1. INTRODUCTION

In the middle of September 2009, prolonged rainfall activated rockfalls from the upper sections of the archaeological site’s northern slope and fall downslope, out of the enclosure wall of the Sanctuary of Apollo, north of the Portico of Attalus. Rockfalls also occur in the stadium from 2003 onwards (Figure 1). The slope, consisting of limestone, is steep and heavily broken as a result of the existing tectonics. For the protection of the above slope and the archaeological site, the present scientific team visited the area, after the last rockfalls and expressed ideas on a protection scenario which must be proposed.
Under its control the sanctuary was, until the 4th and political association of neighboring cites and tribes, undertook the administration of the sanctuary. Reaching the oracle, the Castalian Spring, the sacred spring where Pythia bathed and the visitors purified themselves before other buildings. To the northwest of the sanctuary of Athena lies the gymnasium and further up the slope.

3. ARCHAEOLOGICAL SETTING

In the Pleistos Valley, along the southwestern slopes of Mount Parnassus and within the angle formed by the imposing twin rocks of the Phaedriades (shining ones), lies the Pan-Hellenic sanctuary of Delphi, which had the most renowned and trustworthy oracle. As the oracle’s reputation and influence grew, Delphi became the spiritual center and symbol of unity of the Hellenic world, a place visited by individuals in quest of advice and by delegations from Greek cities and every country of the known world. An ancient legend recounts how Zeus, the father of the gods, dispatched two eagles from either end of the cosmos to determine the center of the earth. The birds met at Delphi, which was henceforth known as the world’s omphalos or “navel”.

The earliest finds in the area date to the Early Neolithic Period (Korykeion Andron, a cave on Parnassus, end of the 5th millennium B.C.). However, permanent inhabitation is attested just in the Early Helladic Period (before 2000 B.C.) in the coastal settlements of Kirrh and Galaxidi. Due to a rise in population during the Middle Helladic Period (2000-1600 B.C.), new mainland sites were inhabited, Delphi possibly being one of them. The settlement of Delphi was established at the beginning and was inhabited throughout the Late Helladic (Mycenaean) Period (1600-1050 B.C.). Some finds support the hypothesis of the presence of an early sanctuary sacred to Mother Earth.

In the 8th century B.C., the cult of Apollo was established at Delphi and the development of the sanctuary and the oracle began. From the 6th century B.C. onwards, the Amphictyonic League, a religious and political association of neighboring cites and tribes, undertook the administration of the sanctuary. Under its control the sanctuary was, until the 4th century B.C., at its peak. Every four years, the Pythian Games, the second most important games in Greece after the Olympics, were held in Delphi in honor of Apollo. The oracle was the core of the sanctuary. Its fame spread throughout the world and visitors thronged to read the prophetic utterances of the god which were delivered by the mouth of the priestess Pythia and interpreted by the priests.

The archaeological site includes two sanctuaries dedicated to Apollo and Athena. The sanctuary of Apollo lies in the westernmost point of the two Phaedriades known as rose-red (ancient Nauplia) and the one of Athena on the Marmaria terrace, below the wild easternmost rock crag Phleboukos (ancient Hyampela) which soars 760 m into the blue sky. Beside the Castalian Spring, where the two Phaedriades have their roots, is the putative chasm of chasms whose two rock walls are separated by a sharp cleft, now known as “Bear Gorge”, which extend far down into the plain of Pleistos.

Visitors coming from Athens first reached the sanctuary of Athena Pronaia, that is to say Athena who is before the main temple of Apollo. Within the sanctuary was the Tholos, a marble rotunda dating back to the beginning of the 4th century B.C., three temples dedicated to the goddess, constructed consecutively from the middle of the 7th century to the beginning of the 4th century B.C., altars, statues, treasuries and other buildings. To the northwest of the sanctuary of Athena lies the gymnasium and further up the slope the Castalian Spring, the sacred spring where Pythia bathed and the visitors purified themselves before reaching the oracle.

The sanctuary of Apollo is the central and most important section of the site. It was surrounded by an enclosure wall and spread over three artificial terraces supported by monumental retaining walls, boarded by porticoes. The main gate was at the southeast corner of the enclosure. From there the Sacred Way led to the temple of Apollo, where Pythia delivered her oracles. Along the Sacred Way and its cross streets were numerous votive monuments dedicated by Greek cities or wealthy individuals (tripods, statues and
4.1 Cross section A-B, passing through the stadium

At the western part of the slope, important rockfalls repeatedly occurred, obliging the authorities to close the entrance to the stadium. Furthermore, recent rockfalls just out of the easternmost part of the Sanctuary of Apollo imposed the temporary closing of the temple's entrance as well.

In Figure 4, a possible rockfall track is simulated along the cross-section A-B (see Figure 2), which passes through the stadium. The mean spacing of the fractures is about 2m, creating the impression that a possible block weight of 20tn would be realistic in our rockfall calculations. According to the data in Figure 4, falling blocks reach the stadium, having significant kinetic energy and continue downslope.

According to the diagrams of Figure 5, a barrier with a height of 2.0-2.5m and capacity of 3000kj could restrain the falling 20tn rocks. These barriers could be elastic, such as metallic barriers which could...
a short distance, to an altitude of about 750m. As a few blocks could roll downslope, a barrier similar to those used in the other sections, could be installed at an altitude of about 730m, higher than the area where the falling rocks obtain their maximum kinetic energy.

Figure 8. Cross section C-D, located to the East of section A-B

5. CONCLUSIONS

The area consists of limestone cut into blocks of various dimensions, as a result of the active tectonics of the area.

The rockfalls are generated on the steep slope located on the northern side of the archaeological site, and have already caused damage to the stadium. The theatre is located at a short distance to the southeast of the stadium.

The falling blocks vary in size and weight and for this reason, the simulation tests were performed for indicative blocks of weight of 20tn.

According to our investigation, we conclude that:

1) In section A-B which crosses the stadium (Figure 3)
   a) The simulation of the falling track confirmed the damage caused to the stadium.
   b) The falling blocks could continue actively till the southern part of the archaeological site (Fig. 4).
   c) The maximum kinetic energy of 20tn falling blocks is about 8MJ in the stadium area (Fig. 4),
   d) A barrier, 2.5m high, installed in the upslope area of the stadium (at an altitude of about 730-740m) at a location just after the rebound of the block, where the kinetic energy is low, could retain the falling blocks. For higher (additional) safety an additional barrier could also be installed in the downslope area of the stadium, for protecting the rest of the archaeological site (Figure 5).

2) In section E-F which crosses the theatre (Figure 3)
   a) The falling blocks roll on the ground in the upslope area of the theatre (Figure 6).
   b) The kinetic energy is relatively low in the upslope area of the theatre (Figure 6)
   c) According to the above results, a barrier, 2.5m high, could be installed at an altitude of about 730m in order to protect the theatre.

3) In section C-D which passes between the stadium and the theatre (Figure 3)
   a) The major part of the falling blocks stops at the plateau at an altitude of 730-750m but a barrier, similar to those in the other sites, could be installed at an altitude of 730m.

4) The more dangerous and difficult in retention rockfall track is that which crosses the stadium.

5) We could finally accept that a 2.5m-high metallic barrier could be installed along the northern steep slope for the protection of the archaeological site.

BIBLIOGRAPHY