



GEOLOGY CLASS  
SPRINGS 2019

# MEXICO

## 1985 EARTHQUAKE

NATURAL DISASTERS

BY:

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## Southern Mexico—Earthquakes & tectonics

The 1985 disaster leads to Mexico's earthquake early warning system

### Topics:

- Earthquake dynamics
- Mexico City Basin geology
- Building resonance

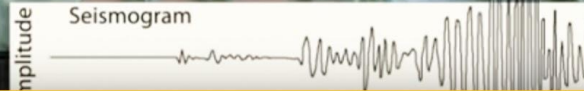
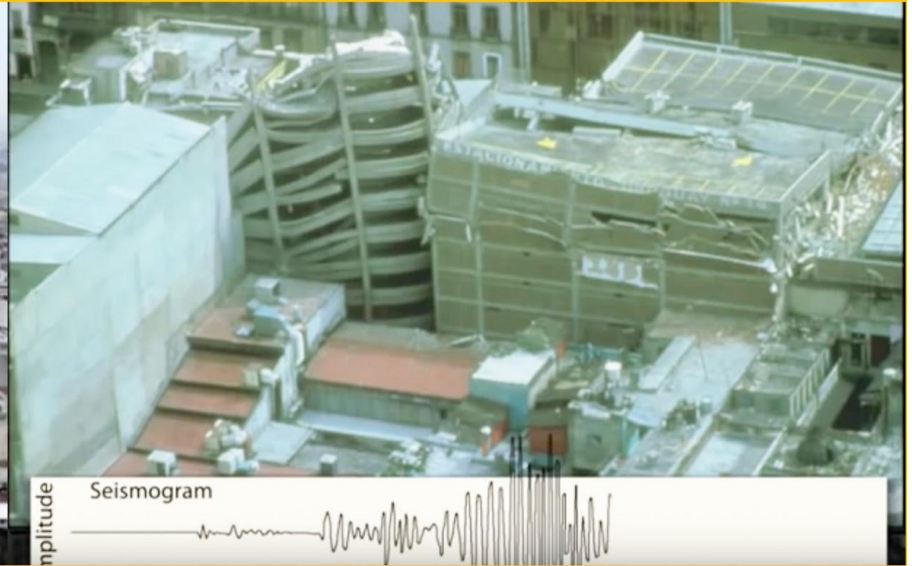
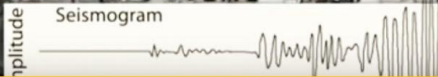


ON SEPTEMBER 19, 1985 A MAGNITUDE 8.1 **SUBDUCTION-ZONE** GREAT EARTHQUAKE OCCURRED BENEATH THE COAST OF MICHOACAN, MEXICO.

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DESPITE THE **350 KMS (217.48 MILES) FROM EARTHQUAKE EPICENTER** TO MEXICO CITY, MOST OF THE 9,500 FATALITIES; **30,000** SERIOUS OCCURRED THERE.

September 19, 1985 Magnitude 8.1 earthquake  
9,500 fatalities; 30,000 serious injuries



THAT QUAKE PROMPTED MEXICO TO BOTH **STRENGTHEN ITS BUILDING CODES** AND TO DEVELOP AN **EARTHQUAKE ALERT SYSTEM** FOR ALL OF SOUTHERN MEXICO.

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TO UNDERSTAND **HOW A SUBDUCTION-ZONE EARTHQUAKES COULD CAUSE SUCH DEVASTATION SO FAR AWAY IN THE MEXICO CITY BASIN,**  
LETS START BY LOOKING AT THE TECTONIC SETTINGS



THE **COCOS PLATE** DIVES BENEATH THE **NORTH AMERICAN PLATE** AT RATES OF 5-7CM/YEAR OFFSHORE OF MICHOACAN, GUERRERO, AND OAXACA. THE **2,700 KM-LONG MIDDLE AMERICA TRENCH** MARKS THE SUBDUCTION BOUNDARY FROM MEXICO TO COSTA RICA.

IN THE PAST **40 YEARS** MEXICO HAD **50 EARTHQUAKES LARGER THAN MAGNITUDE 6 WITH EPICENTERS CONCENTRATED NEAR THE PLATE BOUNDARY.** DURING THAT INTERVAL, A DOZEN MAGNITUDE 7 OR LARGER

# Earthquakes 1973-2014

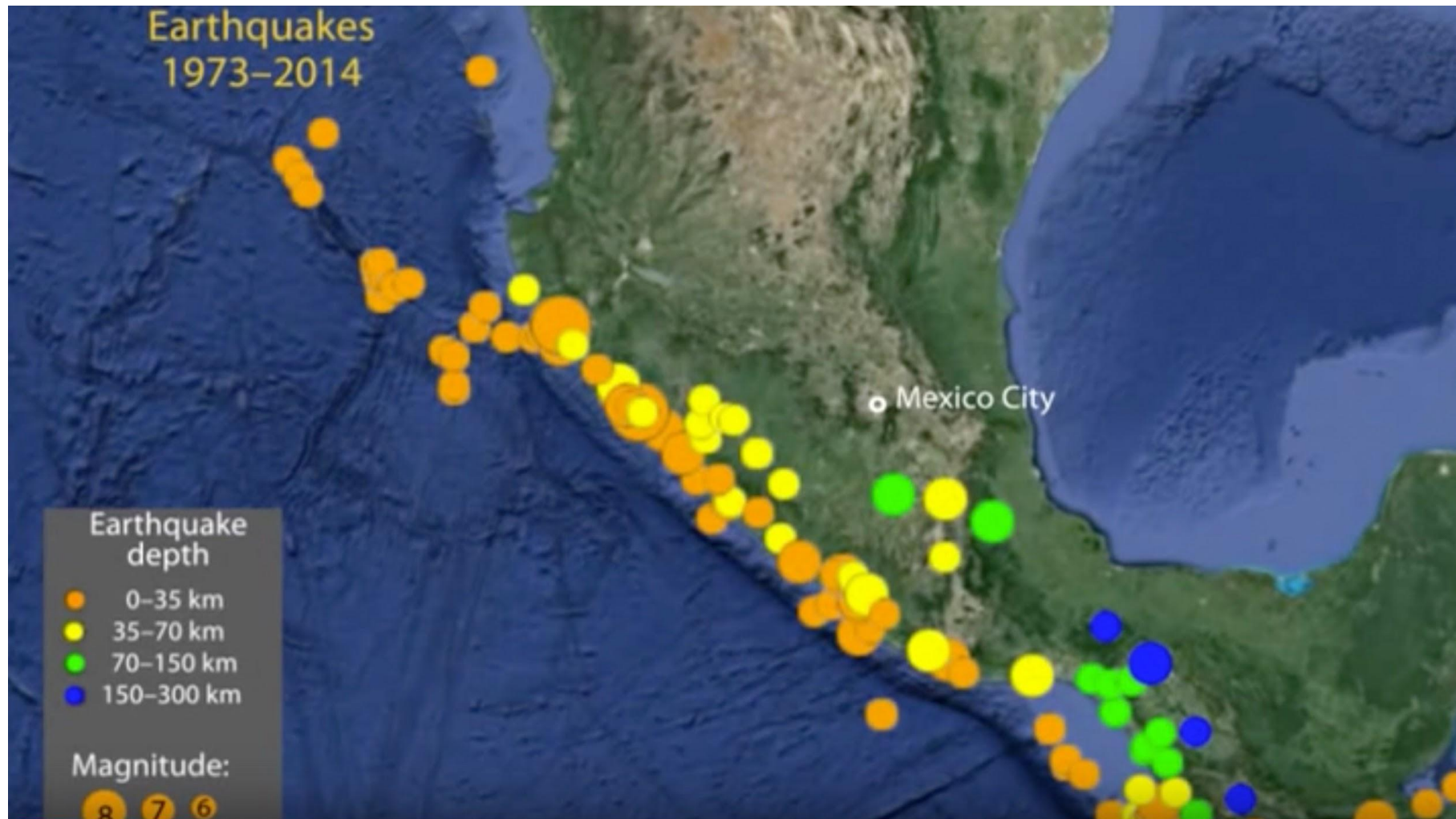
## Earthquake depth

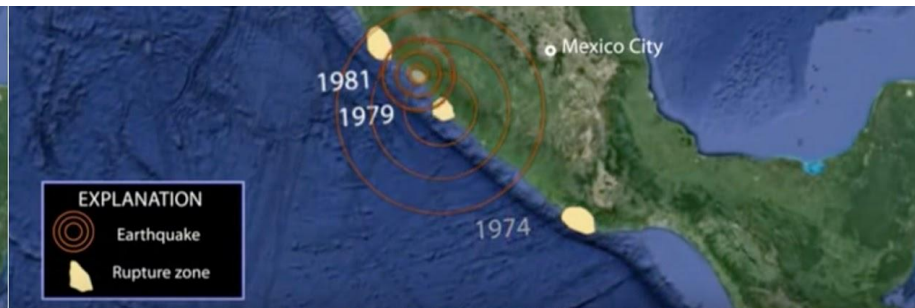
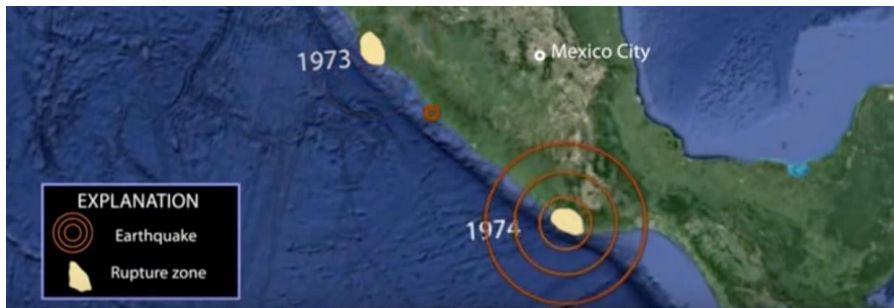
- 0-35 km
- 35-70 km
- 70-150 km
- 150-300 km

## Magnitude:

8 7 6

Mexico City





RED CIRCLES MARK EPICENTERS ABOVE SITE WHERE FAULT RUPTURE BEGAN; YELLOW SHOWS THE RUPTURE AREA.



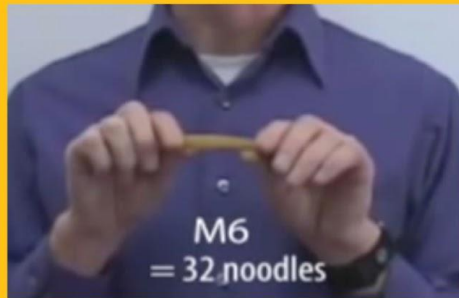
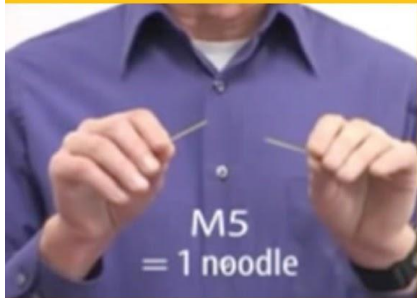


**THE GUERRERO SEISMIC  
GAP IS POTENTIAL HAZARD  
ZONE.**

**HOW CAN WE UNDERSTAND THE RELATIVE ENERGY RELEASED BY A GREAT EARTHQUAKE OF MAGNITUDE 8 OR 9, LIKE THE 1985 EARTHQUAKE, COMPARED TO SMALLER YET STILL DAMAGING EARTHQUAKES?**

**THE ENERGY RELEASED BY EARTHQUAKES INCREASES BY 32X FOR EACH UNIT INCREASE IN MAGNITUDE**

# SPAGUETTI ANALOGY

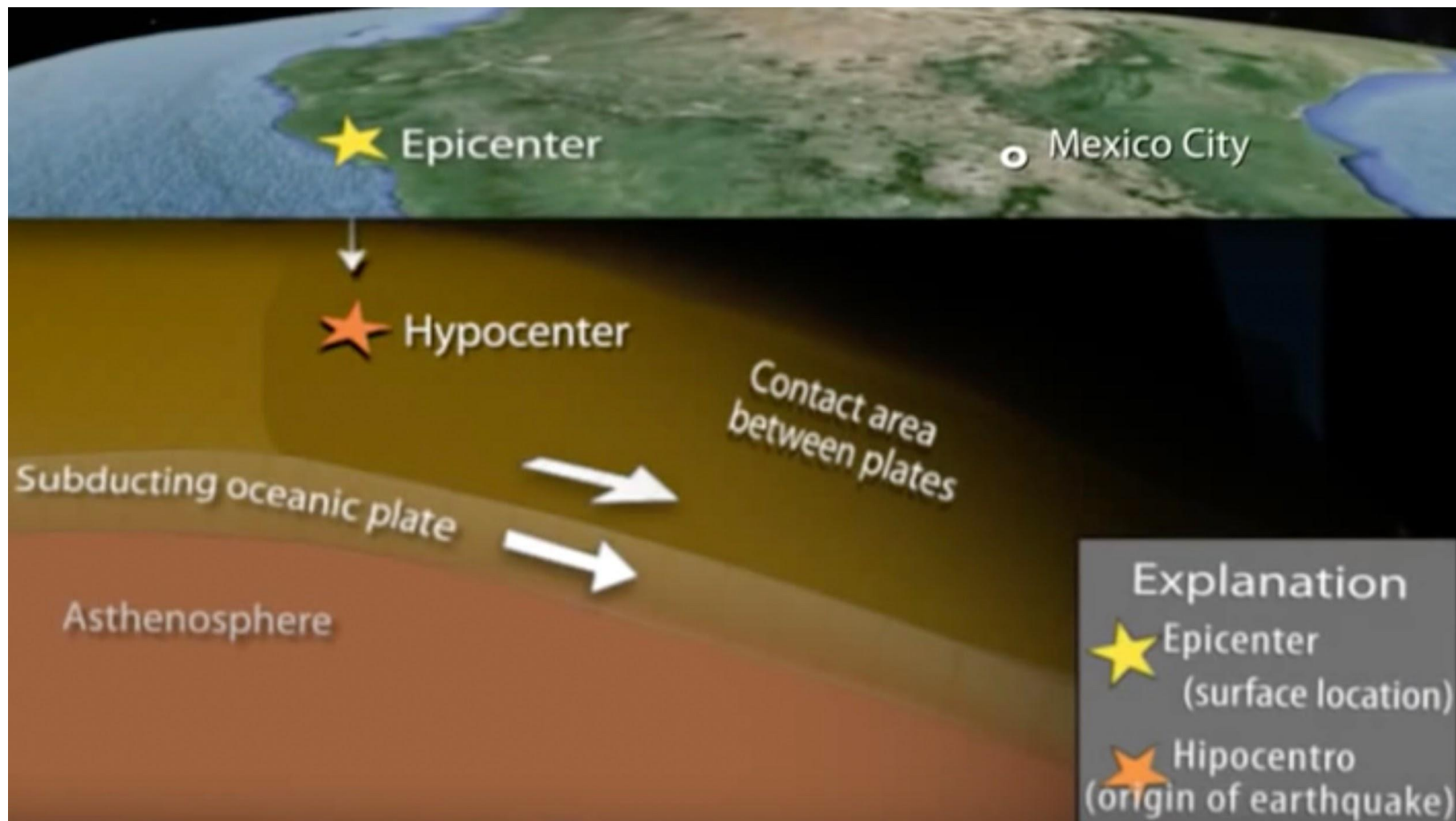


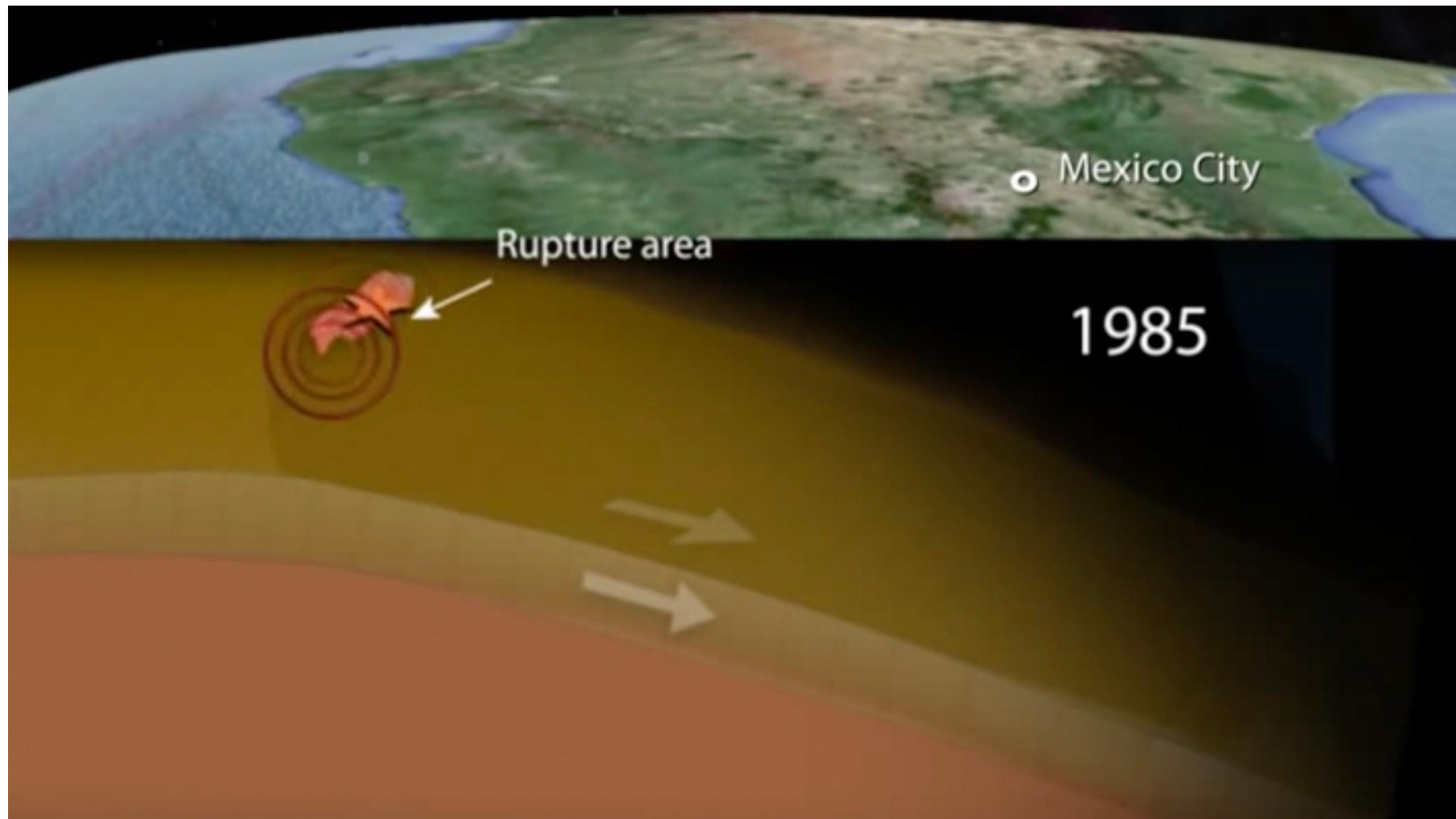
AS AN ANALOGY, IF BREAKING SINGLE STRAND OF SPAGHETTI REPRESENTS A MAGNITUDE 5 EARTHQUAKE, THEN WE NEED TO BREAK 32 TO REPRESENT MAGNITUDE 6. 1,024 STRANDS FOR MAGNITUDE 7, & NEARLY 33,000 NOODLES TO REPRESENT A MAGNITUDE 8. TO REPRESENT ENERGY RELEASED IN A MAGNITUDE 9 EARTHQUAKE, - LIKE JAPAN IN 2011, WE WOULD NEED TO BREAK MORE THAN A MILLION NOODLES! **CHILE 1960 WAS EVEN BIGGER.**

# What happened during the 1985 earthquake?



LET'S ZOOM IN TO VIEW  
THE PLATE INTERACTION





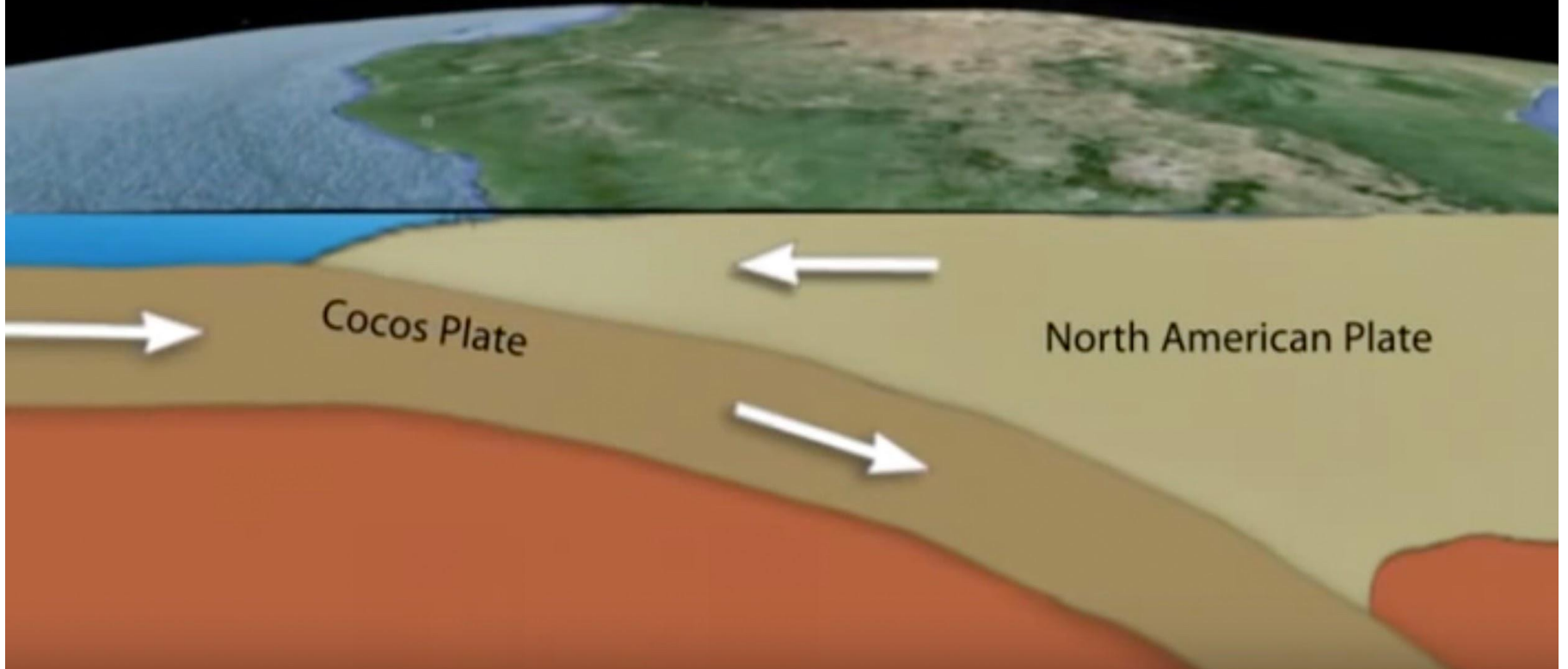
Mexico City

Rupture area

1985

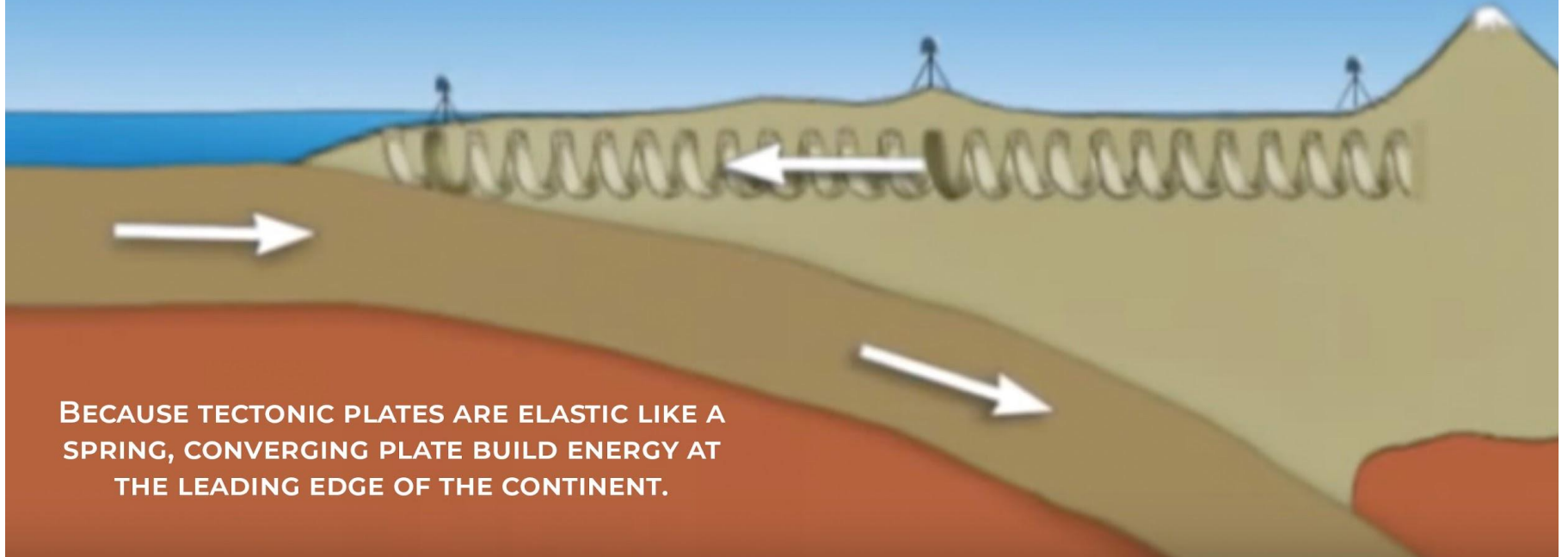
180 km  
(111 mi)

THE DENSE OCEANIC PLATE DIVES BENEATH THE MORE BUOYANT CONTINENTAL PLATE AT A RATE OF ABOUT 6 CM/YR.



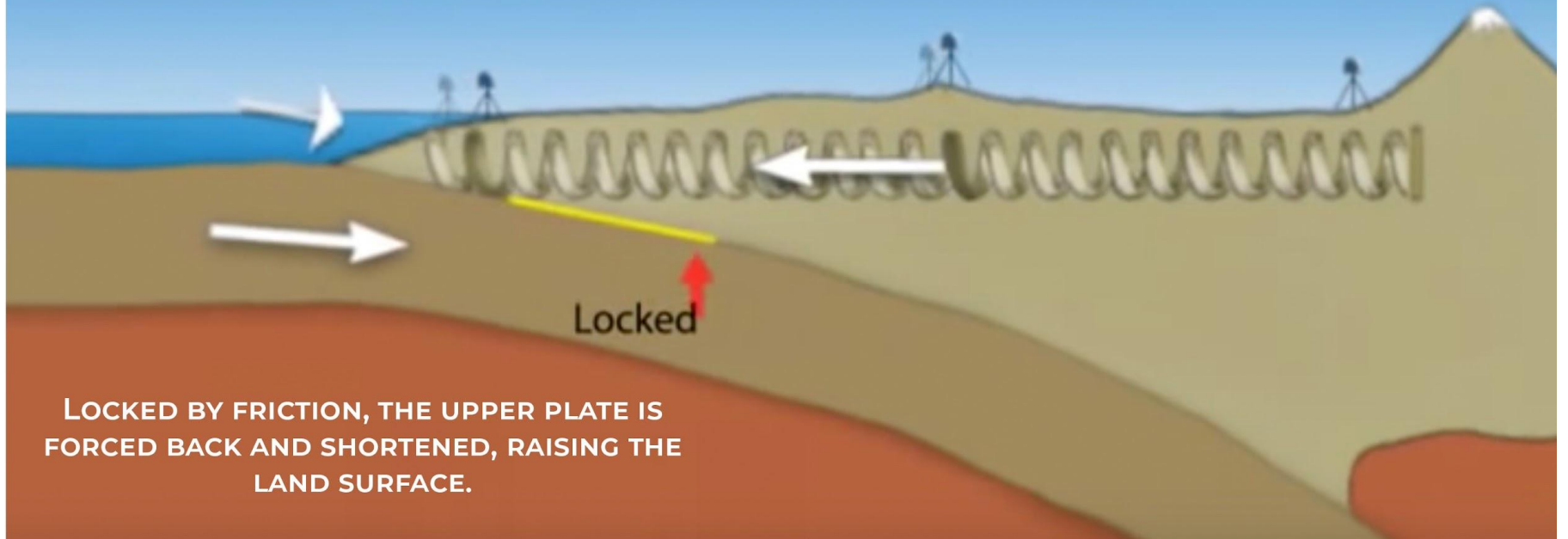


## GPS stations monitor deformation



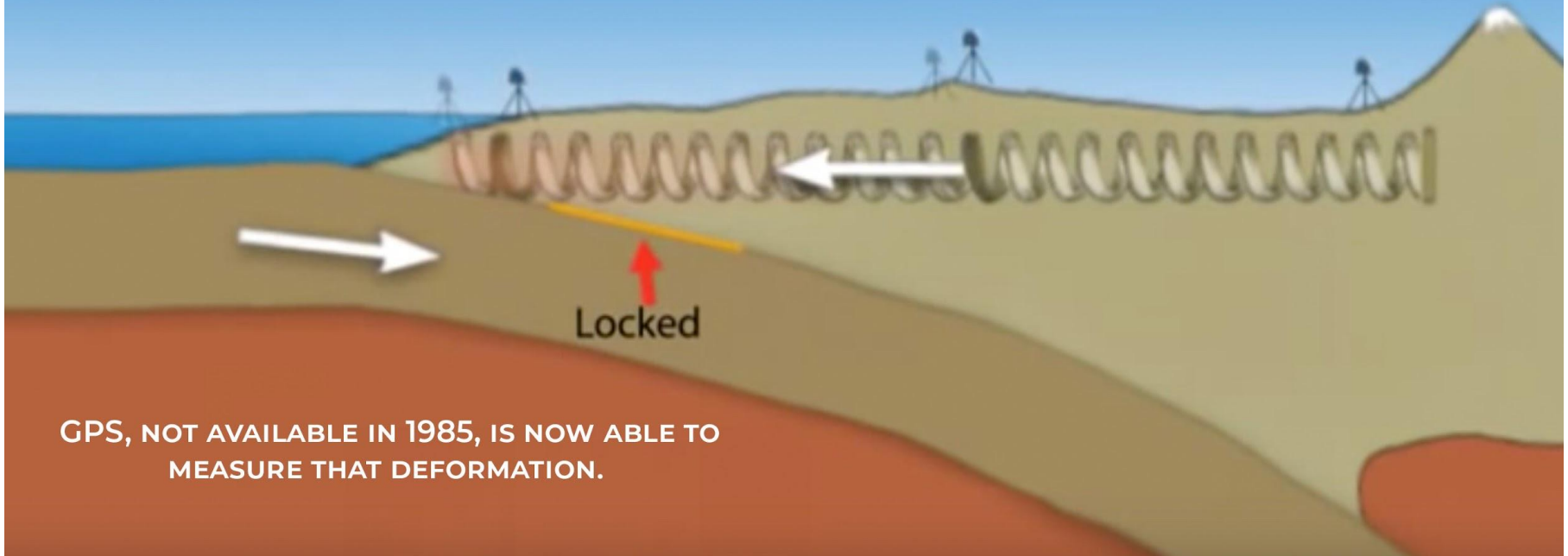
BECAUSE TECTONIC PLATES ARE ELASTIC LIKE A SPRING, CONVERGING PLATE BUILD ENERGY AT THE LEADING EDGE OF THE CONTINENT.

## GPS stations monitor deformation

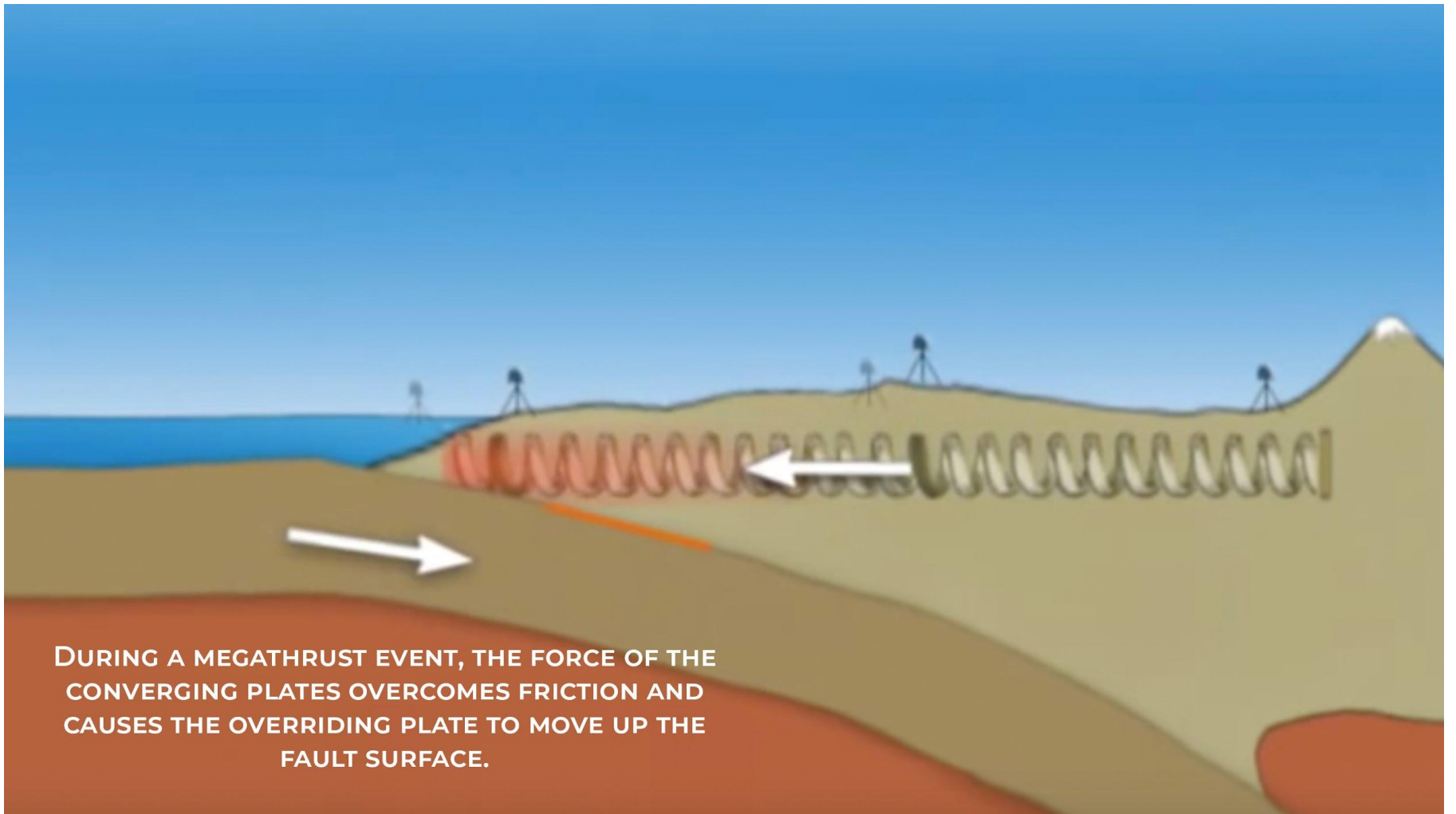


**LOCKED BY FRICTION, THE UPPER PLATE IS FORCED BACK AND SHORTENED, RAISING THE LAND SURFACE.**

GPS stations monitor deformation



GPS, NOT AVAILABLE IN 1985, IS NOW ABLE TO MEASURE THAT DEFORMATION.



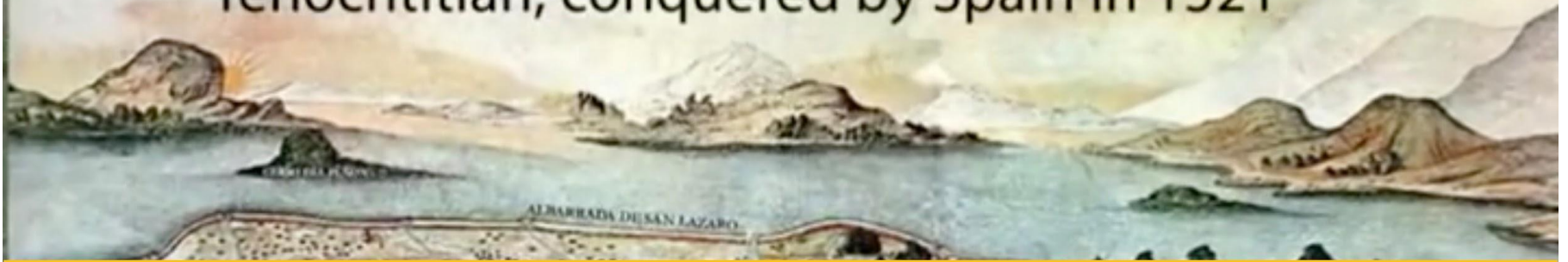
**DURING A MEGATHRUST EVENT, THE FORCE OF THE CONVERGING PLATES OVERCOMES FRICTION AND CAUSES THE OVERRIDING PLATE TO MOVE UP THE FAULT SURFACE.**

WHAT EXPLAINS THE **MUCH STRONGER** GROUND SHAKING IN  
MEXICO CITY?

# Tenochtitlan, conquered by Spain in 1521



# Tenochtitlan, conquered by Spain in 1521



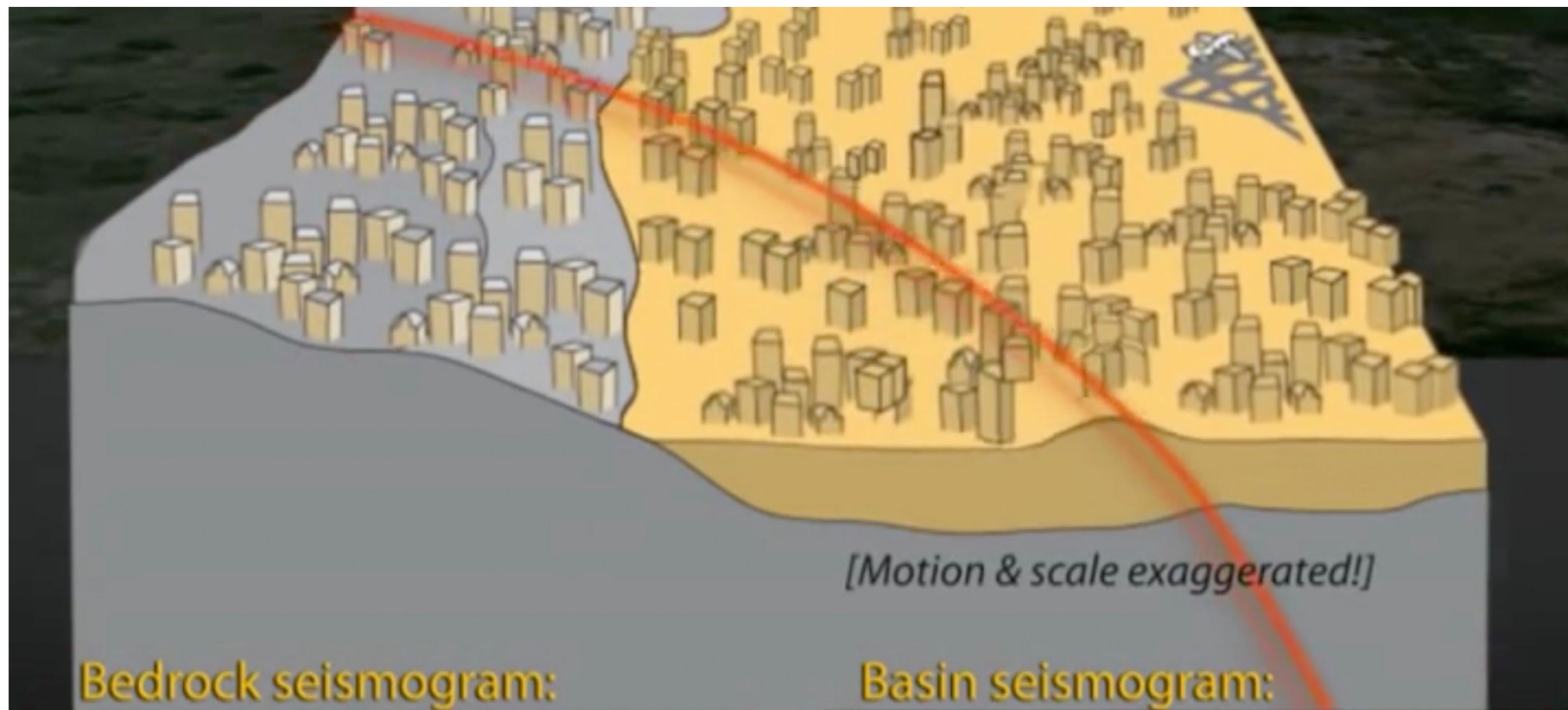
MEXICO CITY SITS ON REMNANTS OF A DRIED UP LAKE THAT ONCE SURROUNDED AZTEC CAPITAL, TENOCHTITLAN, NOW A SEDIMENT-FILLED BASIN SURROUNDED BY HARD VOLCANIC-BEDROCK MOUNTAINS.



Mexico City

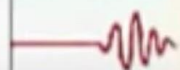






[Motion & scale exaggerated!]

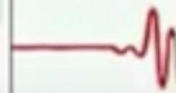
**Bedrock seismogram:**



High-frequency

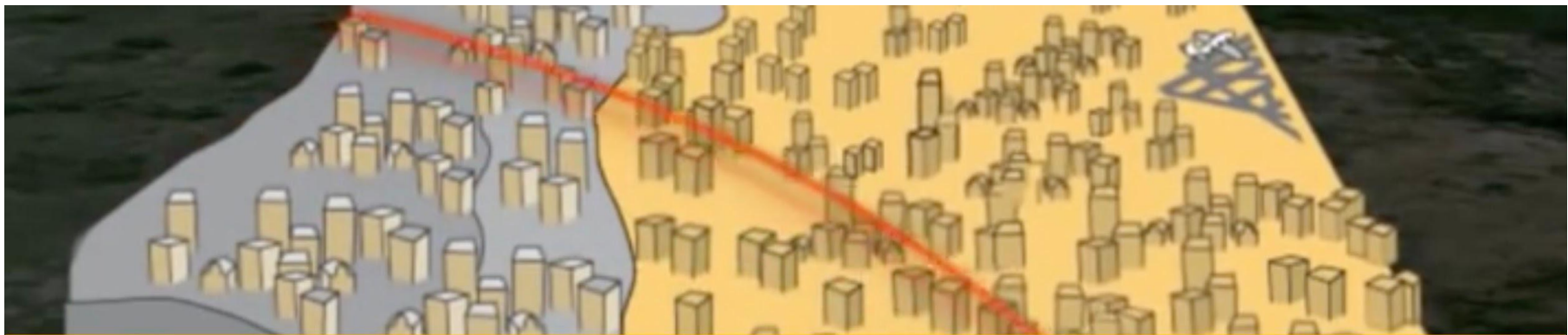
Low-amplitude

**Basin seismogram:**



Low-frequency

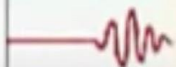
High-amplitude



SHORT PERIOD SEISMIC WAVES PRODUCED **WEAK GROUND MOTION** AS THEY PASSED TO THE BEDROOM **BUT ONCE INSIDE THE LAKE BASIN, THE WAVES SLOWED AND WERE AMPLIFIED CAUSING THE SOFT SEDIMENT TO SHAKE LIKE JELLO IN A BOWL.**

(motion & scale exaggerated.)

Bedrock seismogram:



High-frequency

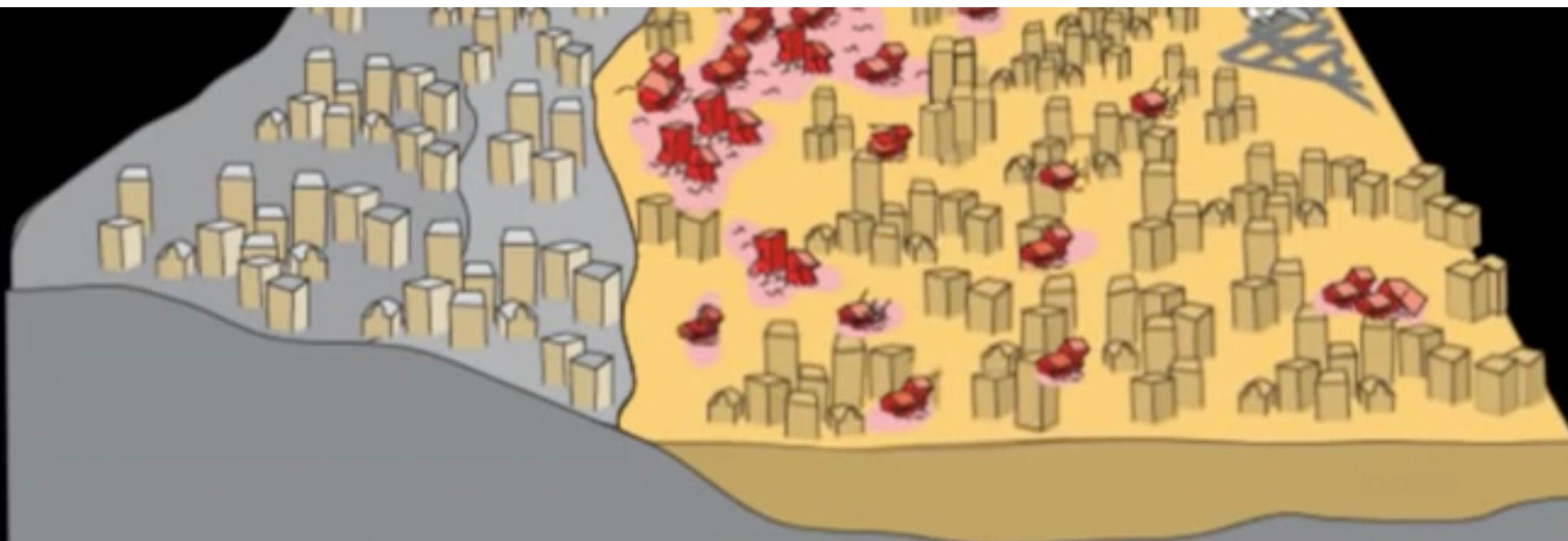
Low-amplitude

Basin seismogram:



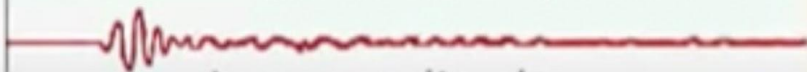
Low-frequency

High-amplitude



Basin amplification:  
increase in magnitude & duration

High-frequency

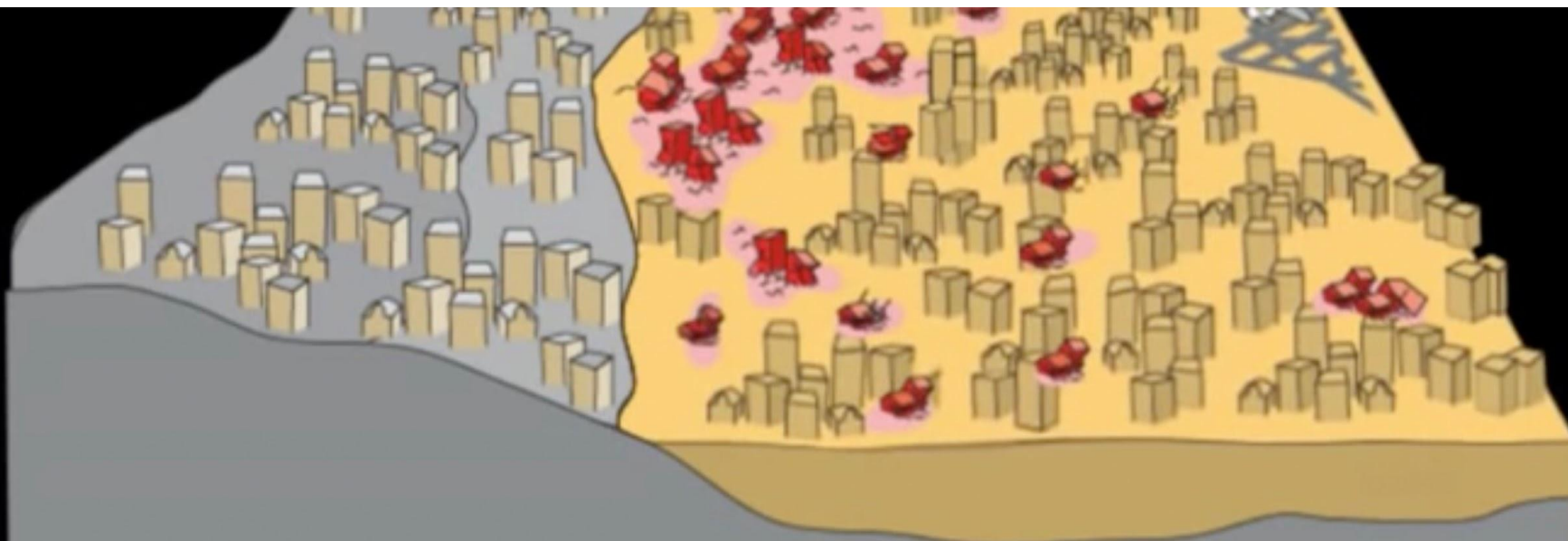


Low-amplitude

Low frequency

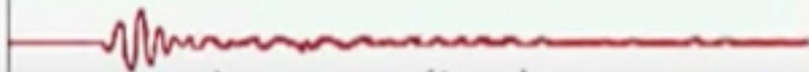


High amplitude



Basin amplification:  
increase in magnitude & duration

High-frequency

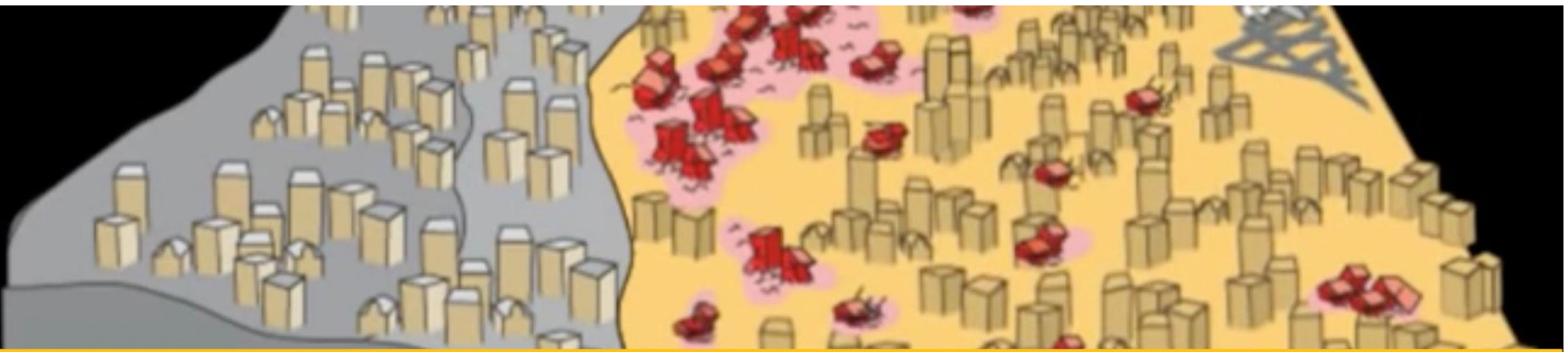


Low-amplitude

Low frequency



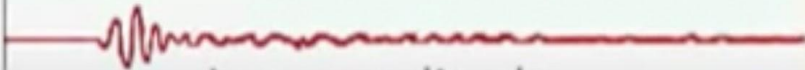
High amplitude



IN THE BROAD MEXICO CITY BASIN THE SEISMIC WAVES **BECAME TRAPPED AND REVERBERATED FOR MANY MINUTES** IN A PHENOMENON KNOWN AS **BASIN AMPLIFICATION**. AS THE WAVES BOUNCED OFF THE BEDROCK, BECOMING SLOWER AND BIGGER IN THE SEDIMENT. THE SEDIMENT “RESONATED” WITH 2-SEC. PERIOD FOR OVER A MINUTE. THE PERIOD OF OSCILLATION OR

increase in magnitude & duration

High-frequency



Low-amplitude

Low frequency



High-amplitude

# The Damages



# The damages

It caused damage over 200 miles from it's focus.

Killed more than 10,000 people.

Left 30,000 injured.

A quarter of a million people were left homeless.

More than 400 buildings collapsed and thousands were left damaged.

A day later, an 7.5 magnitude aftershock hit, making the situation worse.

Between 3-4 million in damage was caused by the quake.



# The Damages

Because the city is built on a drained lake bed, the soil (made out of silt and clay) is high in water content. This makes makes the soil susceptible to liquefaction. This took away support buildings and other structures.





# The Damages

Thousands were left without electricity.

Although power was restored the next day, the aftershock knocked it out again.

Damage to the telephone system lasted for several days.

Medical treatment of tens of thousands who were injured was hampered by the fact that several of the city's major hospitals had been damaged.



# The damages

Video:

<https://youtu.be/zhxCevJZcck>

<https://youtu.be/znl1gEhCIRo>

# Mittigation

## Mexico City Earthquake, 1985

8.1 Magnitude

Poorly constructed buildings caused thousands of deaths



# Mitigation

When 2012 earthquake hit in Mexico, no major damages were reported in Mexico City.

The 2012 earthquake was a little bit weaker it was a 7.4 vs 8.0 and the reason why it wasn't as damaging from 1985 was, because they had more reliable buildings that were stronger.

Once the 1985 earthquake happen, the buildings that were destroyed they replaced them with a better structures with better technology

# Mitigation

For their Anniversary of the 1985 quake. They put warning systems throughout the city with a 15,000 CCTV cameras.

It gives them about 90 seconds warning

A Mexican journalist Leo Zuckerman mention that he is proud to see the efforts that a lot of people have put and the billions of dollars that they have spent to make a better earthquake preparedness and the seismic changes.

For their 30th year Anniversary from the earthquake that hit in Mexico 1985 they put an exhibit for people to see what occur in that year and how memorable it was..

Boston University professor Susan Eckstein “ After the earthquake, it’s a whole story to be told.”

“ The earthquake provided a context in which poor people’s movements could really start to take hold.”



Sergio Toboada, Víctima. Segunda imagen de la serie Terremoto.  
Centro Histórico, 19 de septiembre de 1985.



Sergio Toboada, Víctima. Octava imagen de la serie Terremoto.  
Centro Histórico, 19 de septiembre de 1985.



# Mitigation

<https://www.youtube.com/watch?v=oGkad-FLk0w>



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