Tatort Plattengrenze 2015 - Themen

1 *5. November*
Trailer
Einführung
Entstehung der Erde

2 *12. November* *
Geologische Zeiträume
Plattentektonik
Platten und Plattengrenzen

3 *19. November*
konstruktive Plattengrenzen
destruktive Plattengrenzen
konservative Plattengrenzen

* *im Bernoullianum Hörsaal 223*

4 *26. November*
Plattenrundgang
Tatort: Nepal 2015

5 *3. Dezember* + Nachtrag
Alles über Erdbeben
Magnitude

6 *10. Dezember*
Intensitäten
Berühmte Fälle:
San Francisco, Tohoku

www.iris.edu/hq/retm/event/3363

(1)

(2)

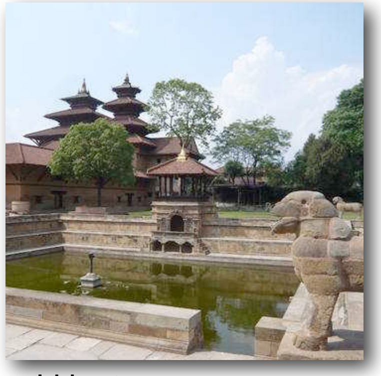
IRIS Teachable Moments

Magnitude 7.8 NEPAL
Saturday, April 25, 2015 at 06:11:26 UTC

A magnitude 7.8 earthquake occurred with an epicenter 77 km (48 miles) northwest of Kathmandu, the capital city of Nepal that is home to nearly 1.5 million inhabitants. The earthquake flattened homes, buildings and temples, causing widespread damage across the region and killing more than 2,300 and injuring more than 5,000.

Rescue workers remove debris as they search for victims of earthquake in Bhaktapur near Kathmandu, Nepal. A major earthquake shook Nepal's capital and the densely populated Kathmandu Valley before noon Saturday, causing extensive damage with toppled walls and collapsed buildings, officials said.

(AP Photo/Niranjan Shrestha)



Kathmandu Valley UNSECO world heritage

(3)

IRIS Teachable Moments

Magnitude 7.8 NEPAL
Saturday, April 25, 2015 at 06:11:26 UTC

The earthquake centered outside Kathmandu, the capital, was the worst to hit Nepal in over 80 years. It destroyed swaths of the oldest neighborhoods of Kathmandu and severely damaged three Unesco World Heritage sites. The earthquake was strong enough to be felt all across parts of India, Bangladesh, China's region of Tibet and Pakistan.

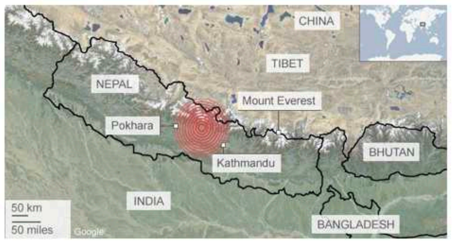


Image courtesy of the BBC

Reports of damage and injuries are still being confirmed. The situation is unclear in remote areas which remain cut off or hard to access. Many mountain roads are damaged or blocked by landslides.

IRIS Teachable Moments

Magnitude 7.8 NEPAL
Saturday, April 25, 2015 at 06:11:26 UTC

The earthquake triggered a major avalanche on the south slopes of Mt. Everest, located approximately 160 km east-northeast of the epicenter. The avalanche destroyed the base camp, where climbers were waiting for a break in the weather to ascend the mountain. According to reports, the avalanche killed at least 17 people and injured 61 others.

People approach the scene after an avalanche triggered by a massive earthquake swept across Everest Base Camp, Nepal on Saturday, April 25, 2015.

(AP Photo/ Azim Afif)

1. Magnitude (Absolutmass, Energie)
2. Epizentrum
3. Human Interest

Intensität: Modifizierte Mercalli Intensität (MMI)

4

Mercalli Skala	
XII	grosse Katastrophe
XI	Katastrophe
X	vernichtend
IX	verwüstend
VIII	zerstörend
VII	sehr stark
VI	stark
V	ziemlich stark
IV	mässig
III	leicht
II	sehr leicht
I	unmerklich

IRIS Teachable Moments

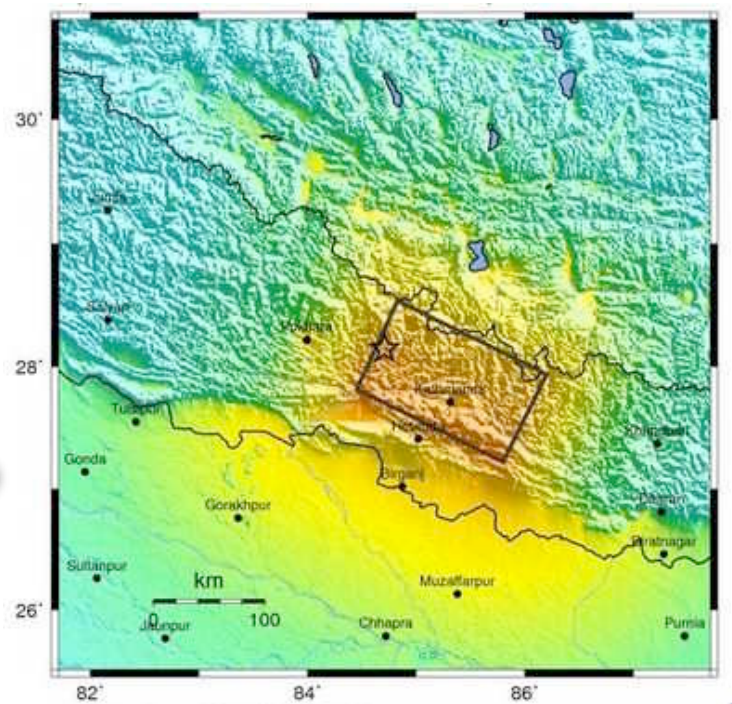
Magnitude 7.8 NEPAL
Saturday, April 25, 2015 at 06:11:26 UTC

Shaking Intensity

The Modified Mercalli Intensity (MMI) scale depicts shaking severity. The area nearest Katmandu experienced very strong to severe shaking.

Modified Mercalli Intensity	Perceived Shaking
X	Extreme
IX	Violent
VIII	Severe
VII	Very Strong
VI	Strong
V	Moderate
IV	Light
II-III	Weak
I	Not Felt

Image courtesy of the US Geological Survey

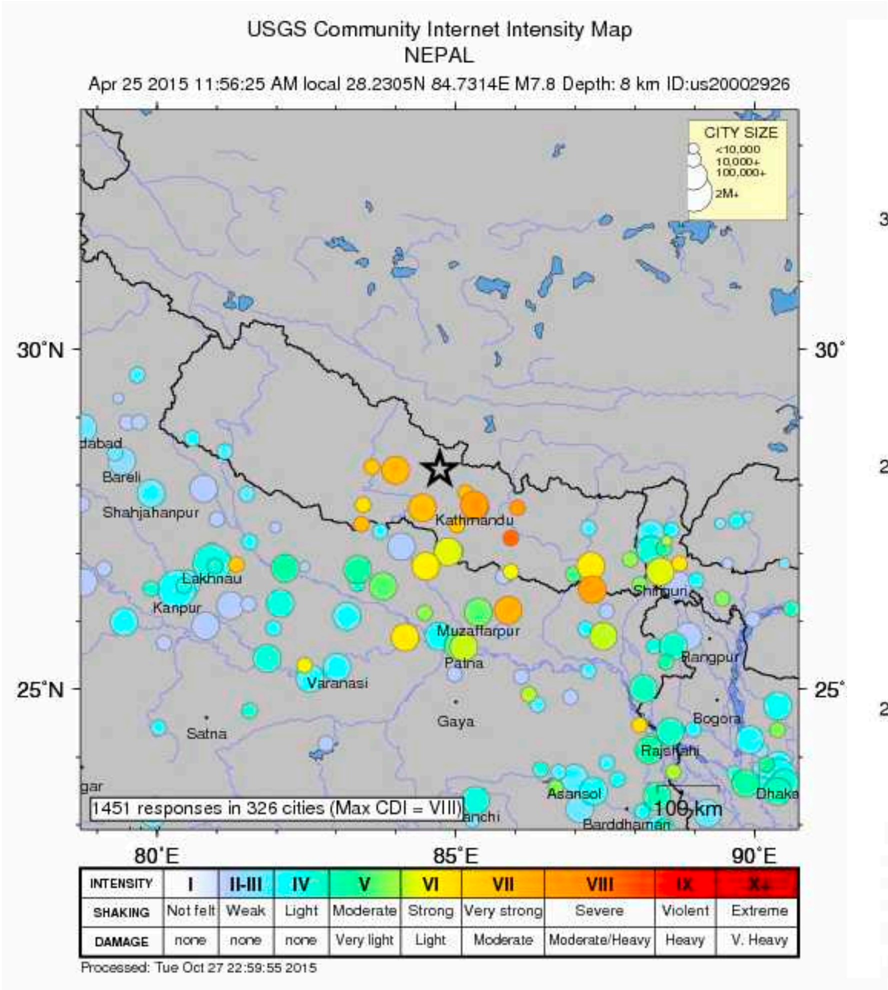


USGS Estimated shaking Intensity from M 7.8 Earthquake

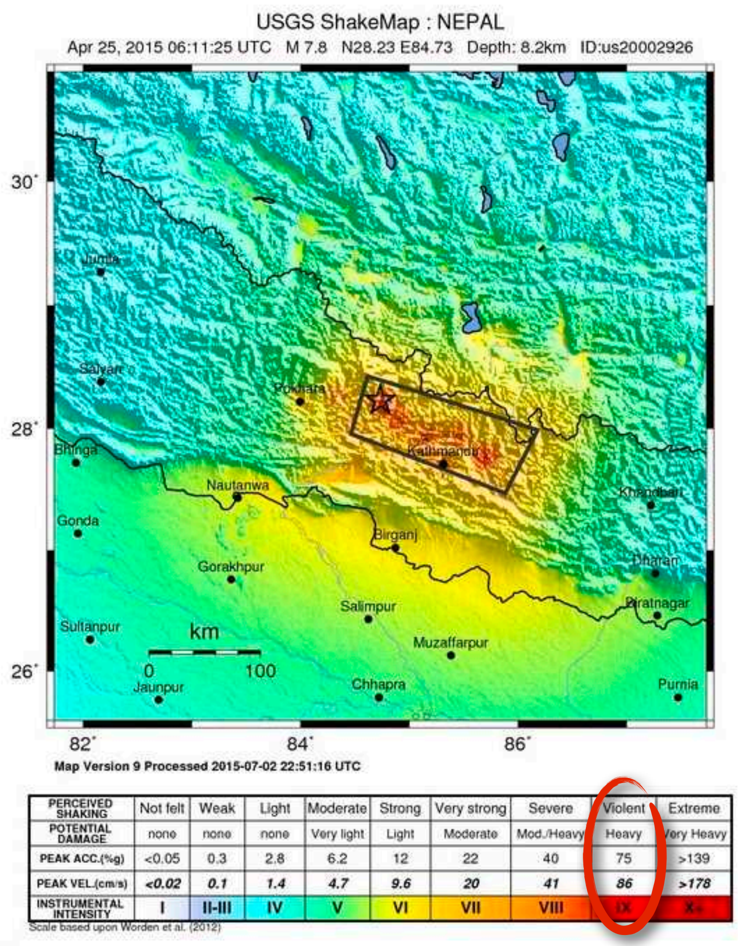
4. Intensität ("gefühlte Magnitude")

earthquake.usgs.gov/earthquakes/eventpage/us20002926

27. Oktober 2015



2. Juli 2015



4. Intensität ("gefühlte Magnitude")

PAGER

Prompt Assessment of Global Earthquakes for Response

5

Magnitude 7.8 NEPAL
Saturday, April 25, 2015 at 06:11:26 UTC

IRIS Teachable Moments

The USGS PAGER map shows the population exposed to different Modified Mercalli Intensity (MMI) levels.

Nearly 5.3 million people experienced severe ground shaking during this earthquake.

MMI	Shaking	Pop.
I	Not Felt	--*
II-III	Weak	--*
IV	Light	5,616k*
V	Moderate	69,912k*
VI	Strong	61,669k
VII	Very Strong	9,288k
VIII	Severe	5,299k
IX	Violent	4k

USGS PAGER
Population Exposed to Earthquake Shaking

The color coded contour lines outline regions of MMI intensity. The total population exposure to a given MMI value is obtained by summing the population between the contour lines. The estimated population exposure to each MMI Intensity is shown in the table.

Image courtesy of the US Geological Survey

5 616 000	69 612 000	61 669 000	9 288 000	5 299 000	4 000

5. PAGER: Exposure (Bevölkerung, Sachwerte)

PAGER Prompt Assessment of Global Earthquakes for Response

USGS science for a changing world

Earthquake Hazards Program

- General
  - Summary
  - Interactive Map
  - Google Earth KML
- Impact
  - Summary
  - Did You Feel It?
  - Tell Us!
  - Shakemap
  - **PAGER**
- Scientific
  - Summary
  - Origin
  - Moment Tensor
  - Finite Fault
  - Waveforms
- Latest Earthquakes
- Earthquakes
- Hazards

M7.8 - 36km E of Khudi, Nepal

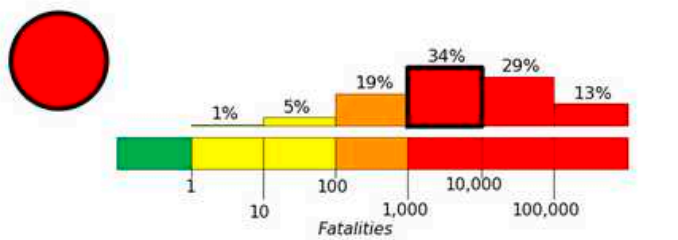
IX IX RED

http://earthquake.usgs.gov/earthquakes/eventpage/us20002926#impact_pager

Impact - PAGER

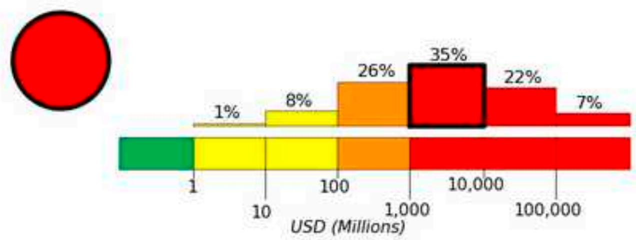
Data Source US

Estimated Fatalities



Red alert for shaking-related fatalities and economic losses. High casualties and extensive damage are probable and the disaster is likely widespread. Past red alerts have required a national or international response.

Estimated Economic Losses



Estimated economic losses are 8-40% GDP of Nepal.

Estimated Population Exposure to Earthquake Shaking

Structure Information Summary

Overall, the population in this region resides in structures that are highly vulnerable to earthquake shaking, though some resistant structures exist. The predominant vulnerable building types are unreinforced brick masonry and rubble/field stone masonry construction.

Secondary Effects

Recent earthquakes in this area have caused secondary hazards such as landslides and liquefaction that might have contributed to losses.

Selected Cities Exposed

Show/Hide Full City List

5. PAGER: Exposure (Bevölkerung, Sachwerte)

Kontinentale Kollision

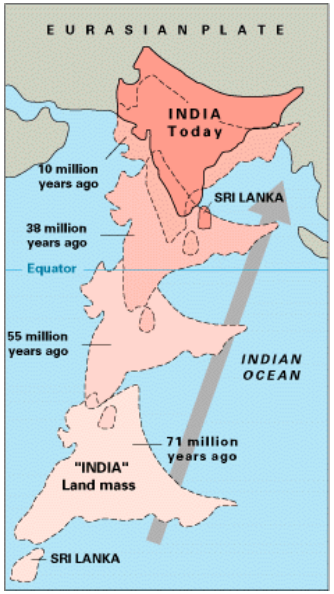
6

Magnitude 7.8 NEPAL
Saturday, April 25, 2015 at 06:11:26 UTC

IRIS Teachable Moments

The earthquake activity in Nepal is caused by the ongoing continent-continent collision between India and Asia. That collision has produced the Himalaya Mountains and the Tibetan Plateau. The collision zone wraps around the northwest promontory of the Indian continent in the Hindu Kush region of Tajikistan and Afghanistan then extends to the southeast through Nepal and Bhutan.

The motion of India into Asia is essentially perpendicular to the Himalaya Mountains in Nepal. So thrust faulting earthquakes are the most common kind of earthquake in the central Himalayan region.



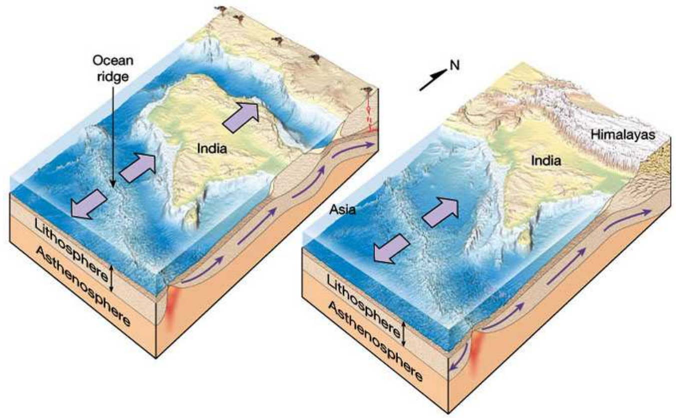
heute
10 Mio Jahre
38 Mio Jahre
55 Mio Jahre
71 Mio Jahre

Herdflächenlösung Bewegungssinn

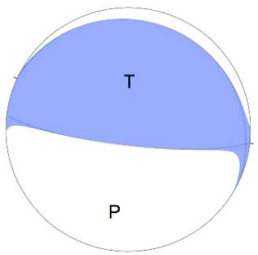
Magnitude 7.8 NEPAL
Saturday, April 25, 2015 at 06:11:26 UTC

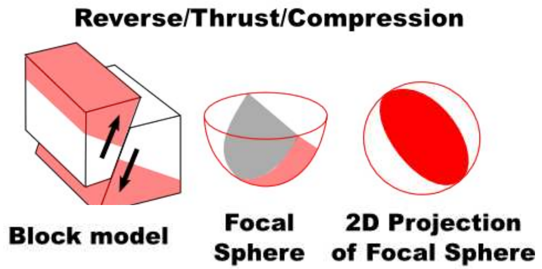
This earthquake occurred as the result of thrust faulting between the subducting Indian Plate and the overriding Eurasian Plate to the north.

At the location of this earthquake the Indian Plate is converging with Eurasia at a rate of 45 mm/yr towards the north-northeast, driving the uplift of the Himalayas and the Tibetan Plateau.



USGS Centroid Moment Tensor Solution





The tension axis (T) reflects the minimum compressive stress direction.
The pressure axis (P) reflects the maximum compressive stress direction.

7

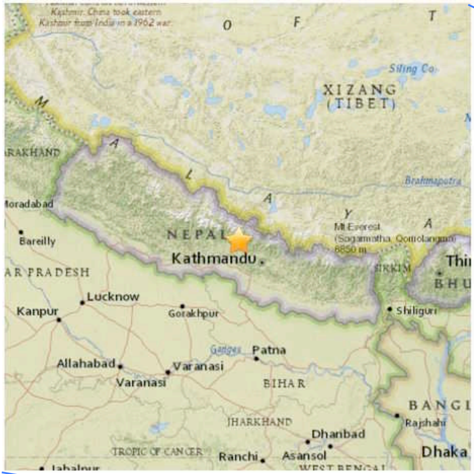
Seismische Gefährdung

8

IRIS Teachable Moments

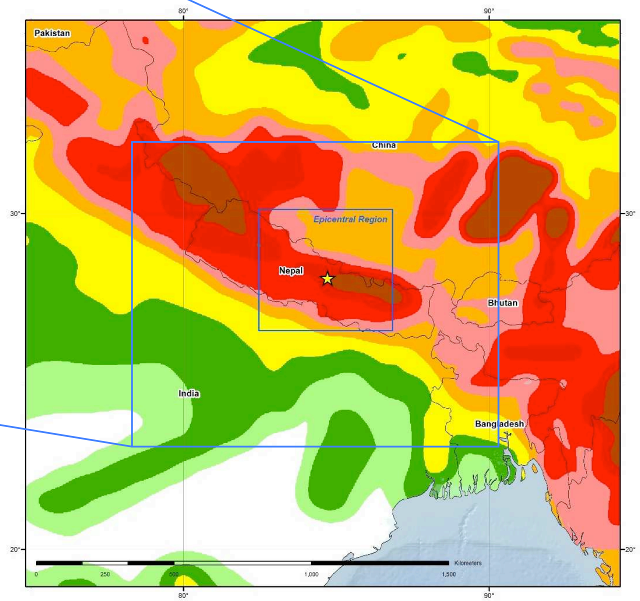
Magnitude 7.8 NEPAL
Saturday, April 25, 2015 at 06:11:26 UTC

Northward underthrusting of India beneath Eurasia generates numerous earthquakes and consequently makes this area one of the most seismically hazardous on Earth.



Peak Ground Acceleration in m/sec**2

This earthquake hazard map illustrates the peak ground acceleration expected to be exceeded with 10% probability during a 50-year period. The dark red zones indicate accelerations of about 0.5g where g=acceleration of gravity.



Seismic Hazard Image courtesy of the US Geological Survey

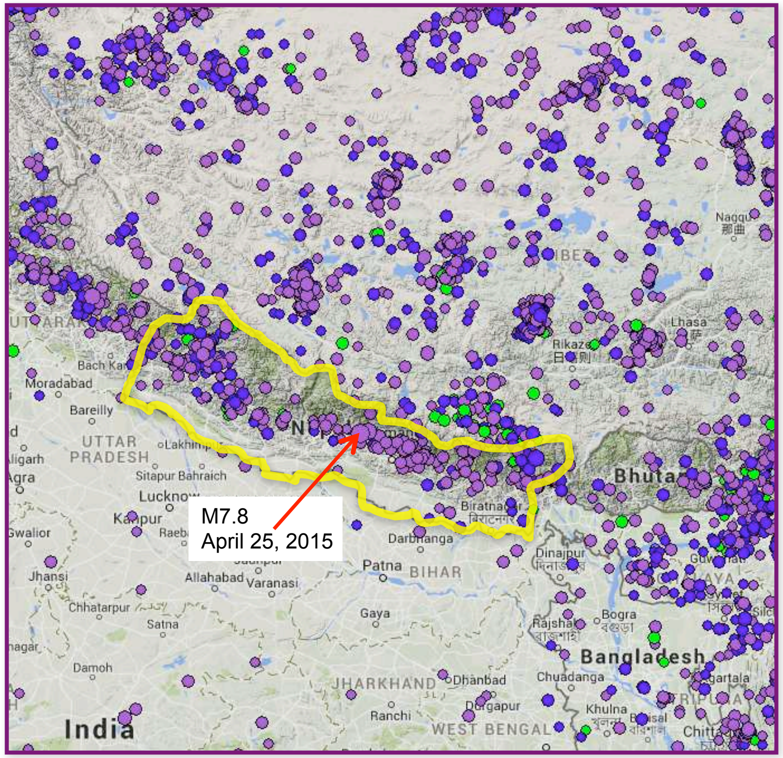
Erbeben seit 1990 Herdtiefe (Hypozentrum)

IRIS Teachable Moments

Magnitude 7.8 NEPAL
Saturday, April 25, 2015 at 06:11:26 UTC

This map shows epicenters of earthquakes since 1990 (>M4) within the India – Asia collision zone. Note the belt of earthquakes along and south of the Himalaya Mountains sweeping through Nepal (yellow outline).

Four earthquakes ≥M6 have occurred within 250 km of the April 25 earthquake over the past century. The largest included a M6.9 in August 1988 and a M8.0 in 1934 which severely damaged Kathmandu. The 1934 earthquake is thought to have caused around 10,600 fatalities.



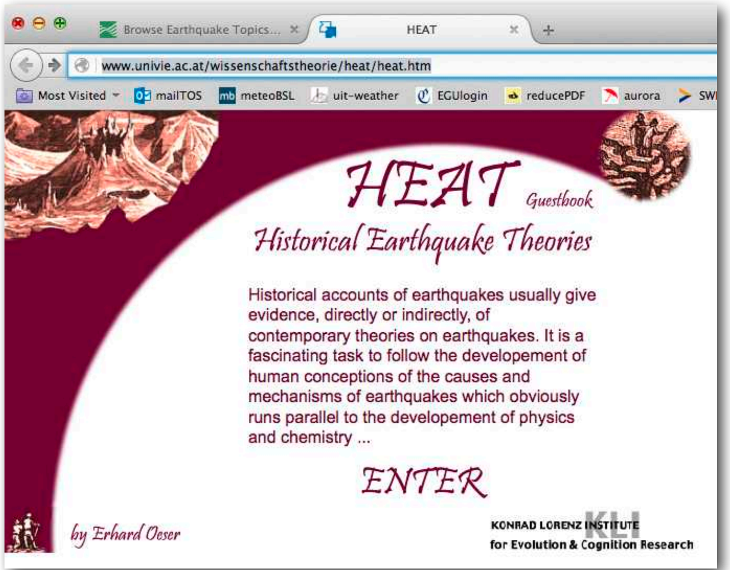
Map created using the IRIS Earthquake Browser: *www.iris.edu/ieb*

- 0-33 km
- 33-70 km
- 70-150 km
- 150-300 km
- 300-500 km
- >500 km

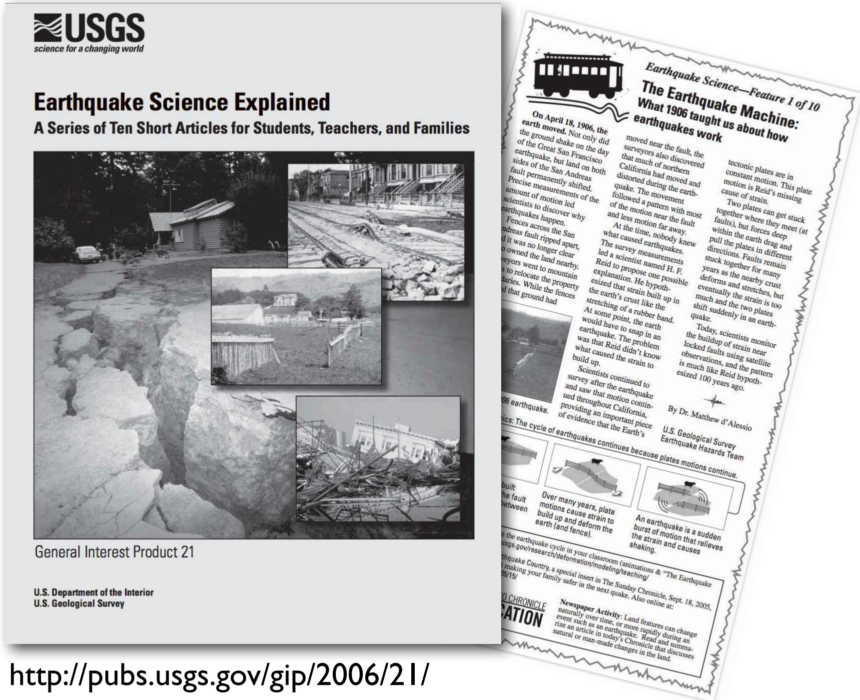
9

http://earthquake.usgs.gov/learn/topics/seismology/determining_depth.php

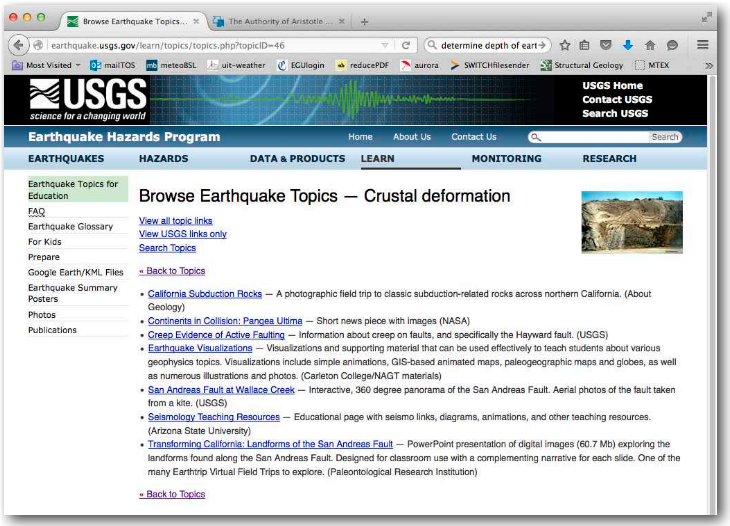
was lernen....



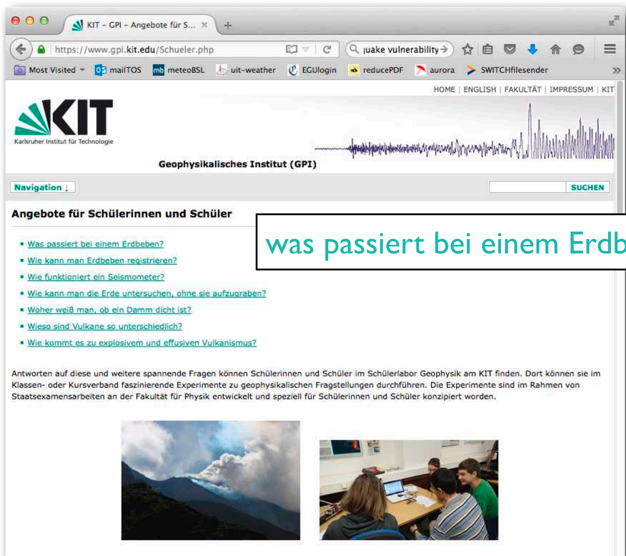
http://www.univie.ac.at/wissenschaftstheorie/heat/heat.htm



http://pubs.usgs.gov/gip/2006/21/



http://earthquake.usgs.gov/learn/topics/topics.php?topicID=46



was passiert bei einem Erdbeben ?

https://www.gpi.kit.edu/Schueler.php

Haupbeben - ....

10

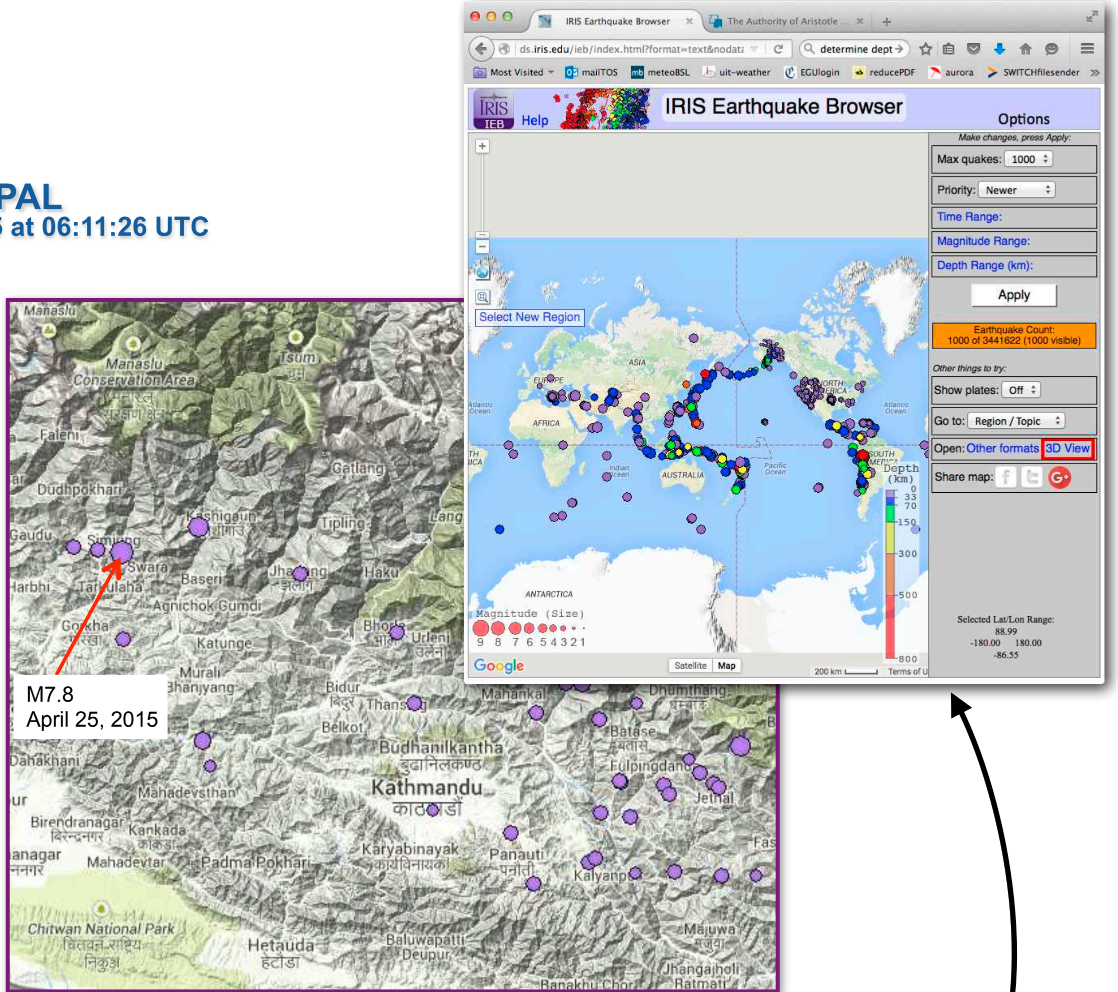
Magnitude 7.8 NEPAL
Saturday, April 25, 2015 at 06:11:26 UTC

IRIS Teachable Moments

This map shows the magnitude 7.8 earthquake (mainshock) and the distribution of 40 aftershocks of magnitude 4 or larger that occurred over the following 27 hours.

The aftershock distribution outlines the rupture zone of the mainshock. The rupture during the mainshock initiated beneath the epicenter and propagated toward the southeast.

On the next slide, a map of fault displacement during the earthquake is superimposed on this same map.



Map created using the IRIS Earthquake Browser: *www.iris.edu/ieb*

IRIS Earth quake Browser

10. Haupt- und Nachbeben

... - Nachbeben

IRIS Teachable Moments

Magnitude 7.3 NEPAL
Tuesday, May 12, 2015 at 07:05:19 UTC

IRIS Teachable Moments

Magnitude 7.8 NEPAL
Saturday, April 25, 2015 at 06:11:26 UTC

A magnitude 6.7 aftershock was felt on Sunday in Nepal, India and Bangladesh, and more avalanches were reported near Mt. Everest. Aftershocks following the magnitude 7.8 mainshock have resulted in additional damage and have been a major disruption to recovery efforts.

10

Aftershock sequences follow predictable patterns as a group, although the individual earthquakes are themselves not predictable. The graph shows how the number of aftershocks and the magnitude of aftershocks decay with increasing time since the main shock. The number of aftershocks also decreases with distance from the main shock.

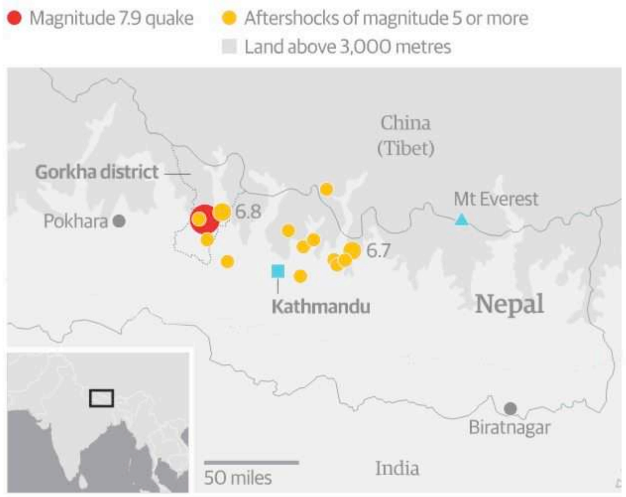


Image modified from the Guardian

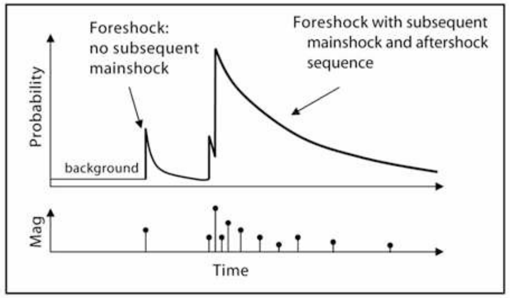
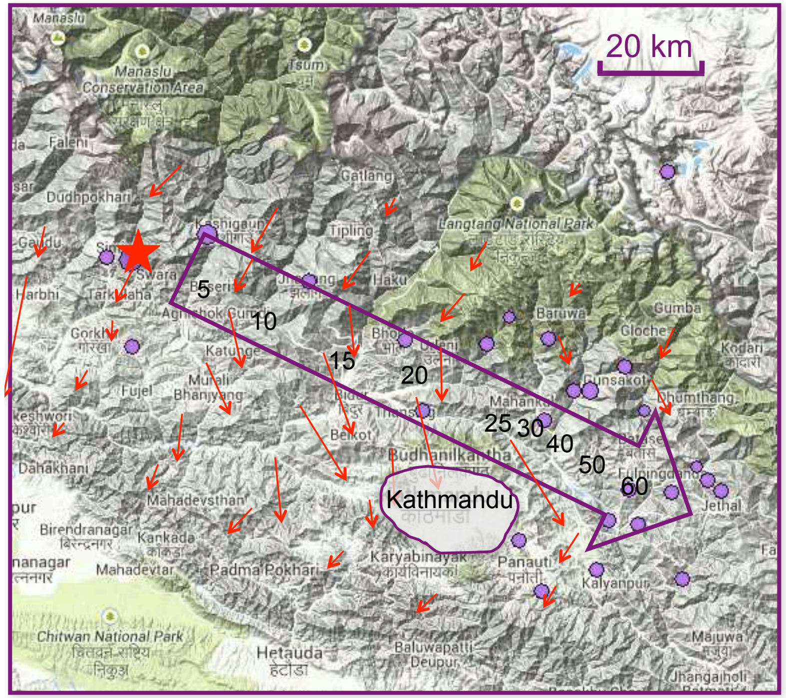


Image and text courtesy of the US Geological Survey

Bruchfläche · Versatz = Grösse des Erdbebens

Magnitude 7.8 NEPAL
Saturday, April 25, 2015 at 06:11:26 UTC

This map shows fault displacement during this earthquake. The red star is the epicenter while the purple arrow shows the direction of rupture propagation towards the southeast. Contours show the rupture front in 5 second increments after rupture initiation. Small red arrows show the direction and amount of motion of the rocks above the fault with respect to the rocks below the fault. The amount of slip is shown by color of shading. Maximum fault displacement of about 3 meters occurred in the rupture zone about 20 km north of Kathmandu.



11

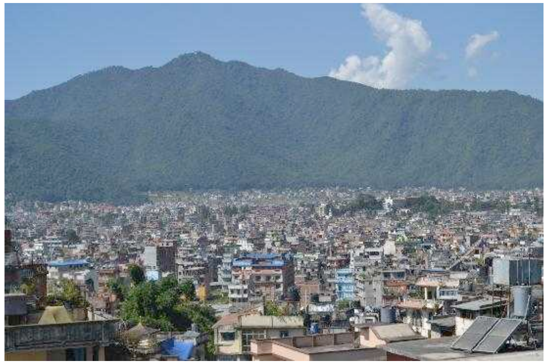
Ausbreitungsgeschwindigkeit: in 60 s ca. 100 km --- Maximaler Versatz: ca. 3 m

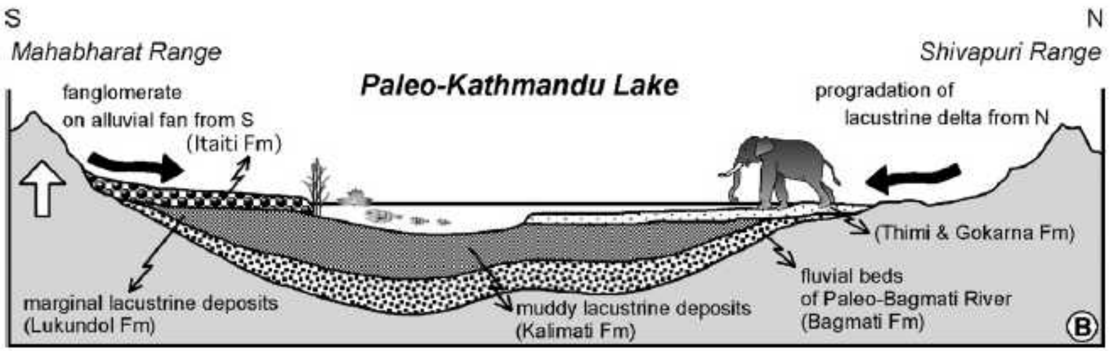
Vulnerabilität

12

Magnitude 7.8 NEPAL
Saturday, April 25, 2015 at 06:11:26 UTC

Because it is built in a basin underlain by lake sediment, Kathmandu was particularly vulnerable during this earthquake. The city is located in a broad valley surrounded by the Himalayas. This valley was formerly the site of a lake within which river delta and lake sediment accumulated to thickness of about 100 meters.





Simplified geologic cross-section of the Kathmandu Valley showing basin-fill sediments. Lakebed deposits are labeled "lacustrine" whereas sediments deposited by rivers are labeled "fluvial". After Sakai et al. Pleistocene rapid uplift of the Himalayan frontal ranges recorded in the Kathmandu and Siwalik basins, Palaeogeography, Palaeoclimatology, Palaeoecology, v. 241, p.1 6–27, 2006.

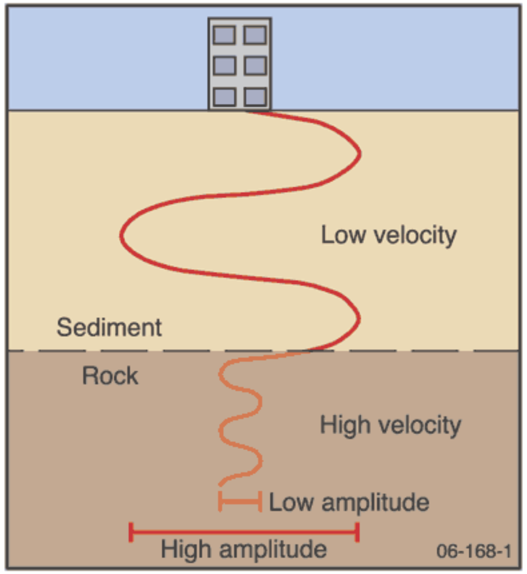
Amplifikation

13

Magnitude 7.8 NEPAL
Saturday, April 25, 2015 at 06:11:26 UTC

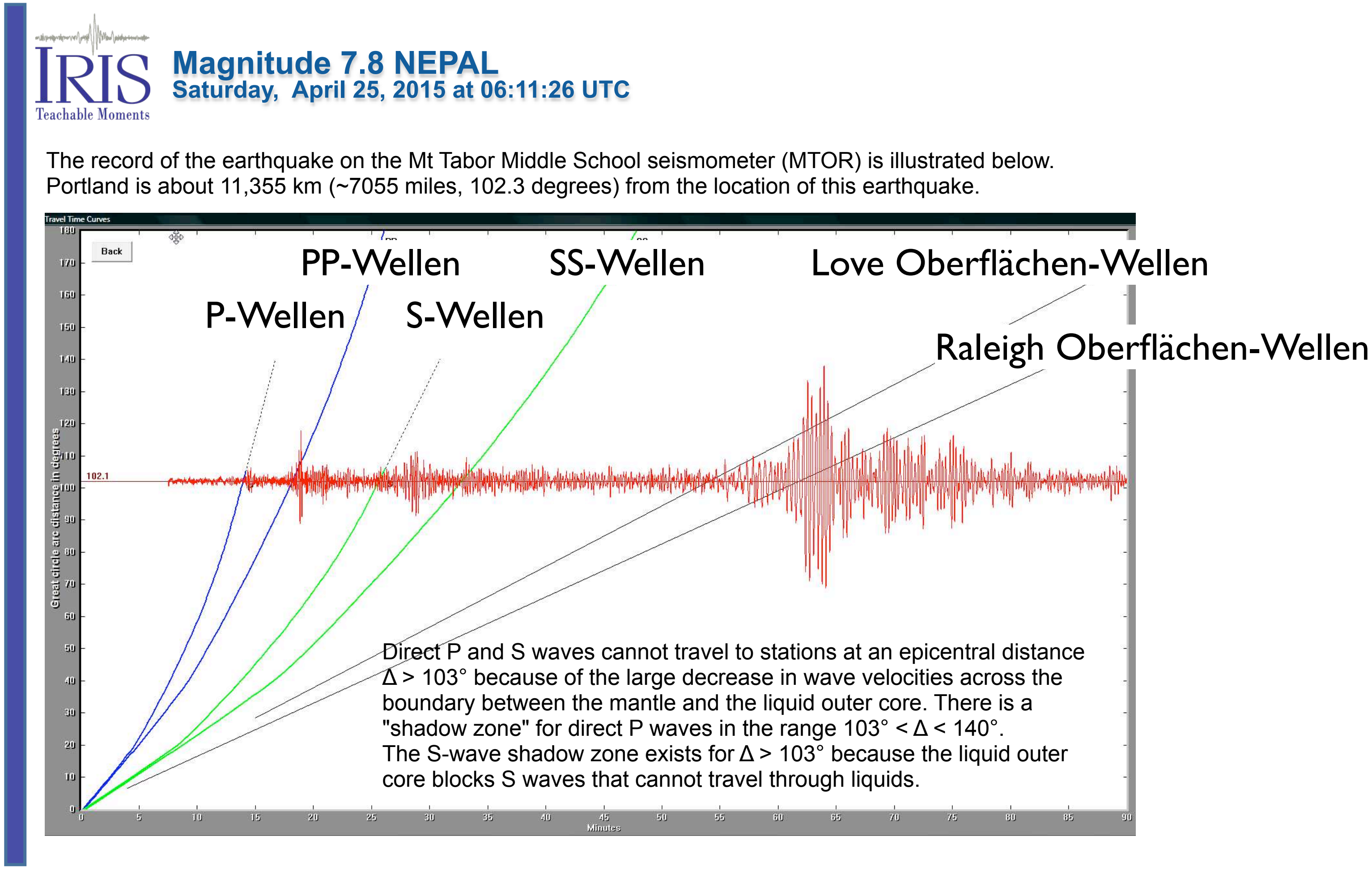
This earthquake was destructive due to both the shallow depth (15 km), and the fact that Kathmandu lies in a basin filled with about 2000 feet of soft sediment.

Sedimentary basins can have a large effect on ground motion above them. Earthquake waves travel at high velocity through the stiff, crystalline rock of the crust but slow dramatically when entering the basin. This increases the amplitude of the earthquake waves within the basin fill. In addition, the sharp density contrast of the soft basin rocks with surrounding material can cause waves to reflect, trapping energy in the basin for a period of time. This extends the duration of shaking.



Seismogramm der Universität Portland

14



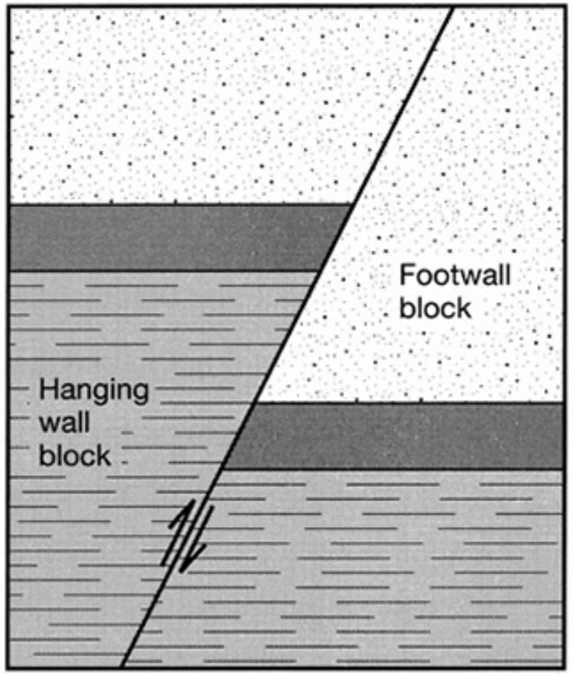
Deformation in der Lithosphäre

Brechen und Fliessen

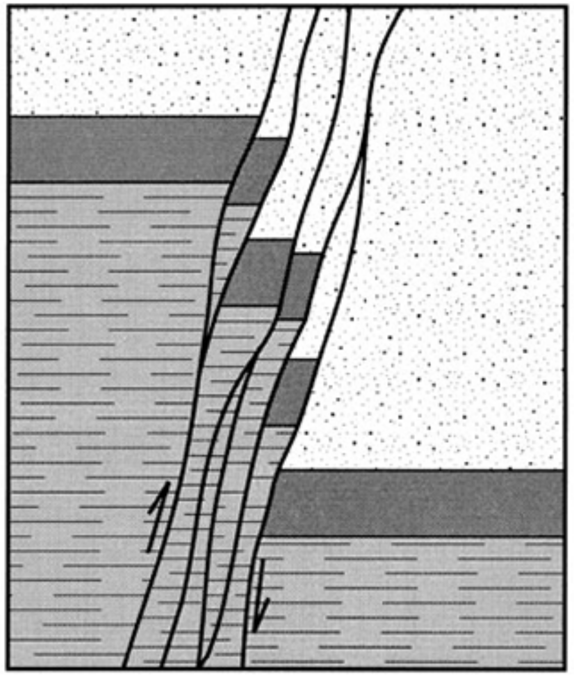
Gestürzte Säulen des Zeustempels
(Olympia, Griechenland)

geflossene Kalkplatte
(Geologisches Institut Universität Toulouse)

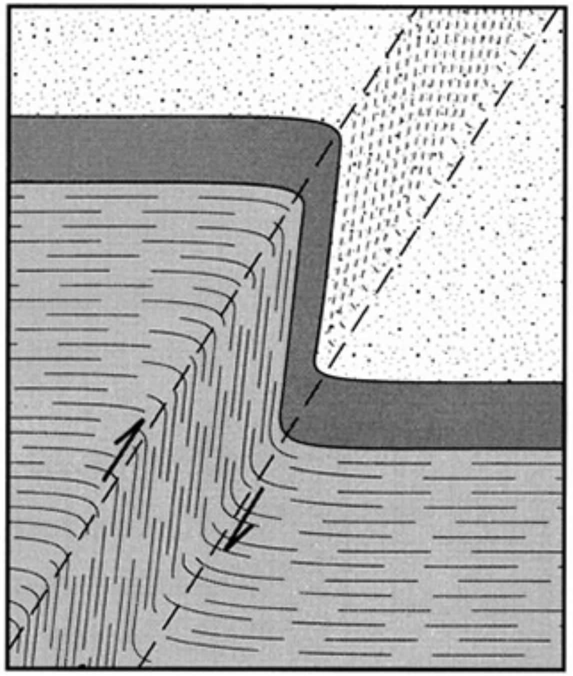
Spröd - Duktil Übergang



Bruch

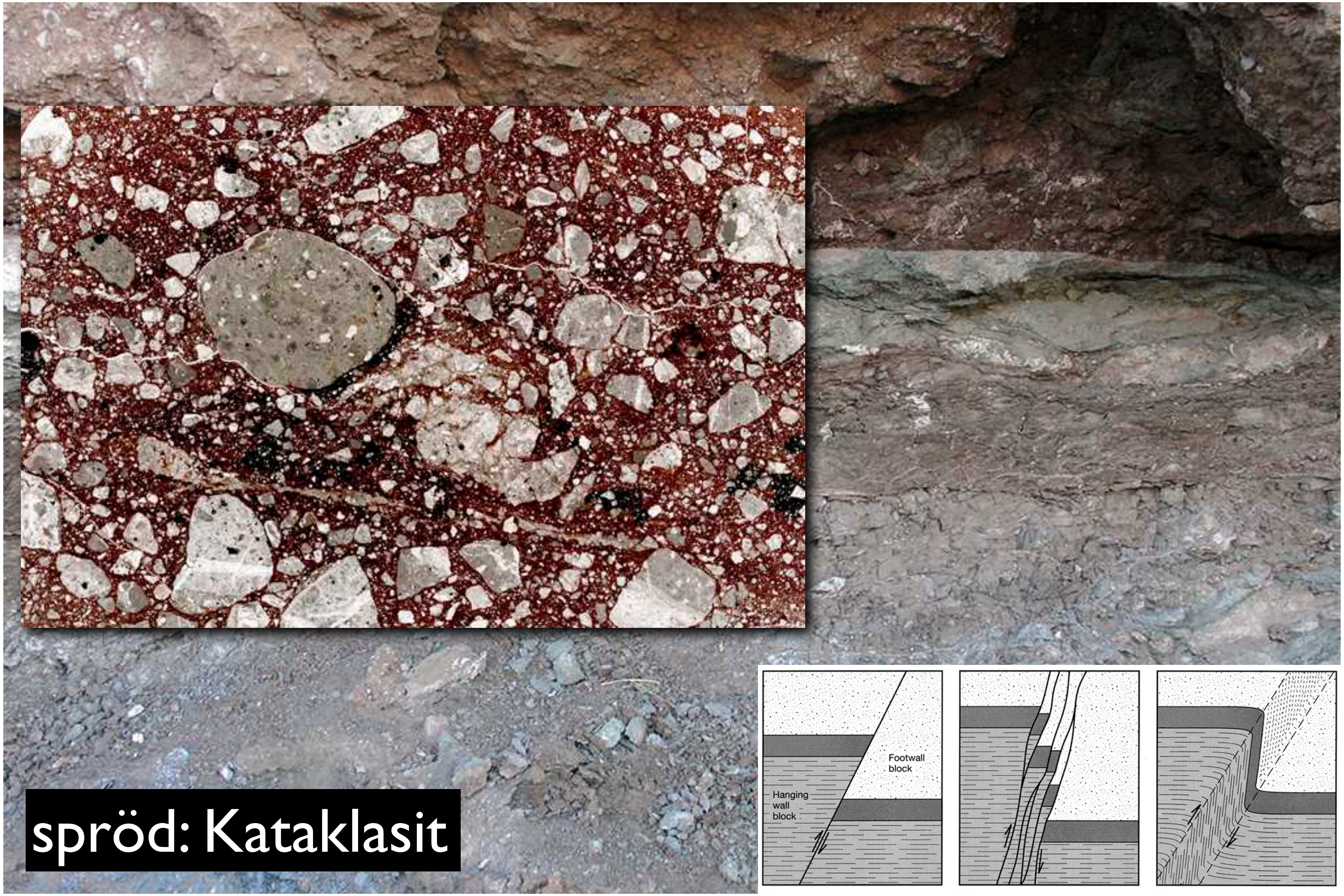


Bruchzone

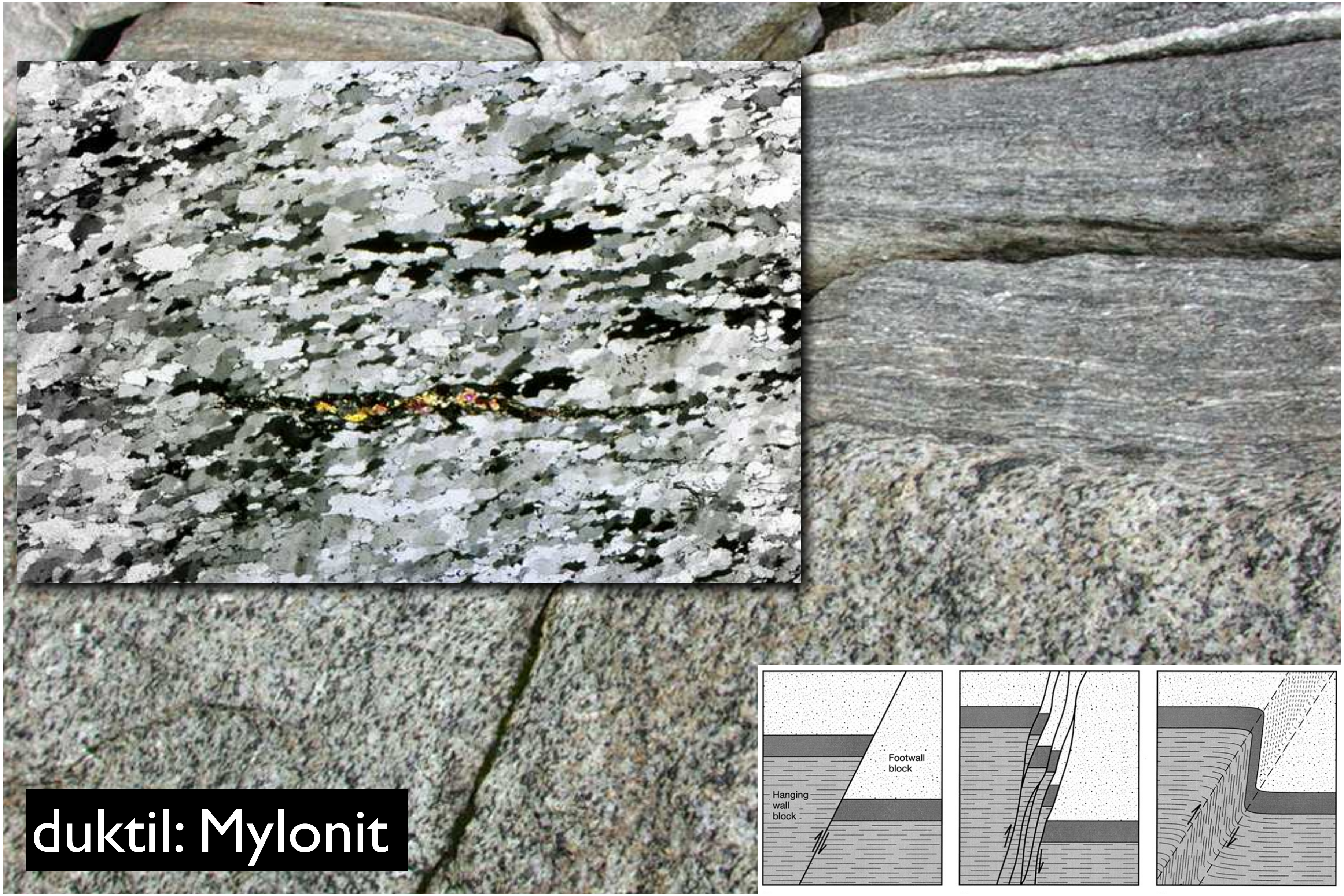


Duktile Scherzone

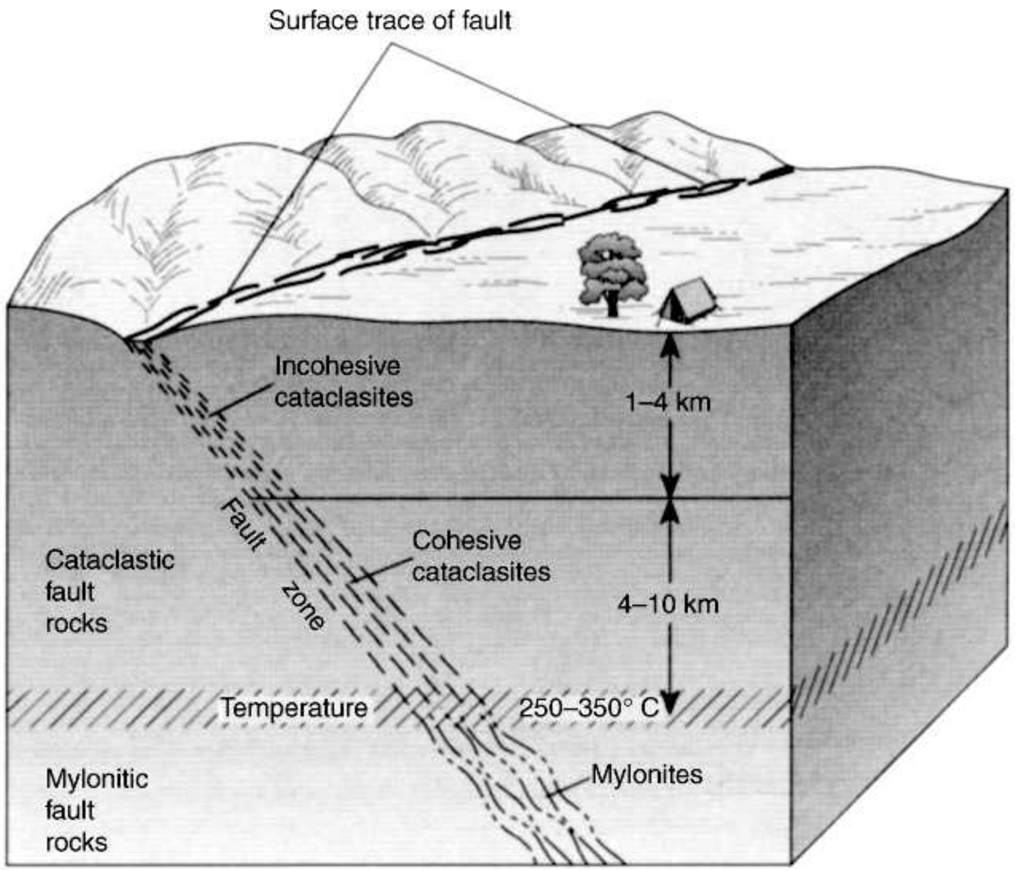
Spröd - Duktil Übergang

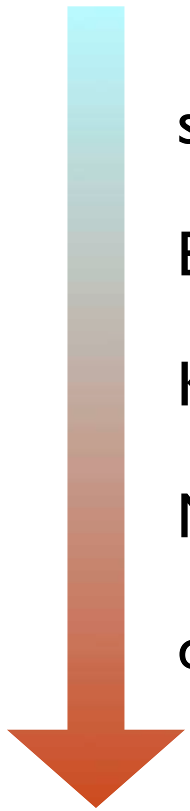


Spröd - Duktil Übergang

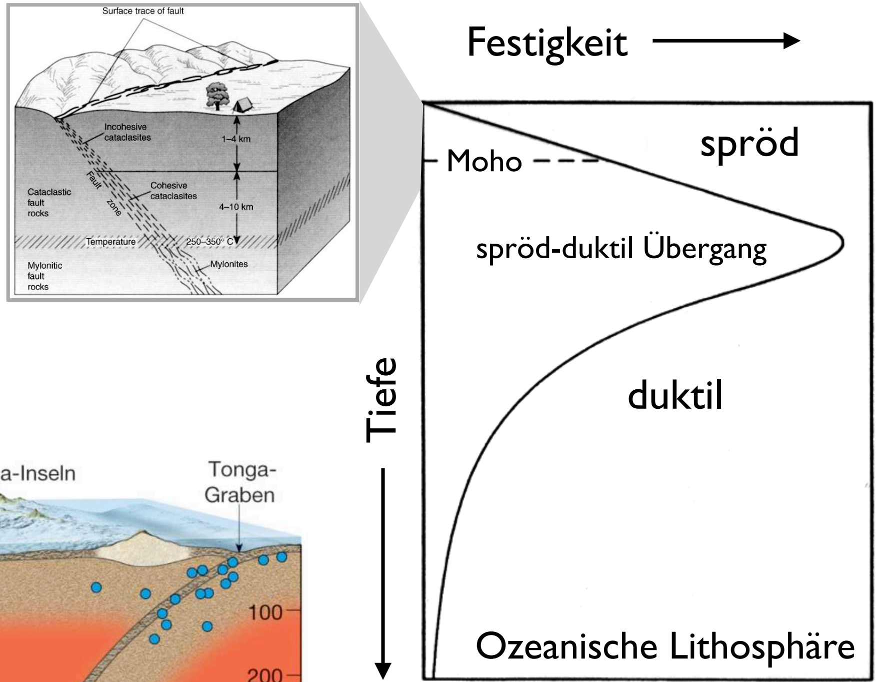


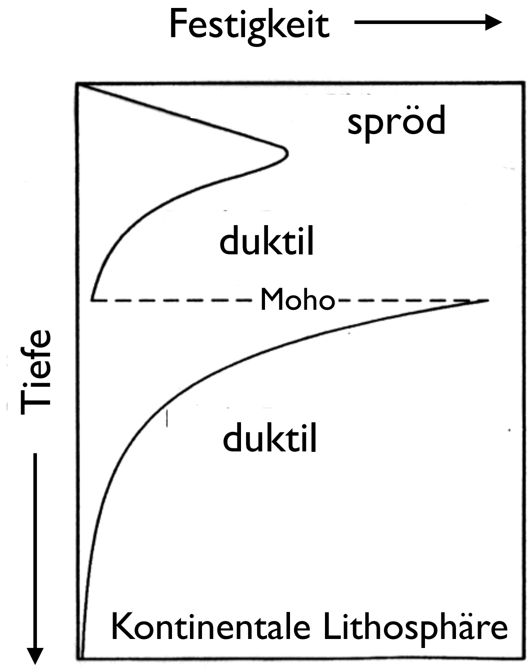
Spröd - Duktil Übergang

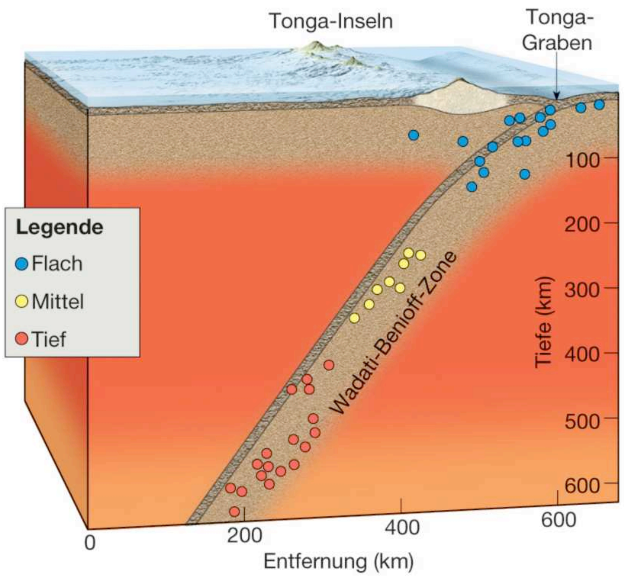




Festigkeits - Profil der Lithospjäre

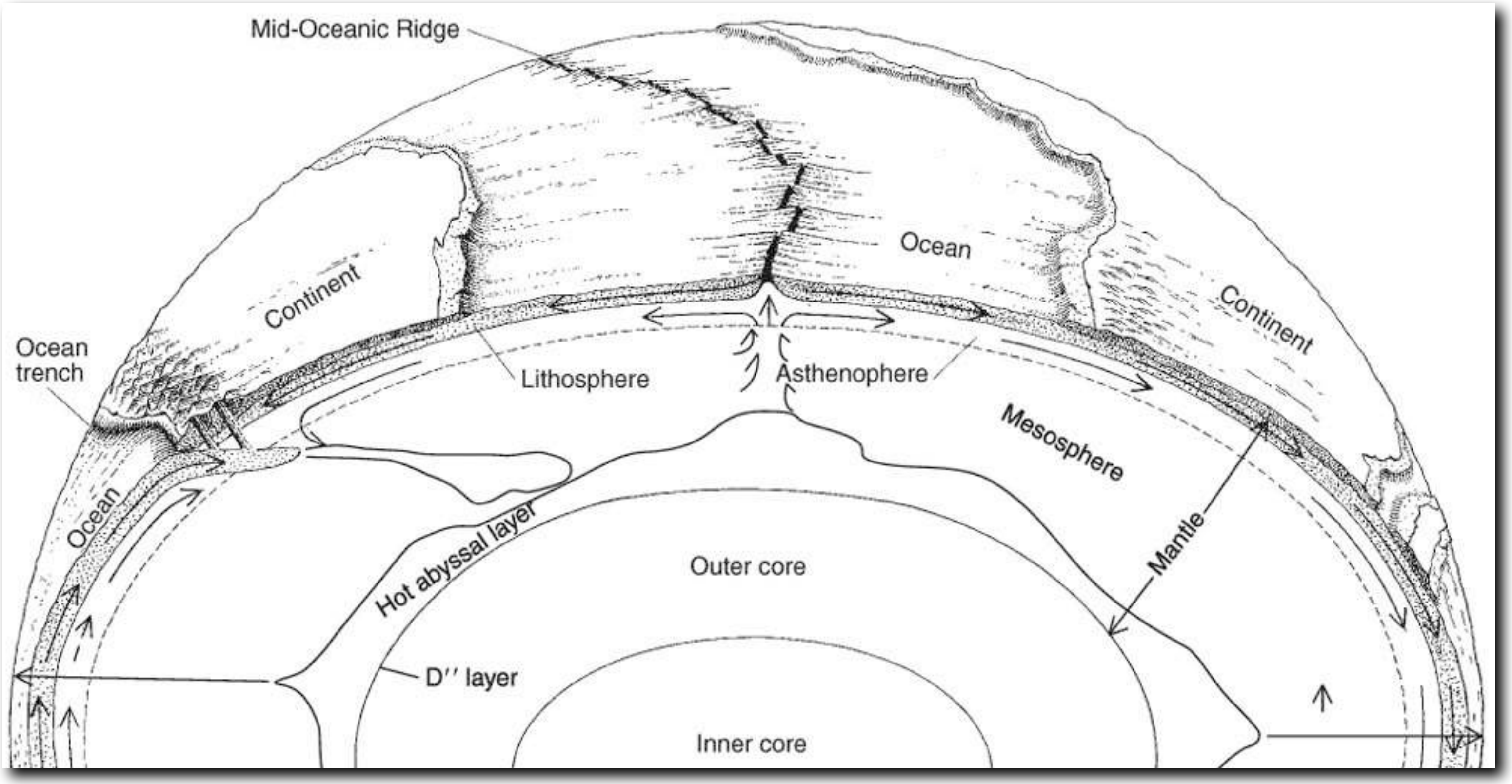






Deformationsraten - geologische Gechwindigkeiten

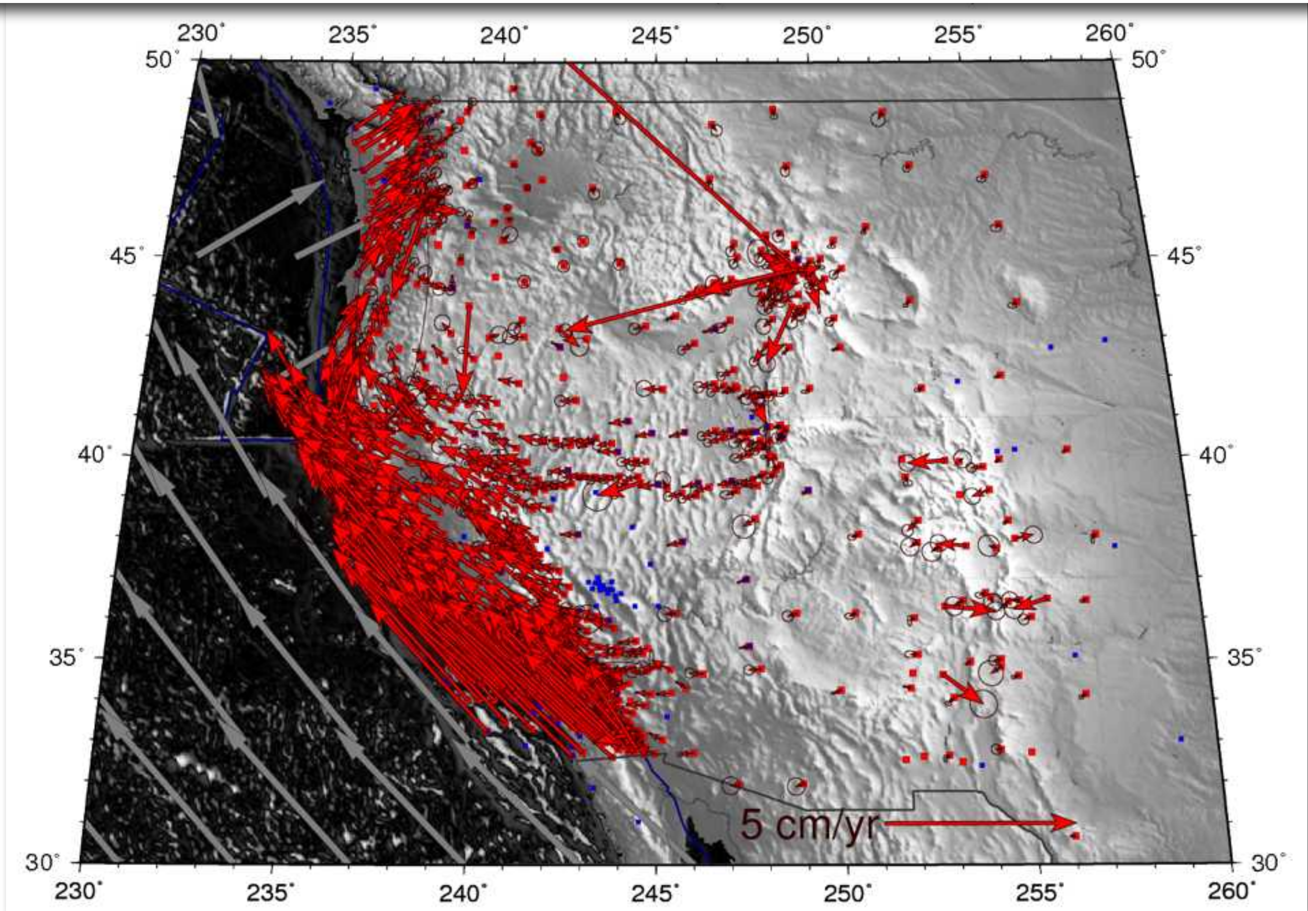
Plattenbewegung



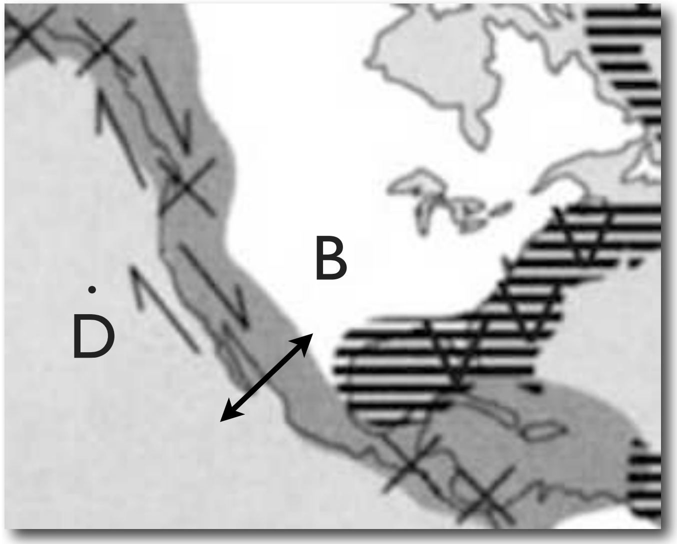
Geschwindigkeit	km / Stunde	m / Sekunde
Auto:	100 km / h	~30 ms^{-1}
zu Fuss:	3.6 km / h	1 ms^{-1}
tektonische Platten:	3 cm / Jahr	~10^{-8} ms^{-1}

was ist langsam - was ist schnell ?

Momentane Geschwindigkeiten:
1 bis 10 cm / Jahr
$= 10^{-2} - 10^{-1}$ m / 31'536'000 s $\approx 10^{-9}$ ms^{-1}



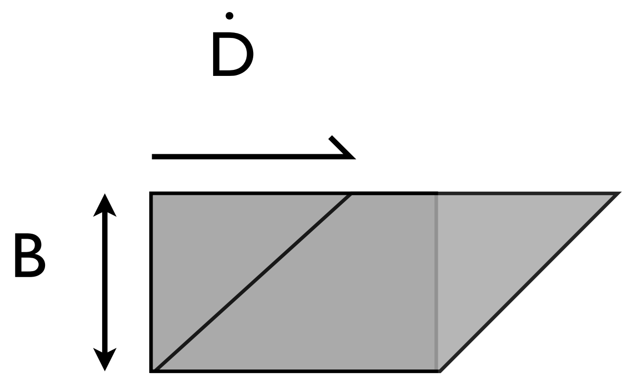
Deformationsraten an Plattengrenzen



Verformungsrate

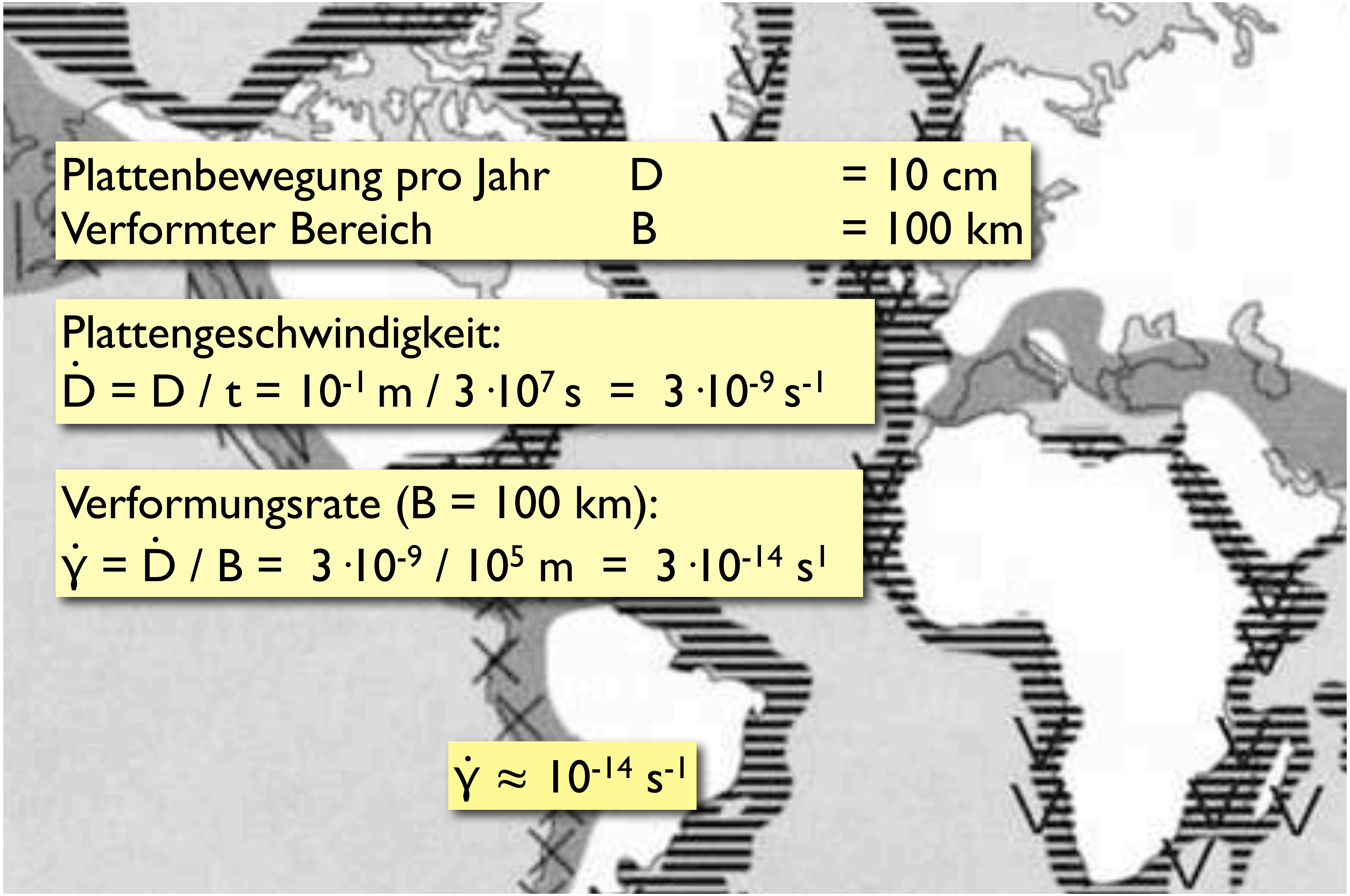
$$\dot{\gamma} = \frac{\text{Geschwindikeit}}{\text{Breite}}$$

Deformationsrate
(-geschwindikeit)



$$\dot{\gamma} = \frac{D}{B}$$

geologische Deformationsraten



Plattenbewegung pro Jahr	D	= 10 cm
Verformter Bereich	B	= 100 km

Plattengeschwindigkeit:

$\dot{D} = D / t = 10^{-1}\, m / 3 \cdot 10^{7}\, s = 3 \cdot 10^{-9}\, s^{-1}$

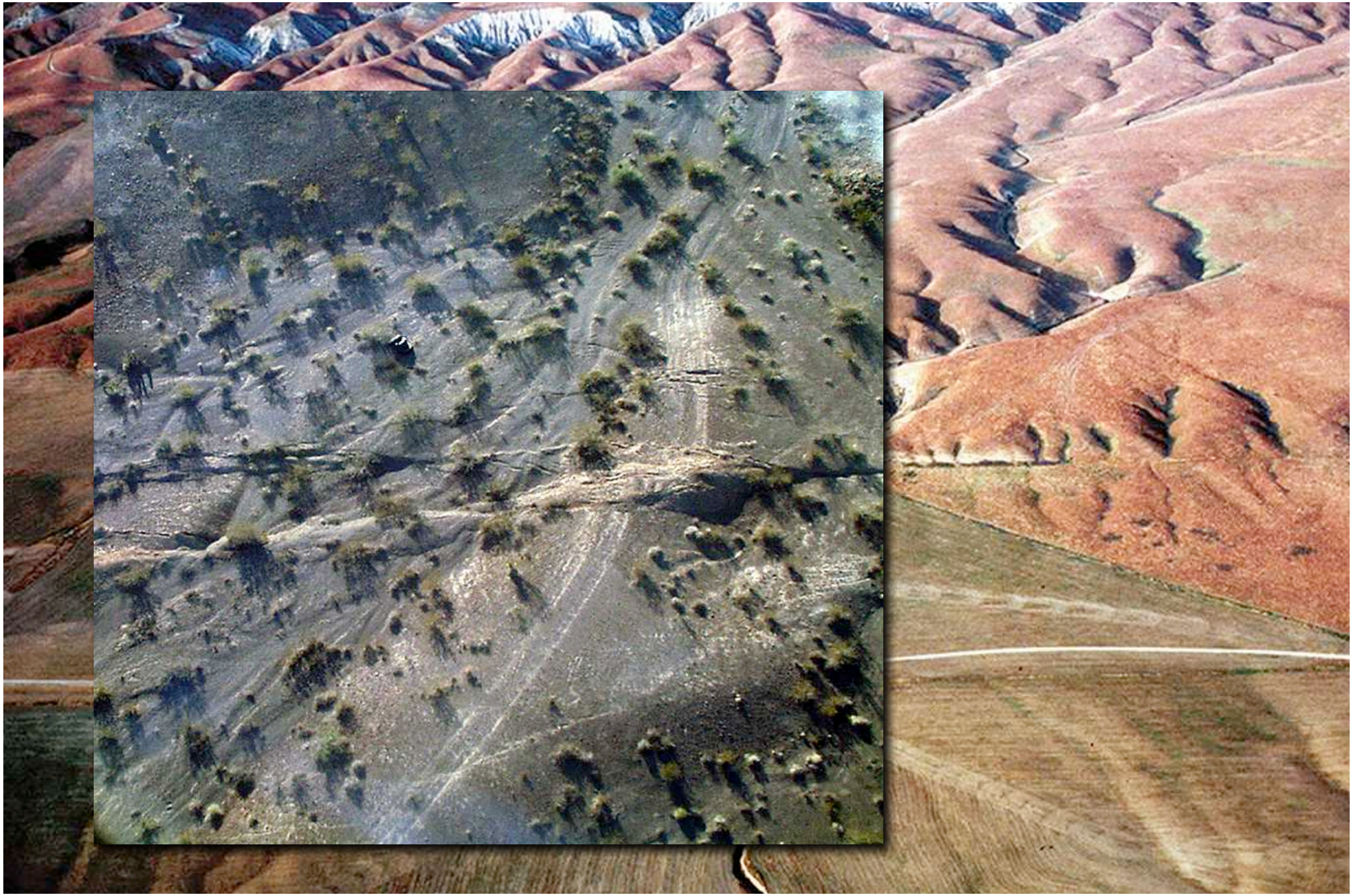
Verformungsrate (B = 100 km):

$\dot{\gamma} = \dot{D} / B = 3 \cdot 10^{-9} / 10^{5}\, m = 3 \cdot 10^{-14}\, s^{1}$

$\dot{\gamma} \approx 10^{-14}\, s^{-1}$

Lokalisierung der Deformation

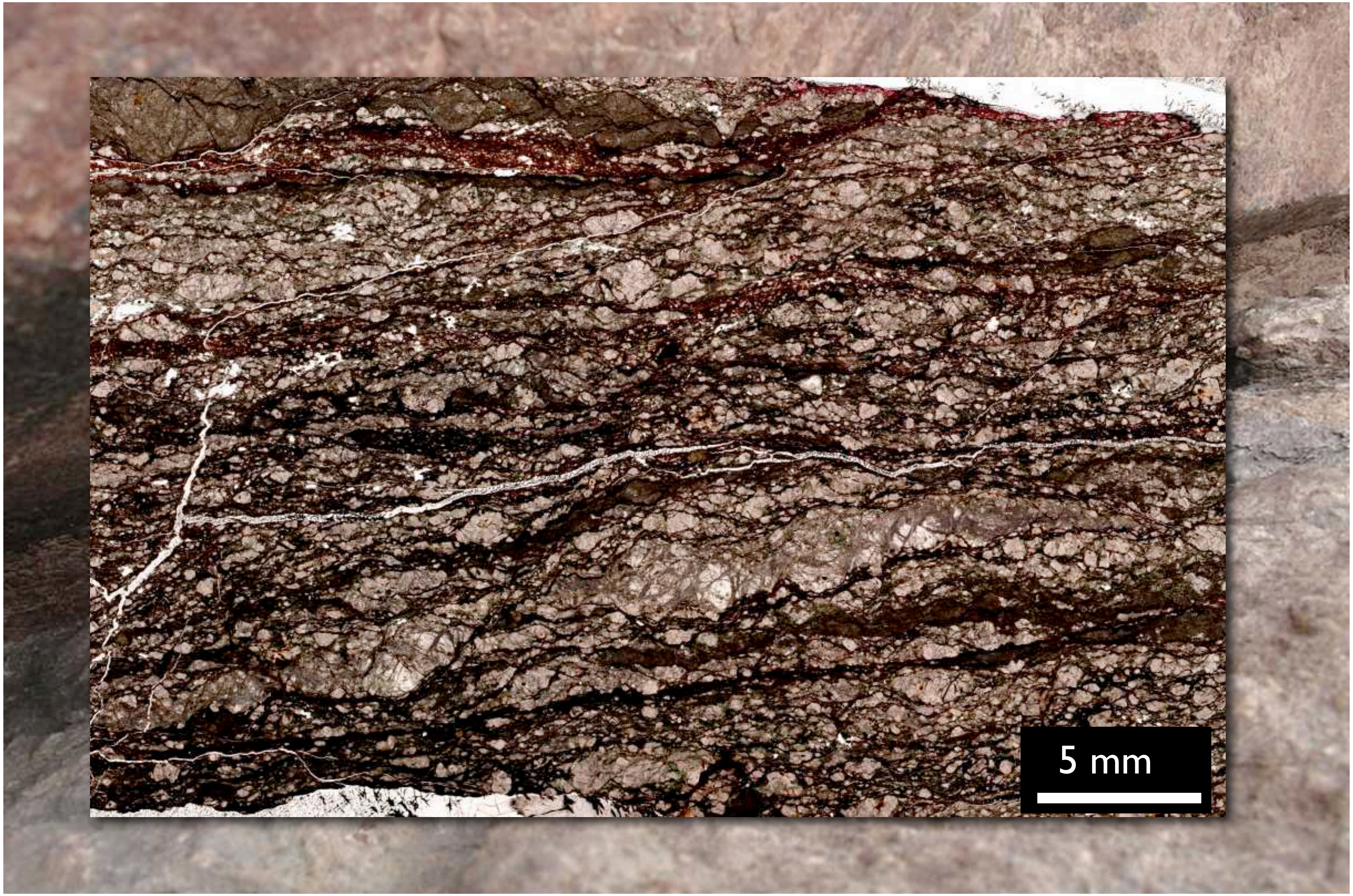
Lokalisierung der Deformation



vom grossen ins kleine

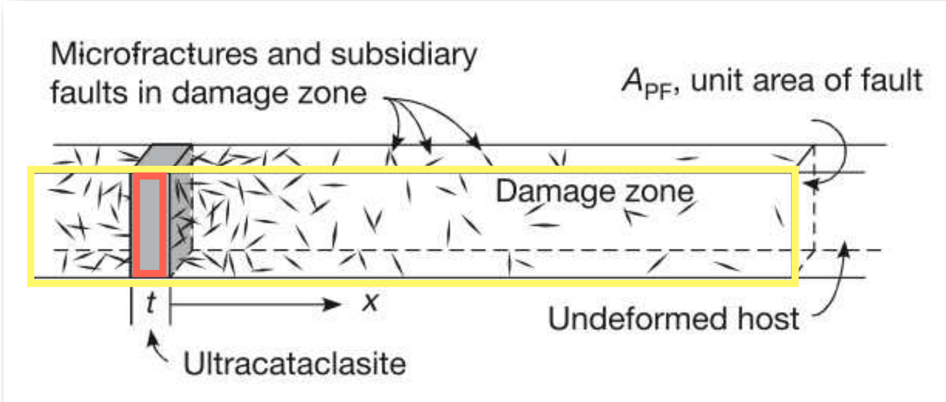
vom grossen ins kleine

vom grossen ins kleine



örtlich und zeitlich lokalisiert...

$\dot{\gamma} \approx 10^{-14}\ s^{-1}$



bei konstanter Plattengeschwindigkeit: $\dot{D} = D / t = 3$ cm / Jahr

100km → 100m (Faktor 10^3)

$\Rightarrow \dot{\gamma} = 10^{-11}\ s^{-1}$

100km → 1mm (Faktor 10^8)

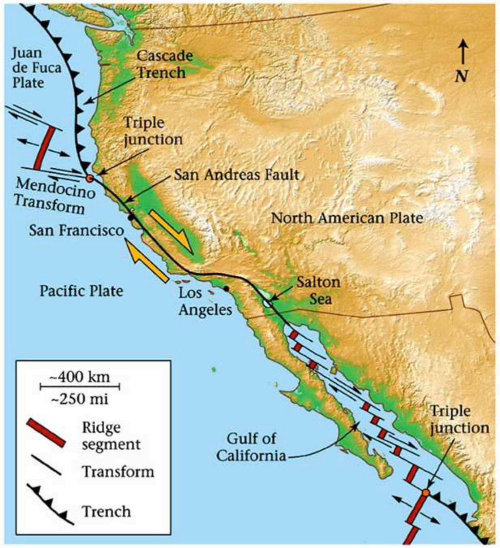
$\Rightarrow \dot{\gamma} = 10^{-6}\ s^{-1}$

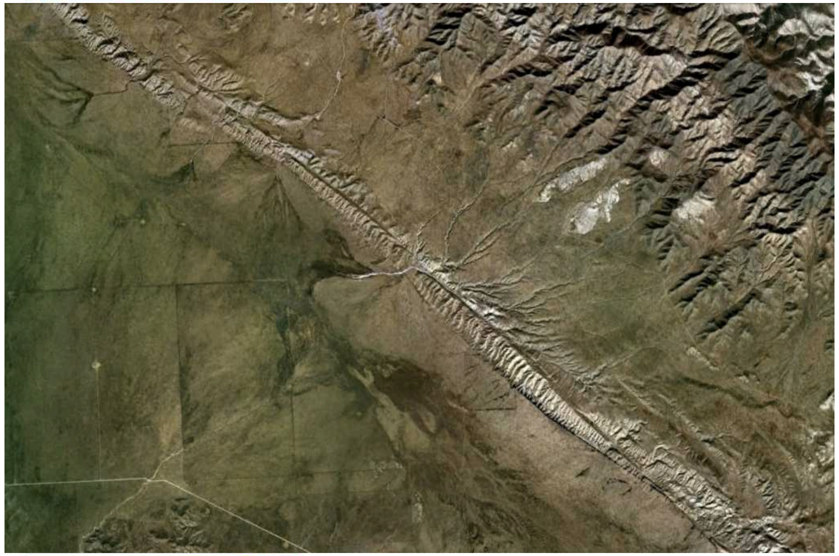
Erdbeben (stick-slip): in 700 Jahren $700 \cdot 3$ cm = 21 m Versatz

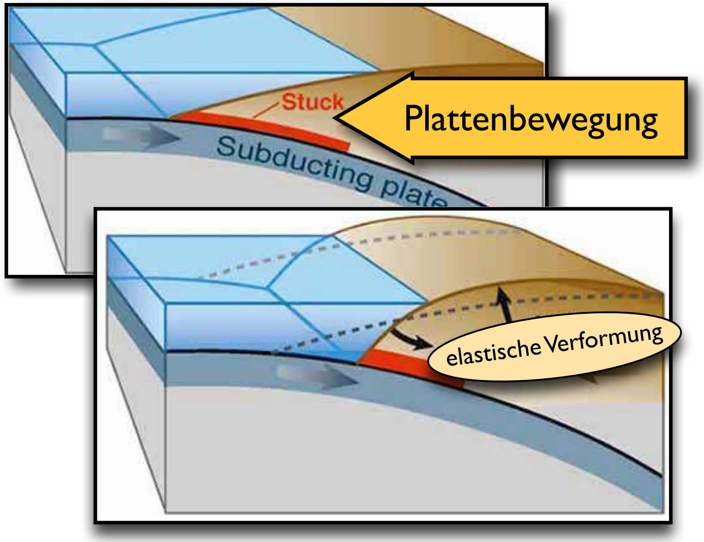
21m / 30s ≈ 1 m/s (über 1 mm): $\dot{\gamma} = (1\ m/s) / 0.001m = 10^{+3}\ s^{-1}$

Anatomie eines Erdbebens

Platten bewegen sich gegeneinander



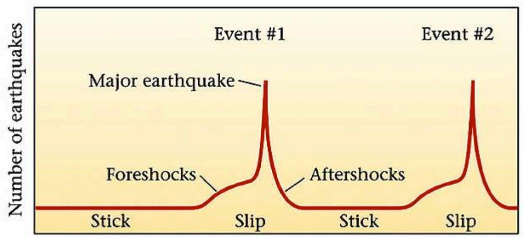


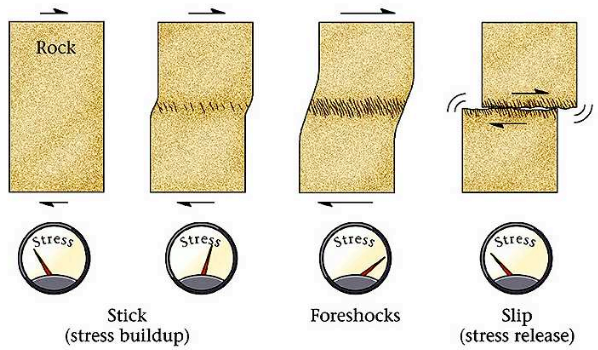


Bewegung ist nicht kontinuierlich:

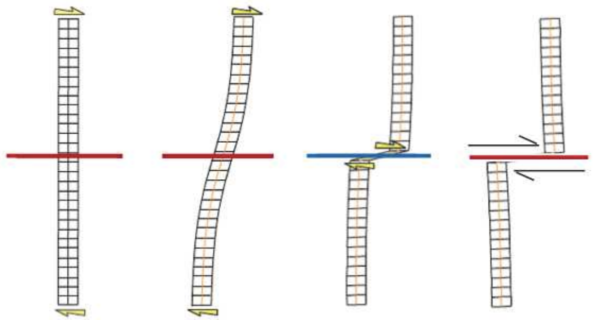
- Hindernisse
- Festigkeit des Materials
- Reibung an der Bruchfläche

Zeitlicher Ablauf

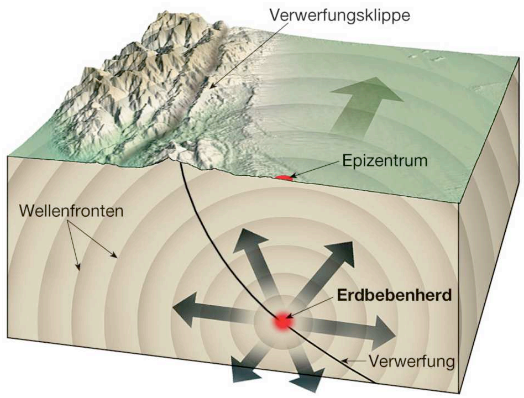




Zeit



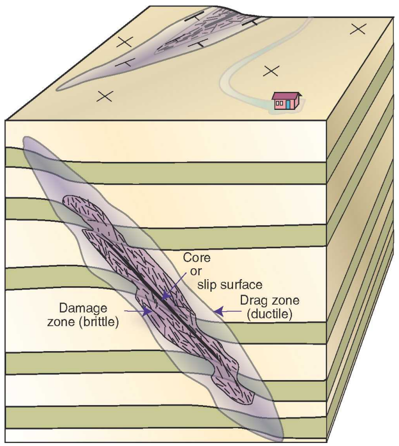
elastic strain co-seismic slip offset

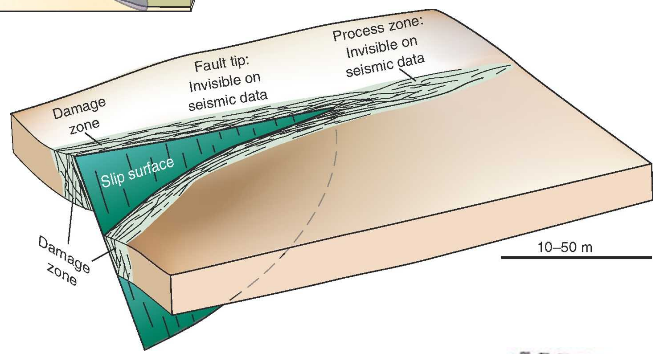


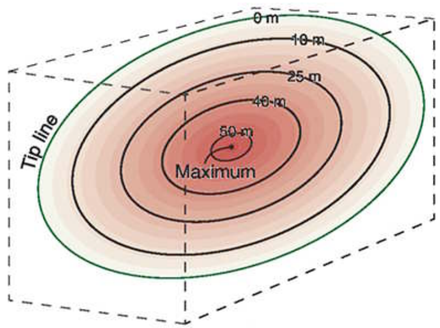
Verschiedene Bewegungen:

1. Plattenbewegung
2. Ausbreitung der Bruchfläche
3. Bewegung auf der Verwerfung
4. Ausbreitung seismischer Wellen

mit Erdbeben assozierte Geschwindigkeiten







Plattengeschwindigkeit:

v_{plate} = 10 cm/Jahr

Bruchbildung:

$v_{rupture}$ = 3-4 km/s

Relativbewegung der Gesteinskörper

v_{slip} ≈ 1 ms^{-1}

≈ 5 km/Stunde

Seismische Wellen:

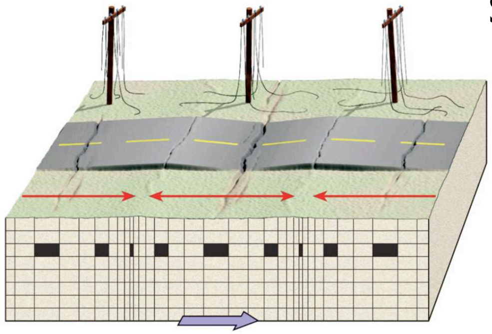
v_p v_s = 5-6 km/s

$v_{surface}$ = 3-4 km/s

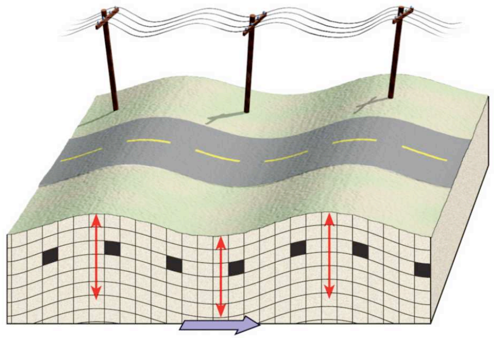
Seismische Wellen

Körperwellen

P-Wellen



S-Wellen

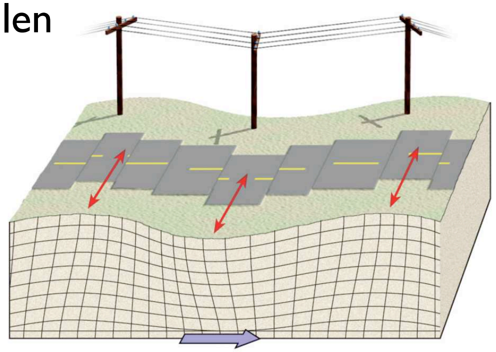


Bewegungsrichtung der Teilchen im Körper

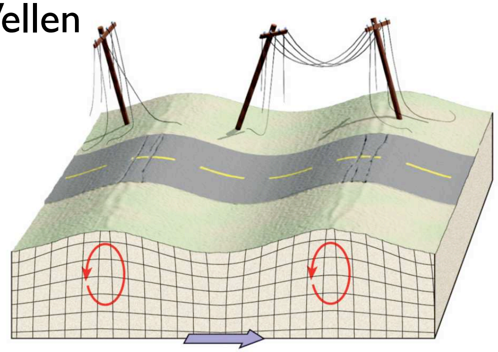
Fortpflanzungsrichtung der Welle

Oberflächenwellen

Love-Wellen

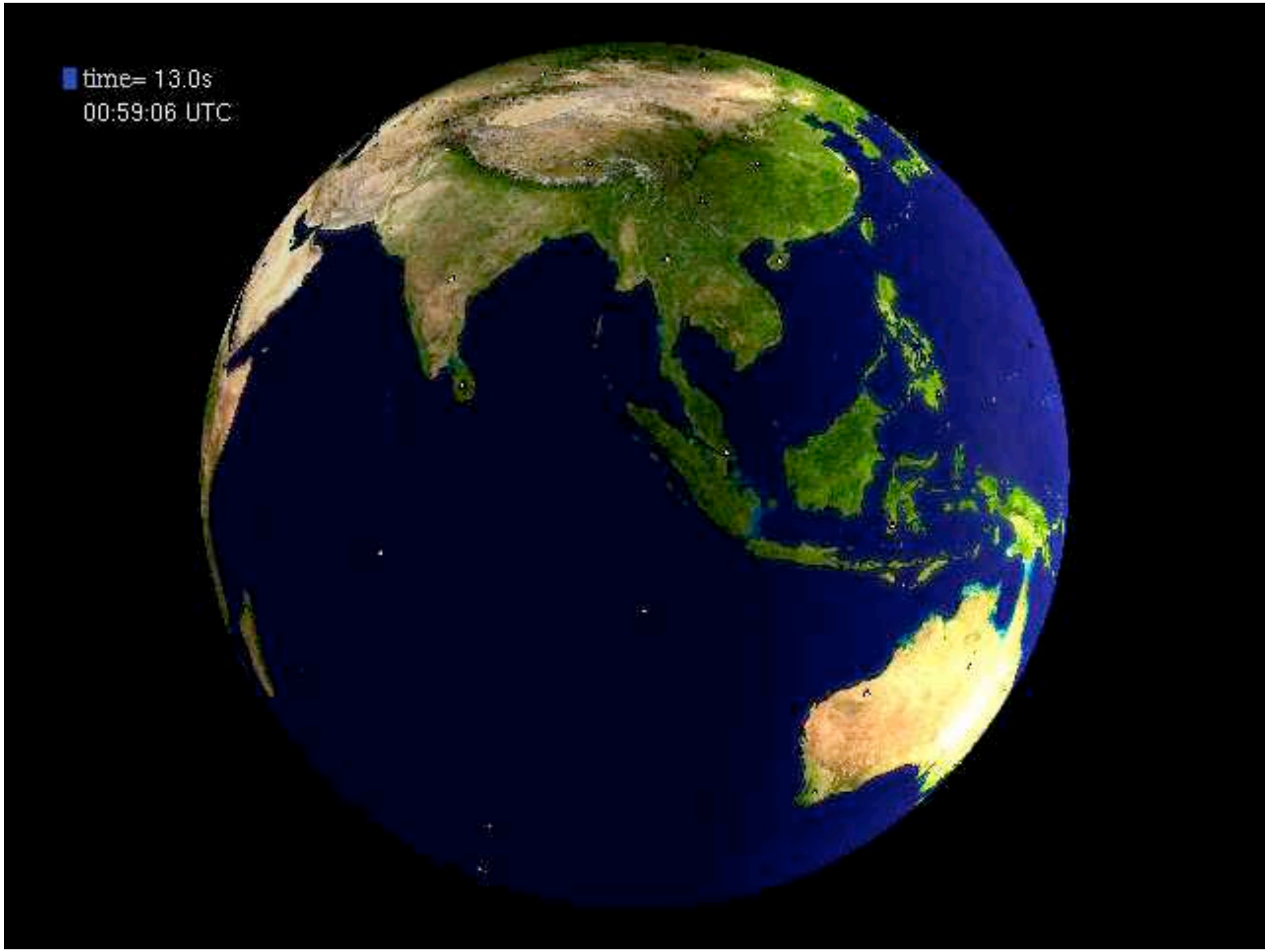


Raleigh-Wellen



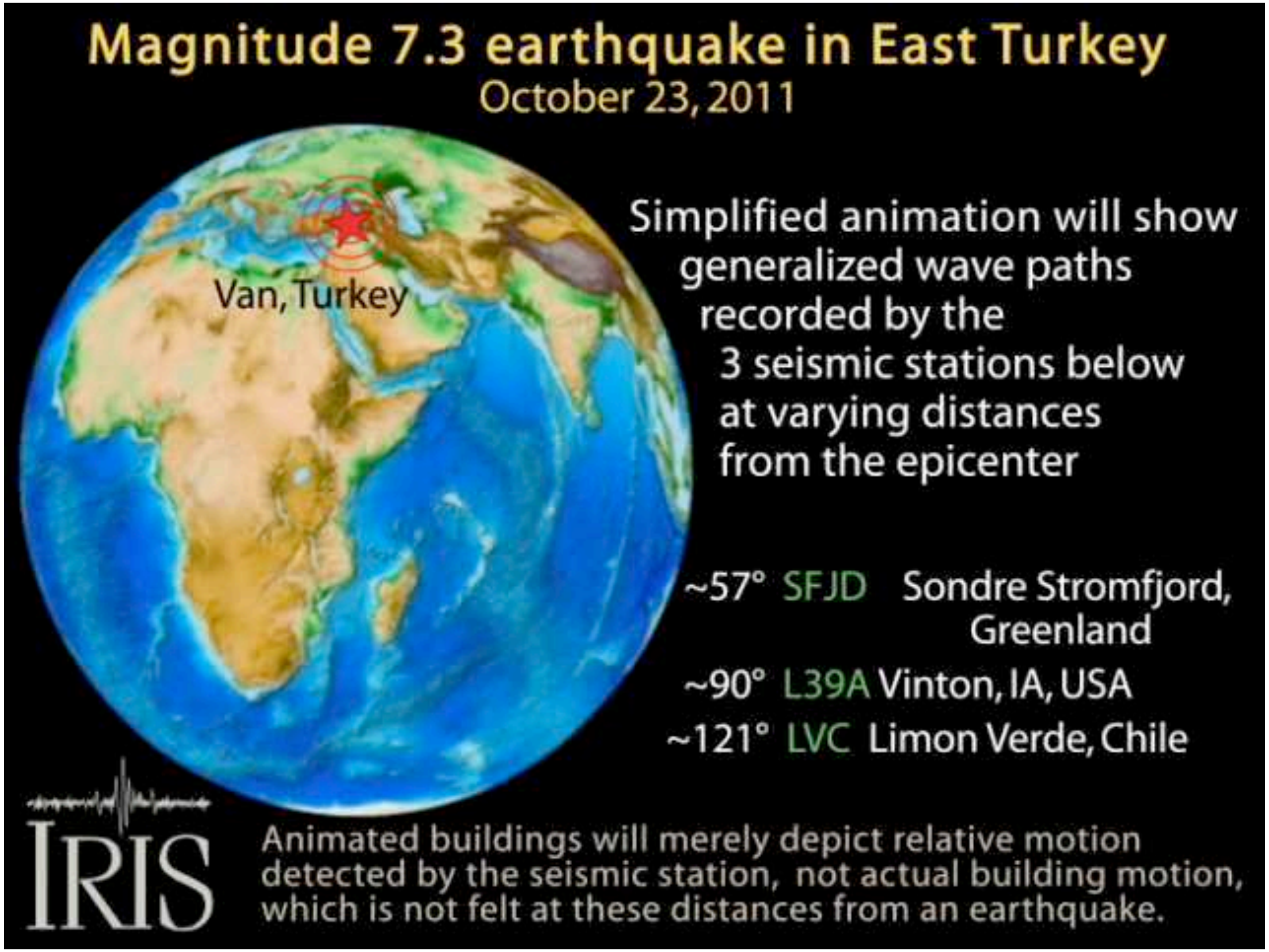
Oberflächenwellen sind zerströrisch → Erdbeben

Sumatre Erdbeben 26. Dezember 2004

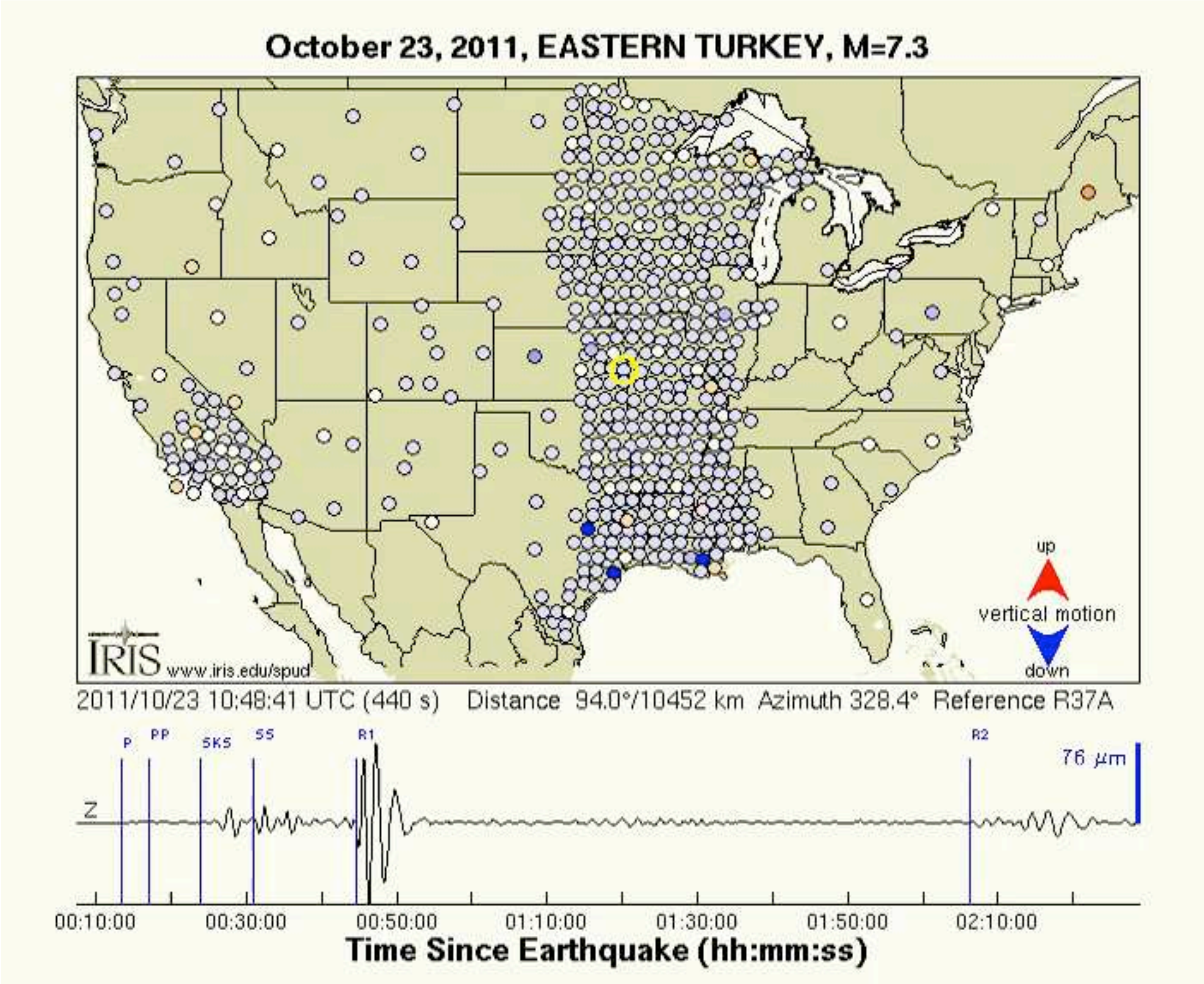


GOODsumatra_velocity_global.mpeg

P- S- (Körper-) und Oberflächenwellen

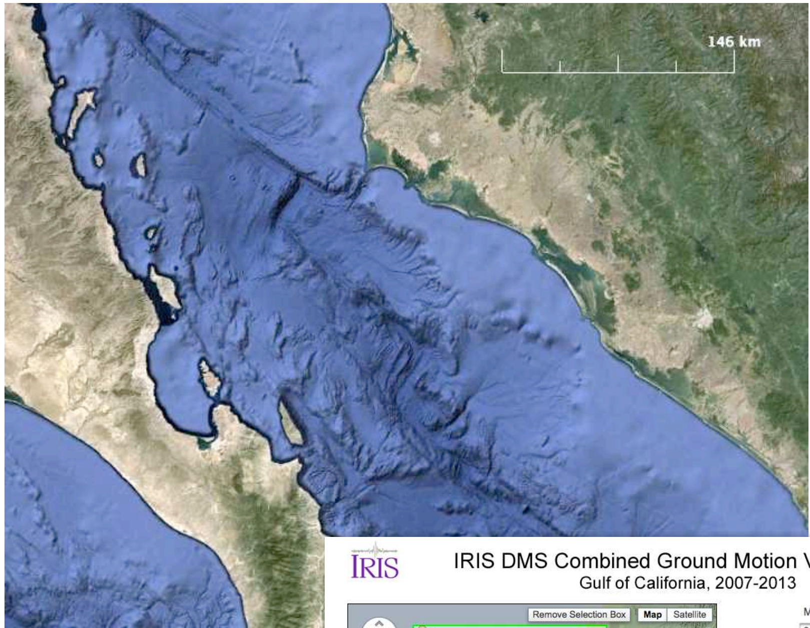


Türkei, 23. Oktober 2011

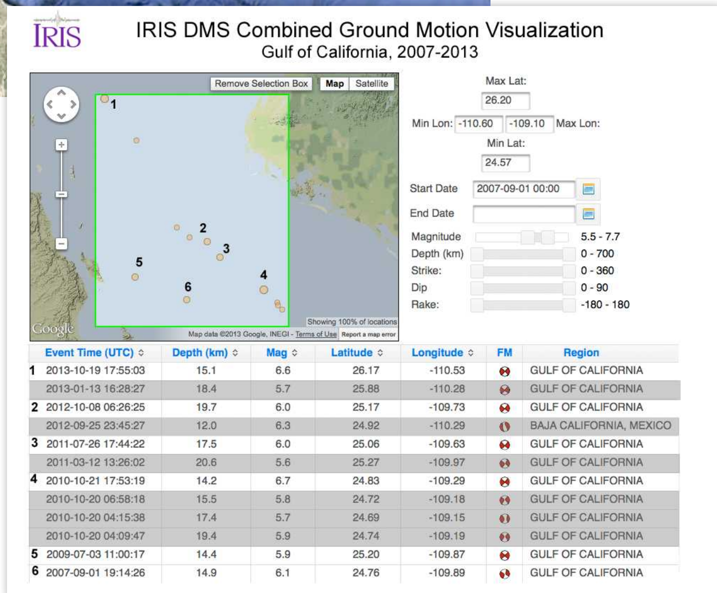


Transportable Array

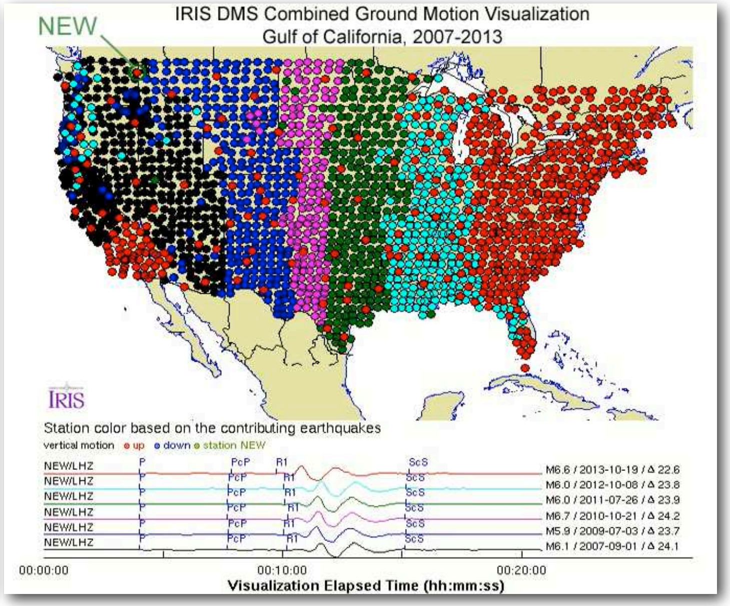
http://ds.iris.edu/ds/products/usarraygmv-super/



Sechs Erdbeben mit ± identischem Herd
(innerhalb 100 km)
(sinistraler strike slip)

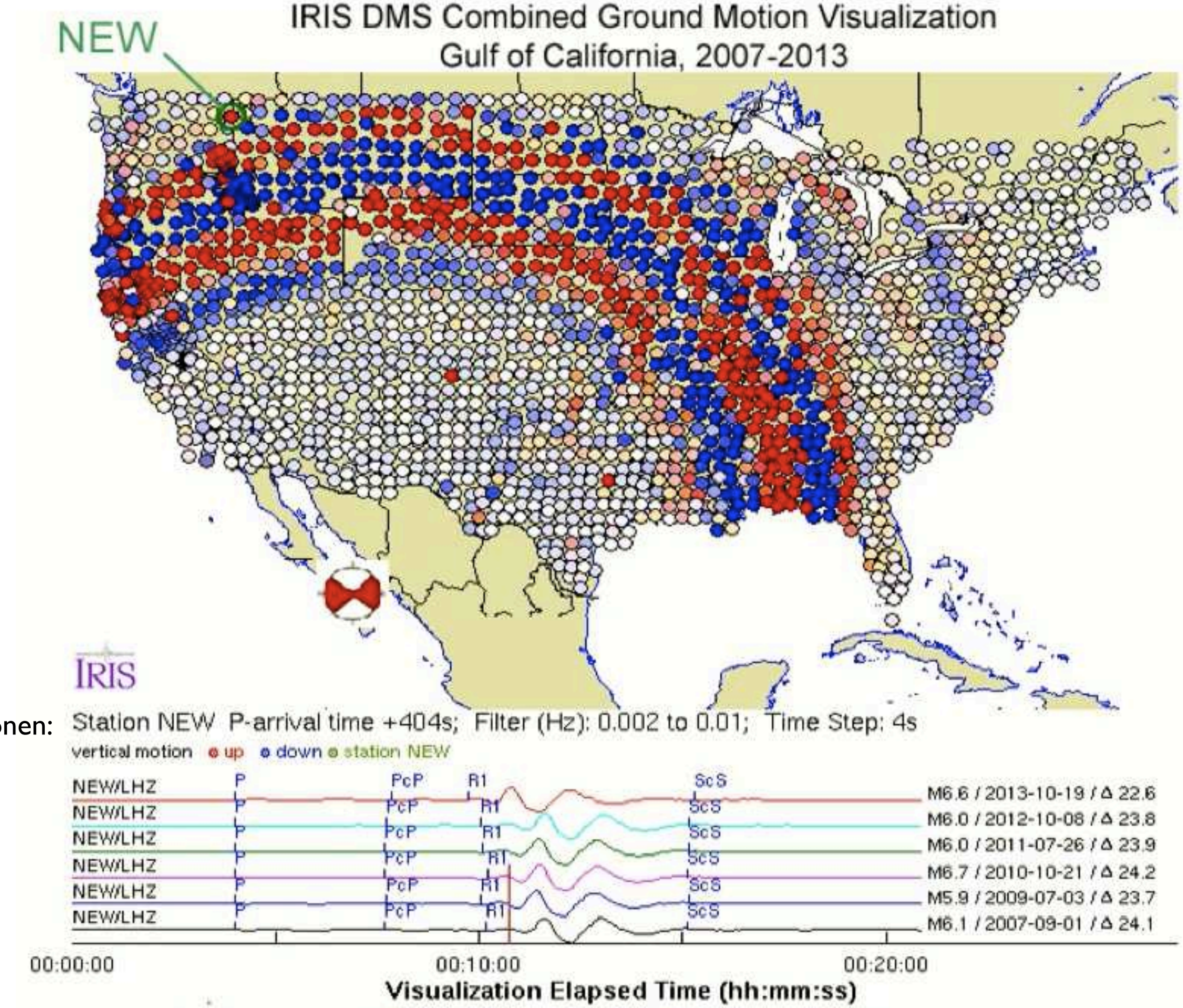


	Event Time (UTC)	Depth (km)	Mag	Latitude	Longitude	FM	Region
1	2013-10-19 17:55:03	15.1	6.6	26.17	-110.53		GULF OF CALIFORNIA
	2013-01-13 16:28:27	18.4	5.7	25.88	-110.28		GULF OF CALIFORNIA
2	2012-10-08 06:26:25	19.7	6.0	25.17	-109.73		GULF OF CALIFORNIA
	2012-09-25 23:45:27	12.0	6.3	24.92	-110.29		BAJA CALIFORNIA, MEXICO
3	2011-07-26 17:44:22	17.5	6.0	25.06	-109.63		GULF OF CALIFORNIA
	2011-03-12 13:26:02	20.6	5.6	25.27	-109.97		GULF OF CALIFORNIA
4	2010-10-21 17:53:19	14.2	6.7	24.83	-109.29		GULF OF CALIFORNIA
	2010-10-20 06:58:18	15.5	5.8	24.72	-109.18		GULF OF CALIFORNIA
	2010-10-20 04:15:38	17.4	5.7	24.69	-109.15		GULF OF CALIFORNIA
	2010-10-20 04:09:47	19.4	5.9	24.74	-109.19		GULF OF CALIFORNIA
5	2009-07-03 11:00:17	14.4	5.9	25.20	-109.87		GULF OF CALIFORNIA
6	2007-09-01 19:14:26	14.9	6.1	24.76	-109.89		GULF OF CALIFORNIA



Bodenbewegung

http://ds.iris.edu/ds/products/usarraygmv-super/



Messstationen:

Ost

↓

West

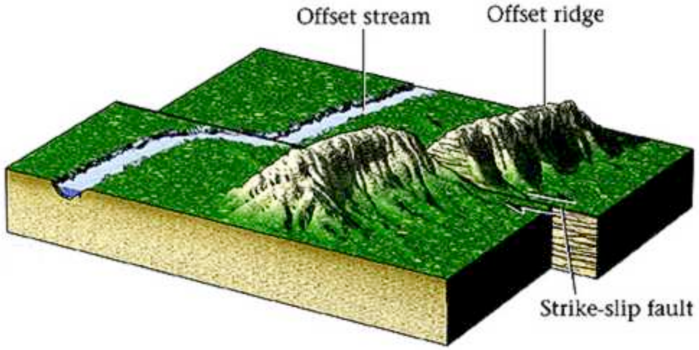
Komniniertes Resultat für 6 Erdbeben 2007-2013

Parkfield Erdbeben 28. September 2004

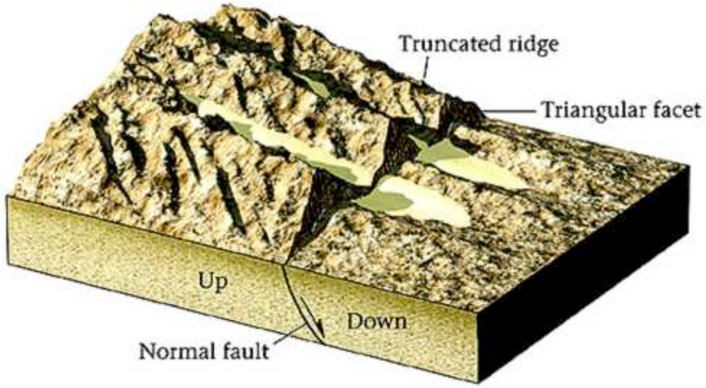
AOFT4-3ParkfieldEQ-USGS.mov, https://www.youtube.com/watch?v=J99VjkKaunA

mögliche Folgen eines Erdbeben

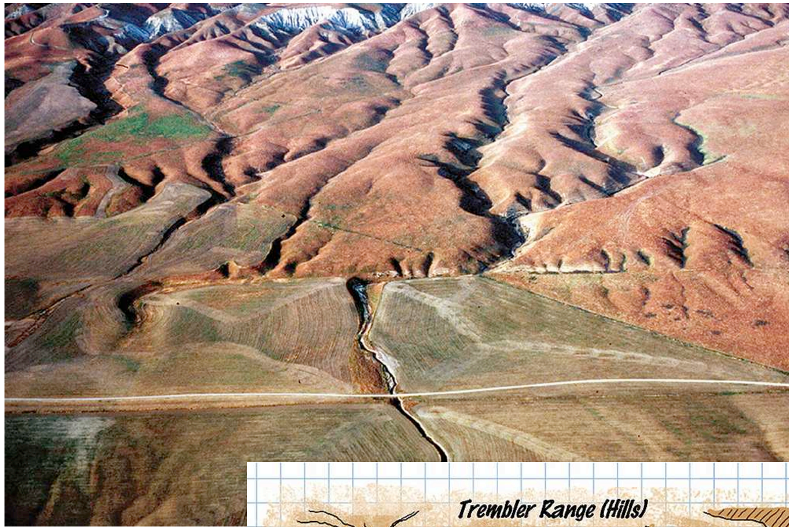
Topographische Ausprägung

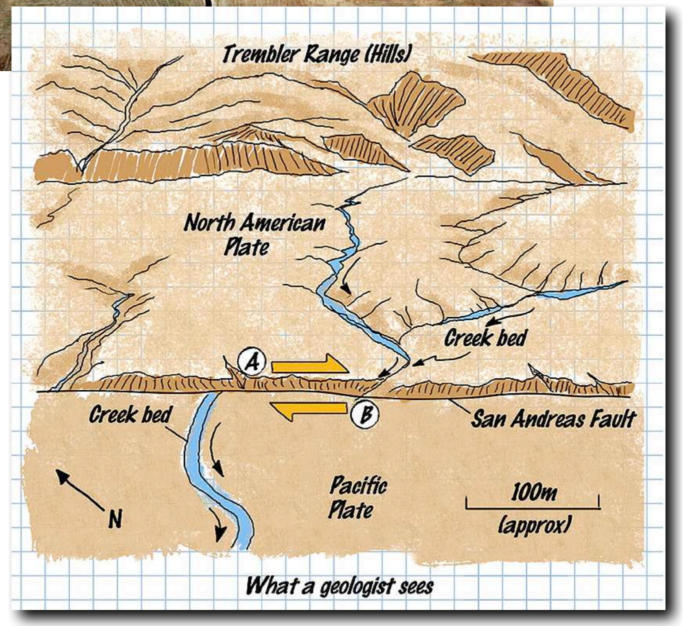


Blattverschiebung

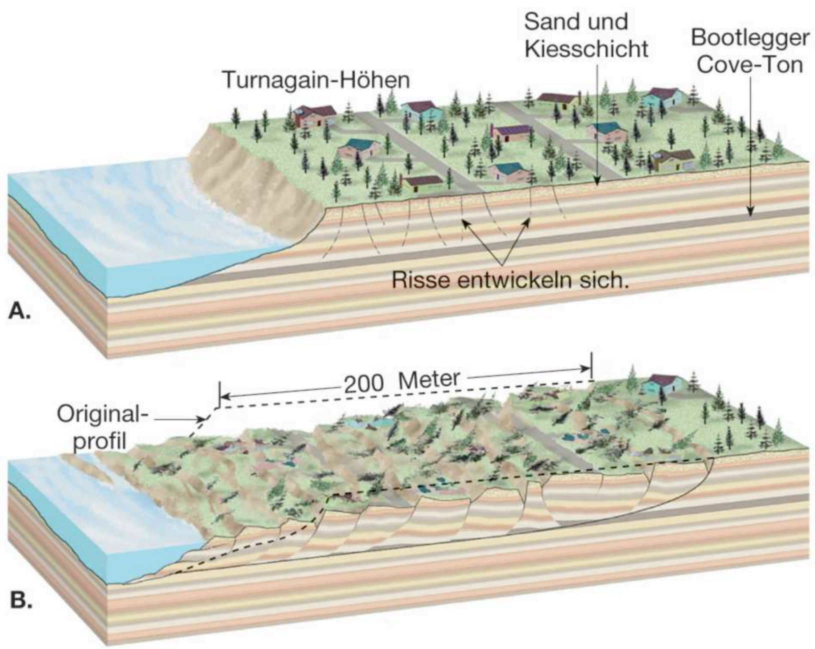


Abschiebung



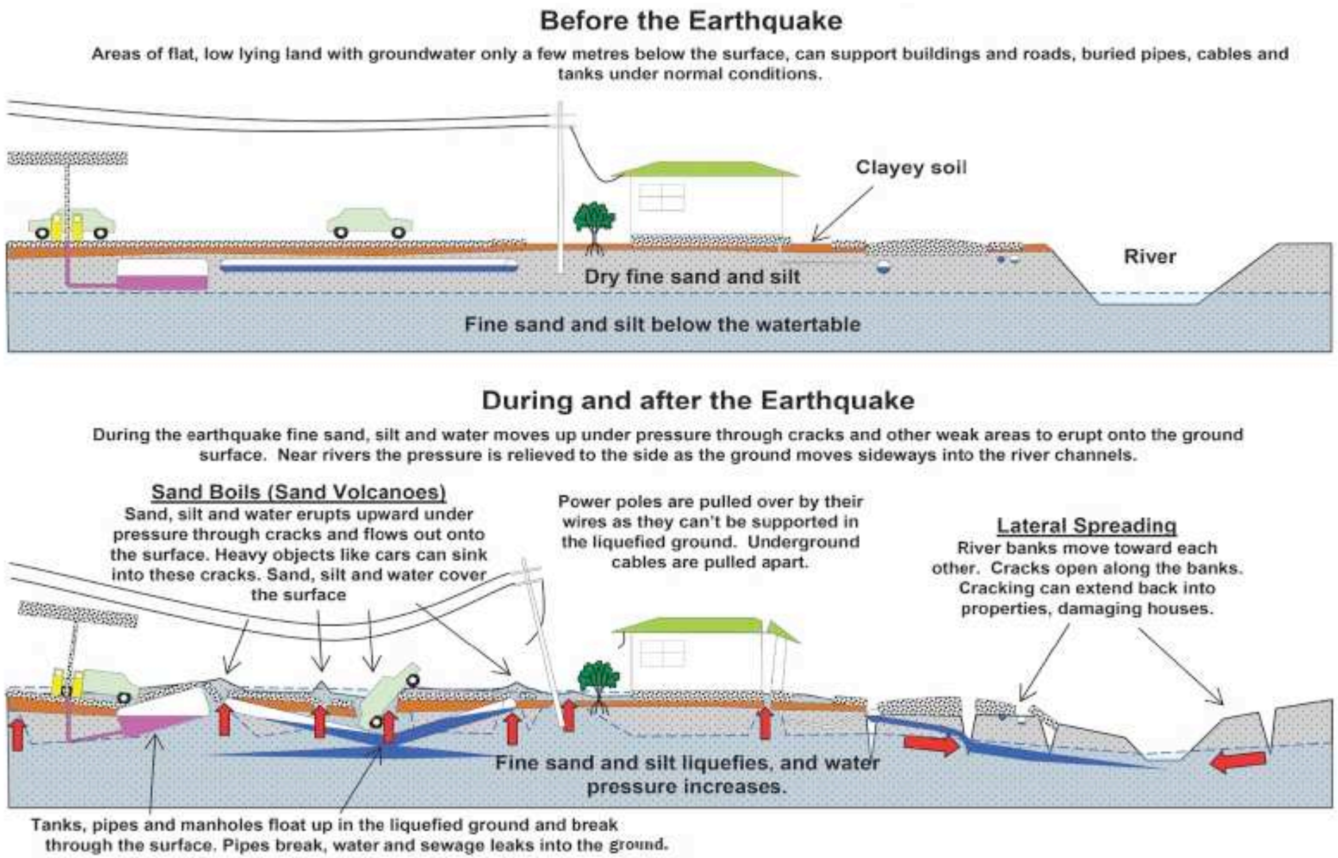


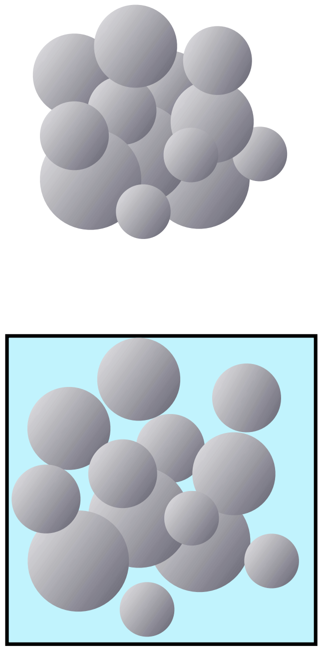
Erdrutsch



Turnagain Height Erdrutsch
Alaska 1964

Bodenverflüssigung





Porendruck

Bodenverflüssigung

Niigata 1964

Chuetsu 2004

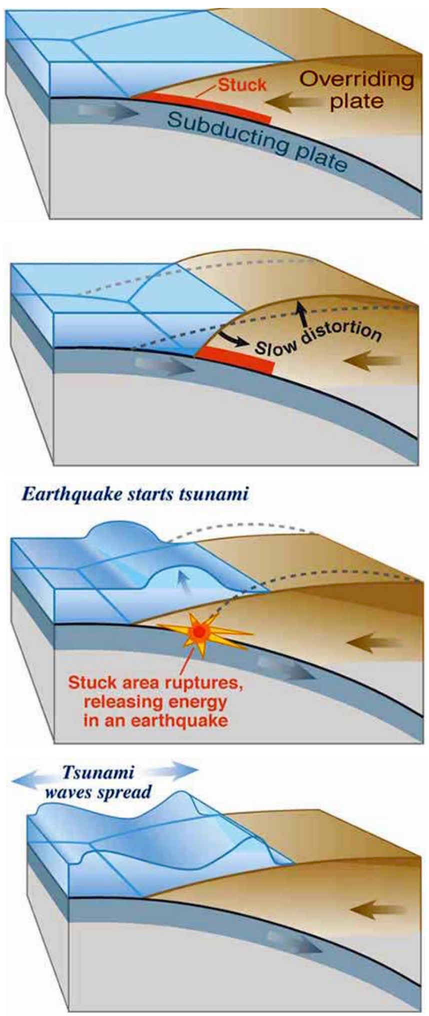
Christchurch 2011

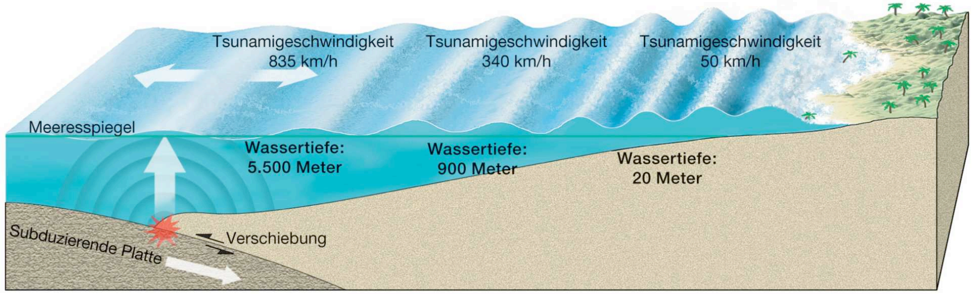
Kobe 1995

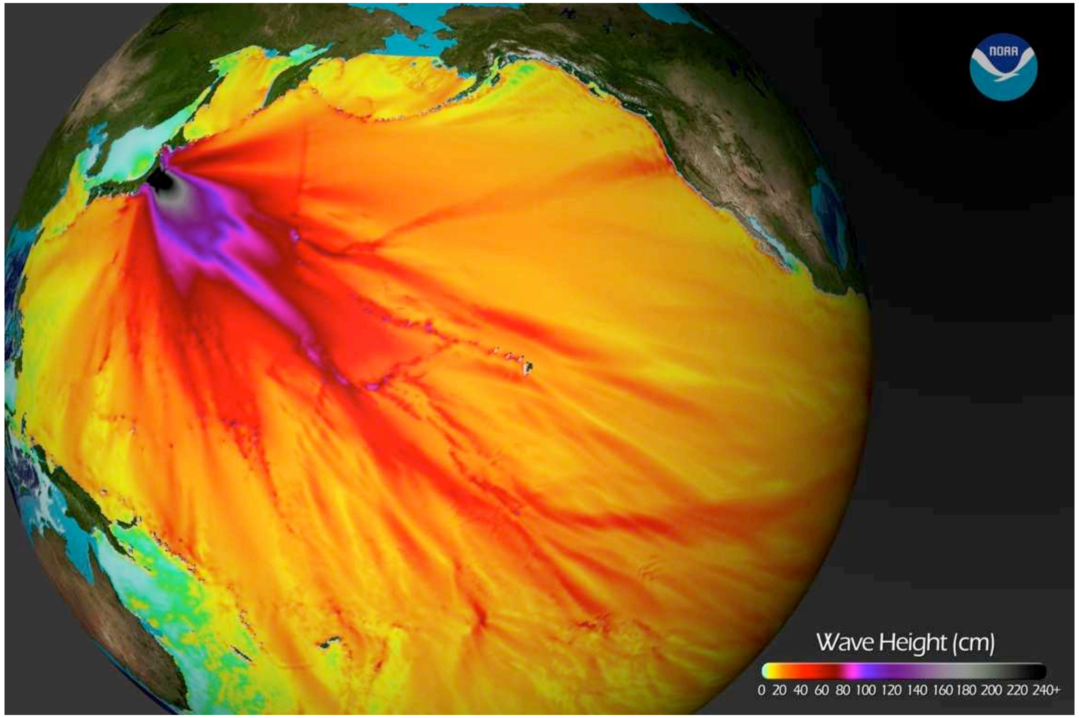
Kobe 1995

Loma Prieta 1989

Tsunami



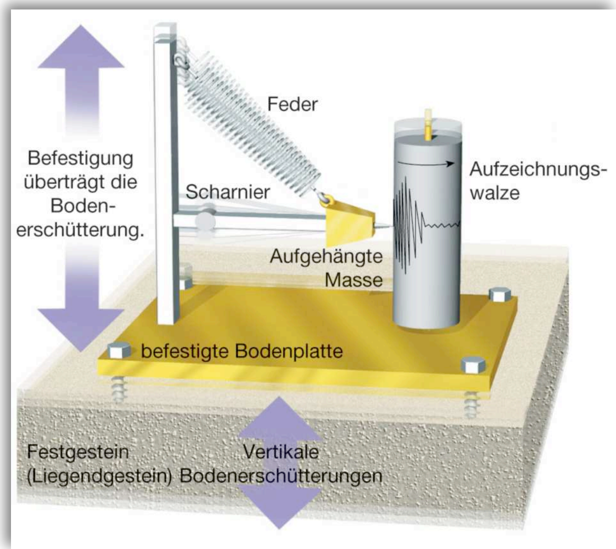




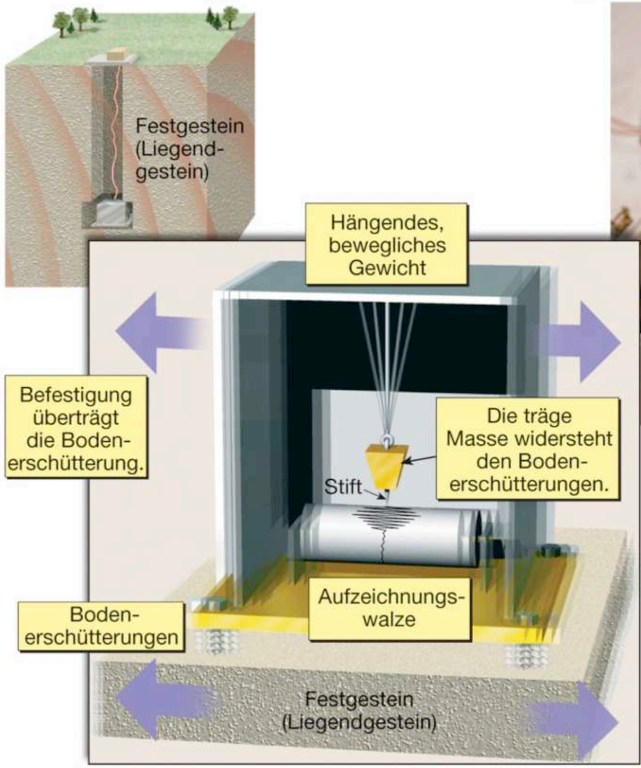
Tohoku 2011

Magnituden

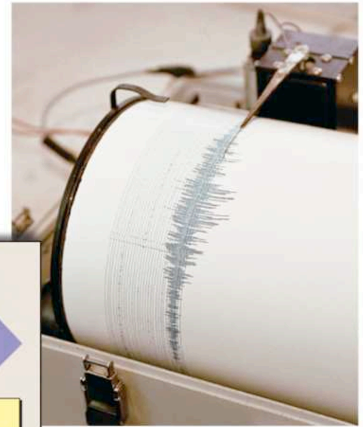
Seismometer (Seismograph)



vertikal



horizontal

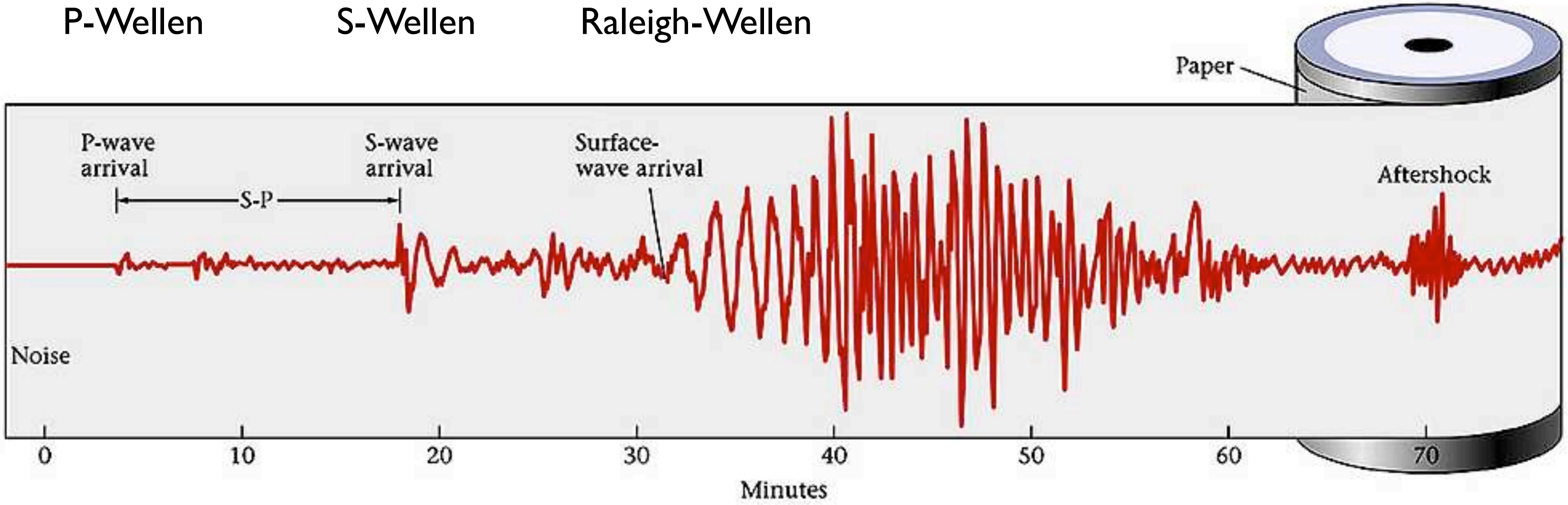


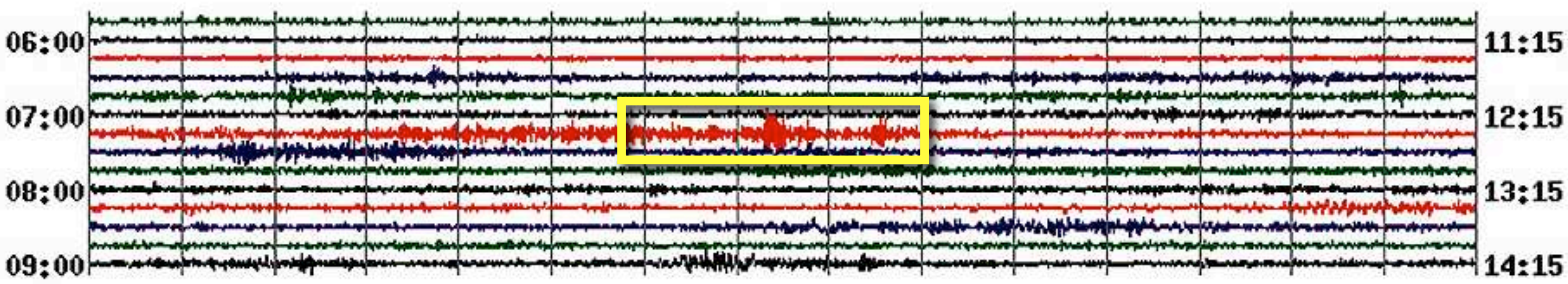
Breitbandseismometer

Amplituden

Love-Wellen

P-Wellen S-Wellen Raleigh-Wellen



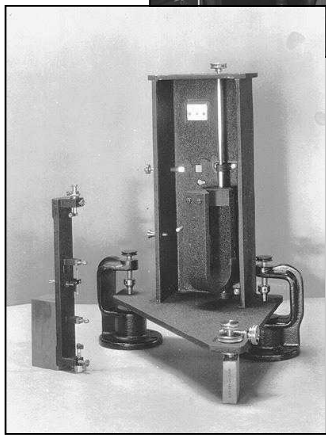


Gutenberg-Richter - Skala

$$M_L = \log_{10}(A/T)_{max} + q(\Delta, h)$$

M_L	Magnitude (body wave magnitude)
A	maximimale Amplitude (µm)
T	Periode (s)
q	Korrekturfunktion
Δ	Winkelabstand Seismograph - Herd (°)
h	Herdtiefe (km)

Gutenberg in seinem Wohnzimmer



Anderson-Wood Seismograf

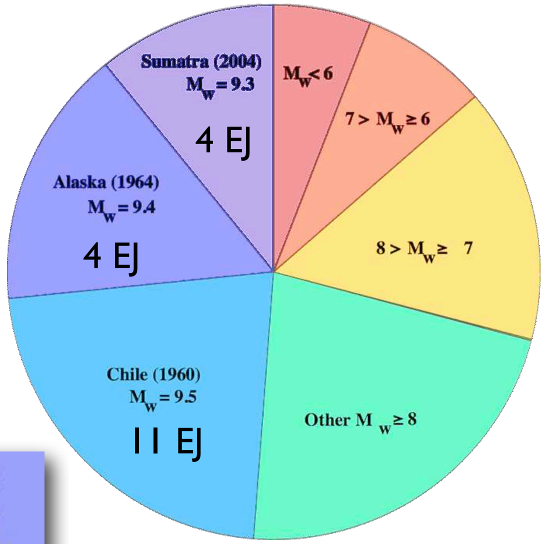
Die Gutenberg-Richter Magnitude (M_L) und
die Oberflächenwellen-Magnitude (M_S)
stimmen beim Wert $M_L = M_S = 6.5$ überein.
Für Magnituden < 6.5 ist $M_L > M_S$, darüber ist $M_S > M_L$

grösste Erdbeben

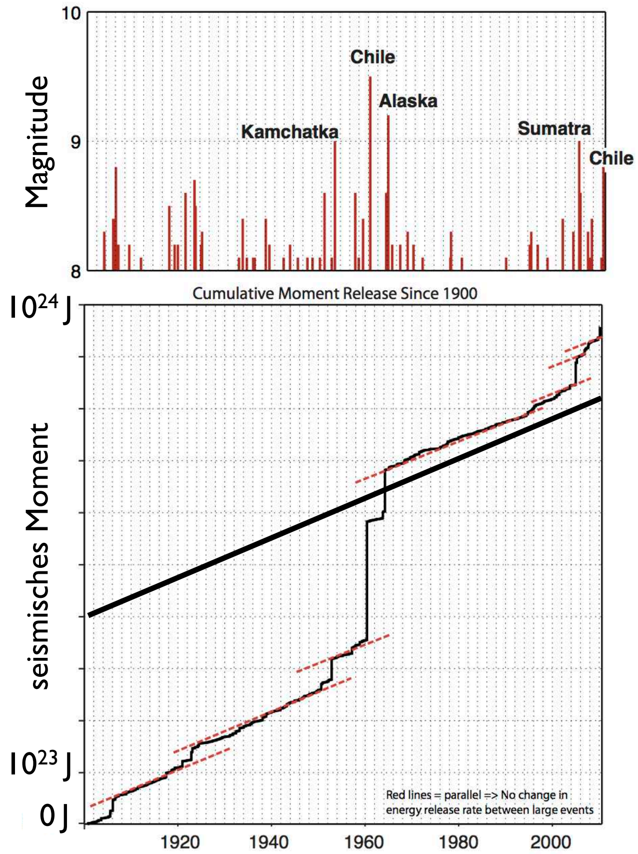
Januar 1906 - December 2005

Totale seismische Energie E_S $\approx 50 \cdot 10^{18}$ Nm = 50 EJ (10^{18} J = 1 Exa-Joule)

Globales seismisches Moment M_0 $\approx 10^{24}$ Nm = 1 YJ (10^{24} J = 1 Yotta-Joule)



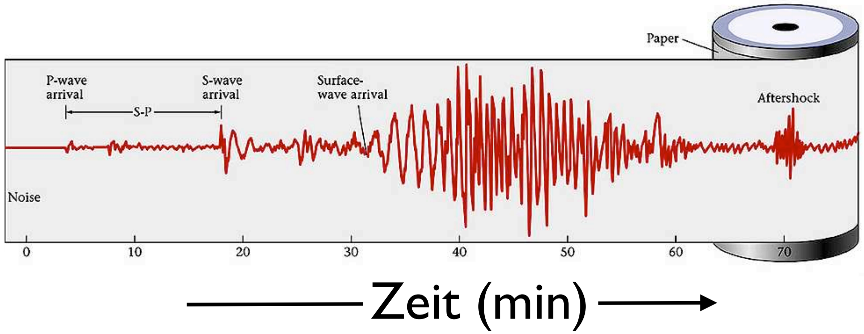
Beachte:
fast 50% des Gesamtmomentes durch die 3 grössten Erdbeben aufgebracht



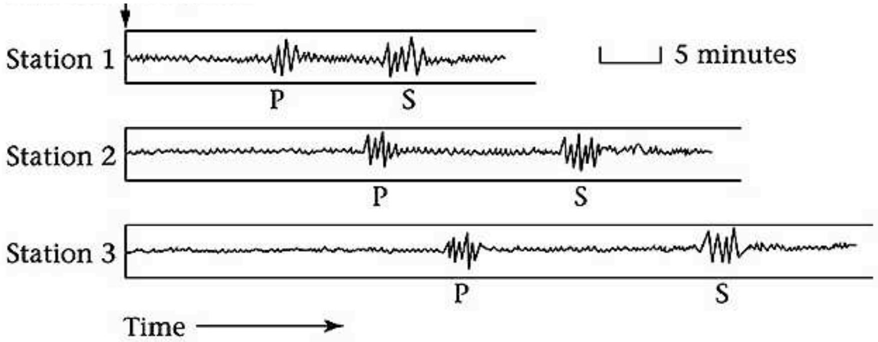
M_w	E_S in Joule	Menge TNT in Tonnen	Äquivalenz Hiroshima-Atombomben (12,5 kT TNT)
4	$6{,}3 \cdot 10^{10}$	15	0,0012
5	$2{,}0 \cdot 10^{12}$	475	0,038
6	$6{,}3 \cdot 10^{13}$	15.000	1,2
7	$2{,}0 \cdot 10^{15}$	475.000	38
8	$6{,}3 \cdot 10^{16}$	15.000.000	1.200
9	$2{,}0 \cdot 10^{18}$	475.000.000	38.000

wo ist das Epizentrum?

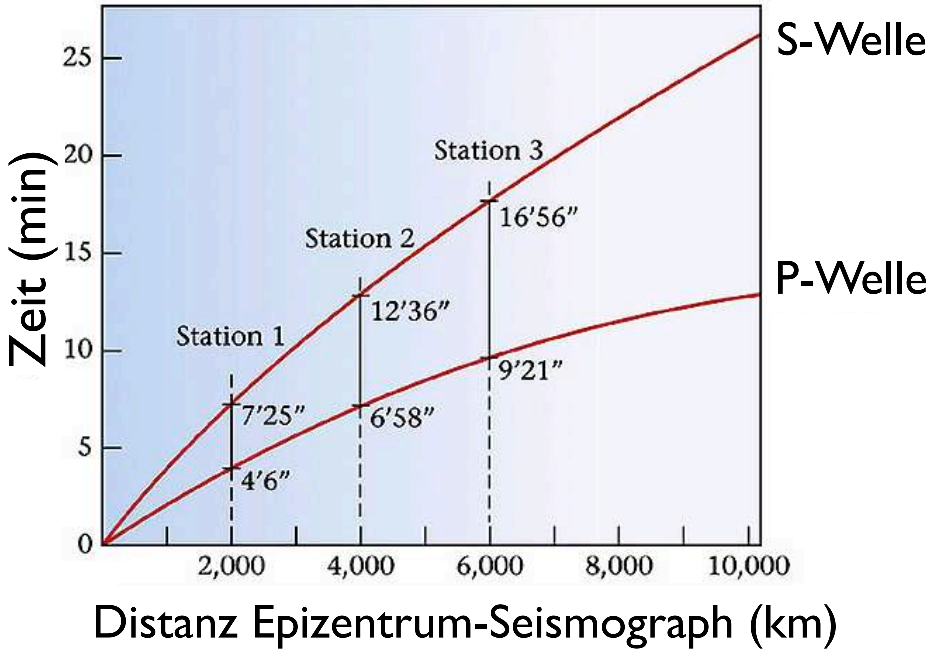
Erdbebenwellen - Laufzeiten



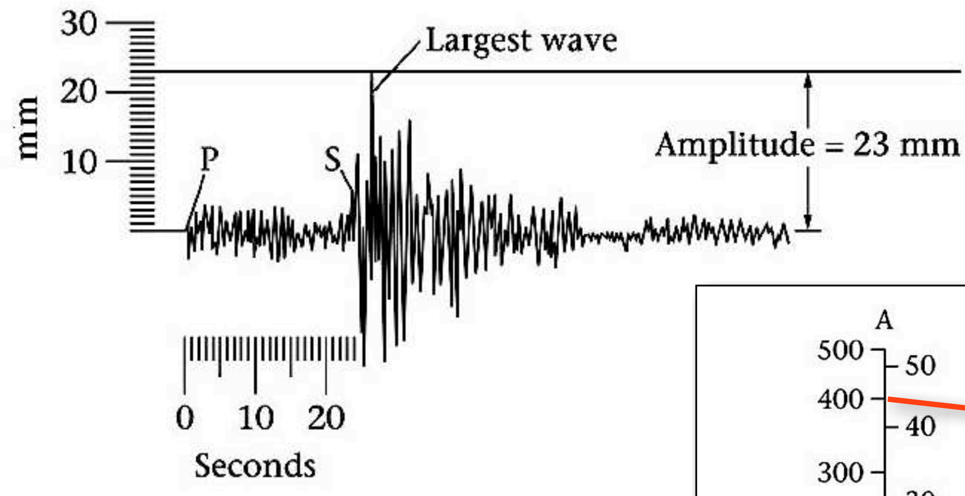
Ankunftszeiten



P - Welle schneller
S - Welle langsamer



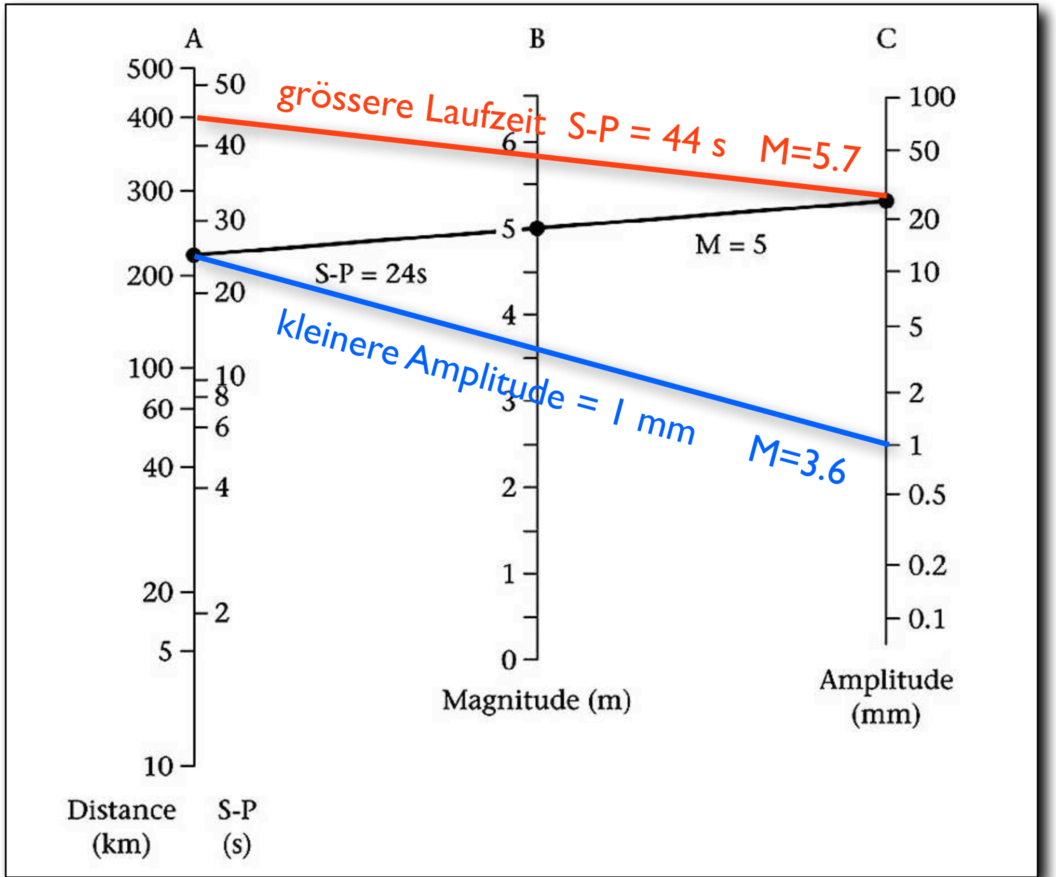
Magnitude



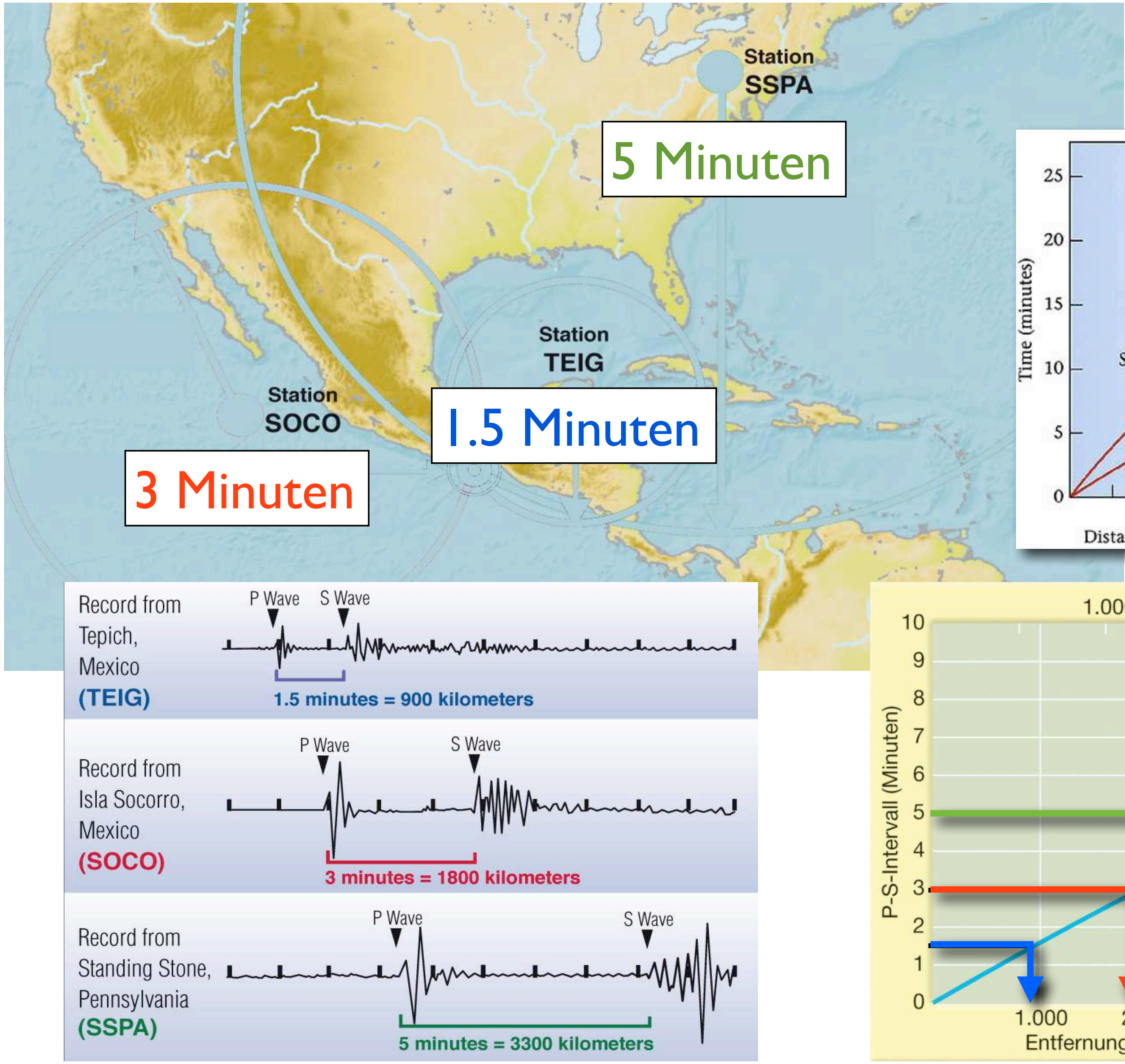
Amplitude = 23 mm
Laufzeitenunterschied S-P = 24 s

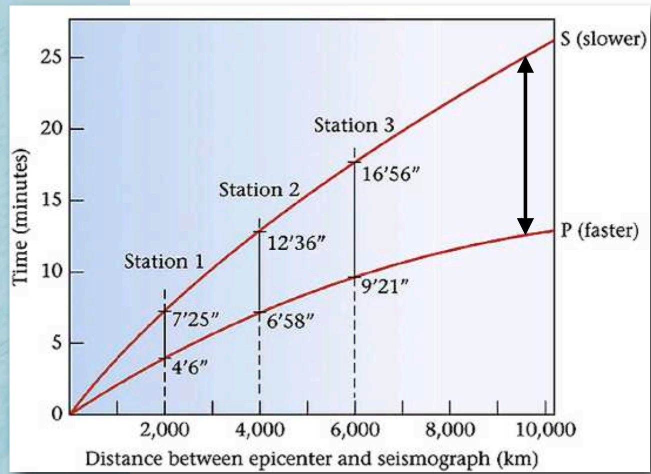
Erdbeben ist gross:

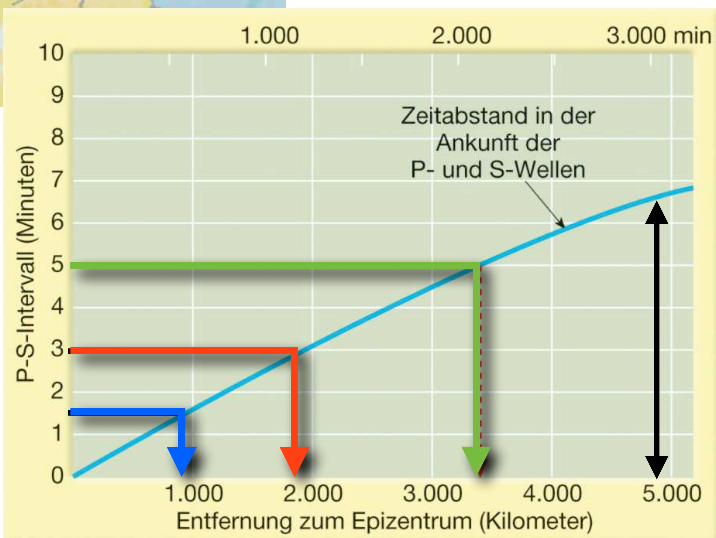
- je grösser die Amplitude (bei gleichem Abstand S-P)
- je grösser der Abstand S-P (bei gleicher Amplitude)



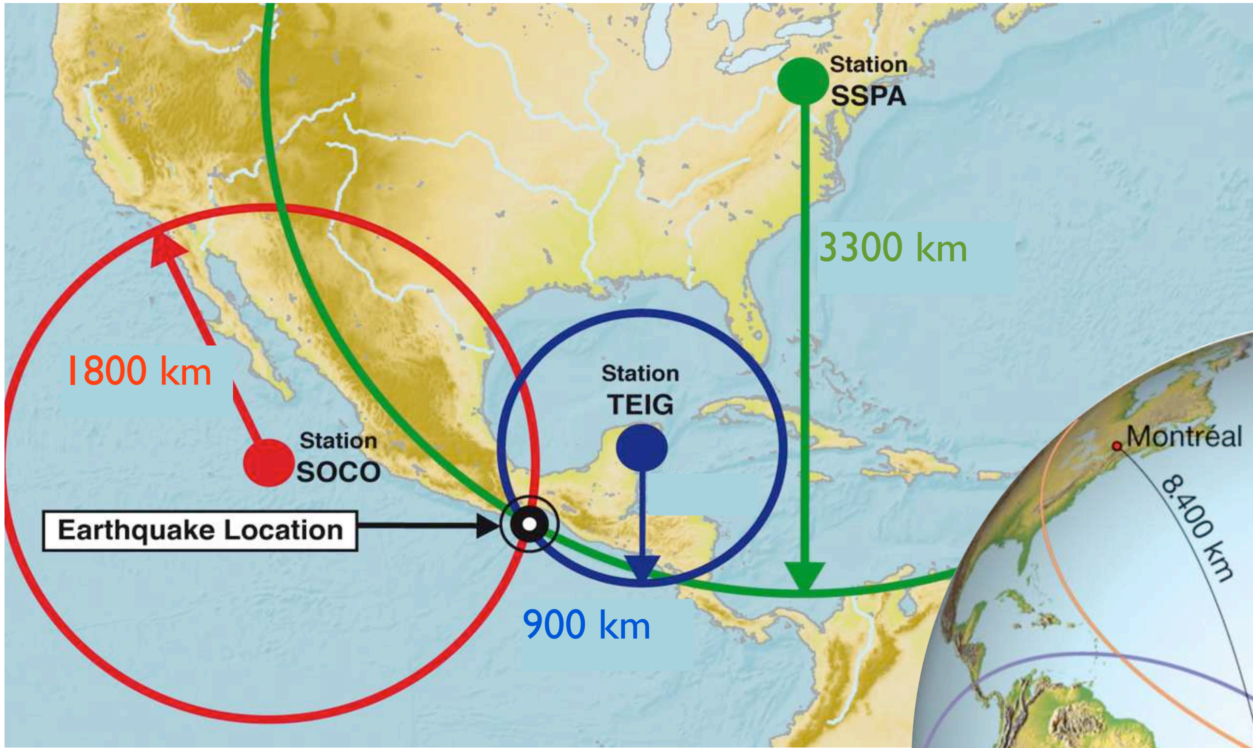
Laufzeitenunterschiede

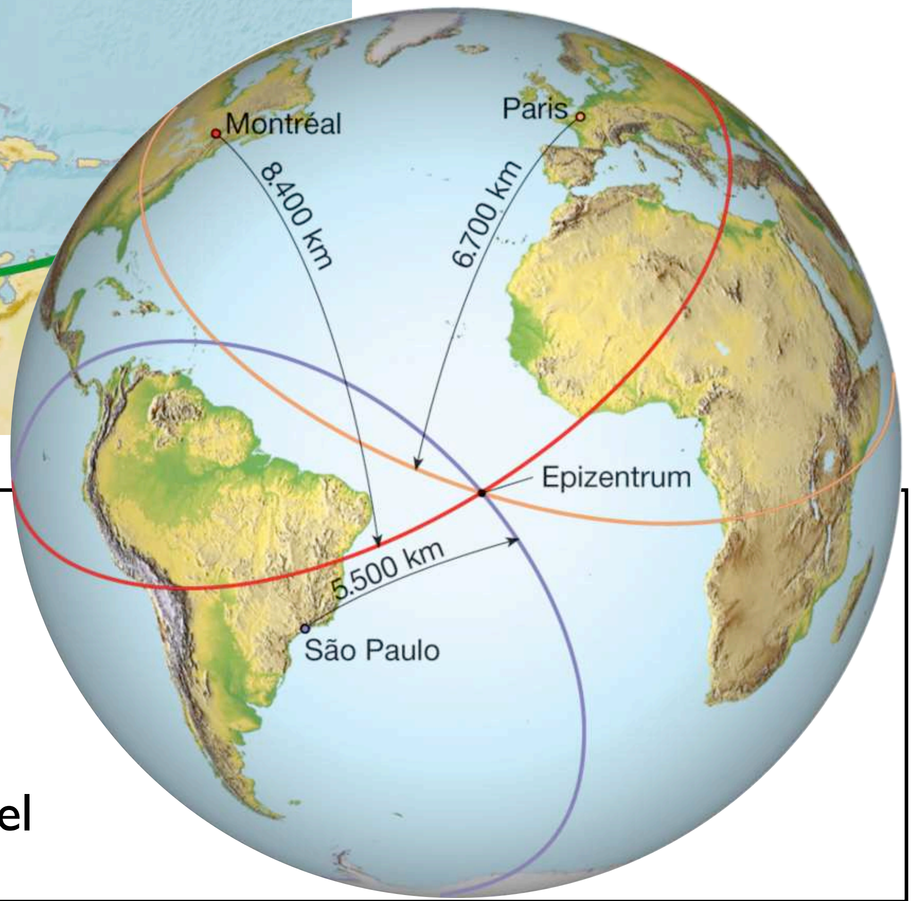






wo ist das Epizentrum ?

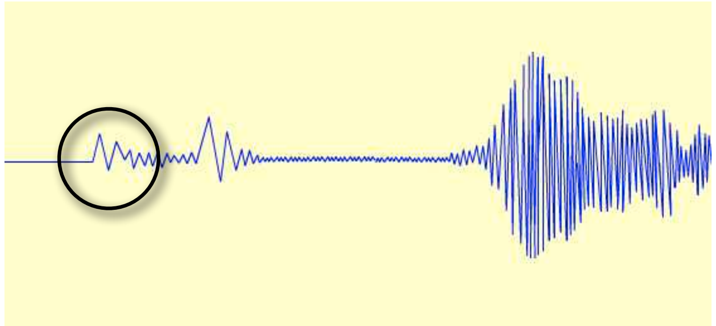




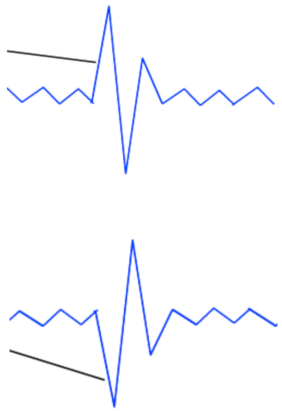
weiteres Beispiel

Erdbeben
Herdflächen

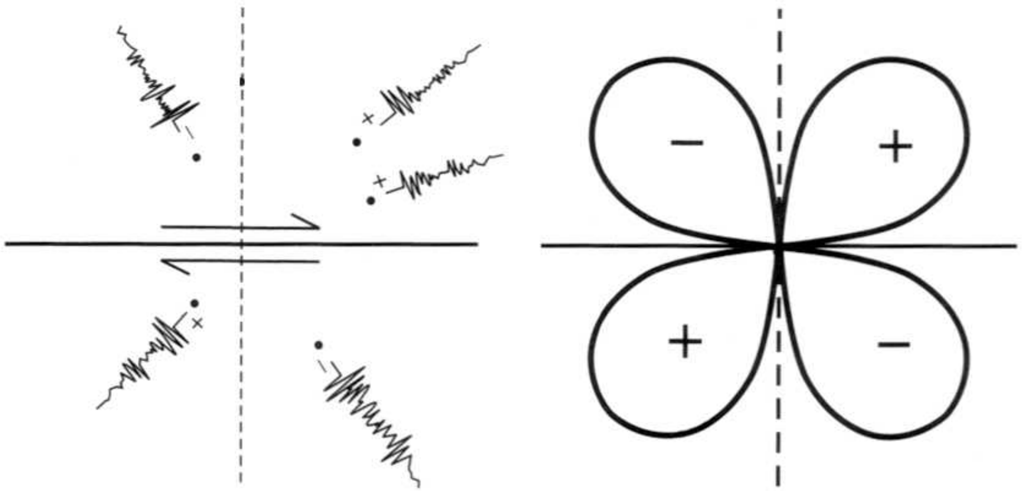
Erstausschlag

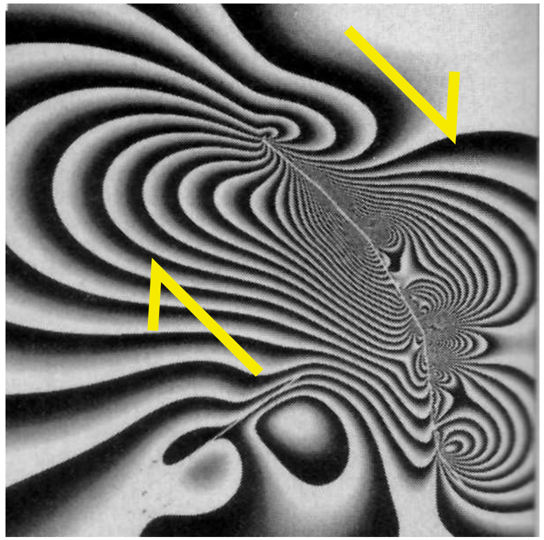


Kompression
an der Messtation = weg vom Epizentrum



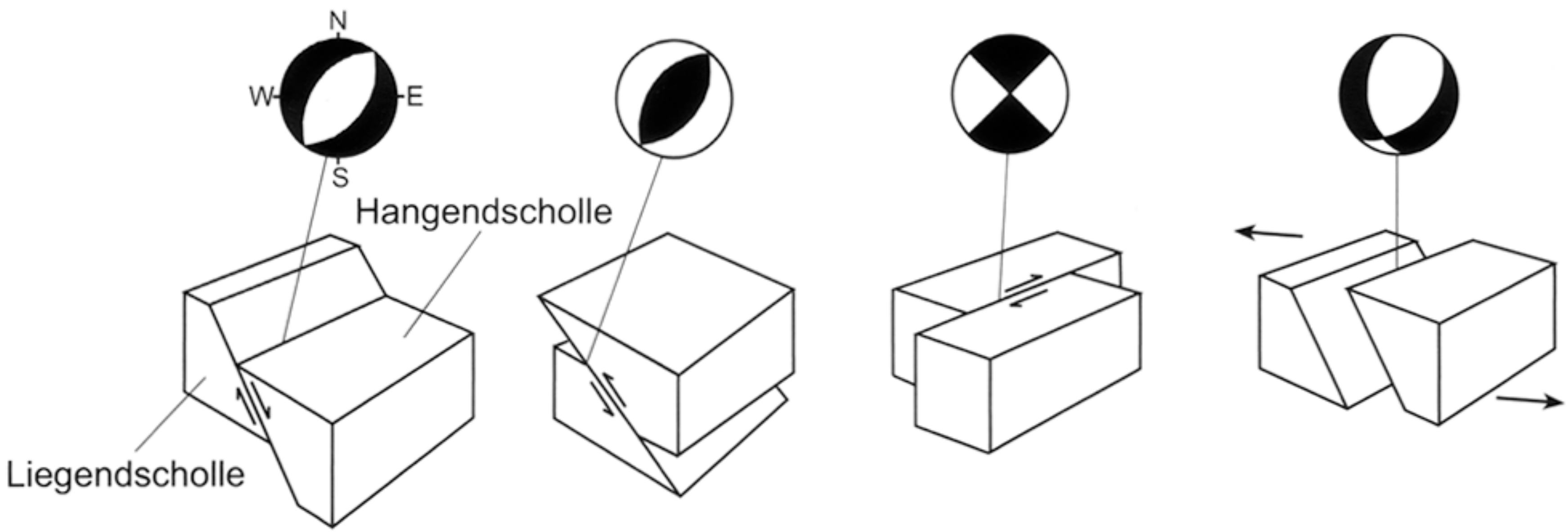
Tension
an der Messtation = hin zum Epizentrum





\+ = up = push = compression
\- = down = pull = tension

Erdbeben - Herdflächenlösung



Abschiebung	Aufschiebung Überschiebung	Blattverschiebung Seitenverschiebung	Transtension
Konstruktive...	Destruktive...	Konservative...	Plattengrenze

Typische Herdflächenlösungen für Plattengrenzen