Geography

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Topics: Development Hazards: Tectonic

The 2023 Turkish-Syrian Earthquake: A Mega Disaster in the Making?

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This **Geography Factsheet**:

- Explores the causes of the earthquake and its impacts and responses.
- Examines the factors contributing to the development of this mega disaster.
- Assesses future earthquake risk within Turkey.

On 6th February 2023, after over a century of seismic inactivity along the East Anatolian Fault, a major M_w 7.8 earthquake struck southern Turkey and north-west Syria, followed nine hours later by another earthquake of M_w 7.5 **(Figure 1)**. It is common for a significant aftershock to follow the initial strongest one, so they will be considered as one event in terms of their impact and response. Details are presented in **Table 1**.

Table 1 Physical characteristics

Event	Earthquake	Aftershock
Moment Magnitude (Mw)	7.8	7.5
Mercalli Intensity	XI (extreme)	X
Depth	18 km	13 km
Epicentre	32 km W-NW of Gaziantep	95 km N-NE of Gaziante
Time of Day (local)	04:17	13:24

The region has consistently experienced tectonic activity. Aleppo (northern Syria) and Gaziantep (southern Turkey), the two largest cities affected by this earthquake, have endured devastating events during the past millennium. This earthquake marks Syria's most severe seismic event since the Aleppo earthquake of 1822.

Causes

Turkey is located along two major fault lines. **Figure 2** illustrates the North Anatolian Fault (NAF) and the East Anatolian Fault (EAF), along with the movement of the three major plates in the region. The Hatay Triple Junction, where the African, Arabian, and Eurasian plates converge, has shifted northeast over the past 15 million years **(Figure 3)**.

The closure of the Mediterranean is occurring as the Arabian and African plates converge with the Eurasian plate along the Cyprus Arc subduction zone. This convergence has resulted in the westward compression of the Anatolian block, primarily along the East and North Anatolian Faults.

Figure 1 Location map

Figure 2 Major fault lines and plate movement

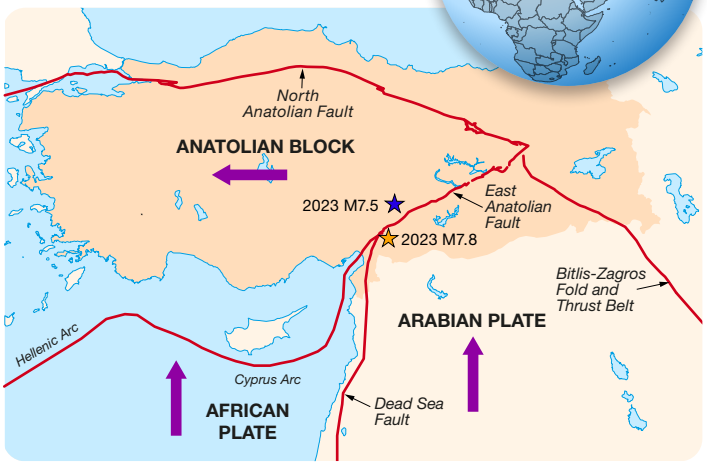

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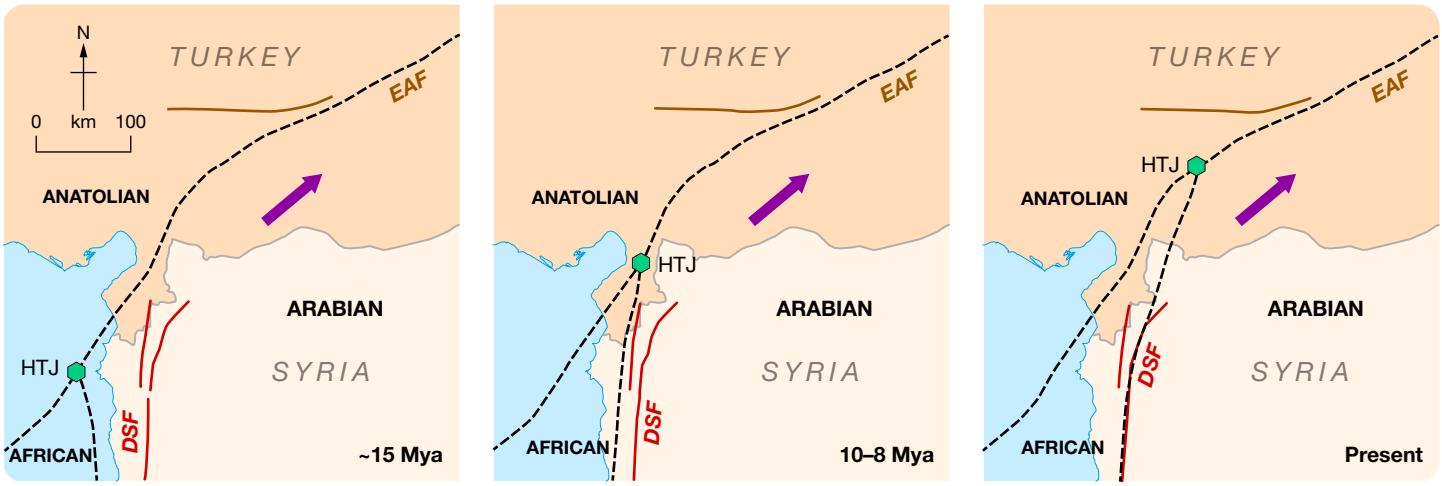
Figure 3 Migration of Hatay Junction



The region has a complex network of faults with varying rates of movement, leading to stress accumulation in different sections:

- The East Anatolian Fault is a 700-km-long transform fault with slip rates decreasing from east (10 mm/year) to west (1–4 mm/year).
- The Dead Sea Fault, a transform fault between the Arabian and African plates, exhibits faster movement in its southern section (10 mm/year) compared to the northern section.

The East Anatolian Fault (EAF) consists of a series of vertical or nearly vertical fractures known as transform (or strike-slip) faults **(Figure 4)**. Similar to the San Andreas Fault in California, these faults involve horizontal movement of blocks. The EAF can be structurally divided into several significant segments **(Figure 5)**, and strain has been accumulating since major earthquakes occurred in 1513 and 1874. In 2023, multiple segments of the fault failed simultaneously, resulting in the huge earthquake. It may take 300–1000 years for strain to build up again for another earthquake of this magnitude, although the risk persists in other areas within this heavily fractured zone.

Figure 4 Transform (or strike-slip) fault

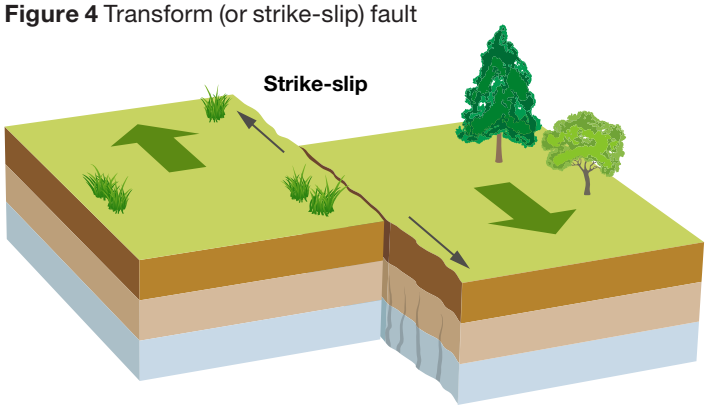
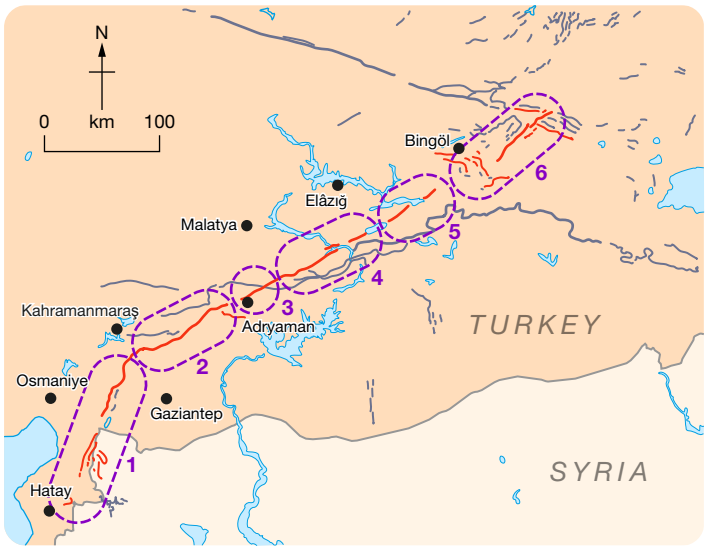


Figure 5 Segments along the East Anatolian Fault



The 2023 earthquake originated on the Dead Sea Fault (DSF) as a result of the movement between the Arabian and African plates. This caused the rupture of the southwestern portion of the East Anatolian Fault (EAF) and the northernmost segment of the DSF until it reached the Hatay Junction. From there, the rupture extended both to the northeast (involving the Anatolian and Arabian plates) and southwest (involving the Anatolian and African plates). Tremors were detected in Cyprus, Lebanon, Iraq, and Jordan. **Figure 6** provides a comparison of the affected area with the size of the UK, highlighting the extensive impact of the earthquake.

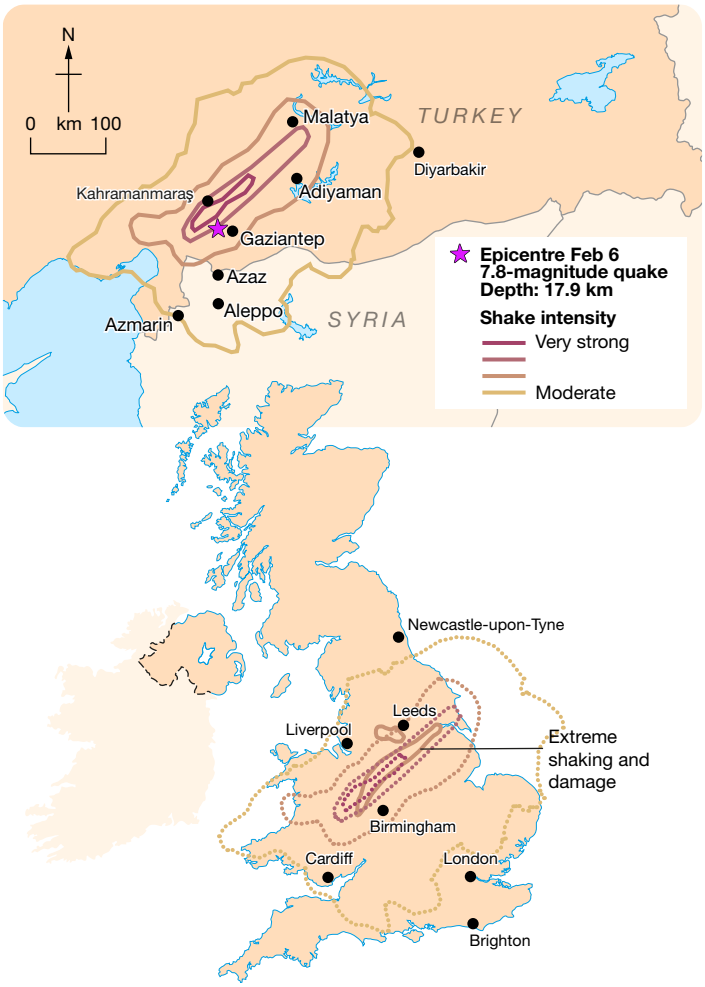
Activity 1

Identify the physical characteristics that contributed to the scale of the disaster. Compare this earthquake's profile with other mega disasters, such as Haiti, Bam, or Kashmir.

Activity 2

Study this complex section and create your own diagram to illustrate how the earthquake occurred.

Figure 6 Affected area and comparison with UK



The initial earthquake caused a 300-km surface rupture, making it one of the longest inland ruptures globally, comparable to the 1906 San Andreas Fault earthquake. Along with the transform movement, there was vertical displacement, reaching a maximum of 11.4 m at the eastern end. The second earthquake on that day resulted in an additional 125 km of rupture. Overall, the causes of the earthquake were the result of highly complex plate movements that proved exceptionally challenging to predict.

Geological Effects

Liquefaction, a secondary hazard, occurred in former lake beds, river valleys, and coastal areas, primarily at the southern end of the East Anatolian Fault. This led to ground failure, specifically lateral spreading, caused by liquefaction. Coastal areas and ports experienced widespread damage due to this phenomenon. Large residential areas, Hatay airport, and canals were extensively affected, resulting in flooding. In Iskenderun, located on the coast, a seawater incursion of up to 200 m inland may have been caused by rupture subsidence, powerful waves from stormy weather, and a minor tsunami measuring 0.12 m.

Impacts

- The disaster affected nearly 18 million people in Turkey and Syria, resulting in approximately 55,000 deaths and 130,000 injuries. This earthquake ranks as the fifth deadliest of the century **(Table 2)**.
- Millions of people were displaced, with 2.6 million accommodated in tent cities and another 1.6 million residing on the streets outside their damaged, unsanitary, and unsafe homes.
- Around 300,000 buildings, including residential apartments, schools, hospitals, and roads, were destroyed or rendered unusable.
- This earthquake ranks as the third costliest of the century **(Table 3)**, accounting for 9% of Turkey's GDP in 2023.
- While the focus of destruction was on urban areas, the disruption to roads leading to rural areas devastated agricultural livelihoods and production, resulting in short-term food shortages and long-term disruption to farming incomes.
- Water pipes and sewers were disrupted by the earthquake, increasing the risk of contagious diseases such as cholera, especially considering the living conditions in temporary shelters. Only 1 in 7 health facilities were partially functioning, preventing those with pre-existing conditions from receiving necessary treatment.
- Tens of thousands of survivors were traumatised by the disaster, dealing with the loss of loved ones, homes, and livelihoods. Long-term investment in mental health services will be required for individuals to recover.
- In the affected area, 5.4 million children are at risk of developing anxiety, depression, and post-traumatic stress syndrome. These challenges come on top of the two years of impacts and restrictions caused by the COVID-19 pandemic.

Table 2 Largest death tolls from earthquakes in the 21st century

Rank	Deaths	Magnitude	Event	Date
1	230,000	9.1–9.3	2004 Indian Ocean earthquake and tsunami	26 Dec 2004
2	160,000	7.0	2010 Haiti earthquake	12 Jan 2010
3	88,000	7.9	2008 Sichuan earthquake	12 May 2008
4	88,000	7.6	2005 Kashmir earthquake	8 Oct 2005
5	55,000	7.8	2023 Turkey–Syria earthquake	6 Feb 2023
6	34,000	6.6	2003 Bam earthquake	26 Dec 2003
7	20,000	7.7	2001 Gujarat earthquake	26 Jan 2001
8	20,000	9.0–9.1	2011 Tōhoku earthquake and tsunami	11 Mar 2011
9	9,000	7.8	2015 Nepal earthquake	25 Apr 2015
10	6,000	6.4	2006 Yogyakarta earthquake	26 May 2006

Quick Question 1

To what extent are the numbers killed related to magnitude?

Table 3 Costliest earthquakes due to damage in 21st century

	Cost $ billion	MW	Place	Date
1	$360	9.0–9.1	2011 Tōhoku earthquake and tsunami	March 11, 2011
2	$150	7.9	2008 Sichuan earthquake	May 12, 2008
3	$119	7.8	2023 Turkey-Syria earthquake	February 6, 2023
4	$40 together	7.0	2010 Canterbury earthquake	September 4, 2010
		6.3	2011 Christchurch earthquake	February 22, 2011
5	$28	6.8	2004 Chūetsu earthquake	October 23, 2004

Quick Question 2

What factors influence the economic costs of earthquake events? *Hint: Magnitude is only one factor.*

Factors Affecting the Scale of the Disaster

The scale of the disaster and the effectiveness of the response were influenced by various factors, both physical and human. The conditions at the time of the earthquake in both countries were exceptionally unfavourable:

- The population affected by the earthquake was already highly vulnerable due to the ongoing civil war in Syria. Millions of people had been displaced, enduring poverty as a consequence.
- The political system in the affected region exhibited corruption, resulting in the disregard of building standards in a known high-risk area.
- The earthquake occurred during the depths of winter across an international boundary, and coincided with a period of significant inflation in the global economy.

Winter weather

At the time of the earthquake, February temperatures were 5–10°C lower than the average. A high-pressure system over Europe prevented warm westerly airflow and trapped cold air over the Middle East. Consequently, clear daytime skies led to extremely cold nights. Survivors were reluctant to reenter still-standing buildings and instead stayed outside during the nights. In March 2023, heavy rainfall caused floods that destroyed temporary shelters like tents and cars **(Figure 7)**.

Time of day

The earthquake struck at 04:17, when the majority of the population was asleep. This factor significantly contributed to the high death toll. However, it is believed that individuals who were kept warm under duvets managed to survive for several days before being rescued.

Figure 7 Flooded camp in NW Syria, March 2023

Large child population

The region affected by the earthquake has a substantial young population, with 2.5 million children now facing increased risks such as poverty, limited access to education, child labour, family separation, and forced child marriage. The earthquake and its aftermath have created a need for humanitarian aid. Prior to the earthquake, there were 130,000 pregnant women in the affected region. Within the first month following the disaster, 14,000 births were registered, with the number rising to 24,000 after two months. Approximately 47% of Syrian refugees in the region are under the age of 18, and over a third of them lack access to education. Children are now particularly vulnerable to waterborne diseases like cholera and hepatitis, as well as hypothermia due to lack of shelter.

Syrian civil war since 2011

Turkey and Syria share a long land border, and as a result of the civil war that began in 2011, around 3.6 million Syrians now reside in southeastern Turkey, making it the largest host country for refugees globally. Rather than alleviating the impact of the civil war on the population, the natural disaster has worsened living conditions. The earthquake-affected northwestern Syrian region is also home to 3 million internally displaced refugees living in substandard accommodation, including tents and fragile buildings. Having already fled their homes in Syria and endured the challenges of the pandemic, these millions of people are highly vulnerable in the aftermath of the earthquake, with limited resilience and scarce resources to rely on. Only 5% of refugees live in camps, while the majority reside in towns and villages. This does not guarantee a higher standard of living or better prospects. Approximately 15.3 million Syrians require humanitarian assistance, with 90% of them living below the poverty line and experiencing increasing deprivation. Some refugees have been forced to return to Syria due to the high cost of living away from home. Following the disaster, house rents in Turkey increased by 16% nationally, 45% in Gaziantep, and 25% in Hatay province.

Civil society in the affected region has gradually weakened over time due to authoritarian rule and ongoing conflict. Corruption, lack of accountability, and political factors further contributed to the high death toll and hindered the response to the earthquake. The earthquake-affected area in Syria is currently under rebel control, and there was no agreement between the rebels and the Assad government regarding the delivery of aid.

Opposition factions, including the Kurdish-led Syrian Democratic Forces and various other armed groups, were accused of impeding the flow of aid. These factions were accused of impeding the flow of aid through theft and the black market selling of aid.

They refused to allow aid to enter if it originated from government-controlled areas. The government, on the other hand, insisted that aid should be directed through Damascus and then its controlled areas, as it perceived direct aid into the affected region as diminishing its chances of regaining control. Reports also indicated that Iran took advantage of the chaotic situation to smuggle advanced weapons into Syria in support of the Assad government.

Prior to the civil war, Aleppo served as Syria's commercial hub. However, in the northern provinces of Idlib and Aleppo, the last areas under rebel control and arguably the least prepared to withstand the impact of the earthquake, there are now more than 1,800 makeshift camps and shelters. These are currently housing 250,000 newly displaced people, in addition to those who were already living in such conditions due to the civil war.

The consequences of the earthquake were reminiscent of the bombing and shelling endured in the previous decade, resulting in collapsed buildings and family members trapped under rubble, while losing all their possessions. The preexisting camps quickly became overcrowded with displaced individuals, and there was a scarcity of available tents. These relief points were ill-equipped to respond to the unexpected disaster and the overwhelming demand for assistance. Hospitals were unable to accommodate the injured, and families lost contact with each other. There was a shortage of burial resources, leading to the necessity of digging mass graves, further distressing the survivors.

Transboundary issues

Prior to the earthquake, there was only one functioning route along the Turkish-Syrian border for humanitarian assistance. This route was damaged, causing a delay of three days before aid could be brought into Syria from Turkey. One week later, two additional local border crossings were opened. Throughout the civil war, Syria has heavily relied on Turkey for aid and trade, but the earthquake created a crisis for both countries. Due to inadequate equipment and rescue personnel, food supplies from Turkey were temporarily halted.

International response

The United Nations (UN) and non-governmental organisations (NGOs), such as the White Helmets, played a leading role in the disaster response, in collaboration with national and local groups. Aid and assistance were provided by 60 countries, with 2,600 foreign personnel participating in the international rescue efforts. However, the UN's appeal for funds faced challenges, as it was slow and fell 50% short of its target of $400 million for Syria. This shortfall aligns with the declining trend of donor contributions for preexisting humanitarian aid. The UN itself released $50 million in emergency funding and set a target of $1 billion for Turkey and $400 million for Syria. In March 2023, the European Union (EU) pledged $7.5 billion for reconstruction, although estimates indicate that this is only a tenth of the required amount.

Since 2011, Syria has been expelled from the Arab League, and many nations have imposed trade sanctions. However, humanitarian exemptions were made immediately after the earthquake. Four days after the earthquake, the United States temporarily lifted sanctions against Syria to facilitate the delivery of aid. The European Investment Bank reversed its previous policy of not providing funding for Turkey. Although the EU has not had diplomatic relations with Syria since the start of the war, it offered $120 million for humanitarian assistance.

What are the greatest challenges to recovery?

- Long-term displacement
- Reconstruction of homes and infrastructure
- More than 90 percent of Syrian refugees depend on humanitarian assistance for survival
- Economic decline and global inflation – Syria has experienced a price increase of over 800 percent in the last two years, resulting in an estimated 12.1 million people facing food insecurity
- The economic downturn has heightened the risk of child labour, gender-based violence, early marriage, and other forms of exploitation
- COVID-19 – overcrowded conditions in refugee camps make it difficult to implement public health measures such as frequent hand washing and physical distancing
- The war in Ukraine has impacted food supplies

Wider Issues for the Future

Turkish politics

President Erdogan rose to power following the 1999 Izmit earthquake, which claimed the lives of 17,000 people. He pledged to bring about economic and social transformation and increase Turkey's resilience to natural disasters. He introduced a tax for post-disaster recovery, raising $3.8 billion to date, and established AFAD (Disaster and Emergency Management Authority), akin to FEMA in the United States. Despite a construction boom in the last two decades, there are concerns regarding the effective utilisation of these funds **(Figure 8)**, as evidence suggests widespread disregard for building regulations.

Criticism has been directed at Erdogan for the nation's slow response to the earthquake, leading to a weakening of his support in the southern regions as survivors endured harsh conditions without adequate assistance. The May 2023 elections presented an opportunity to assess his leadership. Erdogan, known as a populist leader who appointed loyalists rather than professionals to key positions, faced arguments that AFAD was severely underfunded, with funds being diverted towards prestige projects. Nevertheless, Erdogan was reelected after a close-run second ballot in May 2023, with supporters recognising his growing role on the international stage while the opposition blame him for soaring inflation and corruption.

Figure 8 Collapsed buildings in Turkey

Quick Question 3

What does the photo suggest about the nature of these buildings and their contribution to the scale of the disaster?

Dam security

Although there were no reports of dam damage resulting from the earthquake, Turkey's 579 dams drew international attention due to the absence of safety legislation and unknown structural integrity. The downstream countries of Syria and Iraq are highly vulnerable to floods in the event of a dam burst, yet they lack the political and financial leverage to hold Turkey accountable. Such an event would significantly overshadow the current humanitarian crisis. Within the affected area, there are 110 dams, including the Ataturk Dam, one of the world's largest. While officials reported no damage, images of cracks and accounts of emergency water releases to alleviate strain on the dams circulated on social media.

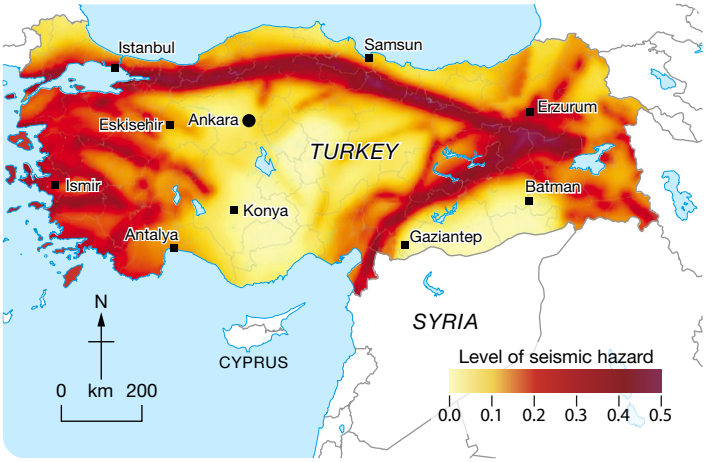
Nuclear facility

At the time of writing, Turkey is constructing a nuclear power station at Akkuyu on the south coast, an area prone to earthquakes. A potential meltdown at the facility would endanger the entire southeastern Mediterranean region, prompting calls to halt construction and engage in consultations with Greece and Cyprus.

The Future Threat

AFAD's hazard map published in 2018 clearly illustrates the areas in Turkey where future earthquakes might be expected **(Figure 9)**. It is important to note that this map does not take into account population density, construction patterns, or economic factors, thus serving as a hazard map rather than a risk map. Despite awareness of the major East Anatolian Fault, the occurrence of the earthquake surprised many due to the prevailing focus on the North Anatolian Fault and the precarious situation of Istanbul, a city with a population of 16 million.

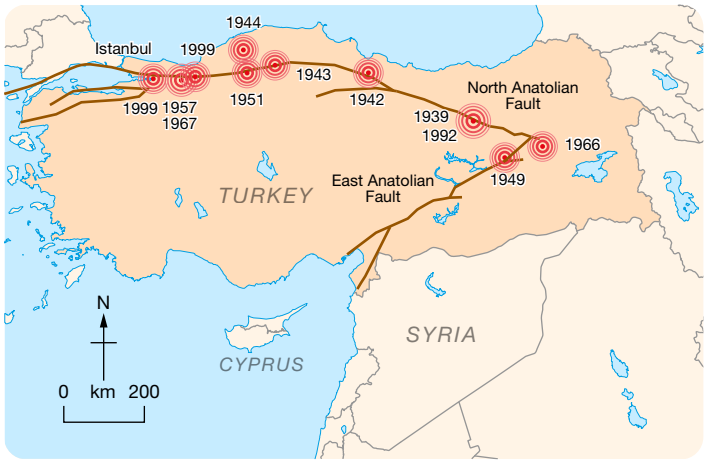
Figure 9 Seismic hazard map of Turkey



In the past century, there have been 11 significant earthquakes along the North Anatolian Fault, typically progressing from east to west. It is widely accepted that Istanbul, situated at the western end of the fault, will inevitably face a major catastrophe. According to the seismic gap theory, segments of a fault that have remained inactive for an extended period are bound to fail eventually. Stress accumulates along the fault, and when it is released at a specific point, it continues to propagate along the fault line.

Figure 10 illustrates the chronological pathway of major earthquakes along the North Anatolian Fault from east to west, highlighting why people have come to accept the inevitability of a disaster in Istanbul, even though the timing cannot be predicted.

Figure 10 Earthquakes along the North Anatolian Fault



Istanbul, with a current population of nearly 16 million and an expected growth to 18 million within the next ten years, is faced with significant seismic risks. The city's ancient buildings pose challenges as retrofitting them against seismic events is not always feasible. The rapid and continuous growth of Istanbul, coupled with experiences from other regions, raises concerns about the diligent application of building codes. Some argue that, given its geographical location, no level of preparedness can completely mitigate the impact of a strong earthquake.

Activity 3

Research the following **Geography Factsheets**:

- 285. Haiti Earthquake 2010
- 336. Nepal "Gorkha" Earthquake, 25th April 2015
- 377. Kaikoura Earthquake – One Year On

Then put the Turkey-Syria earthquake in context to compare the severity of impact and the efficiency of the rescue effort in the two countries affected.

References and Further Research

- **British Red Cross** The latest news on the earthquakes in Türkiye (Turkey) and Syria
  https://www.redcross.org.uk/stories/disasters-and-emergencies/world/turkey-syria-earthquake
- **Earthquake Hazards Program** Frequently Asked Questions about 2023 Earthquakes in Türkiye
  https://www.usgs.gov/programs/earthquake-hazards/science/frequently-asked-questions-about-2023-earthquakes-turkiye
- **OCHA** (Türkiye: 2023 Earthquakes Situation Report No. 16, as of 27 April 2023
  https://reliefweb.int/report/turkiye/turkiye-2023-earthquakes-situation-report-no-16-27-april-2023
- **USGS** (The 2023 Kahramanmaraş, Turkey, Earthquake Sequence
  https://earthquake.usgs.gov/storymap/index-turkey2023.html
- **The World Bank** Earthquake Damage in Türkiye Estimated to Exceed $34 billion: World Bank Disaster Assessment Report
  https://www.worldbank.org/en/news/press-release/2023/02/27/earthquake-damage-in-turkiye-estimated-to-exceed-34-billion-world-bank-disaster-assessment-report
- **World Vision** 2023 Turkey and Syria earthquake: Facts, FAQs, and how to help
  https://www.worldvision.org/disaster-relief-news-stories/2023-turkey-and-syria-earthquake-faqs

Exam Style Question

Evaluate the intrinsic and extrinsic factors that contributed to the Turkey-Syria earthquake becoming a mega disaster.

[25 marks]

Answers to Quick Questions

1 Key to this question is a discussion of what role magnitude played in the number of deaths and what other factors had a significant part:

- In **Table 2**, the magnitude (Mw) does not correlate exactly with the death toll and so other factors need to be assessed for their importance.
- Magnitude will determine the actual force of impact and to some extent the degree of destruction, as well as the areal extent.
- Other physical factors that are very important are the depth of focus of the earthquake – shallower earthquakes are more destructive because the release of energy reaches the earth's surface faster and is not absorbed within the crust – and time of day.
- Human factors that increase people's vulnerability include age and density of population, quality of housing, degree of preparation and governance.

2

- Economic costs will include the loss of buildings, infrastructure like roads and rail, and impact on the workforce.
- Magnitude controls the area affected and the degree of earth shaking, leading to the collapse of buildings. When an earthquake hits any built-up area, industrial or residential, there will be costs of reconstruction, although it offers an opportunity to "build back better".
- Disruption of transport links will delay materials in and out of the area and the workforce may be killed or injured, requiring new people to be trained, lowering productivity in the short term and adding to the economic cost.
- Disruption of supply chains can increase costs to businesses and individuals. The economic development of a country will determine the degree of preparation for an earthquake event and resources that are made available in recovery and reconstruction.
- Richer countries can recover and even improve their economic base in a faster time than less developed nations. Governance also plays a part in this as well-governed countries have efficient and transparent supply lines.
- Corruption and diversion of international aid to political groups is well-documented in some past earthquake events.

3

- The collapsed buildings suggest that building codes for a known earthquake risk region were not followed.
- Poor materials may have been used in order to build quickly and cheaply, but signed off by corrupt officials.
- Rubble fell across roads, blocking access by rescuers.
- People did not have confidence in buildings that remained standing and so stayed out at night in the open, risking hypothermia.
- Water and sanitation services were disrupted and so health issues arose.

Marking Guidance for Exam Style Question

AO1 (5 marks): The answer should include an outline of the following ideas:

- Mega disaster definition – magnitude, areal extent, existing major fault lines, international border issues, death toll, homelessness, economic losses.
- The scale used to measure the magnitude of earthquakes.
- Physical factors that contributed to magnitude – depth, timing, position on East Anatolian Fault, spatial extent.

AO2 (10 marks): Explain how intrinsic and extrinsic factors combined to produce the scale of this disaster. Use Degg's model or PAR model to give a structure for the following factors:

Intrinsic factors

- Destructiveness of transform (strike-slip) faults.
- Shallow earthquakes are more destructive as more energy reaches the surface than is absorbed within the crust.
- Night time meant people did not leave their building at the first moment of danger.
- Whilst no earthquake can be predicted, all attention had been on the North Anatolian Fault and the westward progression or earthquakes towards Istanbul in the last 100 years.
- Spatial extent – length of rupture, area and major cities affected.

Extrinsic factors

- First responders were survivors who dug by hand to find relatives. White Helmets and international groups arrived within two days.
- Young population in SE Turkey now losing out on education, exposed to health issues and brought into poverty by the earthquake.
- Millions of displaced people due to Syrian Civil War in both NW Syria (rebel-controlled) and Turkey – largest refugee donor country in the world.
- Distrust between Syrian Government and rebels led to a lack of aid getting into Syria in the first few days.
- Only one border crossing open at the time of the earthquake – two more opened within a week.
- Turkey had been supporting Syrians around Aleppo but when the disaster struck, restricted resources went firstly to its own population.
- International aid – while it was a huge humanitarian disaster, other countries were reluctant to give aid to Assad's regime and the UN has not met its donation target.

AO3 (10 marks): Evaluate (state their relative importance) the role of the factors above played in the disaster. Come to a conclusion as to whether the intrinsic (physical) or extrinsic (human) factors played the most important part in the scale of the disaster, with supporting evidence.

Acknowledgements: *This* ***Geography Factsheet*** *was written and researched by* ***Dr Debbie Milton****, an author and senior examiner. This* ***Factsheet*** *was published in* ***September 2023*** *by* ***Curriculum Press. Geography Factsheets*** *may be copied free of charge by teaching staff or students, provided that their school is a registered subscriber. No part of these Factsheets may be reproduced, stored in a retrieval system, or transmitted, in any other form or by any other means, without the prior permission of the publisher.*