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MICROSEISMIC EFFECTS OF EARTHQUAKES

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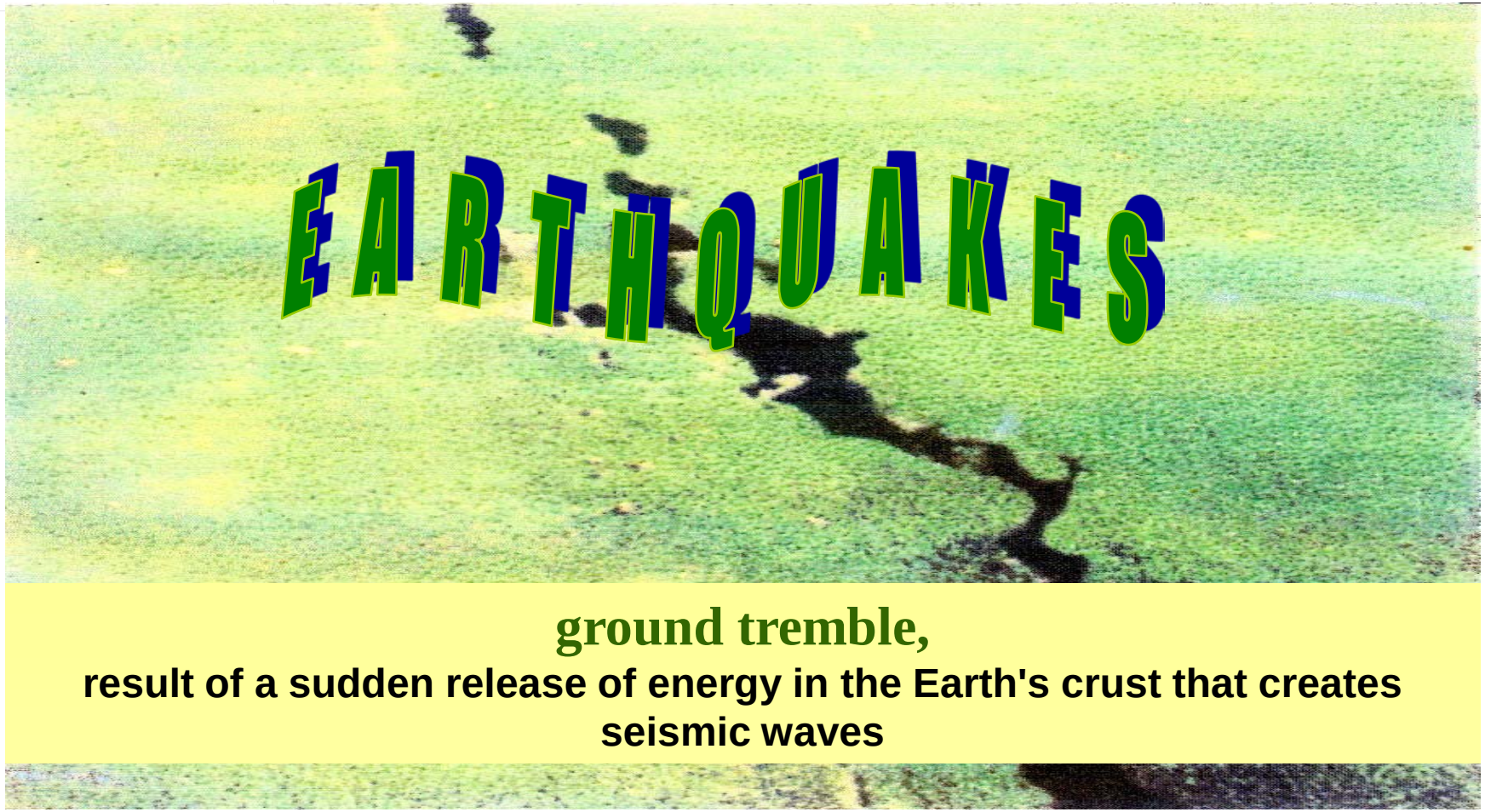

ground tremble,

result of a sudden release of energy in the Earth's crust that creates seismic waves

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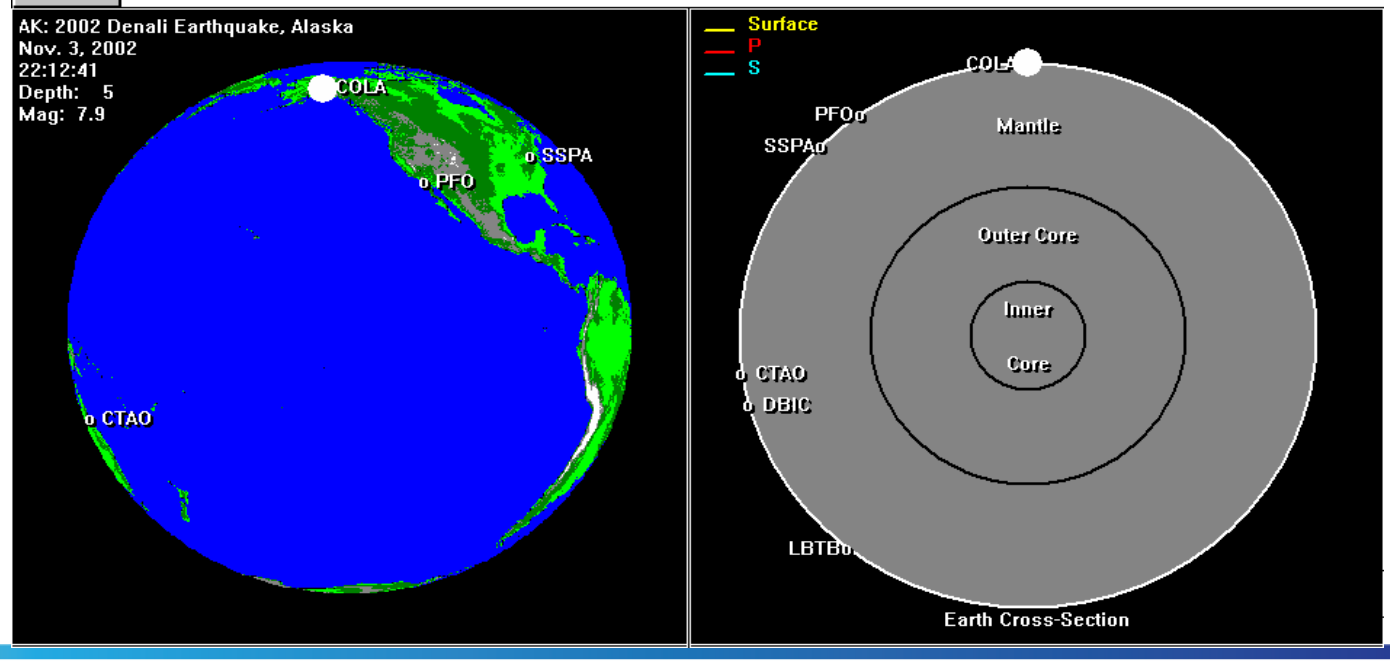
COLA-Z
PFO-Z
SSPA-Z
CTAO-Z
DBIC-Z
LBTB-Z

Seismic Waves generated by the 2002 Denali Fault, Alaska, Earthquake

Screen capture from Alan Jones' Seismic Waves program, which is freely available from his web site.



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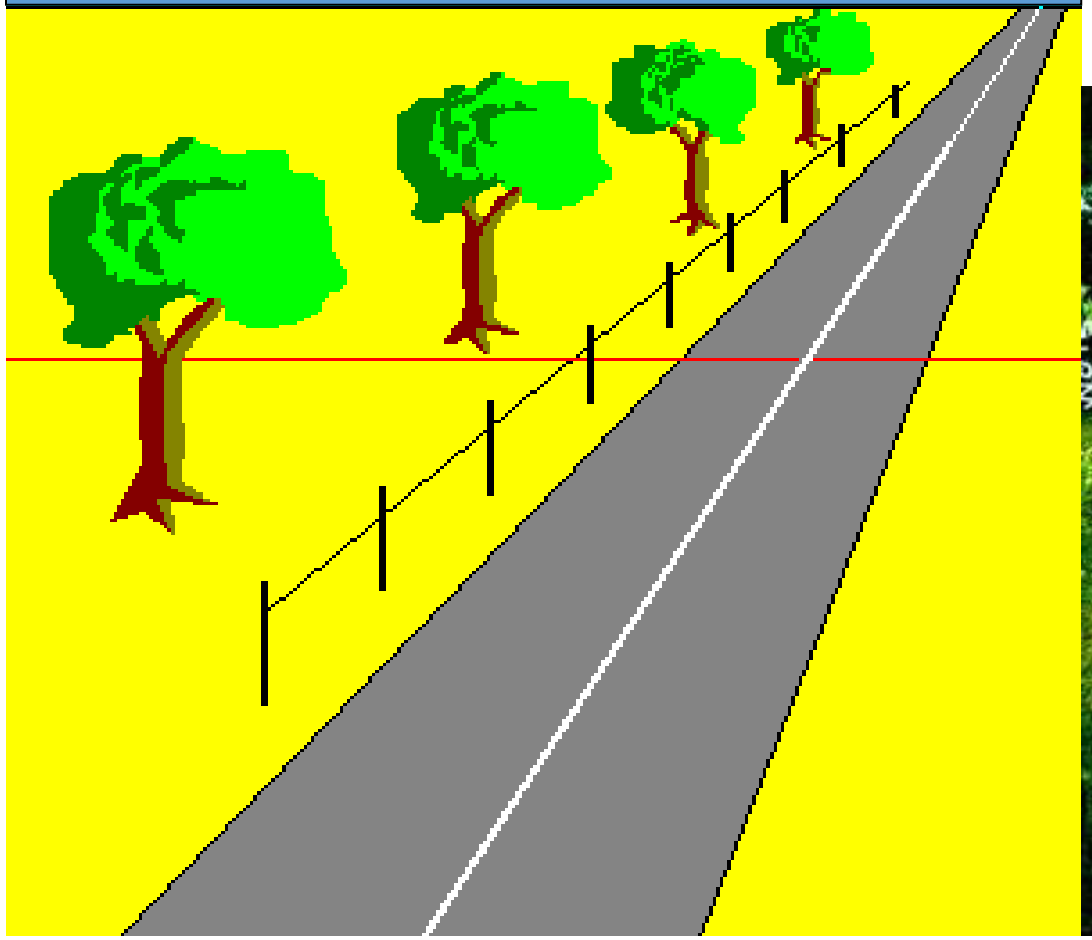
STRESSES ACCUMULATION IN A SITE BEFORE A SHOCK



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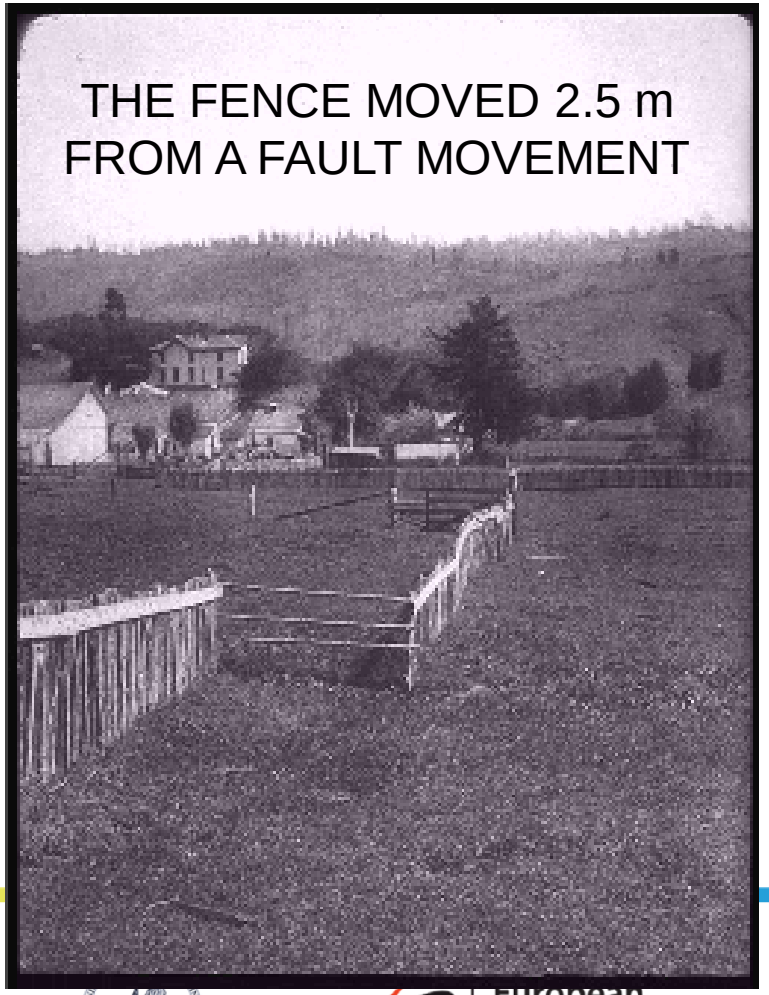

OFFSET OF THE TREES FROM THEIR LINES FROM A FAULT MOVEMENT

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REAL FAULT-RUPTURE
OF NATIONAL ROAD
IN KOZANI EVENT 1995, M=6.6

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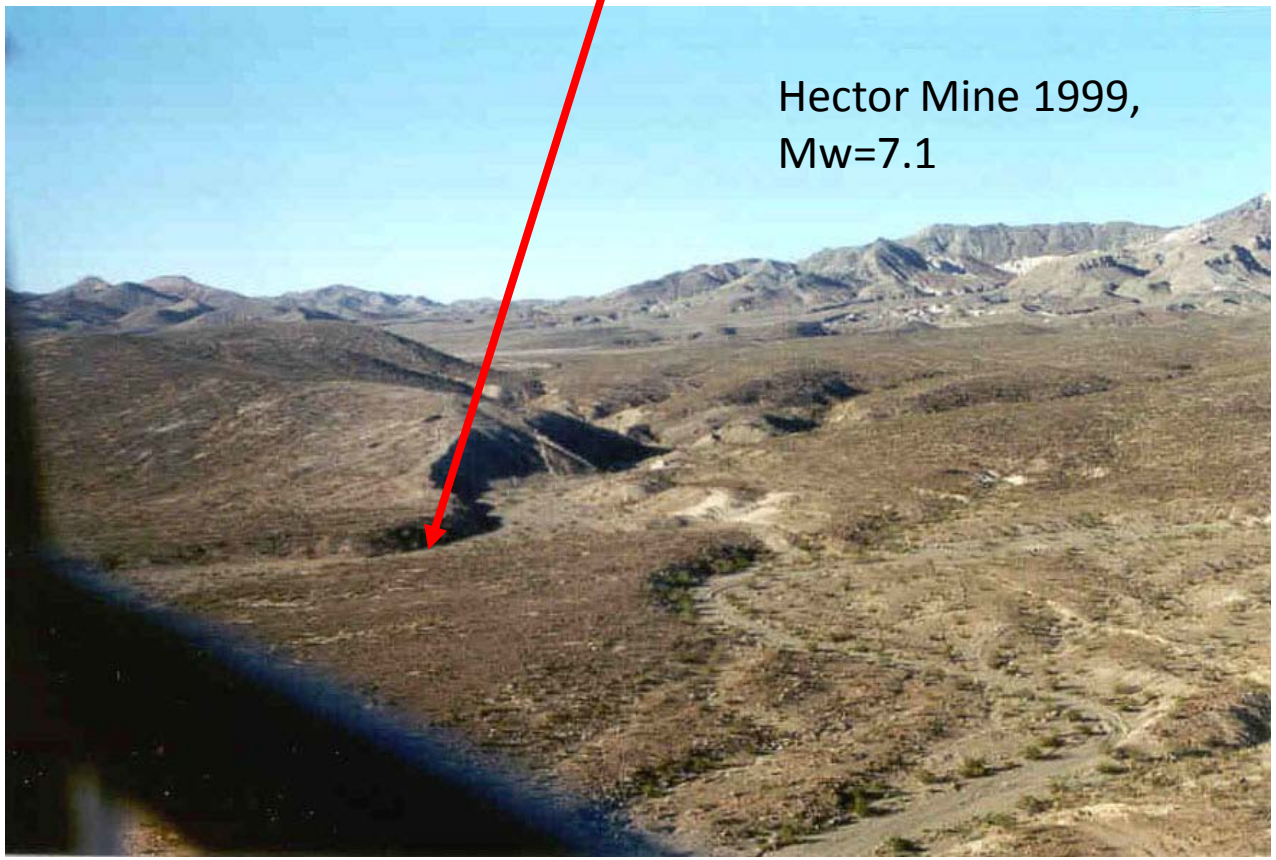
SEISMIC FAULT



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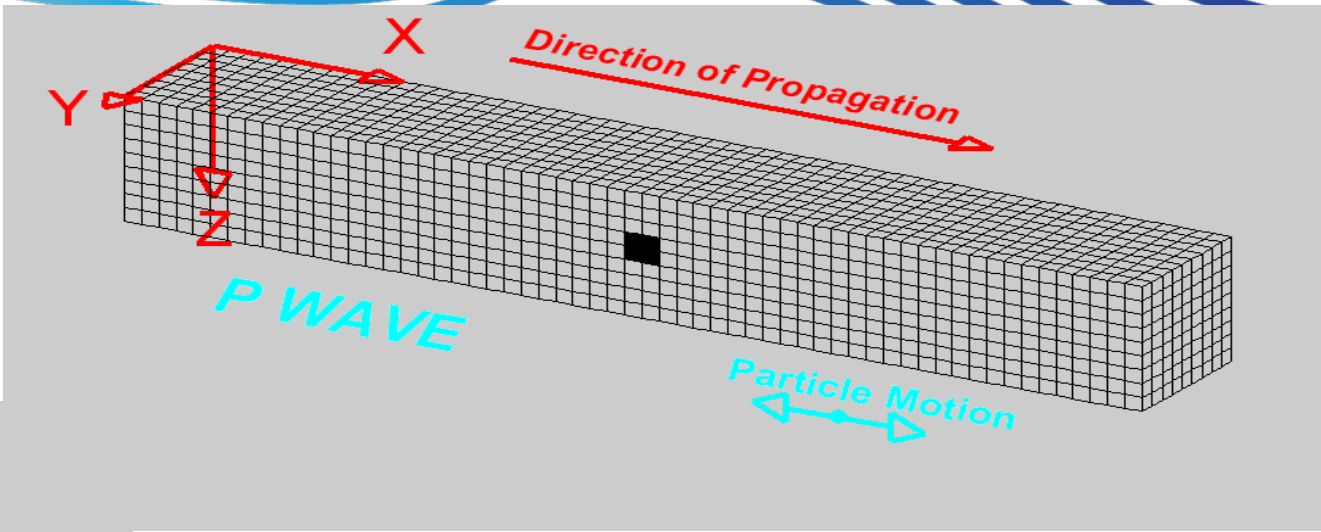

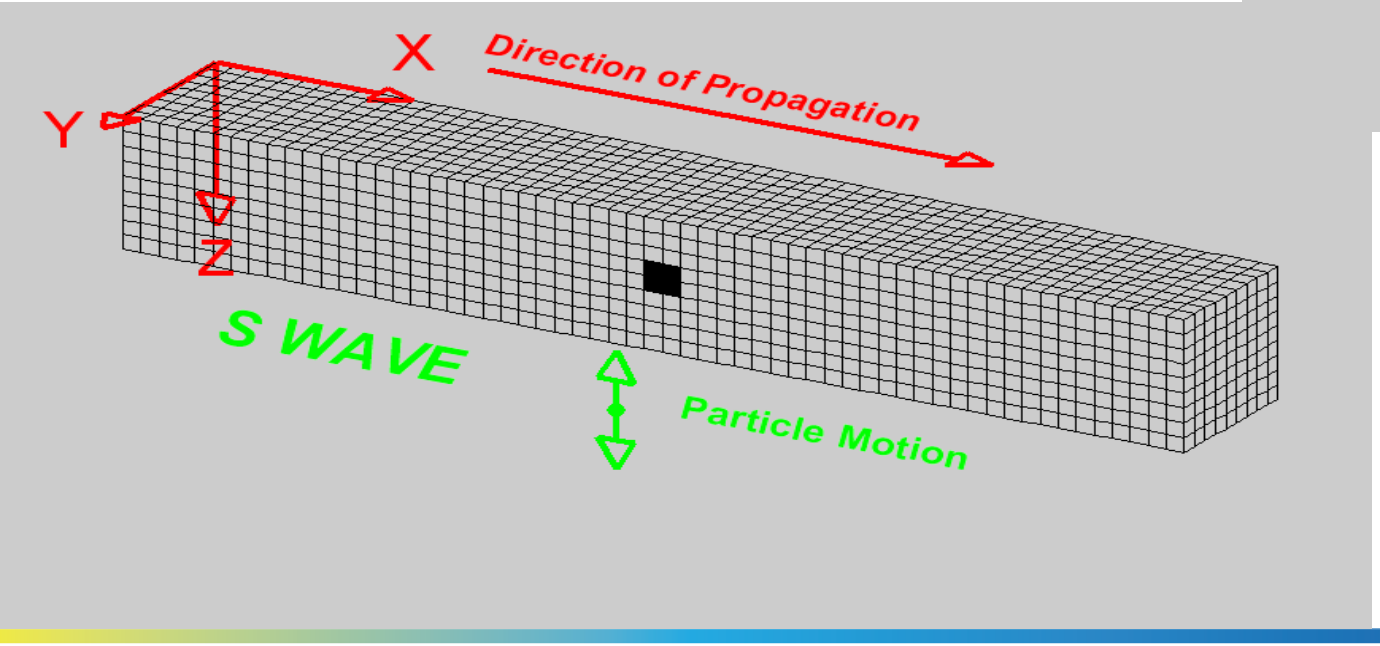

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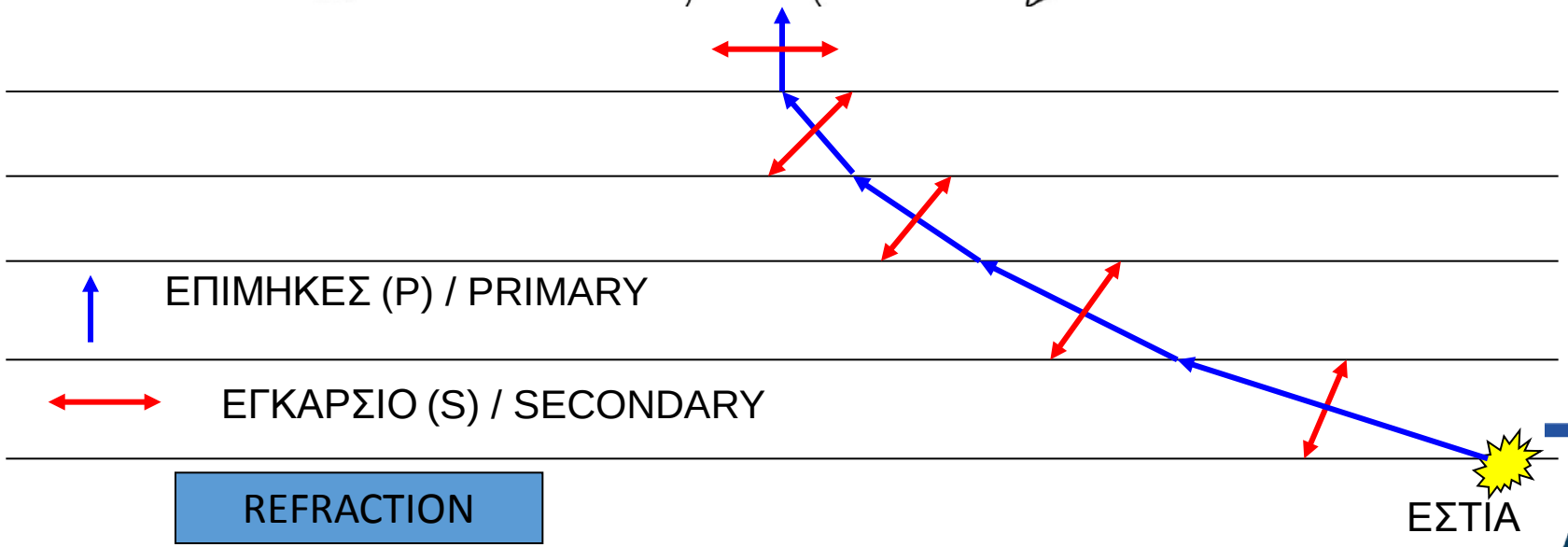

REFRACTION

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MACROSEISMIC EFFECTS OF EARTHQUAKES

Usually seismologists refer the term MACROSEISMIC EFFECTS.

These are the effects of an earthquake that is perceptible without the use of instruments.

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MACROSEISMIC EFFECTS OF EARTHQUAKES

EARTHQUAKES ARE STRONGLY AFFECTED TO:

HUMANS

INFRASTRUCTURES

BULDINGS

GROUND

WATER

DAMS

ANIMALS (among others)

Primary effects considered those which depended on the earthquake itself , while as **consequence effects** are those caused by the pass of seismic waves.

Permanent effects are those which are existed and after the event, while with term **impermanent** we referred to those which are obvious only to the earthquake duration.


Primary effects.
The fault passed
through a house

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Consequence effects
Gerakarou 1978, M=6.5

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Consequence effects
Profitis 1978, M=6.5

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GROUND FISSURES

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DEVASTATION OF IZMIT – TURKEY EARTHQUAKE OF 1999 (M=7.6)

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LANDSLIDES: caused by the reduction of the friction forces, due to earthquake shake, between various soil layers.

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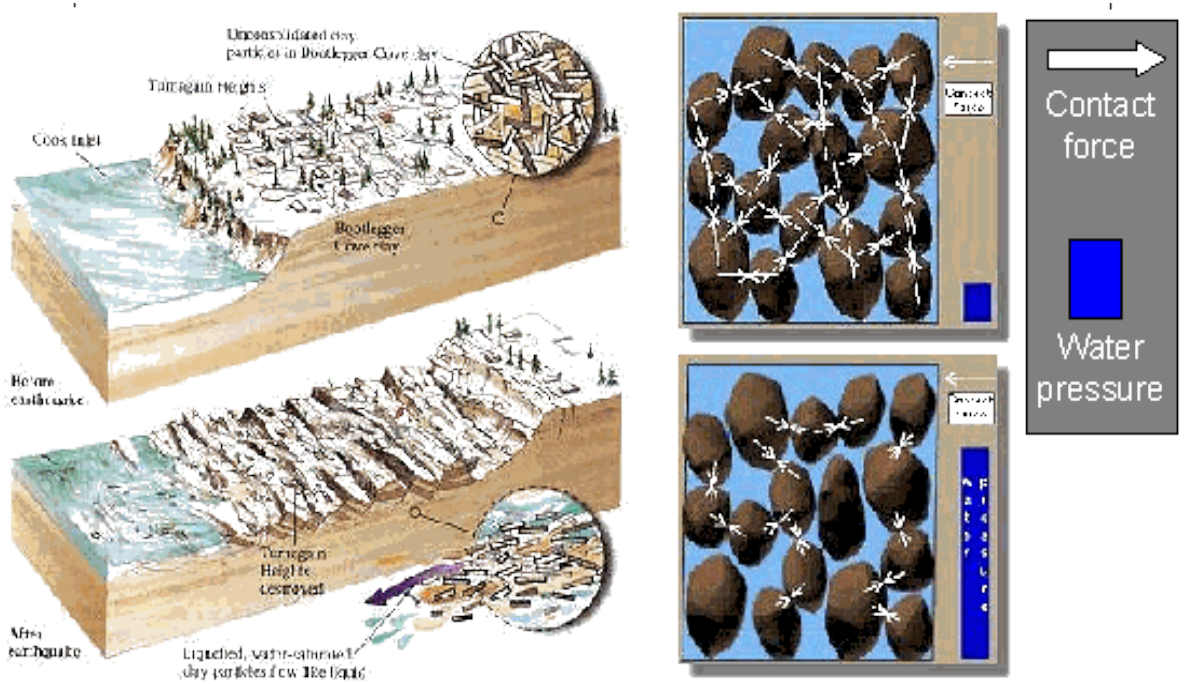
Liquefaction Process: Sand grains of the soil are connected to each other by high friction forces. The pressure of the water inside the pores is low. The shake of the earthquake breaks the structure of the pores, the pressure in the pores is now high, while , at the same time, the friction forces become very low and consequently the soil behaves as liquid. The damages are very heavy.



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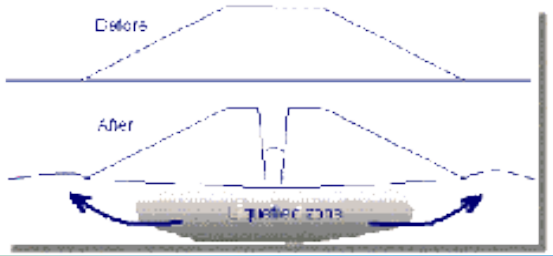
Some examples from liquefactions

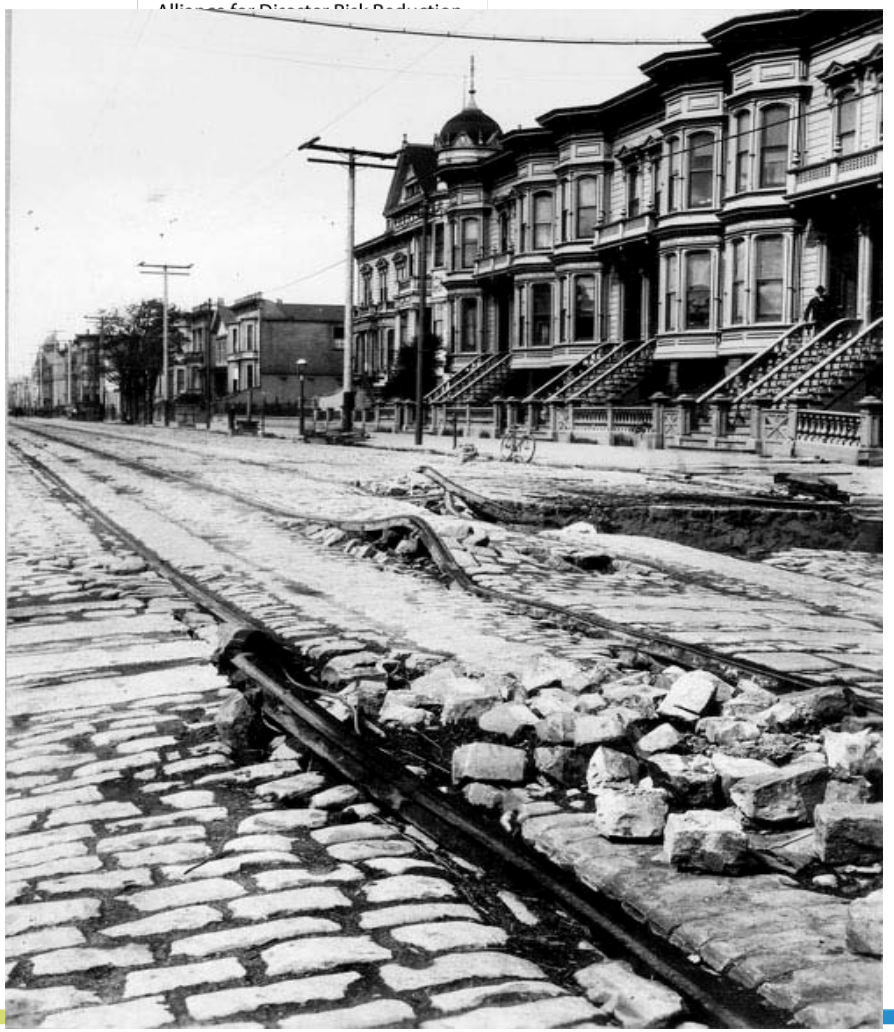
Liquefaction

Alaska, 1964



Mexico City, 1985

Niigata (Japan), 1964



The rail cut during an earthquake and consequently this can cause traffic accidents- San Francisco 1906

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Fires in Kobe Japan during the earthquake of 1995, M=6.9.

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Pipeline fire

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Tsumami in Japan

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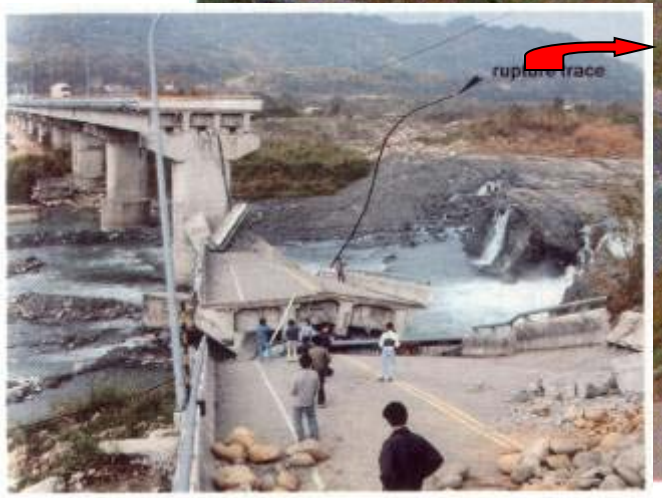
Chi-Chi earthquake in Taiwan. Dams' breaking



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Reasons for earthquakes occurrence different from the typical process

There are evidences that various factors can affect the earthquake occurrence e.g. the fulfill of artificial lakes, the tides, glaciers melt, (among others).

Those phenomena strongly affected to the very shallow layers of the Earth and disturb the balance of the rocks, when this balance is very sensitive (just a little bit before earthquake) and in this way all this process accelerates the generation of an earthquake.

A good paradigm was in Greece – artificial lake of Kremasta - which shows an increase seismic activity which was related with fulfill of the lake .Finally on February 1966 and earthquake with M=6.2 occurred.

According some ideas the same process was responsible for the earthquake occurrence on Kozani (1995-M=6.6) due to the artificial lake of Polyfytos.

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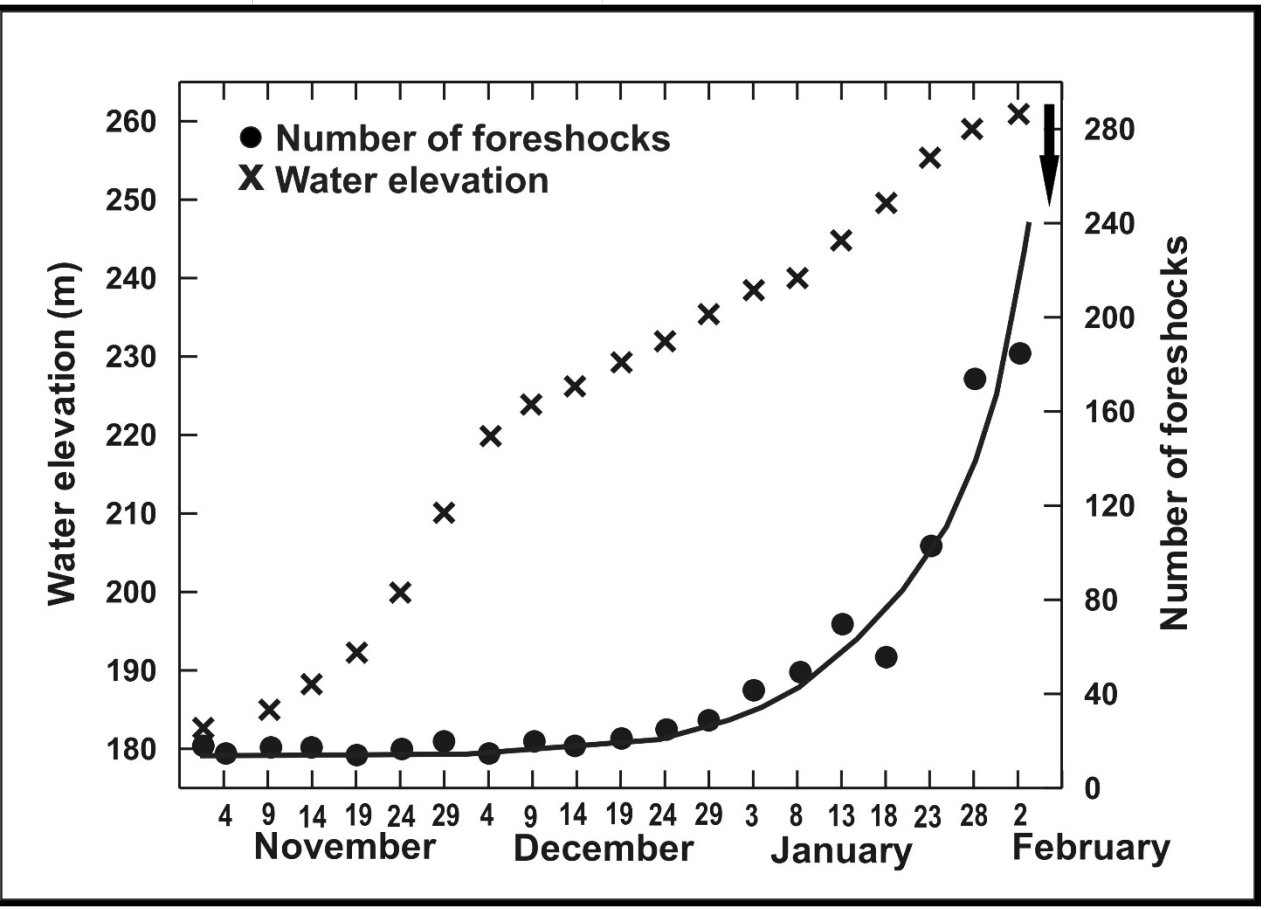

Temporal variation of the foreshocks frequency (black circles) and the waters; level (marked with x) in the artificial lake of Kremasta-Greece. The arrow shows the occurrence date of the main shock which was on February 1966 with M-6.2 (Comninakis et al., 1968)).

THE ARTIFICIAL LAKES MENTIONED BEFORE ARE CLOSELY CONNECTED WITH DAMS.

Earthquakes can be induced by dams. About 2% of dam failures globally are said to be due to seismic activity (Foster, Fell and Spannagle, 2000)

Globally, there are over 100 identified cases of earthquakes that scientists believe were triggered by reservoirs (Gupta 2002).

The most serious case may be the 7.9-magnitude Sichuan earthquake in May 2008, which killed an estimated 80,000 people and has been linked to the construction of the Zipingpu dam.

HOW DAMS RELATED TO EARTHQUAKES RELEASE

FOR TRIGGERED EARTHQUAKES TO OCCUR, WE HAVE TO CONSIDERE THAT **THE AREA IS ALREADY UNDER CONSIDERABLE TECTONIC STRESS**

The most widely accepted explanation of how dams cause earthquakes is related to the extra water pressure created in the micro-cracks and fissures in the ground under and near a reservoir.

When the pressure of the water in the rocks increases, it acts to lubricate faults which are already under tectonic strain, but are prevented from slipping by the friction of the rock surfaces.

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Water pore pressure plays a key role by reducing the normal stress within a rock while not changing the shear stress. Under any circumstances, an increase of pressure of water in pores means that a failure is more likely.

Depth of the reservoir is one of the most important factors.

Two processes of stress modification have been suggested as the dominant mechanisms that are responsible for triggering of earthquakes by LARGE RESERVOIRS (Simpson et al., 1988).

1) the direct effect of loading, through increased elastic shear stress;

2) the effect of increased pore pressure, through decreased effective normal stress.

Large new reservoirs can trigger earthquakes. This is due to either:

a) change in stress because of the weight of water, or more commonly by

b) increased groundwater pore pressure decreasing the effective strength of the rock under the reservoir.

The critical value of shearing stress may be made arbitrarily low by increasing the pore pressure.

It is not easy to predict whether a new reservoir will experience reservoir induced seismicity, because the two most important factors – the state of stress and the rock strength at earthquake depths – cannot be measured directly.

This is the same reason why prediction of normal (non-induced) earthquakes is normally unsuccessful

From the slides demonstrated above we can conclude that all the ideas about the triggering of earthquakes in dams are focused on the pore pressure and the depth of the reservoir (weight of the water).

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ANOTHER SOURCE FOR INDUCED TECTONICS

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OPEN PITS

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MAVROPIGI 2010-2011

“PROGRESS” OF THE MAIN CRACK

AUG 2011

DEC 2011

MAY 2012

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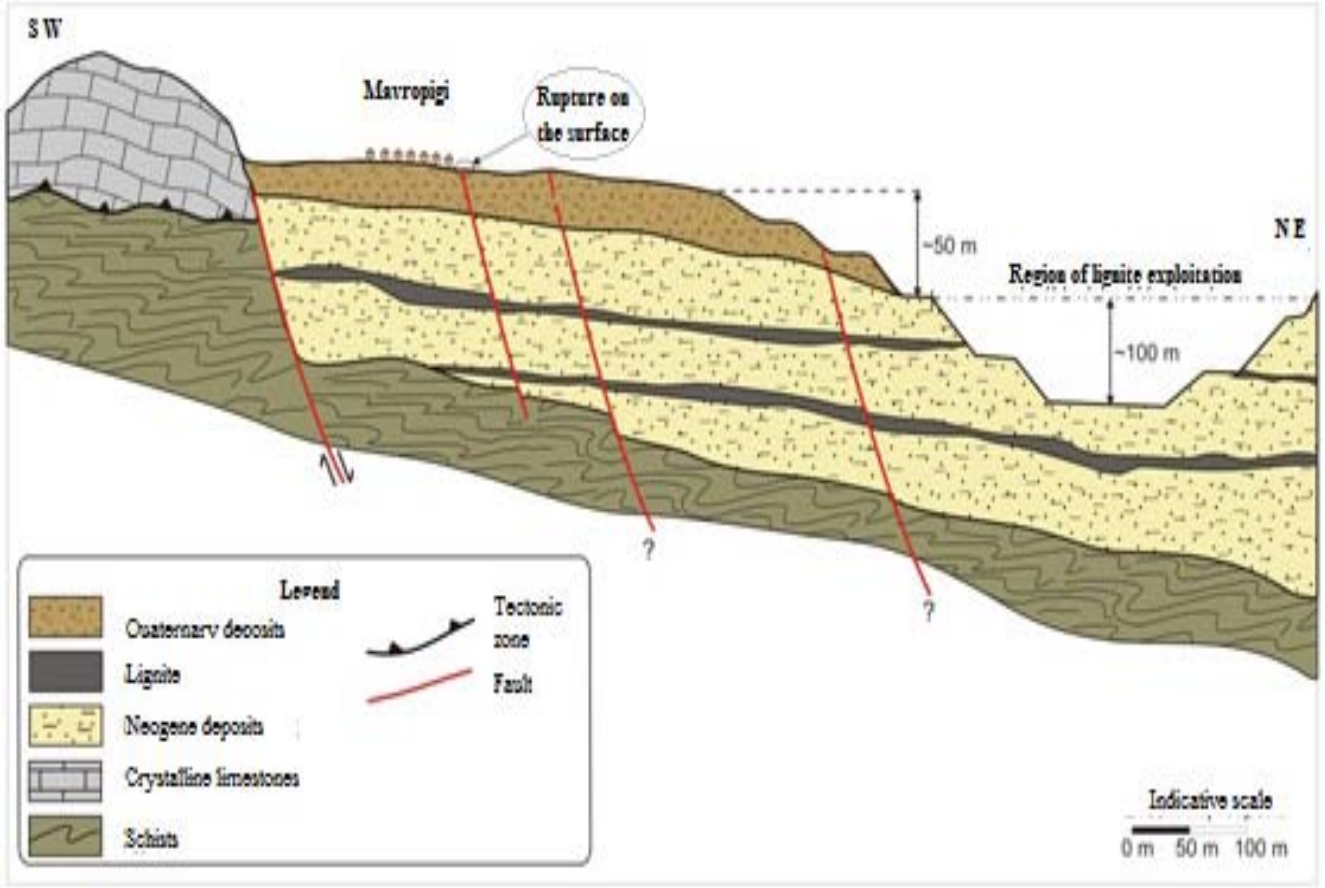
MAVROPIGI 2010-2011


SW
Mavropigi
Rupture on the surface
~50 m
NE
Region of lignite exploitation
~100 m
?
?
Legend
Quaternary deposits
Lignite
Neogene deposits
Crystalline limestones
Schists
Tectonic zone
Fault
Indicative scale
0 m 50 m 100 m

WHY?

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EARTHQUAKES AND WATER

HOW EARTHQUAKES ACT IN SURFACE WATERS?

THE INFLUENCE TO THE SURFACE WATER IS THE PRODUCT OF THE ROCKS RUPTURE.

THE RESULT IS THE LOSS OF THE WATERS AND THE EXSICCATION OF LAKES, PONDS etc. OR

LANDSLIDES PRODUCED, MAY LEAD TO OBSTRUCTION OF THE RIVERS FLOW AND CONSEQUENTLY THE GENERATION OF FLOODS OR THE FORMATION LAKES OR PONDS OR SWAMPS WITH STANDING WATERS, etc.

THE MOST IMPORTANT IS THE POSSIBLE VARIATION OF WATER SUPPLY FROM SPRINGS IN THE AREA (or their permanently stop). MANY TIMES THIS IS A REASON FOR PEOPLES REMOVE FROM THEIR OWN HOMES. PROBLEMS OBSERVED IN HISTORY IS THE DESERTIFICATION OF SUCH AREAS IN SUCH CASES

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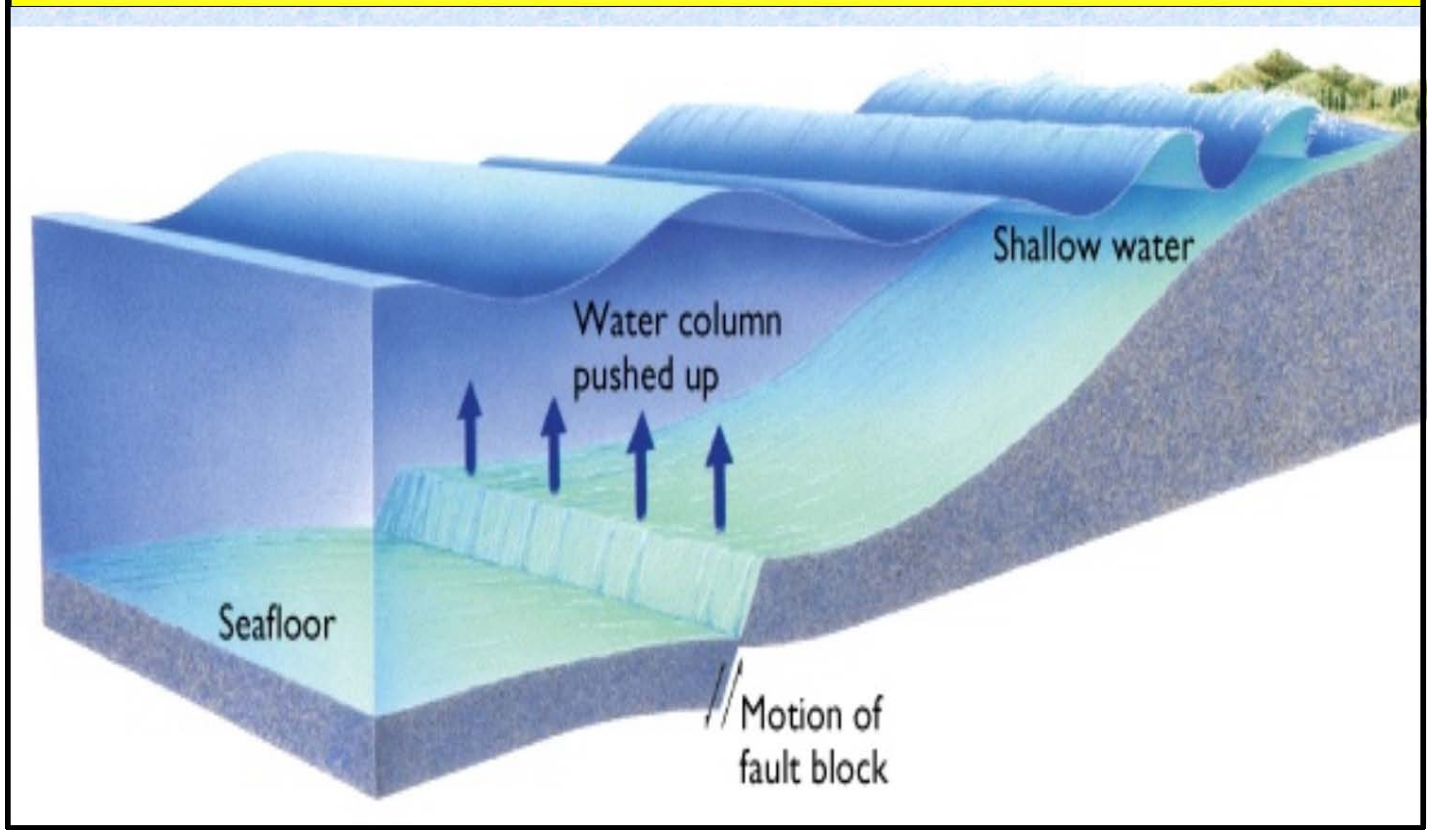
Αποτελέσματα των σεισμών στο νερό της θάλασσας



TSUNAMIS

(συνέχεια)

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- Tsunamis are waves with large wavelength and the are propagated in the sea level. They transfer huge tones of water to different directions. The biggest of them generated, as earthquakes; effects, in the ocean trenches of Pacific