

Archaeological evidence for a destructive earthquake in Patras, Greece

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Abstract Oriented collapse of columns, large-scale destruction debris and temporary abandonment of the area deduced from an archaeological excavation provide evidence for a major (intensity IX) earthquake in Patras, Greece. This, and possibly a cluster of other earthquakes, can be derived from archaeological data. These earthquakes are not included in the historical seismicity catalogues, but can be used to put constraints to the seismic risk of this city. Patras was affected by a cluster of poorly documented earthquakes between 1714 and 1806. The city seems to be exposed to risks of progressive reactivation of a major strike-slip fault. A magnitude 6.4 earthquake in 2008 has been related to it. This fault has also been associated with a total of four events in the last 20 years, a situation reminiscent of the seismic hazard at the western edge of the North Anatolian Fault.

Keywords Earthquake · Seismic hazard · Archaeological evidence · Risk

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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; Margaritis 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 eighteenth to nineteenth centuries and a vague

report of an earthquake in AD 551 (see below), no other earthquakes are known to have hit Patras. 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 the transportation of the relics of Saint Andrews from Patras, where he martyred (crucified on an X-shaped cross), to St. Andrews in Scotland in the 6th c AD.

In order to contribute to the understanding of the seismic history of Patras, in this article, we focus on the 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 a few lines in length. Only in the case of very important remains (temples, gates in walls, etc.) is the site confiscated by the government and then partially excavated and preserved in a proper manner.

Because most excavations in Patras were of the rescue type, during the building boom period of the city (1970–2000), very little is known about the findings, and for this reason, detailed studies of the history and archaeology of Patras provide no information of earthquakes (e.g. Rizakis 1995). While this study permits to present for the first time evidence of seismic destruction in Patras, it does not permit to associate it with a specific fault. It allows only for an estimate of the earthquake intensity and restriction of the causative fault at a distance of 15–20 km from the city.

2 Historical evidence of earthquakes in the Patras area

Historical seismicity catalogues (e.g. Guidoboni et al. 1994; Papazachos and Papazachou 1997) include a few entries for earthquakes in the wider Patras region in AD 551 (a rather vague report, probably mixing several events), in 1714, 1785, 1804 and 1806. Very few details are known about these earthquakes, for which Papazachos and Papazachou (1997) estimated

magnitudes between 6.2 and 6.5 of the Richter scale and intensities up to IX.

The only additional information concerning these events comes from a passing report of Leake, a famous traveller who, during his visit in the area circa 1805, noticed that the town was frequently shaken by earthquakes, and for this reason, he reported that the house of the British consulate was made of timber, earthquake resistant (see Stiros 1995). Leake’s report is likely to indicate effects of the 1804 (and 1806?), of the 1785 or even of the 1714 earthquakes.

3 Excavation data

Two rescue excavations provide clear evidence of earthquake destruction.

3.1 Excavation 1: road with collapsed columns

3.1.1 Excavation data

According to Stavropoulou-Gatsi (1985), a rescue archaeological excavation in 1979 in the centre of the modern city of Patras (Kalamodgati 10-Kanakari st.), at a depth of approximately 3.5 m below modern ground level, brought to light remains of a paved road of the Roman period. The excavation was confined to a specific lot covering an area approximately 11 m by 10 m wide and was made in the framework of excavations for the foundations of a new building. The output of the excavation was summarized in a short report containing a detailed drawing, a photo (Fig. 1) and a short text.

According to the excavation report, the main finding was part of a well-built paved road, on which four columns from the façade of a major building were found toppled down as a rigid body, nearly parallel to each other. This colonnade was built in the position of the northern sidewalk of the road, while another, later wall was built on the sidewalk of the south side of the road, destroying the uppermost part of the fallen columns (Fig. 1). The original road was approximately 4 m wide, and signs of erosion from wheels of coaches were reported to have been preserved on the road pavement. All remains were assigned to the Roman period, but no artefacts permitting a finer dating were found.

After the excavation, a new building was erected but the remains of the road are preserved beneath a protective layer of sand and gravel, while the column

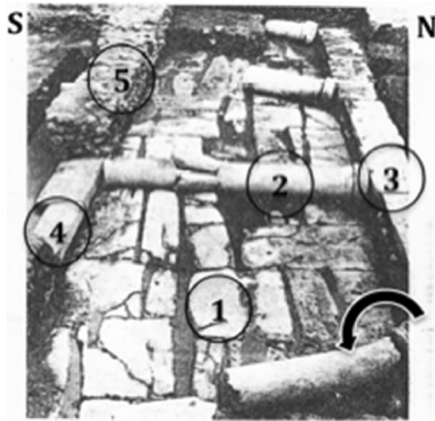


Fig. 1 Evidence of a seismic collapse at Patras. Modified after Stavropoulou-Gatsi (1985). 1 excavated paved road (phase A); 2 columns of phase B, toppled down; a curved arrow indicates sense of movements; 3 stylobate (base of columns) of phase B, built along the north sidewalk of the road of phase A; 4 south sidewalk of the initial road; 5 foundations of a later building (phase C)

fragments and other significant remains have been transported to the warehouse of the local museum. No other excavations in the vicinity of this site were made.

3.1.2 Building and destruction phases

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

3.1.3 Causes and dating of building phases

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

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

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

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

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

The excavation data do not provide detailed dating of the building phases, but the style of the colonnade is likely to indicate the first centuries of the Roman occupation. The defeat of Greeks by the Romans in 146 BC or even the installation of a Roman colony in Patras after the Battle of Actium in 31 BC can be considered as a lower bound for phase A, while phase C can be dated to the Byzantine period (approximately before AD 1000).

3.2 Excavation 2: collapsed oracle workshop

A few hundred metres away from the first excavation, another excavation near the ancient Patras harbour and St. Andrews Cathedral (67-69 Bouboulinas Street) brought to light the remains of a workshop for oil lamps sold at a nearby oil lamp oracle, popular especially among sailors in Roman times. A major destruction of this workshop was observed and was assigned to a destructive earthquake, because of the style of collapsed buildings and abandonment of the workshop. This earthquake was dated shortly after AD 300 on the basis of the artefacts found and was assumed responsible for the subsequent demise of Patras (Petropoulos 1999). The available data, however, do not satisfy the strict criteria for identification of earthquakes from the archaeological data of Stiros (1996) because the available data

focus on the typology of important archaeological findings and the possible seismological evidence is not available, no signs of destruction beyond the capacity of human beings are available, and in addition, the destruction is dated to a turbulent period marked by the war between paganism and Christianity, which ended in AD 310 with the Edictum Mediolani (Decree of Constantine the Great for recognition of Christianity).

4 Seismological and archaeological implications

The destruction of the building with the colonnade can be assigned with much confidence to an earthquake with an intensity of at least IX. The epicentre of this earthquake should have been close to the centre of Patras, perhaps not more than 10–15 km away, because on the grounds of earthquake engineering, a local earthquake is required to explain the destruction of one- or two-storey buildings (Stiros 2001; 2010). There is independent evidence for that in the wider study area: Ambraseys and Jackson (1990) showed that the attenuation of seismic waves in central Greece is rather quick—among at least ten well-documented shocks with magnitude between 6.5 and 7.2 that occurred in Greece between 1890 and 1990, none produced intensities larger than VI at a distance of a few tens of kilometres from its epicentre. The inferred scale of destruction in Patras requires either an earthquake of minimum magnitude 7.0 at a distance of up to 20–30 km from Patras or a smaller, magnitude 6.0 to 6.5 earthquake with an epicentre much closer to the town.

The possibility of another, older event which led to partial abandonment of a central street also exists, but the available evidence does not permit any further hypotheses, including the association of these events with the AD 61 or other earthquakes of the first century mentioned above, which, however, may have their epicentres away from Patras.

The destruction of the oil lamp workshop at circa AD 300 clearly indicates a major catastrophe, which, according to Petropoulos (1999), was seismic in origin and may have led to the demise of Patras. This last destruction cannot be safely assigned to an earthquake, and despite the proximity of the two sites, and even if it reflects an earthquake, it is not safe to be correlated with the first excavation because the dating of both events is not precise and Patras may have been affected by several earthquakes in the Roman period (in fact, even the transition from phase A to B may indicate an earthquake; see above).

The earthquake or possibly the earthquakes deduced from the archaeological excavations may have been associated with the destruction of the theatre (odeon) of Patras (Fig. 2; an aerial view of this theatre is available in <http://www.stepka.gr/mnemeia/patra/romaiko-odeio/>), roughly dated to the end of the third century AD. Due to the lack of other evidence, the destruction of this theatre, built after AD 125, is assigned to a barbaric invasion (see Rizakis 1995, entry 259). Still, the scale of structural damage in this structure (Fig. 2) calls for forces far beyond those of vandalizing raids and may reflect seismic effects, as has been documented in two other theatres, the theatre of Aigeira (about 60 km east

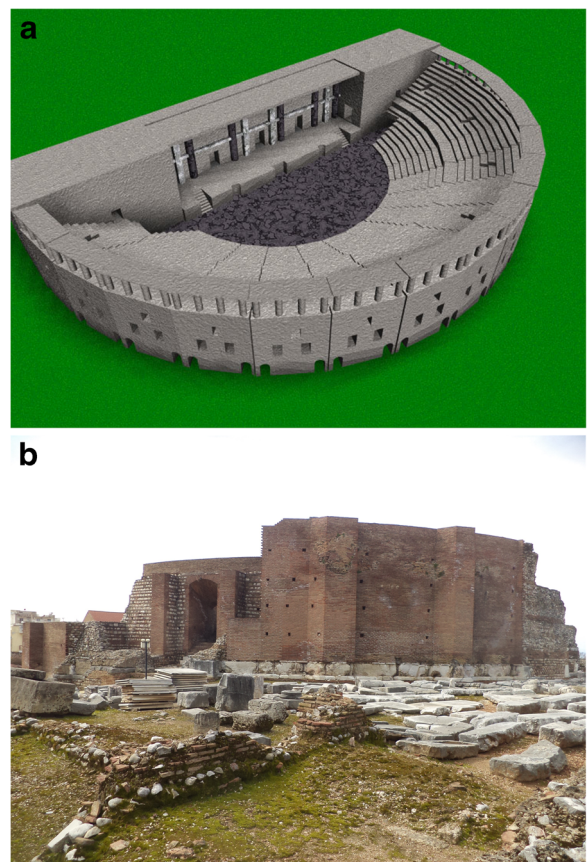


Fig. 2 **a** A typical Roman odeon, a relatively small to very small theatre usually made of brick, concrete and hewn rocks (after <http://www.vroma.org/~plautus/theatmod.jpg>). **b** Side view of the Patras odeon, after its reconstruction in the 1960s. The contrast in building material indicates surviving ruins and reconstruction material. The scale of damage (derived from missing parts and the reconstruction) and the abandonment of the ruins of this building at the end of the third century testify to forces beyond those of invading tribes and can conspicuously be assigned to seismic forces

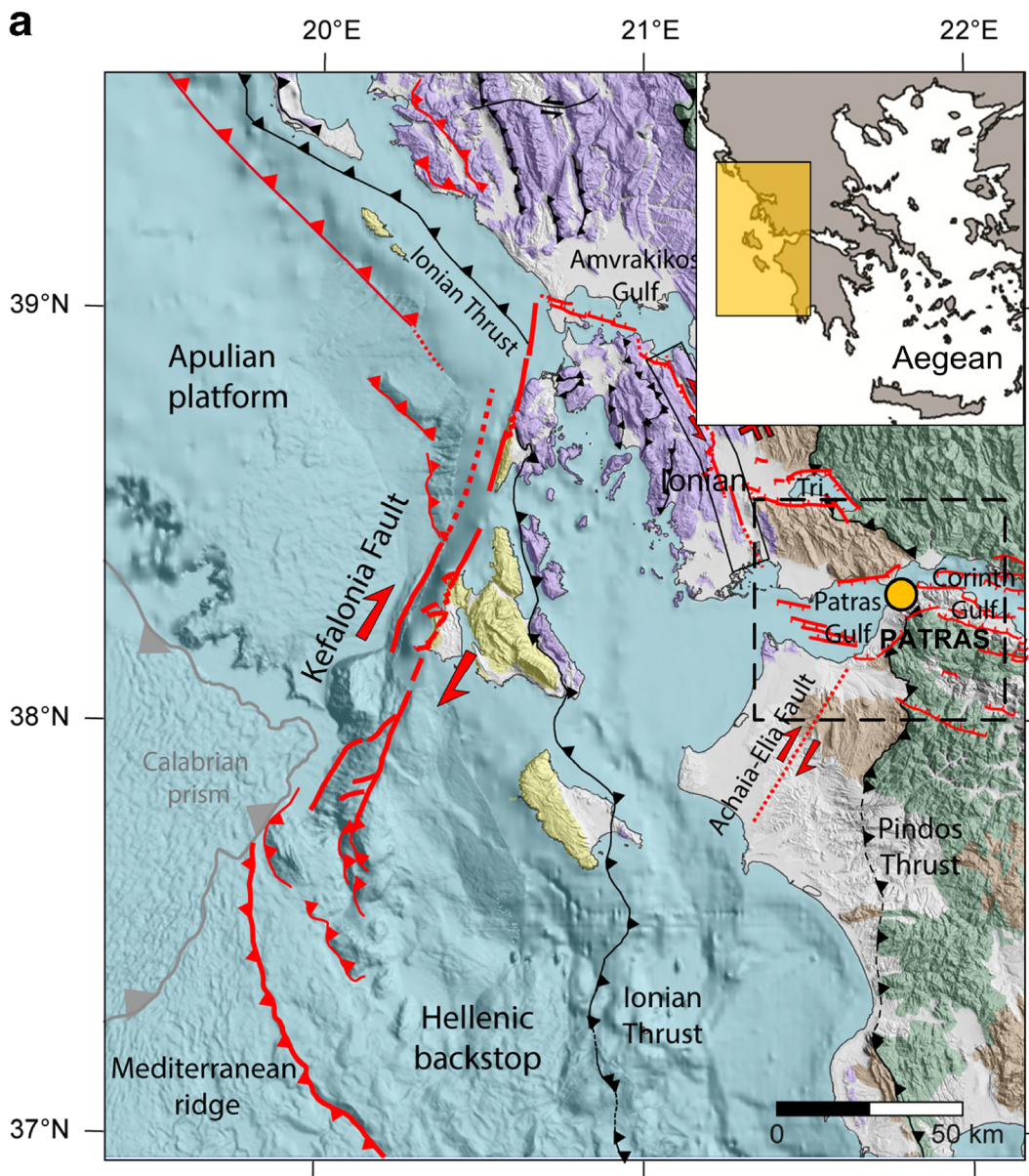


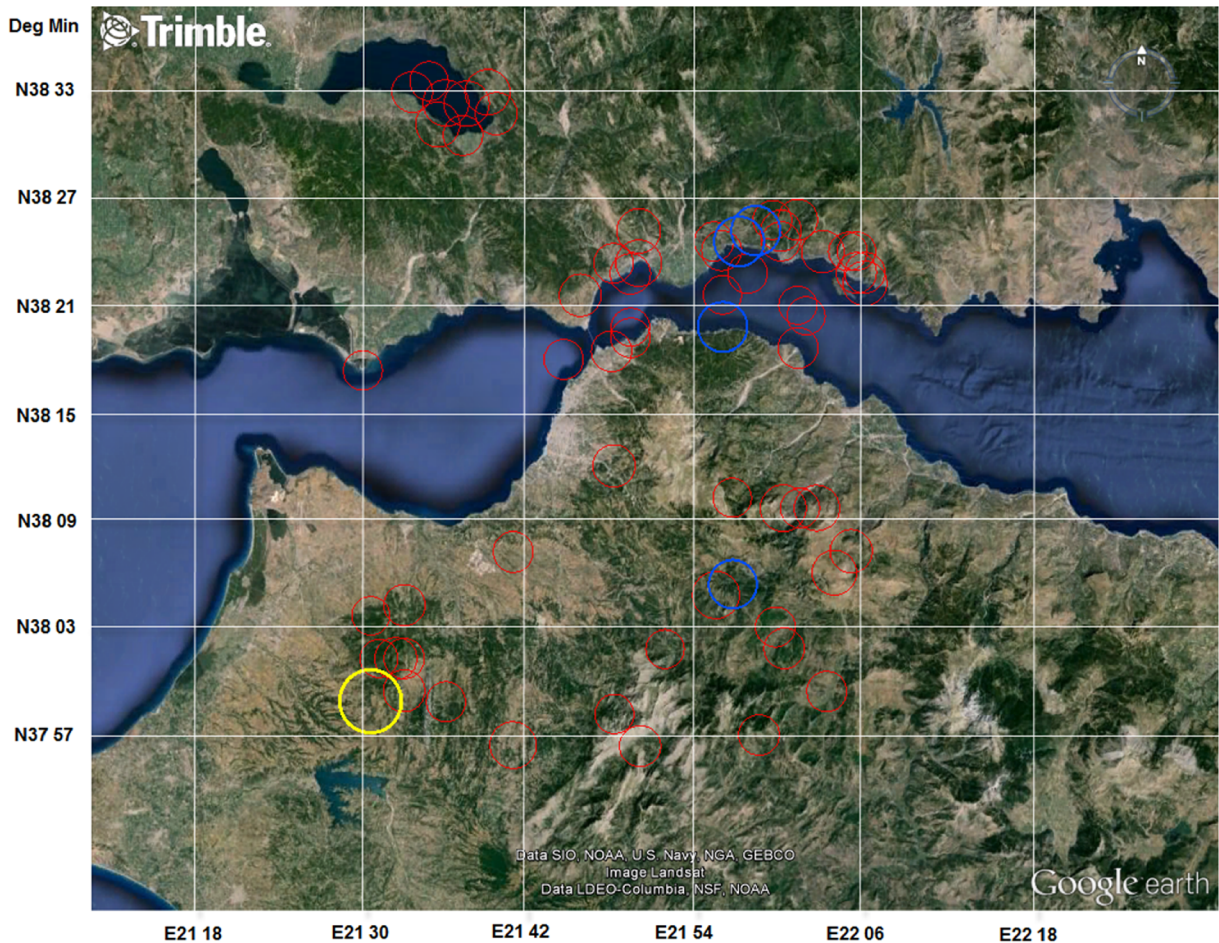
Fig. 3 a Location and tectonic map of the wider Patras area, modified after Pérouse (2013). The 2008 strike-slip fault which was reactivated four times in the last 20 years and with a principal sense of migration of fault activity towards the NE (i.e. towards Patras; Feng et al. 2010; Stiros et al. 2013) is marked as the Achaia-Elia Fault. The area within the *black dashed box* is the

area presented in **b**. **b** Recorded moderate seismicity ($M > 4$) for the region of Patras within the period 1994–2014. *Red circles* represent earthquakes with $4 \leq M < 5$, *blue* for $5 \leq M < 6$ and *yellow* for $M \geq 6$ (**b** was created using Trimble Business Centre with data obtained from the National Observatory of Athens earthquake catalogue and directly exported to Google Earth)

of Patras in the 3rd c. AD affected by a major earthquake associated with coastal uplift Stiros 1998) and the theatre of Larissa (in north-central Greece, damaged by an earthquake; Caputo et al. 2011).

There are some additional remarks to make.

First, archaeological data permit to identify earthquakes and estimate their local intensity and date of occurrence, but they do not usually permit to associate them with specific tectonic features. In the best of the cases, these earthquakes are related

b**Fig. 3** (continued)

to nearby faults, most likely some of those shown in Fig. 3a. To provide an idea of the moderate seismicity, which for the region of Patras is of magnitude above 4 of the Richter scale, we provide the location of all earthquakes with $M > 4$ that occurred in the period 1994–2014 within a radius of 40 km from the city of Patras (Fig. 3b). *Second*, evidence presented indicates that the absence of reports of earthquakes in the ancient texts is not indicative of absence of earthquakes.

Third, barbaric invasions (or other deliberate destructions) may offer a good explanation for observed damages in ancient buildings or sites only if damages are below a certain level. For instance, the destruction of whole, well-built towns in Libya cannot be assigned to camel-riding tribes, which

at best could set fires or make damages, but is associated with the AD 365 earthquake sequence (Stiros 2001). Similarly, earthquakes may represent a reliable explanation for destructions only if the additional necessary evidence for a strong earthquake with an epicentre at a distance less than 20 km away, either historical or with destructions having a characteristic pattern, exists (Stiros 1996).

5 Conclusions

After a period of relative seismic quiescence of about 200 years, the city of Patras in SW Greece is possibly exposed to the threat of earthquakes, but its seismic risk is

poorly constrained. This is to some degree due to the poor knowledge of the seismic record of the area.

In this paper, we documented the first case of a destructive earthquake in Patras. The evidence comes from a small ancient site in the centre of Patras, but it provides clear evidence of a town-wide devastation which can be explained by an earthquake which produced a minimum intensity of IX. The association of this earthquake with a specific fault is, however, for the present not possible.

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