



Earthquake-induced deformations at the Lion Gate, Mycenae, Greece

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Abstract: One of the most famous monuments of Mediterranean antiquity, the Lion Gate of the citadel in Mycenae, Argolis, Greece, shows damage, including shifted, rotated, broken, and fallen masonry, and also fractures in the famous lion relief which might be of seismogenic origin. The damage occurred after the peak of Mycenaean rule (after the middle of the 13th century BC). In case of seismic origin, the damage corresponds to intensity VIII. Local faults are potential sources of damaging earthquakes and further research is necessary to test the hypothesis.

Key words: Antiquity, archaeoseismology, Mycenae, Greece.

INTRODUCTION

Mycenae is a mountain citadel that commands the broad Argolis basin, part of the Peloponnesos Peninsula in southern Greece. Homer tells us that Agamemnon set out from here to lead the Greeks to the Trojan war (Korfmann, 2004).

Elisabeth French (1996) was the first to consider the possibility of seismic damage in the destruction of the citadel of Mycenae. However, the Lion Gate, thought to be built shortly before the calamity described by her, was considered as counter-evidence for an earthquake, surviving the collapse event intact (French, 1996: 54). For a historical overview of the development of opposing ideas see Nur & Cline (2000) and Nur & Burgess (2008).

Archaeological excavations discovered houses with skeletons covered with fallen stones (Shear, 1987, Mylonas 1975a & b). In these buildings and elsewhere in the citadel a horizon of destruction was identified and dated to the middle of the LH IIIB period (Taylour, 1981). Interpretation derived from recent excavations directed by Maggidis (2011) operates with the role of seismic activity in the destruction of Mycenae.

There is a planar rock surface next to the entrance to the citadel, at the Lion Gate. It has suffered only minor erosion, indicating it is an active, i.e. Holocene fault (Stewart & Hancock, 1988). There are further active fault planes within a few hundred metres distance. Solid, cyclopean walls are built on top of the fault; these are symbols of inactivity since the time of construction (Sintubin, 2011, his fig. 5a). However, a serious contradiction remains: the citadel has been damaged repeatedly (e.g. Nur & Burgess, 2008, 11-20, 26, his fig. 1.2), while the Lion Gate and surroundings – built shortly before the destructive events – apparently do not show any seismic record.

In this paper we put the hypothesis that at least one strong earthquake damaged the Lion Gate and the adjoining wall.

This paper is an effort to inventory and catalogue specific earthquake archaeological effects as suggested by Rodríguez-Pascua et al. (2011).



Figure 1: Mycenae, the Lion Gate before excavations and restoration (Tsountas 1893, fig. 3). The famous fault plane – which did not move for at least 3000 years – is on the lower left. Note the missing two ashlar right of the lion relief. The dressed exterior and rubble interior of the western wall on the right was still visible at that time.

During repeated field trips we identified and surveyed structural failures visible in the forecourt of the Lion Gate. Those attributable to earthquakes are described, illustrated, and explained here. Measuring tape, clinometer, and a laser distance meter were used for the survey. In absence of direct access, high-resolution photographs were used for detailed observation of the lion relief.

RESULTS

Masonry. The walls of the forecourt are made of well-dressed ashlar of Pliocene conglomerate. Size is up to 80 cm high and longer than 1 m. Thickness of ashlar cannot be seen.

Inner structure of the western wall cannot be observed today. However, a photo of Tsountas (1893, 1897, his fig. 3, our Fig. 1) exposes the inner structure: there is a mantle of elaborately carved ashlar surrounding



irregular blocks of the core. There is no mortar between the dressed stones.



Figure 2: The western wall in the forecourt of the Lion Gate. There are eight rows of well-dressed ashlars, obviously not in the same plane. Top of the long wall is 6.85 m above ground level. People for scale. Photo Kázmér, #1097.

Shifted and/or rotated ashlars. The western wall certainly has been built planar: the Lion Gate was the main access road to the citadel of Mycenae, of high royal and religious significance. Today the wall is not planar anymore. Its well-dressed ashlars are not parallel with the surface of the wall (Fig. 2): some are rotated, both clockwise and counterclockwise, up to 10° around a vertical axis relative to each other. Several centimetres of relative displacement between blocks can be easily measured (Fig. 3). There is no obvious pattern among the direction and amount of displacements, except that blocks on top suffered more shift than blocks in the bottom row.

Rodriguez-Pascua et al. (2011) ranges similar blocks among clear evidences of earthquake shaking.

Fallen ashlars. Schliemann (1878) recorded a less complete Lion Gate than it is today. His Plate III shows random fallen ashlars, partly blocking the road. One missing ashlar to the left of the relief is not a window but place of a fallen block (Wace, 1949: 52). Those two ashlars, which are obviously missing to the right of the relief, are lying on the road (Fig. 1). All three have been restored to their original position by the Athens Archaeological Society in 1950 (Mylonas, 1957: 25). Further ashlars on the road (as variously illustrated on an etching by Schliemann, 1878, his plate III) and by Tsountas (1893, 1897) on a photo are probably from the top rows of the western wall on the left. The single ashlar in row A on the top of the western wall is witness of a wall higher than today.

Repairs. There are small, irregular pieces of light-coloured limestone, stuffed in the wide gaps between the rotated ashlars. These pieces are undressed without exception.

Fractured lion relief. Above the lintel of the gate there is a monolithic block: two lions and a column are sculpted on the external surface. The lion heads – made of different material – are missing (Mylonas, 1957: 25). The dowel holes of the fixtures are still visible. The front of the relief is clean and the texture is obvious; it has been cleaned probably not later than the restoration work in 1950 (Fig. 4).

The front is criss-crossed by narrow, open fractures, directed from upper right to lower left (Fig. 4). Some of the fractures do not extend from margin to margin; they tend to terminate within the relief block.

There are two missing blocks to the right of the relief (Schliemann, 1878). We hypothesize that while still shaking on top of the wall or when falling from the top – possibly due to an earthquake – either or both of them hit the triangular block of the relief. This sudden (probably repeated) collision initiated the fractures within the block. The fracture pattern is typical of shearing stress, exerted by the blocks hitting the relief at their respective elevation.



Figure 3: Displaced ashlars as seen from below. Blocks of rows 6 and 7 suffered opposite rotation. Blocks on the right suffered 6 cm right-lateral displacement. There are undressed limestone pieces stuffed in the wide gap between adjacent blocks. #1103.

Subsoil. Most of the subsoil below the Lion Gate is soft rock – which, among others, allowed the digging of the famous royal Shaft Graves where most of the treasures of Mycenae have been found. An exception is the portion under the eastern wall, where the foundation rests on hard Mesozoic limestone (Wace, 1950: 204), of which most of the Citadel is composed. The surface separating them is an active fault plane (Stewart & Hancock, 1988). It is common that buildings and other constructions erected upon softer soil suffer greater damage than those built upon hard rock. (Mention the well-known example of the Colosseum in Rome: Funicello et al., 1995.) Here we see more damage in the western wall built on soft subsoil than on the eastern wall built on hard Mesozoic limestone.



Constraints on dating. The construction of the Lion Gate and the cyclopean walls to the south and west occurred in Late Helladic IIIB times, i.e. between 1300 and 1200 B.C. and late rather than early within these limits (Mylonas, 1957: 34). The other cyclopean walls to the east can be contemporary, later or earlier than the Lion Gate.

The damage certainly occurred after the peak of the Mycenaean rule by one or more earthquakes. Surface of the shifted blocks could have been carved flat again with minimal cost. Instead, rotated blocks were left unchanged, and the gaps opened during the earthquake were filled by poorly concealed limestone rubble at some later time.

DISCUSSION

In this paper we put the hypothesis that at least one strong earthquake damaged the Lion Gate and the adjoining wall.

Rotated and displaced masonry blocks (Figs 2-3) are often taken as telling records of earthquake shaking (Rodriguez-Pascua et al., 2011). Pervasive fractures (Fig. 4) are also clear records of major stress exerted on the monolith. The relief block is cross-cut by oblique fractures, never from margin to margin, but often terminating inside the block (Fig. 4). A transient shear stress, exercised by the hit of the upper two blocks while falling from the wall into the forecourt, is suggested to produce the fractures within the stressed relief block.

What we can assess is the intensity, characterizing the maximum shaking at this place during the last three millennia (Sintubin, 2011).

Earthquake parameters - Date. Direct dating of this earthquake is not possible at the moment. However, more than a century of archaeological excavation in the citadel of Mycenae established a detailed chronology of construction and destruction.

At Mycenae, successive repairs and modifications define at least two major LH IIIB destruction horizons: one in the transition of LH IIIB1/B2 (ca. 1240 BC) and another one towards the end of LH IIIB2 (ca. 1200/1180 BC). The former, which is defined by a number of contemporary destruction layers all linked by qualitative and quantitative association (i.e. containing groups of identical vases), was apparently caused by severe earthquakes, as indicated by the type and extent of structural damage (collapsed buildings, walls curved or shifted off from their foundations), by the spatial distribution of partial and total damage inside and outside the citadel, cases of human victims buried under collapsed debris (Panagia I, Plakes), abandonment and repairs (Maggidis, 2011).

Intensity. Rapp (1986) assigned an intensity of VIII to 'considerable damage in ordinary substantial buildings' - 'some masonry walls fall'. His intensity IX is described as 'buildings shifted off foundations'.

Modified Mercalli intensity VII is widely held as the damage threshold for many archaeological sites (Kovach and Nur, 2006). Bilham et al. (2010) described

displacement of heavy masonry blocks in the Pandrethan Shiva temple, related to a minimum intensity of VII and maximum intensity of IX on the MSK scale. We suggest a minimum intensity VIII for the Lion Gate earthquake.

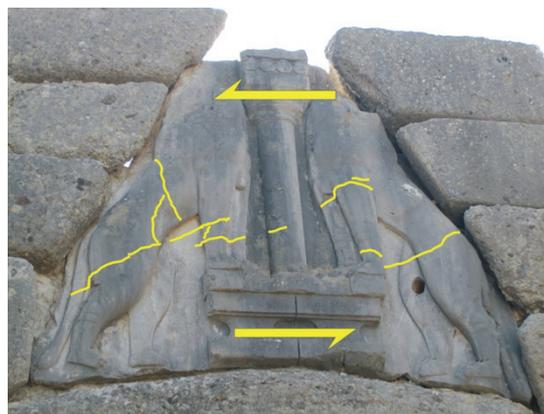


Figure 4: The lion relief. The monolith is 3.9 m wide, 3.3 m high and up to 0.7 m thick. A network of open fractures (marked by thin lines) across the relief is interpreted as caused by the hit of the two ashlars on the upper right side during seismic shaking. These two blocks fell to the ground and were still there in the 19th century as shown in Fig. 1. Apparent lack of continuity of the fracture on both sides of the half-column is due to thin, dark crust produced by blue-green algae. #1095.

Whether the damage observed on the Lion Gate complex is related in any way to the suspect active normal fault of Mycenaean age E and SE of the citadel (Maroukian et al. 1996) cannot be answered at this moment. A proposed seismological revision of the destruction horizons in the citadel will bring us closer to the right answer to this question.

This is a first attempt for an interpretation of probably Mycenaean seismic activity in terms of earthquake parameters. A detailed study of the Lion Gate, involving modelling, a thorough revision of destruction horizons within the citadel is a matter of future research. Quantitatively assessing the site-specific effects on any archaeological site (e.g. Kamai & Hatzor, 2008) we can narrow down earthquake parameters associated to the maximum credible earthquake in the region, irrespective to the time of occurrence (Sintubin, 2011).

CONCLUSIONS

We put the hypothesis that the Lion Gate in the citadel of Mycenae, Greece, suffered damage from an earthquake. Shifted, rotated, fractured, and fallen ashlars, and open fractures within the lion relief are possible indicators of seismic shaking. In case of seismic origin, the damage corresponds to intensity VIII. The famous active fault underlying the gate did not move, but another fault nearby probably did. Further research is suggested to test this hypothesis.



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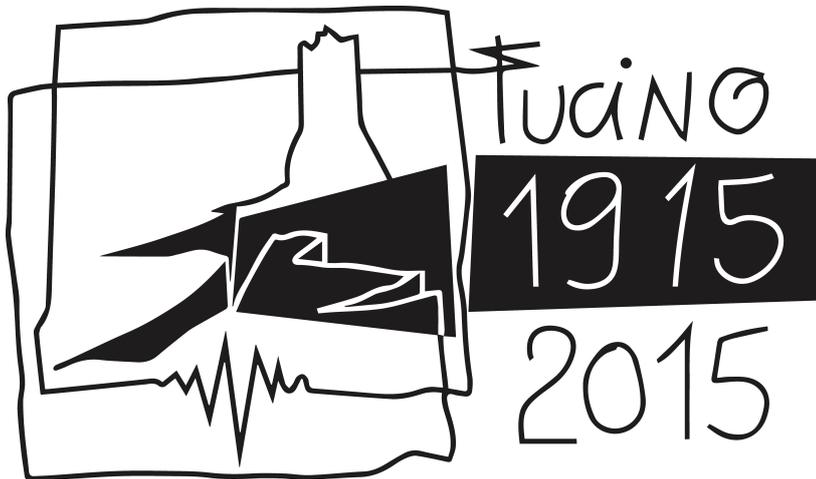
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