

Tatort Plattengrenze: Smoking Guns

Der Plattentektonik auf der Spur

volks— hochschule beider basel

Kurse buchen

Wissen + Hintergründe

Natur

- Astronomie
- Klima - Wetter
- Geografie - Geologie
- Biologie - Chemie
- Mathematik - Physik

Medizin / Psychologie

Gesellschaft

Kultur

Grundbildung

Kreativität + Praxis

Sprachen

Senioren Uni

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Portale ▼

Wissen + Hintergründe > Natur > Geografie - Geologie > **Tatort Plattengrenze**

Tatort Plattengrenze

Der Plattentektonik auf der Spur

Kurs-Nr. K 100 3520
 Kurspreis CHF 155.00, inkl. Unterlagen
 Kursleitung **Renée Heilbronner**, Professorin für Geowissenschaften, Universität Basel

Die "smoking" der Plattentektonik sind Vulkane und Erdbeben, die entlang von Plattengrenzen vorkommen. Sie liefern uns wertvolle Informationen aus der Tiefe, sodass wir die innerste Struktur unseres Planeten dreidimensional abbilden und die plattentektonischen Prozesse weit unten im Erdmantel beobachten können. Unsere Spurensuche beginnt deshalb bei den konstruktiven Plattengrenzen, den mittelozeanischen Rücken, wo heisse Magmen bis zum Ozeanboden emporsteigen, und endet an den destruktiven Plattengrenzen, den Subduktionszonen, wo die erkalteten Platten beim Wiederabtauchen die stärksten Erdbeben auslösen, die wir kennen.

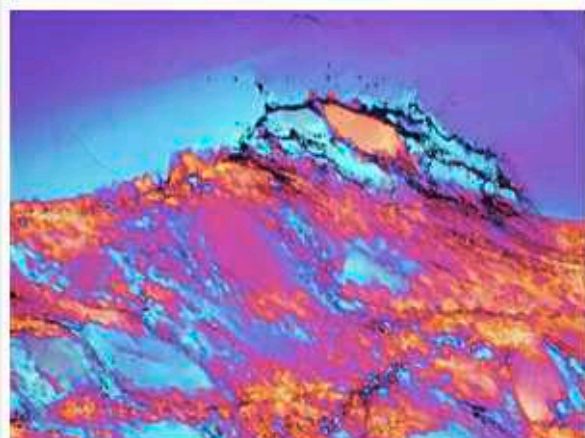
Kurstermine	Kurszeit	Kursort
Do, 31.10.2013	18:15-20:00	Universität Basel, Kollegienhaus, Petersplatz 1, Basel
Do, 07.11.2013	18:15-20:00	Universität Basel, Kollegienhaus, Petersplatz 1, Basel
Do, 14.11.2013	18:15-20:00	Universität Basel, Kollegienhaus, Petersplatz 1, Basel
Do, 21.11.2013	18:15-20:00	Universität Basel, Kollegienhaus, Petersplatz 1, Basel
Do, 28.11.2013	18:15-20:00	Universität Basel, Kollegienhaus, Petersplatz 1, Basel
Do, 05.12.2013	18:15-20:00	Universität Basel, Kollegienhaus, Petersplatz 1, Basel

- BASEL UNIVERSITY HOMEPAGE
- BASEL UNIVERSITY SCIENCE FACULTY (PHIL II)
- DEPARTMENT OF ENVIRONMENTAL SCIENCES
- GEOLOGICAL INSTITUTE

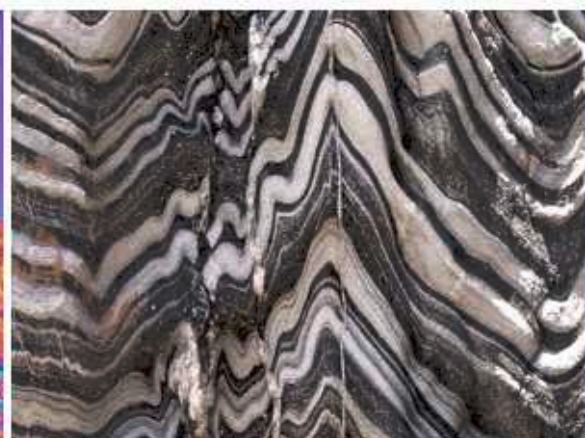
- UNIBIB -- Universitätsbibliothek
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- VLV -- Vorlesungsverzeichnis
- PERSSEARCH -- Personensuche



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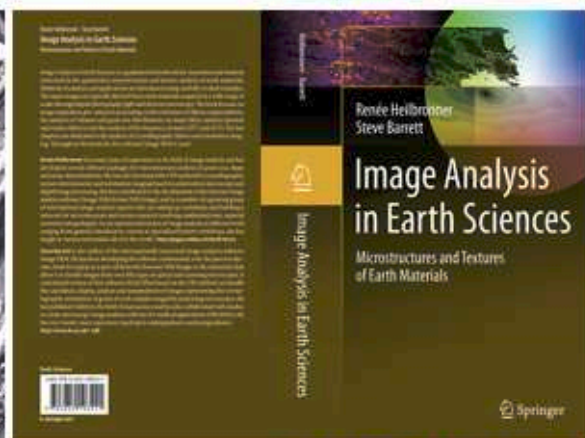


IMAGE ANALYSIS TEXTBOOK
chapters and figures
additional material
worked examples
various PDFs

Rock Deformation & Structure Analysis

http://earth.unibas.ch/micro/

NZZ E-Paper Tagi eTagi SRF2 meteoBFY meteoBSL meteoradar Image SXM meteoBSL meteoTOS nih manual eq Micro-DICE

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ROCK DEFORMATION group software SXM macros workshops chapters extras examples PDFs IMAGE ANALYSIS BOOK

LINKS & INFO

INFO www.seismo.ethz.ch Schweizerischer Erdbebendienst
earthquake.usgs.gov/earthquakes/map/ USGS Earthquake Hazard Program

SKRIPTEN & BEILAGEN [Tatort Plattengrenze: Smoking Guns](#) Volkshochschule beider Basel: Vorlesungsbeilagen HS2013
[Tatort Plattengrenze: Fokus Erdbeben](#) Volkshochschule beider Basel: Vorlesungsbeilagen HS2011
[Tatort Plattengrenze](#) Volkshochschule beider Basel: Vorlesungsbeilagen HS2009
[Deep Earth - oder wie Langsamkeit entsteht](#) Naturforschende Gesellschaft Basel: Vortrag, April 2010

ON-LINE TEACHING MATERIALS [Structural Geology](#) Haakon Fossen, University of Bergen, Norway
[WEBGEOLOGY](#) Kåre Kullerud, University of Tromsø, Norway
[Outcropedia](#) Online public database initiated by a group of structural geologists sponsored by Tectask
[Virtual Explorer](#) Journal of the Virtual Explorer devoted to rapid electronic publication

SOFTWARE LINKS [Image SXM](#) [Image Analysis Software \(for Mac\)](#)
[Fiji Is Just ImageJ](#) [Image Analysis Software \(Java\)](#)

Einführungsbeispiel: Pakistan 24. Sept. 2013

Aktuelle Erdbeben und Vulkanausbrüche

Schweizerischer Erdbebendienst (SED)

Der Schweizerische Erdbebendienst (SED) an der ETH Zürich ist die Fachstelle des Bundes für Erdbeben. In dessen Auftrag überwacht er die Erdbebenaktivität in der Schweiz sowie im grenznahen Ausland und beurteilt die Erdbebengefährdung in der Schweiz. Im Falle eines Erdbebens informiert der SED Öffentlichkeit, Behörden und Medien über den Ort, die Stärke und mögliche Auswirkungen. Die Aktivitäten des SED sind im Massnahmenprogramm des Bundes zur Reduktion des Erdbebenrisikos eingebunden.

Aktuelle Erdbeben: Schweiz / Welt

Date/Time(UTC)	Lat	Lon	Mag Region
2013/10/28 11:34 -10.11	161.03	4.8	SOLOMON ISLANDS
2013/10/28 07:34	8.65	93.58	4.4 NICOBAR ISLANDS, INDOA REGION
2013/10/28 07:14	7.93	127.01	4.7 THAILAND, MALAYA REGION
2013/10/28 05:10	-6.93	125.18	4.1 Banda Sea
2013/10/28 04:50	36.60	71.10	4.1 Afghanistan, TAIKISTAN
2013/10/28 04:48	-14.87	148.32	4.9 VANUATU
2013/10/28 01:38	-18.46	-177.84	4.6 FIJI REGION

In der Schweiz verspürte Erdbeben der letzten 72 Stunden: Keine

Aktuelles

Leichtes Erdbeben bei Saxon (V5)

Am späten Abend des 23. Oktober 2013 hat sich um 22:42 Uhr nördlich von Saxon (V5) in der Nähe von Ovrinnax ein leichtes Erdbeben ereignet. Das Beben der Magnitude 2.4 lag in geringer Tiefe und wurde daher im Umkreis von ungefähr 9 km deutlich wahrgenommen. Beim Schweizerischen Erdbebendienst sind etwa 25 Meldungen aus der Bevölkerung eingegangen. Aus diesen geht hervor, dass das Beben oft wie eine starke Erschütterung wahrgenommen wurde. Derartige Beobachtungen sind typisch für kleine Erdbeben in den obersten Kilometern des Erdbodens. Bei einem Erdbeben dieser Stärke sind keine Schäden zu erwarten.

24.10.2013

<http://www.seismo.ethz.ch/>

USGS Earthquake Hazards Program

Earthquakes

Significant Earthquakes Past 30 Days

Magnitude	Location	Time (UTC)	Depth (km)
6.5	73km SW of El Estero, Mexico	2013-10-19 17:54:56 UTC	83.0 km deep
6.8	54km WSW of Paganua, Papua New G...	2013-10-16 10:31:00 UTC	54.1 km deep
7.1	8km NE of Cebu, Philippines	2013-10-10 12:12:32 UTC	20.0 km deep
6.4	30km W of Pitalos, Greece	2013-10-12 13:11:52 UTC	36.2 km deep
6.1	33km N of Queira, Venezuela	2013-10-12 02:10:29 UTC	79.4 km deep
4.9	33km WNW of Eureka, California	2013-10-11 20:05:07 UTC	8.7 km deep
6.4	113km SE of Amstegden Island	2013-10-04 17:26:19 UTC	12.9 km deep
6.7	Sea of Okhotsk	2013-10-01 03:38:21 UTC	580.8 km deep
6.5	78km NE of L'Esperance Rock, New Ze...	2013-10-05 09:05:06 UTC	47.7 km deep

Today's Earthquake Fact

Earthquakes tend to reoccur along faults, which reflect zones of weakness in the Earth's crust. Even if a fault zone has recently experienced an earthquake, however, there is no guarantee that all the stress has been relieved. Another earthquake could still occur. Further, more, relieving stress along one part of the fault may increase stress in another part.

Today in Earthquake History

October 23, 1992

M 5.2, Morocco - The epicenter was located about 70 kilometers south of El-Rhachid and 300 kilometers southeast of Rabat. There was damage and at least two people were killed. [Read More](#)

<http://earthquake.usgs.gov/earthquakes/>

IRIS INCORPORATED RESEARCH INSTITUTIONS FOR SEISMOLOGY

Recent Earthquake Teachable Moments

October 25, 2013 (17:10:16 UTC)

Magnitude 7.1 Off the east coast of Honshu, Japan

A magnitude 7.1 struck early Saturday off Japan's east coast. The quake hit at 2:10 a.m. Tokyo time about 170 miles from Fukushima and was felt in Tokyo, 300 miles away. There were no immediate reports of damage.

Teachable Moment Presentation

9 slide PowerPoint presentation (ppted ppt 3.22 MB / pdf 816 kB)

<http://www.iris.edu/hq/retm>

USGS Volcano Hazards Program

Current Alerts for U.S. Volcanoes

Volcano Name	Alert Level	Location
Kilauea	Watch Orange	Hawaii
Cleveland	Advisory Yellow	Alaska
Veniaminof	Advisory Yellow	Alaska
Pagan	Advisory Yellow	Micronesia
Cascade Range	Normal Green	Washington
Mauna Loa	Normal Green	Hawaii
Hualalai	Normal Green	Hawaii
Haleakala	Normal Green	Hawaii
Mauna Kea	Normal Green	Hawaii
Yellowstone	Normal Green	Wyoming
Le'ihi	Unassigned	Hawaii

Subscribe to the Volcano Notification Service

Subscribe to our feed

To view the interactive volcano activity map, please visit our [home page](#).

<http://volcanoes.usgs.gov/activity/status.php>

INGV Istituto Nazionale di Geofisica e Vulcanologia

Active volcanoes

you are here: [volcani](#) > [active volcanoes](#)

Active volcanoes

Volcanoes are the most spectacular surface manifestations of the geodynamic processes acting in the Earth's interior. Volcanology is the science that studies their behavior. The knowledge of volcanoes and their mechanisms has a primary role in the comprehension of the evolution of our planet and is also fundamental for the evaluation of the related hazard.

Italian active volcanoes

Ten active volcanoes are present in the Italian territory, "active" in that they gave manifestations in the last 10,000 years.

Colli Albani | Campi Flegrei | Vesuvio | Ischia | Stromboli | Lipari | Vulcano | Etna | Pantelleria | Isola Ferdinandea

Etna and Stromboli only have persistent activities, that is they erupt continuously or with intervals of months or a few years. Nevertheless, all the above listed volcanoes can produce eruptions within medium-long term.

These volcanic systems are monitored via integrated multiparametric systems. The collection of data about activity status of a volcano is supplemented by the study of data that have been collected during significant eruptions.

<http://vulcani.ingv.it/en/>

1



Magnitude 7.7 PAKISTAN
Tuesday, September 24, 2013 at 11:29:48 UTC



2

A powerful earthquake has killed at least 208 people in Pakistan's remote south-west province. Many houses were flattened and thousands of people have spent the night in the open.

3

The earthquake was felt across Pakistan. Residents rushed into the streets as tall buildings swayed in Karachi, the country's most densely populated city (11.6 million), 270 km south of the epicenter.



Pakistani villagers look for belongings amid the rubble of their destroyed homes following an earthquake in the remote district of Awaran, Baluchistan province, Pakistan.

Rescuers struggled Wednesday to help thousands of people injured and left homeless after their houses collapsed in a massive earthquake in southwestern Pakistan Tuesday, as the death toll rose to hundreds.

(AP Photo/Arshad Butt)



Teachable Moments are a service of
IRIS Education & Public Outreach
and
The University of Portland



Intensität: Modifizierte Mercalli Intensität (MMI)



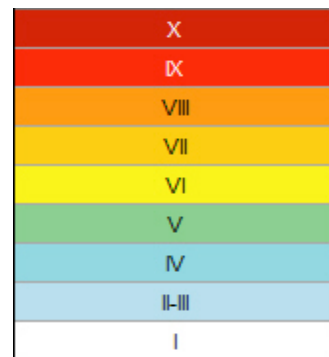
Magnitude 7.7 PAKISTAN
 Tuesday, September 24, 2013 at 11:29:48 UTC

Shaking Intensity

The Modified Mercalli Intensity (MMI) scale depicts shaking severity. The area nearest the earthquake experienced violent shaking.

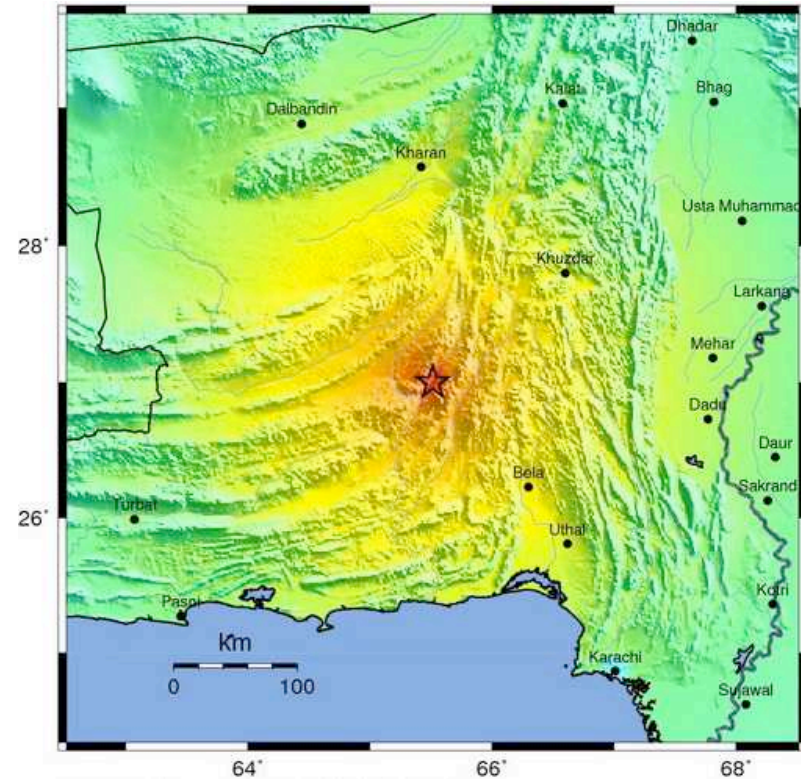
Mercalli Skala	
XII	grosse Katastrophe
XI	Katastrophe
X	vernichtend
IX	verwüstend
VIII	zerstörend
VII	sehr stark
VI	stark
V	ziemlich stark
IV	mässig
III	leicht
II	sehr leicht
I	unmerklich

Modified Mercalli Intensity



Perceived Shaking
Extreme
Violent
Severe
Very Strong
Strong
 Moderate
 Light
 Weak
 Not Felt

Image courtesy of the US Geological Survey



USGS Estimated shaking Intensity from M 7.7 Earthquake

4

☆ = Epizentrum

PAGER

Prompt Assessment of Global Earthquakes for Response

4



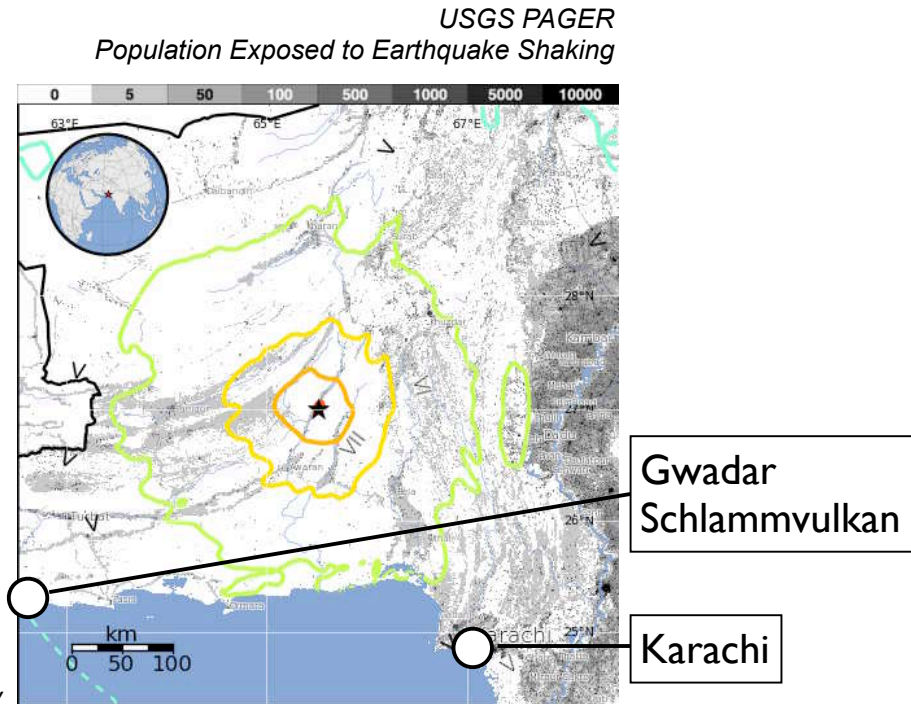
Magnitude 7.7 PAKISTAN
 Tuesday, September 24, 2013 at 11:29:48 UTC

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

The USGS is estimating that 18,000 people were exposed to violent shaking, and 30,000 exposed to severe shaking during this earthquake.

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 below.


Image courtesy of the US Geological Survey



Estimated <u>Modified Mercalli Intensity</u>	I	II-III	IV	V	VI	VII	VIII	IX	X
Est. Population Exposure	--*	--*	9,642k*	20,769k*	1,203k	181k	30k	18k	0k
Perceived Shaking	Not Felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme

9 642 000 20 769 000 1 203 000 181 000 30 000 18 000 0


schneller Blick auf den update: onepager.pdf



USGS
science for a changing world

M 7.7, PAKISTAN
Origin Time: Tue 2013-09-24 11:29:48 UTC (16:29:48 local)
Location: 27.00°N 65.51°E Depth: 20 km

Earthquake Shaking ● Red Alert

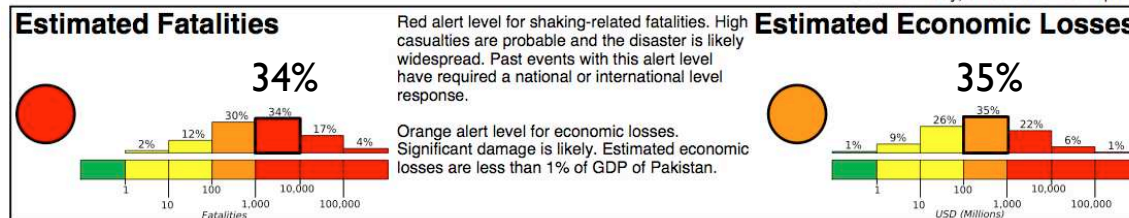


USAID
FROM THE AMERICAN PEOPLE

PAGER
Version 9
Created: 1 day, 6 hours after earthquake

5

Tote

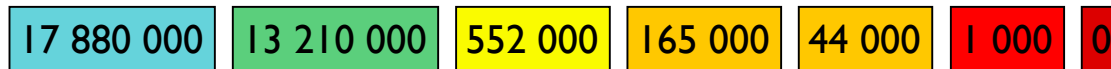


Schaden
(in Mio. US\$)

Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)	--*	--*	17,880k*	13,201k	552k	165k	44k	1k	0
ESTIMATED MODIFIED MERCALLI INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	Resistant Structures	none	none	V. Light	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy
	Vulnerable Structures	none	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy

*Estimated exposure only includes population within the map area.



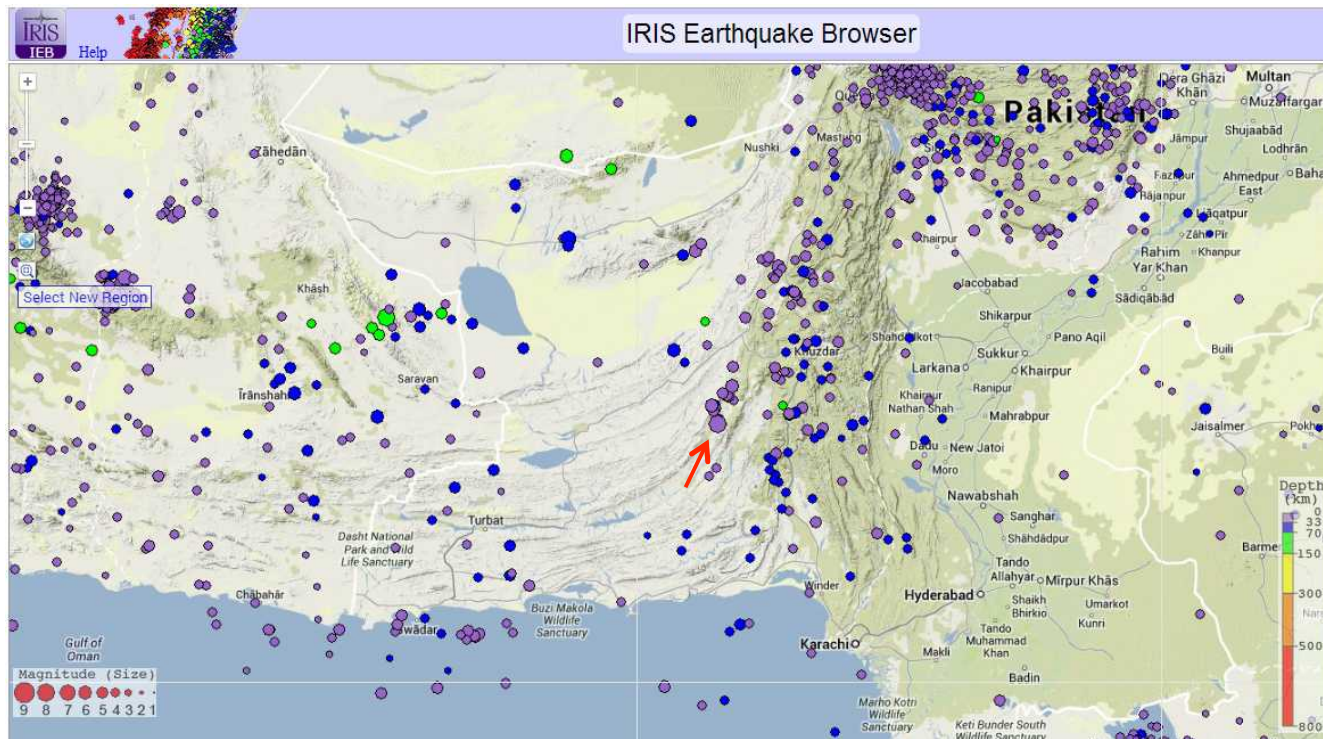
erste Schätzung war:



Erdbeben-Epizentren und -magnituden seit 1990

IRIS Magnitude 7.7 PAKISTAN
Teachable Moments Tuesday, September 24, 2013 at 11:29:48 UTC

This earthquake epicenter is plotted on the map with regional seismicity since 1990.



6

Plattengrenzen - Tripelpunkt



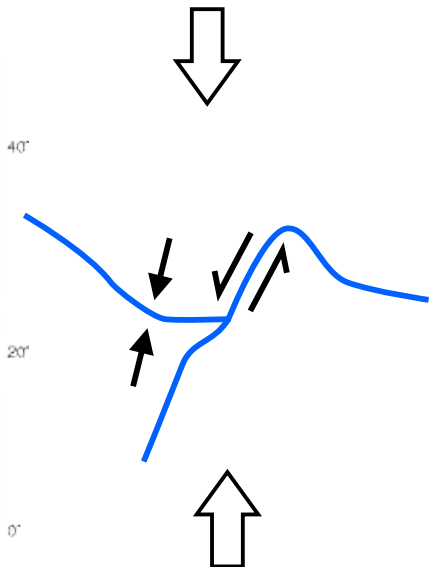
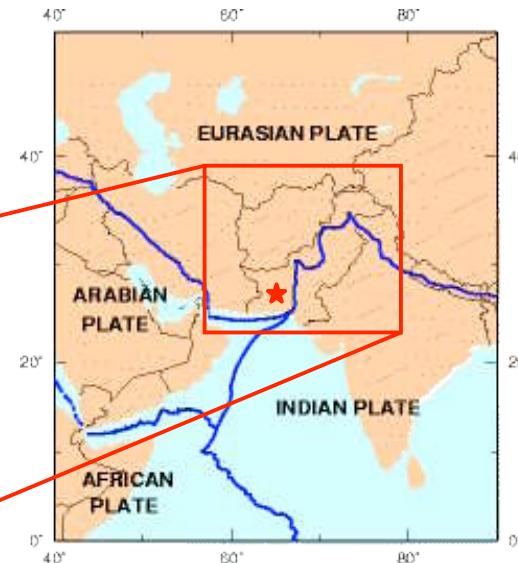
Magnitude 7.7 PAKISTAN
Tuesday, September 24, 2013 at 11:29:48 UTC

This earthquake occurred near the plate boundaries of the Eurasian, Arabian, and Indian Plates.

7

The tectonics of southern and central Pakistan reflect a complex plate boundary where the India Plate slides northward relative to the Eurasian Plate in the east, and the Arabian Plate subducts northward beneath the Eurasian Plate in the Makran (western Pakistan).

These motions typically result in north-south to northeast-southwest strike-slip motion at the latitude of this earthquake.



Plattentektonische Situation



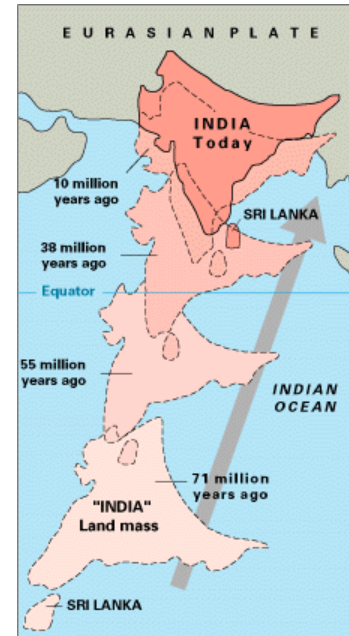
Magnitude 7.7 PAKISTAN
Tuesday, September 24, 2013 at 11:29:48 UTC

8

The earthquake activity in Pakistan is related to 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 southwest through Pakistan.



9



Whereas the motion of India into Asia is essentially perpendicular to the Himalaya Mountains, the motion in Pakistan is “oblique convergence”. This region is quite complex with earthquakes that have thrust (compressional), strike-slip (shearing), and occasionally normal (extensional) faulting mechanisms.

Bewegungssinn der Erdbeben:

Überschiebung
(Kompression)

Blattverschiebung
(Scherung)

Abschiebung
(Dehnung)

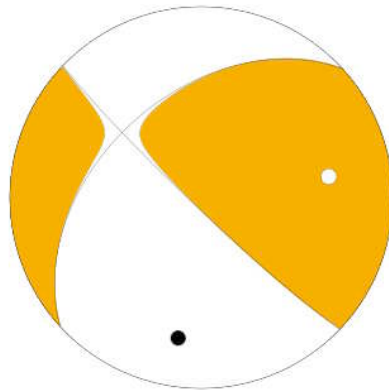
Herdfächen - Bewegungssinn



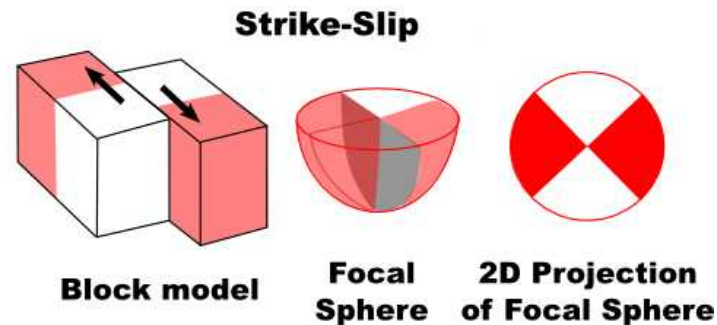
Magnitude 7.7 PAKISTAN
Tuesday, September 24, 2013 at 11:29:48 UTC

This earthquake occurred as the result of left-lateral oblique-strike-slip motion at shallow crustal depths. The location and mechanism of the earthquake are consistent with rupture within the Eurasian Plate above the Makran subduction zone where the Arabian Plate is subducting beneath the Eurasian Plate.

10



USGS Centroid Moment Tensor Solution



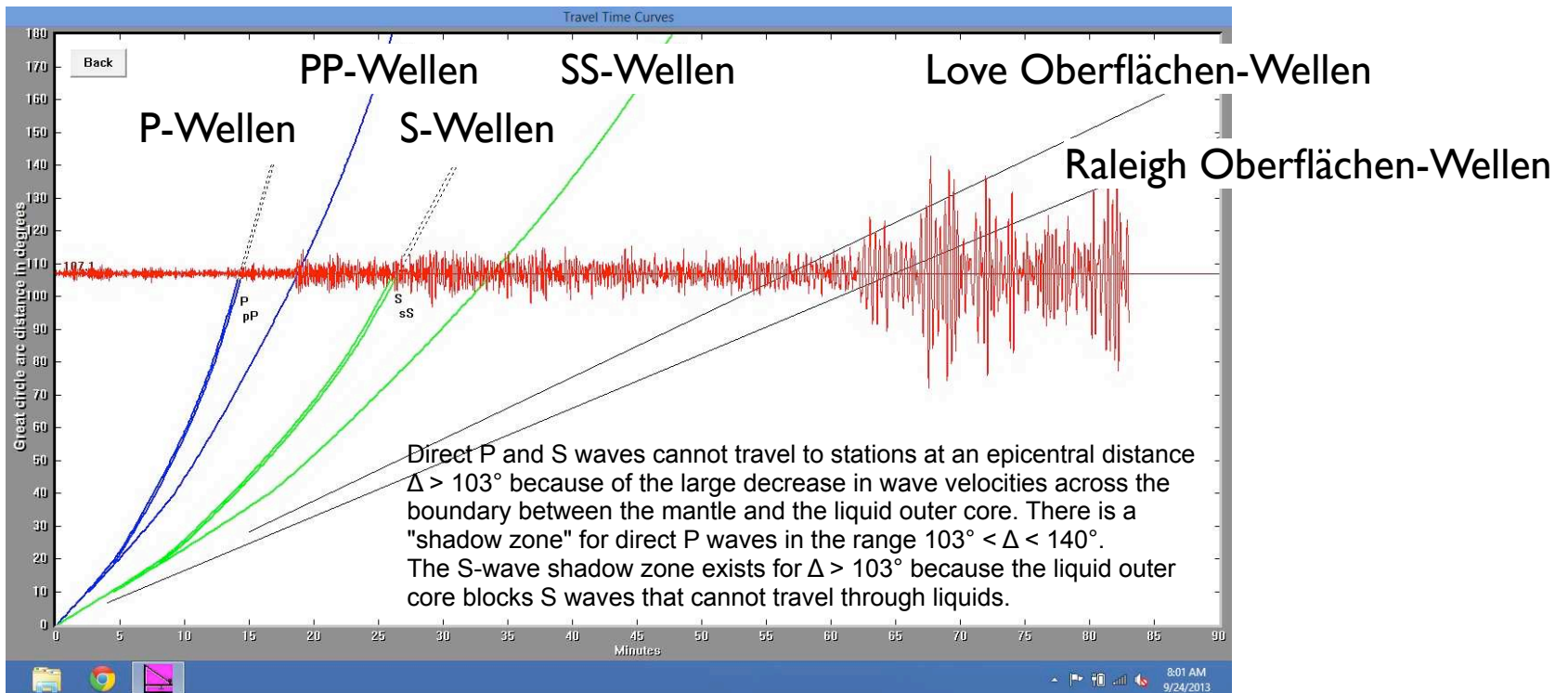
Shaded areas show quadrants of the focal sphere in which the P-wave first-motions are away from the source, and unshaded areas show quadrants in which the P-wave first-motions are toward the source. The dots represent the axis of maximum compressional strain (in black, called the "P-axis") and the axis of maximum extensional strain (in white, called the "T-axis") resulting from the earthquake. An introduction to focal mechanisms can be found in the animation at following URL: http://www.iris.edu/hq/programs/education_and_outreach/animations/25

Seismogramm der Universität Portland



Magnitude 7.7 PAKISTAN
Tuesday, September 24, 2013 at 11:29:48 UTC

The record of the earthquake on the University of Portland seismometer (UPOR) is illustrated below. Portland is about 11,733 km (~7290 miles, 105.7 degrees) from the location of this earthquake.



Seismische Schattenzone der P- und S-Wellen

12

IRIS
Teachable Moments

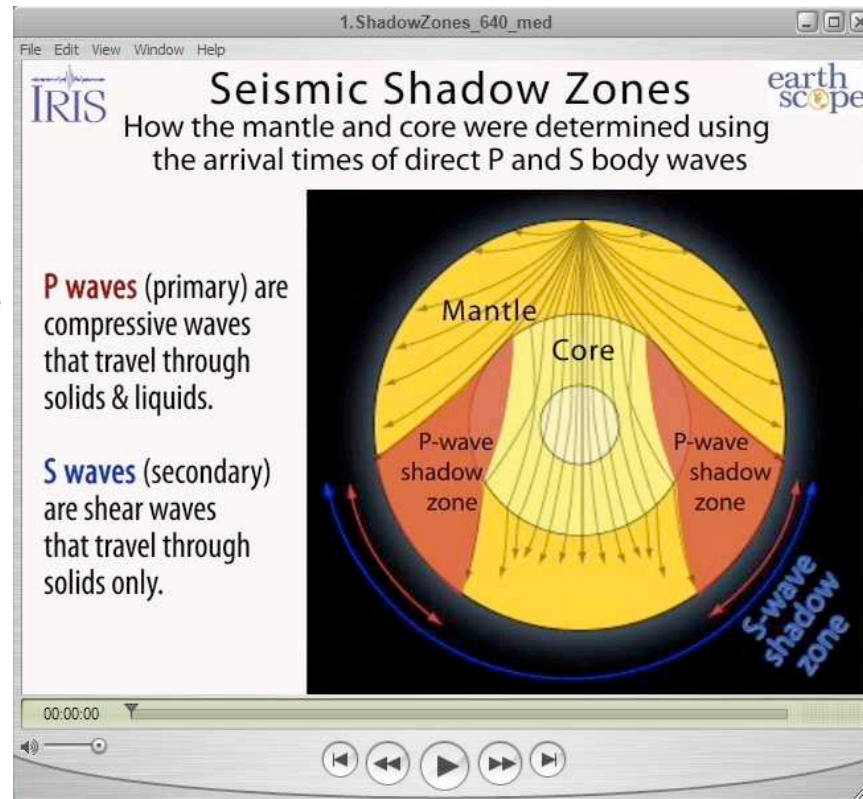
Magnitude 7.7 PAKISTAN
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Animation explaining the seismic shadow zone.

Epicentral distance is the angle formed by the intersection of the line from the earthquake to Earth's center with the line from the observing point to the Earth's center.

S waves are seen up to a distance of 104° from an earthquake, but direct S waves are not recorded beyond this distance.

P waves also have a shadow zone between 104° and 140° .



http://www.iris.edu/hq/programs/education_and_outreach/animations/18

Jenda Johnson

Geologische Wissenschaften heute

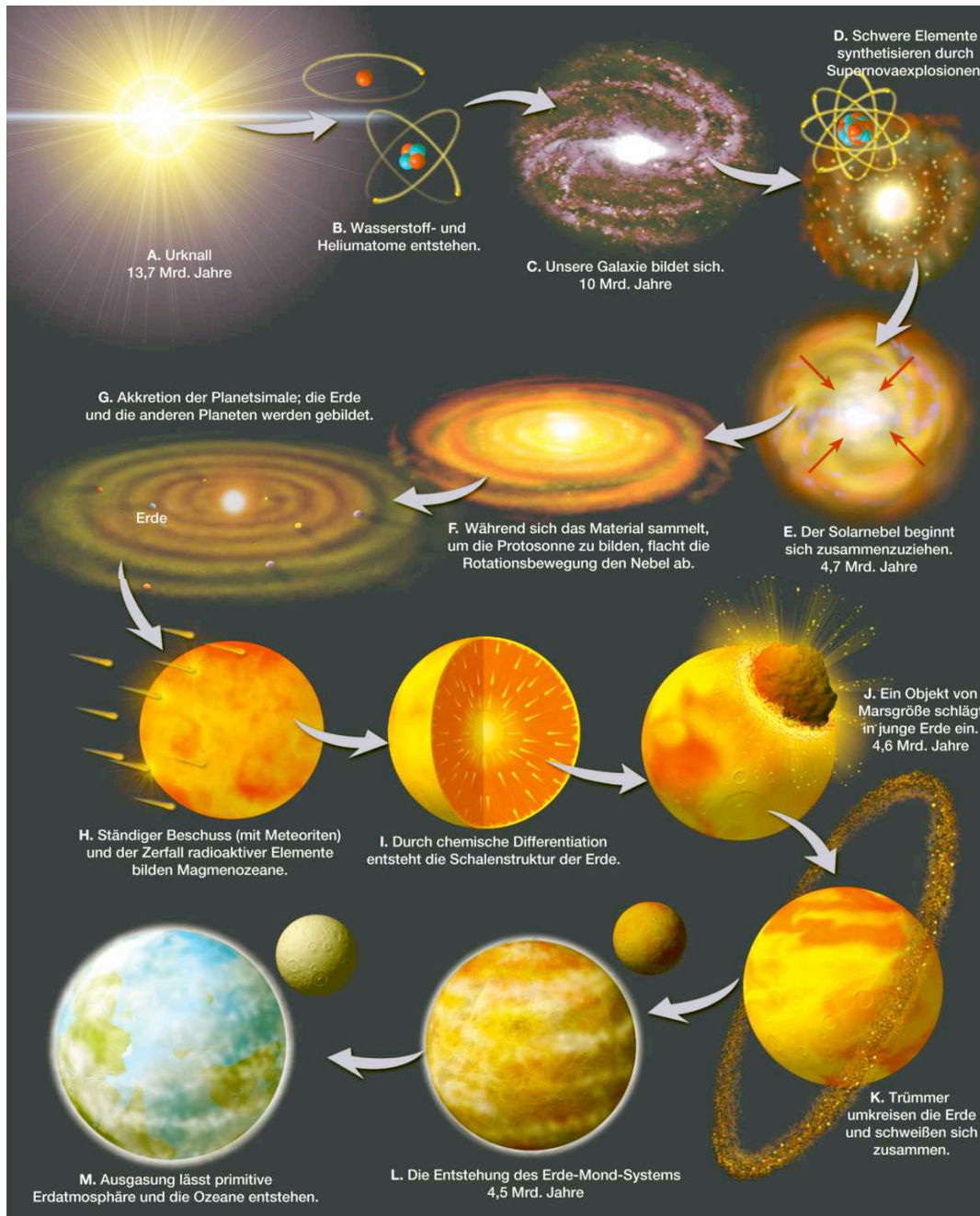
Themen

- (1) Der Planet Erde: der Schauplatz der 'Verbrechen'
- (2) Entwicklung der geologischen Wissenschaften, die grossen Detektive des 19. und 20. Jahrhunderts
- (3) Vom Kontinentaldrift zur Plattentektonik
- (4) Unser Forensisches Labor: Geologische und geophysikalische Untersuchungsmethoden im 21. Jahrhundert

Bemerkungen

- Die Natur kennt keine Katastrophen oder Verbrechen
- Die Dynamik der Erde folgt Naturgesetzen
- Wir Menschen können die daraus folgenden natürlichen Ereignisse (Erdbeben, Vulkanausbrüche) nicht verhindern
- Aber wir können lernen, sie zu verstehen
- Wenn wir sie verstehen, können wir uns vor ihnen schützen und ihr Eintreffen voraussagen

Entstehung der Erde



Universum

- A. Urknall 13.7 Ga
- B. H- und He- Atome entstehen
- C. Bildung unserer Galaxis 10 Ga
- D. Supernova-Explosion: schwere elemente werden synthetisiert
- E. Solarnebel 4.7 Ga
- F. Rotation und Protosonne
- G. Akkretion von Planetesimalen
- H. Meteoritenbeschuss

Erde

- I. Chemische Differentiation
- J. Kollision mit Objekt von Marsgröße 4.6 Ga
- K. Trümmer versammeln sich auf Bahn
- L. Erde-Mond-System 4.5 Ga
- M. Ausgasung: Primitive Athmosphäre

unsere Galaxis - die Milchstrasse



Durchmesser

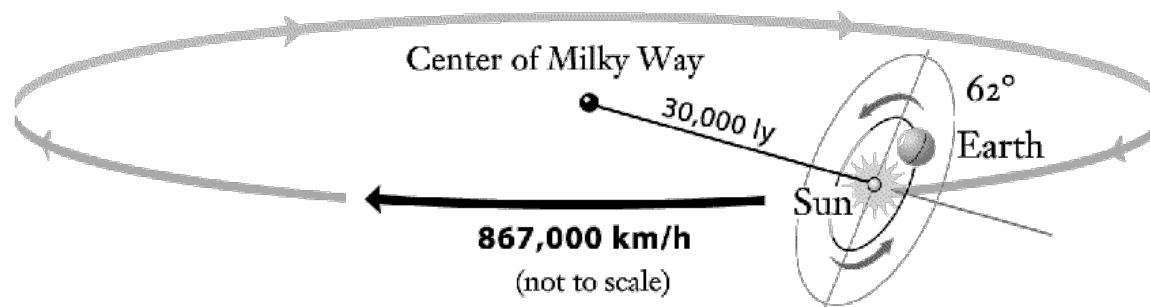
$\sim 100'000$ Lichtjahre $\approx 10^{21}$ m

Höhe

~ 1000 Lichtjahre $\approx 10^{19}$ m

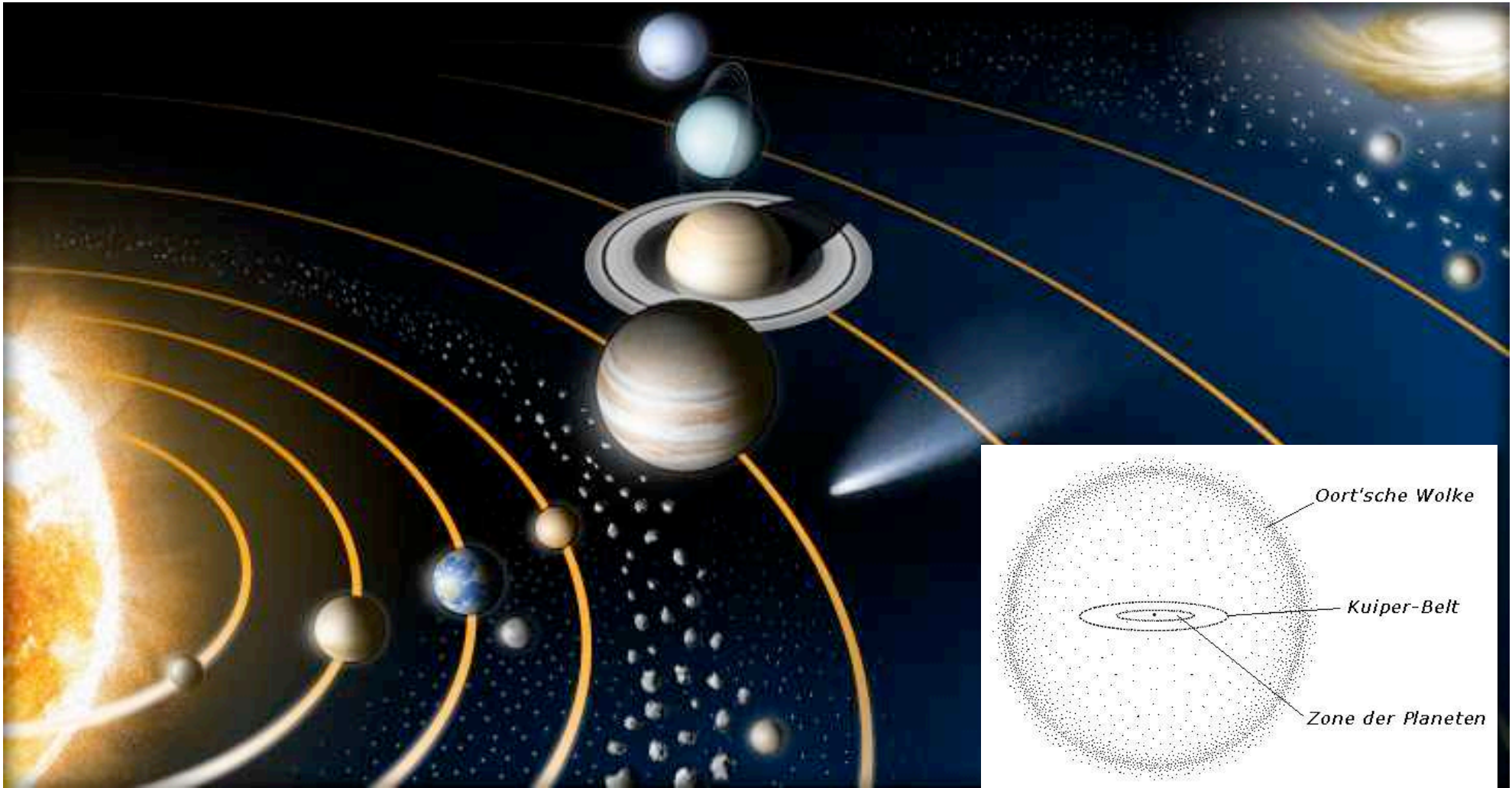
100 - 300 Milliarden Sterne:

$\sim 100 \cdot 10^9 \approx 10^{11}$



grosse Zahlen:	10^6	10^9	10^{12}	10^{15}	10^{18}	10^{21}	10^{24}
	Mega	Giga	Tera	Peta	Exa	Zetta	Yotta

unser Sonnensystem



Sonne - Gesteinsplaneten (Merkur, Venus, Erde, Mars) - Asteroiden -
Gasplaneten (Jupiter, Saturn, Uranus, Neptun) -
Kuiper-Gürtel (Pluto) - Oort'sche Wolke

im Masstab 1: 10^{17} (= 1: 100 000 000 000 000 000)



Galaxis

$d = 10^{21}$ m

$h = 10^{19}$ m

10^{11} Sterne

(incl. Pluto bzw.
Kuiper-Gürtel)

Sonnensystem

$d = 10^{13}$ m

Sonne

$d = 10^9$ m

Erde

$d = 10^7$ m

Schneegestöber

10^4 m = 10 km

100 m ($V = 10$ km³)

10^{11} Flocken ($\sim 10 / \text{m}^3$)

Schneeflocke

$d = 10^{-4}$ m = 0.1 mm

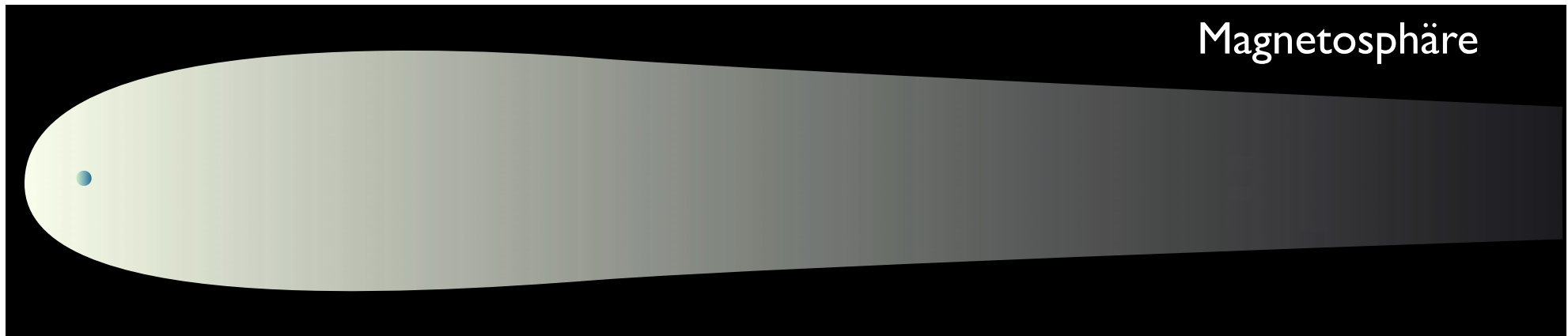
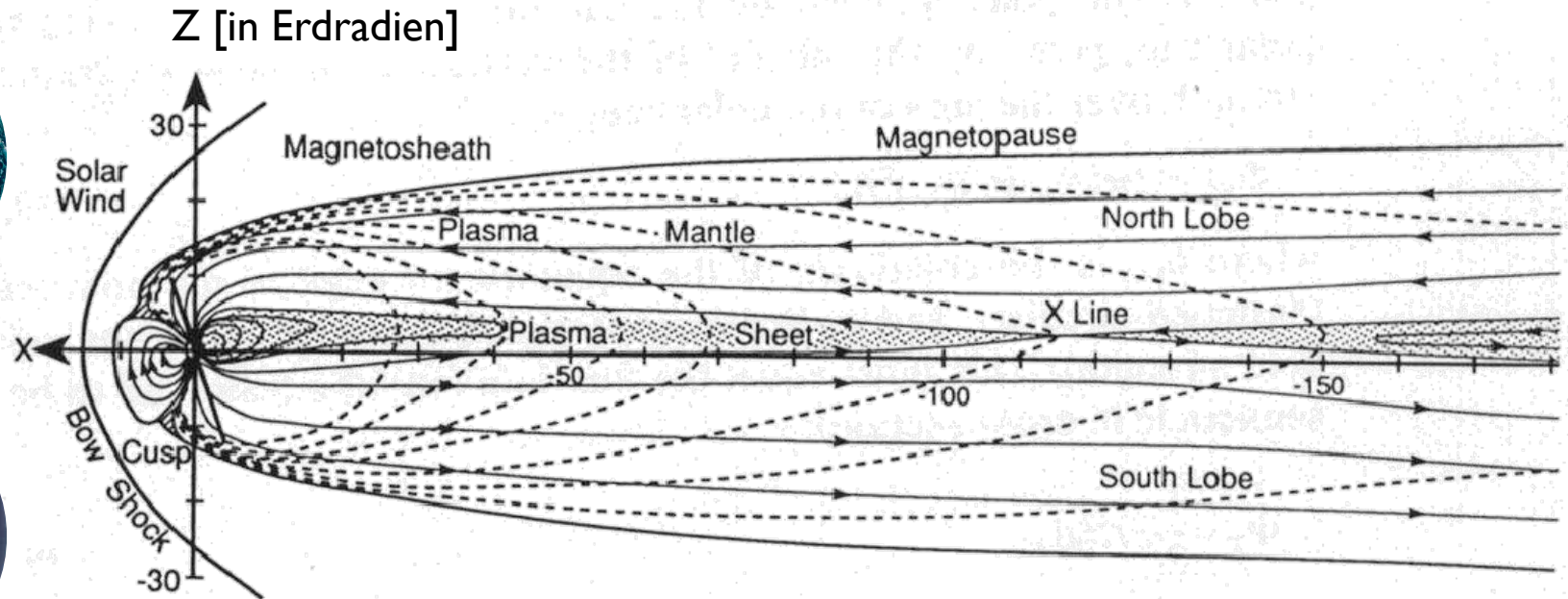
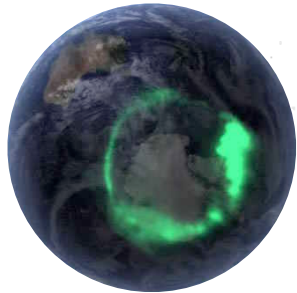
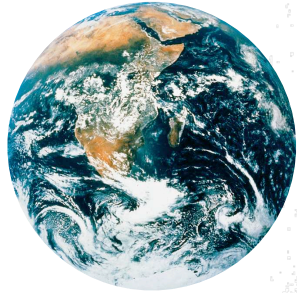
winziger Eiskristall

10^{-8} m = 10 nm

ein Wassermolekül

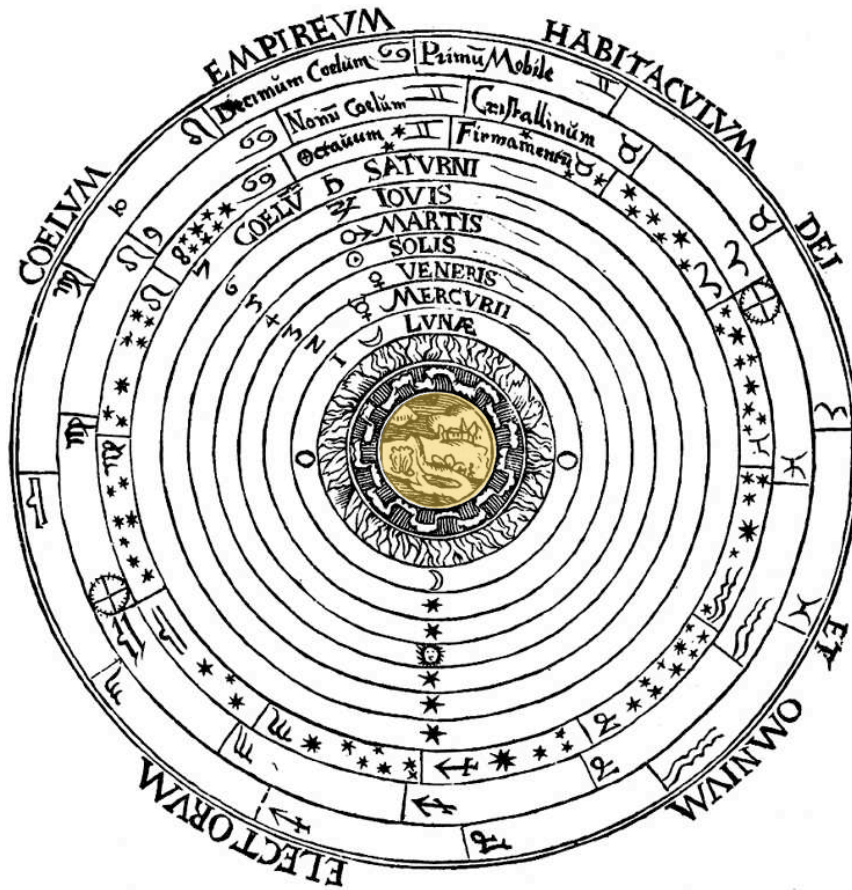
10^{-10} m = 0.1 nm (= 1 Å)

Lost in space - die winzige Erde



Entwicklung der geologischen Wissenschaften

Unser Platz im Sonnensystem



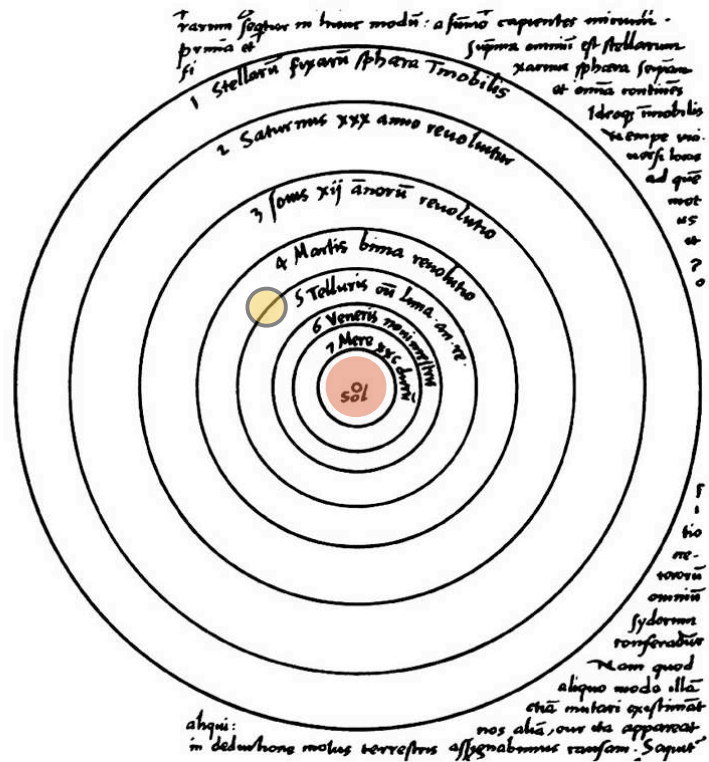
Claudius Ptolemäus
~100 - 175



Tycho Brahe
1546 - 1601

Das Ptolemäische Weltbild ist
geozentrisch - die Erde ist im Zentrum

das heliozentrische Weltbild



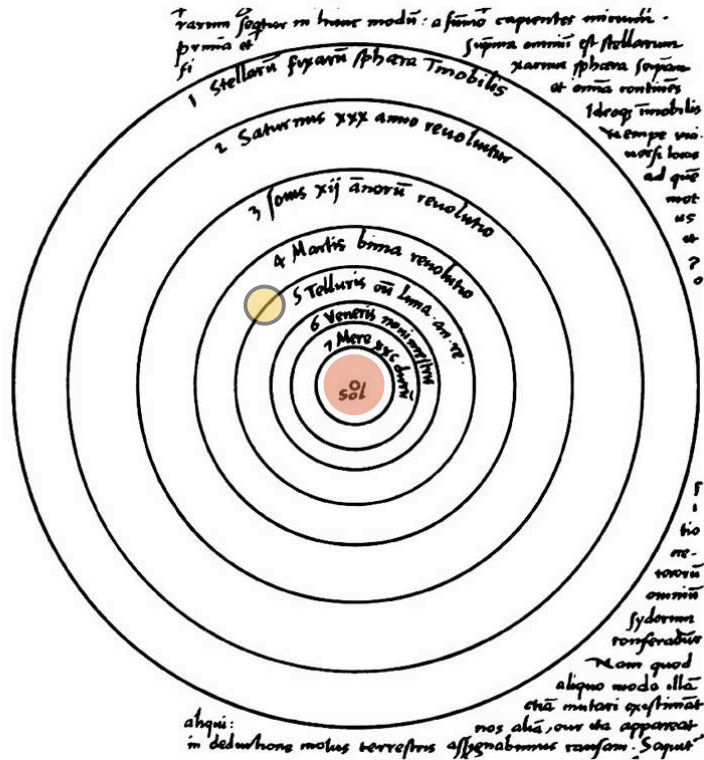
De Revolutionibus Orbium Coelestium



Nicolaus Copernicus
1473 - 1543

"So lenkt die Sonne, gleichsam auf königlichem Thron sitzend, in der Tat die sie umkreisende Familie der Gestirne. Auch wird die Erde keineswegs der Dienste des Mondes beraubt [...]. Indessen empfängt die Erde von der Sonne und wird mit jährlicher Frucht gesegnet."

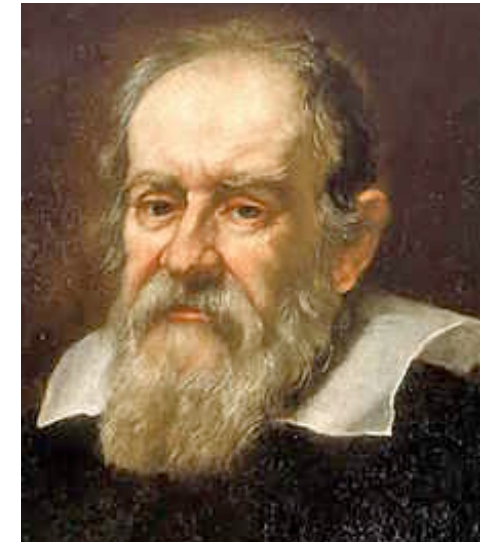
die Kopernikanische Wende



Johannes Kepler
1571 - 1630



Tycho Brahe
1546 - 1601



Galileo Galilei
1564 - 1642

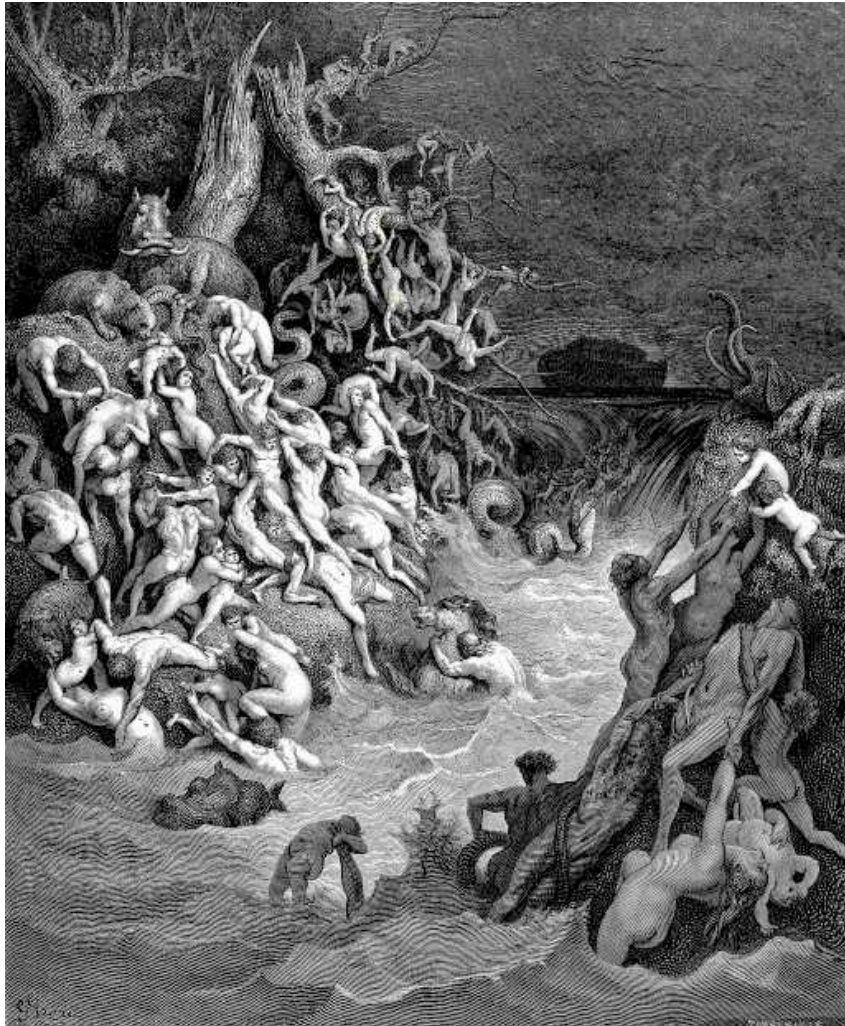
Tycho Brahe (geozentrisch) - genaue Bahnberechnung

Kopernikus: Kreisbahnen - ungenaue Bahnberechnung

Kepler: elliptische Bahnen - genaue Bahnberechnung

Gallilei: Beobachtungen - durch Kepler erklärbar

Katastrophen- (Kataklysmen-) theorie



Oberflächenformationen sind durch Katastrophen (z.B. Sintflut) entstanden



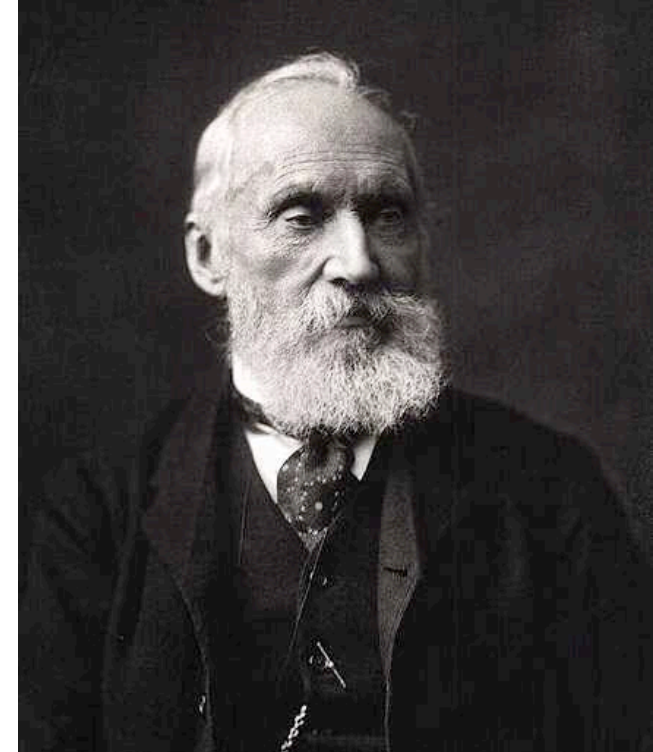
Baron Georges Léopold
Chrétien Frédéric Dagobert
Cuvier (1769-1832)

Altersabschätzungen



Jean Baptiste Joseph Fourier
(1768 - 1830)

$$q_x = -k \frac{dT}{dx}$$



William Thomson,
1st Baron Kelvin of Largs
(1824 - 1907)

Annahmen: Temperaturzunahme mit Tiefe:
1° F / 50 feet (20° C / km)
Anfangstemperatur:
7000° F (3900° C)
(geschmolzenes Gestein)
eingesetzt in Fourier-Gleichung:
Erdalter \approx 100 Ma

Ordnung ins Ganze: Superpositionsprinzip

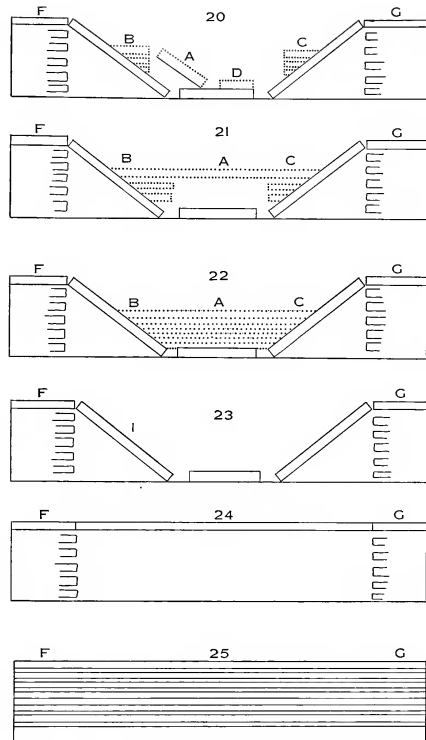


Figure 20 shows the hills and valleys produced there by the breaking of the upper sandy strata.

Figure 21 shows a portion of the lower strata in the new beds destroyed, while the upper strata remain unbroken.

Figure 22 shows new strata, made by the sea, in the valleys.

Figure 23 shows the mountains and valleys caused by the breaking of the upper strata.

Figure 24 shows the huge cavities eaten out by the force of fires or waters while the upper strata remained unbroken.

Figure 25 shows the vertical section of Tuscany at the time when the rocky strata were still whole and parallel to the horizon.



Nikolaus Steno
(1638-1686)

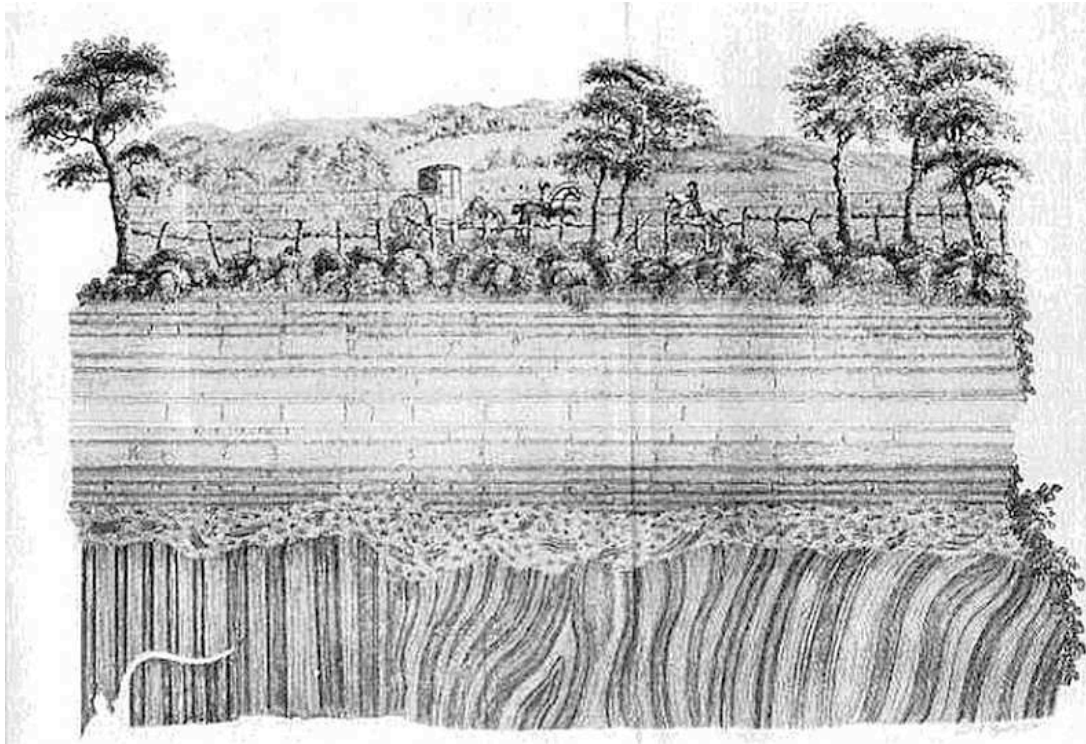
"De solido intra solidum" (1669)

Altersabfolge:

unten (= Liegendes) ist älter

oben (= Hangendes) ist jünger

Aktualismus - (engl. uniformitarianism)



Jedburgh Unconformity

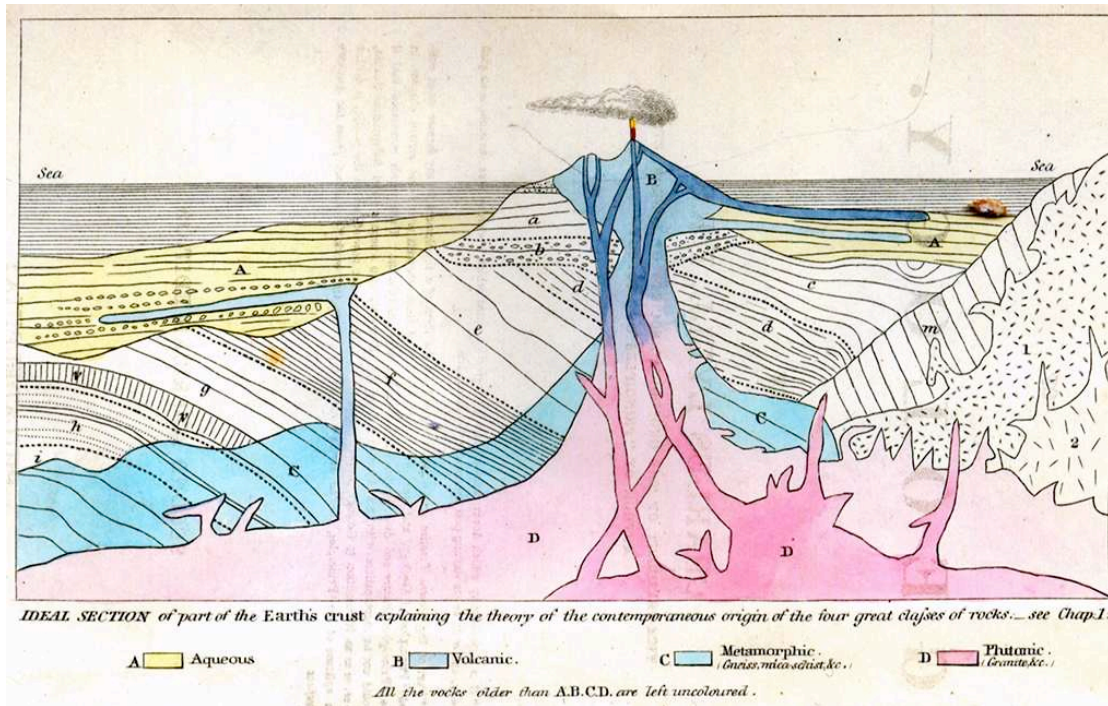
"Theory of the Earth" (1785)

"... we find no vestige of a beginning, no prospect of an end..."



James Hutton
(1726 - 1797)

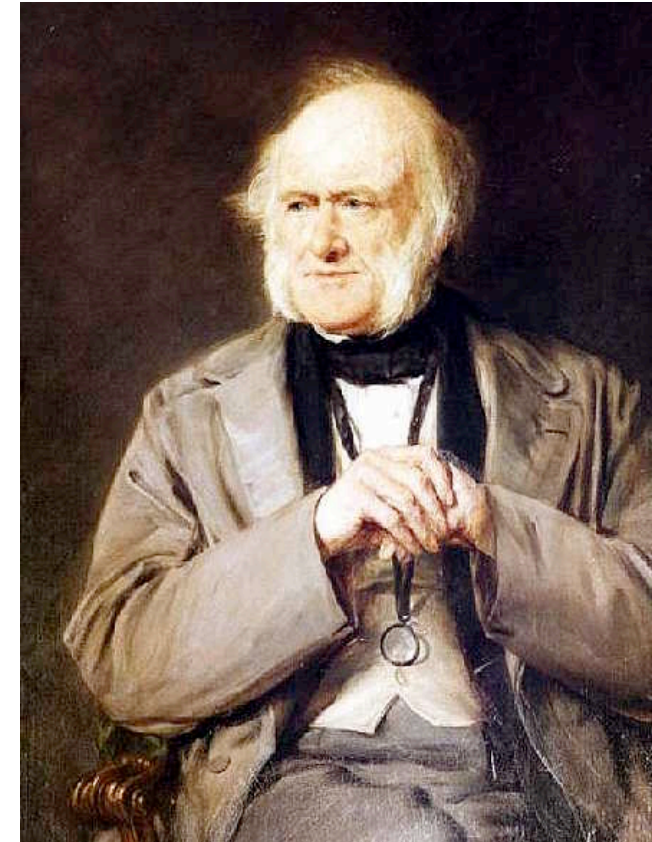
Aktualismus - (engl. uniformitarianism)



"The Principles of Geology" (1830)

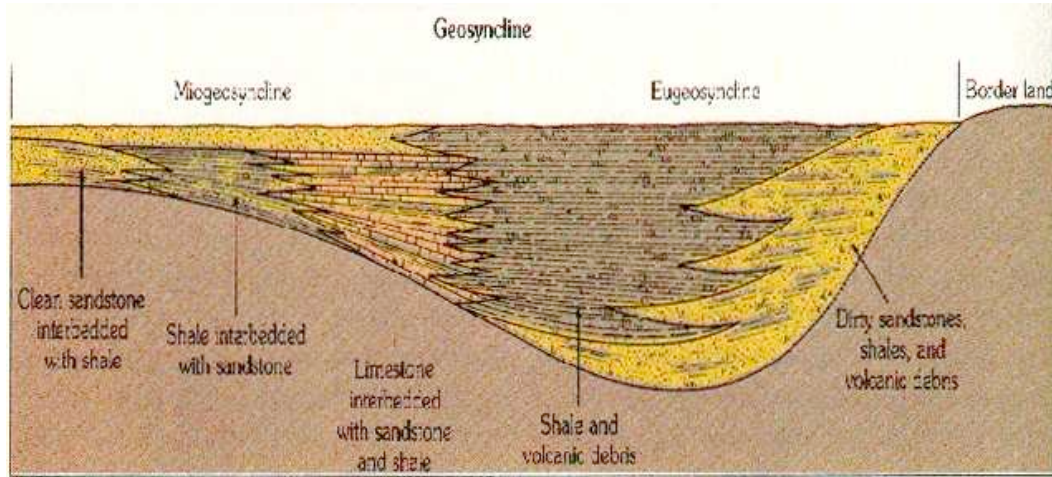
"... the present is the key to the past..."

Physikalische, chemische, biologische
Gesetzmässigkeiten, die heute gültig sind,
waren auch in der Vergangenheit gültig



Charles Lyell
(1797 - 1875)

Geosynklinal - Theorie



James Hall
(1811 - 1898)



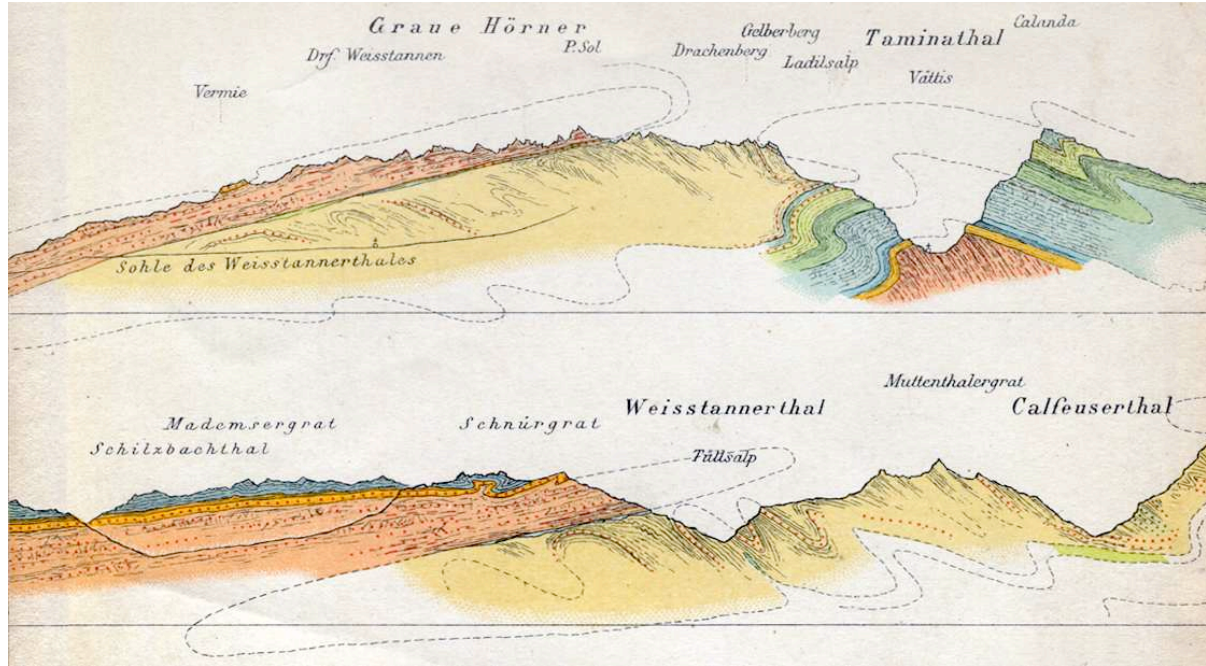
James Dwight Dana
(1813 - 1895)

Phasen der Gebirgsbildung:

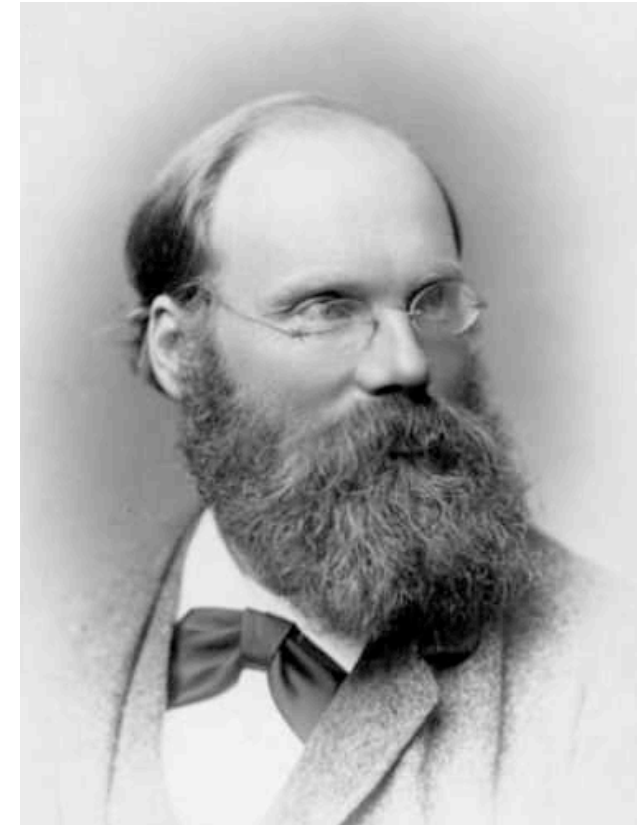
1. Bildung eines Troges - Ablagerung von Sedimenten
2. Zusammenschub - Faltung
3. Hebung und Erosion

*"It [the geosynclinal theory] constitutes a great—probably one of the greatest—unifying principles in geologic science."
(Knopf, A., 1948)*

Problem mit der horizontalen Verkürzung



*Geologie der Hochalpen zwischen Reuss und Rhein.
(Albert Heim, 1891)*



Albert Heim
(1849 - 1937)

Glarner Hauptüberschiebung als Doppelfalte

Geophysikalischer Input

Uran - Blei Datierung

Radioaktiven Zerfall von Uran

	Alter (Ga)	Methode Material	
1930	1.5 - 3	Uran Blei Gestein	Otto Hahn
1953	4.55	Blei-Isotopen Meteorit	Clair Patterson



Otto Hahn
(1879 - 1968)

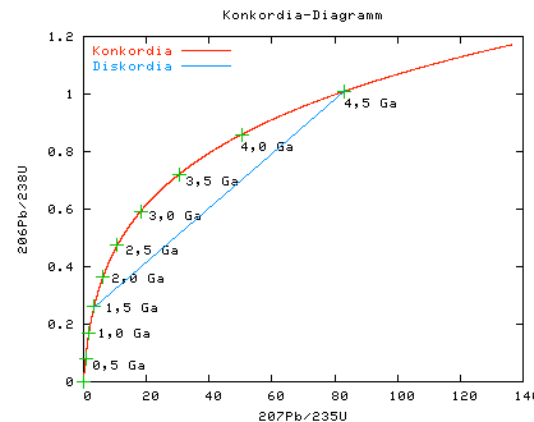


Clair Patterson
(1922 - 1995)

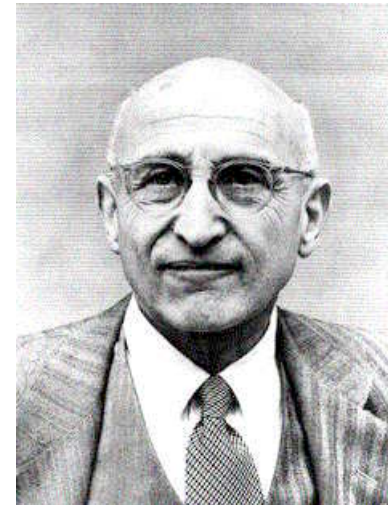
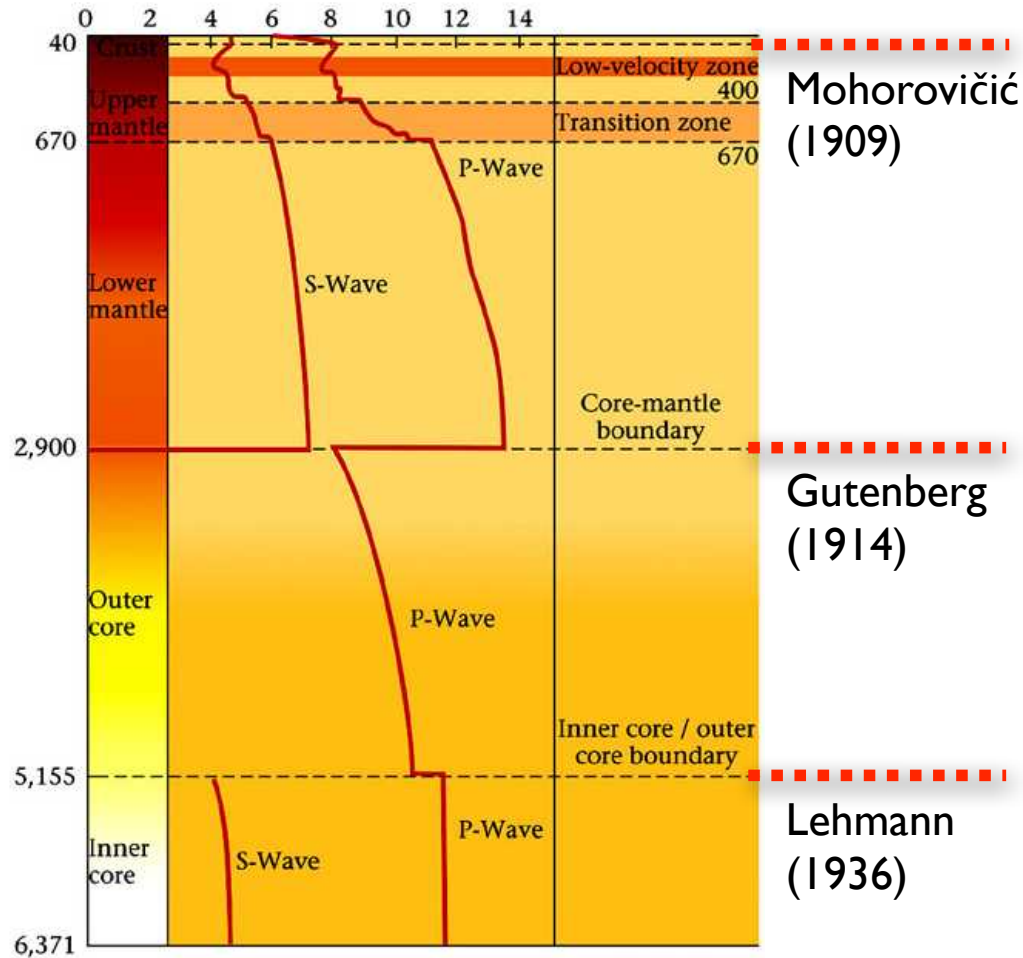
Pb/U Isotopenverhältnisse

$$\frac{^{206}\text{Pb}^*}{^{238}\text{U}} = e^{\lambda_{238}t} - 1$$

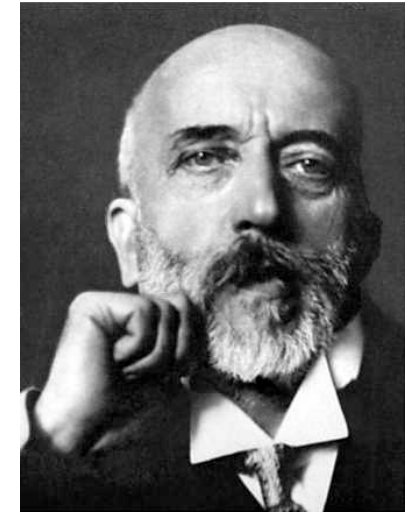
$$\frac{^{207}\text{Pb}^*}{^{235}\text{U}} = e^{\lambda_{235}t} - 1$$



Aufbau der Erde



Beno Gutenberg
(1889 - 1960)

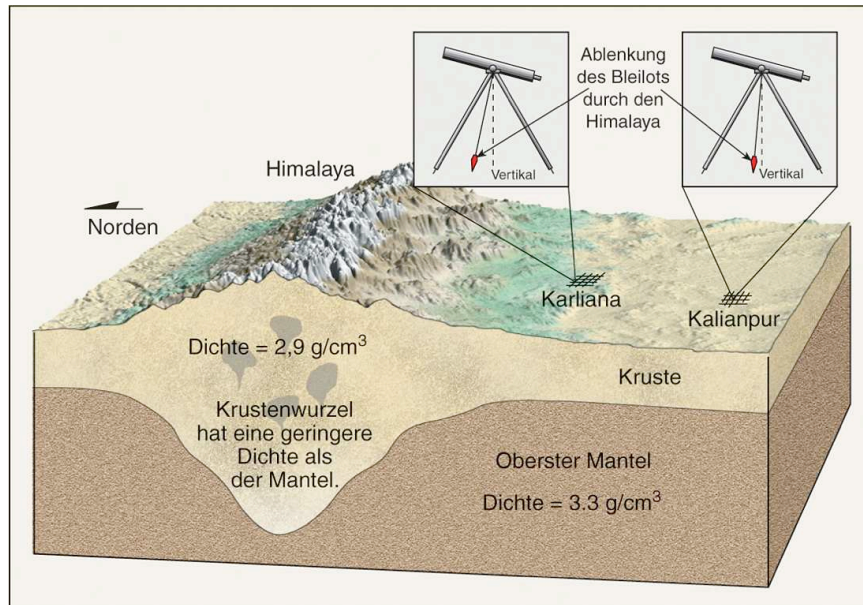


Andrija Mohorovičić
(1857 - 1936)

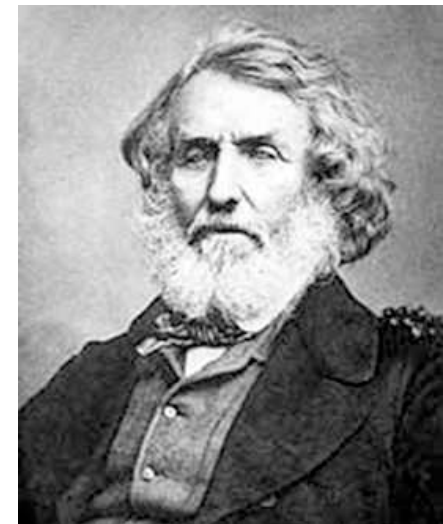


Inge Lehmann
(1888 - 1993)

Dichteverteilung in der Erde



Pierre Bouguer
(1698 – 1758)



Sir George Everest
(1790 - 1866)

19. Jh. Everest misst im Himalaya (1823-1843)

18. Jh. Bouguer misst in den Anden (1735-1745)

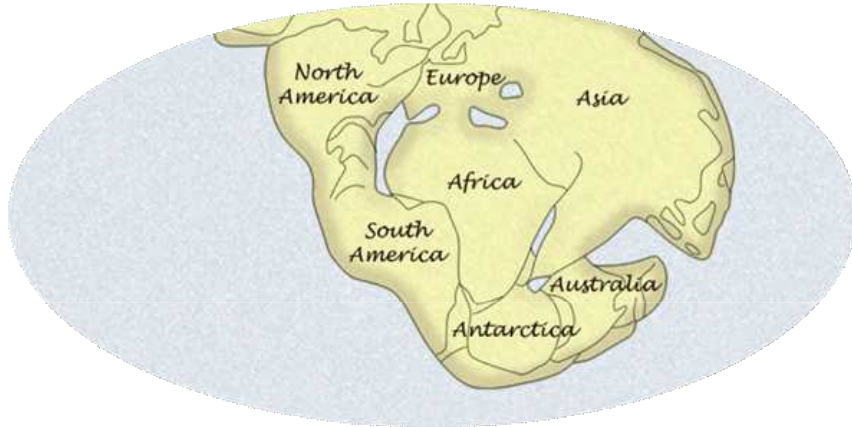
Beide: zu wenig Lotabweichung

⇒ Berg sitzt nicht auf ebener dichter Plattform -

⇒ "Gebirgs Wurzel"

vom Kontinentaldrift zur Plattentektonik

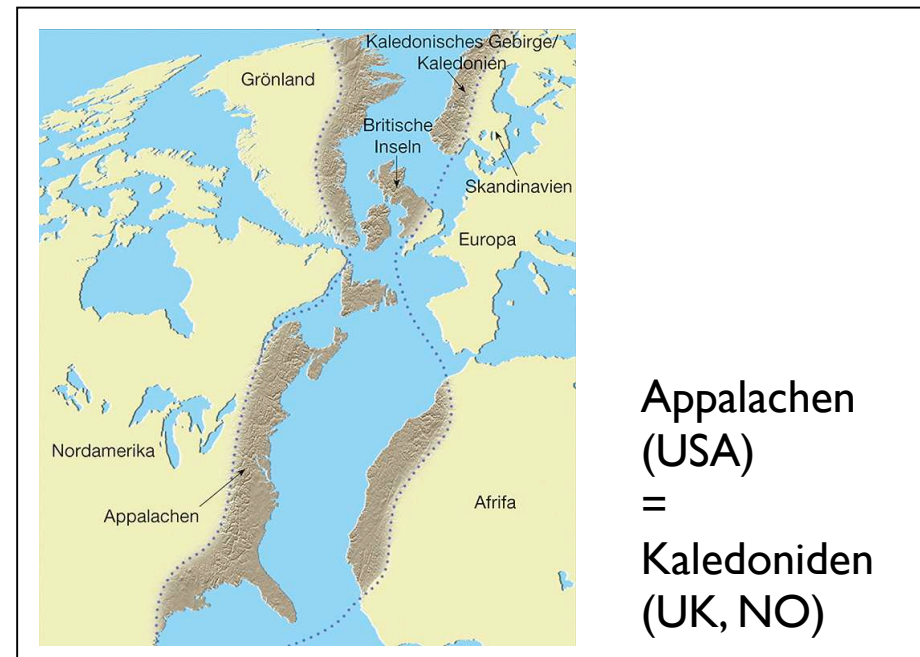
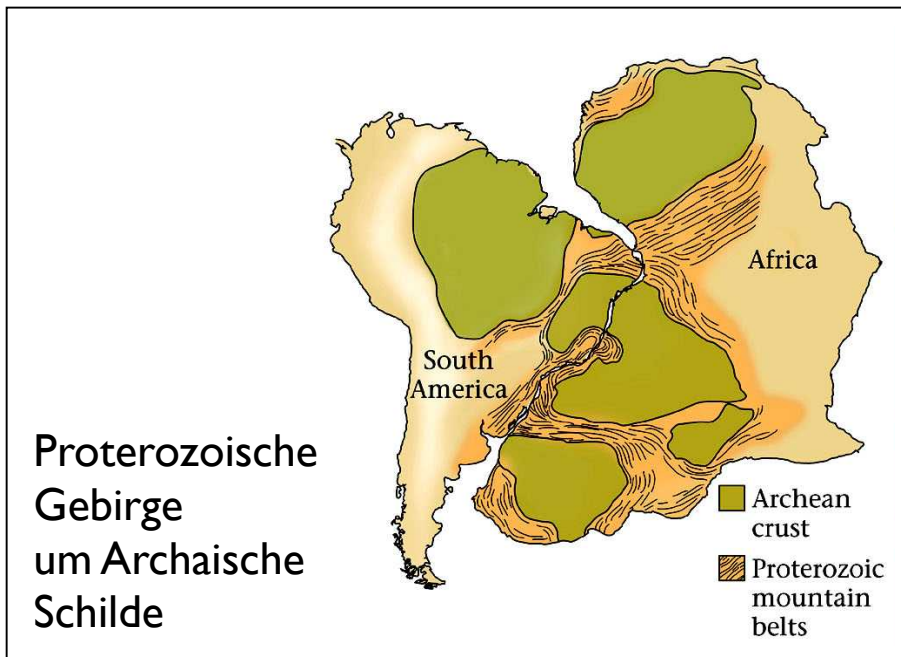
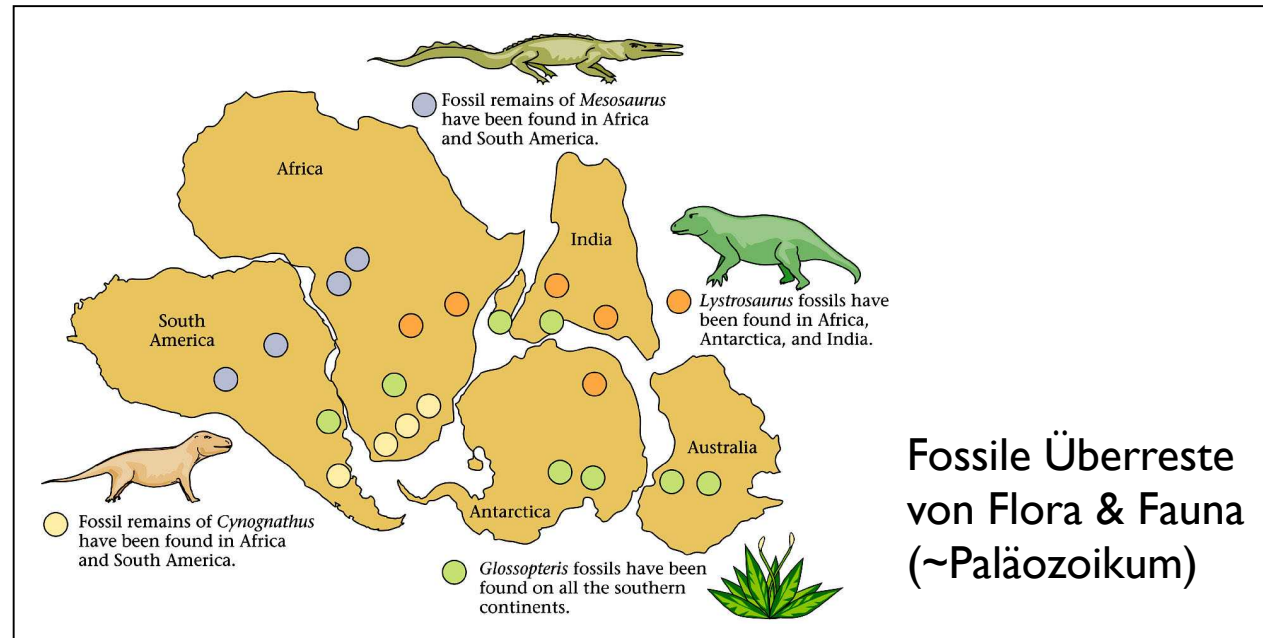
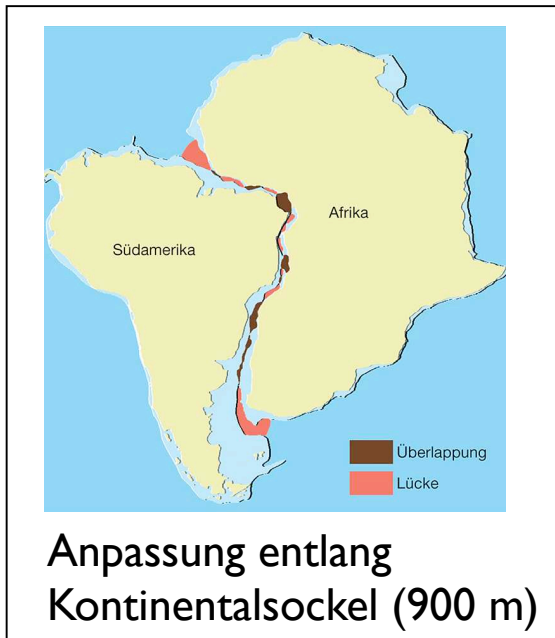
Kontinentaldrift - Hypothese



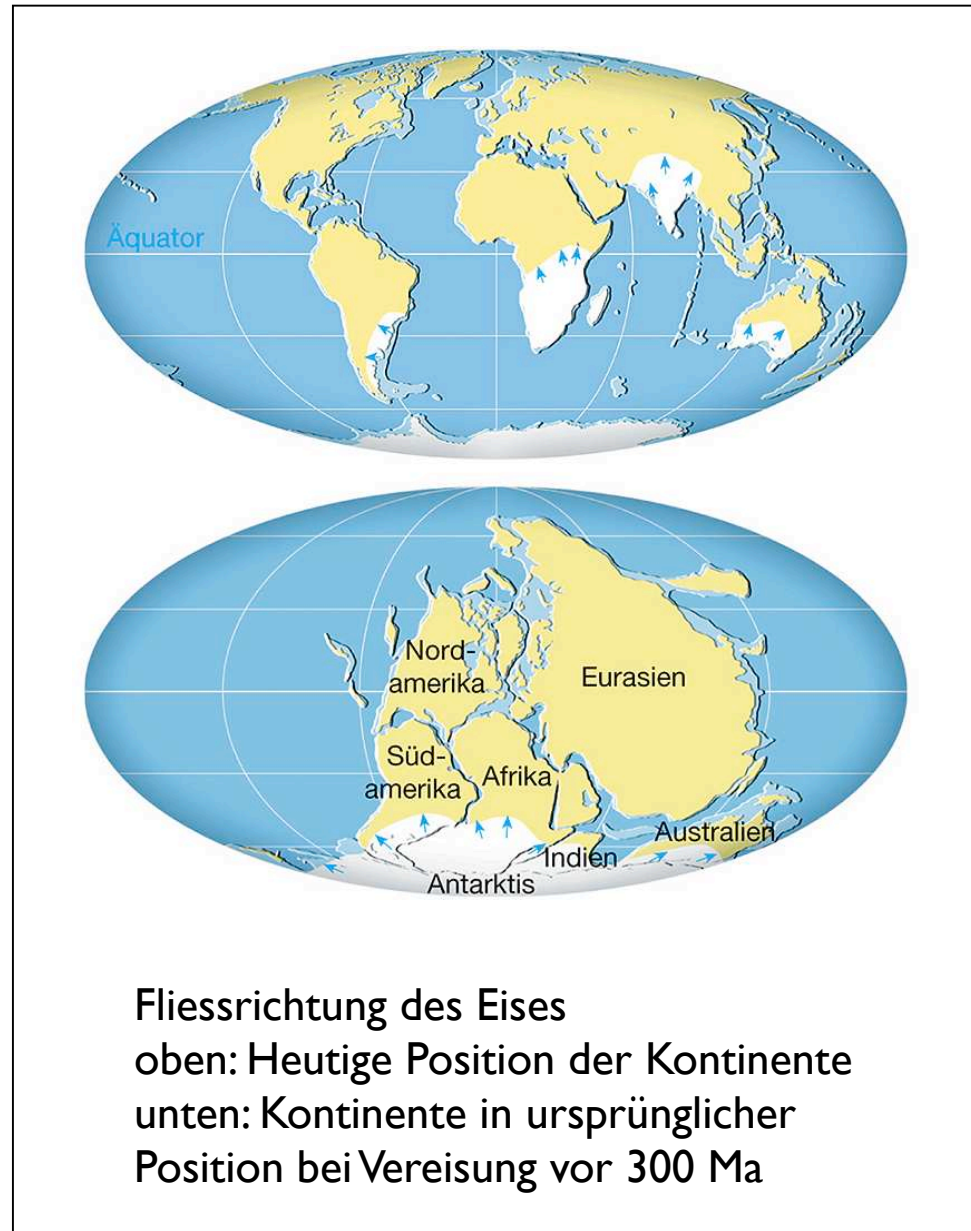
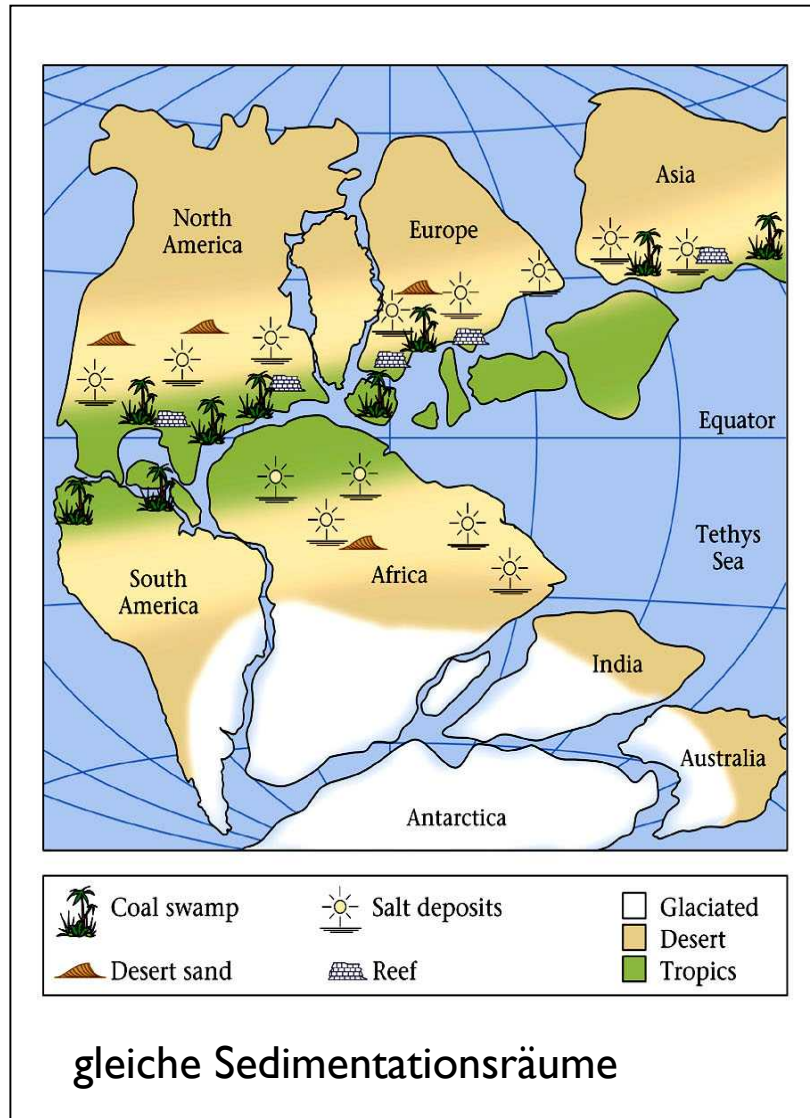
Alfred Lothar Wegener
(1880 - 1930)

Hypothese (1912):
Superkontinent "Pangäa" bricht auseinander
- vor 200 Ma - Kontinente beginnen zu driften

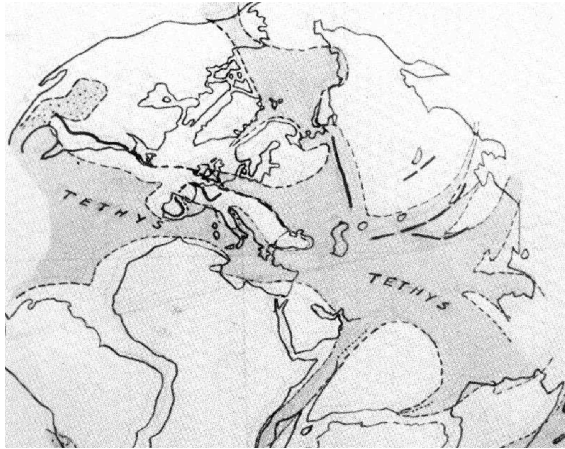
Evidenz für die Existenz von Pangäa



Evidenz für die Existenz von Pangäa



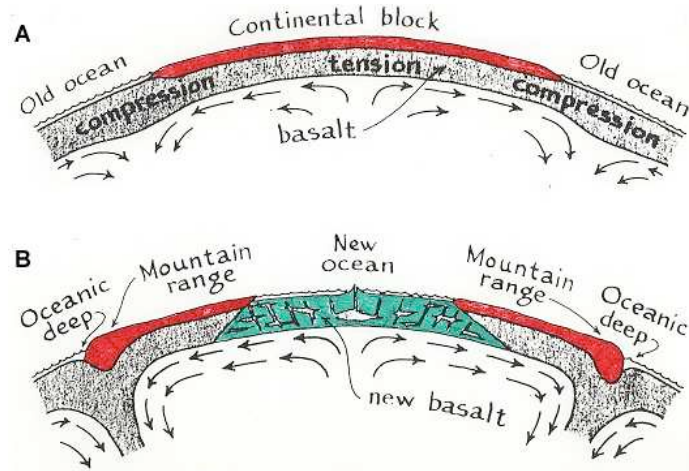
Kontinentaldrift findet Unterstützung



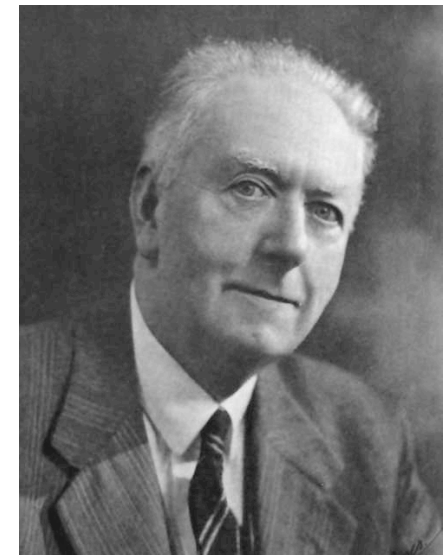
"Our wandering Continents" (1937)
Pangäa → Laurasia + Gondwana



Alexander Logie du Toit
(1878 - 1948)



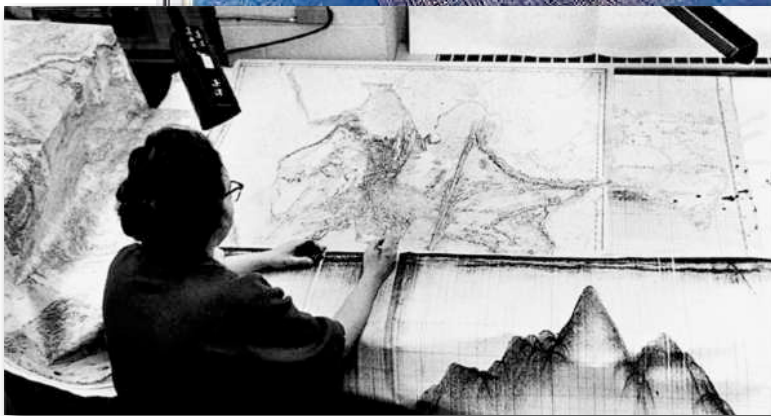
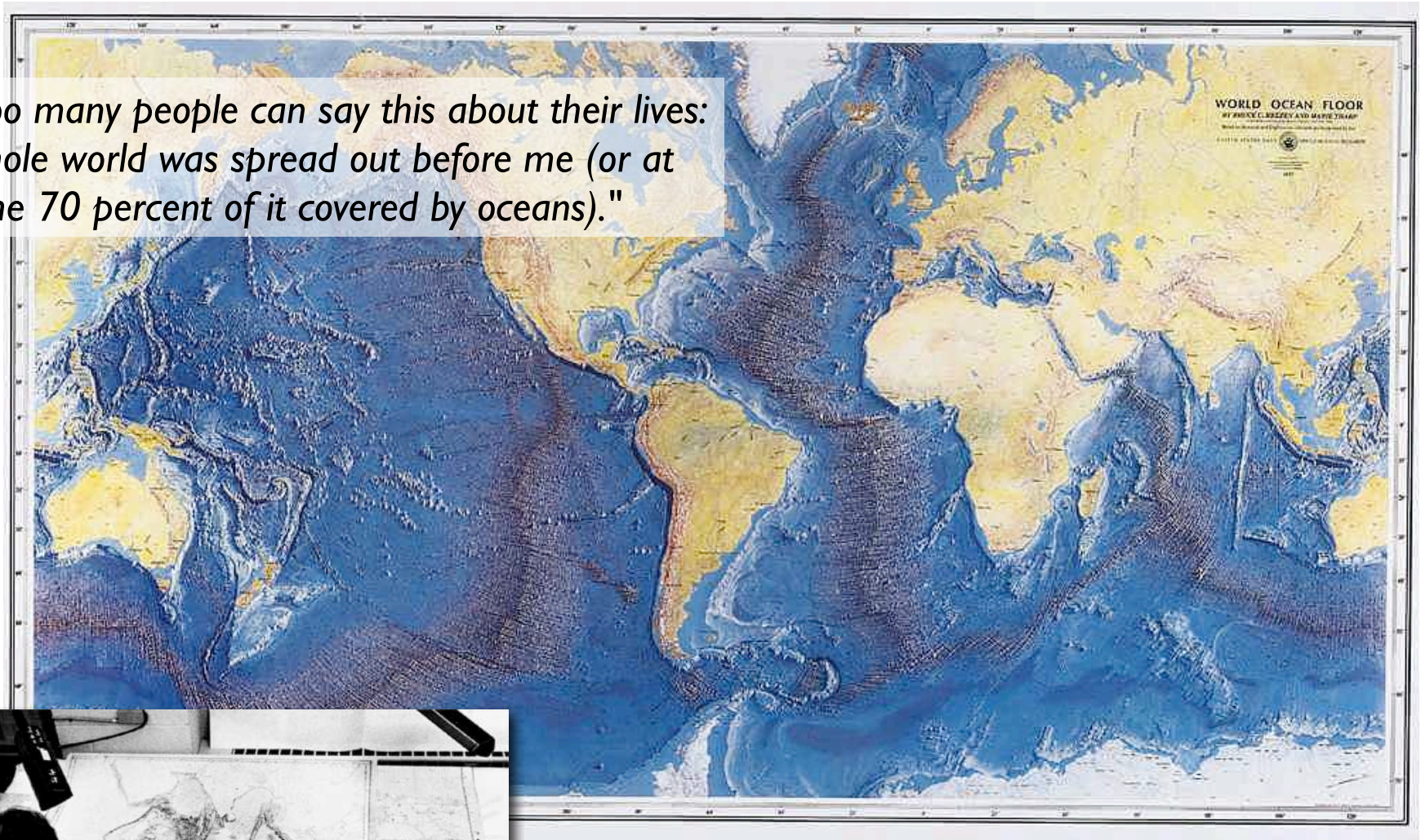
"Principles of Physical
Geology" (1944)
"Spekulation" über
Kontinentaldrift



Arthur Holmes
(1890 - 1965)

Kartierung des Ozeanbodens

"Not too many people can say this about their lives: The whole world was spread out before me (or at least, the 70 percent of it covered by oceans)."



Marie Tharpe (1920 - 2006)

Seafloor Spreading - aber wohin mit dem Material ?



Marie Tharpe
(1920 - 2006)

Bruce Heezen
(1924 - 1977)



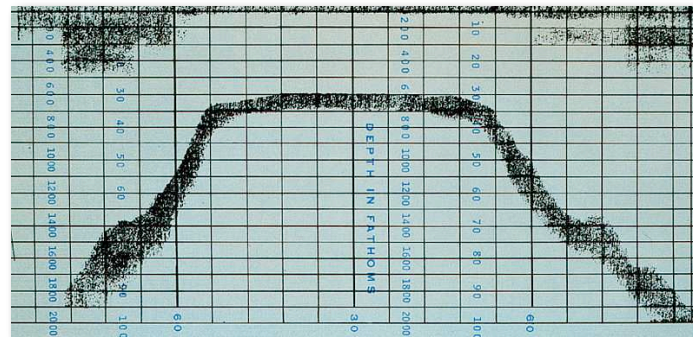
Expanding Earth Idee -
wurde u.a. unterstützt
von Bruce Heezen



Harry Hammond Hess
(1906 - 1969)



Robert Sinclair Dietz
(1914 - 1995)



Echolot-Aufzeichnung des "ersten Guyots",
entdeckt von Harry Hess, Universität Princeton

Magnetische Anomalien

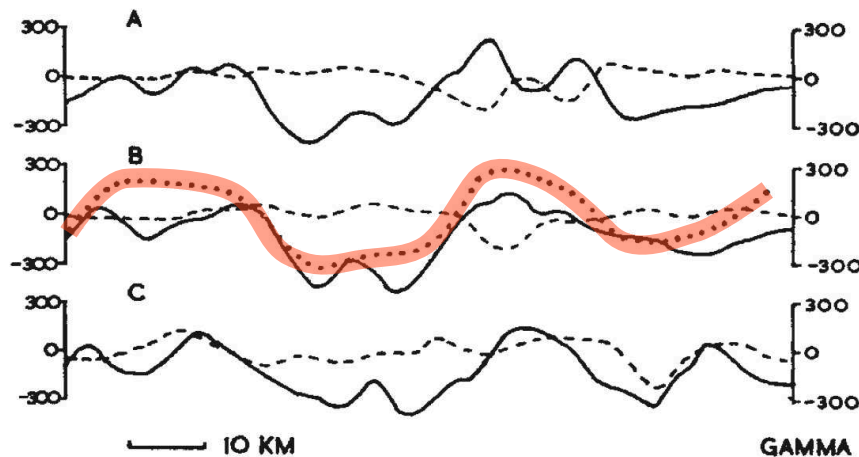
September 7, 1963

NATURE

MAGNETIC ANOMALIES OVER OCEANIC RIDGES

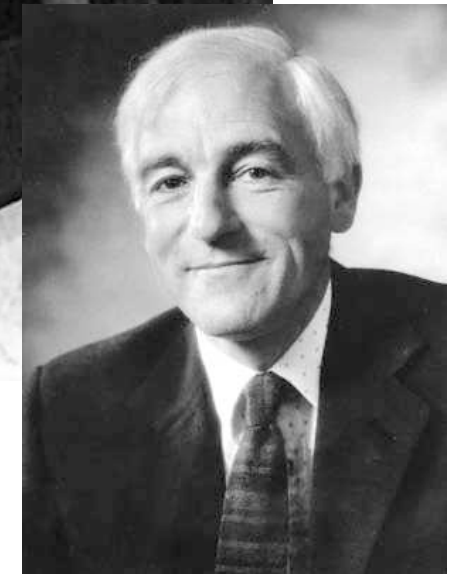
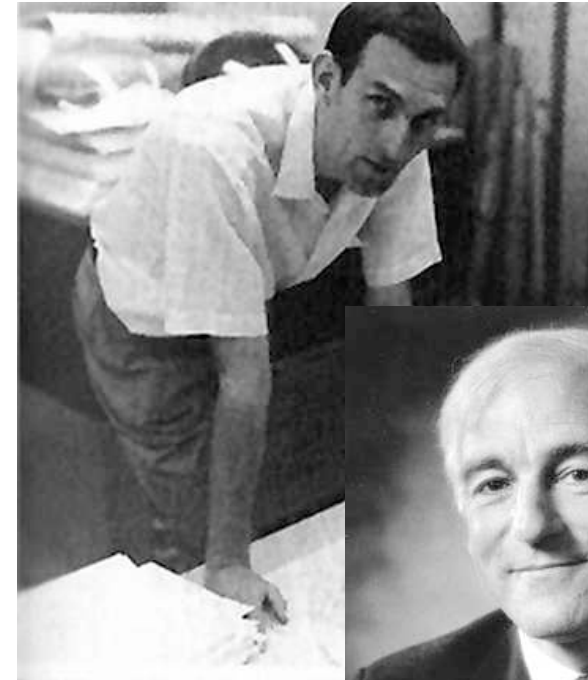
By F. J. VINE and DR. D. H. MATTHEWS

Department of Geodesy and Geophysics, University of Cambridge



The theory is consistent with, in fact virtually a corollary of, current ideas on ocean floor spreading⁷ and periodic reversals in the Earth's magnetic field⁸.

- beobachtet
- - - berechnet - mit konstanter Magnetisierung
- berechnet - mit Annahme von Feldumkehr



Frederick John Vine
(* 1939)

Drummond Hoyle Matthews
(1931 - 1997)

Magnetische Streifen

16 December 1966, Volume 154, Number 3755

SCIENCE

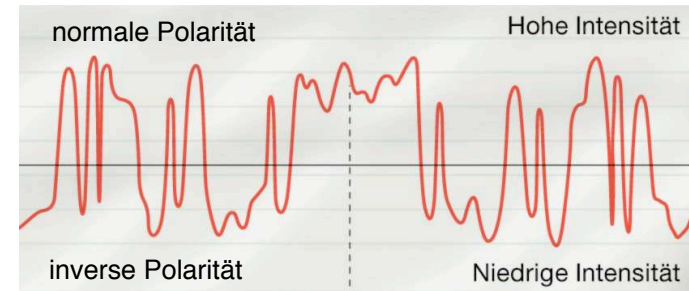
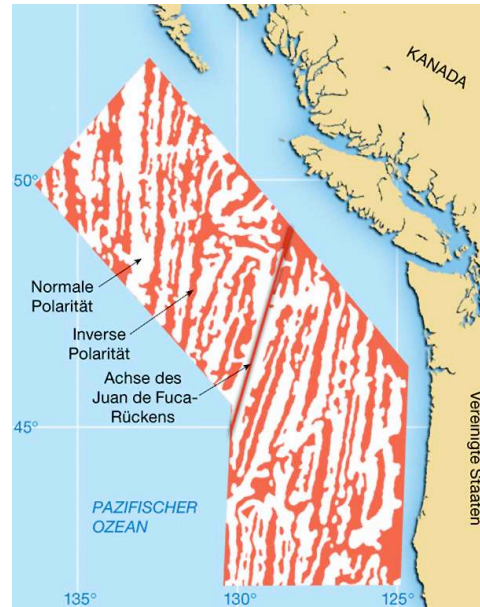
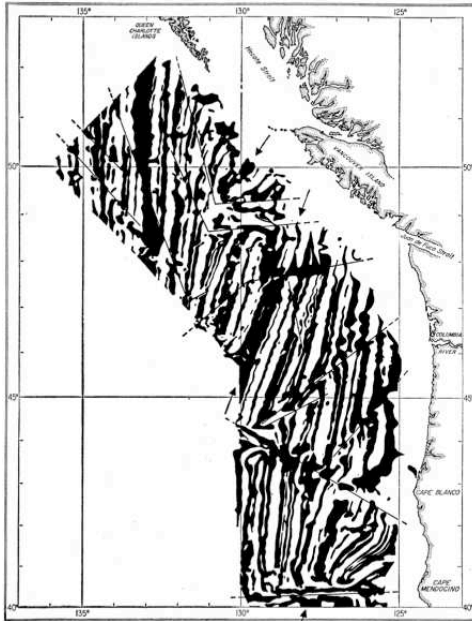
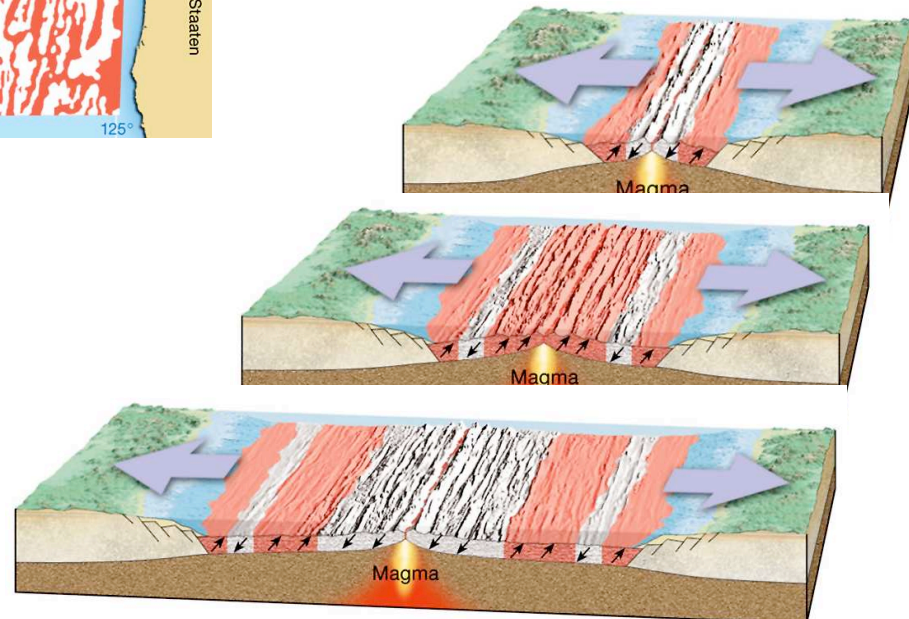


Fig. 1. Summary diagram of total magnetic-field anomalies southwest of Vancouver Island. Areas of positive anomaly are shown in black. Straight lines indicate faults offsetting the anomaly pattern; arrows, the axes of the three short ridge lengths within this area—from north to south, Explorer, Juan de Fuca, and Gorda ridges. See also Fig. 15. [Based on fig. 1 of Raff and Mason (27); courtesy Geol. Soc. Amer.]

Spreading of the Ocean Floor: New Evidence

Magnetic anomalies may record histories of the ocean basins and Earth's magnetic field for 2×10^8 years.

F. J. Vine



Formulierung des Plattentektonischen Konzeptes

(1) Hotspots (1963)

Platten bewegen sich über stationäre hotspots hinweg. Das bedeutet, dass die Platten relativ steif sind und sich über die weiche (schwache) Asthenosphäre hinwegbewegen, ohne sich intern zu verformen.

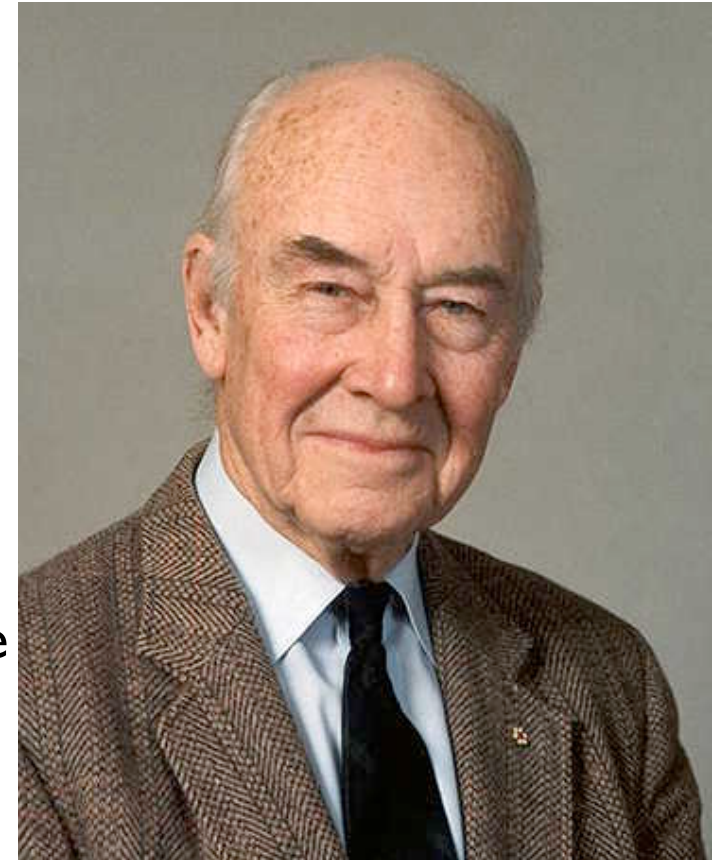
(2) Transformbrüche (1965)

Die Erde expandiert nicht, deshalb muss es auch destruktive Plattengrenzen geben. Transformbrüche verbinden Seafloor Spreading und Subduktionszonen und bilden so eine zusammenhängende Plattengrenze.

PS:

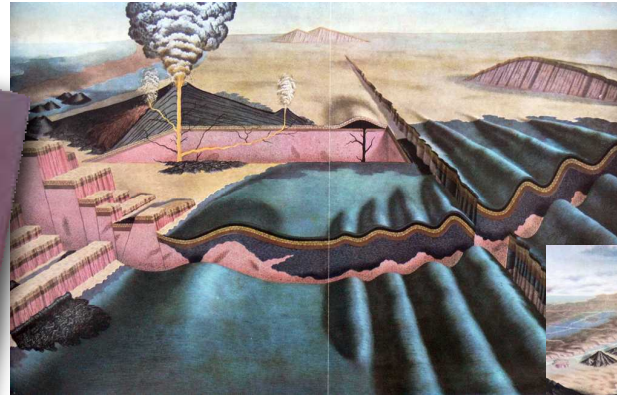
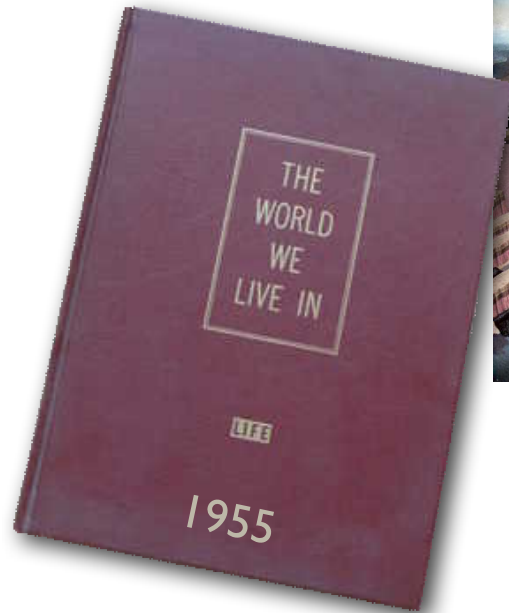
Wilson Zyklus ~ 300 - 500 Ma

Pangäa ⇨ Kontinente ⇨ Pangäa



John Tuzo Wilson
(1908 - 1993)

Paradigmenwechsel 1965



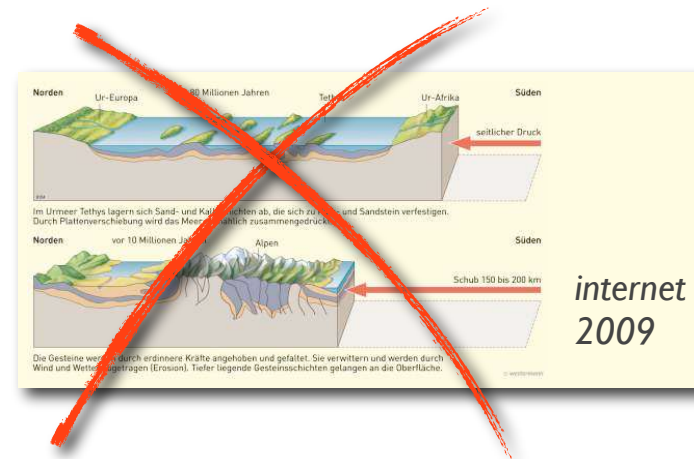
"It [the geosynclinal theory] constitutes a great—probably one of the greatest—unifying principles in geologic science."

(Knopf, A., 1948)

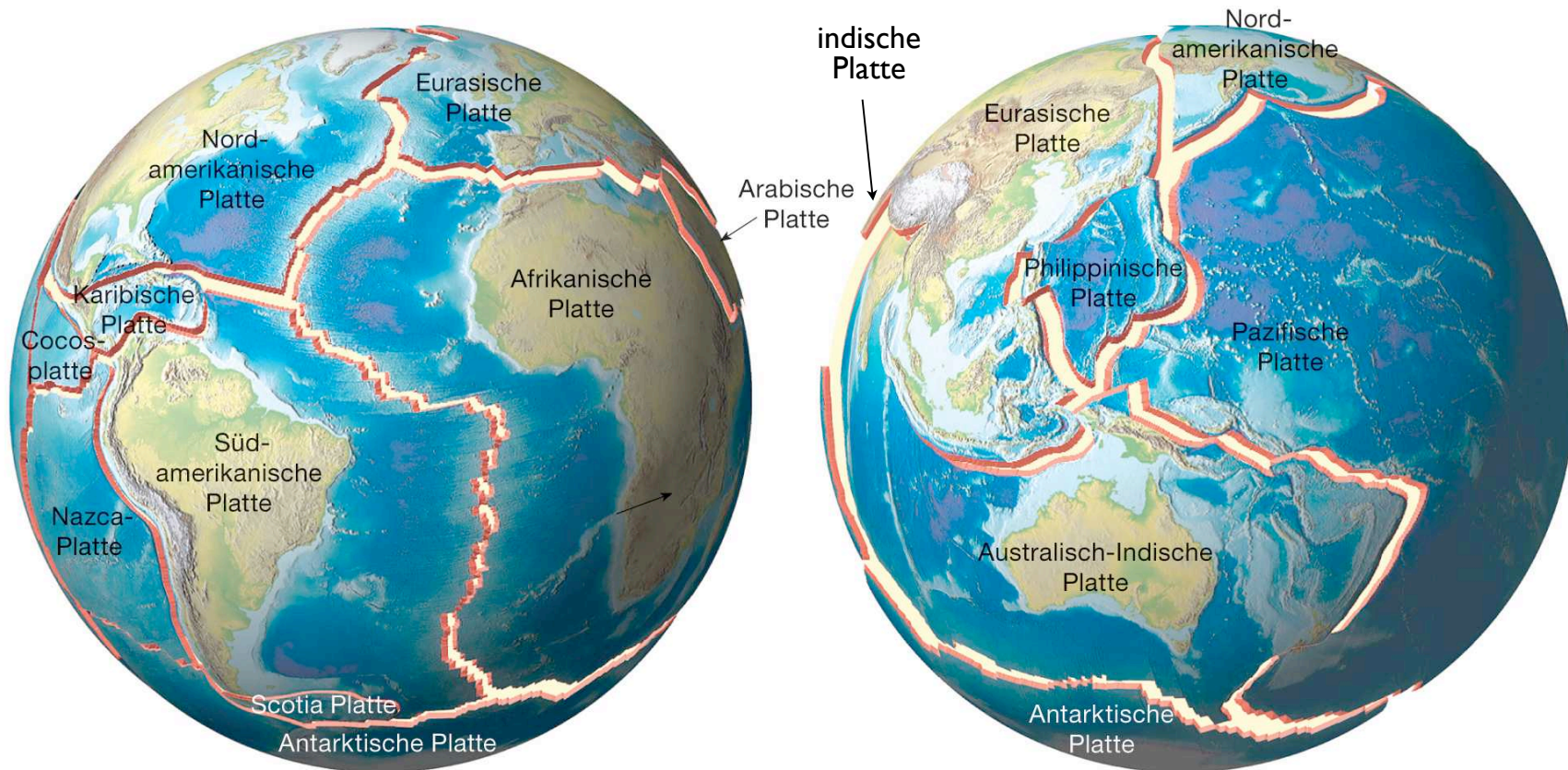
Aber....

"The trouble with geosynclines is like the Trouble with Harry [A. Hitchcock 1955]; they are dead."

(Dietz, R.S., 1965)

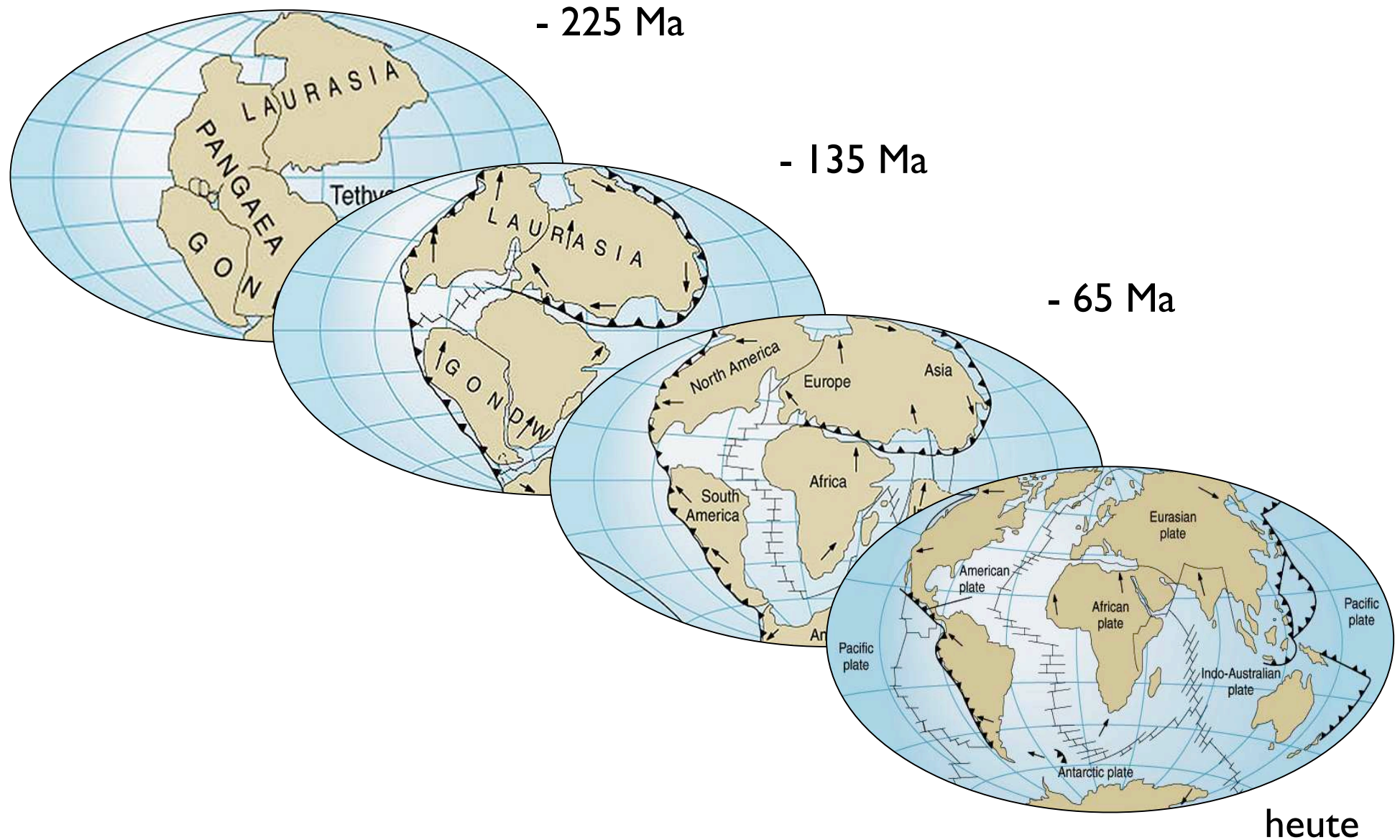


Tektonische Platten

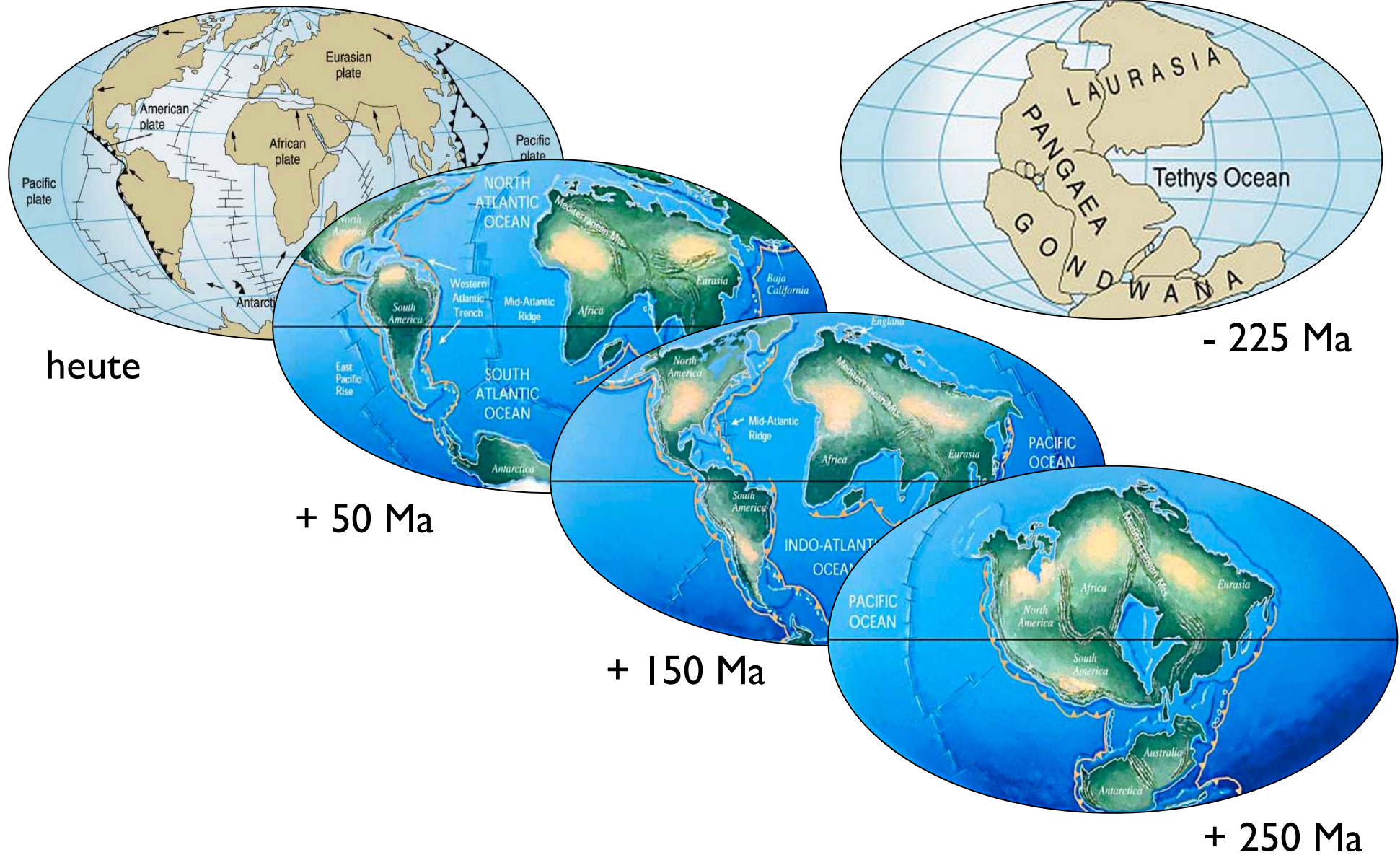


Erdoberfläche ist aufgeteilt in
7 grössere und 6 kleinere Platten
mit kontinentalen und ozeanischen Anteilen

Wilson Zyklus - von Pangäa bis heute



Wilson Zyklus - die nächsten 250 Ma

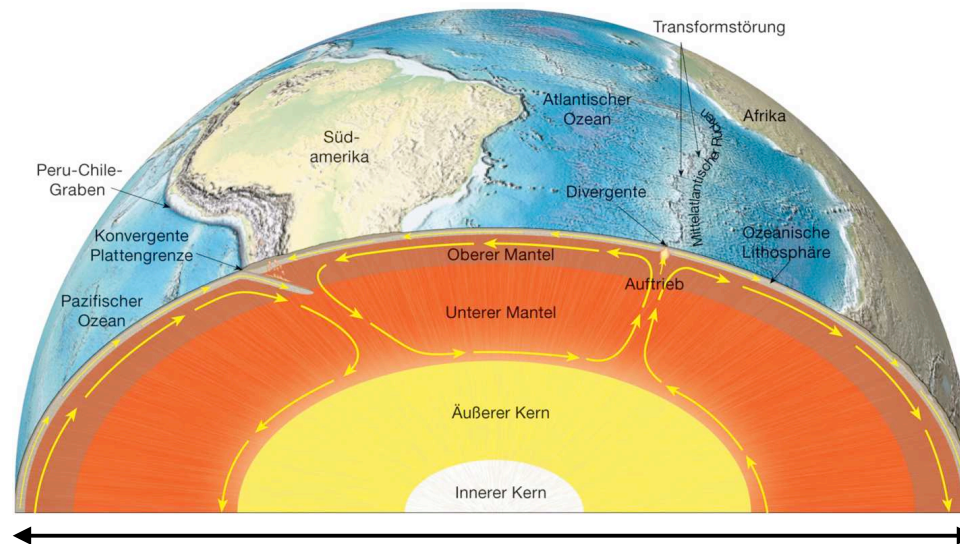


Zusammenfassung

Subduktion

Platte taucht in den Mantel zurück

Erdoberfläche wird vernichtet



Seafloor Spreading

Mantelmaterial wird an die Platten angefügt

Neue Erdoberfläche entsteht

$r = 6375 \text{ km}$ $d = 12750 \text{ km}$

Erde

Radius: $\sim 6500 \text{ km}$

Masse: $\sim 6 \cdot 10^{24} \text{ kg}$

Alter: $\sim 4.5 \text{ Ga}$

Schalenbau

Lithosphärenplatten

Re-Cycling

Mantelkonvektion

Plattengrenzen:

- Seafloor Spreading
- Subduktionszonen
- Transformstörungen

A microscopic view of a rock sample showing olivine crystals in peridotite. The image displays a complex, interlocking pattern of various colored regions, including shades of blue, yellow, green, brown, and purple, separated by dark, thin lines representing grain boundaries. The overall appearance is highly textured and irregular.

Ende 1. Stunde

Olivin Kristalle in Peridotit