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Granite tafoni in Chalkidiki, Greece

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Sithonia Peninsula in Chalkidiki is an area dominated by the Sithonia Plouton occurrence and its characteristic geomorphic appearance of granite weathering. In the area of the Akti Kalogrias beach there is a significant number of cavities and surface potholes. Granite caves and tafoni formations have been described from several areas in Greece, such as Serres, Kavala (Lazaridis and Pipera, 2008), Fthiotida (Modianaki 2012) Naxos and Tinos (Evelpidou et al. 2010 and references therein), Paros and Ios (Hejl, 2005).

Several opinions, and sometimes controversial, can be found in literature about the formation of caves in granite rocks. The main processes that have been described in order to interpret their development (i.e. vidal romani, 1989; 1990; Cambell 1997; Twidale 2008; Uña Alvarez 2008; Romani 2008, Groom et al. 2015; Klimchouk 2017): 1. eolian deflation; 2. weathering through insolation; 3. frost action; 4. wetting and drying; 5. chemical and salt weathering; 6. biological decay; 7. gravitational forces (imposed by large boulder resting on an outcrop and causing crystal strain at the point or point of contact, eventually leading to rock basins on the outcrop and tafoni on the underside of the boulder); 8. microclimatic conditions; 9. exfoliation; 10. haloclasty [this category emracing crystal growth, hydration expansion and osmotic pressure]; endogenous processes.

In the present study two adjacent locations in Akti Kalogrias have been recorded in detail in order to describe the type of the cavities on the basis of their location and morphology, and to discuss their origin.

Methods

Track and cave positions are recorded with a Garmin GPSmap 60GSx and the track's length and area are estimated by MapSource software (v. 6.13.7 Garmin). Each cavity was labeled, morphologically categorized, measured and documented. Some of the cavities were surveyed in detail.

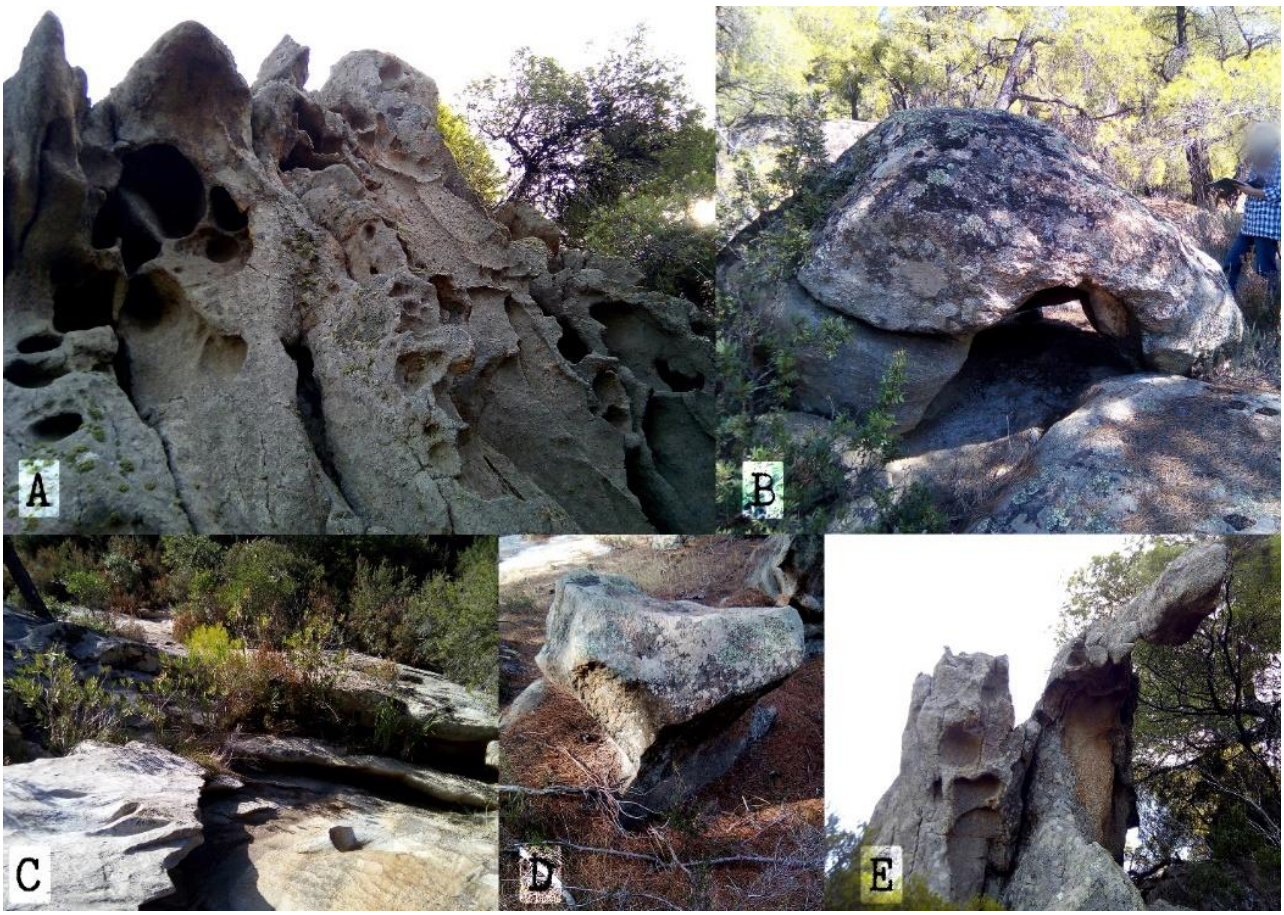

Figure 1. Morphological categories of tafoni in Akti Kalogrias area: A. tafone formed in the side of the rock host with honeycombed erosion; B. tafone formed in the base of the rock form; C. tafone develobed among discontinuities; D. a mushroom-like form; E. a complex tafone form.

Results

Their dimensions do not exceed 8 m. Their dimensions range along horizontal axis from 0.9m to 8m (mean 2.4 m); vertically (height) from 0.2 m to 3.0 m (mean 1,2 m); and their depth ranges from 0,15 m to 4.1 m with (1.2 m).

Morphologically they can be distinguished in 5 categories that groups cavities with similar number of openings, their location in relation to the boulder and any discontinuities. These categories are the following (Figure 1): 1.tafoni that are formed in the side part of the rock; 2. tafoni that are formed in the base or at the above a horizontal discontinuity and the erosion continues at the inside of the host rock and sometimes resembles a "tortoise shell" form; 3. tafoni that are formed between discontinuities; 4.tafoni that are formed in the base and around of the host rock giving a "mushroom-like shape to that; and 5. combination of the above-mentioned groups. Honeycomb erosion is observed in tafoni from various categories but mainly in basal, and side-wall tafoni.

Regarding their spatial distribution, two parameters are estimated: the number of cavities larger than 0.5 m found in the surveyed area; and number of cavities divided to the walked distance. These two parameters are 1/284 cavities/m^2 and 1/52 cavity/m^2 for the first area and 1/520 cavities/m^2 and 1/72 cavity/m^2 for the second area, respectively. In total, the two areas covered 21.500 m^2 and 3 km of distance that means 1/407 cavity/m^2 and 1/63 cavity/m.

The hypothesis that a preferred orientation exists was checked with directionality tests. The possibility of random orientation cannot be rejected. The logarithm of the cavity volume and the boulder that hosts the cavity are moderately correlated (n=22).

There are 3 main discontinuities recorded in the area (J_1: 126/85, J_2: 237/85 and J_3: 320/20). Their density decreases from J_3 to J_1. Among 43 tafoni, 21% is formed in boulders that are not *in situ*. Regarding the *in situ* tafoni, 29%, 18% and 35% are associated with the discontinuities J_1, J_2 and J_3, respectively. In 21% the cavities are formed along the combination of J_1, and J_3 discontinuities. In 38% of *in situ* there is no obvious relation to discontinuities.

Concluding remarks

With this work the tafoni weathering morphology in Sithonia is described qualitatively and quantitatively. Despite that large caves are commonly unexpected in this setting, it seems that these forms occur in large numbers. This means relatively high values in the estimated parameters. The results is expected to be used for comparisons with other granite tafoni occurrences.

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