Report on 30th October, 2020 earthquake in Turkey

Introduction: On October 30, when a powerful magnitude 7.0 earthquake struck under the Aegean Sea, dozens of buildings collapsed and water rushed into the streets of the coastal city of Izmir, Turkey, and on the island of Samos, Greece. At least 14 people have died and more than 400 were injured. This region is no stranger to earthquakes, with a written record of tectonic destruction stretching back centuries. But while many earthquake-prone places around the world can trace their seismic activity to the meeting of just two main tectonic plates, the situation is far messier around the Aegean. The source of all the shaking is instead a complicated geologic jigsaw that makes up the area, cut through with a web of faults. "This is definitely one of the most complex regions in the world," says Joao Duarte, a marine geologist from the Institute Dom Luiz at the University of Lisbon (Konatania Makra, 2020).

Causes of Major Attack: The tectonic complexity behind these events makes it even more challenging to understand hazards in the region, says Laura Gregory, an earthquake researcher at the University of Leeds in the U.K. "There isn't one big fault that we can focus on, but instead many faults located over a huge area, most of which could cause a devastating earthquake like today's (WEI-HAAS, OCTOBER 30, 2020)

The complex geology of the region makes it difficult to study and predict its hazards, University of Leeds earthquake researcher Laura Gregory tells. "There isn't one big fault that we can focus on, but instead many faults located over a huge area, most of which could cause a devastating earthquake," like the one on October 30, says Gregory through direct messages to *National Geographic* on Twitter. (Isil Sariyuce, 2020)The many shifting tectonic plates and other seismic forces at play prime the region for frequent earthquakes. A temblor with an estimated magnitude of 7 previously struck near the city of Izmir back in 1688. That quake shifted the landscape so much that the surface dropped by more than a foot, and the shaking toppled buildings and ignited fires—killing up to 16,000 people.

In 1903, a magnitude 8.2 earthquake struck near the Greek island of Kythira, representing one of the largest Mediterranean quakes recorded by modern seismic instruments. And between 1993 and 1999, multiple devastating quakes greater than magnitude 7.0 struck along the northern zone of the Anatolian plate, the main tectonic segment that lies under Turkey.

Geologically speaking, this region is wedged between the zone where the African, Eurasian, and Arabian plates meet up. To the east of the Aegean, the Arabian plate collides with the Eurasian plate, shoving up a series of mountains including the Zagros, a range that runs through Iran, Iraq, and Turkey. The colliding plates also send the Anatolian plate westward, as if it "is being pushed out like a watermelon seed between two fingers," says Robert Stern, a tectonics expert at the University of Texas at Dallas.

The latest earthquake struck roughly 13 miles beneath the Aegean seafloor, some nine miles off the shore of Samos. This relatively shallow depth meant that strong shaking was felt on both the Greek island and in cities along the Turkish coast. The epicenter sits at the western edge of the

Anatolian plate, where the rocks at the surface are being stretched like putty. This stretching produces a series of deep fractures in the ground, and movement along one of these cracks set off the recent temblor.

The reason this region is stretching apart like this "is highly debated," Ezgi Karasozen, a seismologist at the Alaska Earthquake Center whose doctoral research focused on earthquakes in Iran and Turkey, says via email. There is likely some combination of three main forces behind the extension, she notes. One source comes from the watermelon seed effect, which causes what Karasozen calls "escape tectonics." As the larger Arabian and Eurasian plates shift around the Anatolian plate, the crustal rock gets shoved and squeezed.

Another major source of stretching is known as slab rollback, which occurs when one tectonic plate curls down under another and into the mantle, Robin Lacassin of the Institut de Physique du Globe de Paris says by direct message on Twitter. You can envision slab rollback by placing your left hand flat on top of your right and slowly curling the fingers of your right hand—that's the slab dropping back and down into the deep.

This movement tugs at the overlying plate, and the resulting stretching is called "slab suction," Duarte says, because the underlying plate essentially sucks at the surface rocks. This process happens as the African plate dives under the western half of the Anatolian plate, under the Aegean Sea. Another likely force at play could be a fairly simple one: gravity. The center of the Anatolian plate is thick, which means "everything wants to kind of sink down and expand around the edges," Gregory says.

Scientists are now puzzling over this latest event, which is unusually large for the region where it struck, Karasozen says. As teams monitor for aftershocks, which continue to rumble through, the data promises to help future scientists better understand the hazards woven into the region's wild tectonics. Only by studying both past and current events can scientists hope to improve their understanding of the risks around the Aegean and potentially, one day, forecast the quakes of the future.

Impacts of Earthquake (BBC, 2020)**:**

October 30, a 7.0 magnitude earthquake struck the eastern Aegean Sea between Turkey and Greece. The tremblor shook Izmir, Turkey, where it severely damaged 20 buildings. As of Monday, the death toll reached 91, including two teenagers in Greece (Jazeerah, 2020).

Greece and western Turkey sit above a complicated convergence of chunks of Earth's crust called tectonic plates. Four plates meet under the Aegean Sea, putting immense pressure on the plate directly below Turkey, Maya Wei-Haas reports for *National Geographic*. That makes the region one of the most geologically active in the world. It's seen at least 29 earthquakes with magnitudes above 6.0 in the last century (Arvin, 2nd November, 2020). Last week's earthquake has caused more than 900 aftershocks, 42 of which had a magnitude above 4.0 (Isil Sariyuce, 2020). When two massive slabs of Earth's crust push, pull or slide against each other suddenly, earthquakes shake the surface. Modern buildings in earthquake-prone areas make use of construction techniques like base isolation to prepare for the natural disasters. In base isolation, the floor of a building is separated from its foundation, connected by strong but flexible isolators that allow the ground to shift underneath while the building wobbles above. But Izmir has many older buildings that aren't equipped for quakes, the (Times, Oct. 31, 2020) reports.

Figure: Collapse of a building

Turkey's last earthquake of this scale happened in January, when a magnitude-6.8 earthquake killed more than 30 people in the eastern Elazig and Malatya provinces, BBC News reported at the time.

The region is so active because a trio of colliding plates are squeezing the Anatolian plate westward, almost like it "is being pushed out like a watermelon seed between two fingers," University of Texas at Dallas tectonics expert Robert Stern tells *National Geographic*. At the same time, the African plate is diving below the western half of the Anatolian plate. That creates "slab suction," University of Lisbon marine geologist Joao Duarte tells *National Geographic*. As one plate dips into the mantle, it drags everything above it along for the ride.

Figure: Emergency rescue operation

Rescue teams are still searching for survivors in the rubble. One man, Oguz Demirkapi, was rescued after spending 30 minutes under 12 feet of debris, per the *Times*. He was in his third-floor apartment when the earthquake started, and he survived by curling up in a corner of the room while the building crumbled. Teams have also rescued a 70-year-old man after 34 hours under rubble, a three-year-old girl after more than 60 hours.

Murat Boz, who leads a civilian search and rescue team, tells the rescue efforts would continue "nonstop, without a break, for 24 hours, day and night."

What cause building Collapse (TEMBLOR, 2020)**:** At that time in Turkey, 4% of the city's buildings were affected — six collapsing completely. The cause for these losses appears to stem from three elements: strong amplification of shaking throughout the basin in which Izmir sits, poor code compliance and inadequate construction inspections that prevailed in the 1990's when many of these heavily damaged and collapsed buildings were constructed.

Figure: Vertically damage of a building

The city of İzmir is located around the Inner İzmir Bay. Inner İzmir Bay is an actively growing shallow marine basin controlled by active E-W trending extensional ('normal') faults in the Aegean Extensional Province. The young (Holocene) alluvium and fan-delta to shallow marine deposits, confined and controlled by the İzmir Fault to the south and the Karşıyaka-Bornova fault to the north, constitute the uppermost sediments in the basin. The fault lines indicated on Figures 1 and 3 are taken from the fault maps prepared by the General Directorate of Mineral Research and Exploration. The soft sediments and basin structure itself played a large role in amplifying the shaking.

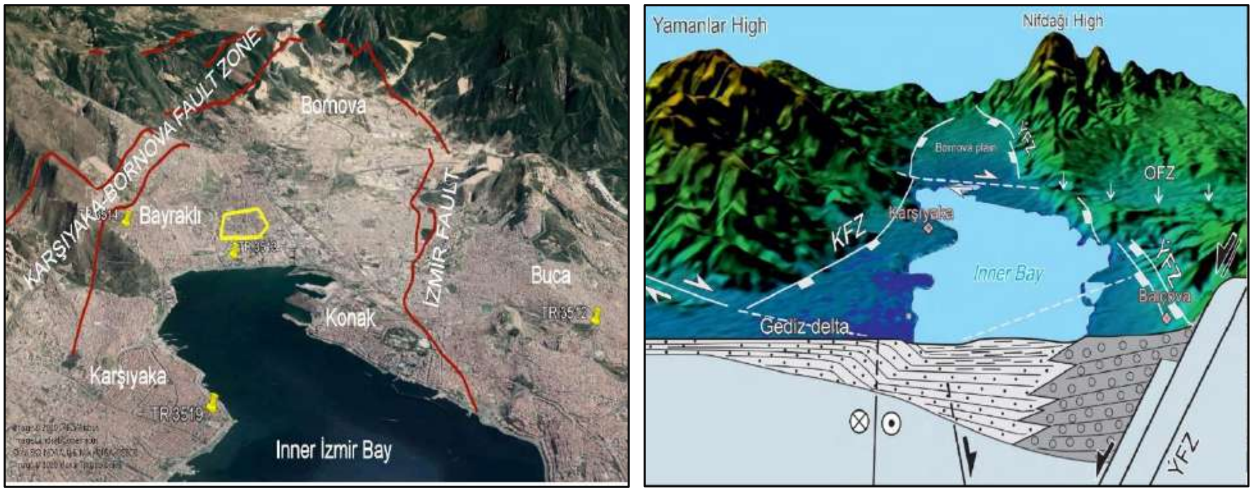

Figure: Izmir city morphology

a. Izmir is built on very soft, young sediments that amplified shaking

The expected amplification of seismic shaking is generally inferred by the average seismic shear wave velocity in the upper 30 m ('Vs30'). A Vs30 map of the Inner İzmir Bay Basin is provided in, after İzmir Earthquake Masterplan. Most of the heavily built areas are located on the soft sediments of the city located in Karşıyaka, Bayraklı, Bornova and Konak districts. The distribution of Vs30 (average shear wave velocity in the upper 30m) map of the Inner İzmir Bay Basin (after İzmir Earthquake Masterplan). The polygon enclosing the collapsed building in Figures 1 and 3 lies in the red zone of highest amplification of the seismic waves. (Jazeerah, 2020)

b. Shaking in Izmir was strong but hardly extreme

The earthquake strong ground motion was recorded by the extensive network of AFAD (Disaster and Emergency Management Presidency). Four of these stations (TR3512, TR3513, TR3414 and TR3519) that were considered for the assessment of basin response, are shown in Figure 1 and Figure 2. The Vs30 values at these stations and the PGA, PGV and the PGD values associated with the ground motion records are provided in Table 1.

Stations TR3512 and TR3514 — located on stiff soil sites outside the basin — have very similar ground motion records to one another. The stations TR3513 and TR3519 are located on soft sediments of the basin have also similar ground motion records. The horizontal 5% damped response spectra of these records and the site-specific design basis response spectra (for 475-year average return period) associated with these station locations are provided in Figure 5 for the N-S direction. The low rise (1-3 stories) and mid-rise (4-9 stories) buildings located in stiff soils were exposed to only a fraction (about 10% and 20%, respectively) of the ground motion level if they were designed to code. However, for buildings located on softer soils of the basin, these percentages respectively increase to 30% and 50% and even higher for taller buildings. It can be inferred that if the earthquake were associated with any one of faults around the basin (Izmir and

Karşıyaka-Bornova Faults), the ground motion level would have exceeded the code-based site-specific design basis response spectra.

c. Basin Effects in İzmir

It is well known that the ground shaking in sedimentary basins is amplified by 2-D and 3-D basin effects and by 1-D soil amplification due to soft soil profiles. The response spectra associated with the stations located on the soft sediments of the Izmir Basin certainly incorporate both the soil amplification (site response) and the basin effects.

The transfer functions of horizontal ground motion between records from stiff soils outside the basin and those from soft soils inside the basin shed light on the amplification of ground motion due to basin and site effects. Such transfer functions can be obtained either by the division of their respective Fourier Spectra or, for earthquake resistant design purposes, by the division of their respective response spectra. As observed in these transfer functions, the period-dependent amplification factors reach about 5 and 3, respectively, for periods of about 1.5 s and 3 s. The amplification factor remains in vicinity of 2 for periods 4 s, 5 s and 6 s. It should be noted that these values are associated with the linear response of the basin sediments. It should be noted that, under higher amplitude ground motions, the amplifications might be lower due to the possible non-linear response of the sediments.

d. Design-Basis Ground Motion for Long Period Structures in Izmir

In addition to site response and basin effects, the design-basis ground motion spectra should also incorporate rupture directivity effects, if any. Fault directivity motions typically occur at sites near the end of a strike-slip fault when the rupture moves towards the site, and at sites located in the up-dip projection of a ruptured dip slip fault (i.e., reverse or normal fault). The radiation pattern of the shear dislocation on the fault causes this large pulse of motion to be oriented in a direction perpendicular to the fault plane. These effects are typically long-period in nature and are observed as large amplitude velocity pulses. The earthquakes associated with the normal faults framing Izmir Inner Bay Basin to the north and south have the capability to produce such rupture directivity effects.

Conclusion: The seismic survey from the Turkish National Geographic Survey shows that there will be more massive earthquake happen in the century. These are mainly tectonically problem. Scientist always predicted for chain earthquake of small size. So, National level preparedness program, building code and emergency situation must be taken for reduce causalities.

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