

# Tatort

# Plattengrenze

# Fokus Erdbeben

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## Aktuelles



### Erdbeben am 23. Oktober 2011 Türkei

Am 23. Oktober 2011 ereignete sich in der Türkei nahe der Stadt Van um 10:41 GMT (12:41 in der Schweiz) ein Erdbeben mit einer Magnitude von 7.2. Auf das Hauptbeben folgten mehrere, teils starke Nachbeben mit Magnituden von bis zu 5.7. Beben in dieser Region sind auf die Kollision der Arabischen mit der Europäischen Platte zurückzuführen, die sich dort mit ca. 24 mm/Jahr aufeinander zu bewegen.

Weil das Epizentrum lediglich 5 Kilometer unter der Erdoberfläche lag, forderte es nach aktuellen Schätzungen zwischen 500 und 1'000 Todesopfer und richtete erhebliche Sachschäden an. Die Türkei liegt in einem tektonisch aktiven Gebiet und ist immer wieder von schweren Erdbeben betroffen.

Weitere Informationen finden Sie unter folgenden Links:

[USGS](#)

[INGV](#)

[KOERI](#)

Erdbeben - Hauptbeben - Nachbeben  
Magnitude  
Platten-Kollision  
Epizentrum  
tektonisch aktiv

## Magnitude 7.2 - EASTERN TURKEY

2011 October 23 10:41:21 UTC

Details

Summary

Maps

Scientific & Technical

Additional Info

[Versión en Español](#)

### Earthquake Summary



[Earthquake Summary Poster](#)

#### Tectonic Summary

Turkey is a tectonically active country that experiences frequent destructive earthquakes. On a broad scale, the seismotectonics of the region near the October 23, 2011 earthquake are controlled by the collision of the Arabian Plate and Eurasian plates; at the latitude of this event, the Arabian plate converges with Eurasia in a northerly direction at a rate of approximately 24 mm/yr. West of the October 23, 2011, earthquake tectonics are dominated by strike-slip faulting on the East (in southern Turkey) and North (in northern Turkey) Anatolian fault zones. These large, translational fault systems extend across much of the region and accommodate the western motion of the Anatolian block as it is being squeezed between the Arabian and Eurasian plates. In the area of Lake Van and further east, tectonics are dominated by the North Anatolian Fault Zone (in eastern Turkey) and Zagros fold and thrust belt (toward Iran). The October 23, 2011 earthquake occurred in a broad region of convergence beyond the eastern extent of the North Anatolian Fault. The focal mechanism of today's earthquake is consistent with oblique-thrust faulting in the region.

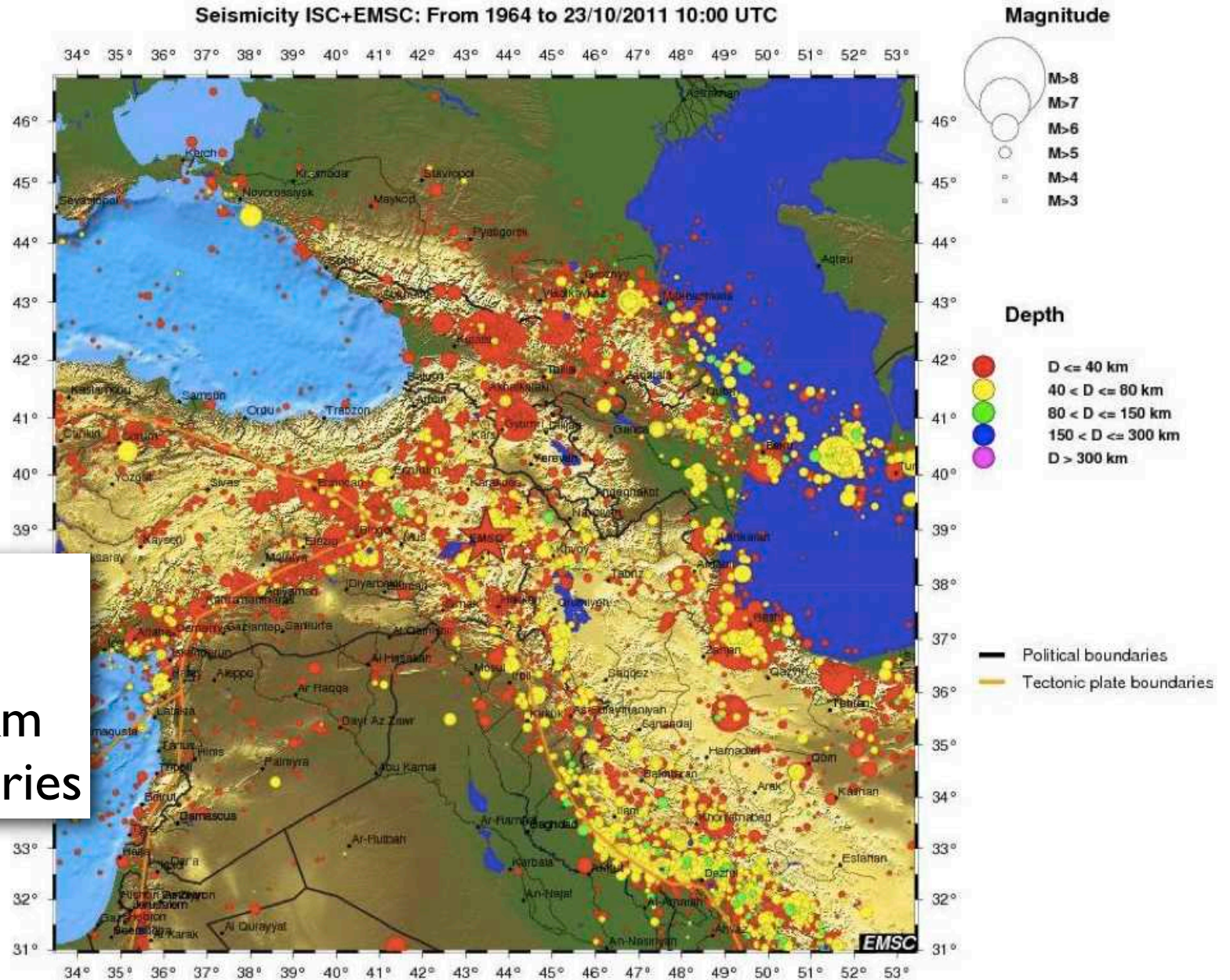
This earthquake is a reminder of the many deadly seismic events that Turkey has experienced. The devastating Izmit earthquake of 1999 (M = 7.6) broke a section of the North Anatolian Fault to the west of the October 23 event and killed 17,000 people, injured 50,000, and destroyed 1.5 million people.

Approximately 70 km from this earthquake a M7.3 earthquake occurred on November 11, 1976 destroying 1.5 million people and Iran border and killing several thousand people. A M7.8 earthquake struck Erzincan in 1939, killing an

seismotectonics  
plate convergence  
strike slip  
Anatolian Fault  
focal mechanism  
oblique thrust faulting

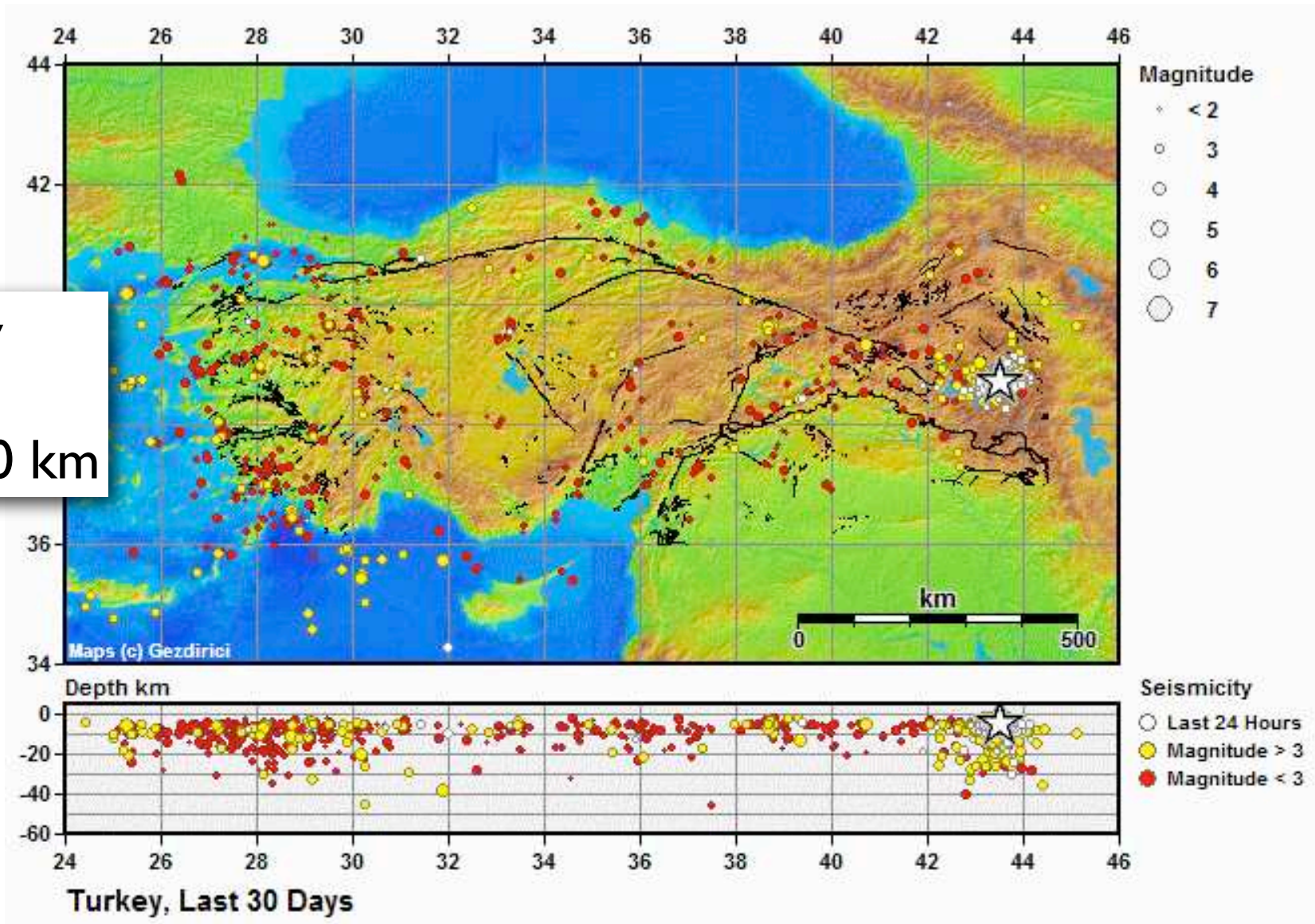
# INGV EMSC

<http://www.ingv.it/primo-piano/comunicazione/2011/10231522/>



seismicity  
magnitude  
depth < 40 km  
plate boundaries

seismicity  
magnitude  
depth < 10 km



## Recent Earthquake Teachable Moments

[Home](#) » Recent Earthquake Teachable Moments

 Like 1K  Tweet 334  +1 2



[What Are Teachable Moments?](#)

October 23, 2011 (10:41:21 UTC)



### Magnitude 7.2 Eastern Turkey

A major earthquake has occurred in Eastern Turkey. The US Geological Survey reports "The ... earthquake occurred in a broad region of convergence beyond the eastern extent of Anatolian strike-slip tectonics. The focal mechanism of today's earthquake is consistent with oblique-thrust faulting on a south-southwest trending fault, similar to the trend of mapped faults in the region."

### Teachable Moment Presentation

- 11 slide Powerpoint presentation ([zipped ppt/animations](#) 11.4 MB / [pdf](#) 1.55 MB)
- Classroom-ready Powerpoint presentation ([zipped ppt/animations](#) 11.4 MB / [pdf](#) 1.57 MB)

### Animations and Visualizations

- Wave Propagation ([Quicktime](#) 3.01 MB / [YouTube](#))
- USArray Ground Motion Visualization ([mpeg-4](#) 6.84 MB)
- Back Projection ([mpeg-4](#) 47.9 kB)

### USGS Resources

- [Earthquake Information](#)

## Magnitude 7.2 EASTERN TURKEY

Sunday, October 23, 2011 at 10:41:21 UTC



Major earthquake in Eastern Turkey.  
Epicenter near Van with population of  
372,000.

### Impact

- 138 reported dead
- Dozens of buildings collapsed
- Frequent aftershocks hampering rescue efforts

**Local Time** 1:41 PM  
**Latitude** 38.628°N  
**Longitude** 43.486°E  
**Depth** 20 km

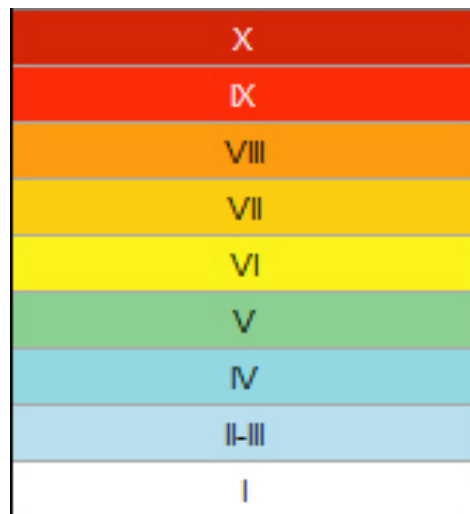
*Images courtesy of the US Geological Survey*



## USGS Estimated Shaking Intensity:

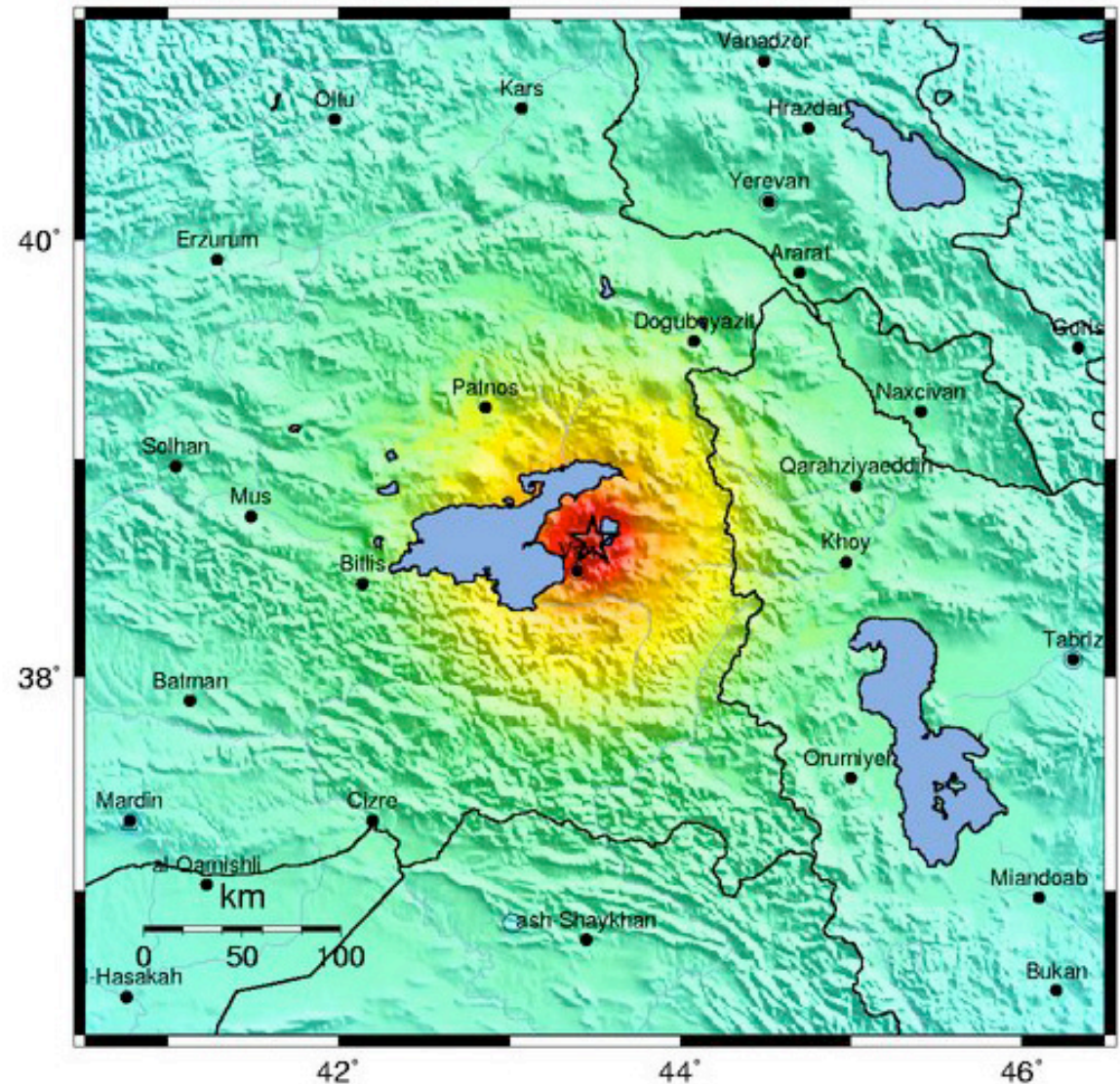
The Modified-Mercalli Intensity scale is a twelve-stage scale, numbered from I to XII.

### Modified Mercalli Intensity



Perceived Shaking

**Extreme**  
**Violent**  
**Severe**  
**Very Strong**  
**Strong**  
Moderate  
Light  
Weak  
Not Felt





# Magnitude 7.2 EASTERN TURKEY

Sunday, October 23, 2011 at 10:41:21 UTC

USGS PAGER

Population Exposed to Earthquake Shaking

Structures are a mix of vulnerable and earthquake resistant construction.

Most vulnerable are

- unreinforced brick masonry
- nonductile reinforced concrete frame construction

Table below shows populations within MMI zones.

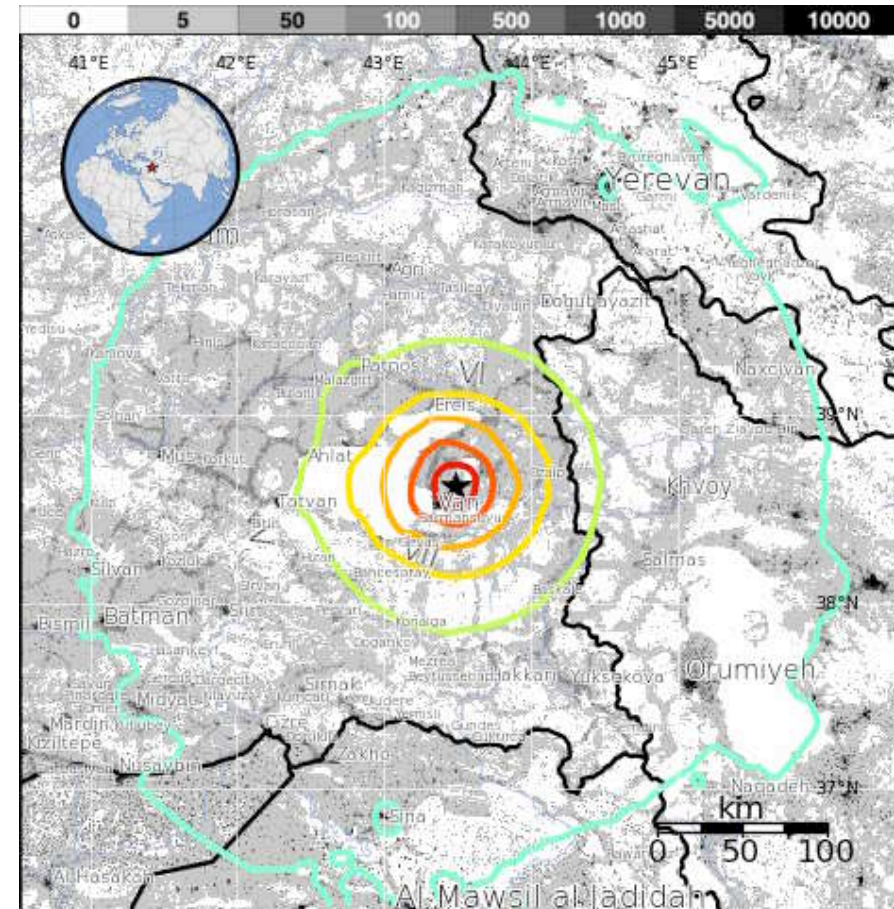


Image courtesy of the US Geological Survey

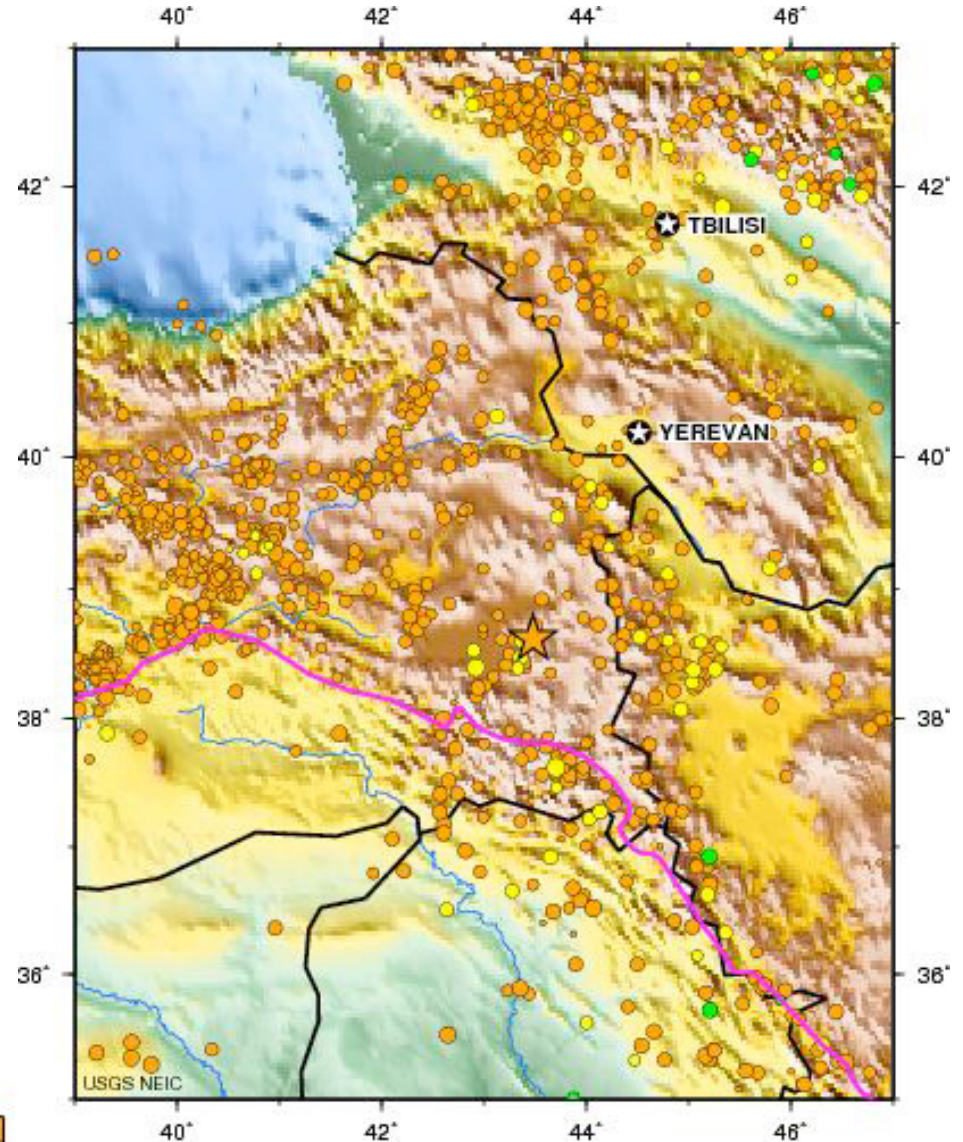
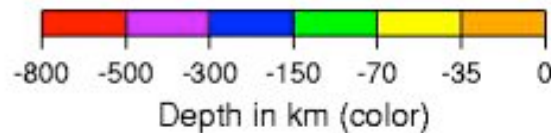
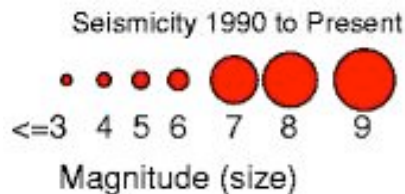
Estimated <a href="#">Modified Mercalli Intensity</a>	I	II-III	IV	V	VI	VII	VIII	IX	X
Est. Population Exposure	---	357*	8,454k*	9,435k	482k	265k	67k	377k	29k
Perceived Shaking	Not Felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme

# Magnitude 7.2 EASTERN TURKEY

Sunday, October 23, 2011 at 10:41:21 UTC

Turkey is a tectonically active with frequent destructive earthquakes.

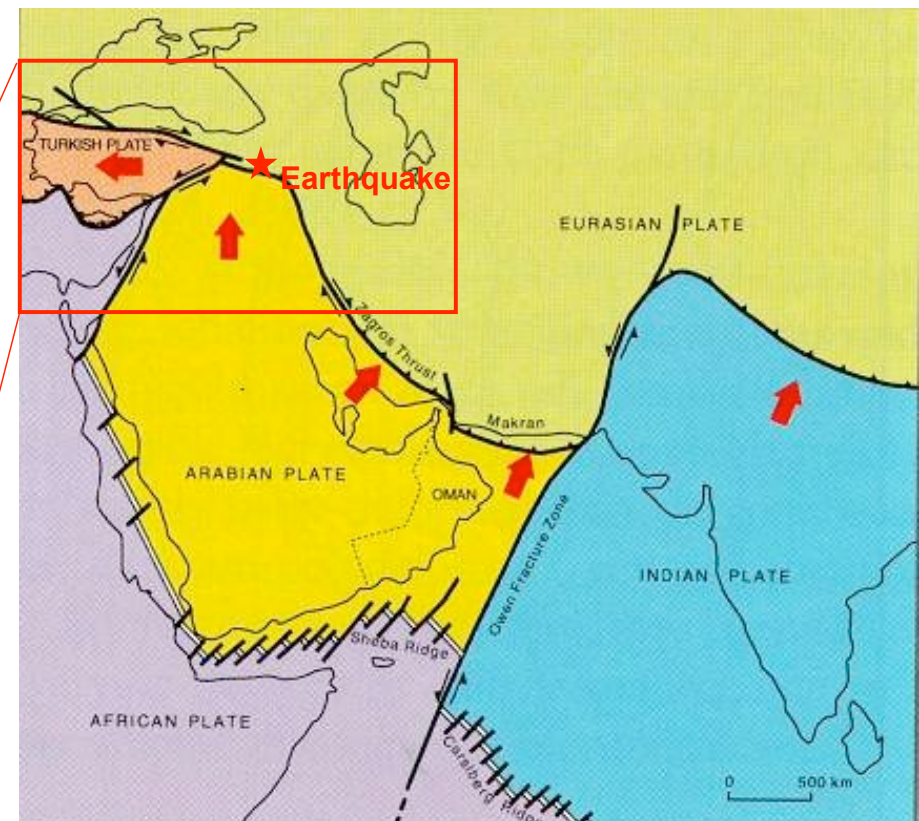
Map shows earthquakes recorded from 1990 to present with October 23 earthquake represented by orange star.



*Image courtesy of the US Geological Survey*

The Arabian Plate is colliding with Eurasia, and has built a complex mosaic of mountains by thrust and strike-slip faulting.

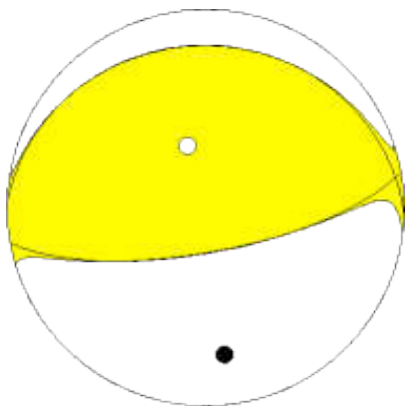
This earthquake occurred in Eastern Turkey on the Bitlis Suture, a large thrust fault.



Summary tectonic map of eastern Turkey. The large arrows are the approximate directions of motion of Turkey, Arabia, and central Iran relative to Eurasia. NAF=North Anatolian Fault; EAF=East Anatolian Fault; DSF=Dead Sea Fault (*Sandvol et al.*)

This earthquake was in a broad region of convergence east of the Anatolian strike-slip faults.

P-wave first-motion solution indicates oblique-thrust faulting.



USGS WPhase Centroid Moment Tensor Solution

Reverse (or Thrust) Fault

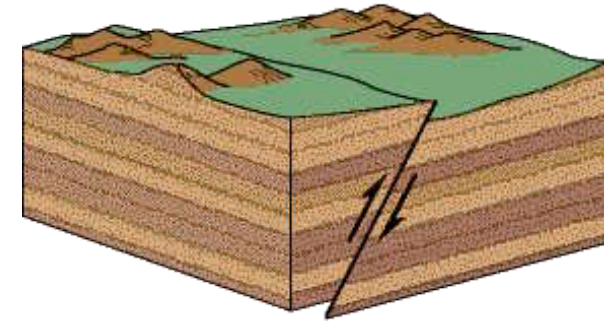
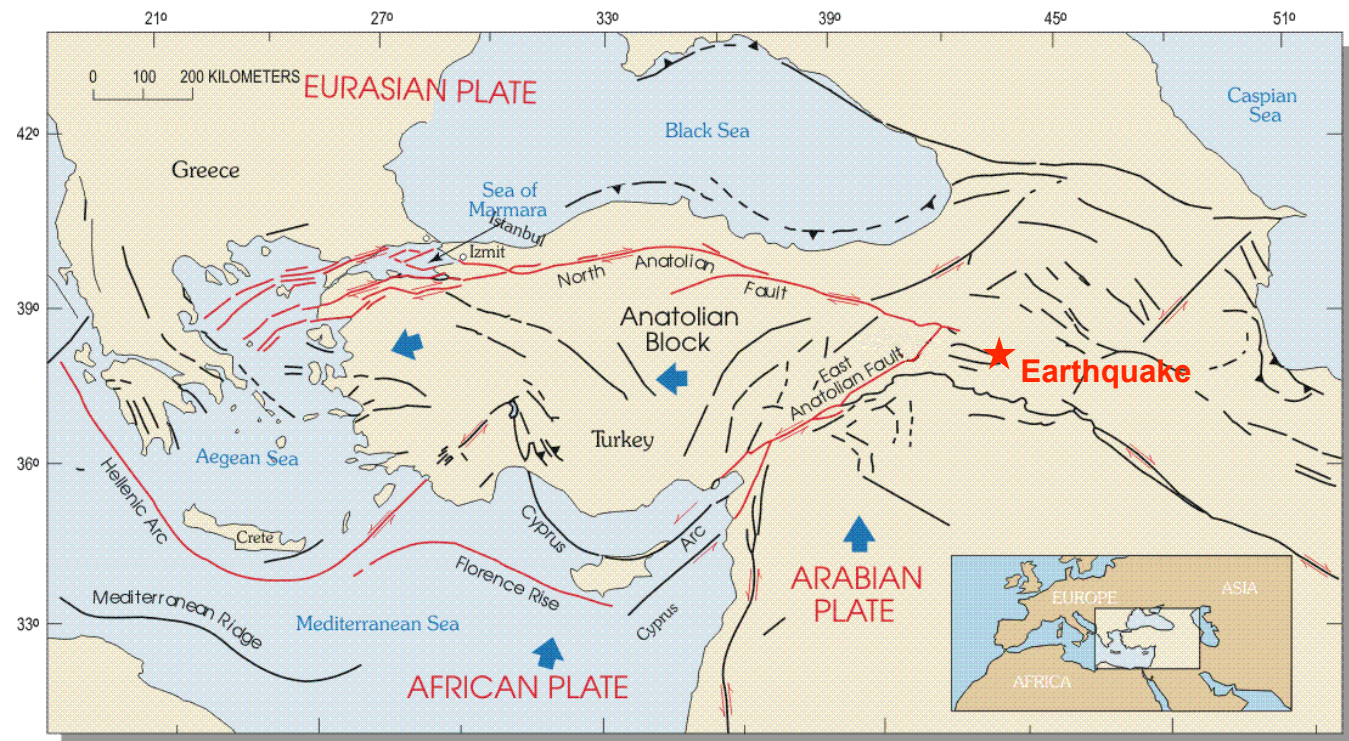
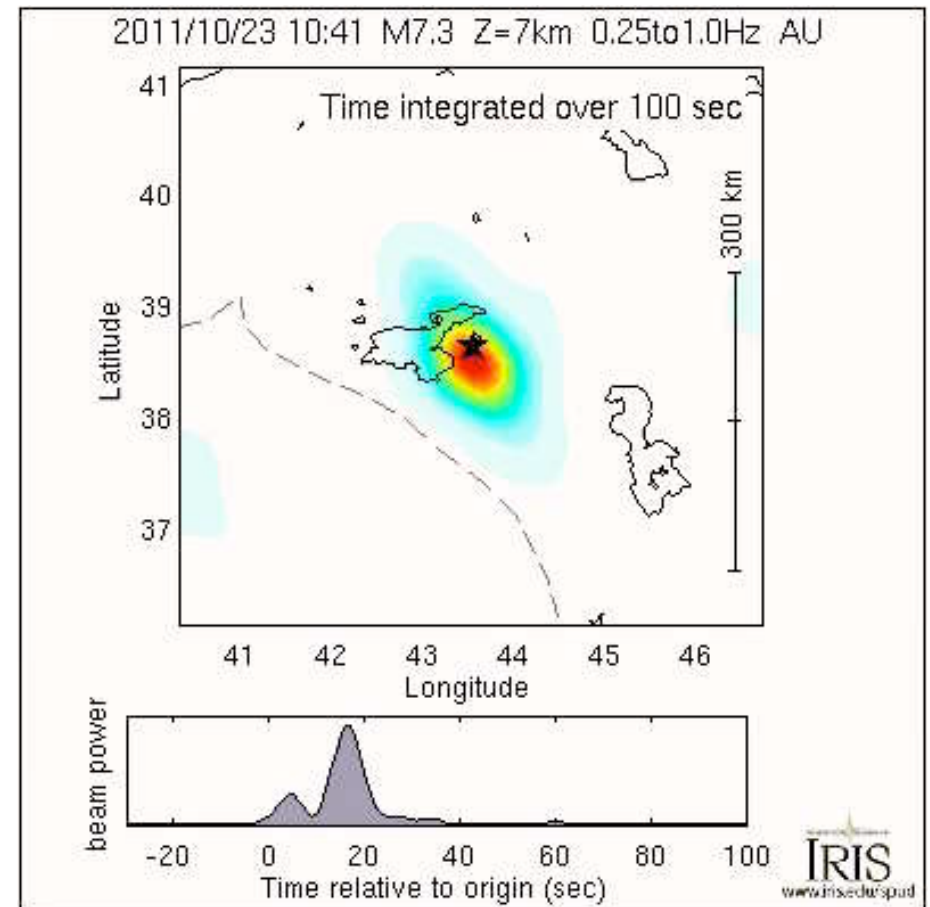


Image courtesy of the US Geological Survey



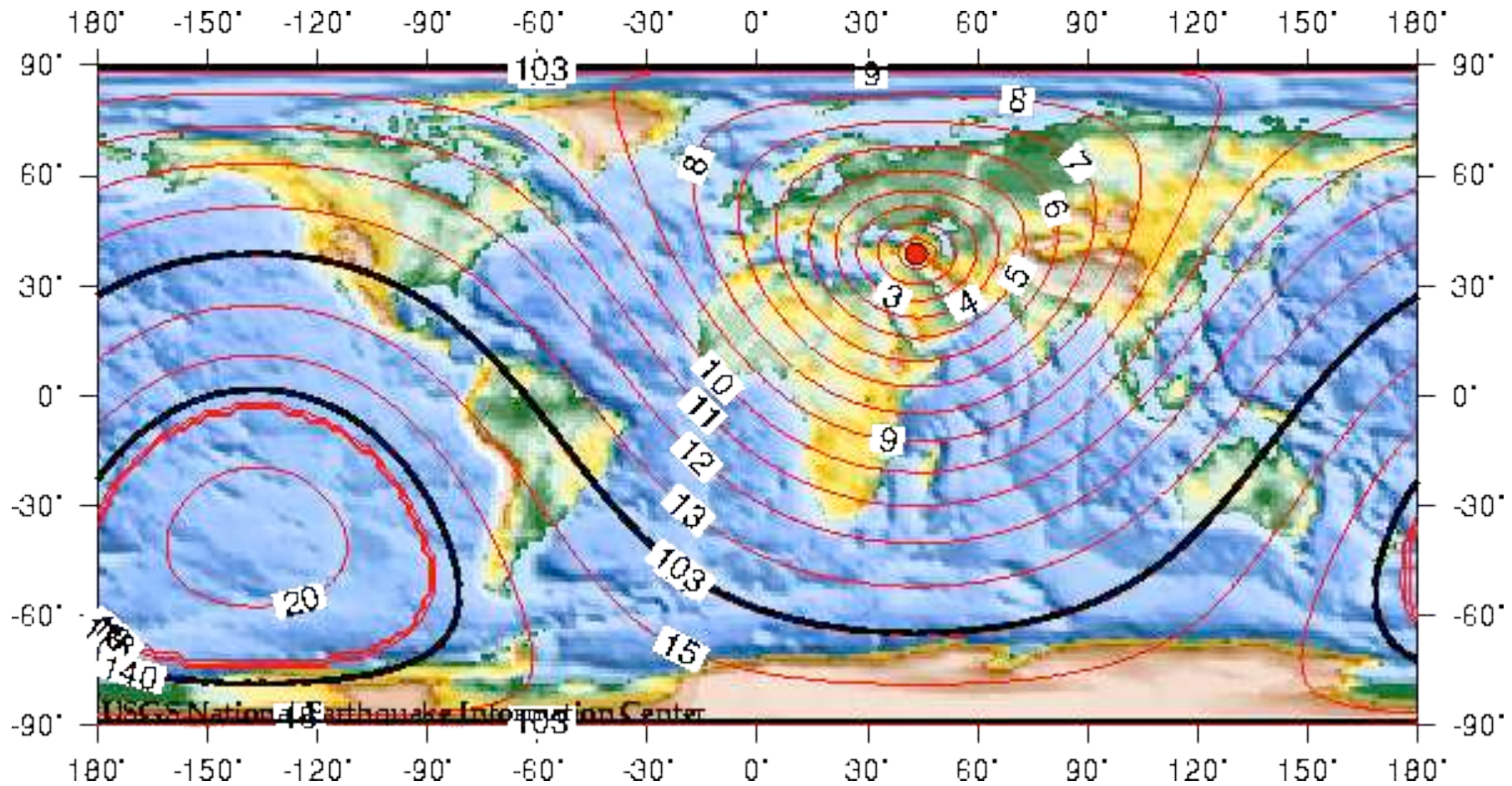
Back Projections are models of the times and amounts of displacement on the fault that produced the earthquake.

- warmer colors indicate greater displacement on the fault.
- graph shows the time distribution of rupture during the earthquake



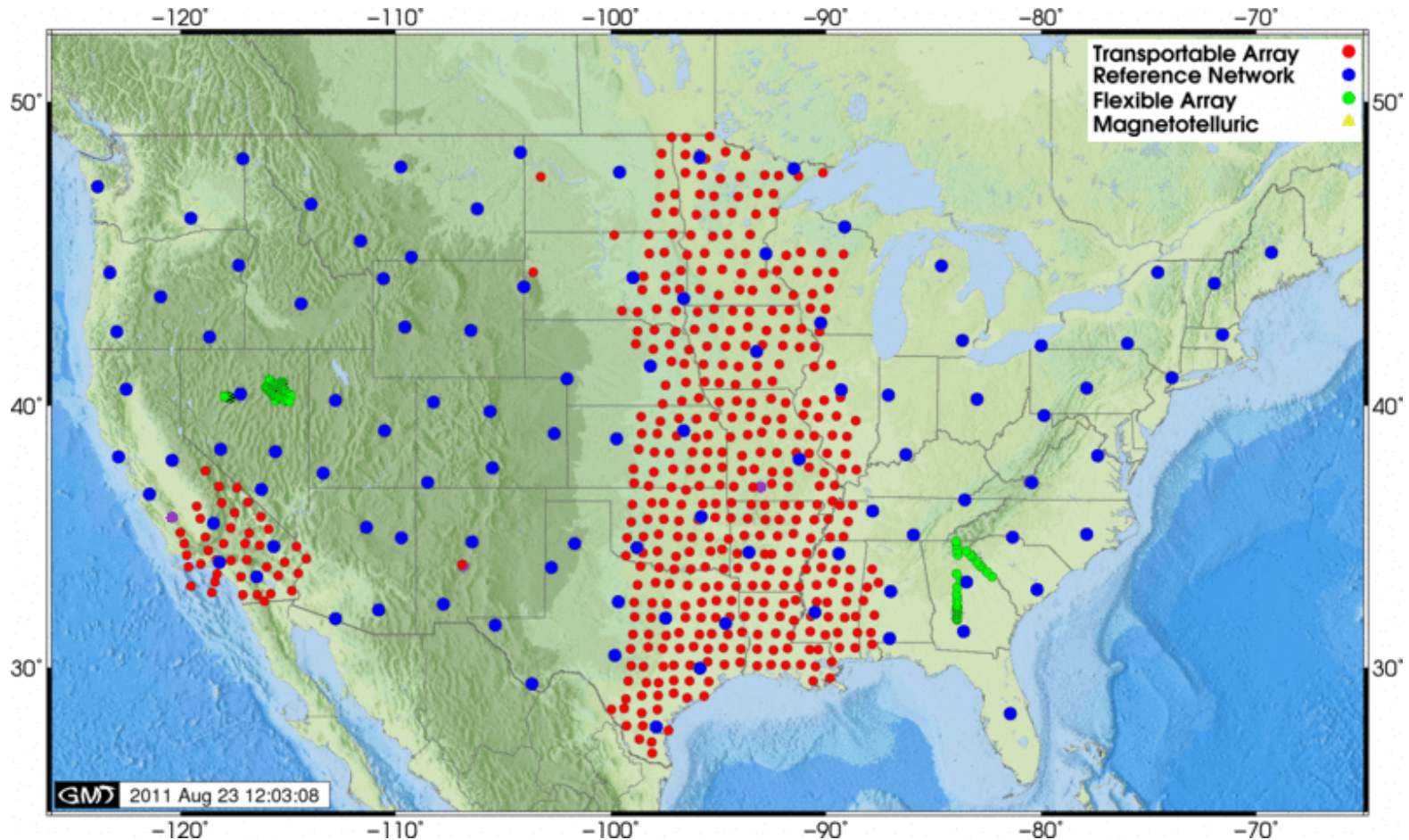
# Magnitude 7.2 EASTERN TURKEY

Sunday, October 23, 2011 at 10:41:21 UTC



Predicted travel times, in minutes, of the first P wave arrival

## USArray: A Continental-Scale Seismic Observatory

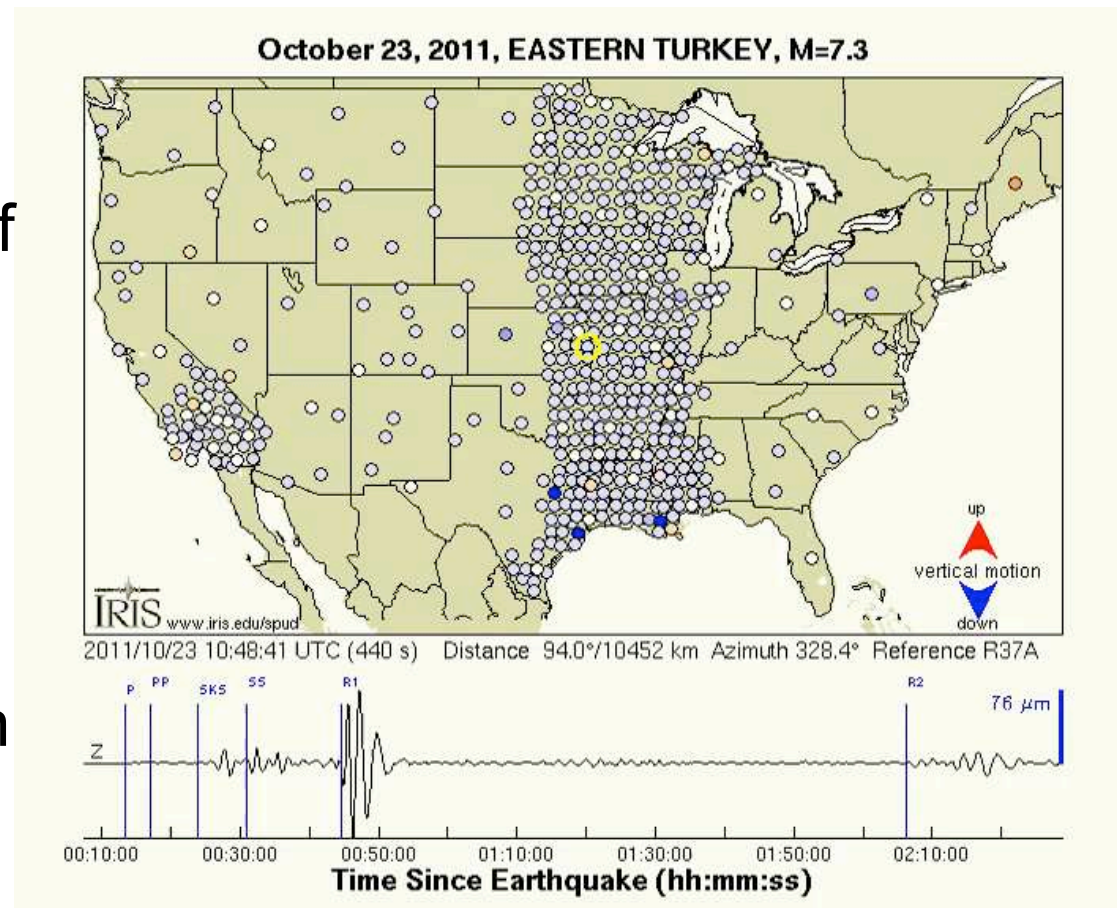


USArray Stations. The 400 active transportable array stations are shown by red dots. Permanent stations are shown in blue.

Animation of ground motion recorded on EarthScope's Transportable Array can provide an effective visual of relative velocities of the fast P, slower S, and slowest surface waves sweeping across the array.

- Red, station moving up
- Blue, station moving down

The seismogram along the bottom is from the station at the yellow circle.





## Quick Time Required

Animation of the generalized paths of seismic waves traveling from Turkey to three stations at varied distances around the globe.

## Magnitude 7.3 earthquake in East Turkey October 23, 2011



Simplified animation will show generalized wave paths recorded by the 3 seismic stations below at varying distances from the epicenter

~57° **SFJD** Sondre Stromfjord, Greenland

~90° **L39A** Vinton, IA, USA

~121° **LVC** Limon Verde, Chile

# Einteilung

- Einleitung, Geschichte der Plattentektonik IRIS
- Platten, Plattengrenzen und tektonische Prozesse  
Google Earth
- Erdbeben: vom ersten Vorbeben bis zum Tsunami  
Google Earth
- Erdbeben: Konflikt an Plattengrenzen
- Erdbeben: Aufzeichnen, messen, erforschen  
SAFOD, Nojima
- Historische Erdbeben an Transformalgrenzen und Subduktionszonen IRIS

# Stichworte

Platten

Plattengrenzen

Subduktion

Vor- Haupt- Nachbeben

Lithosphäre

Kruste-Mantel

Überschiebung Abschiebung

StrikeSlip

....

Tremor

Vor- Haupt- Nachbeben

Seismische Wellen

Seismograf

Magnitude

Richter- Mercalliskala

Tsunami

Gefährdung

seismic networks

....

# Geschichte der Plattentektonik

# Kontinentaldrift

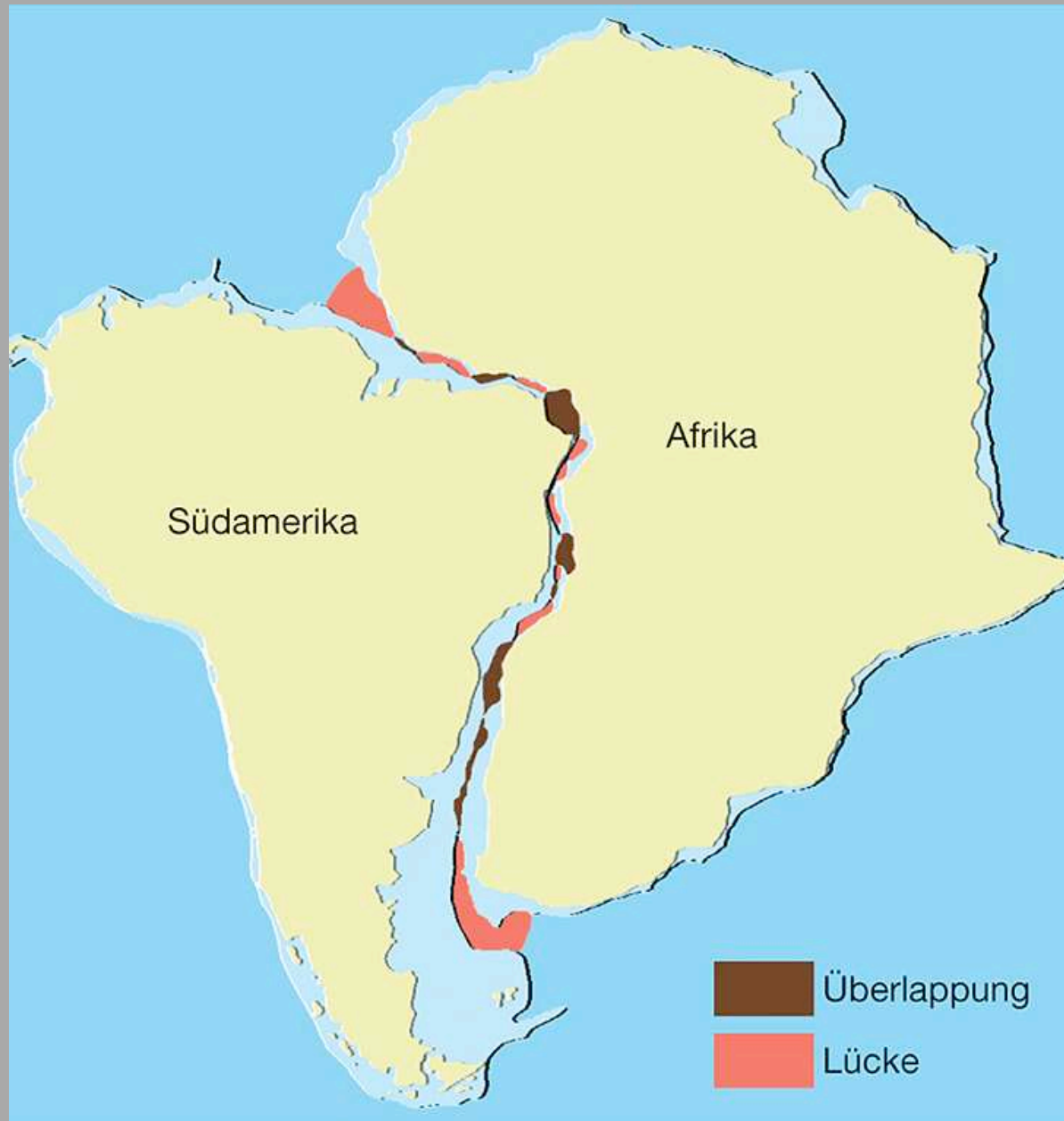


Hypothese (1912):  
Superkontinent Pangäa bricht  
auseinander - vor 200 Ma



Alfred Wegener  
(1880 - 1930)

# Evidenz für die Existenz von Pangäa



Anpassung entlang  
Kontinental sockel  
(900 m)

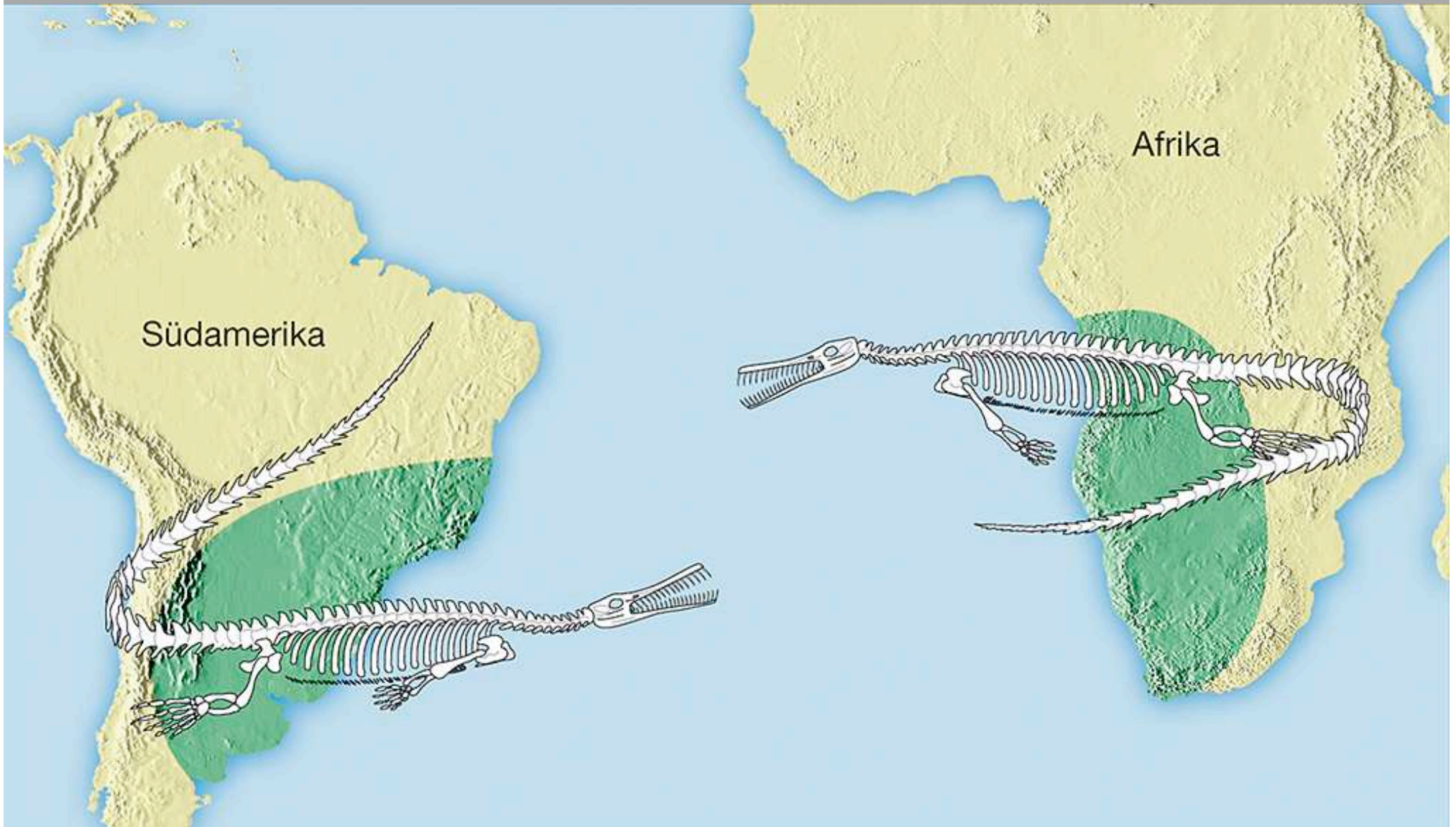
# Evidenz für die Existenz von Pangäa



Appalachen  
(USA)  
=  
Kaledoniden  
(UK, NO)

Gebirge (~300 Ma)  
gebildet bei der  
Kollision  $\Rightarrow$  Pangäa

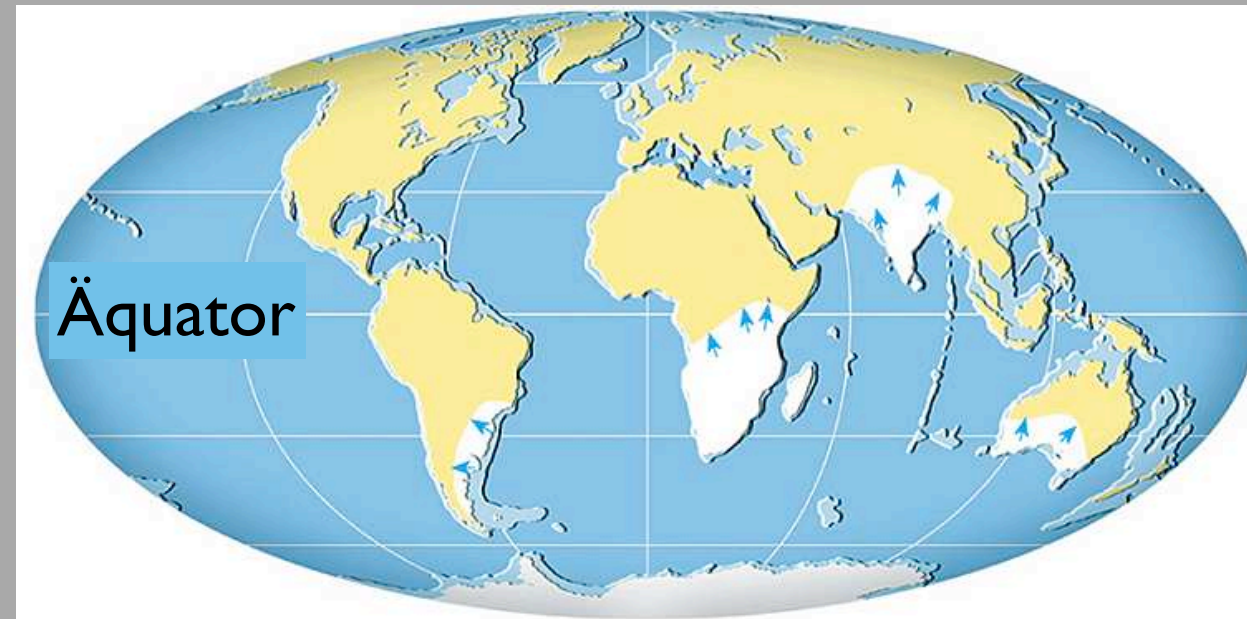
# Evidenz für die Existenz von Pangäa



Fossile Überreste von Mesosaurus (~Paläozoikum)



# Weiterer Hinweis



Vereisung 300 Ma

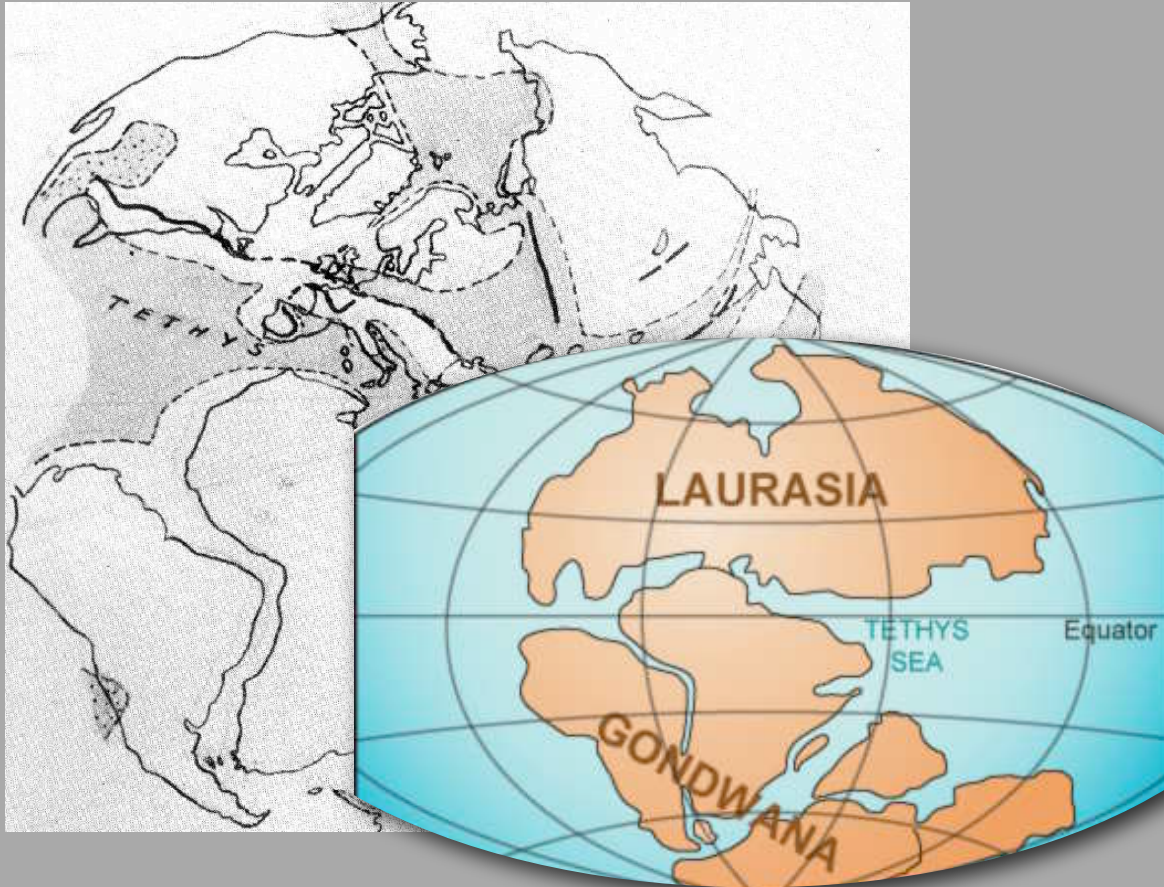
Fließrichtung  
des Eises →

Heutige Position  
der Kontinente



Kontinente in  
ursprünglicher  
Position

# Unterstützung für Kontinentaldrift

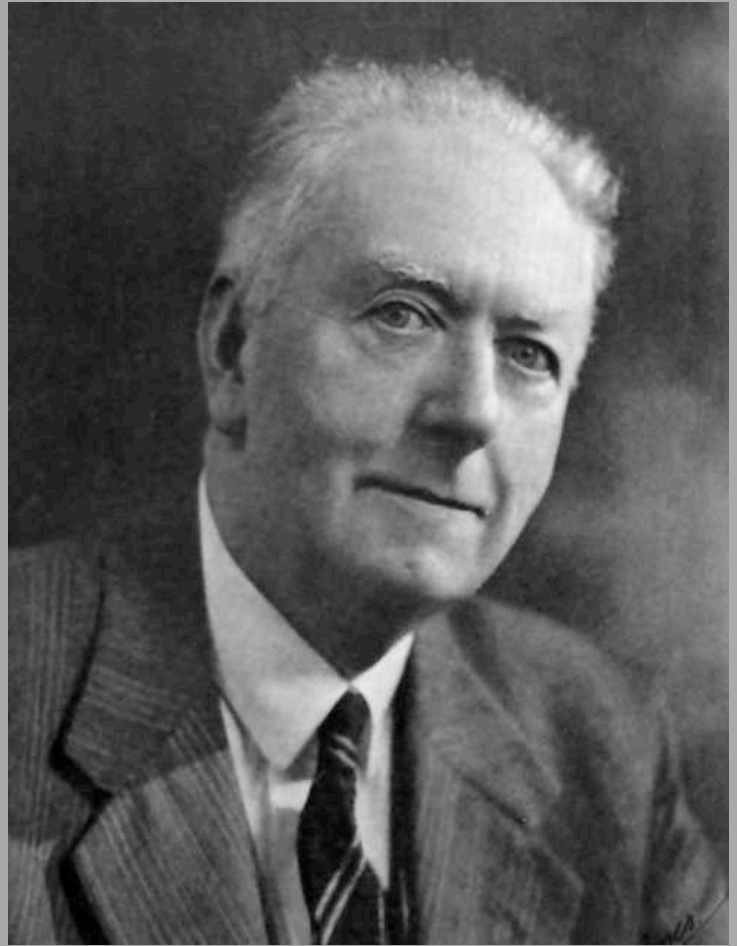
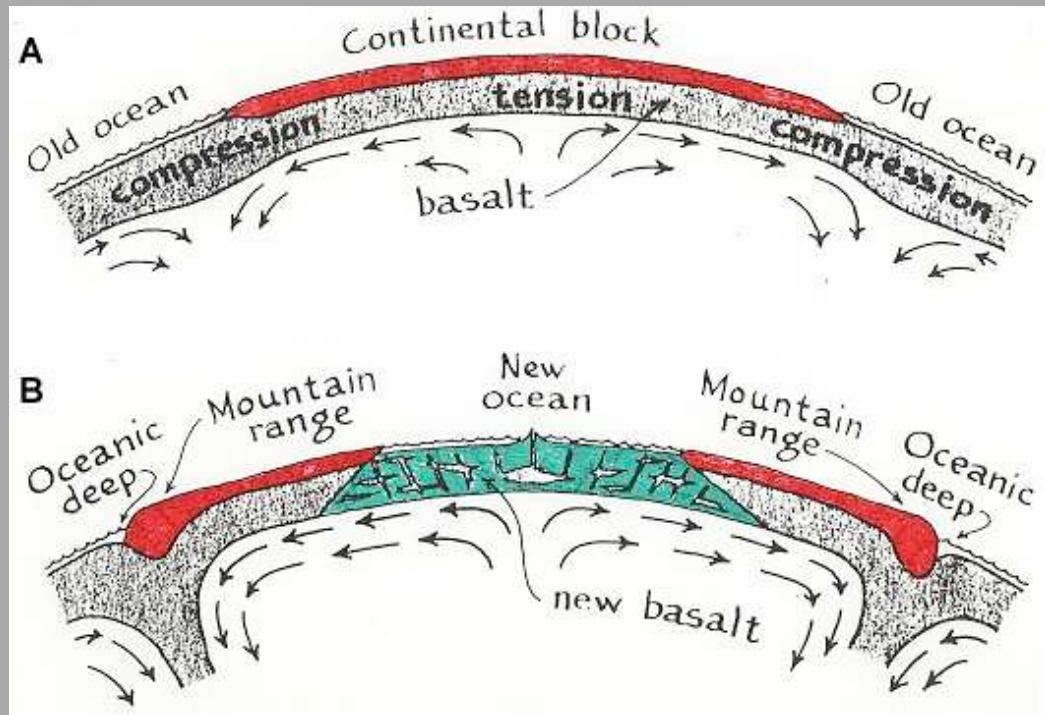


Alexander Logie du Toit  
(1878 - 1948)

"Our wandering Continents" (1937)  
Pangäa → Laurasia\* + Gondwana

\* Nordamerika Grönland Europa Asien

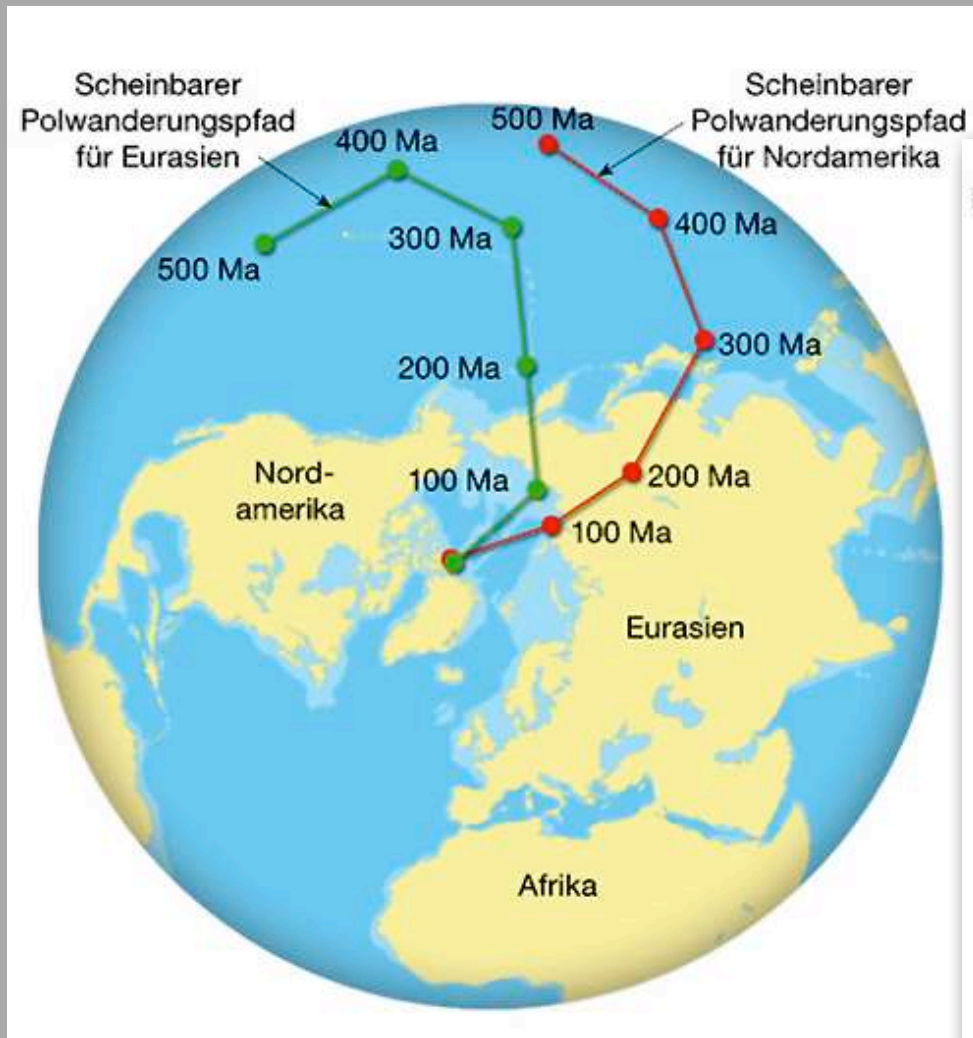
# Modell für Kontinentaldrift



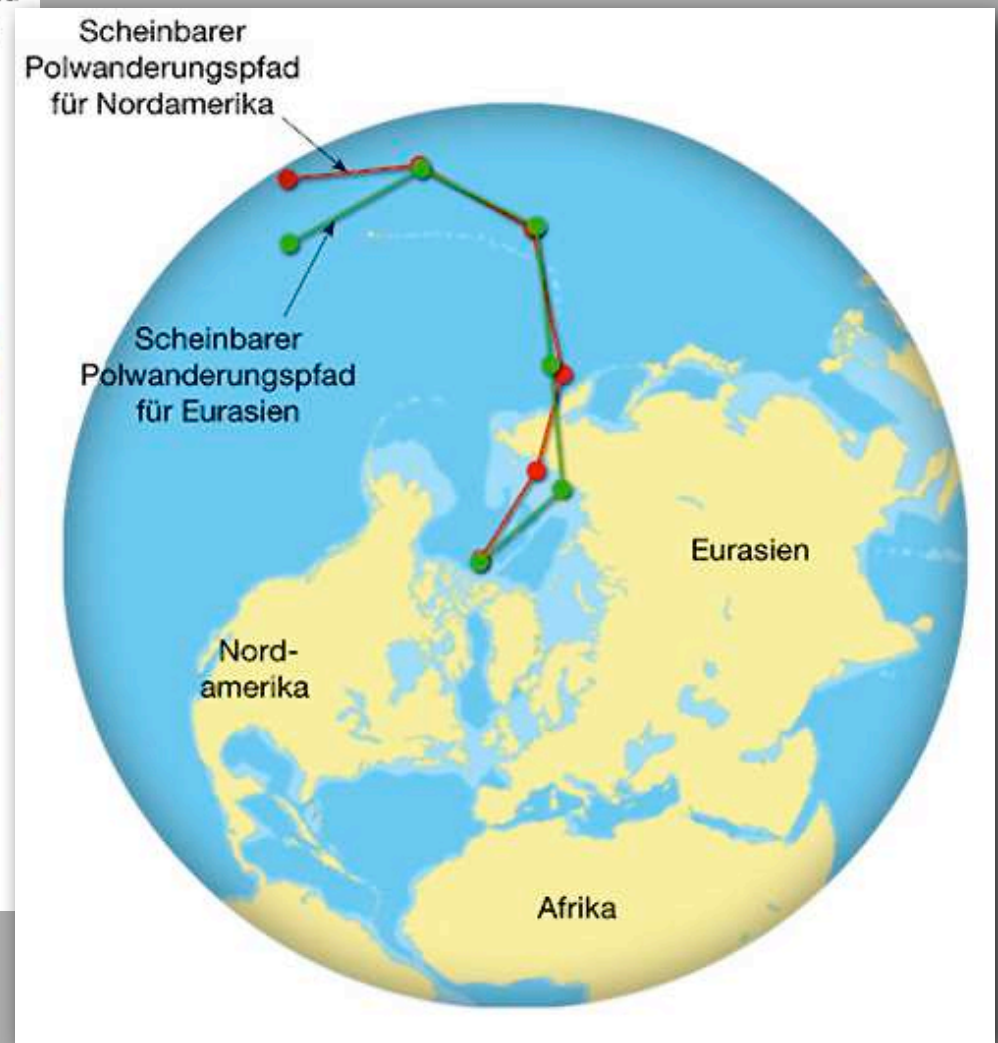
Arthur Holmes  
(1890 - 1965)

"Principles of Physical Geology"  
(1944)  
mit Kapitel über Kontinentaldrift

# Scheinbare Polwanderung



aus heutiger Sicht



Kontinente zurückrotiert

# Kartierung des Ozeanbodens



Marie Tharpe  
(1920 - 2006)

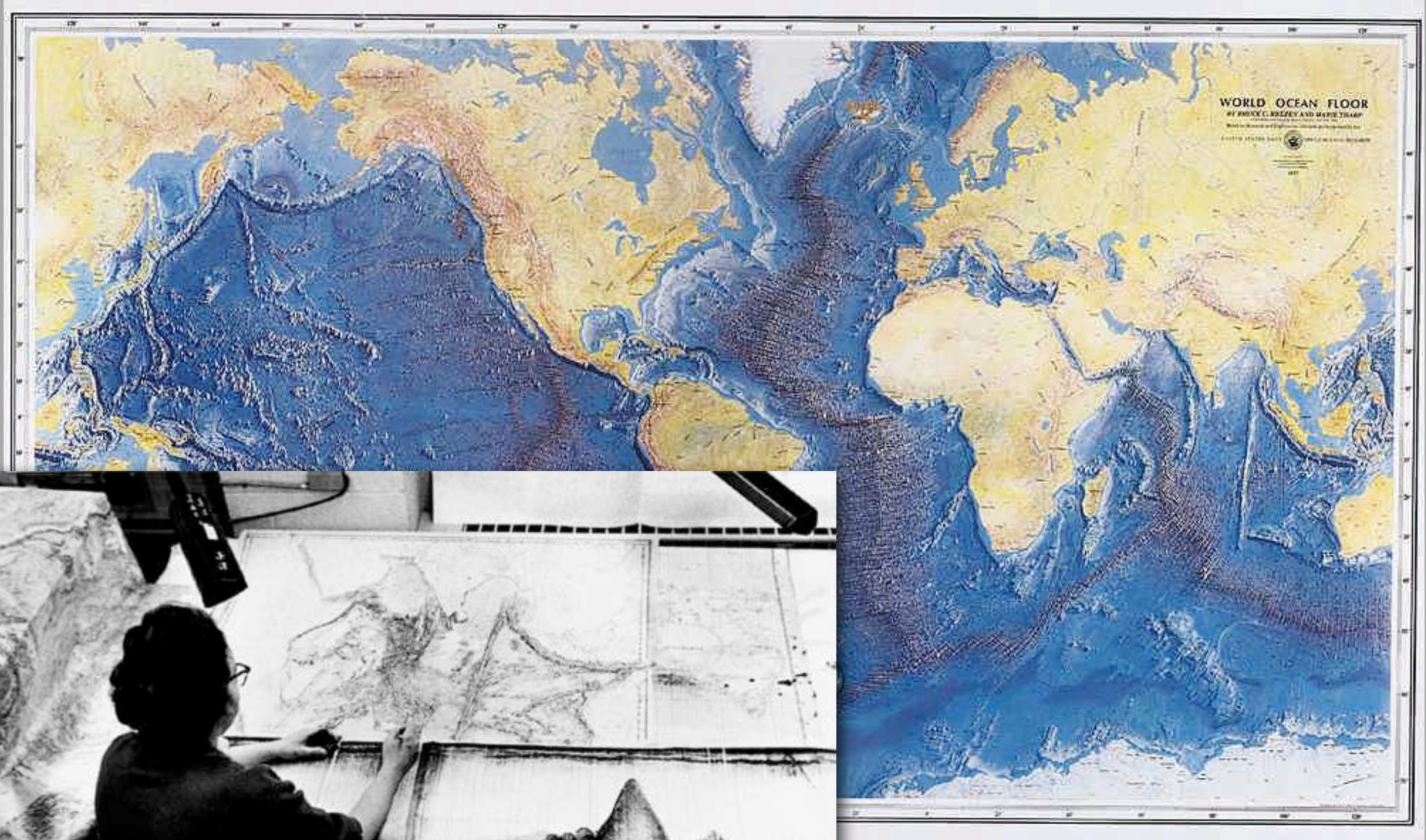
Bruce Heezen  
(1924 - 1977)



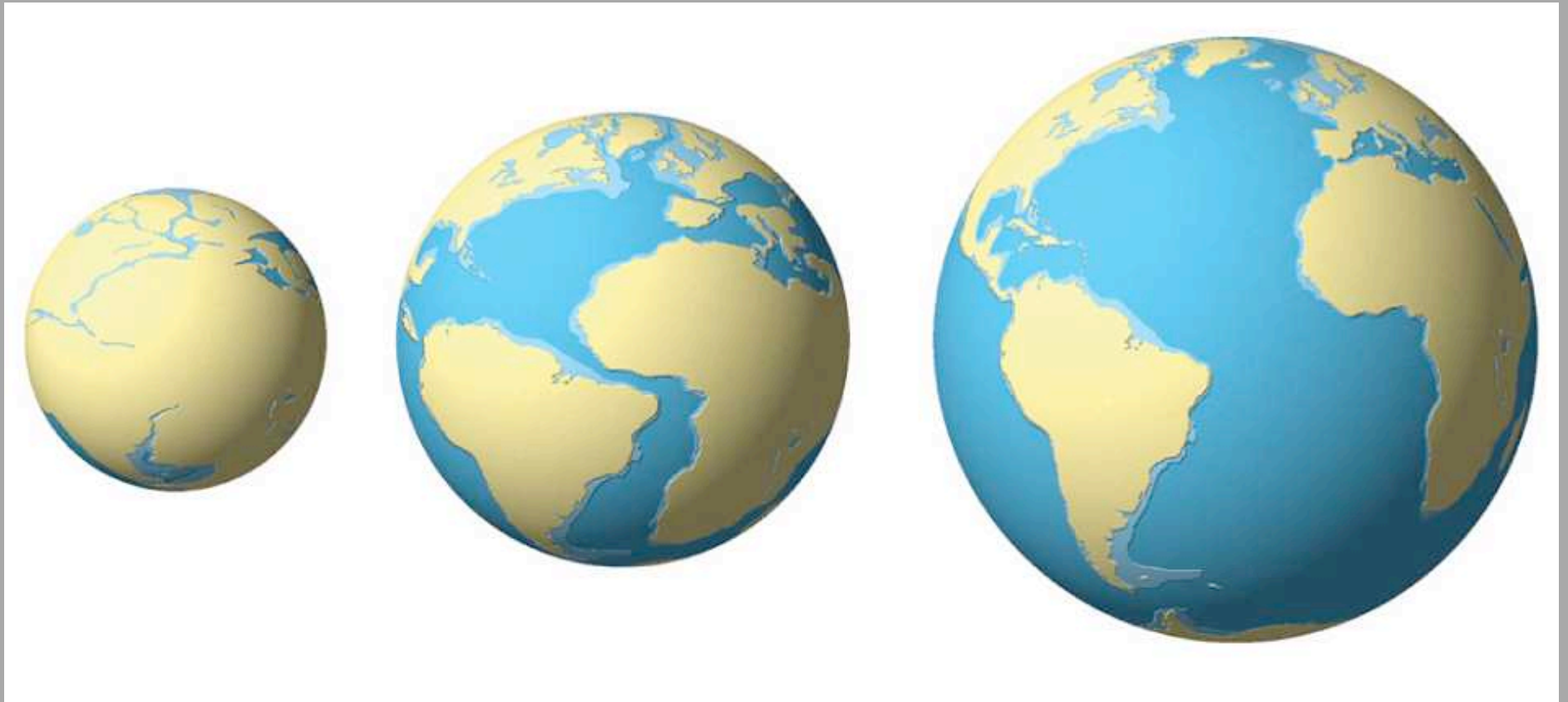
Harry Hammond Hess  
(1906 - 1969)

postuliert: Erdkruste  
entsteht an Ozeanrücken

# grossartige Karten !

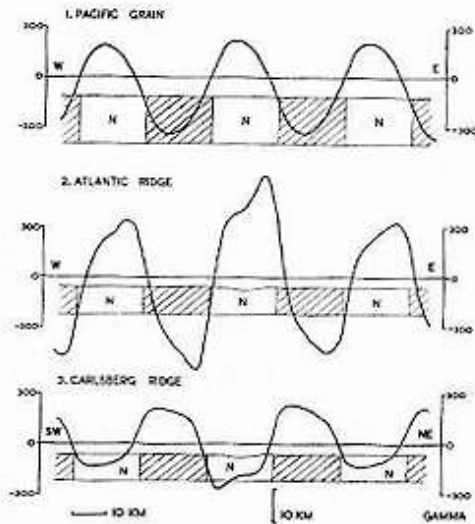


noch immer kein Mechanismus

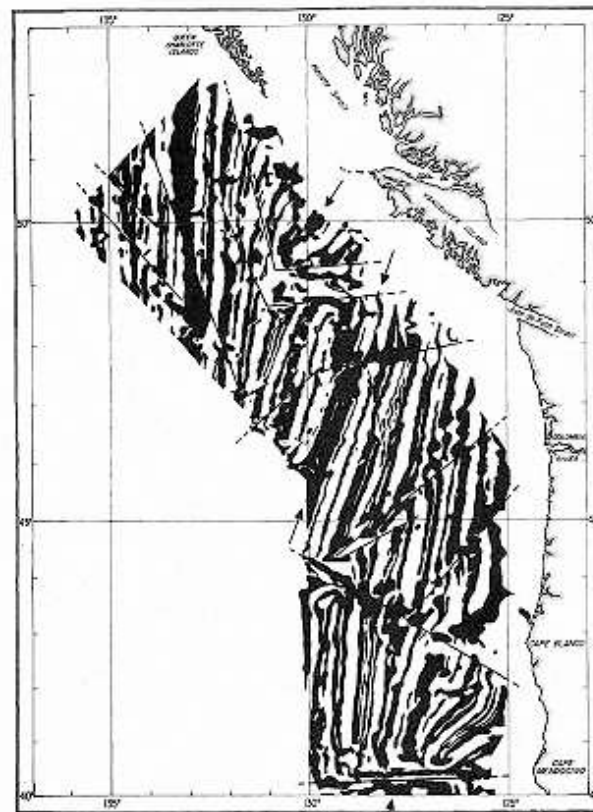


Expandierende Erde ?

# der Durchbruch !



**Fig. 4.** Magnetic profiles computed for various crustal models. Crustal blocks marked N, normally magnetized; diagonally shaded blocks, reversely magnetized. Effective susceptibility of blocks, 0.0027, except for the block under the median valley in profiles 2 and 3, 0.0053. (1) Pacific Grain. Total field strength,  $T = 0.5$  oersted; inclination,  $I = 60^\circ$ ; magnetic bearing of profile,  $\theta = 073^\circ$ . (2) Mid-Atlantic Ridge,  $T = 0.48$  oersted;  $I = 65^\circ$ ;  $\theta = 120^\circ$ . (3) Carlsberg Ridge,  $T = 0.376$  oersted;  $I = -6^\circ$ ;  $\theta = 044^\circ$ .



Summary of anomalies in the earth's magnetic field measured at sea level off British Columbia, Washington, and Oregon. Areas of anomalously high field strength are shown in black. Straight lines indicate faults offsetting the anomaly pattern; arrows, the axes of three short ridge lengths in the area - from north to south, the Explorer, Juan de Fuca, and Gorda Ridges. Reproduced courtesy of the Geological Society of America. (Raff and Mason, 1961, note 11.)

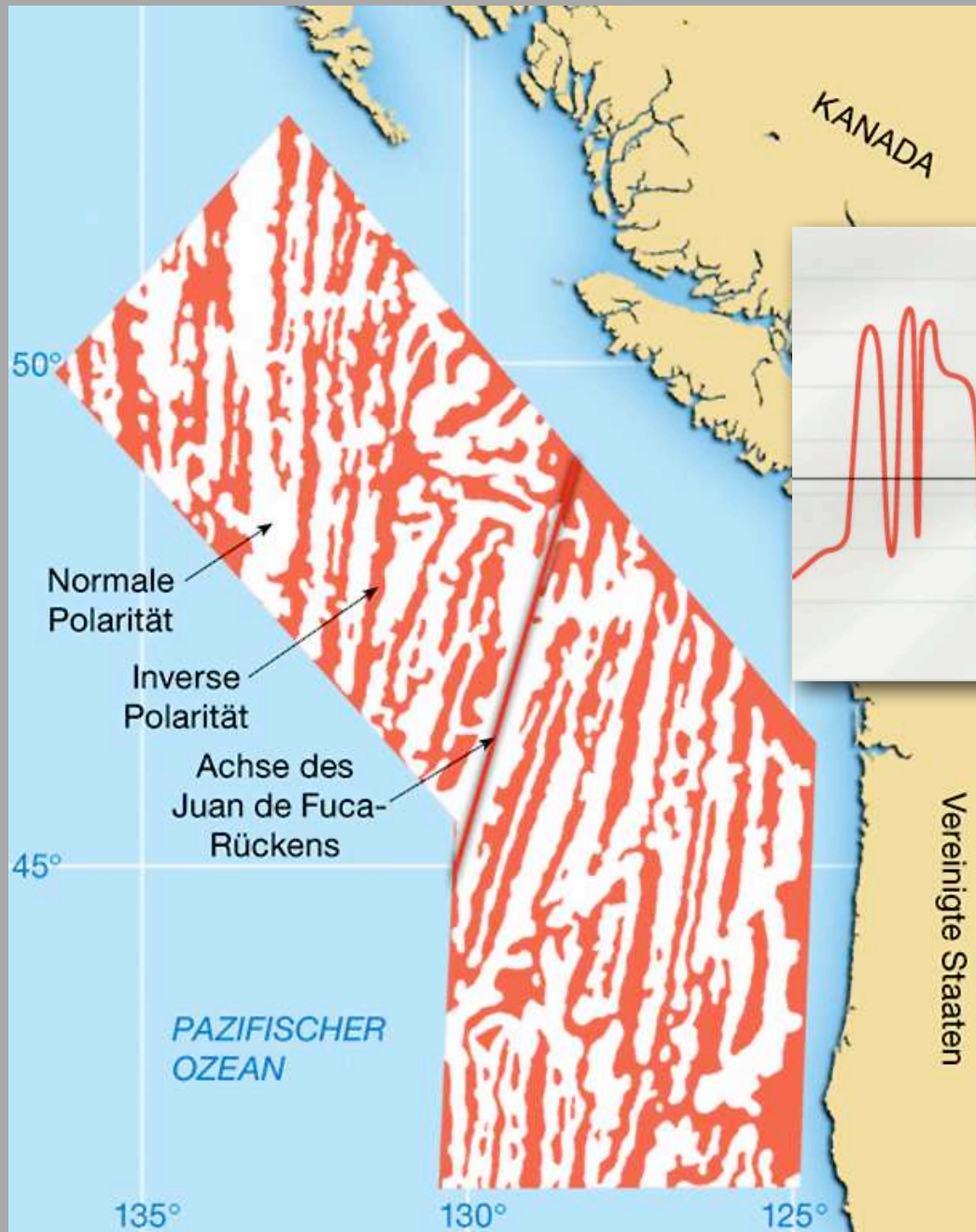


Frederick Vine  
(\* 1939)

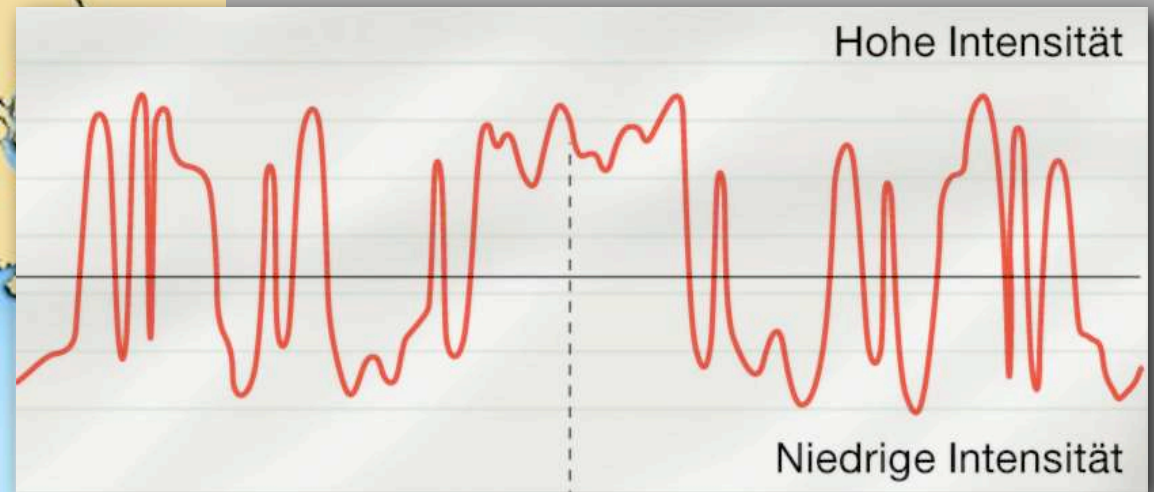
Drummond Hoyle  
Matthews (1931 - 1997)



# magnetische Lineationen

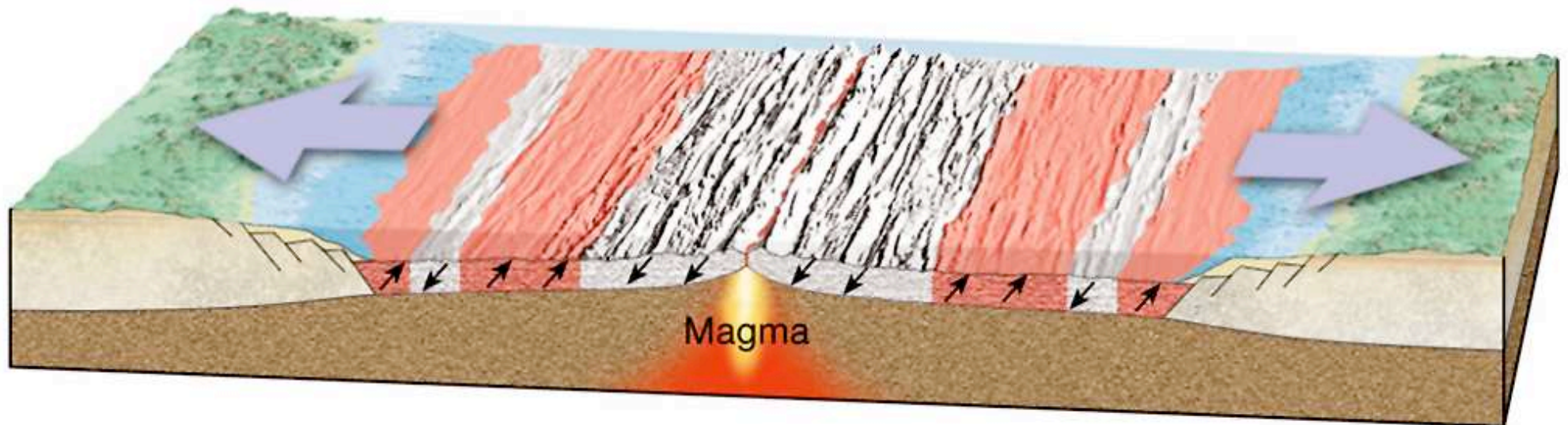
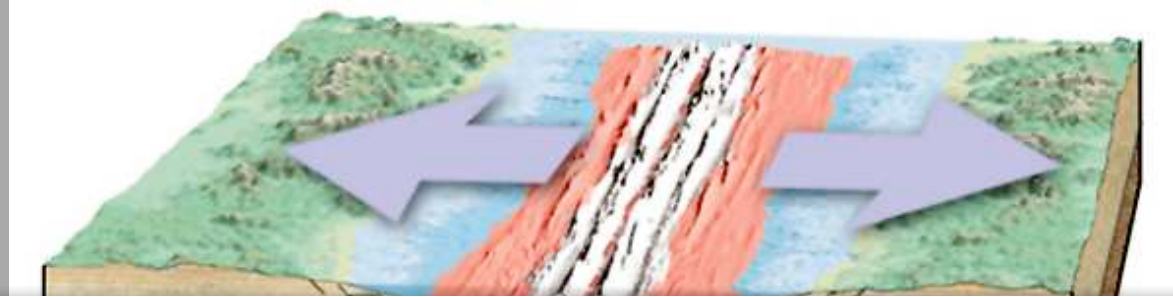


normale Polarität



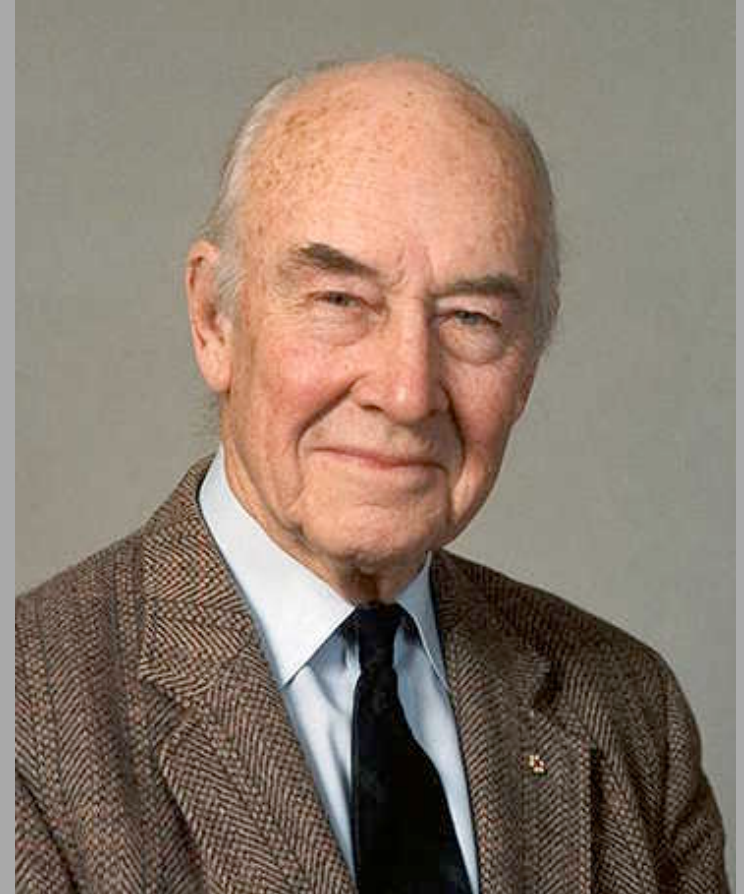
inverse Polarität

# Sea Floor Spreading !



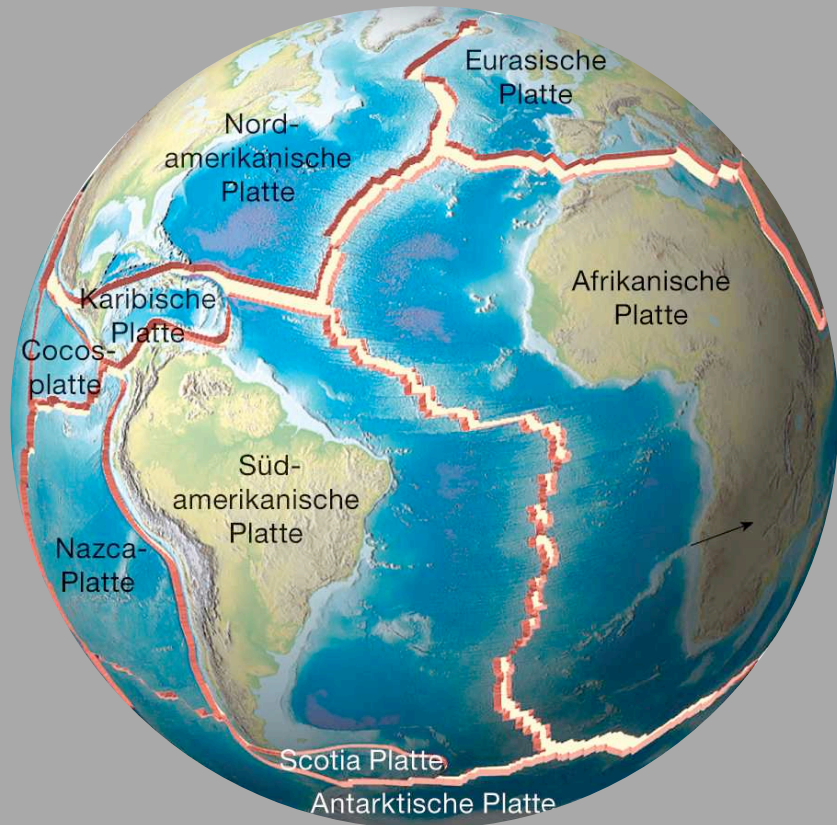
# Theorie der Plattentektonik

1.  
Neues Material an konstruktiven Plattengrenzen (sea floor spreading)
2.  
Erdoberfläche = konstant: Subduktion an destruktiven Plattengrenzen
3.  
Platten sind steif, können Spannungen übertragen



John Tuzo Wilson  
(1908 - 1993)

# "Plattentektonik" !



John Tuzo Wilson  
(1908 - 1993)

Wilson Zyklus = 500 Ma

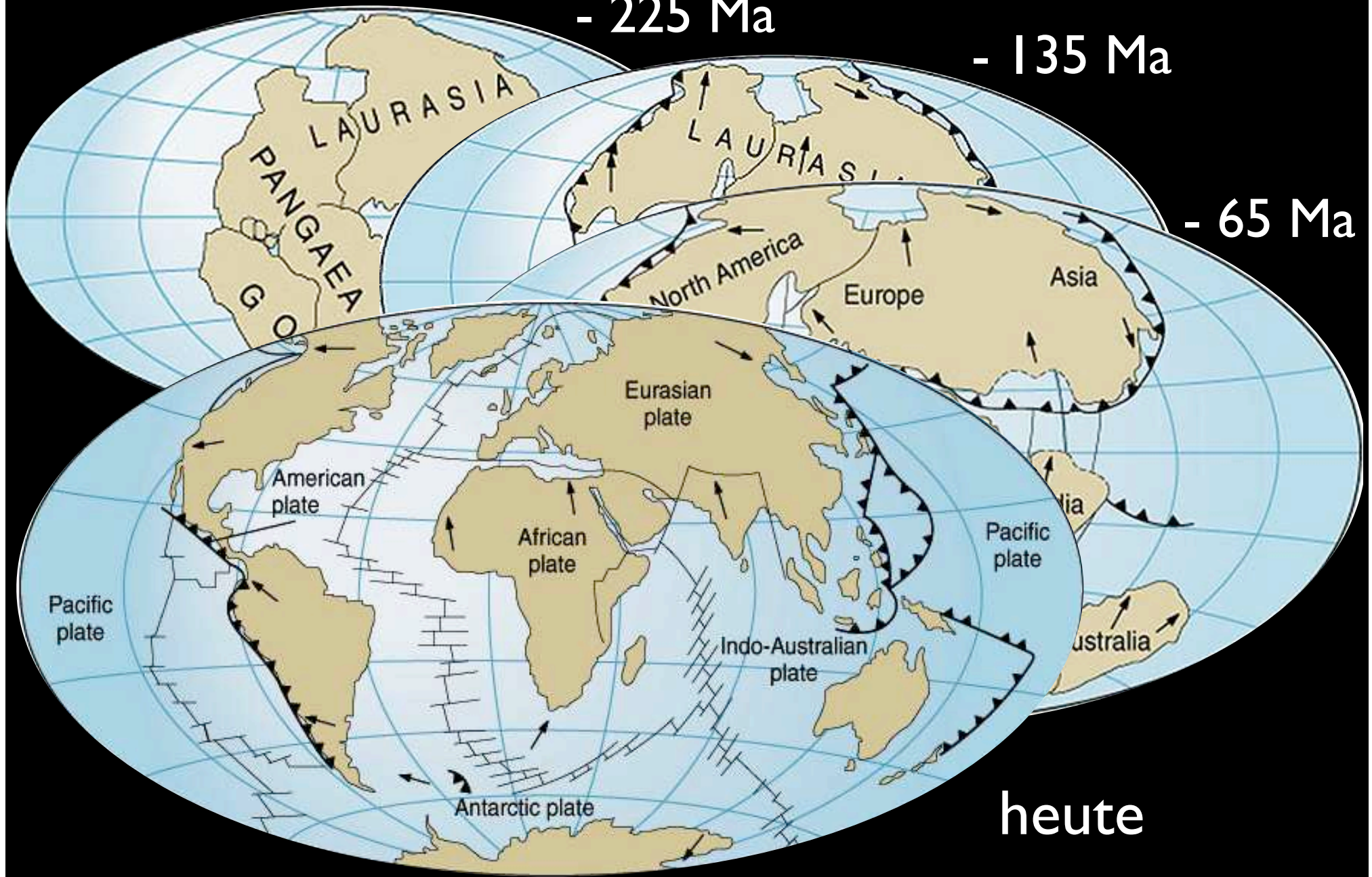
Pangäa  $\rightleftarrows$  Kontinente  $\rightleftarrows$  Pangäa

# Wilson Cycle

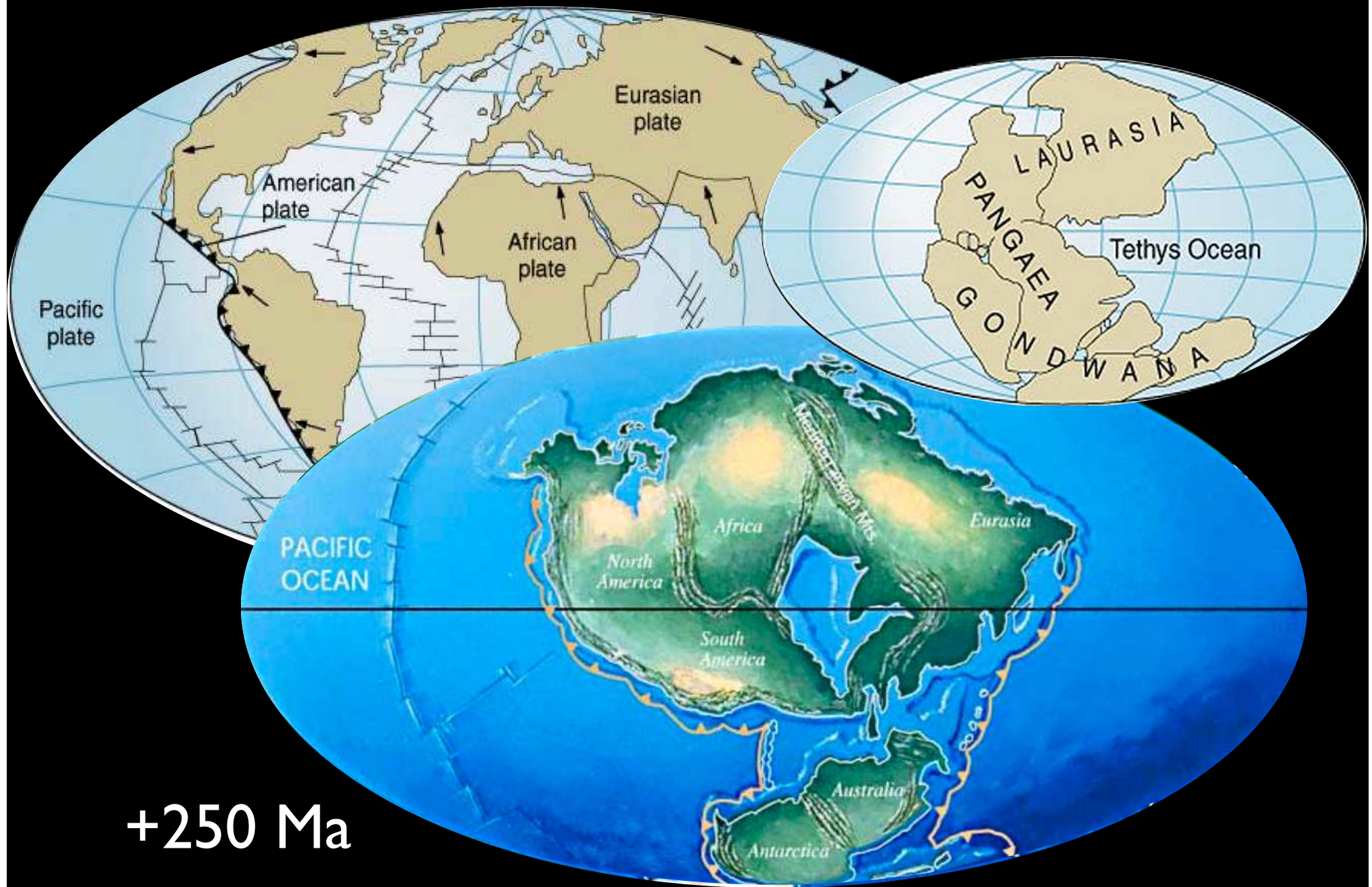
- 225 Ma

- 135 Ma

- 65 Ma



# Wilson Zyklus zu Ende geführt ...



# Google Earth: Plate boundaries

- Learn\_about\_Plate\_Tectonics.kmz
- USGS Real-time Earthquakes.kmz ARIA Envisat InSAR.kmz
- ARIA\_TohokuEQ\_Envisat\_InSAR.kmz
- Global\_Topography V14.kmz
- Historic Earthquakes.kmz
- Largest Earthquakes in the World Since 1900.kmz
- ShakeMap b0006bqc.kmz