SCIENTIFIC CULTURE
www.sci-cult.com

SCIENTIFIC CULTURE, Vol. 9, No. 3, (2023), pp. 13-43
Open Access. Online & Print

DOI: 10.5281/zenodo.7978079

ASSESSING AND PROMOTING THE COASTAL GEOMORPHOLOGICAL HERITAGE OF THE EASTERN COAST OF RHODES ISLAND, SOUTHEASTERN AEGEAN, GREECE

Niki Evelpidou*, Anna Karkani, Evangelos Spyrou, Aristogeiton-Theodoros Gavalas and Giannis Saitis

Department of Geography and Climatology, Faculty of Geology and Geoenvironment, National and Kapodistrian University of Athens, Panepistimioupoli, Zografou, Athens, Greece, 15784

Received: 12/05/2023
Accepted: 30/05/2023
Corresponding author: Niki Evelpidou (evelpidou@geol.uoa.gr)

ABSTRACT

Geomorphological heritage refers to the total number of sites that are characterized by a significant geomorphological, as well as environmental, economic, cultural etc. value. The assessment of the geomorphological interest of several sites of an area is very useful for promoting its geoheritage. Among the most geomorphologically interesting areas are those that are or have been subject to continuous and/or intense tectonic movements, sea-level changes, erosion and deposition cycles etc. Among others, for areas with these characteristics, not only is their scientific interest itself very high, but they are usually characterized by stunning landscapes, thus attracting geotourists. Rhodes, the largest island among the Dodecanese Archipelago, Southeastern Aegean Sea, Greece, is one such area, characterized by a complicated geological, tectonic and geomorphological regime and thus impressive geomorphological heritage. In this context, the aim of our work was to produce an inventory of the main geomorphosites of Rhodes' eastern coasts. A total of 18 geomorphosites were selected and assessed, based on their scientific, ecological, cultural, economic, and aesthetic value. Our results show that all geomorphosites are characterized by a high scientific and many are also characterized by high aesthetic or cultural values. These results highlight the geotouristic potential of Rhodes Island. Presently, Rhodes contributes by approximately 10% to the overall tourism of Greece, while tourism in the island is the typical beach form of tourism. In order to promote the geomorphological heritage of the island, we created a story map of eastern Rhodes, through which visitors of the island can comprehend its recent geological history, evolution, tectonic and geomorphological processes.

KEYWORDS: geomorphosite assessment, geomorphological heritage, geomorphological synthesis, geomorphosite mapping.

1. INTRODUCTION

The term "geological heritage" refers to the total of geosites of an area, i.e. the sites that are characterized by a significant geological value. This means that geosites reflect an important moment of the Earth's history (Reynard, 2004), thus rendering them significant for the comprehension of this history and the natural processes (Bruno, 2016), as they have formed under specific geological, geotectonic, geomorphological, climatic etc. conditions (Brilha, 2016; Strasser et al., 1995; Wimbledon et al., 1999). When the geological value of a site is mainly geomorphological, the geosite is referred to as "geomorphosite". This means that geomorphosites are a type of geosites (Reynard et al., 2009). Geomorphosites reveal an area's recent geological and geomorphological history, its tectonics, palaeogeography, palaeoecology etc. (Grandgirard, 1997; Panizza, 2001; Panizza & Piacente, 1993).

Geomorphosites are a very important part of geoheritage, because the relief features can directly be observed by non-experts (Pralong, 2005). A geomorphosite's geomorphological (scientific) value may have either of the following aspects: it could be related to geomorphological processes, it could be of educational value, it could be an important indicator of an area's palaeogeographical evolution or it can be characterized by a great ecological value (Panizza, 2001).

A geomorphosite is, however, only rarely exclusively characterized merely by an intense geological interest. The value of a geomorphosite can be scientific in general (ecological, environmental, biological etc.), socio-economical, historical, and/or aesthetic as well. In fact, it is essential for a region's interest to include some of these aspects so that it can be considered as a geomorphosite. As a result, areas whose geomorphological interest is intense need to be conserved.

There are many ways through which a geosite, and by extension a geomorphosite can be selected (Wimbledon, 1996; Wimbledon et al., 1999). The selection is usually dependent on the researchers' opinion and/or experience (Reynard et al., 2016). De Lima et al. (2010) defined four criteria for the selection of geosites, which can be applied to geomorphosites as well (Reynard et al., 2007, 2016): representativeness, rarity, potential for revealing the geological processes, geodiversity, integrity, and scientific value. Several authors (Pereira & Pereira, 2010; Reynard et al., 2009) suggested that the selection of geomorphosites be based on scientific criteria (geomorphological importance in relationship to natural processes, rarity and exemplarity), but the other values must be taken into account as well.

Due to its geotectonic location, i.e. in the convergent zone between African and Eurasian plates, Greece is characterized by a unique geological, geomorphological etc. value, meaning that it contains many sites of geological interest, considering all individual branches of geology (Drinia et al., 2021; Evelpidou, Karkani, Tzouxanioti, et al., 2021; Georgousis et al., 2021; Spyrou et al., 2022; Triantaphyllou et al., 2023; Vlachopoulos & Voudouris, 2022; Zafeiropoulos et al., 2021). Rhodes is one of the areas of Greece that shows a great interest regarding all branches of geology (i.e. structural geology, palaeontology, sedimentology, stratigraphy, geomorphology, oceanography etc.), as well as other scientific disciplines (e.g. ecology, biology, archaeology, religion and environment) (Vandarakis et al., 2019). It is also characterized by a great aesthetic value. Additionally, due to its high touristic activity, especially during summer months, it does not lack the necessary facilities to house geotourists. Therefore, it is an ideal area for the development of geotourism.

This is the reason why it was selected for this study. Rhodes island hosts a huge number of local and foreign tourists every year, mainly during spring, summer, and autumn months, rendering it one of Greece's most touristic destinations (Karamanakou & Karamountzou, 2014). Yet, despite its geological wealth, alternative forms of tourism (including geotourism) have not been well-developed (Antoniou, 2021; Prokopiou et al., 2014). At the same time, mass beach tourism has already had significant environmental impacts on the island (Lagos et al., 2015).

As the island contains many sites of great geomorphological interest, thus rendering their inclusion into one single paper impossible. Therefore, only part of the island was chosen, namely its eastern coast, where one can comprehend the recent geological and palaeogeographical evolution of Rhodes, its geoarchaeology, the sea-level changes etc. to the maximum possible extent. A total of 18 geomorphosites were selected. The selected geomorphosites were assessed using the criteria proposed by Reynard et al. (2007). In particular, the criterial used were a) their scientific values, which include representativeness (i.e. geomorphosite exemplarity), integrity (geomorphosite state and condition), rareness (geomorphosite rarity) and palaeogeographical interest (i.e. the importance of the geomorphosite's location in relationship to the Earth's recent evolution), b) the additional values, which include ecological, cultural, economic and aesthetic value. Upon assessment, the geomorphosites were imported into the G.I.S. software ArcGIS Pro v.2.8.3 and its modules, to produce thematic maps. In addition, a story map was created. It consists of sites of geomorphological interest. It was created through the ArcGIS platform by ESRI. The latter offers many abilities, as will be further discussed, and can aid the promotion of the geological heritage of a region and the attraction of more tourists, both geotourists, i.e. tourists that are actually interested in viewing a site from the geological point of view, and common tourists as well.

Through this research, the island's geomorphological heritage and, by extension, its cultural heritage and natural environment, can be promoted and raise awareness regarding the preservation and promotion of geomorphological heritage. On the other hand, the island itself will be widely known, not solely as a massive tourist destination, but rather as a region with significant cultural value, aesthetics, and geomorphological interest, increasing this way the thematic tourism i.e. educational and geological. In this context, the aim of our research was to develop an inventory of geomorphosites of the eastern coasts of Rhodes that could form the basis to raise awareness into the geomorphological heritage of the island and, contribute to the development of alternative forms of tourism (in this case, geotourism) and to support the education of geomorphology.

2. REGIONAL SETTING

Rhodes is the largest island among the Dodecanese Archipelago in the Southeastern Aegean Sea and the fourth largest island of Greece, covering an area of ~1,400 km^2, with a coastline of 220 km (Fig. 1). It has a spearhead-like shape, with a length of 80 km and a width of 38 km. The top of Attavyros Mount is the island's highest point of elevation, reaching 1,216 m.

Rhodes forms, along with the islands of Kasos, Karpathos and Crete, the western part of the Peloponnese and the Ionian islands, the Hellenic Island Arc, part of the active Hellenic Orogenic Arc, located between the Volcanic Arc to the north and the Hellenic Trench to the south. The orogenic arc has resulted from the convergence between the Eurasian and African lithospheric plates and the subduction of the Eastern Mediterranean crust (Dewey and Sengor, 1979; Le Pichon & Angelier, 1979; Mckenzie, 1970; McKenzie, 1972). The island of Rhodes belongs to the overriding Aegean microplate, representing an uplifted segment of the eastern branch of the Hellenic forearc.

The alpine basement of Rhodes is composed of sedimentary, metamorphic and ophiolitic rocks (Fig. 2) belonging to six alpine units, which form a stack of Alpine nappes of the Hellenides-Taurides orogen exposed in uplifted fault blocks. The said units include the units of Lindos, Attavyros – Akramytis, Archangelos, Profitis Ilias, the Wild Flysch of Laerma and the Ophiolitic Nape, all correlated with well-studied alpine units known from mainland Greece. Oligocene molassic rocks are also present on the island (Lekkas et al., 1993; Mutti et al., 1970; Sakellariou et al., 2010). Lindos is a metamorphic unit on the island consisting of thick Mesozoic limestones and marbles that pass upwards to a metamorphic flysch. Attavyros – Akramytis unit consists of a pelagic sequence composed of thin bedded, often microbrecciated limestones and cherts. Archangelos unit consists of a thick sequence of shallow water carbonates and flysch. Profitis Ilias unit is composed of thin bedded marly or microbreciated limestones with silex, red marls and radiolarites. Laerma or Kattavia unit is composed of clays, pelites, shales, sandstones and conglomerates. The Ophiolitic nappe is composed of Mesozoic ophiolitic rocks, such as gabbros, diabases and serpentinites.

The area has been struck by a number of strong earthquakes during historic times that produced extensive damage and loss of human lives. The walls and the harbor of the ancient city of Rhodes, as well as the statue of Colossus were destroyed by an earthquake in 227 B.C. Other earthquakes accompanied by tsunamis were those of 142 A.D. and 1481. The earthquake of 1303 A.D. devastated the island, causing 4000 deaths. Two strong earthquakes on April 22, 1863, and June 26, 1926 destroyed about 2,000 and 3,000 houses, respectively (Papazachos & Papazachos, 1989).

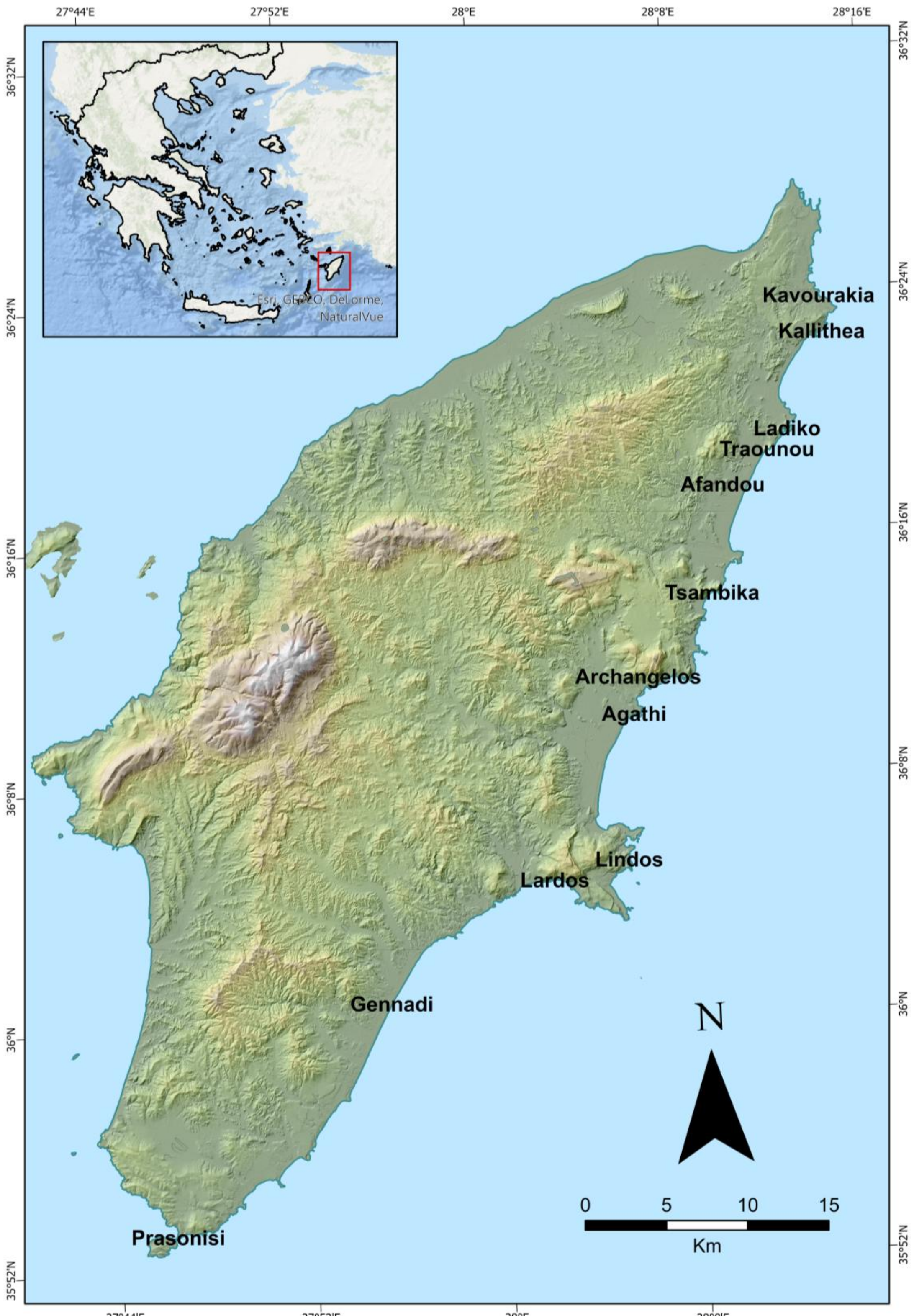


Figure 1. Relief map of Rhodes Island and main locations discussed in the text. The Digital Elevation Model has derived from the digitization and processing of topographic maps of scale 1:50,000 from the Hellenic Military Geographical Service.

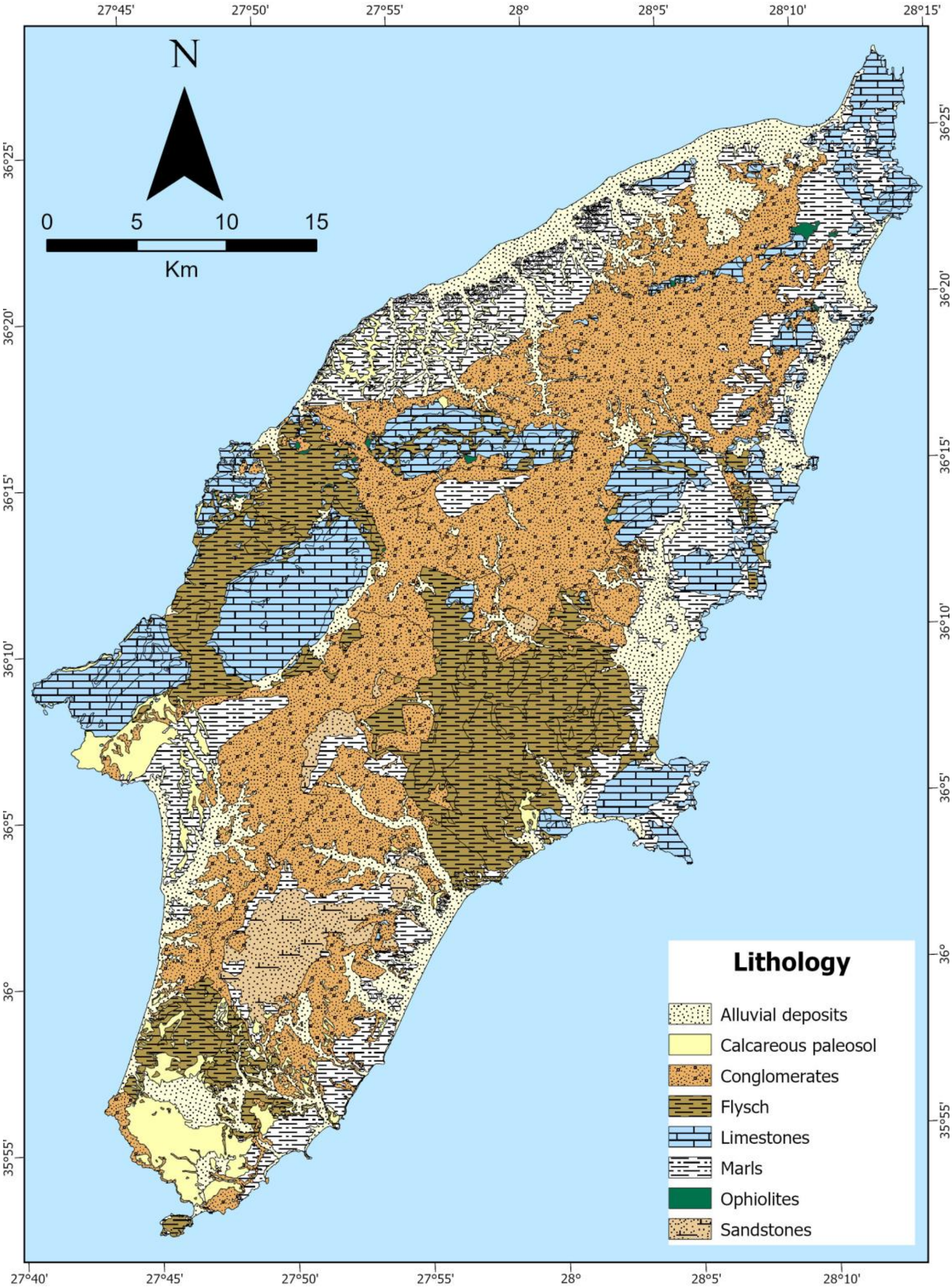


Figure 2. Simplified geological map of Rhodes Island (based on Lekkas et al., 1993).

2.1. Geomorphology

The active tectonics has clearly induced some of the geomorphological features of Rhodes Island. The drainage network is asymmetric with the drainage divide of the catchment basins, near the western coast of the island (Sakellariou et al., 2010). A number of Quaternary marine terraces are found near the eastern and northwestern coastal zone of the island, at elevations as high as 250 m near the Holocene palaeoshorelines (Gauthier, 1979; Howell et al., 2015; Kontogianni et al., 2002; Sakellariou et al., 2010). According to Kontogianni et al. (2002), the terraces have a characteristic pattern comparable to that of Holocene notches. More specifically, their number, elevation and spacing decrease southwards, until they disappear. In some of the lowest terraces, Quaternary fauna has been identified (Kontogianni et al., 2002). In terms of dating, a terrace located at +10 m, at Lindos area, has been dated at 120±10 ka ($^{230}Th/^{234}U$) based on a *Spondylus gaederopus* (Keraudren, 1971). According to Sakellariou et al. (2010), the ESE tilting of the island has also affected the development of the marine terraces, which are slightly inclined southeastwards due to the rotation of the island.

Holocene coastal features also attest to the active tectonics of the Island. Pirazzoli et al. (1989) systematically surveyed the coastal zone of Rhodes and reported evidence of up to eight stepped Late Holocene palaeo-shorelines. Their findings led them to the suggestion that Rhodes is divided into several small crustal blocks, with different tectonic behaviour. They further reported uplift and subsidence movements for each block, with a recurrence interval varying between a few centuries and 1,000-2,000 years. An overall tendency of uplift has been noted, which increases from south to north, reaching about 1 mm/yr in the northern part (Pirazzoli et al., 1989). Kontogianni et al. (2002) have suggested that these shorelines, up to +3.8 m high, were probably originally continuous along the 75-km-long SE Rhodes coast, possibly disturbed locally by minor normal faults, and reflect the last phases of the uplift and tilting of the island as a rather rigid block since Late Pliocene. According to Kontogianni et al. (2002), the earthquakes responsible for the vertical displacement of the shorelines are probably associated with a major reverse offshore fault, running along the coast of Rhodes. This fault model has been confirmed from reflection profiles offshore and seems to be also responsible for the Pliocene-Pleistocene terraces and the tilting of the island as a rather rigid block (Sakellariou et al., 2010). This fault model can also explain why the SE edge of the Hellenic Arc is associated with strong earthquakes (Ms 7.5) producing destruction at an eastern Mediterranean scale, as well as tsunamis. Causative faults are large enough to generate earthquakes of such magnitude and cut through to the seabed, and hence can generate tsunamis (Kontogianni et al., 2002). According to Howell et al. (2015), the fault responsible for the uplift dips at an angle of 30–60° above the more gently dipping oblique subduction interface. The same authors modelled tsunami propagation from a range of tectonically plausible earthquake sources, which suggested that earthquakes on the fault uplifting Rhodes represent a significant tsunami hazard for Rhodes, SW Turkey, and possibly for Cyprus and the Nile Delta as well.

2.1.1. Landforms of eastern Rhodes

Given the described geomorphological regime, Rhodes island's eastern coasts are characterized by a significant number of landforms corresponding to different geomorphic environments (coastal, fluvial, aeolian, karstic etc.) (Fig. 3). This subsection lists the most typical landforms of the island's landscape.

1. **Karstic cavities.** Karst cavities are formed by the corrosive action of water. More specifically, carbonate rocks are dissolved by meteoric and ground water (Bosák, 2002; Davronovna et al., 2022; Frisia & Borsato, 2010). Karst cavities may or may not have an entrance. In Rhodes, several karst cavities can be found, with the most typical ones being those in Lindos, Ladiko and Kalythies (Steinthorsdottir & Håkansson, 2017).
2. **Sea arches and sea caves.** These landforms are created on rocky coasts and are owed to the wave activity (Limber & Murray, 2015; Mylroie, 2019). Sea arches are landforms whose shape resembles that of a natural bridge, whereas sea caves resemble typical caves, but differ in the formation process and therefore lack speleothems. They usually have one chamber or a small number of lesser chambers (Mylroie, 2019). In Rhodes, sea caves and arches are not common. The most typical appearance is in the broader area of Traounou beach's limestone cliffs, as well as in the limestone cliffs of Lindos coast.
3. **Tidal notches.** Tidal notches are U- or V-shaped undercuttings found mainly in carbonate coastal cliffs. They form in the tidal zone (roughly at sea-level) (Evelpidou et al., 2012) due to bioerosion by the living organisms, in association with the wave activity (Pirazzoli, 1986). They are often found either submerged or uplifted, indicating vertical tectonic movements, as well as their type (e.g., rapid, or gradual) (Evelpidou et al., 2012) and their morphology is dependent on the local tidal range (Pirazzoli & Evelpidou, 2013). In Rhodes, uplifted tidal notches are the most typical coastal landform. They are found almost across its entire coastal carbonate cliffs from Cape Ladiko to Lardos (Kontogianni et al., 2002; Pirazzoli et al., 1989).
4. **Marine terraces.** Marine terraces are wave-cut platforms whose formation is a result of wave scouring. They are formed close to the sea-level and are typically found uplifted, due to vertical tectonic movements, in combination with eustatic (global) sea-level changes (Limber & Murray, 2011; Marquardt et al., 2004; Saillard et al., 2009). They are often found in succession, indicating multiple phases of sea-level fluctuations. In

Rhodes, uplifted marine terraces can be found across its entire coasts from Faliraki to Kiotari (Howell et al., 2015; Sakellariou et al., 2010).

5. **Beachrocks.** Beachrocks are sedimentary formations of the coastal zone, composed of coastal material (e.g., sand, pebbles, biogenic material) and carbonate cement (Bricker, 1971). They generally form near sea-level (Kelly et al., 2014; Mauz et al., 2015). The coastal material is generally rapidly lithified. They too are found submerged or uplifted in several cases, indicating vertical tectonic movements (Alexandrakis et al., 2021; Karkani et al., 2017). In Rhodes, beachrocks can be found in the areas of Lardos and Gennadi (Pirazzoli et al., 1989; Sakellariou et al., 2010).

6. **Sand dunes.** Sand dunes are coastal landforms owed to aeolian deposition. Their formation is an indicator of the prevalence of strong winds towards the mainland, in combination with high amounts of coastal sediments. Other factors that favor their development include a small beach inclination and a relatively high tidal range (Costas et al., 2016; Psuty & Silveira, 2010). For their stabilization, they require the presence of an obstacle, such as wood, rocks, a coastal cliff or vegetation (Polidorou & Evelpidou, 2021; Pye & Blott, 2017). In Rhodes, sand dunes can be found in several beaches, such as Tsambika (K. Hansen, 2001; Milàn et al., 2007).

7. **Tombolo.** Tombolos are sandy landforms which fall into the category of barrier landforms and are created through the transportation of sand by the coastal currents and its deposition due to the presence of an obstacle or a shift in the coast's direction. In the case of tombolos, the obstacle is an island, and the landform connects this island with the mainland. Tombolos, like all barrier landforms, are highly dynamic and easily affected by the morphodynamics of the coast (Allard et al., 2008; De Mahiques, 2016; Robin et al., 2020). Therefore, their morphology can change within a short period of time. Prasonisi is a prominent island and tombolo in southern Rhodes. It is typical evidence of the formation's dynamic character, as its morphology changes throughout the year (Malliouri et al., 2022).

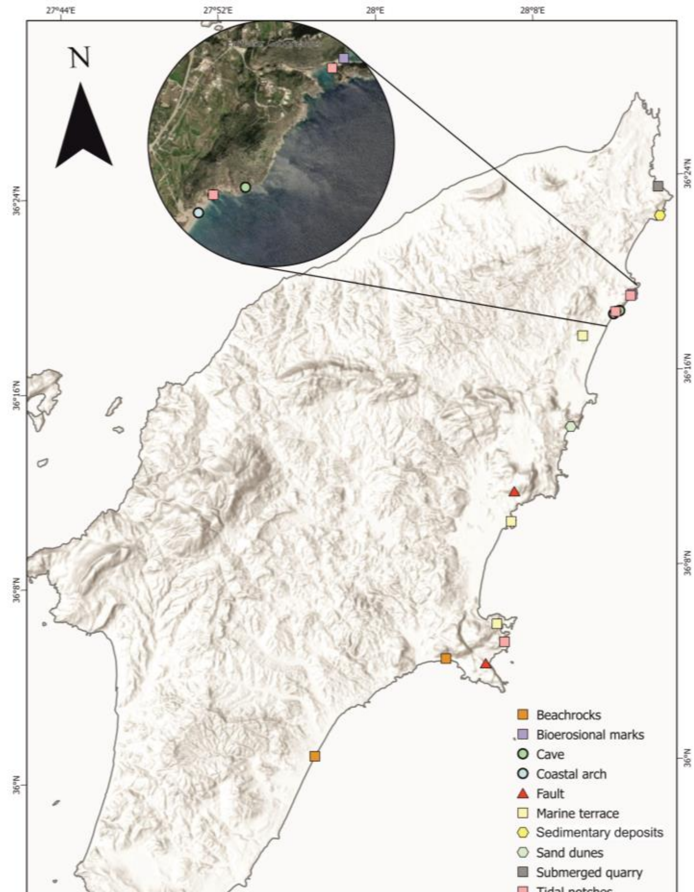


Figure 3. Location of selected geomorphosites on Rhodes Island.

3. MATERIALS AND METHODS

3.1. Assessment method of geomorphosites

For this study, the geological and mainly geomorphological features of the island were initially studied. For this purpose, topographical, geological and other maps, as well as satellite images were utilized. Afterwards, several field trips took place on the island, where the most significant coastal landforms were recorded, mapped and photographed. Photographic and video material was taken both terrestrially and through unmanned aerial vehicles (drones). The most significant sites were chosen, i.e. the sites where one can comprehend the recent geological and palaeogeographical evolution of Rhodes, its geoarchaeology, the sea-level changes etc. to the maximum possible extent. The selection criteria were the geomorphosites' representativeness, geomorphological interest (e.g., indicators of the palaeogeographical structure) and rarity compared to the rest part of Greece, following the proposals of previous authors (de Lima et al., 2010; Pereira & Pereira, 2010; Reynard et al., 2007, 2009, 2016; Wimbledon, 1996; Wimbledon et al., 1999). Based on that, a total of 18 geomorphosites were selected.

The selected geomorphosites were assessed using the criteria proposed by Reynard et al. (2007) (Table 1). In fact, they divided the criteria into five categories, namely general data, descriptive data, scientific value, additional values and synthesis. The scientific value includes representativeness (i.e. geomorphosite exemplarity), integrity (geomorphosite state and condition), rareness (geomorphosite rarity) and palaeogeographical interest (i.e. the importance of the geomorphosite's location in relationship to the Earth's recent evolution) (Reynard et al., 2007, 2016). Additional values include ecological, cultural, economic and aesthetic value. The ecological value is divided into two categories: ecological impact (i.e. the geomorphosite's significance from an ecological point of view) and its protection status (for instance, based on national or European legislation). The aesthetic value refers to the geomorphosite's visibility (or viewpoints) and its overall structure (for example, colour contrasts and intense vertical relief development gain a high score). When it comes to the cultural value, the categories it is divided into include the geomorphosite's importance historically, religiously, artistically, regarding literacy and geological history. Economic value includes both a qualitative and a quantitative assessment.

Table 1. The criteria proposed by Reynard et al. (2007, 2016).

General information		
General data		**Descriptive data**
integrity		description
representativeness		morphogenesis
rareness		
Assessment criteria		
Scientific value	**Additional values**	**Other characteristics**
integrity	ecological value	visit conditions (accessibility etc.)
representativeness	aesthetic value	educational value
rareness	cultural value	protection, management, damages etc.
palaeogeographical interest	economic value	

The geomorphosites' coding was done according to the method proposed by Reynard et al. (2007, 2016). Each geomorphosite name is a combination of its location (in capital letters), its main formation process (in small letters) and a number. The locations of our proposed geomorphosites and their corresponding abbreviations include: AGA (Agathi), AFA (Afandou), GEN (Gennadi), KAL (Kalithea), KAV (Kavourakia), LAD (Ladiko), LAR (Lardos), LIN (Lindos), PRA (Prasonisi), TRA (Traounou) and TSA (Tsambika). The formation and/or shaping processes and corresponding abbreviations include: slc (sea-level change), bio (biogenic activities such as bioturbation and bioerosion), dep (coastal deposition), ero (coastal erosion), kar (karstic features) and tec (tectonic features).

The numerical assessment of the values of the geomorphosites was based on their particularity, their contribution to scientific knowledge, and their diversity. The geomorphosites have been assessed in three stages, that is according to their scientific value, their additional values and the synthesis. For the first two cases, each value is composed of sub-values, each one of them is given a grade ranging from 0 to 1 (with a step of 0.25), with 0 corresponding to no value and 1 to a very high value (Reynard et al., 2007, 2016). The overall scientific value of the geomorphosites is the average score of the four sub-criteria (integrity, representativeness, rarity and palaeogeographical value). The ecological value is calculated as the mean of (a) the ecological impact, which accounts for the significance of a geomorphosite for the development of a particular ecosystem, and (b) the protection status of the geomorphosite. The aesthetic value is calculated as the mean of two parameters: (a) the viewpoints of a particular geomorphosite, i.e. its visibility, and (b) structure, which takes into account the contrasts and vertical development of a landform. The cultural value consists of historic, religious, literature and geo-historical importance (importance for the history of geosciences). Its value is the largest score among the four. The synthesis part is made of three components, namely "global value" (the combination of the former two), "educational value", "threats/endangerment level" (potential threats, both natural and human) and "management measures" (proposal of protection and promotion measures) (Reynard et al., 2007, 2016).

3.2. GIS-based platform

The selected geomorphosites were imported into the G.I.S. software ArcGIS Pro v.2.8.3 and its modules, to produce thematic maps. In addition, a story map was developed. The platform used was ArcGIS Story Map by ESRI. ArcGIS StoryMaps application gives the opportunity to use the power of maps to explore areas, events, and situations of interest. By combining text, photography and video with maps, narratives, experiences or information can be created and shared. ArcGIS Story Map gives the users the ability to observe a broader area, as well as zoom in in order to better view each geosite. Additionally, this platform allows users to view any site of interest in three dimensions, as well as from different aspects. The developed story map shows the locations of selected geomorphosites, and indicative photographs can be viewed. The story map can be accessed via the link: https://arcg.is/1izK5O.

4. RESULTS AND DISCUSSION

4.1. Description of the geomorphosites

In this research, a total of 18 geomorphosites were selected, mapped and assessed. They are categorized according to their location. These geomorphosites are found in eleven regions, which include the following, from north to south:

1. **Submerged quarry (Kavourakia):** A number of slightly submerged quarries suggest that, during historical times, the sea-level was located about 0.4 m below the modern level (Pirazzoli et al., 1989) (Fig. 3). The quarries consist of Pleistocene carbonates or sandstones and their material was used for the majority of the ancient and Medieval buildings in Rhodes (Sakellariou et al., 2010). According to Flemming (1978), the coastal quarries between the city of Rhodes and Kallithea have been dated at about 2400-2300 yr B.P., when the classical city was founded, or at about 1305-1522 AD, i.e. to the time of the Knights of St. John. Conversely, Pirazzoli et al. (1989) performed field observations and radiocarbon dating on barnacle samples and suggested that the relative sea-level was located almost 4 m above the quarries' floor at 2280±110 yr. B.P., during Classical times, as well as during Medieval times. According to Pirazzoli et al. (1989), the coastal quarries were most likely cut during Roman times, like many other Mediterranean sites. This suggests that slightly after 2280±110 yr. B.P., the relative sea-level fell by 3.8 m, i.e. from +3.4 m to -0.4 m. Pirazzoli et al. (1989) linked this rapid sea-level fall to the great earthquake of 227 B.C., which was accompanied by a sudden uplift movement and destroyed the Colossus in the harbour of Rhodes.

(a) 

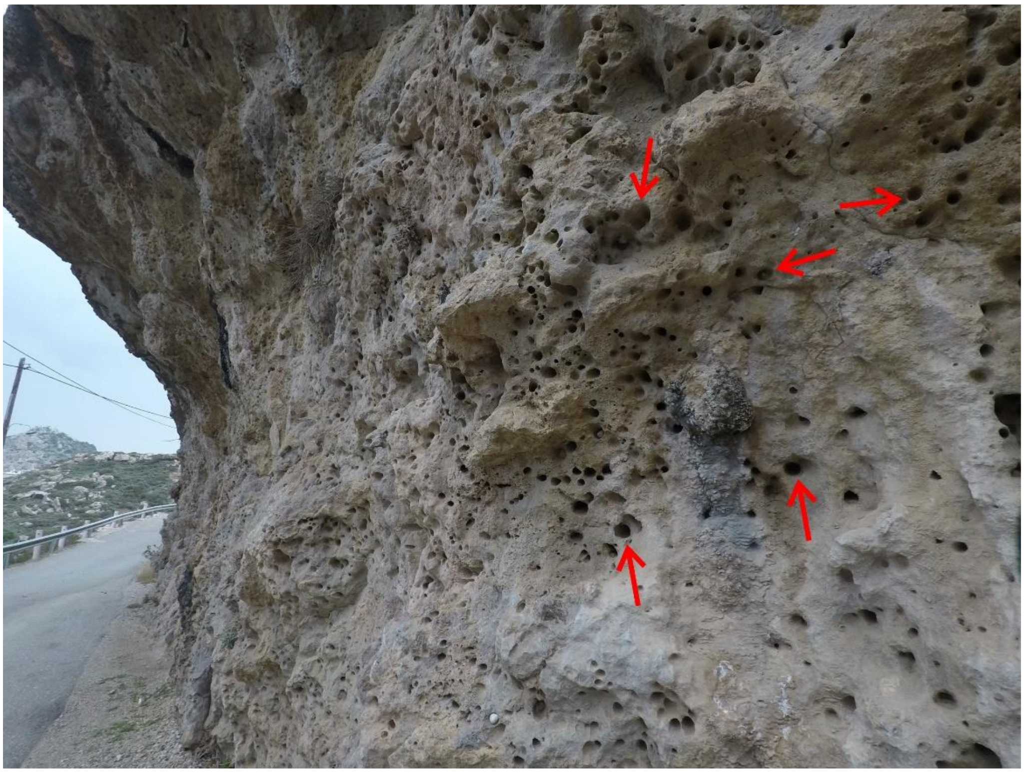
(b) 

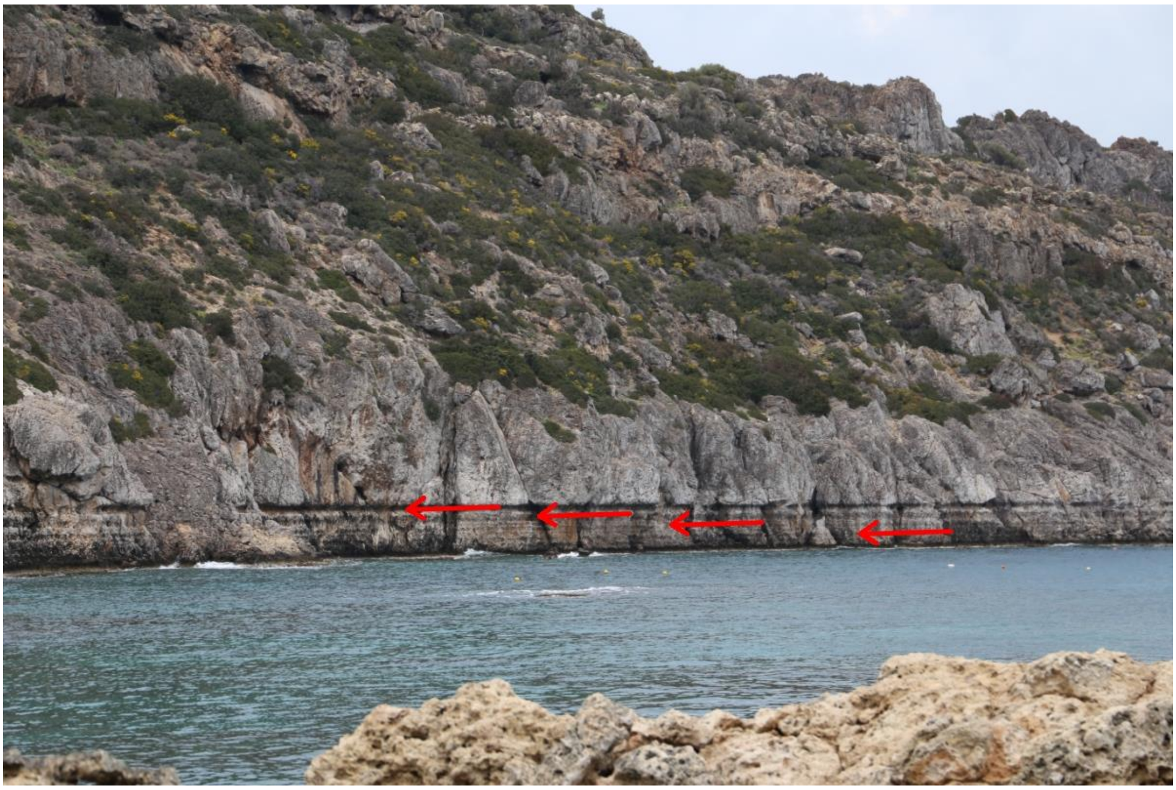
Figure 3. (a) Close view of quarrying marks, slightly submerged, at Kavourakia; (b) Drone image of the submerged quarry at Kavourakia. Its submergence was owed to tectonic movements (Photo: N. Evelpidou, 2019).

2. **Sedimentary deposits (Kallithea):** Kallithea is a small bay with steep cliffs consisting of marine and coastal Pleistocene sediments (Hanken et al., 1996; Hansen, 1999), which were developed in a steep coastal basin during a larger-scale forced regression (Fig. 4). It is dominated by the Cape Archangelos calcarenite facies group. According to Hansen (1999), the foreset packages are evidence of progradation of a carbonate platform that is no longer preserved. The platform prograded towards the basin, similar to a process of highstand shedding commonly known from tropical carbonates (Hansen, 1999). The average progradation direction of the foreset facies indicates that the Pleistocene shoreline was lying towards the west and northwest. The giant foresets show rhythmic alternation between bioturbated and cross-bedded foresets and are interpreted as recording seasonal changes. Deep scouring on the platform took place during major storms (Hansen, 1999), which created strong and probably very concentrated flows that were directed offshore to the giant foresets. The resulting chute-and-pool bedforms generated landward-migrating antidune stratification (Hansen, 1999). The process of scouring and infilling must have been almost simultaneous, while immediately after planar lamination and undulating beds were formed.

Figure 4. Part of the sedimentary deposits at Kallithea. (Photo: N. Evelpidou, 2019).

3. **Biological remains (Cape Ladiko)**: On the alpine limestones of the coastal cliff at Cape Ladiko, a number of bioerosional marks by the well-known marine bivalves Lithophaga lithophaga may be identified, in an altitude of several tens of meters (Sakellariou et al., 2010) (Fig. 5a). These marks suggest that this cliff was below sea-level during the Pleistocene and that the area has undergone strong uplift.
4. **Tidal notches (Cape Ladiko):** The Late Holocene uplift is evidenced and clearly observable along the island's eastern coast by a spectacular series of continuous ripple notches cut along the Mesozoic limestone cliffs, on the western side of Ladiko bay (Pirazzoli et al., 1989) (Fig. 5b). Pirazzoli et al. (1989) have identified at least six superimposed shorelines (i.e. ripple notches), at the basis of marine deposits and bioerosional marks. According to Pirazzoli et al. (1989), the relative sea-level history of the site may be deciphered based on the following: The uppermost shoreline, at +3.75 m, is represented by a well-preserved tidal notch. An algal sample of Lithophyllum cf. lichenoides, slightly below the notch base, was dated at 4895±100 yr. B.P. An algal crust at +2.6 m, was related to the second sea-level and has been dated at 3465±80 yr. B.P. A lower sea level was identified at +1.9 mm mainly from a Neogoniolithon notarisii rim and few clear erosional features, and was dated at 4050±80 yr B.P. These ages were corrected to 5000±530 yr. (i.e. not much younger than B1) and 3635±135 yr. B.P. (Pirazzoli et al., 1989).
5. **Cave (Ladiko):** In the steep carbonate cliffs of the broader area of Ladiko, a small cave can be found. It consists of one room of small dimensions, with one entrance towards the southeast (Fig. 5c). The cave bears small and large speleothems, such as stalactites, stalagmites and curtains (Fig. 5d). The largest one is a stalagmite with approximately 1 m height. Caves are important geomorphic formations since they indicate geomorphic chemical processes of carbonate rocks. They are important land characteristics as they have often been used by humans during prehistoric times. The presence of speleothems, which are abundant in Ladiko cave, are also valuable and may potentially give information about paleoclimatic and paleoenvironmental conditions.


(a)


(b)

(c) (d)

Figure 5. Geomorphological features at Ladiko: (a) Bioerosional marks (see arrows for example), created by Lithophaga bivalves, suggesting that the hosting cliff lied below sea level during the Pleistocene; (b) Ripple tidal notches are visible on the lower part of the carbonate cliff, revealing the late Holocene uplift of the area; arrows point the notches (palaeo-shorelines) (Photos: N. Evelpidou, 2019); (c) the entrance of Ladiko cave; (d) a large stalagmite in Ladiko cave (Photos: E. Spyrou, 2022).

6. **Coastal caves (Traounou beach):** In the northern edge of Traounou beach, several erosional coastal caves can be found. These landforms are found on limestones and were created by erosion caused by the wave activity.
7. **Coastal arch (Traounou beach):** It is a coastal arch to the south of the caves, located on the landward part of the beach. This landform is also a result of wave erosion.
8. **Tidal notches (Traounou beach):** In this part of the beach, a series of uplifted tidal notches can be found. This notch series continues on other beaches as well (e.g. Tsambika, Agathi, Ladiko, Anthony Quinn etc.).
9. **Uplifted fossiliferous terraces (Afandou):** The broader area of Afandou consists of several uplifted marine terraces, many of which bear fossilised bivalve shells. Most of the area's terraces do not bear an inner edge (Fig. 6).

Figure 6. Marine terraces with no inner edge at Afandou. They can easily be observed as outcrops with flat areas in front of the village, located at a lower altitude; the terraces (palaeo-sea-levels) are shown by the red dotted lines (Photo: E. Spyrou, 2022).

10. **Uplifted shorelines (Tsambika):** The wider area of Tsambika beach and the surrounding mountainous landscape is characterised by the presence of numerous active faults, which bring about significant morphological discontinuities and steep slopes, and complicate the geological structure of the region. Along the limestone cliffs of Tsambika, Pirazzoli et al. (1989) have identified a series of palaeo-shorelines (Figs 7a, b). The oldest one lies at an altitude of +2.3 to +2.45 m. Based on an algal sample, it is older than 5,000 years and, based on its diagenetic features, it suggests emergence, submergence and reemergence after deposition. The elevation of the samples further indicates that such a sequence of events would have only been possible if the sea-level had first fallen below +1.15 m (probably D6) and had risen to slightly above +3 m (uppermost shoreline D1) after a short time (Pirazzoli et al., 1989). The uppermost shoreline was already deep enough to enable a Neogoniolithon notarisii crust to develop on its floor, at about 4300 yr B.P. and the sea level remained at the same position until at least 3600 yr B.P. (Pirazzoli et al., 1989). Later, uplift movements affected the relative sea level in steps. A palaeo-shoreline was dated between 2580±70 and 2745±75 yr B.P., while another shoreline was dated at 1205±100 yr B.P., based on an algal crust at +0.5 m (Pirazzoli et al., 1989). A comparison of the geomorphological and biological evidence in Tsambika and Ladiko show that the vertical movements and the corresponding relative sea level changes in the two areas differ significantly (Sakellariou et al., 2010).
11. **Sand dunes (Tsambika):** Along the coast of Tsambika, sand dunes are present, most of them being stabilized due to the development of vegetation (Fig. 7c). The largest dune, located at the northern edge of the beach, exceeds 4 m in height (Fig. 7c).

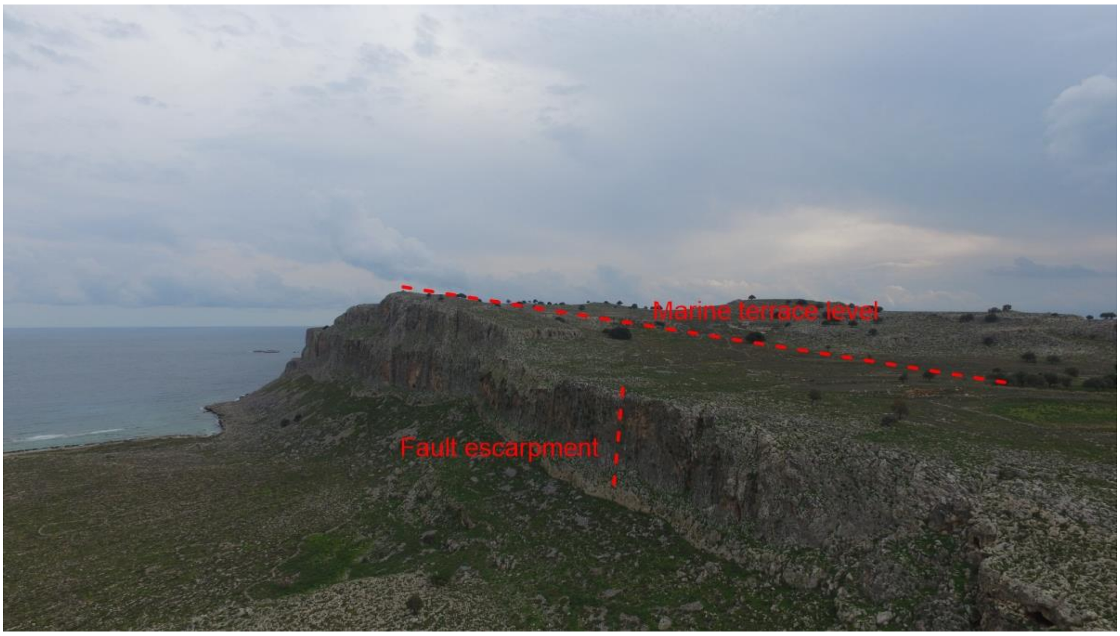
(a) (b) (c)

Figure 7. (a, b) A series of uplifted tidal notches at Tsambika can be identified as indentations in the lower parts of the coastal limestone cliffs, indicating tectonic uplift; the palaeo-shorelines are shown with red arrows in (a) (Photos: N. Evelpidou, 2019); (c) The largest of the sand dunes in northern part of Tsambika beach, indicating a combination of strong winds towards the mainland and a high amount of sediment input (Photo: E. Spyrou, 2022).

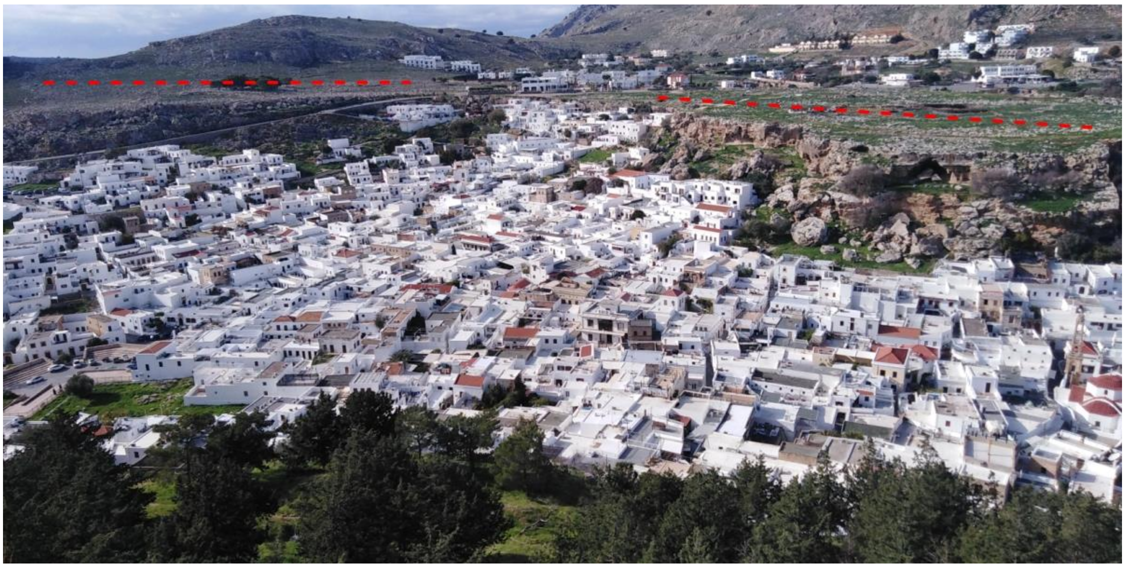
12. **Faults and uplifted terraces (Agathi):** A spectacular tectonic graben structure, formed on Mesozoic limestones of the Archangelos unit, is visible towards Karavos Mountain (Sakellariou et al., 2010). The three faults that dominate the

graben run N-S to NNE-SSW and are subparallel to each other. The western margin of the graben is controlled by one eastward-dipping fault, while the eastern one displays a step-like structure developed by two westward dipping faults (Lekkas et al., 1993) .On the southern part of the mountain, morphological terraces are visible. Considering that the bedding of the massive limestones in this area is strongly deformed and deviates from horizontality, the terraces may be only considered as secondary, of erosional or depositional origin (Sakellariou et al., 2010). On most of the terraces, traces or thin deposits of marine Pleistocene bioclastic limestone have been found, indicating their marine origin. Therefore, the step-like landscape owes its shape to the development of successive marine terraces, which were originally formed at the sea-level and were gradually uplifted since the Pleistocene. Although the terraces have not been studied in detail, their elevation changes abruptly from the one side of each fault to the other, which also strongly suggests that these faults have been active in recent geological time (Sakellariou et al., 2010).

13. **Active faults (Lindos):** The acropolis of Lindos is a naturally fortified hill, corresponding to a typical tectonic horst developed on the footwall of two cross-cutting faults (Lekkas et al., 1993; Sakellariou et al., 2010). The bay of St. Paul was formed as a graben structure on the hanging wall of the two cross-cutting faults. The steep cliffs of the western and eastern side of the hill correspond to the active normal faults forming the horst. The fault pattern of Lindos peninsula is very impressive. Lindos is tectonically separated from the rest of the island by a series of faults that create an arc from Vlycha Bay to the north, to Cape Pefkos to the southeast. The small block of Lindos belongs to the hanging-wall of this arc-shaped fault-zone and, hence, it subsides in relationship to the rest of Rhodes Island (Kontogianni et al., 2002; Pirazzoli et al., 1989; Sakellariou et al., 2010). To the south of Lindos, the northern flank of the elongated Pefkos cape is characterised by spectacular outcrops of active faults. The main fault runs parallel to the steep NE-facing cliff. Three minor faults crosscut the main one, developing remarkable morphological steps on the landscape of the rocky ridge (Kontogianni et al., 2002). The top flat surfaces are covered by Pleistocene marine sediments. The base of the steep limestone cliff along the Pefkos fault (Fig. 8a) is characterised by the presence of a light colored, <1m wide stripe, different from the dark grey color of the rest of the cliff and visible from a distance (Kontogianni et al., 2002). This light-colored stripe is the youngest exposed part of the Pefkos fault plain. This colour change indicates that until recently, it was covered by slope debris and/or the Pleistocene deposits, which occur at the base of the cliff, and was abruptly exposed on the surface. Hence, it provides evidence of the most recent movement of the Pefkos fault, which has possibly taken place during historical times.
14. **Marine terraces (Lindos):** In the broader area of Lindos settlement, we have a panoramic view of several uplifted marine terraces; the plain where the village of Lindos is located, as well as the flat plain right above it, are two prominent terraces, whose traces can be followed all along the flanks surrounding the bay (Sakellariou et al., 2010) (Figs 8b, c). Remnants and thin drapes of marine carbonate deposits are visible at various altitudes along the flanks, evidenced from their yellowish color in contrast to the dark grey colour of the Lindos Mesozoic limestones and may be followed along the morphological steps of the landscape (Sakellariou et al., 2010).
15. **Palaeo-shorelines (Lindos):** On the coastal limestone cliffs of Lindos area, six superimposed shorelines are well preserved and are evident by erosional marks (Pirazzoli et al., 1989)(Fig. 8d). Similar to other parts of the eastern coast, the shoreline located at about + 2m is the oldest one and has been dated between 3800 and 5000 yr. B.P. (Pirazzoli et al., 1989). This shoreline has also experienced a sequence of emergence-submergence-emergence phases. According to Pirazzoli et al. (1989), the uplift-re-subsidence events of this shoreline took place shortly after 3800 yr. B.P. and ended by 2620 yr. B.P. At that time marine deposits were developed at about +1.5 m, just below a notch cut. The shoreline reached its present position due to uplift movements, which occurred in two steps.



(a)



(b)

(c)


(d)

Figure 8. (a) Pefkos fault, which is the front of a marine terrace. The red arrow highlights a light-colored stripe on the lower part of the fault, which is the youngest exposed part of the Pefkos fault plain (Photo: N. Evelpidou, 2019); (b) Lindos village, built atop a marine terrace; a second marine terrace can be discerned above it, indicated by the red arrows; (c) marine terrace as seen from Lindos village, indicated by a red arrow; the marine terrace levels are shown in the three pictures as red dotted lines; (d) Six uplifted tidal notches at St. Paul's Bay, Lindos; they are visible as indentations on the lower part of the limestone cliff. The relative sea level fluctuations do not have a uniform pattern since these indicators show a sequence of emergence-submergence-emergence phases. These sea level fluctuations took place within ~1180 years (Photos: E. Spyrou, 2022).

16. **Uplifted beachrocks (Lardos):** On Lardos beach, uplifted beachrock outcrops may be found (Fig. 9). According to Sakellariou et al. (2010), the beachrock outcrop of Lardos beach may have formed at the sea-level during the Early Bronze Age. On the bedding of the beachrock, trace fossils are visible, possibly from worms. The trace fossils must have been imprinted on the bedding plain before the beachrock cementation and were preserved during the consolidation of the coastal formation (Sakellariou et al., 2010).


(a)


(b)

Figure 9. Uplifted beachrock slabs (a) from close and (b) from above (Photos: N. Evelpidou, 2019).

17. **Beachrocks - potential tsunami deposits (Gennadi):** Pirazzoli et al. (1989) have noted the presence of an uplifted beachrock outcrop between Lardos and Gennadi, at an elevation of +0.6 to +0.8 m. This outcrop's age is probably correlated with the age of an algal sample collected at the base of a notch located at +0.8 m and may therefore be dated at about 4030±30 yrs B.P. (corrected age for the presence of a second generation of younger marine cements; cf. Pirazzoli et al. (1989) for details). On Gennadi beach, we can observe an extensive beachrock outcrop. An interesting feature on this site is the numerous broken beachrock slabs, primarily in its southern part. The slabs are mainly positioned landwards behind the in situ beachrocks and they appear displaced, indicating that their dislocation could be owed to a high energy event (Fig. 10).


(a) (b)

Figure 10. (a) a close view of the displaced beachrock slabs at Gennadi (Photo: E. Spyrou, 2022); (b) Drone image of the beachrock slabs (Photo: N. Evelpidou, 2019).

18. **Tombolo (Prasonisi):** Prasonisi is a ca. 3 km² islet in the southern tip of Rhodes, occasionally connected with the main island by a sandy isthmus. This hourglass-shaped sandbank has a length of ~700 m, a width of ~400 m on the side of Rhodes, ~200 m on the side of Prasonisi and ~70 m in the middle of the tombolo, and a maximum depth of 9 m. It is a lowland coastal area that hosts a variety of sedimentary bedforms, such as a double-sided shore, sand dunes, submarine barriers etc. The two bays separated by the sandbank have different wave microclimate depending on direction of dominant winds. Usually, when a bay is calm the other is wavy. Because of this particularity, the area is considered ideal for sports activities, such as windsurfing and kitesurfing. In general, the northwest bay is wavier than the southeastern.

The tombolo is partly flooded by seawater during high meteorological tides for hours or a few days. In this case, the water depth rarely exceeds 10-30 cm and the flow is usually too low to develop any significant erosive process on the tombolo. After the resetting of the usual weather conditions, the water is retrograded. However, during strong winter storms, the tombolo breaks down and Prasonisi is cut off from Rhodes Island (Malliouri et al., 2022). Then a relatively wide and deep channel exists for months (rarely for years). In general, the tombolo appears for a few months per year and disappears for the rest months (Fig. 11).

Figure 11. The Prasonisi tombolo, as seen from the islet. The sandy barrier's size fluctuates throughout the year. In summer, it usually connects the islet with Rhodes. This photo was taken in June and the tombolo almost connects the islet with the island of Rhodes (Photo: E. Spyrou, 2022).

4.2. *Quantitative Assessment of the Geomorphosites*

The numerical assessment of the values of the geomorphosites was based on their particularity, their contribution to scientific knowledge, and their diversity. The geomorphosites have been assessed in three stages, that is according to their scientific value, their additional values and the synthesis. The scientific value includes representativeness (i.e. geomorphosite exemplarity), integrity (geomorphosite state and condition), rareness (geomorphosite rarity) and palaeogeographical interest (i.e. the importance of the geomorphosite's location in relationship to the Earth's recent evolution) (Reynard et al., 2007, 2016). Additional values include ecological, cultural, economic and aesthetic value. According to the assessment criteria for the geomorphosites as proposed by Reynard et al. (Reynard et al., 2007, 2016), eastern Rhodes is characterized by a significant number of sites of geomorphological interest (Table 2).

It consists of a series of landforms that are quite rare in most countries, whereas the synchronous presence of all of them renders the island geomorphologically and geologically unique. It is also an area where the major exogenous (erosion and deposition) and endogenous processes (tectonic/seismic activity) can be understood and their combined impacts on the relief can be clearly observed, which is a very significant aspect in a region's geomorphological heritage (Grandgirard, 1997; Panizza, 2001; Panizza & Piacente, 1993; Strasser et al., 1995).

Table 2. List of the assessed geomorphosites from north to south.

Identification Code	Location	Scientific value	Ecological value	Aesthetic value	Cultural value	Economic value
AFAslc01	Afandou	0.88	0.00	0.88	1.00	0.50
AGAslc01	Agathi	0.88	0.00	0.63	0.75	0.75
ARCtec01	Archange-los	0.88	0.00	0.50	0.75	0.75
GENdep01	Gennadi	0.81	0.38	0.25	1.00	0.75
KALdep01	Kallithea	0.81	0.13	0.50	0.75	0.75
KAVslc01	Kavoura-kia	0.75	0.50	0.50	1.00	0.50
LADbio01	Ladiko	0.75	0.13	0.25	1.00	0.50
LADkar01	Ladiko	0.50	0.75	0.38	0.75	0.50
LADslc01	Ladiko	0.75	0.00	0.63	1.00	0.50

LARslc03	Lardos	0.75	0.38	0.38	0.50	0.50
LINslc01	Lindos	0.69	0.00	0.63	1.00	1.00
LINslc02	Lindos	0.69	0.00	0.50	1.00	1.00
LINtec02	Lindos	0.63	0.00	0.50	1.00	1.00
PRAdep01	Prasonisi	0.63	0.13	1.00	0.75	1.00
TRAero01	Traounou	0.63	0.00	0.63	0.75	0.75
TRAero02	Traounou	0.56	0.00	0.63	0.75	0.75
TRAslc01	Traounou	0.56	0.00	0.63	0.50	0.75
TSAdep01	Tsambika	0.56	0.88	0.75	1.00	1.00

The scientific value of all geomorphosites is high, exceeding the value of 0.5 according to the assessment method (Fig. 12). The highest-scoring geomorphosites, whose grade exceeds 0.8, include Agathi terraces, Kallithea palaeodelta, Lindos palaeo-shorelines, Archangelos faults and Gennadi tsunami deposits. Another three of the 18 geomorphosites were graded with less than 0.6, whereas the remaining 11 geomorphosites have a grade of 0.6 to 0.8.

The integrity of the geomorphosites, that is their extent of conservation, is high, as there exist only six sites with an integrity value of 0.5 m and one (Afandou) with 0.25, the rest being graded with 0.75 or 1. The reason for this is that most of Rhodes' geomorphosites include areas which are very easy to observe and approach, however, not favoring human interventions (such as touristic activities, constructions etc.), but rather on their vicinity. As a result, most of the island's geomorphosites are intact by humans. In fact, the geomorphosites graded with 0.5 include the beaches, which are very crowded during the touristic season (April to November) but return to their natural form during winter. Afandou terraces have been graded with 0.25, because some of them have constructions on them.

The representativeness is also high, because the landforms and the geomorphosites are representative of their geomorphological types and their formation processes. Rareness was found intermediate for most geomorphosites, except for certain sites whose morphological features, or the landforms themselves, are very rare. Finally, the palaeogeographical value was graded very high for most of the selected geomorphosites, as they are valuable sea-level indicators, meaning that they can reveal the island's recent geological history and tectonic evolution.

As far as the additional values are concerned (Fig. 13), the aesthetic value was found to be intermediate to high (according to the geomorphosite). The cultural value ranged from low to high with a relatively even distribution. The economic value was found to be high, due to the sites' high touristic dynamics, as every year, a significant number of international tourists arrive at Rhodes and contribute to its local economy through visiting most of the proposed geomorphosites. The ecological value was not found high, apart from the dunes and beachrocks sites (Fig. 14).

Overall, it can be seen that many geomorphosites present a high scientific value as well as a cultural value. The aesthetic values are variable but are generally above 0.5 with the exception of three sites (GENdep01, LADbio01, LARslc03). Conversely, the vast majority of geomorphosites are characterized by low ecological value. The aforementioned values highlight the geoheritage potential of Rhodes Island. The vast majority of geomorphosites are clearly visited and easily accessible. Some of the geomorphosites are hosted on known touristic areas, however, no information (e.g. information boards) is usually available to inform visitors.

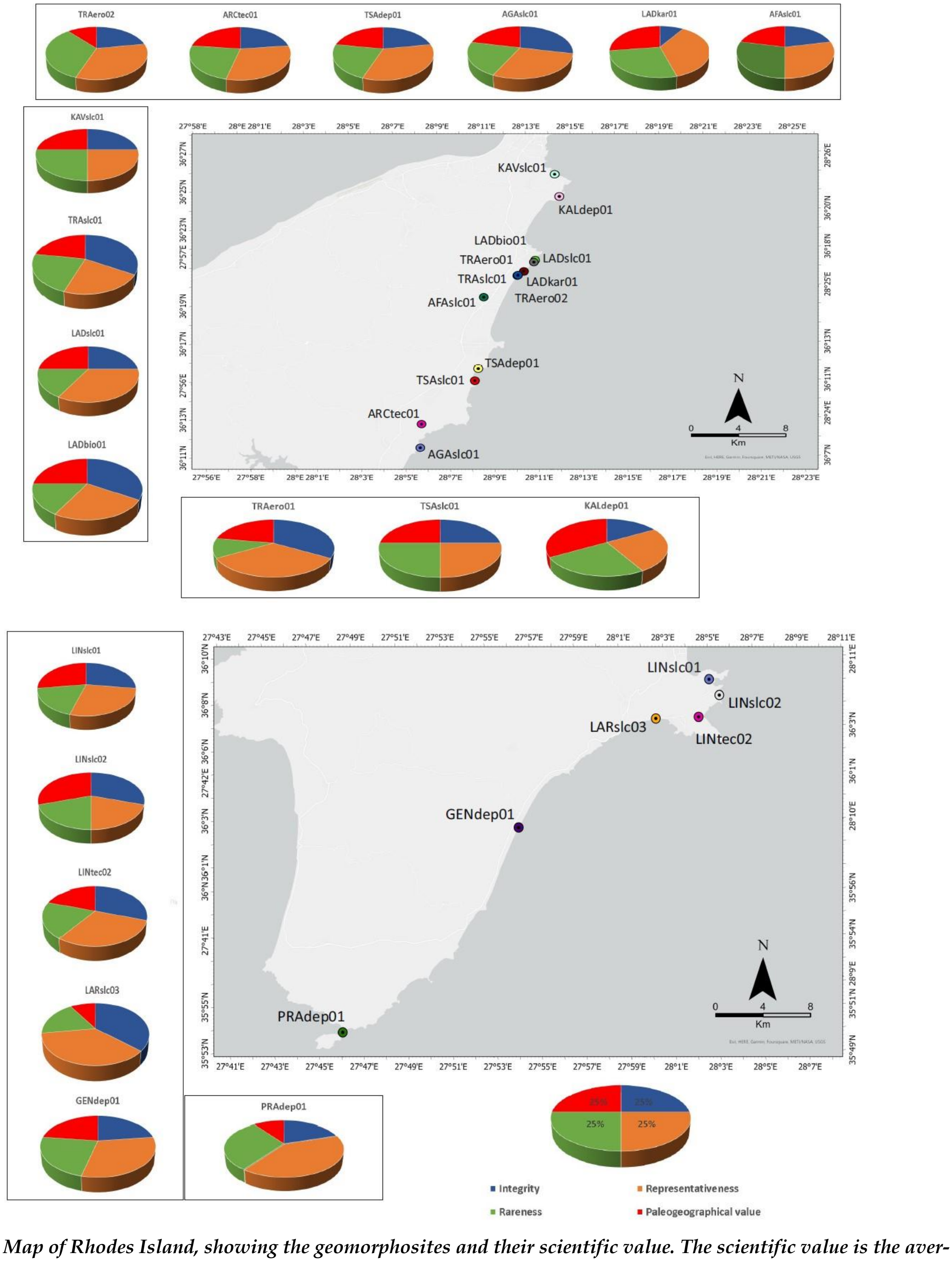


Figure 12. Map of Rhodes Island, showing the geomorphosites and their scientific value. The scientific value is the average of 4 sub-parameters, described in the methodology section. The diagrams framing the map show as pie chart the contribution of each parameter (integrity, representativeness, rareness, and palaeogeographical value) to the final calculation of the scientific value for each geomorphosite. Blue section: integrity, Green: rareness, Orange: representativeness, Red: palaeogeographical value.

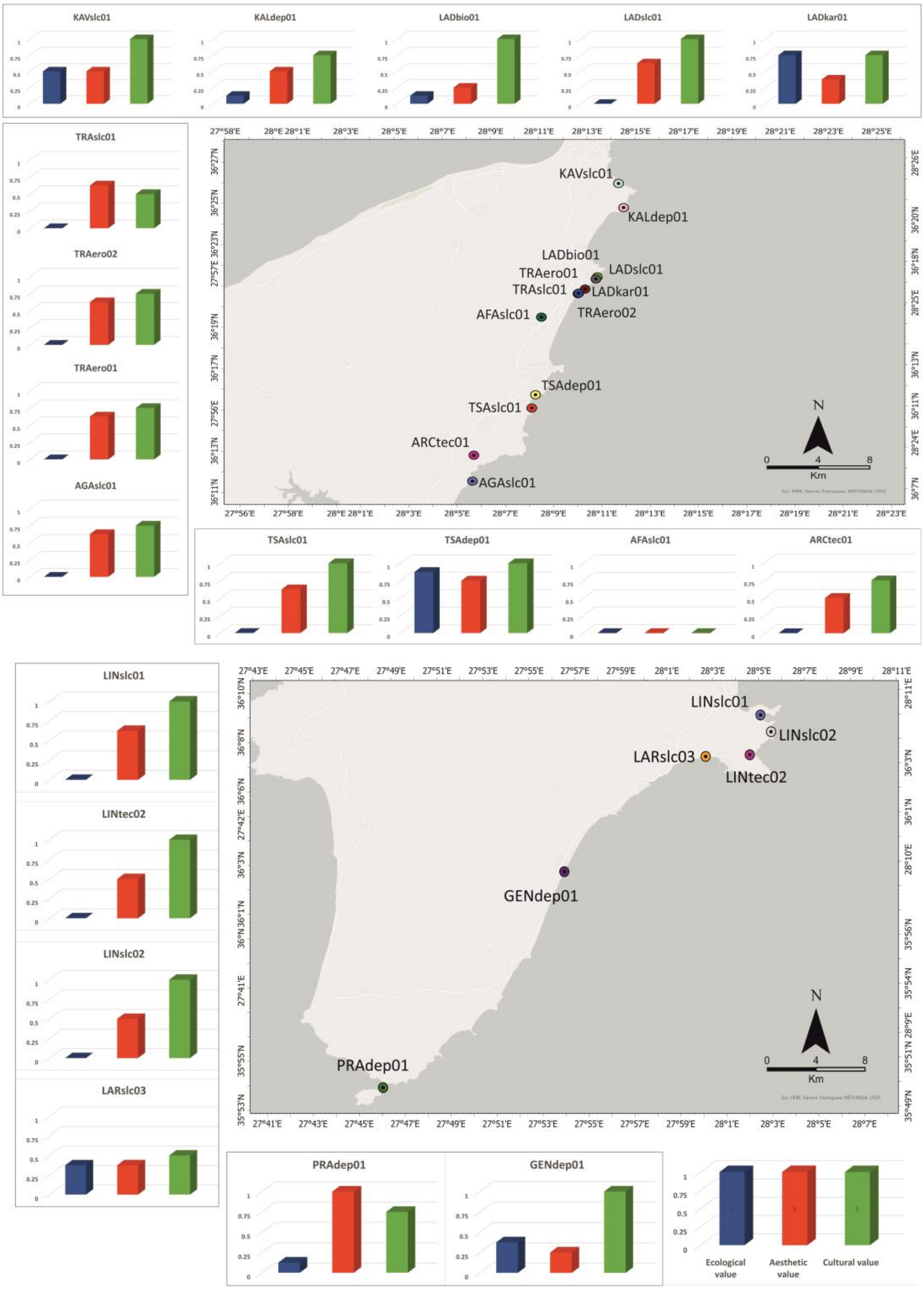


Figure 13. Map of Rhodes Island, showing the geomorphosites and their additional values. The diagrams framing the map show the relationship between ecological, aesthetic, and cultural value for each geomorphosite. For each of the additional values we followed a different assessment method, as described in the materials and methods section. The blue columns represent ecological value, the red columns represent aesthetic value, and the green columns represent cultural value.

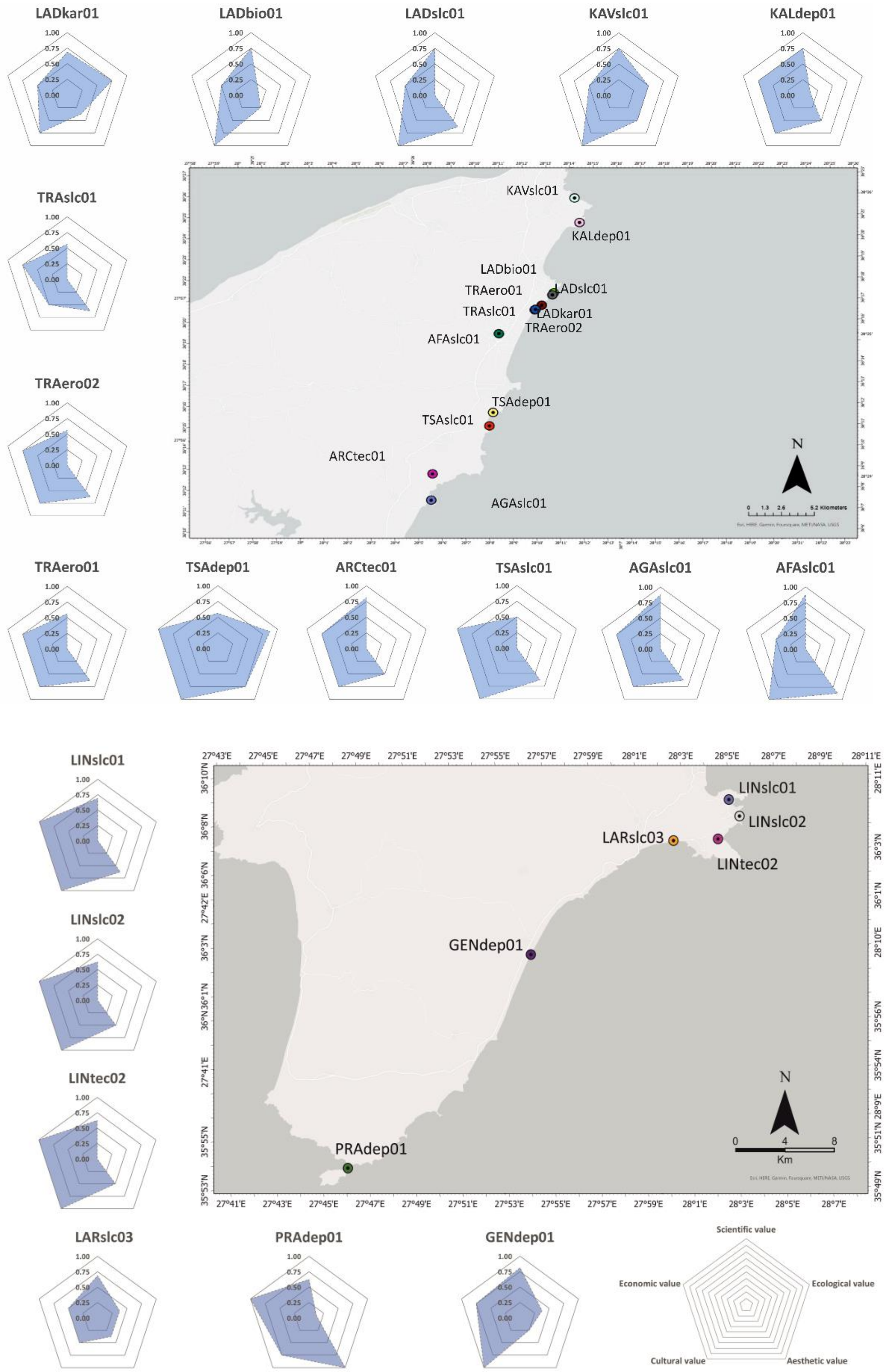


Figure 14. Map of Rhodes Island, where the selected geomorphosites, as well as spider diagrams regarding their values are depicted. Each spider diagram consists of a sequence of equi-angular spokes, with each spoke representing one of the following variables: scientific value, economic value, ecological value, cultural value, and aesthetic value (See Table 2).

4.3. Promotion of Rhodes' geomorphological heritage

Rhodes island hosts a significant proportion of Greece's tourism during spring and summer months (Lagos et al., 2015); in fact, it has been estimated to contribute to the country's annual tourism by 10-11% (Karamanakou & Karamountzou, 2014), occupying almost 40% of the locals. Tourism in Rhodes is almost exclusively the typical beach tourism (Antoniou, 2021). Alternative forms of tourism are only found rarely (Antoniou, 2021; Prokopiou et al., 2014). This is mainly because the tourists themselves are unaware of the island's geological interest and the various sites of geological value. At the same time, the locals mainly promote the beach tourism. This form of tourism has been shown to bear many negative impacts on touristic areas, regarding for example the natural beauty and the environment. This is particularly the case of Rhodes Island, where massive tourism has already damaged many natural habitats and attractions (Lagos et al., 2015). And geographically speaking, the part of the islands that is typically the most crowded during summer and spring months is the northern and eastern (Kyriakou et al., 2017; Prokopiou et al., 2014; Tselentis et al., 2006; Vandarakis et al., 2019).

The above situation renders the development of alternative forms of tourism necessary. Massive tourism in Rhodes has already started degrading its natural environment (Darivianaki, 2022; Kyriakou et al., 2017; Lagos et al., 2015; Vandarakis et al., 2019). Rhodes is not the only case study in Greece where massive tourism has resulted in an environmental and cultural degradation. Many Greek sites exist, predominantly insular ones, where tourism has born many negative impacts (Dimelli, 2017; Papadopoulos, 1988).

Alternative forms of tourism have been shown to have positive effects on an area's natural environment (Oriade & Evans, 2011). It is important to note that, even in cases where alternative forms of tourism bear a negative effect on the natural and cultural environment, they have a significantly lesser contribution compared to massive tourism. Among the most important of the pressures of mass tourism, most of which have also been exerted to Greece, include the depletion of natural resources, degradation of the natural environment, pollution, waste disposal, as well as pressures on the cultural heritage (Dimelli, 2017; Oriade & Evans, 2011; Papadopoulos, 1988).

Based on the above, alternative forms of tourism are necessary in order for Rhodes island's cultural and aesthetic value, as well as the natural environment itself, to be preserved (Kyriakou et al., 2011; Kyriakou et al., 2017; Neto, 2002; Tselentis et al., 2012). Not only have alternative forms of tourism been shown to have less impact on the environment (Oriade & Evans, 2011) but raised awareness regarding a region's natural heritage may lead tourists to have a more environmentally friendly behavior as well. Additionally, in this way, natural heritage can be protected and preserved.

The promotion of geoheritage can attract a number of geotourists, thus contributing to the financial prosperity and sustainable development of an area (Cappadonia et al., 2018; Eder & Patzak, 2004; Errami et al., 2015; Filocamo et al., 2019; Marchetti et al., 2017; Newsome et al., 2012; Newsome & Dowling, 2018). Geotourism is a relatively new type of tourism (Newsome et al., 2012; Newsome & Dowling, 2018). As opposed to other forms of tourism, it regards the geological heritage of an area, i.e., sites of geological interest (Dowling, 2011; Hose, 2012; Kubalíková, 2014; Newsome et al., 2012; Newsome & Dowling, 2018; Pralong, 2006; Ruban, 2015). During the last decades, there have been several attempts for the promotion and preservation of the geological heritage in several regions. It is worth mentioning that geotourism does not only regard geoscientists, but non-experts (including for instance families) can luxuriate in it as well (Gordon, 2018).

In the case of Greece, it should be noted that in a recent review, Zafeiropoulos et al. (2021) stress the need for the establishment of an appropriate legal framework to protect geotopes, given the fact that this will facilitate their promotion and appropriate management. The same authors highlight the lack of "geodiversity" as a term, as opposed to biodiversity.

The authors believe that, for alternative tourism to develop in Rhodes Island, its natural heritage needs first to become acknowledged and widely known. For a better promotion of Rhodes island's geomorphological heritage, a story map was created through the ArcGIS platform. The platform is particularly practical for such purposes, as users can easily observe many sites of interest, as well as surrounding areas, in all three dimensions and from different aspects. In this way, they can have an overall view of any area they wish to observe, meaning that it is much easier for them to comprehend its recent geological, geomorphological and tectonic evolution, as well as the processes to which it is owed (see for example Evelpidou et al. (2021)).

Through this story map, one can virtually navigate over the studied areas in order to obtain the information they desire; thus, it is a tool to create virtual field trips. Virtual field trips in general can be very useful for anyone who wishes to visit an area. Before the physical visit of the area, one can for example prepare themselves as to which points specifically one wishes to visit, to what extent and in what way they are accessible etc. They are a particularly useful tool for geoscientists, as they can study a region's relief and geomorphological structure, thus better comprehending the processes that have taken place, as well as the area's recent geological evolution. Furthermore, they can prepare themselves regarding sites that will need further studying, measurements, sample collection etc. and, of course, regarding how the said sites can be accessed (Cliffe, 2017; Evelpidou et al., 2021; Stainfield et al., 2000). Additionally, they can function as an alternative to the actual visit of an area, when the latter is very far away and/or not accessible (Hurst, 1998).

Furthermore, they can be very helpful when it comes to geographical aspects. For example, this paper issues a story map in Rhodes Island. A simple map or a number of maps would not give potential users the ability to understand where this location is, or at least not efficiently. On the contrary, through the ArcGIS Story Map platform, one can zoom in or out, thus observing the relative location of any area in comparison to a location they are familiar with.

And as far as geology is concerned, it is a useful tool for any geological work, mainly as a means of preparation. Another usage is the promotion of geoheritage, as is proposed in this paper. One can use the story map to view an area's primary geological sites, where one can comprehend for example its geological history and the geological processes that have acted over the last thousand to a few million years. In this way, they can select the sites with the highest geological interest (objectively or subjectively), so that they visit them in the future. Additionally, they can learn about sites that are not very "famous", sites, for instance, for which there is scarce information in common websites or books. It is clear that in this way, not only can the geomorphological wealth of a region be promoted to geologists, but to non-experts (geotourists) as well.

Such a story map can further aid the promotion of geoheritage, as users do not solely observe the area of interest in all dimensions and/or aspects, but they can obtain information about the individual sites of interest as well, as ArcGIS offers the story map creators the ability to add information in the form of texts, as well as photos, videos etc. Additionally, satellite images of previous periods can be successively studied, which can aid them in the comprehension of the area's recent evolution, thus the palaeogeographical aspect of its total geological interest for example.

5. CONCLUSION

Through our research, we selected and assessed 18 sites of geomorphological interest on Rhodes' eastern coast. The overall scientific value of the geomorphosites was found to be very high, due to their very good conservation, rare character, high palaeogeographical value and high representativeness. They are also characterized by high cultural values and aesthetic values mostly above 0.5. Our work can serve for both educational and touristic purposes. Given the geomorphological abundancy of Rhodes Island, our approach may also be used for educational purposes as an introduction to the geomorphological features of Rhodes Island for higher education students. With regard to tourism, presently, in Rhodes Island the typical, insular massive tourism dominates, which has led to a significant environmental degradation of the island. Our findings highlight the geoheritage potential of Rhodes Island, which can contribute to a different form of tourism, such as geotourism. Given the fact that the island is highly popular, it does not lack the corresponding facilities for hosting geotourism. Alternative forms of tourism can be developed, in order for an environmental restoration to be achieved. We believe that through our research, we can promote the geomorphological value of the island and contribute to the development of geotourism.

Author Contributions: Conceptualization, N.E.; methodology, N.E., A.K. and E.S.; investigation, N.E., A.K. and E.S.; writing—original draft preparation, N.E., A.K. and E.S.; writing—review and editing, N.E., A.K., E.S., A.-T.G. and G.S.; visualization, A.-T.G. and G.S.; supervision, N.E. All authors have read and agreed to the published version of the manuscript.

ACKNOWLEDGEMENTS

We thank the anonymous reviewers for their constructive comments.

REFERENCES

Alexandrakis, G., Petrakis, S., & Kampanis, N. A. (2021). Integrating geomorphological data, geochronology and archaeological evidence for coastal landscape reconstruction, the case of Ammoudara Beach, Crete. *Water*, Vol. 13(9), 1269. https://doi.org/10.3390/w13091269

Allard, J., Bertin, X., Chaumillon, E., & Pouget, F. (2008). Sand spit rhythmic development: A potential record of wave climate variations? Arçay Spit, western coast of France. *Marine Geology*, Vol. 253(3–4), 107–

131. https://doi.org/10.1016/j.margeo.2008.05.009

Antoniou, M. (2021). Alternative forms of tourism: The case study of Rhodes. Aegean University, Chios, Greece.

Bosák, P. (2002). Karst processes from the beginning to the end: How can they be dated? *Speleogenesis and Evolution of Karst Aquifers*, Vol. 1, 1–24. http://speleogenesis.com/archive/publication.php?PubID=3253&Type=publication

Bricker, O. P. (1971). Introduction: beachrock and intertidal cement. In O. P. Bricker (Ed.), *Carbonate Cements*. Johns Hopkins Press, pp. 1–13.

Brilha, J. (2016). Inventory and Quantitative Assessment of Geosites and Geodiversity Sites: a Review. *Geoheritage*, Vol. 8(2), 119–134. https://doi.org/10.1007/s12371-014-0139-3

Bruno, D. E. (2016). Encyclopedia of Mineral and Energy Policy. Encyclopedia of Mineral and Energy Policy, 3–7. https://doi.org/10.1007/978-3-642-40871-7

Cappadonia, C., Coratza, P., Agnesi, V., & Soldati, M. (2018). Malta and Sicily joined by geoheritage enhancement and geotourism within the framework of land management and development. *Geosciences*, Vol. 8, 253. https://doi.org/10.3390/geosciences8070253

Cliffe, A. D. (2017). A review of the benefits and drawbacks to virtual field guides in today's Geoscience higher education environment. *International Journal of Educational Technology in Higher Education*, Vol. 14(1). https://doi.org/10.1186/s41239-017-0066-x

Costas, S., Naughton, F., Goble, R., & Renssen, H. (2016). Windiness spells in SW Europe since the last glacial maximum. *Earth and Planetary Science Letters*, Vol. 436, 82–92. https://doi.org/10.1016/j.epsl.2015.12.023

Darivianaki, A. (2022). *Social, environmental and economic impacts of tourism on Rhodes*. Aristotle University of Thessaloniki, Thessaloniki, Greece.

Davronovna, K. M., Sadriddinovich, E. S., & Yigitali Jo'ra o'g, J. (2022). Dependence of Karst Processes on Physico-Chemical Properties of Salts. *American Journal of Social and Humanitarian Research*, Vol. 3(9), 25–28.

de Lima, F. F., Brilha, J. B., & Salamuni, E. (2010). Inventorying Geological Heritage in Large Territories: A Methodological Proposal Applied to Brazil. *Geoheritage*, Vol. 2(3), 91–99. https://doi.org/10.1007/s12371-010-0014-9

De Mahiques, M. M. (2016). Tombolo. In M. J. Kennish (Ed.), *Encyclopedia of Estuaries*. Encyclopedia of Earth Sciences Series. Springer, pp. 713–714.

Dewey J. F and Sengor A. M. C. (1979). Aegean and surrounding regions: Complex multiplate and continuum tectonics in a convergent zone. *Geological Society of America Bulletin*, Vol. 90(1), 84–92. https://doi.org/10.1130/0016-7606(1979)90<84

Dimelli, D. P. (2017). The Effects of Tourism in Greek Insular Settlements and the Role of Spatial Planning. *Journal of the Knowledge Economy*, Vol. 8(1), 319–336. https://doi.org/10.1007/s13132-016-0364-x

Dowling, R. K. (2011). Geotourism's Global Growth. *Geoheritage*, Vol. 3(1), 1–13. https://doi.org/10.1007/s12371-010-0024-7

Drinia, H., Tsipra, T., Panagiaris, G., Patsoules, M., Papantoniou, C., & Magganas, A. (2021). Geological heritage of syros island, cyclades complex, Greece: an assessment and geotourism perspectives. *Geosciences*, Vol. 11(3), 1–21. https://doi.org/10.3390/geosciences11030138

Eder, F. W., & Patzak, M. (2004). Geoparks-geological attractions: A tool for public education, recreation and sustainable economic development. *Episodes*, Vol. 27(3), 162–164. https://doi.org/10.18814/epiiugs/2004/v27i3/001

Errami, E., Brocx, M., & Semeniuk, V. (2015). *From Geoheritage to Geoparks: Case Studies from Africa and Beyond*. Springer.

Evelpidou, N., Kampolis, I., Pirazzoli, P. A., & Vassilopoulos, A. (2012). Global sea-level rise and the disappearance of tidal notches. *Global and Planetary Change*, Vol. 92–93, 248–256. https://doi.org/10.1016/j.gloplacha.2012.05.013

Evelpidou, N., Karkani, A., Saitis, G., & Spyrou, E. (2021). Virtual field trips as a tool for indirect geomorphological experience: A case study from the southeastern part of the Gulf of Corinth, Greece. *Geoscience Communication*, Vol. 4(3), 351–360. https://doi.org/10.5194/GC-4-351-2021

Evelpidou, N., Karkani, A., Tzouxanioti, M., Spyrou, E., Petropoulos, A., & Lakidi, L. (2021). Inventory and assessment of the geomorphosites in central cyclades, Greece: the case of paros and naxos islands. *Geosciences*, Vol. 11, 512. https://doi.org/10.3390/geosciences11120512

Filocamo, F., Rosskopf, C. M., & Amato, V. (2019). A Contribution to the Understanding of the Apennine

Landscapes: the Potential Role of Molise Geosites. *Geoheritage*, Vol. 11(4), 1667–1688. https://doi.org/10.1007/s12371-019-00365-2

Flemming, N. . C. . (1978). Holocene Eustatic Changes and Coastal Tectonics in the Northeast Mediterranean : Implications for Models of Crustal Consumption. *Philosophical Transactions of the Royal Society of London. Series A*, Vol. 289(1362), 405–458.

Frisia, S., & Borsato, A. (2010). Karst. In A. M. Alonso-Zarza & L. H. Tanner (Eds.), *Developments in Sedimentology*. Elsevier B.V., Vol. 61, pp. 269–318. https://doi.org/10.1016/S0070-4571(09)06106-8

Gauthier, A. J. (1979). Contribution a l' etude neotectonique du domaine egeen: l' ile de Rhodes. Universite Paris XI, Paris, France.

Georgousis, E., Savelides, S., Mosios, S., Holokolos, M. V., & Drinia, H. (2021). The need for geoethical awareness: The importance of geoenvironmental education in geoheritage understanding in the case of meteora geomorphes, greece. *Sustainability*, Vol. 13(12). https://doi.org/10.3390/su13126626

Gordon, J. E. (2018). Geoheritage, geotourism and the cultural landscape: Enhancing the visitor experience and promoting geoconservation. *Geosciences*, Vol. 8, 6626. https://doi.org/10.3390/geosciences8040136

Grandgirard, V. (1997). Geomorphologie et gestion du patrimoine naturel. La memoire de la Terre est notre memoire. *Geographica Helvetica*, Vol. 2, 47–56.

Hanken, N. M., Bromley, R. G., & Miller, J. (1996). Plio-Pleistocene sedimentation in coastal grabens, north-east Rhodes, Greece. *Geological Journal*, Vol. 31(4), 393–418. https://doi.org/10.1002/(SICI)1099-1034(199612)31:4<393::AID-GJ712>3.3.CO;2-8

Hansen, K. (2001). *Sedimentology of Pliocene–Pleistocene temperate water carbonates from northeast Rhodes, Greece*. University of Copenhagen, Copenhagen, Denmark.

Hansen, K. S. (1999). Development of a prograding carbonate wedge during sea level fall: Lower Pleistocene of Rhodes, Greece. *Sedimentology*, Vol. 46(3), 559–576. https://doi.org/10.1046/j.1365-3091.1999.00238.x

Hose, T. A. (2012). Editorial: Geotourism and Geoconservation. *Geoheritage*, Vol. 4(1–2), 1–5. https://doi.org/10.1007/s12371-012-0059-z

Howell, A., Jackson, J., England, P., Higham, T., & Synolakis, C. (2015). Late Holocene uplift of Rhodes, Greece: Evidence for a large tsunamigenic earthquake and the implications for the tectonics of the eastern Hellenic Trench System. *Geophysical Journal International*, Vol. 203(1), 459–474. https://doi.org/10.1093/gji/ggv307

Hurst, S. D. (1998). Use of "virtual" field trips in teaching introductory geology. *Computers and Geosciences*, Vol. 24(7), 653–658. https://doi.org/10.1016/S0098-3004(98)00043-0

Karamanakou, M., & Karamountzou, E. (2014). *The evolution of the tourist movement In Greece and the competition with other countries*. Higher Educational Institution of Piraeus.

Karkani, A., Evelpidou, N., Vacchi, M., Morhange, C., Tsukamoto, S., Frechen, M., & Maroukian, H. (2017). Tracking shoreline evolution in central Cyclades (Greece) using beachrocks. *Marine Geology*, Vol. 388, 25–37. https://doi.org/10.1016/j.margeo.2017.04.009

Kelly, C. S., Green, A. N., Cooper, J. A. G., & Wiles, E. (2014). Beachrock facies variability and sea level implications: A preliminary study. *Journal of Coastal Research*, Vol. 70, 736–742. https://doi.org/10.2112/SI70-124.1

Keraudren, B. (1971). Les formations quaternaires marines de la Grèce (deuxième partie). *Bulletin Du Musée d'anthropologie Préhistorique de Monaco*, Vol. 17, 87–169.

Kontogianni, V. A., Tsoulos, N., & Stiros, S. C. (2002). Coastal uplift, earthquakes and active faulting of Rhodes Island (Aegean Arc): modeling based on geodetic inversion. *Marine Geology*, Vol. 186, 299–317. www.elsevier.com/locate/margeo

Kubalíková, L. (2014). Geomorphosite assessment for geotourism purposes. *Czech Journal of Tourism*, Vol. 2(2), 80–104. https://doi.org/10.2478/cjot-2013-0005

Kyriakou K., Hatiris G.-A., Kapsimalis V., Sourianos E., & Vandarakis D. (2017). The application of GIS in Tourism Carrying Capacity Assessment for the Island of Rhodes, Greece. Proceedings 15th International Conference on Environmental Science and Technology (CEST), 31 August - 2 September 2017.

Kyriakou, K., Sourianos, E., & Vagiona, D. (2011). Tourism development and carrying capacity in the Rhodes Island, Greece. 3rd International Conference on Environmental Management, Engineering, Planning and Economics (Cemepe).

Lagos, D., Papatheodorou, A., & Stavrinoudis, T. (2015). Comparative assessment of tourism bearing capacity in Kos and Rhodes 711 islands. *Insularity and Sustainability: The Case of the Aegean Islands*, 57–73.

Le Pichon, X., & Angelier, J. (1979). The Hellenic Arc and trench system: a key to the neotectonic evolution of the Eastern Mediterranean area. *Tectonophysics*, Vol. 60, 1–42.

Lekkas, E., Papanikolaou, D., & Sakellariou, D. (1993). Neotectonic map of Greece, 1:100.000 scale: Rhodos.

Limber, P. W., & Murray, A. B. (2011). Beach and sea-cliff dynamics as a driver of long-term rocky coastline evolution and stability. *Geology*, Vol. 39(12), 1147–1150.

Limber, P. W., & Murray, A. B. (2015). Sea stack formation and the role of abrasion on beach-mantled headlands. *Earth Surface Processes and Landforms*, Vol. 40(4), 559–568. https://doi.org/10.1002/esp.3667

Malliouri, D. I., Petrakis, S., Vandarakis, D., Kikaki, K., Hatiris, G. A., Gad, F. K., Panagiotopoulos, I. P., & Kapsimalis, V. (2022). The Role of Sea State to the Morphological Changes of Prasonisi Tombolo, Rhodes Island, Greece. *Water*, Vol. 14, 2016. https://doi.org/10.3390/w14132016

Marchetti, M., Soldati, M., & Vandelli, V. (2017). The great diversity of Italian landscapes and landforms: Their origin and human imprint. In M. Soldati & M. Marchetti (Eds.), *Landscapes and Landforms of Italy*. Springer, pp. 7–20.

Marquardt, C., Lavenu, A., Ortlieb, L., Godoy, E., & Comte, D. (2004). Coastal neotectonics in Southern Central Andes: Uplift and deformation of marine terraces in Northern Chile (27°S). *Tectonophysics*, Vol. 394(3–4), 193–219. https://doi.org/10.1016/j.tecto.2004.07.059

Mauz, B., Vacchi, M., Green, A., Hoffmann, G., & Cooper, A. (2015). Beachrock: A tool for reconstructing relative sea level in the far-field. *Marine Geology*, Vol. 362, 1–16. https://doi.org/10.1016/j.margeo.2015.01.009

Mckenzie, D. (1970). Plate tectonics of the Mediterranean Region. *Nature*, Vol. 226, 726–734. http://www.mendeley.com/research/discreteness-conductance-chnge-n-bimolecular-lipid-membrane-presence-certin-antibiotics/

McKenzie, D. (1972). Active Tectonics of the Mediterranean Region. *Geophysical Journal of the Royal Astronomical Society*, Vol. 30(2), 109–185. https://doi.org/10.1111/j.1365-246X.1972.tb02351.x

Milàn, J., Bromley, R. G., & Theodorou, G. (2007). A diverse vertebrate ichnofauna from a Quaternary eolian oolite, Rhodes, Greece. In *Sediment–Organism Interactions: A Multifaceted Ichnology* (Issue 88, pp. 333–343). SEPM Special Publication.

Mutti, E., Orombelli, G., & Pozzi, R. (1970). Geological Studies of the Dodecanese Islands (Aegean Sea). Geological map of the Island of Rhodes and Explanatory Notes. *Annales Géologiques Des Pays Helléniques*, Vol. 22, 77–226.

Mylroie, J. E. (2019). Coastal caves. In *Encyclopedia of Caves*. Elsevier Inc., 3rd ed., pp. 301–307. https://doi.org/10.1016/b978-0-12-814124-3.00033-9

Neto, F. (2002). Sustainable Tourism, Environmental Protection and Natural Resource Management: Paradise on Earth? International Colloquium on Regional Governance and Sustainable Development in Tourism, 20–22 February, 2002. Driven Economies, United Nations.

Newsome, D., & Dowling, R. (2018). Geoheritage and Geotourism. In E. Reynard & J. Brilha (Eds.), *Geoheritage: Assessment, Protection, and Management*. Elsevier, pp. 305–321.

Newsome, D., Dowling, R., & Leung, Y. F. (2012). The nature and management of geotourism: A case study of two established iconic geotourism destinations. *Tourism Management Perspectives*, Vol. 2–3, 19–27. https://doi.org/10.1016/j.tmp.2011.12.009

Oriade, A., & Evans, M. (2011). Sustainable and Alternative Tourism. In P. Robinson, S. Heitmann, & P. Dieke (Eds.), *Research Themes for Tourism*. CABI, pp. 69–86. https://doi.org/10.1080/1743873x.2011.601882

Panizza, M. (2001). Geomorphosites: Concepts, methods and examples of geomorphological survey. *Chinese Science Bulletin*, Vol. 46, 4–6. https://doi.org/10.1007/bf03187227

Panizza, M., & Piacente, S. (1993). Geomorphological assets evaluation. *Zeitschrift Für Geomorphologie, Supplement Issues*, Vol. 87, 13–18.

Papadopoulos, S. I. (1988). An examination of non-economic factors related to tourism in Greece. *Revue de Tourisme*, Vol. 2, 24–27.

Papazachos, V., & Papazachos, K. (1989). *The earthquakes of Greece*. Ziti.

Pereira, P., & Pereira, D. (2010). Methodological guidelines for geomorphosite assessment. *Geomorphologie: Relief, Processus, Environnement*, Vol. 2, 215–222. https://doi.org/10.4000/geomorphologie.7942

Pirazzoli, P. A. (1986). Marine notches. In O. Plassche (Ed.), *Sea-level research*. Springer, pp. 361–400. https://doi.org/10.1007/978-94-009-4215-8_12

Pirazzoli, P. A., & Evelpidou, N. (2013). Tidal notches: A sea-level indicator of uncertain archival trustworthiness. *Palaeogeography, Palaeoclimatology, Palaeoecology*, Vol. 369, 377–384. https://doi.org/10.1016/j.palaeo.2012.11.004

Pirazzoli, P. A., Montaggioni, L. F., Saliège, J. F., Segonzac, G., Thommeret, Y., & Vergnaud-Grazzini, C. (1989). Crustal block movements from Holocene shorelines: Rhodes Island (Greece). *Tectonophysics*, Vol. 170(1–2), 89–114. https://doi.org/10.1016/0040-1951(89)90105-4

Polidorou, M., & Evelpidou, N. (2021). Geomorphology of the coastal sand dune fields and their association with the palaeolandscape evolution of Akrotiri peninsula, Lemesos, Cyprus. *Geosciences*, 11, 448. https://doi.org/10.3390/geosciences11110448

Pralong, J. P. (2005). A method for assessing tourist potential and use of geomorphological sites. *Géomorphologie: Relief, Processus, Environnement*, Vol. 11(3), 189–196.

Pralong, J. P. (2006). Geotourism: A new Form of Tourism utilising natural Landscapes and based on Imagination and Emotion. *Tourism Review*, Vol. 61(3), 20–25. https://doi.org/10.1108/eb058476

Prokopiou, D. G., Tselentis, B. S., Mavridoglou, G., & Lagos, D. (2014). Prototype model of carrying capacity in tourism: the implementations for the island of Rhodes. *European Scientific Journal*, Vol. 2, 434–442.

Psuty, N. P., & Silveira, T. M. (2010). Global climate change : an opportunity for coastal dunes ? *Journal of Coastal Conservation*, Vol. 14, 153–160. https://doi.org/10.1007/s11852-010-0089-0

Pye, K., & Blott, S. J. (2017). Evolution of a Sediment-Starved, over-Stabilised Dunefield. *Journal of Coastal Conservation*, Vol. 21(5), 685-717.

Reynard, E. (2004). Geosites. In A. S. Goudie (Ed.), *Encyclopedia of Geomorphology* (p. 440). Routledge.

Reynard, E., Coratza, P., & Regolini-Bissig, G. (2009). *Geomorphosites.* Verlag Dr. Friedrich Pfeil.

Reynard, E., Fontana, G., Kozlik, L., & Scapozza, C. (2007). A method for assessing "scientific" and "additional values" of geomorphosites. *Geographica Helvetica*, Vol. 62(3), 148–158. https://doi.org/10.5194/gh-62-148-2007

Reynard, E., Perret, A., Bussard, J., Grangier, L., & Martin, S. (2016). Integrated Approach for the Inventory and Management of Geomorphological Heritage at the Regional Scale. *Geoheritage*, Vol. 8(1), 43–60. https://doi.org/10.1007/s12371-015-0153-0

Robin, N., Levoy, F., Anthony, E. J., & Monfort, O. (2020). Sand spit dynamics in a large tidal-range environment: Insight from multiple LiDAR, UAV and hydrodynamic measurements on multiple spit hook development, breaching, reconstruction, and shoreline changes. *Earth Surface Processes and Landforms*, Vol. 45(11), 2706–2726. https://doi.org/10.1002/esp.4924

Ruban, D. A. (2015). Geotourism - A geographical review of the literature. *Tourism Management Perspectives*, Vol. 15, 1–15. https://doi.org/10.1016/j.tmp.2015.03.005

Saillard, M., Hall, S. R., Audin, L., Farber, D. L., Hérail, G., Martinod, J., Regard, V., Finkel, R. C., & Bondoux, F. (2009). Non-steady long-term uplift rates and Pleistocene marine terrace development along the Andean margin of Chile (31°S) inferred from 10Be dating. *Earth and Planetary Science Letters*, Vol. 277(1–2), 50–63. https://doi.org/10.1016/j.epsl.2008.09.039

Sakellariou, D., Nomikou, P., Baika, K., & Stiros, S. (2010). *Fieldtrip Guide.* IGCP 521 - INQUA 501 Sixth Plenary Meeting and Field Trip, September 27– October 5.

Spyrou, E., Triantaphyllou, M. V., Tsourou, T., Vassilakis, E., Asimakopoulos, C., Konsolaki, A., Markakis, D., Marketou-Galari, D., & Skentos, A. (2022). Assessment of Geological Heritage Sites and Their Significance for Geotouristic Exploitation: The Case of Lefkas, Meganisi, Kefalonia and Ithaki Islands, Ionian Sea, Greece. *Geosciences*, Vol. 12(2), 55. https://doi.org/10.3390/geosciences12020055

Stainfield, J., Fisher, P., Ford, B., & Solem, M. (2000). International Virtual Field Trips: A new direction? *Journal of Geography in Higher Education*, Vol. 24(2), 255–262. https://doi.org/10.1080/713677387

Steinthorsdottir, M., & Håkansson, E. (2017). Endo-and epilithic faunal succession in a Pliocene–Pleistocene cave on Rhodes, Greece: record of a transgression. *Palaeontology*, Vol. 60(5), 663–681.

Strasser, A., Heitzmann, P., Jordan, P., Stapfer, A., Stürm, B., Vogel, A., & Weidmann, M. (1995). Géotopes et la protection des objets géologiques en Suisse: un rapport stratégique. In *Groupe de travail suisse pour la protection des géotopes*.

Triantaphyllou, M. V, Firkasis, N., Tsourou, T., Vassilakis, E., Spyrou, E., Koukousioura, O., Oikonomou, A., & Skentos, A. (2023). “Geo-Archaeo-Routes” on the Island of Lemnos: The “Nalture” Experience as a Holistic Geotouristic Approach within the Geoethical Perspective. *Geosciences*, Vol. 13, 143. https://doi.org/https://doi.org/10.3390/geosciences13050143

Tselentis, B. S., Prokopiou, D. G., & Toanoglou, M. (2006). Carrying capacity assessment for the Greek islands of Kalymnos, Kos and Rhodes. *WIT Transactions on Ecology and the Environment*, Vol. 97, 353–363. https://doi.org/10.2495/ST060331

Tselentis, V. S., Prokopiou, D. G., & Toanoglou, M. (2012). Comparative analysis of carrying capacity indices for the central Aegean islands. *European Research Studies Journal*, Vol. 15(1), 155–170. https://doi.org/10.35808/ersj/349

Vandarakis, D., Kyriakou, K., Gad, F. K., Kapsimalis, V., Panagiotopoulos, I., Loukaidi, V., Hatiris, G. A., & Sioulas, A. (2019). The carrying capacity and environmental friendly plans for future tourism development in Rhodes Island, Greece. *European Journal of Geography*, Vol. 10(4), 149–159.

Vlachopoulos, N., & Voudouris, P. (2022). Preservation of the Geoheritage and Mining Heritage of Serifos Island, Greece: Geotourism Perspectives in a Potential New Global Unesco Geopark. *Geosciences*, Vol. 12, 127. https://doi.org/10.3390/geosciences12030127

Wimbledon, W. A. P. (1996). GEOSITES — a new conservation. *Episodes*, Vol. 19(3), 87–88.

Wimbledon, W. A. P., Andersen, S., Cleal, C. J., Cowie, J. W., Erikstad, L., Gonggrijp, G. P., Johanson, C. E., Karis, L. O., & Suominen, V. (1999). Geological World Heritage: GEOSITES - a global comparative site inventory to enable prioritisation for conservation. *Memorie Deser. Carta Geologique d'Italie*, Vol. 54, 45–60.

Zafeiropoulos, G., Drinia, H., Antonarakou, A., & Zouros, N. (2021). From geoheritage to geoeducation, geoethics and geotourism: A critical evaluation of the Greek region. *Geosciences*, Vol. 11, 381. https://doi.org/10.3390/geosciences11090381