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Anthropogenic degradation of the tourist trail in the Samaria Gorge (Western Crete)

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Abstract: The aim of this research was to estimate the scale and rate of tourist degradation in the surroundings of the trail in the Samaria Gorge. The extent of erosion was estimated based on field measurements.

The biggest tourist degradation marks the section between the 2nd and the 7th km of the trail The traces of treading are marked by: uncovered tree roots, showing the indentation of the trail at over 20 cm, stones protruding from the path, trampled roadsides and additional paths trodden along the trail. In the extreme case, the width of the trodden area exceeds 5 m. Below the Samaria village the trail leads mainly on the stony stream bed and there are no permanent traces of trampling.

The research has proven that hiking can be a serious threat to relief of Crete due to the high human congestion on a small area. However, it is not the amount of the tourist movement that decides about the rate and scale of degradation, but the relation of the path to the forms of relief, the character of the ground, and the dynamics of the meteorological phenomena in the tourist season.

Key words: Samaria Gorge, tourist degradation, hiking, erosion, tourist trail

Introduction

The influence of tourism on the shape of mountain areas is an interesting subject for many scientists. Many works concerning this topic have been published with regard to the Tatra Mountains, many of them being concerned with the morphological influence of hiking (Czochański & Szydarowski, 1996; Krusiec, 1996; Gorczyca & Krzemień, 2002; Kotarba, 2002). Similar research has been conducted in the Karkonosze Mountains (Parzóch & Katrycz, 2002), and outside Poland in the French Massif Central (Krzemień, 1995), in the Alps (Robens & Blacek, 1993), and in the Rocky Mountains (Price, 1985). In Greece, where hiking has developed only recently, and man has been heavily influencing the environment for the tens of centuries, tourist degradation of mountain slopes has not so far been in the centre of attention of geomorphologists. Many aspects of human impact have been considered but not the significance of contemporary leisure activities (Lyrintzis & Papanastasis, 1995; Rackham & Moody, 1996). This problem has not been reflected either in numerous works concerned with the influence of man on biotic elements of the environment in the Samaria Gorge (Spanos *et al*., 2008).

Aim of research and methods employed

The aim of the research conducted by the authors in September 2007 was to estimate the extent and rate of tourist degradation in the surroundings of the trail in the Samaria Gorge. The measurements of the depth and width of the path were done in the characteristic points – they were taken in the largest part in the most frequented places. At the same time the natural forms of relief crossed by the tourist trail were mapped. The extent of erosion was estimated based on the direct measurements of the width of treading and the depth of indentation of the paths as well as the observations of the extent of tree roots exposure. The enlargements of the topographic map at

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the scale of 1: 50,000 were the basis for field research (Topographical Map..., 1993).

Research area

The Samaria Gorge is one of the biggest forms of this kind in Europe (Fig. 1). It is located in the south-west of Crete, in the massive of the White Mountains, the highest peak of which reaches 2,454 m above the sea level. The length of the gorge is 18 km (16 km of tourist trail included), and the width of its bottom varies from 40 to only 3 m. The height of the slopes exceeds 300 m and locally it reaches almost 600 m. The surrounding of the gorge consists mainly of carbonate rocks. The upper part of the valley has been carved in Triassic limestones and dolomites, the lower part – in Permian-Carboniferous platy crystalline limestones with thin phyllitic intercalations (Fitrolakis, 1978). The gorge owes its origin to the combination of karst processes and river erosion, responding to strong neotectonic uplift.

The climate of Crete is described as subtropical continental and dry (Martyn, 2000). It is characterized by hot summers and mild, rainy winters. Precipitation in the White Mountains is one of the highest on Crete. In the highest parts, which are the area that supplies the Samaria Gorge in water, the annual precipitation exceeds 1,600 mm. On the recently opened Samaria station in the upper part of the gorge, there was 1457,6 mm precipitation noted down from September 2008 until March 2009 (data of the National Observatory of Athens).

The National Park White Mountains-Samaria Gorge is the largest protected area in Greece. It was established in 1962. In 1981 it became the UNESCO Biosphere Reserve. Currently, it covers the area of 4,850 ha. The most popular Greek mountain tourist trail goes through its area, along the axis of the Samaria Gorge. Even the path leading to the top of the Olympus does not match its popularity.

The valleys of the White Mountains have been inhabited since prehistoric times. In the upper part of the Samaria Gorge an ancient village of Kaino was likely located, and at its mouth the port of Tarra was established. In the modern times, in the widening of the valley over the middle part of the stream taking water from the above mentioned area, the village of Samaria was located. The only road leading to it was the today's tourist trail, but the congestion did not have such a significance for the environment of the gorge. The problem of erosion processes initiated by the tourists who visit this place is still unnoticed by the majority of naturalists. Even in the works of famous specialists dealing with the Mediterranean area there one can found the following statement: "Tourism is still underdeveloped in many areas, especially the mountains of Greece and Crete" (Grove & Rackham, 2003, p. 91). According to the authors, in the light of the facts mentioned below, this opinion, at least concerning the Samaria Gorge, seems to have no grounds.

Tourist movement in the Samaria Gorge

The creation of the national park took place during the time of considerable development of tourism in Crete. In 1962, the island was visited by ca. 23,000 tourists, whereas in 1999 by as many as over 12,000,000 (an over 500-fold increase!) (Andriotis, 2003). Around 2–3% of this number made a trip to the Samaria Gorge. The tourist season lasts there from April until October. In the other months, the bottom of the gorge changes into a strong stream, which makes hiking along the marked trail impossible. Particular congestion of the tourist trail takes place in the summer months – the journey between the Omalos Plateau and the port of Agia Roumeli is taken by over 2,000 people a day (personal information from the park warden). In the scale of the whole season, the number of visitors approaches 300,000. In the years 1981–2005, entry tickets to the gorge were purchased by 5.7 million people (data of Forestry Directoriate of Chania). A small part of this group chooses the path from the mouth to the upper part of the valley and back, but only on the 2-km distance. The majority uses the whole trail, going over the 1,227-m drop all along the run of the gorge.

Trail degradation in the Samaria Gorge

The trail starts at the altitude of 1,227 m a.s.l. The initial part is very steep – it traverses the slopes of the valley until it reaches its axis at the altitude of about 700 m a.s.l. Beyond that point the gradient of the trail is around 15 degrees. It leads mainly through the stairs made of stone and wood closely fitting the rock walls. Some parts of the path were secured from the plunged pieces of limestone with metal nets. Locally, this material gathers in the form of large scree (Fig. 2a).

Significant changes in the relief were needed in order to locate the trail in the place mentioned above. Currently, it is prone only to small anthropogenic changes. A considerable steepness of the slopes and the presence of the protecting nets make the widening of the path due to its being trodden upon practically impossible (Fig. 2b). However, a slight (ca. 20 cm) lowering of the trail is visible on the side of the upper slope, as the tourists choose mostly that part due to higher sense of safety.

The biggest tourist degradation marks the section between the 2nd and the 7th km of the journey. The trail approaches there the axis of the gorge, but it still

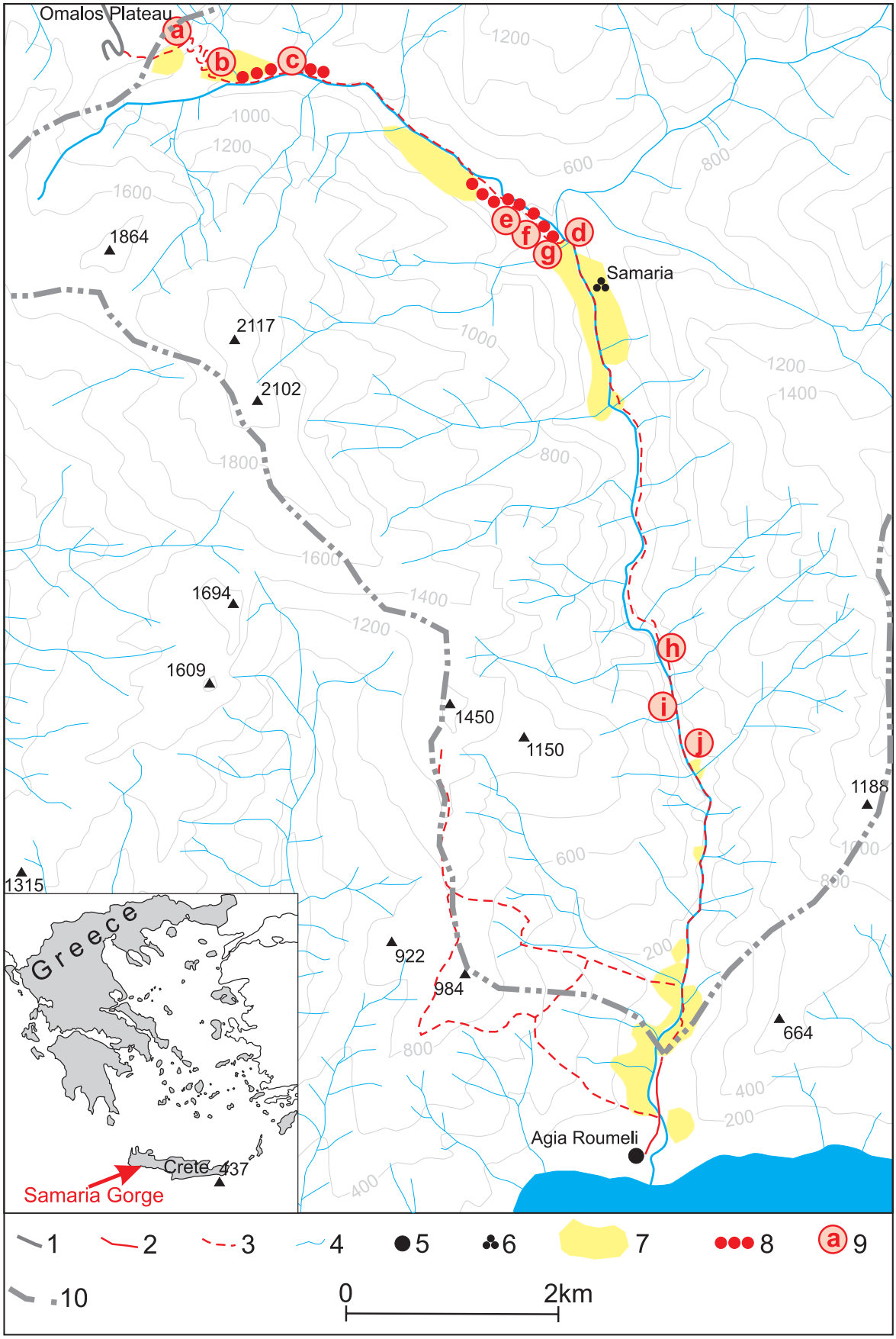

Fig. 1. The location and situation sketch of the surroundings of the Samaria Gorge
1 – road, 2 – ground road, partly hardened, 3 – path (tourist trail), 4 – beds of the temporary and episodic streams, 5 – village, 6 – abandoned settlement, 7 – slope fragments covered by the Quaternary deposits, 8 – the most degraded trail fragments, 9 (a, b, c, ...) – the location of the parts of the trail shown in Fig. 2, 10 – the limits of National Park

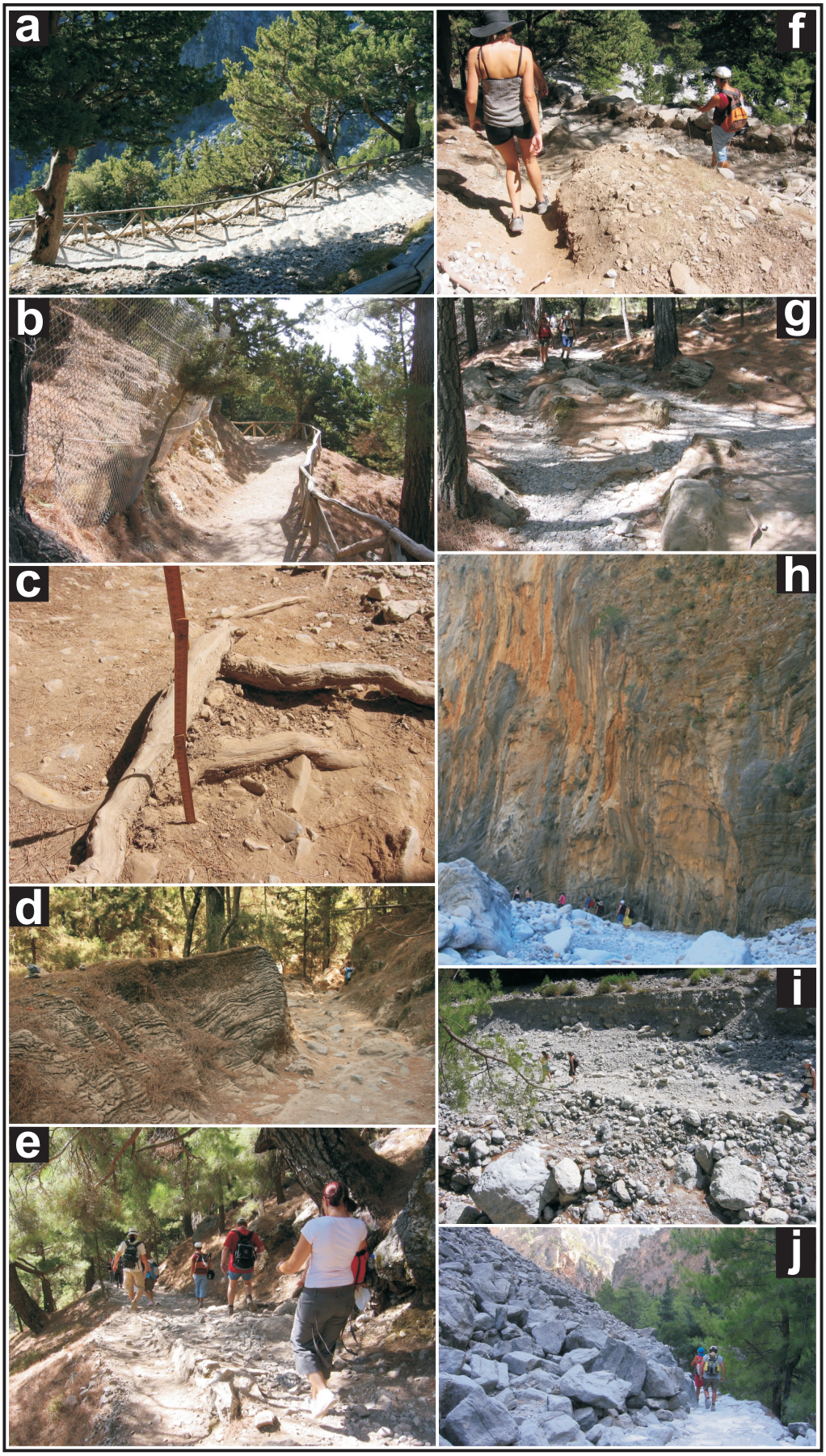

Fig. 2. The level of the conversion of different parts of the hiking trail in the Samaria Gorge. Letters a, b, c, ... refer to the location of the correct parts in Fig. 1. See text for explanation

leads above its bottom, traversing the slopes covered with a thick weathering mantle and pine forest. The traces of treading are clearly visible in this part, inclined at 4 degrees on average. They are marked by:

- uncovered tree roots, showing the indentation of the trail at over 20 cm (Fig. 2c),
- stones protruding from the path, as the run-off water has washed off minor stones trodden out by tourists (Fig. 2d),
- trampled roadsides (Fig. 2e),
- additional paths trodden along the trail (Fig. 2f).

In the extreme case the width of the trodden area exceeds 5 m (Fig. 2g).

Below the village of Samaria the valley narrows, and its indention reaches its maximum size. Directly above the valley floor there are one hundred-metre high rock walls (Fig. 2h). The trail leads mainly on the stony stream bed that drains water from the gorge. Every spring it is created anew – the workers of the Park mark it so that it does not come near the largest stone blocks. Therefore, there are no permanent traces of trampling (Fig. 2i). The parts of the trail that cross the scree built at the bottom of the gorge walls are slightly more stable, but also within their area the surface of the path undergoes only seasonal anthropogenic degradation – it is narrow and in winter it is covered with the material from the slopes; the following year the trail is marked up anew (Fig. 2j).

The last 3 km of the trail are located outside the national park's limits, they use a hardened road available to vehicular traffic with many parts being covered with asphalt in the last years. There are no traces of tourist degradation there. Slight erosion marks itself only on the paths, which run from the main road to the mountains surrounding the gorge. They are used by less than 1% tourists visiting the gorge; therefore, they are degraded mainly by natural processes.

Conclusions

It is commonly assumed that a typical Mediterranean landscape is the result of the many ages of environment degradation by humans (Rackham & Moody, 1996). The morphogenetic significance of human impact in the last part of the long history of Mediterranean areas is frequently ignored. The influence of tourism on relief is mainly taken into consideration in reference to the degradation of the shores. The research reported here has proven that hiking can be a serious threat to relief on Crete due to the high human congestion on a small area. The part which is especially severely damaged is the upper part of the trail in the Samaria Gorge, and particularly its part comprised between the 2nd and 7th kilometre (counting from the top). The trail in this part is locally widened up to over 5 m or indented by 30 cm. It should be highlighted that these changes have taken place during the last 40 years and especially in the first half of the 1990s – earlier the number of tourists visiting the Samaria Gorge was significantly lower.

The degradation of the highest (first 2 km) part of the trail is small, but it leads mainly through substantially altered, reinforced ground. Significant anthropogenic changes in the relief had been implemented there before the road was opened.

On the other hand, the upper part of the trail was directed along the path used by the local population for ages. Cretan highlanders, basing on their experience, had chosen an option that guaranteed the lowest threat of erosion. This fragment of the trail was earlier used also in winter. After the eviction of the inhabitants of Samaria village it is open only in the tourist season and fixed every spring. It can be assumed, therefore, that its most degraded parts had been partially damaged even before the opening of the national park.

The lower part of the trail below the village Samaria is degraded only along short fragments. The main factor that influences its modifications is nature itself – channel processes are of the intensity that vastly exceeds the capabilities of a few hundred thousands tourists yearly. The huge natural dynamics of the relief provides, therefore, a perfect protection from anthropogenic degradation.

Probably, it is of great importance that during the rainy time the gorge is closed. Hikers move there practically only on dry surface. Therefore, the material loosened by tourists is removed mainly at the beginning of the rainy season.

Natural water erosion does not play here such a big role in the transformation of the trails, as compared for example to the one in the Polish mountains. Practically, there are no clear erosion troughs. It comes from the fact that water flows very fast from the steep slopes of the gorge to the dense network of stream channels and it has no possibility to concentrate on the long parts of the trail.

The research indicates, therefore, that it is not the amount of the tourist movement that decides about the rate and scale of degradation of the most frequented tourist trail, but the relation of the path to the landforms, the character of the ground,and the dynamics of the meteorological phenomena in the tourist season.

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