

## How Imminent is the Earthquake Expected in Istanbul? And How Potentially Deadly?

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Dear Editor,

According to geodetic measurements by satellite, a 4.92-m displacement has occurred in the northern branch of the North Anatolian Fault (NAF) in the Sea of Marmara over the last 247 years. This is a sign that energy has been accumulating for at least 247 years for an earthquake that may cause enormous destruction in Istanbul in the Central Marmara Fault with an annual  $22 \pm 3$  displacement (1, 2).

The threat of an earthquake in the Sea of Marmara has been known for many years. In a paper published in *Nature* in 1971, the geologist Ambraseys N has reported the presence of records of a major earthquake that damaged Istanbul in the historical period. He has further mentioned that the last major earthquake in Istanbul had struck in 1894, no major earthquake had struck in the following 80 years up to 1970, and destructive earthquakes may occur in the near future (3).

According to studies by Ambraseys and Finkel, Istanbul and the surrounding areas have suffered destructive earthquakes since the 1st century. These studies state that earthquakes in the Sea of Marmara and the surrounding area in the years 32, 121, 128, 155, 181, 269, 358, 362, 447, 460, 478, 484, 557, 740, 861, 869, 967, 989, 1011, 1063, 1296, 1323, 1343, 1345 and 1419 AD were probably of a magnitude of 7 or more. The earthquake on November 4, 447 was described as a "disaster." In that earthquake, houses and buildings in Istanbul (Constantinople) were reported to have collapsed; 57 of the 96 towers on the city walls fell down; and the earthquake was followed by a tsunami, landslides, and deep fissures in several places (2, 4).

An examination of earthquake catalogs reveals that the 1509 Istanbul earthquake was described as the "Little Apocalypse." Between 1500 and 13,000 people are recorded to be dead. The loss of life was reported at between 4/1000 and 2%. In proportion to the present-day population of 15 million, these death rates correspond to a death toll of between 60,000 and 300,000 (1).

The earthquakes in the last 500 years in the Sea of Marmara, those of 1509, 1719, 1754, May 1766, August 1766, 1894, and 1912, have been reassessed, considering the data provided by August 17, 1999 earthquake (Figure 1, Table 1) (5). New estimates have been performed regarding the fault lines on which these earthquakes, re-analyzed using computer software, occurred and their magnitudes. According to the new findings, all earthquakes in question were  $\geq 7$  in magnitude, with recurrence intervals ranging between 140 and 280 years. Further, earthquakes are believed to have migrated toward Istanbul along NAF in the last 60 years and to have triggered one another; the Izmit earthquake was the end result of this progression (2). The Marmara earthquake of August 17 has increased the probability of a major earthquake in the region by 12% to  $62\% \pm 15\%$  (6).

What may be the scale of the losses inflicted on Istanbul by a probable earthquake? Public bodies and universities have been engaged in intensive efforts for providing scientific data on this subject since the Marmara earthquake of August 17. The report emerging from joint collaboration by the Greater Istanbul Municipality and the Japanese International Cooperation Agency describes the lessons learned from the Kobe and Kocaeli earthquakes of 1999 and provides important clues as to the scale of loss of life and property that an earthquake in Istanbul may cause (7). According to that report, the 1999 Marmara earthquake occurred in a densely populated area, the heartland of Turkish industry, and resulted in the second worst quake-related loss of life in Turkey in the 20<sup>th</sup> century. The earthquake affected 7 provinces and led to the loss of 15,000 lives and more than 77,000 buildings being seriously damaged. All telephone lines were severed in the first 48 hours, and the president and prime minister were unable to communicate with Istanbul for 4 h. Moreover, contact could only be established by wireless. However, problems with the spare batteries required for wireless implied that communications were constantly interrupted. Therefore, it took 2

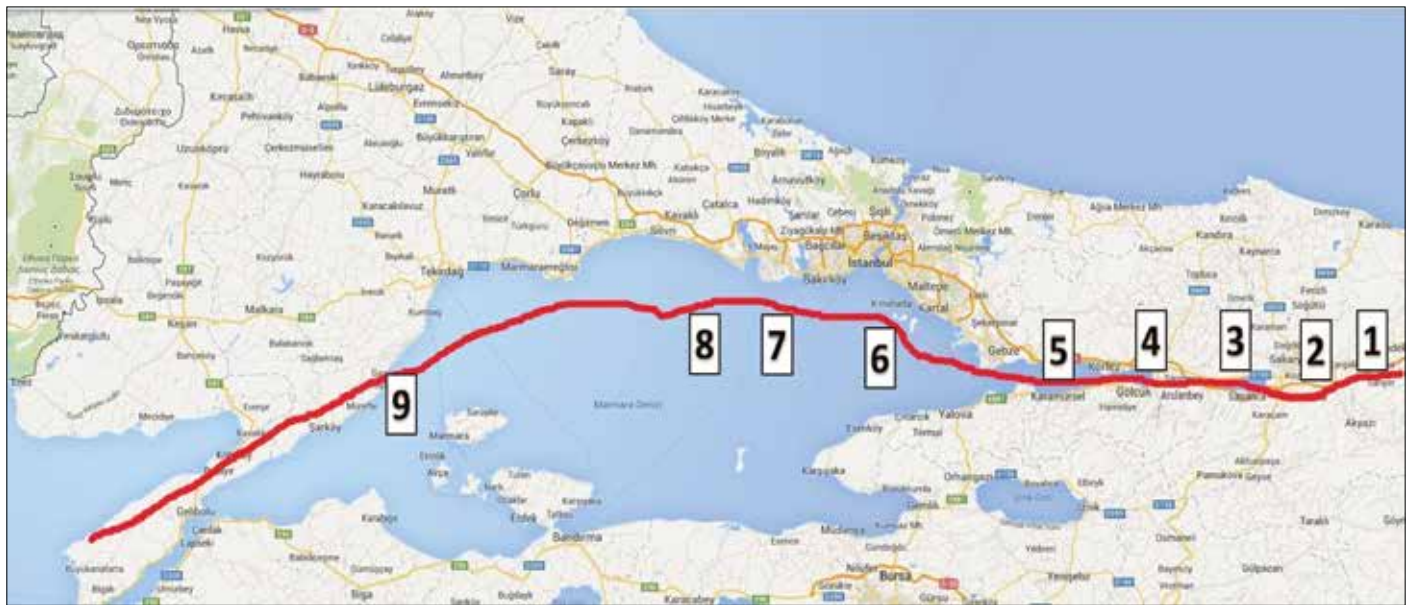
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**Figure 1.** Earthquakes in the Sea of Marmara in the last 500 years

**Table 1.** Earthquakes in the Sea of Marmara in the last 500 years and the affected fault line segments

Earthquake date	Magnitude scale (Ms)	Fault line segments affected
10.09.1509	7.2	7, 8
25.05.1719	7.2	2, 3, 4, 5
02.09.1754	6.8	6
22.05.1766	7.1	7, 8
05.08.1766	7.4	9
10.07.1894	7.3	3, 4, 5
09.08.1912	7.3	9
17.08.1999	7.4	1, 2, 3, 4

days for the severity of the situation in the region to emerge. The first Turkish rescue team from the outside arrived at Izmit at around 5 pm on the 2<sup>nd</sup> day. At the time of the disaster, there were civil defense teams comprising 50-150 people in every province; however, these existed only on paper. Most teams were untrained, with no mobilization and action plans and lacked equipment when they did reach the area. Rescue teams with no knowledge of buildings and structures posed a danger during the search and rescue operations. Due to power cuts and limited lighting, rescue operations at night were particularly difficult. Logistic support, such as heavy machinery and fuel provision, were insufficient. Fire-fighting teams lacked sufficient equipment for heavy rescue operations. Fire-fighters themselves were also unprepared for heavy rescue operations. Further, volunteers arriving for help but lacking food and accommodation represented another problem. Rescue teams with no news of their families' health experienced psychological troubles. Difficulties were experienced in working with foreign rescue teams because of the lack of interpreters in the emergency management center. Some drugs from abroad could not be used because their instructions could not be read (7).

Some lessons drawn by the team responsible for that report from the Japanese earthquake in Kobe in 1995 in terms of representing a model for a likely Istanbul quake are as follows.

The death toll in the city of Kobe exceeded 6000, with more than 14,000 people injured. The number of people rendered homeless was 230,000. Investigations have revealed that the deaths in this quake occurred in approximately the first 15 min. Helicopters were not used to provide emergency aid, and problems occurred with the use of airlines and air traffic control. Marine transport was employed; however, the damage caused to harbors hindered this. Because triage on the basis of victims' conditions could not be performed at once and on site, the injured victim poured into hospitals. The involved doctors also lacked sufficient triage experience. Information concerning medical needs and treatment capacity was lacking as was information about structural or nonstructural problems occurring in the involved hospitals. The result was large numbers of patients arriving at severely damaged hospitals. Insufficient working areas, inexperience, and local management organization deficiencies made it difficult for outside teams to help. The local management also lacked an experience of working together with volunteer aid teams from outside (7).

This is the most comprehensive report so far published concerning what may be expected to happen in Istanbul. The probable scenarios it describes regarding likely numbers of deaths and injuries provide important information regarding the scale of the disaster that medical aid organizations may face (Table 2) (7).

This city that has grown in a largely unplanned and unsupervised manner as well as very fast and unbalanced in the last 50-60 years is now under threat from a more destructive quake, or from more than one, that may strike from as close as 10 km from the shore, as occurred in the 18<sup>th</sup> century. Further preparations require to be conducted to prepare for a probable earthquake, including speeding up urban renewal projects. The emergency health system in Turkey requires to be structured to meet such a disaster, and education programs need to be implemented.

There is much to be mentioned regarding the imminence and scale of an Istanbul earthquake. Our last words on the subject are as

**Table 2.** Losses of life and property in a likely major Istanbul earthquake

Earthquake magnitude according to Model A (Mw: 7.5)		Earthquake magnitude according to Model C (Mw: 7.5)	
Severely damaged buildings	51,000	Severely damaged buildings	59,000
Death toll	73,000	Death toll	87,000
Severely injured	120,000	Severely injured	135,000
Mw: Magnitude moment			

follows: "To all those making earthquake preparations for Istanbul! A major earthquake in Istanbul awaits us all; one of the type that strikes every 250 years. Those who survive will see how destructive and deadly it is."

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