PROCEEDINGS

ITECOM
European Conference

Innovative Technologies and Materials for the Protection of Cultural Heritage. Industry, Research, Education: European Acts and Perspectives

December 16 - 17, 2003
Athens, Greece

In the memory of the late and regretted
Professor Theodore Skoulikidis

Scientific Editor:
A. Moropoulou

Organized by:
National Technical University of Athens
Technical Chamber of Greece

Under the auspices of:
European Commission, Directorate General Research

Published in Athens, March 2007
TECHNICAL CHAMBER OF GREECE

PRELIMINARY DATA ON THE STABILITY CONDITIONS OF POLIPHIMOS CAVE, NEAR MARONIA TOWN IN EASTERN GREECE

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Abstract

Poliphimos Cave is an under development site for touristic purposes. The cave is full of beautiful stalactites and stalagmites and it is of great palaeontological and touristic interest. In the present paper the stability conditions were studied regarding to wedge and planar failures. For this purpose, all the tectonic data were determined and recorded separately for each site in the cave and tectonic and stability diagrams were elaborated, in order to determine stability factors. The main purpose, after determining any type of potential failure, was to propose the more appropriate stability methods. It is obvious that all the ordinary methods, used in underground construction, are not appropriate for use in caves. Supporting methods have to be adapted, taking into account the already existing natural stability conditions, the safety of visitors and the monumental character of the cave.

Introduction

The cave is located in a distance of 5 km from Maronia Town, near Komotini City, in Thrace – Eastern Greece. It is considered as an important natural monument which unfortunately has not already developed. According to the Greek mythology, Cyclope Poliphimos is considered that was living in the cave. A big stalagmite of 5 m wide and 2 m high located now behind the entrance was used as the door. According to the archaeological research, the cave was used as living and religious site, from the Neolithic until the Byzantine period. The cave is 2000 m long and covers an area of 10.000 m^2. The proposed visiting route is 355 m. The inside temperature is about 16 ^oC. For the development an integrated study was performed regarding to its geotechnical stability, together with speleological and ecological studies.

The present study is a part of a bigger project, included in the 3rd EU Framework Program. The aim of the project is the touristic and scientific development of the cave. For this purpose, the tectonic features of the cave were studied in order to determine the stability conditions and propose the proper retaining and protection measures.

Geological and geotechnical conditions

The area, geologically, consists of compact coarse-grained karstic limestone and tectonically it is traversed mainly by faults of NNW-SSE to NW-SE and E-W directions. The cave is formed in low depth and the width of the upper layers appears to be small as roots of plants are visible on the ceiling of the cave. The stability of the cave is mainly determined by the tectonic regime of the area. Field measurements were made, statistically interpreted and the results were plotted in stereographic projections. In Figure 1, tectonic stereonets are given on the topographic sketch of the cave, separately for each site. The main directions of the discontinuities are given in Table 1 and Figure 2.

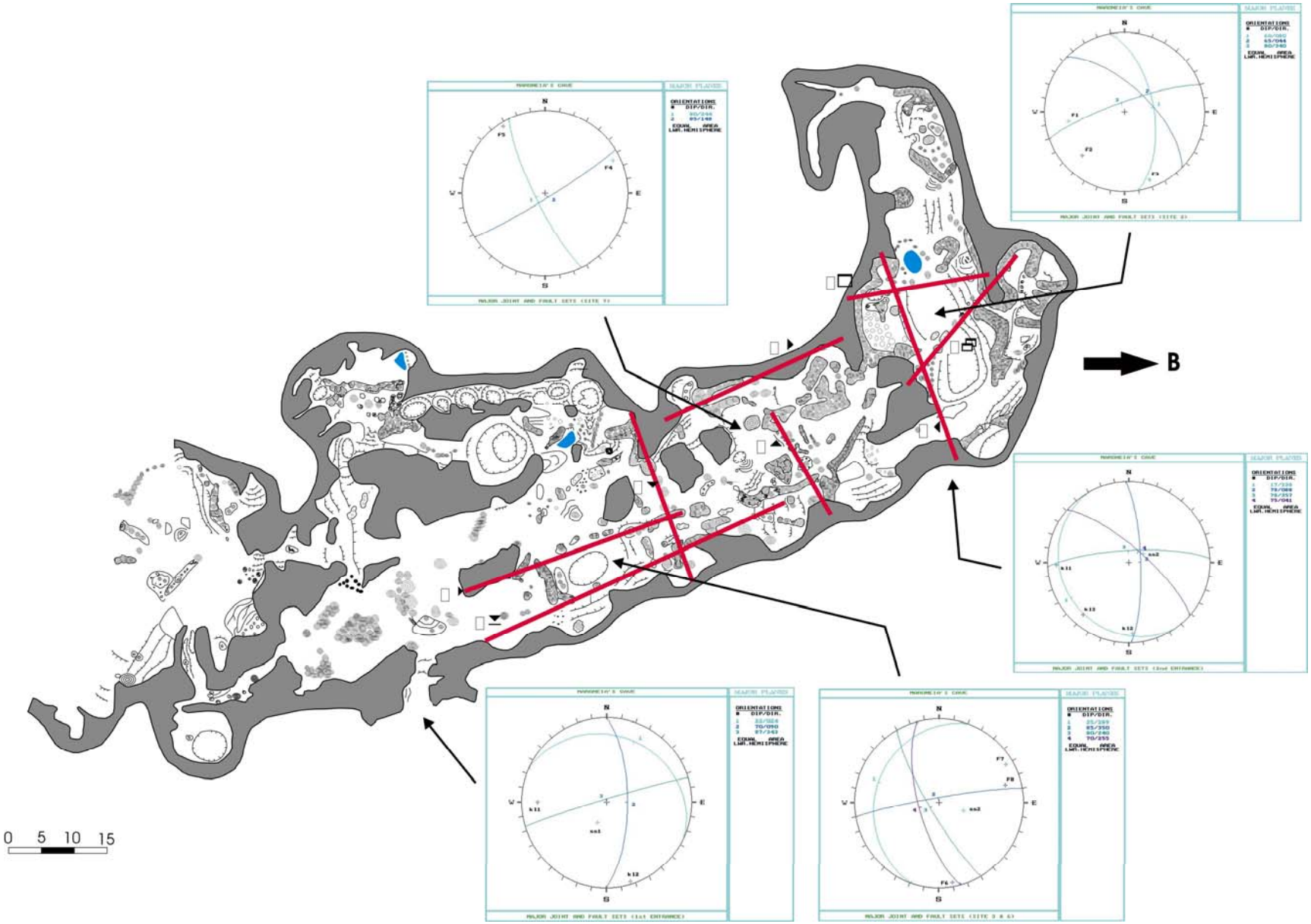

Figure 1. Topographic Sketch of Maronia Cave (Petrohilou[1]), with faults and stereonets of discontinuities

Table 1. Major discontinuities sets

Joints-Faults	kl1	kl2	kl3	kl4
Mean values (°)	089/68	344/80	246/75	041/77
Bedding	ss1	ss2		
Mean values (°)	032/31	279/17		

According to table 1, the rock mass is traversed by at least three major sets of discontinuities. The spacing between the discontinuities changes from 20 to 100 cm, their length appears to be more than 1 m and their dip is close to vertical. The majority of the discontinuities are opened and filled with deposits of calcite carbonate which formed as calcite precipitates in a limestone cavern. The above mentioned geometrical features in conjunction to the practically horizontal dip of the bedding of the limestone form rectangular blocks that appear to be unstable on the roof of the natural cave (Figure 3). In addition to that wedge failure type could be presented as recorded from in situ observations (Figure 4).

The RQD of the rock mass is estimated 75-90 (according to the relation proposed by Palmstrom[2]) and the unconfined compressive strength 35-60 MPa using a Schmidt hammer (Hoek & Bray[3]). The rock mass quality can be characterized as good (RMR= 61-70) according to RMR method (Bieniawski[4]).

The stability conditions are variable and different stability problems occur along the visiting route. Therefore each stability problem should be dealt separately.

The tectonic data will be elaborated, using UNWEDGE software, in order to determine the unstable wedges or blocks in each room of the cave.

The representative analysis of Figure 5 was performed taking into account the geometry of the tectonic features in relation to the worst mechanical properties of the existing discontinuities (open joints with no infilling c=0,

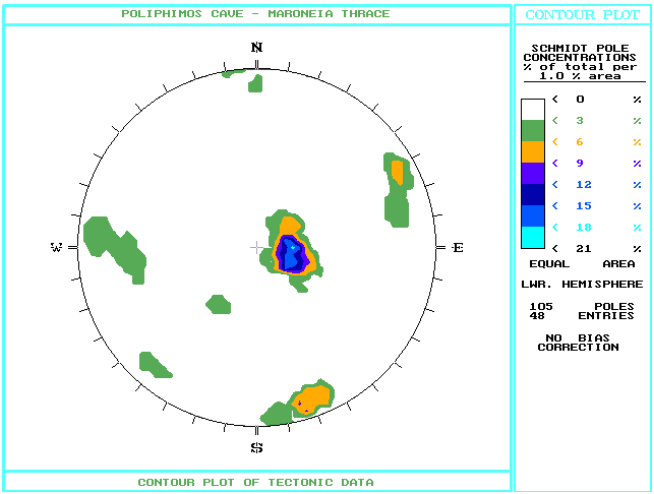

Figure 2. Contour plot of discontinuities

Figure 3. Failure on the roof on the bedding plane

Figure 4. Potential wedge failure

φ=30^{o}),. The intersection of the joints of 350/85 and 240/80 directions creates potential wedge failures (Figure 5).

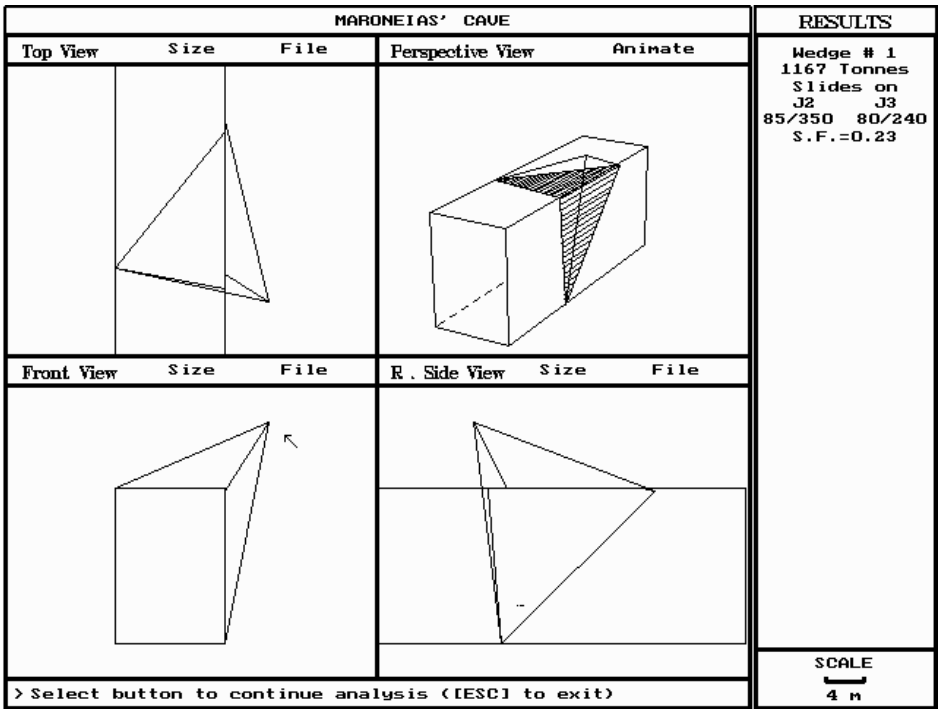

Figure 5. Wedge failure analysis at the main room of the cave (room direction: NW-SE)

However, the only failures recorded in situ were situated at the ceiling of the cave (Figure 3) and no failures were observed at the sides. This is probably because the mechanical behavior of the joints appears to be better due to the existence of the infilling material at the majority of them as mentioned above (Figure 6). The values of the mechanical properties used in this analysis appear to be representative only for the bedding planes where no filling material is present.

Figure 6. In filled joints at the roof of the cave

General conclusions and recommendations

- A stress-strain analysis as performed in tunneling is not recommended in cases of natural caves because of the slow procedure of its formation which allows the full relief of the applied stresses. So the stability analysis of the natural cave is based only on the behavior of the blocks formed by the tectonic features.
- The limestone rock mass is traversed by at least three major sets of practically vertical discontinuities of big length. The limestone bedding is horizontal.
- The geometry of the blocks formed by the combination of the vertical discontinuities sets with the horizontal bedding creates potential instability conditions.

- The instability conditions observed in situ are mainly unstable blocks falling from the roof.
- The cave system tends to become exposed at the surface by the gradual collapse of the roof.
- The filling material of the discontinuities seems to improve their mechanical properties.
- The proposed reinforcing and supporting measures are recommended to be locally applied only on sites where block instability occurs.
- Specific care should be taken on sites where other interventions need to be performed for the shaping of the visiting route.
- At this point of the data elaboration the use of rock bolting as reinforcing measure appears to be the most appropriate.
- The design of the proposed supporting measures aim to the least disturbance of the natural cave.

Acknowledgement

The present research, for the development of Poliphimos Cave, is funded by the 3rd EU framework program and the District of Macedonia and Thrace.

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