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Archaeological evidence for a destructive earthquake in Patras, Greece

1 Introduction

The understanding of the seismic hazard in certain parts of the world, for instance in Italy, Greece, Turkey and the Middle East is to a major degree based on historical data. Historical seismicity catalogues are based on such data (for instance, Papazachos and Papazachou 1997; Guidoboni et al. 1994). Still, such catalogues are silent for certain areas and periods, indicating either absence of seismicity or incompleteness of historical data.

The town of Patras is a notable example. The wider area is seismically active and adjacent to the west edge of the Aegean Arc, marked by intense ground deformation. It was last hit in 2003 by a magnitude 5.1 earthquake (Plicka et al. 1998) and in 2008 by an earthquake of magnitude 6.4 (Ganas et al. 2009; Gallovič et al. 2009; Margaris et al. 2010; Feng et al. 2010). The particularity of the latter earthquake, the first strike slip event documented on land in Greece, is that it corresponds to a blind young or nascent fault, which is likely to have been associated with at least four events with magnitude >5.0 in the last 20 years, and with a sense of NW progression; Feng et al. 2010, Stiros et al. 2013). If this is true, then a new earthquake with epicentre close to Patras may be expected in the near future. This situation is reminiscent of the seismic risk of Istanbul, in relation to the westward reactivation of the North Anatolian Fault (Stein et al. 1997; Atakan et al. 2002).

This possibility makes necessary the study of the seismic history of the Patras area. A history that appears at least questionable. Apart from a cluster of earthquakes in the 18-19th century, and a vague report for an earthquake in AD551 (see below) no other earthquakes are known to have hit Patras. And this is quite surprising, for this town was a major harbour and administrative centre in the Roman period, a theatre of military activities, as well as a religious and cultural centre for various periods. Interestingly, the Scottish flag and the spread of Christianity in Scotland are associated with transportation of the relics of Saint Andrews from Patras, where he martyred (crucified in a X-shaped cross), to St Andrews in Scotland in the 6th c AD. In order to contribute in the understanding of the seismic history of Patras, in this article we focus on evidence of earthquakes derived from archaeological excavations and try to correlate this evidence with the available historical data.

Evidence comes from “rescue” (rapid, emergency) excavations. In such cases, the only aim and possibility for the excavator is simply to identify possible ancient remains, collect important artefacts to be transported in the warehouses of a museum, and leave the space ready for building activities. In rare cases, a report for the excavation is published, hardly exceeding few lines in length. Only in the case of very important remains (temples, gates in walls etc.) the site is confiscated by the government and then partially excavated and preserved in a proper manner.

Because most excavations in Patras were of rescue type, during the building boom period of the city (1970-2000) very little is known about the findings,

1 and for this reason detailed studies of the history and archaeology of Patras
2 provide no information of earthquakes (e.g. Rizakis 1995).

3 While this study permits to present for the first time evidence of seismic
4 destruction in Patras, it does not permit to associate it with a specific fault. It
5 allows only for an estimate of the earthquake intensity and restriction of the
6 causative fault at a distance of 15-20km from the city.

7 8 **2 Historical evidence of earthquakes in Patras area**

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10 Historical seismicity catalogues (e.g. Guidoboni et al. 1994; Papazachos and
11 Papazachou 1997) include a few entries for earthquakes in the wider Patras
12 region in AD 551 (a rather vague report, probably mixing several events), in
13 1714, 1785, 1804 and 1806. Very few details are known about these
14 earthquakes, for which Papazachos and Papazachou (1997) estimated
15 magnitudes between 6.2 and 6.5 of the Richter scale and intensities up to IX.
16 The only additional information concerning these events comes from a
17 passing report of Leake, a famous traveller who, during his visit in the area
18 circa 1805, noticed that the town was frequently shaken by earthquakes, and
19 for this reason he reported that the house of the British consulat was made of
20 timber, earthquake resistant (see Stiros 1995). Leake's report is likely to
21 indicate effects of the 1804 (and 1806?), of the 1785 or even of the 1714
22 earthquakes.
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27 28 **3 Excavation data**

29
30 Two rescue excavations provide clear evidence of earthquake destruction

31 32 **3.1 Excavation 1: Road with collapsed columns**

33 34 **3.1.1 Excavation data**

35 According to Stavropoulou-Gatsi (1985), a rescue archaeological excavation
36 in 1979 in the centre of the modern city of Patras (Kalamodgarti 10-Kanakari
37 st.), at the depth of approximately 3.5m below modern ground level, brought
38 to light remains of a paved road of the Roman period. The excavation was
39 confined to a specific lot covering an area approximately 11m by 10m wide
40 and was made in the framework of excavations for the foundations of a new
41 building. The output of the excavation was summarized in a short report
42 containing a detailed drawing, a photo (Fig. 2) and a short text.
43 According to the excavation report, the main finding was part of a well-built
44 paved road, on which four columns from the façade of a major building were
45 found toppled down as a rigid body, nearly parallel to each other. This
46 colonnade was built in the position of the northern sidewalk of the road, while
47 another, later wall was built on the sidewalk of the south side of the road,
48 destroying the uppermost part of the fallen columns (Fig. 2). The original road
49 was approximately 4 m wide, and signs of erosion from wheels of coaches
50 were reported to have been preserved on the road pavement. All remains
51 were assigned to the Roman period, but no artefacts permitting a finer dating
52 were found.

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58 After the excavation a new building was erected but the remains of the road
59 are preserved beneath a protective layer of sand and gravel, while the column
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1 fragments and other significant remains have been transported to the
2 warehouse of the local museum. No other excavations in the vicinity of this
3 site were made.

4 5 3.1.2 Building and destruction phases

6 The available excavation data permit to identify several phases of
7 construction-destruction in this excavation: After a certain period of use of the
8 road (phase A), testified by the signs of erosion by wheels on the road
9 pavement, a public building with a colonnade on its façade was built along the
10 northern sidewalk of the road (phase B). Phase B ended with the collapse of
11 the building and toppling of the columns on the road pavement. A layer of
12 debris from the destruction covered the area, and at a later period a new
13 building phase (phase C) started, as derived from the wall founded along the
14 south sidewalk.
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17 18 3.1.3 Causes and dating of building phases

19 The excavation report, despite its short length, is clear and complete and
20 permits certain reliable conclusions for the sequence of building phases and a
21 rough dating of destruction reported. The change from phase A to B indicates
22 a major discontinuity in the history of the town, the causes of which cannot be
23 inferred; the possibility of a major destruction and partial change of the urban
24 plan of the area cannot be excluded (cf. Rheidt 1996).

25 Concerning the destruction marking the passage from phase B to C, on the
26 contrary, certain lines of evidence provide clear evidence of earthquake
27 destruction:
28

29 *First*, the oriented collapse of the four monolithic columns provides evidence
30 of a pattern of seismic destruction first recognized by Lanciani (1918) and
31 subsequently classified as a criterion of seismic destruction (Stiros 1996;
32 Jones and Stiros 2000; Hancock and Altunel 1997; Galadini et al. 2006;
33 Hinzen 2009; Bottari et al., 2009). This pattern excludes the possibility of a
34 deliberate destruction, usually during a civil war, demolition of ancient temples
35 by Christian zealots, etc.
36

37 *Second*, the four monolithic columns, a precious building material in antiquity,
38 were abandoned and buried under a large mass of debris, representing the
39 background for a new building phase C.
40

41 This situation testifies to a major destruction causing disorganization of the
42 city, somewhat analogous to what has been observed in a larger scale in
43 other regions (Rheidt 1996; Stiros and Papageorgiou 2001). The evidence
44 permits to safely assign the destruction marking the end of phase B according
45 to the criteria of Stiros (1996) and an intensity of the order of IX is likely.
46

47 The excavation data do not provide detailed dating of the buildings phases,
48 but the style of the colonnade is likely to indicate the first centuries of the
49 Roman occupation. The defeat of Greeks by Romans in 146BC or even the
50 installation of a Roman colony in Patras after the Battle of Actium in 31BC can
51 be considered as a lower bound for phase A, while phase C can be dated to
52 the byzantine period (approximately before AD 1000).
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57 3.2 Excavation 2: Collapsed Oracle Workshop

58 A few hundred meters away from the first excavation, another excavation,
59 near the ancient Patras harbour and St Andrews Cathedral (67-69
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1 Bouboulinas Street) brought to light the remains of a workshop for oil lamps
2 sold at a nearby oil-lamp oracle, popular especially among sailors in Roman
3 times. A major destruction of this workshop was observed and was assigned
4 to a destructive earthquake, because of the style of collapsed buildings and
5 abandonment of the workshop. This earthquake was dated shortly after AD
6 300 on the basis of the artefacts found, and was assumed responsible for a
7 subsequent demise of Patras (Petropoulos 1999). The available data,
8 however, do not satisfy the strict criteria for identification of earthquakes from
9 archaeological data of Stiros (1996), because the available data focus on the
10 typology of important archaeological findings and the possible seismological
11 evidence is not available, no signs of destruction beyond the capacity of
12 human beings are available, and in addition, the destruction is dated to a
13 turbulent period marked by the war between paganism and Christianity, which
14 ended in AD 310 with the Edictum Mediolani (Decree of Constantin the Great
15 for recognition of Christianity).
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19 **4 Seismological and archaeological implications**

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22 The destruction of the building with the colonnade can be assigned with much
23 confidence to an earthquake with intensity at least IX. The epicentre of this
24 earthquake should have been close to the centre of Patras, perhaps not more
25 than 10-15 km away, because on the grounds of earthquake engineering a
26 local earthquake is required to explain destruction of one or two-storey
27 buildings (Stiros 2001; 2010). There is independent evidence for that in the
28 wider study area: Ambraseys and Jackson (1990) showed that the attenuation
29 of seismic waves in central Greece is rather quick: Among at least ten well
30 documented shocks with magnitude between 6.5 and 7.2 that occurred in
31 Greece between 1890 and 1990, none produced intensities larger than VI at a
32 distance of a few tens of kilometres from its epicentre. The inferred scale of
33 destruction in Patras requires either an earthquake of minimum magnitude 7.0
34 at a distance of up to 20-30km from Patras, or a smaller, magnitude 6.0 to 6.5
35 earthquake with an epicentre much closer to the town.
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38
39 The possibility of another, older event which led to partial abandonment of a
40 central street also exists, but the available evidence does not permit any
41 further hypotheses, including the association of these events with the AD 61
42 or other earthquakes of the 1st century mentioned above, which, however,
43 may have their epicentres away from Patras.
44

45 The destruction of the oil lamp workshop at circa AD 300 clearly indicates a
46 major catastrophe, which, according to Petropoulos (1999), was seismic in
47 origin and may have led to the demise of Patras. This last destruction cannot
48 be safely assigned to an earthquake, and despite the proximity of the two
49 sites, and even if it reflects an earthquake, it is not safe to be correlated with
50 the first excavation because the dating of both events is not precise and
51 Patras may have been affected by several earthquakes in the Roman period
52 (in fact, even the transition from phase A to B may indicate an earthquake,
53 see above).
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56 The earthquake or possibly the earthquakes deduced from the archaeological
57 excavations may have been associated with the destruction of the theatre
58 (Odeon) of Patras (Fig.3; an aerial view of this theatre is available in
59 <http://www.stepka.gr/mnemeia/patra/romaiko-odeio/>), roughly dated to the end
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1 of the third century AD. Due to lack of other evidence, the destruction of this
2 theatre, built after AD 125, is assigned to a barbaric invasion (see Rizakis
3 1995, entry 259). Still, the scale of structural damage in this structure (Fig. 3)
4 calls for forces far beyond those of vandalizing raids, and may reflect seismic
5 effects, as has been documented in two other theatres, the theatre of Aigeira
6 (about 60km east of Patras in the 3rd c. AD affected by a major earthquake
7 associated with coastal uplift Stiros, 1998) and the theatre of Larissa (in north-
8 central Greece, damaged by an earthquake; Caputo et al. 2011).

9 There are some additional remarks to make.

10
11 *First*, archaeological data permit to identify earthquakes and estimate their
12 local intensity and date of occurrence, but they do not usually permit to
13 associate them with specific tectonic features. In the best of the cases, these
14 earthquakes are related to nearby faults, most likely some of those shown in
15 Fig. 1a. To provide an idea of the moderate seismicity, which for the region of
16 Patras is of magnitude above 4 of the Richter scale, we provide the location of
17 all earthquakes with $M > 4$ that occurred in the period 1994 – 2014 within a
18 radius of 40km from the city of Patras (Fig. 1b).

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21 *Second*, evidence presented indicates that the absence of reports of
22 earthquakes in the ancient texts is not indicative of absence of earthquakes,
23 and

24
25 *Third*, barbaric invasions (or other deliberate destructions) may offer a good
26 explanation for observed damages in ancient buildings or sites only if
27 damages are below a certain level. For instance, the destruction of whole,
28 well-built towns in Libya cannot be assigned to camel-riding tribes, which at
29 best could set fires or make damages, but are associated with the AD 365
30 earthquake sequence (Stiros 2001). Similarly, earthquakes may represent a
31 reliable explanation for destructions only if the additional necessary evidence
32 for a strong earthquake with an epicentre at a distance less than 20 km away,
33 either historical or with destructions having a characteristic pattern, exists
34 (Stiros 1996).

35 36 37 38 **5 Conclusions**

39
40 After a period of relative seismic quiescence of about 200 years, the city of
41 Patras in SW Greece is possibly exposed to the threat of earthquakes, but its
42 seismic risk is poorly constrained. This is to some degree due to the poor
43 knowledge of the seismic record of the area.

44
45 In this paper we documented the first case of a destructive earthquake in
46 Patras. The evidence comes from a small ancient site in the centre of Patras,
47 but it provides clear evidence of a town-wide devastation which can be
48 explained by an earthquake which produced minimum intensities IX.

49
50 Association of this earthquake with a specific fault is, however, for the present
51 not possible.

52 53 54 55 **Acknowledgements**

56 This paper has benefited from the comments of an anonymous reviewer and
57 the Editor-in-Chief.
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Figure captions

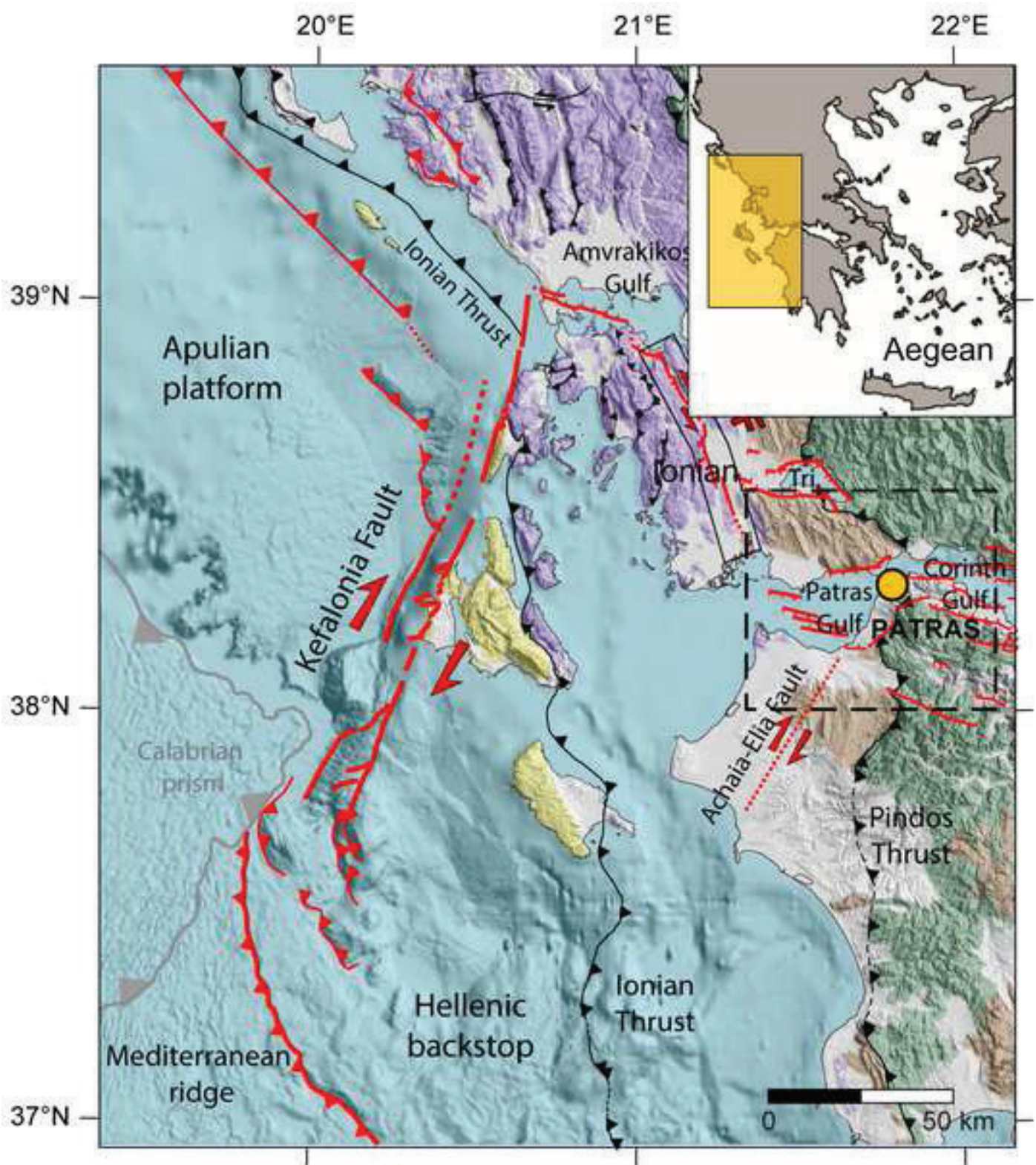
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48 **Fig. 1** (a) Location and tectonic map of the wider Patras area, modified after
49 Pérouse et al (unpublished). The 2008 strike-slip fault which was reactivated
50 four times in the last 20 years and with a principal sense of migration of fault
51 activity towards NE (i.e. towards Patras; Feng et al. 2010; Stiros et al. 2013) is
52 marked as the Achaia-Elia Fault. The area within the black dashed box is the
53 area presented in Fig. 1b. (b) Recorded moderate seismicity ($M > 4$) for the
54 region of Patras within the period 1994 – 2014. Red circles represent
55 earthquakes with $4 \leq M < 5$, blue for $5 \leq M < 6$ and yellow for $M \geq 6$ (fig. 1b
56 was created using Trimble Business Centre with data obtained from the
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1 National Observatory of Athens earthquake catalogue and directly exported to
2 Google Earth).

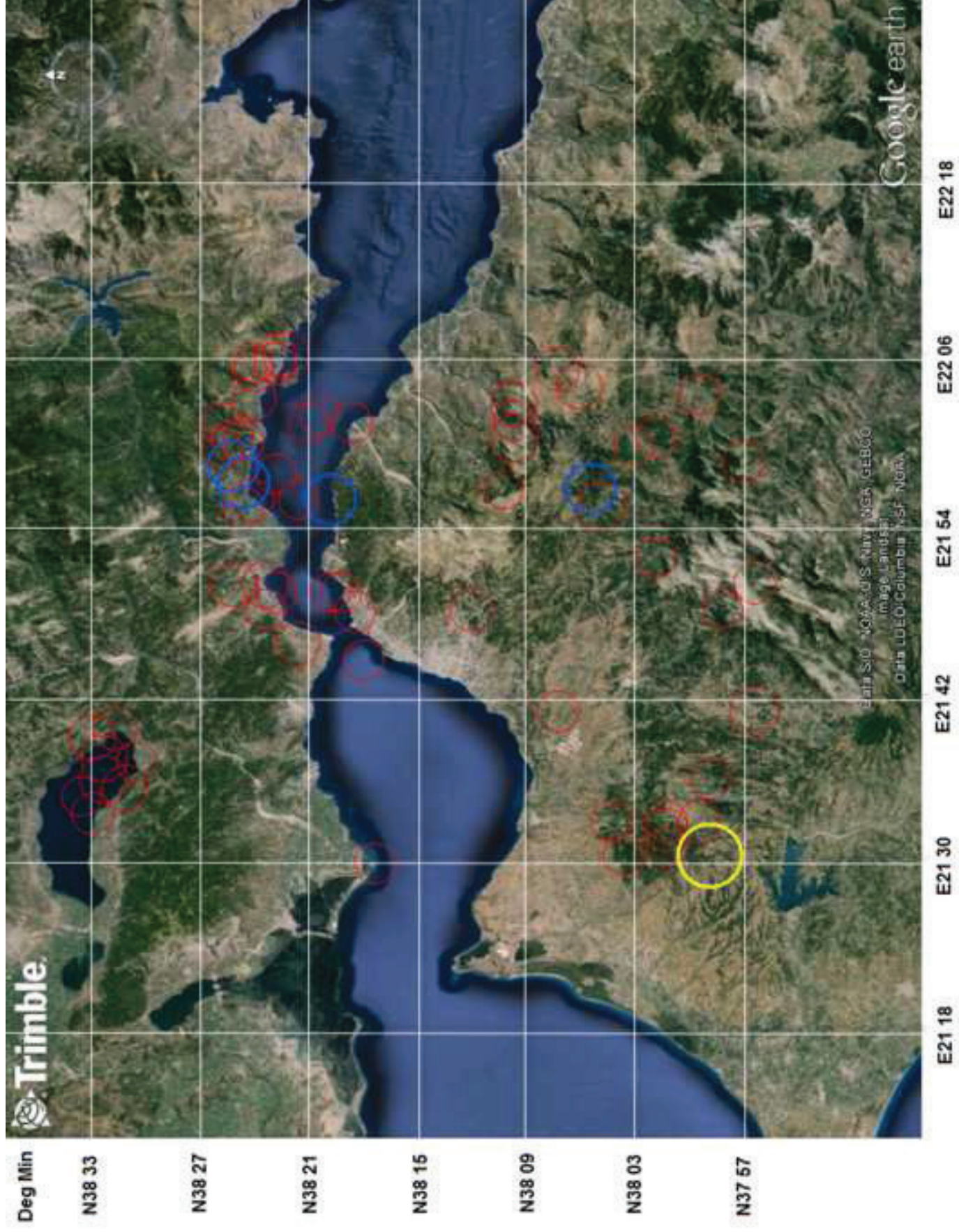
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6 **Fig. 2** Evidence of a seismic collapse at Patras. Modified after Stavropoulou-
7 Gatsi (1985). 1: excavated paved road (phase A), 2: columns of phase B,
8 toppled down; a curved arrow indicates sense of movements, 3: stylobate
9 (base of columns) of phase B, built along the north sidewalk of the road of
10 Phase A, 4: south sidewalk of the initial road, 5: foundations of a later building
11 (phase C)
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14 **Fig. 3** (a) A typical Roman Odeon, a relatively small to very small theatre
15 usually made of brick, concrete and hewn rocks (after
16 <http://www.vroma.org/~plautus/theatmod.jpg>).
17 (b) Side view of the Patras Odeon, after its reconstruction in the 1960's.
18 Contrast in building material indicates surviving ruins and reconstruction
19 material. The scale of damage (derived from missing parts and the
20 reconstruction) and the abandonment of the ruins of this building at the end of
21 the 3rd century testify to forces beyond those of invading tribes and can
22 conspicuously be assigned to seismic forces.
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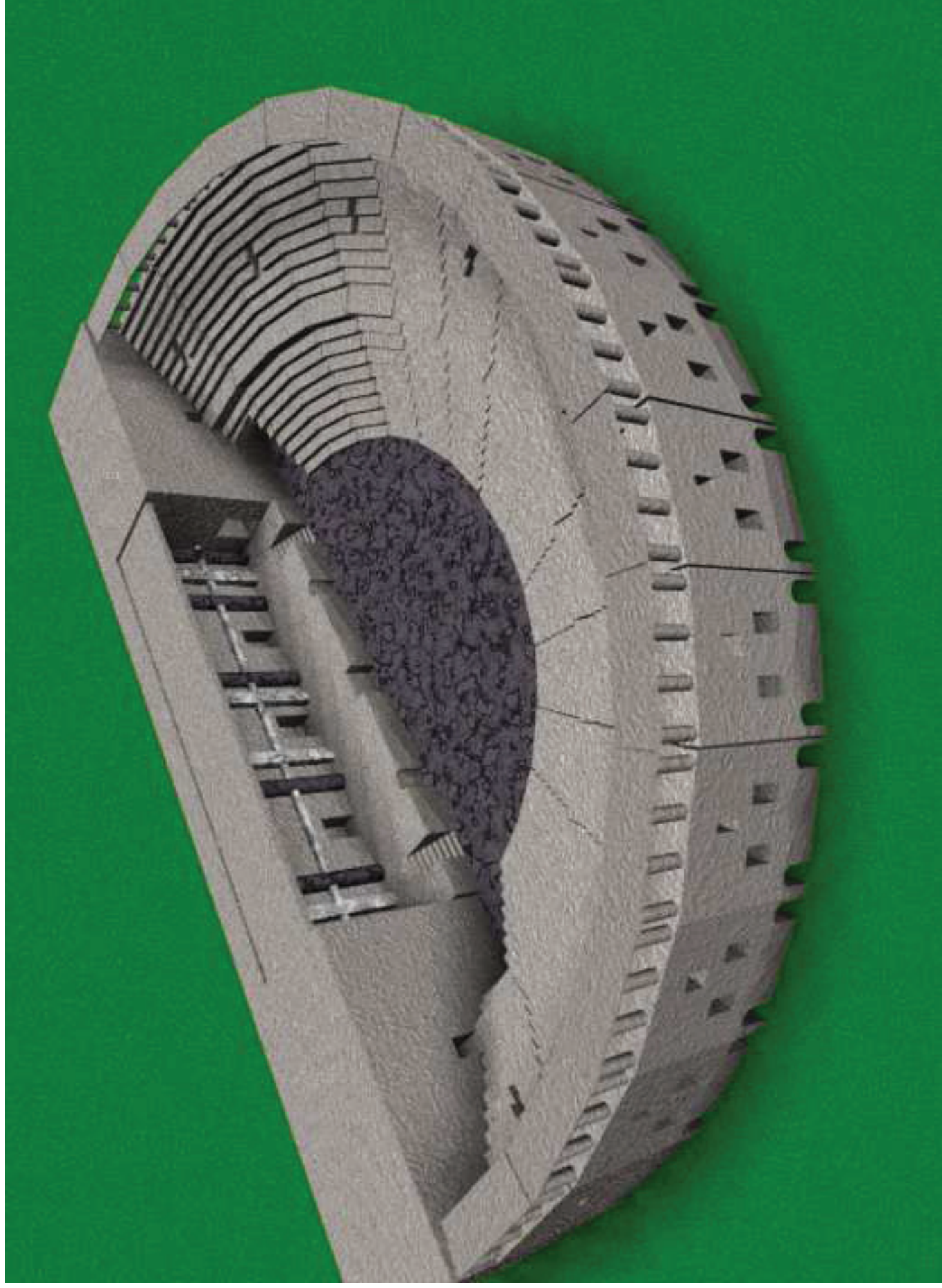


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