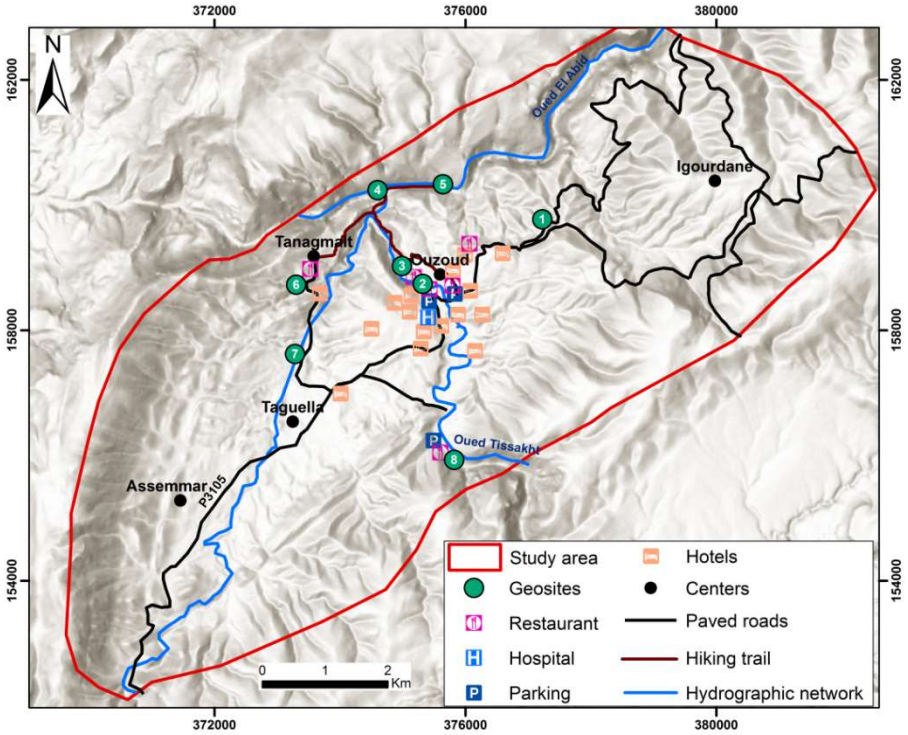


Figure 2. Map of inventoried geosites in the Ouzoud syncline.

The assessment showed that the average ecological value of the geosites is moderate (0.65). Indeed, the fertile soil of the study area and the relatively dense hydrographic network have contributed to the development of a dense and diversified vegetation cover represented by a forest of thuja, juniper, holm oak, euphorbia, and acacia. The latter constitutes a habitat for several rare animal species, such as the magot monkey and some bird and bat species. This explains the classification of Ouzoud as a site of biological and ecological interest, which means that the selected geosites are protected except for the sites of magmatic interest due to their location outside the wetland .Concerning the aesthetic value, we note that most geosites present several points of view with a rather important vertical development, particularly in the cascades of Ouzoud, the estuary of Oued Tissakht, and the gorges of Oued El Abid. The contrast of the water's blue colour with the green vegetation and the reddish, greyish, and dark geological formations gives these geosites a high aesthetic value (0.86). The cultural value is very important and reflects the authenticity of the Berber tribes of the HAC. This heritage is represented by architectural sites such as the traditional mills at the top of the waterfalls and the traditional earthen and adobe houses in the surrounding douars. The Zaouia (religious building) and the mosque of Tanaghmelt represent a religious and spiritual destination that annually receives students who come to profit from the old library containing one of the oldest and most precious book collections. The study area also contains socio-cultural sites (Souk) where the people exchange their often traditional products without neglecting the customs related to traditional hammams and irrigation. Among the selected geosites, the site of the Ouzoud waterfalls and the chocolate marls intruded by the Tanaghmelt dolerite sill are the most important, with a high cultural value (1). The increase in tourist offer around the waterfalls and the development of hiking tourism have led to the development of accommodation structures, so the province of Azilal has more than 107 tourist establishments with a total of 57915 arrivals in 2018 (Provincial Delegation of Azilal 2020). These tourist infrastructures offer many jobs contributing to developing the local population's economic situation. Table 2 represents the quantitative assessment results of scientific and additional values of the selected geosites.

Table 1: Quantitative assessment of scientific and additional value of inventoried geosites (According to Reynard et al. 2016)

Geosites		Scientific Value					Additional Value			
Code	Name	Int	Rep	Rar	Pal	Sci Val	Eco Val	Aes Val	Cul val	Add Val
OUZmag001	Doleritic sill of Ouzoud	0.75	0.75	0.5	1	0.75	0.62	0.87	0.25	0.58
OUZhyd002	Ouzoud waterfalls	1	1	1	1	1	0.87	1	1	0.96
OUZkar003	Ouzoud travertines	1	1	0.5	1	0.87	0.87	1	0.75	0.87
OUZflu004	Estuary of Oued Tissakht (Ouzoud caves)	1	1	0.75	0.75	0.87	0.5	1	0.5	0.66
OUZgem005	Oued El Abid Gorges	1	1	0.75	0.5	0.81	0.5	1	0.5	0.66
OUZmag006	Chocolate marl intruded by Tanaghmelt sill	1	1	0.75	0.75	0.87	0.5	0.75	1	0.75
OUZmag007	Basaltic flows of Ouzoud	0.5	1	0.5	0.75	0.69	0.5	0.5	0.25	0.42
OUZkar008	Karstic spring of Ouzoud	0.75	1	0.75	0.5	0.75	0.87	0.75	0.75	0.79

4.2. Use and Management Characteristics

The assessment of use and management characteristics is a method to evaluate the level of protection and potential uses of geosites. Protection is associated with the current status of integrity and vulnerability of the site, while promotion is based on accessibility, visit conditions, security and infrastructures. Table 3 shows an appreciation of the use and management value of geosites

In the Ouzoud locality, the demographic pressure is generally low, which means limited threats. However, the tourist flow reaches its maximum during the summer period, which increases the degradation risks of the site. The most vulnerable geosites are the waterfalls and springs of Ouzoud because they receive a considerable flow of tourists. At the same time, the magmatic sites present another risk of degradation linked to rock extraction work. The selected geosites present, in general, good conditions for a visit with better accessibility and tourist offer, only the geosites of "Estuary of Oued Tissakht" and "Oued El Abid gorges" which are accessible through footpaths but well traced and secured. Visitors can stay overnight in about 15 hotels and guesthouses or with local inhabitants. The tourism infrastructure is good, generally based on commercializing an attractive sites and drawer products such as olive oil, honey, and traditional crafts. These tourism activities can positively impact the local population, by creating considerable economic inputs that will improve the general quality of life in the syncline.

Table 2: Quantitative assessment of use and management value

Geosites	Use and Management Values					
	Protection Status	Eventual Threats	Touristic Infrastructure	Conditions of Visit	Access Road	Enhancement Installation
Doleritic sill of Ouzoud	**	***	**	****	****	Absent
Ouzoud waterfalls	****	***	****	****	****	Present
Ouzoud travertines	***	**	****	***	***	Absent
Estuary of Oued Tissakht (Ouzoud caves)	***	**	**	**	**	Absent
Oued El Abid Gorges	**	**	**	**	**	Absent
Chocolate marl intruded by Tanaghmelt sill	**	**	**	***	***	Absent
Basaltic flows of Ouzoud	**	****	**	***	***	Absent
Karstic spring of Ouzoud	***	***	***	***	***	Present

5. Conclusion and Discussion

The present study aimed to carry out an inventory and quantitative evaluation of the Ouzoud syncline geoheritage. The results showed that the study area is dominated by geosites of high scientific and additional value suitable for scientific, tourist, and educational use; it is a territory rich in geosites of international interest that deserves to be preserved and promoted the benefit of the local population. However, these geosites do

not benefit from any legal protection as geological heritage despite being part of the Unesco M'Goun Geopark and a SEBI. A national heritage protection law and comprehensive heritage management are missing. This management must consider the significance of geological forms, cultural buildings, and socio-economic activities concerning biological diversity [30]. Geotourism and geoeducation are vital tools that could be essential in protecting and enhancing national heritage. Thus, the Ouzoud waterfalls have benefited in recent years from extensive development to ensure sustainable and non-destructive tourism. As a result, the site has become cleaner, with rehabilitated restaurants and boutiques that respect the natural environment and the Amazigh architecture. Access has become easier with several footpaths equipped with interpretation panels. However, the development of regional geotourism requires good management and the best decisions to attract more visitors while ensuring the sustainability and conservation of the interest sites. This can only be achieved by promoting geoheritage to the local population and visitors; such action will provide the appropriate tools to make the local population more aware of the threats that may affect the heritage that belongs to them. It is, therefore, one of the essential steps in the concept of geoconservation [31]. On the other hand, geoeducation aims to disseminate geosciences to the public to conserve geodiversity and ensure its sustainability for future generations. Indeed, the geosites of the syncline offer a range of educational activities that can be applied outside the classroom. Thus, teachers can teach the principles of geology, such as stratigraphy, karstology, hydrology, magmatism, and the restitution of regional palaeogeography. Field visits can therefore be beneficial in stimulating learning about various geological phenomena.

In this sense, the UGGp of M'Goun seems to be the main actor who contributes directly to the socio-economic development of the region, it supports all tourism development projects, in particular geotourism. As a result, several mountain sports are mapped and listed (hiking, canyoning, climbing, etc.), and local products are encouraged through the social and solidarity economy (cooperatives), as well as producing digital tools that facilitate geopark location and the discovery of these geosites and tourist circuits. The Geopark managers also organise training courses, webinars, events and national and international conferences as tools for promoting and enhancing the territory.

In conclusion, to make the geosites more profitable within the M'goun geopark, it is recommended that new footpaths should be established to cover all sites in the syncline in order to reduce tourist concentration around the waterfalls and springs of Ouzoud; these footpaths should contain interpretive panels that explain the potential of this area as a tourist and geoeducational destination. The tourist infrastructure and offer should also be improved to attract different categories of tourists.

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References

1. Panizza, M., & Piacente, S. Geomorphosites: a bridge between scientific research, cultural integration and artistic suggestion. Il Quaternario, 2005, 18(1), 3-10
2. Newsome, D., & Dowling, R. Geoheritage and geotourism. In Geoheritage (pp. 305-321), 2018. Elsevier.doi: https://doi.org/10.1016/B978-0-12-809531-7.00017-4
3. Bruschi, V. M., & Cendrero, A. Geosite evaluation: can we measure intangible values. Il Quaternario (2005), 18(1), 293-306.
4. Pralong, J. P. Géotourisme et utilisation de sites naturels d'intérêt pour les sciences de la Terre: les régions de Crans-Montana-Sierre (Valais, Alpes suisses) et Chamonix-Mont-Blanc (Haute-Savoie, Alpes françaises). Univ. de Lausanne 2006, Faculté des Lettres, Inst. de Géographie.
5. Pereira, P., & Pereira, D. Methodological guidelines for geomorphosite assessment. Géomorphologie: relief, processus, environnement 2010, 16(2), 215-222. doi : https://doi.org/10.4000/geomorphologie.7942.
6. Brilha, J. B. (2014). Mining and geoconservation. Doi: 10.1007/978-3-642-40871-7_9-1.

7. Reynard, E., Perret, A., Bussard, J., Grangier, L., & Martin, S. Integrated approach for the inventory and management of geomorphological heritage at the regional scale. Geoheritage 2016, 8(1), 43-60.doi: https://doi.org/10.1007/s12371-015-0153-0.
8. Kubalíková, L., & Kirchner, K. Geosite and geomorphosite assessment as a tool for geoconservation and geotourism purposes: a case study from Vizovická vrchovina Highland (eastern part of the Czech Republic). Geoheritage 2016, 8(1), 5-14. doi : https://doi.org/10.1007/s12371-015-0143-2.
9. Enniouar, A., Errami, E., Lagnaoui, A., Bouaala, O. The Geoheritage of the Doukkala-Abda Region (Morocco): An Opportunity for Local Socio-Economic Sustainable Development. In: Errami, E., Brocx, M., Semeniuk, V. (eds) From Geoheritage to Geoparks. Geoheritage, Geoparks and Geotourism. Springer 2015, Cham. https://doi.org/10.1007/978-3-319-10708-0_7
10. Berred, S., Fadli, D., El Wartiti, M. et al. Geomorphosites of the Semi-arid Tata Region: Valorization of an Unknown Geoheritage for Geotourism Sustainable Development (Anti-Atlas, South Morocco). Geoheritage 11, 1989–2004 (2019). https://doi.org/10.1007/s12371-019-00414-w
11. Beraaouz, M., Macadam, J., Bouchaou, L. et al. An Inventory of Geoheritage Sites in the Draa Valley (Morocco): a Contribution to Promotion of Geotourism and Sustainable Development. Geoheritage 11, 241–255 (2019). https://doi.org/10.1007/s12371-017-0256-x
12. Rais,J. Barakat, A. Louz,E. Ait Barka,A. Geological heritage in the M'Goun geopark: A proposal of geo-itineraries around the Bine El Ouidane dam (Central High Atlas, Morocco). International Journal of Geoheritage and Parks (2021), 9 (2), 242-263. https://doi.org/10.1016/j.ijgeop.2021.02.006.
13. Arrad, T. Y., Errami, E., Ennih, N., Ouajhain, B., & Bouaouda, M. S. From geoheritage inventory to geoeducation and geotourism implications: Insight from Jbel Amsittene (Essaouira province, Morocco). Journal of African Earth Sciences (2020), 161, 103656. doi: https://doi.org/10.1016/j.jafrearsci.2019.103656.
14. Louz,E. Rais,J. Ait Barka,A. Nadem,S. Barakat,A. Geological heritage of the Taguelft syncline (M'Goun Geopark): Inventory, assessment, and promotion for geotourism development (Central High Atlas, Morocco). International Journal of Geoheritage and Parks (2022), 10(2), 218-239. https://doi.org/10.1016/j.ijgeop.2022.04.002.
15. Lahmidi, S., Lagnaoui, A., Bahaj, T., El Adnani, A., & Fadli, D. First inventory and assessment of the Geoheritage of Zagora province from the project Bani Geopark (South-Eastern Morocco). Proceedings of the Geologists' Association (2020), 131(5), 511-527. https://doi.org/10.1016/j.pgeola.2020.05.002
16. Ait Barka, Abdellah, Rais, Jamila, Barakat, Ahmed, Louz, Elhassan and Nadem, Samir. "The Karst Landscapes of Beni Mellal Atlas (Central Morocco): Identification for Promoting Geoconservation and Tourism" Quaestiones Geographicae, vol.0, no.0, 2022, pp.-. https://doi.org/10.2478/quageo-2022-0027
17. Moufti, M.R., Németh, K. Volcanic Geoheritage of Other Harrats of Kingdom of Saudi Arabia. In: Geoheritage of Volcanic Harrats in Saudi Arabia. Geoheritage, Geoparks and Geotourism (2016). Springer, Cham. https://doi.org/10.1007/978-3-319-33015-0_4
18. Charrière, A., Ibouh, H., & Haddoumi, H. Le Haut Atlas central de Beni Mellal à Imilchil. Nouveaux Guides géologiques et miniers du Maroc (2011), 4, 109-164.
19. El Wartiti, M., Malaki, A., Zahraoui, M., Di Gregorio, F., & De Waele, J. Geosites and touristic development of the Northwestern Tabular Middle Atlas of Morocco Desertification and risk analysis using high and medium resolution satellite data (pp. 143-156): Springer (2009), Dordrecht. doi : 10.1007/978-1-4020-8937-4_13.
20. Martínez-Graña A, Legoinha P, Goy JL, González-Delgado JA, Armenteros I, Dabrio C, Zazo C. Geological-Geomorphological and Paleontological Heritage in the Algarve (Portugal) Applied to Geotourism and Geoeducation. Land. 2021; 10(9):918. https://doi.org/10.3390/land10090918
21. Ouchouia,I. Chaouki.A. (2022). De la variabilité climatique au changement du régime hydrologique dans le bassin de l'oued Ouzoud/ Haut Atlas Central/ Maroc. ffhal-03581861f.
22. Bouzekraoui, H., El Khalki, Y., Mouaddine, A. et al. Characterization and dynamics of agroforestry landscape using geospatial techniques and field survey: a case study in central High-Atlas (Morocco). Agroforest Syst 90, 965–978 (2016). https://doi.org/10.1007/s10457-015-9877-8
23. Monbaron, M.. Précision sur la chronologie de la tectogenèse atlasique: exemple du domaine atlasique mésogéen de Maroc. C.R.Acad.Sci. Paris, t.294, 1982, Sér.II, p.883-886,2 tabl.
24. Guezal, J., El Baghdadi, M., & Barakat, A. Les basaltes de l'Atlas de Béni-Mellal (Haut Atlas Central, Maroc): un volcanisme transitionnel intraplaque associé aux stades de l'évolution géodynamique du domaine atlasique. Anuário do Instituto de Geociências (2013), 36(2), 70-85. doi: http://dx.doi.org/10.11137/2013_2_70_85.
25. Grandgirard V. L'évaluation des geotopes. Geologia Insubrica (2010) 4:59–66
26. Brilha, J. Inventory and Quantitative Assessment of Geosites and Geodiversity Sites: a Review. Geoheritage, 2016, 8(2), 119-134. doi: 10.1007/s12371-014-0139-3.
27. Bensalah,MK., Youbi,N., Mata,J., Madeira,J., Martins,L., El Hachimi,H., Bertrand,H., Marzoli,A., Bellieni, G., Doblas,M., Font,E., Medina,F., Mahmoudi,A., Beraâouz,E., Miranda,R., Verati, C., De Min,A., Ben Abbou,M., Zayane, R. The Jurassic–Cretaceous basaltic magmatism of the Oued El-Abid syncline (High Atlas, Morocco): Physical volcanology, geochemistry and geodynamic implications. Journal of African Earth Sciences, 2013, 81, 60-81. https://doi.org/10.1016/j.jafrearsci.2013.01.004
28. Rolley, J. P. Etude géologique de l'Atlas d'Afourer-Haut-Atlas central-Maroc. Stratigraphie. Doctoral dissertation, Thèse Doctorat 3ème cycle, Université. de Grenoble. 1973, 100 p. Français. ⟨tel-00759967⟩

29. Arfib, B. Gilli, E. Karst côtier et sources sous-marines- fonctionnement et exploitation. P. Audra, Association Française de Karstologie. Grottes et karsts de France, 2010, pp.128-129, Karstologia Mémoires 19, 978-2-9504222-5-5. ⟨hal-01458718⟩
30. Gordon, J.E. Geoconservation principles and protected area management. International Journal of Geoheritage and Parks, 2019, 7(4), 199-210. https://doi.org/10.1016/j.ijgeop.2019.12.005.
31. Brilha, J. Geoheritage: inventories and evaluation Geoheritage (pp. 69-85): Elsevier, 2018.