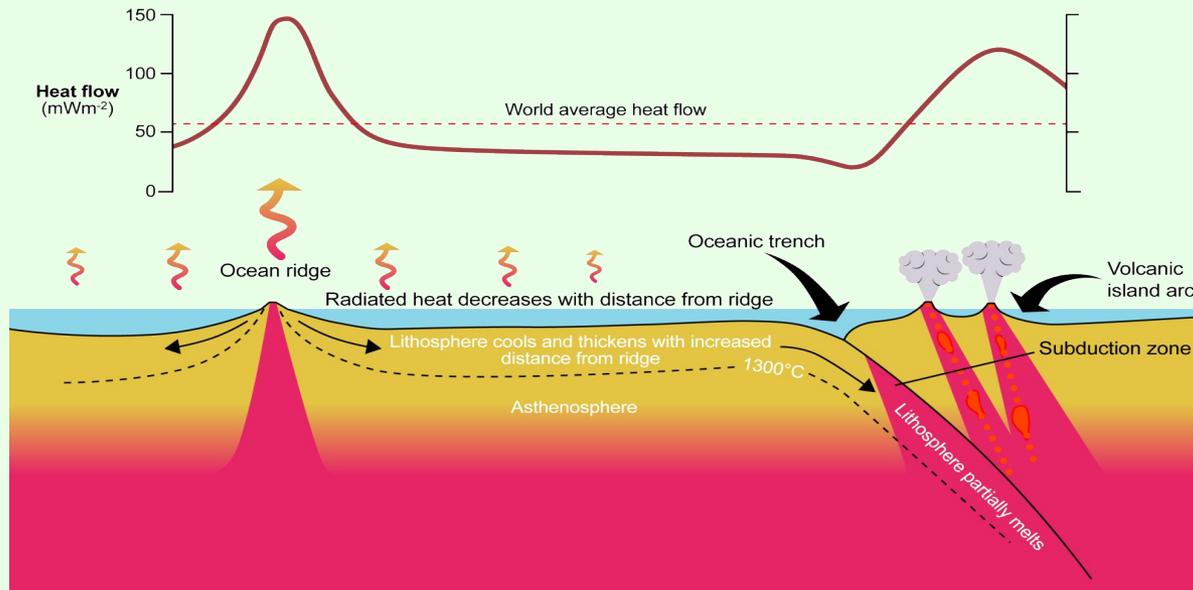


The plate tectonic story – online

Part 2

Earth Science for science and geography – video workshop



Developed from
the Earth Science
Education Unit
'The plate tectonic
story' workshop,
with permission

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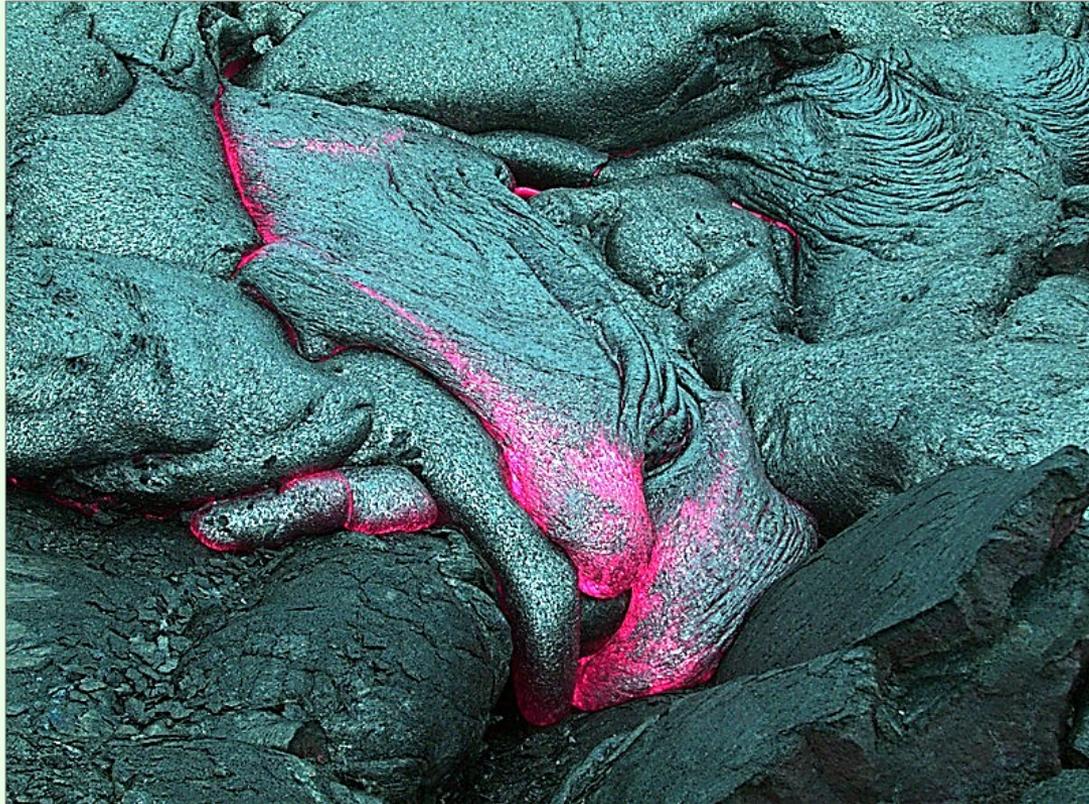
The plate tectonic story

- **Divergent margins**

Go to: https://www.earthlearningidea.com/Video/V29_Divergent_margins1.html
hyperlink

The plate tectonic story

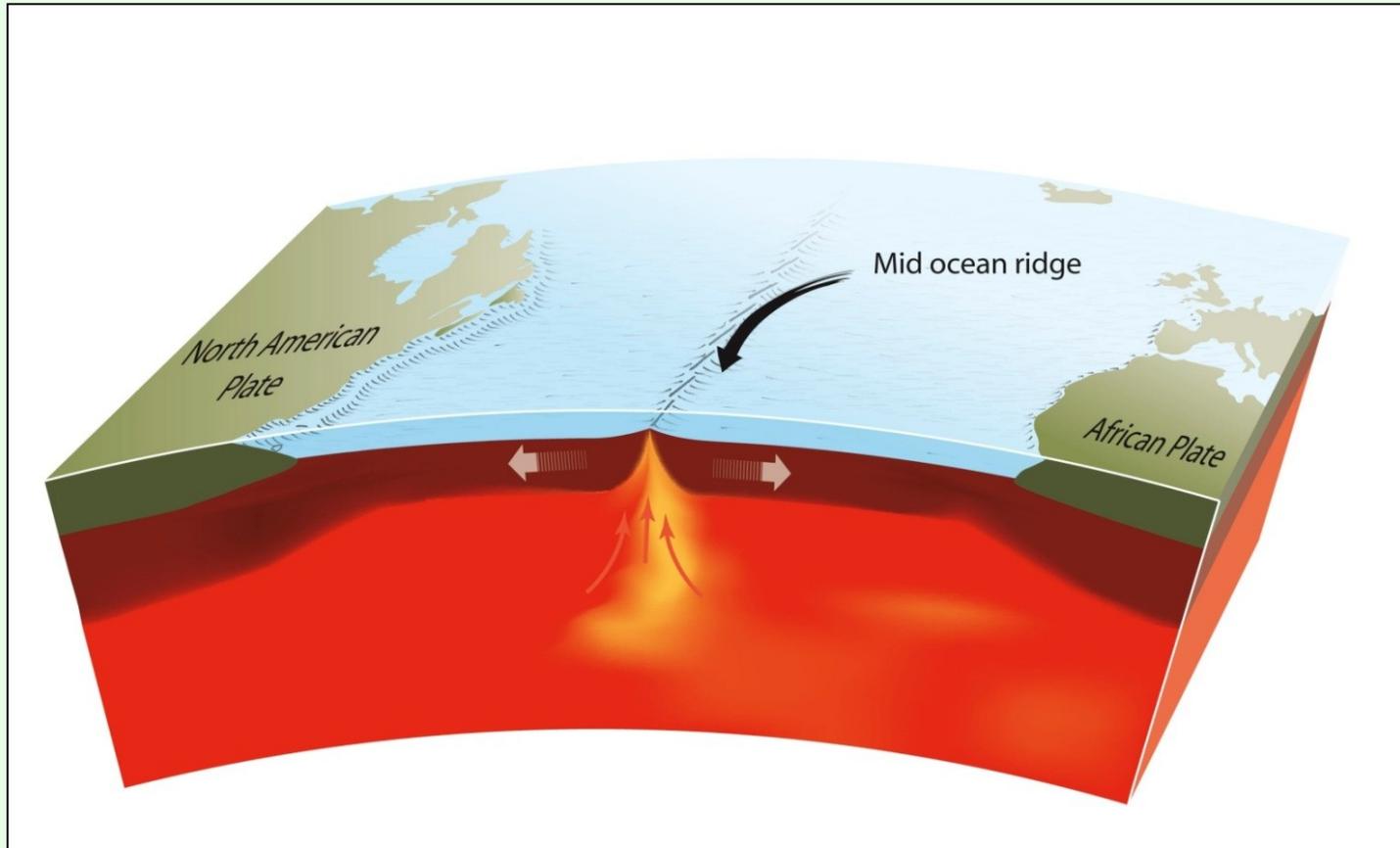
Divergent plate margins -
adding new plate material



Underwater basalt lava at a divergent margin in the public domain by Vintei

The plate tectonic story

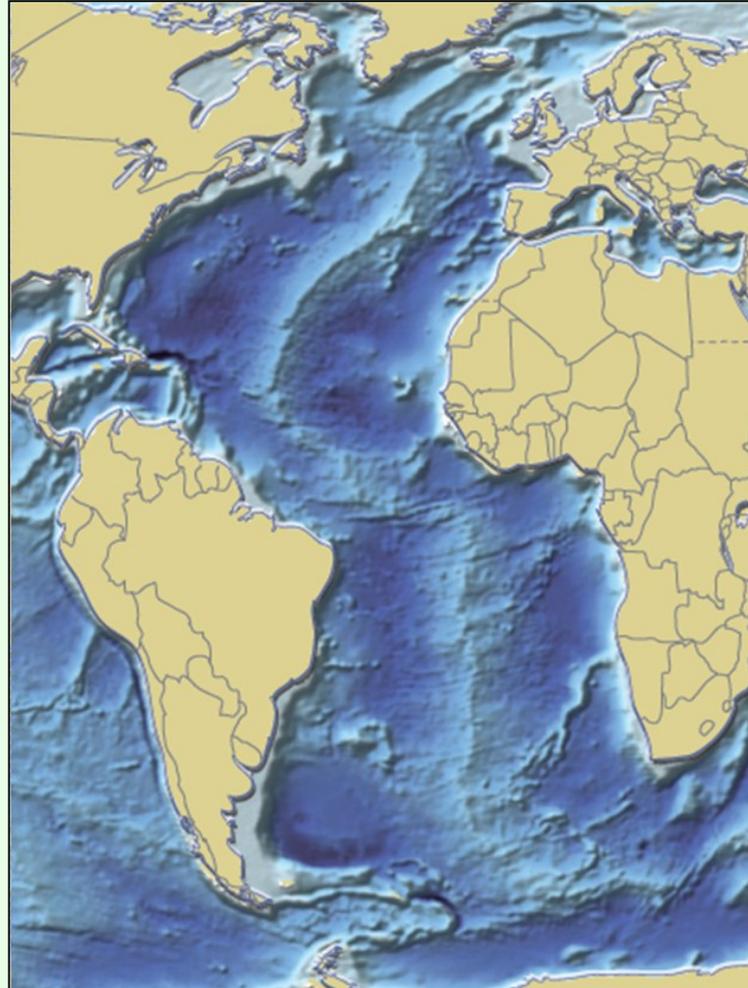
Activity at an oceanic ridge – a divergent plate margin



An oceanic ridge © Press & Siever, redrawn by ESEU

The plate tectonic story

Mid-Atlantic ridge



<http://maps.grida.no/go/graphic/world-ocean-bathymetric-map>
(Hugo Ahlenius, UNEP/GRID-Arendal)

The plate tectonic story

Icelandic-type eruption



Icelandic-type eruption - reproduced with kind permission of U.S. Department of Interior, USGS

The plate tectonic story

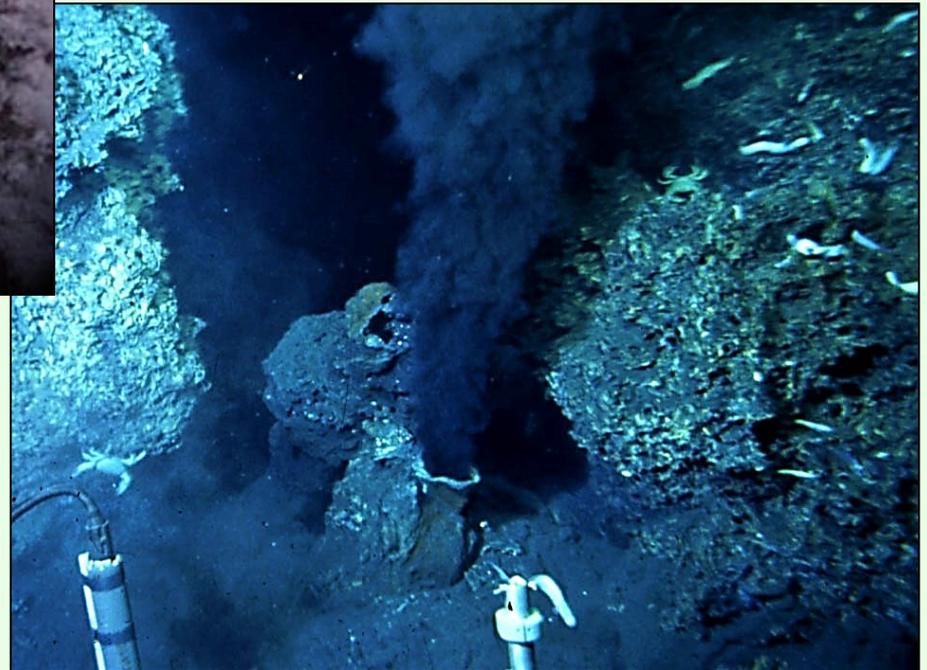
Ancient pillow lavas



Ancient Pillow lavas © Peter Kennett

The plate tectonic story

Black smoker activity



Black Smoker' by US National Oceanic & Atmospheric Administration (public domain)

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The plate tectonic story

- **Faults in a Mars™ bar**

Go to: https://www.earthlearningidea.com/Video/V29_Divergent_margins2.html
hyperlink

The plate tectonic story

Faults in a Mars™ Bar
Modelling a divergent plate margin



Gap between the North American and Eurasian continental plates © Randomskk

The plate tectonic story

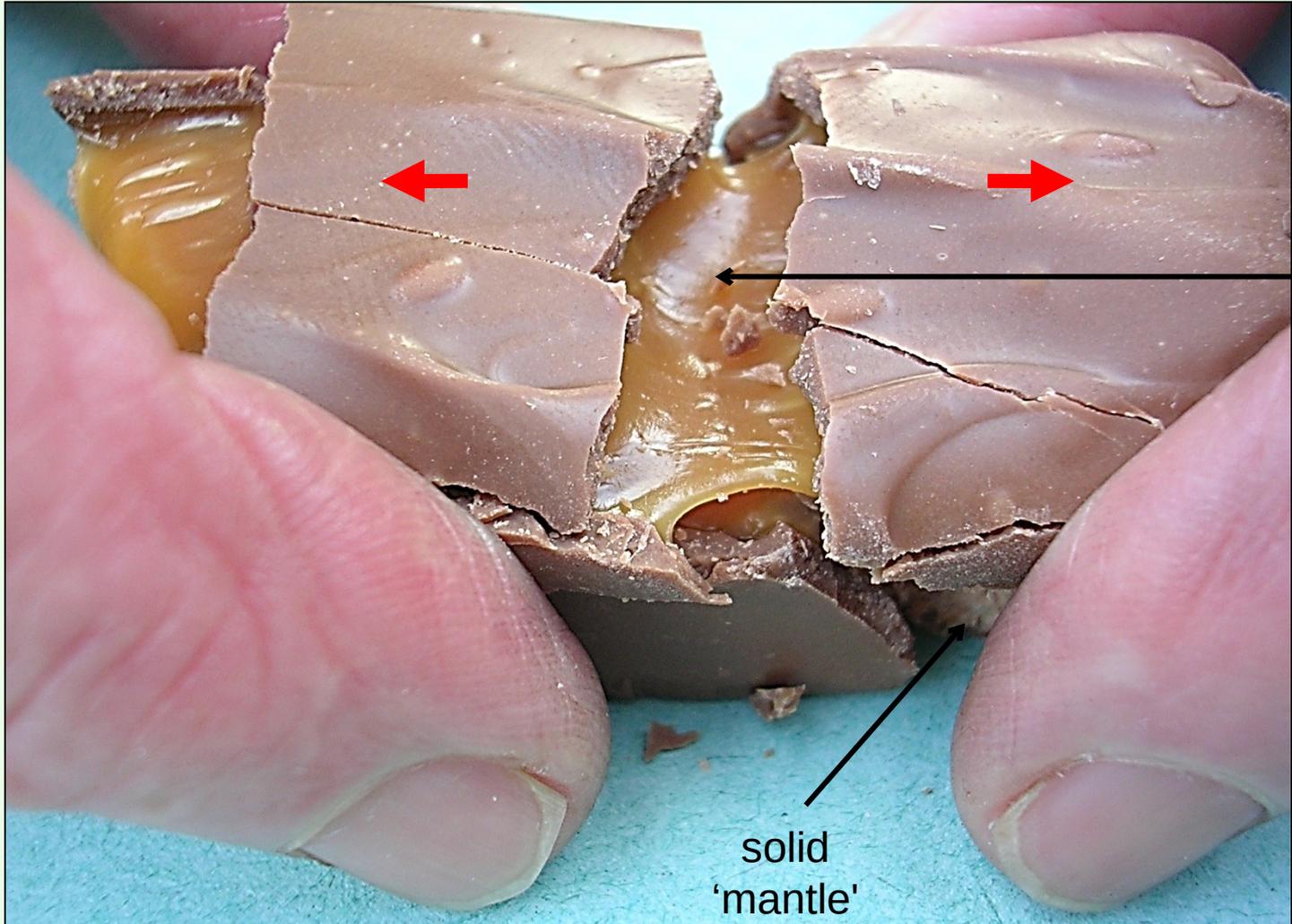
Faults in a Mars™ Bar



The plate tectonic story

Faults in a Mars™ Bar

rigid 'lithosphere' moving left central 'rift valley' rigid 'lithosphere' moving right



ductile
flowing
'asthenosphere'

solid
'mantle'

The plate tectonic story

A divergent margin rift valley on land
Iceland



Gap between the North American and Eurasian continental plates © Randomskk

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The plate tectonic story

- **Magnetic stripes**

Go to: https://www.earthlearningidea.com/Video/V30_Magnetic_stripes.html
hyperlink

The plate tectonic story

The magnetic stripes evidence



Research ship used to tow magnetometer

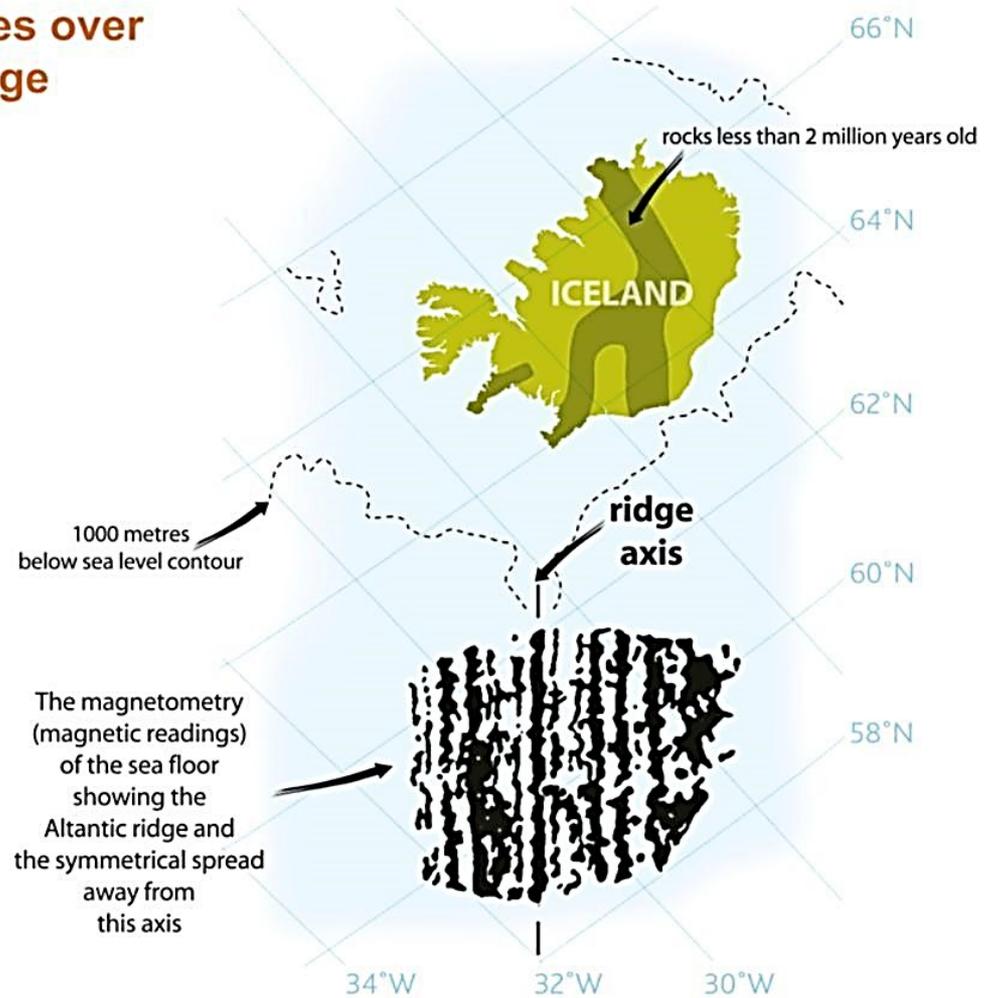
The plate tectonic story

Magnetic anomalies over the Reykjanes Ridge

Black = positive anomaly
White = negative anomaly



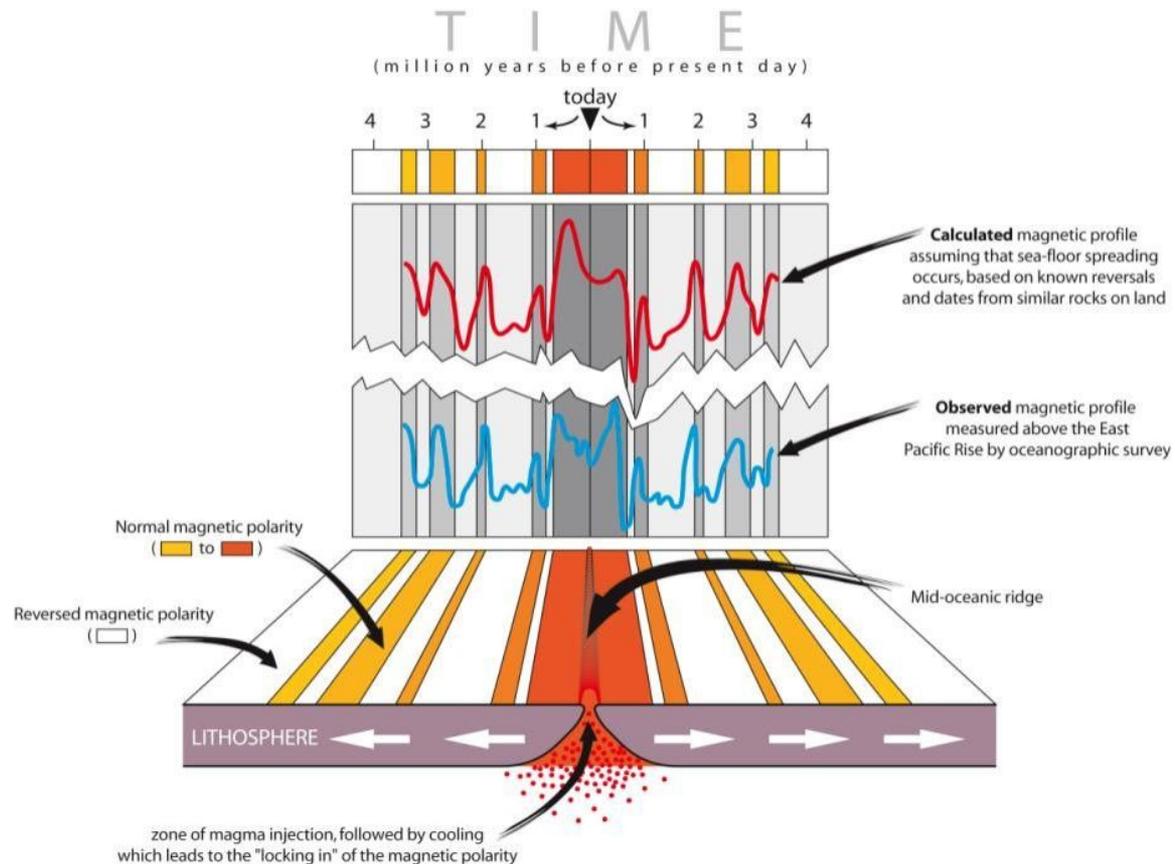
The equipment used to show magnetic anomalies © Peter Kennett



Magnetic anomalies over the Reykjanes Ridge © Geoscience, redrawn by ESEU

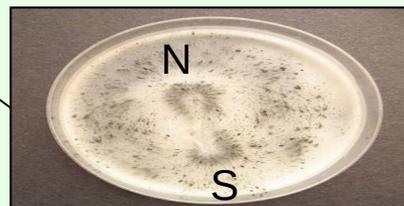
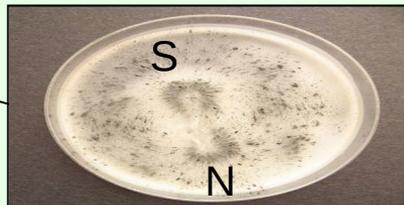
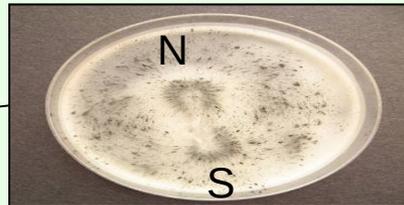
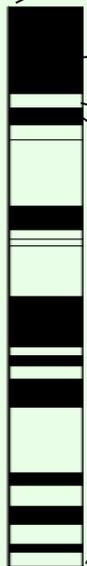
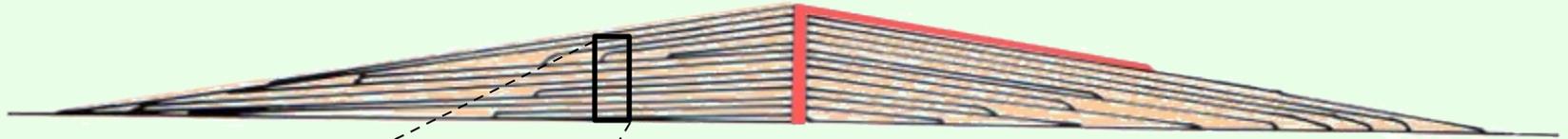
The plate tectonic story

Magnetic evidence for ocean floor spreading



The plate tectonic story

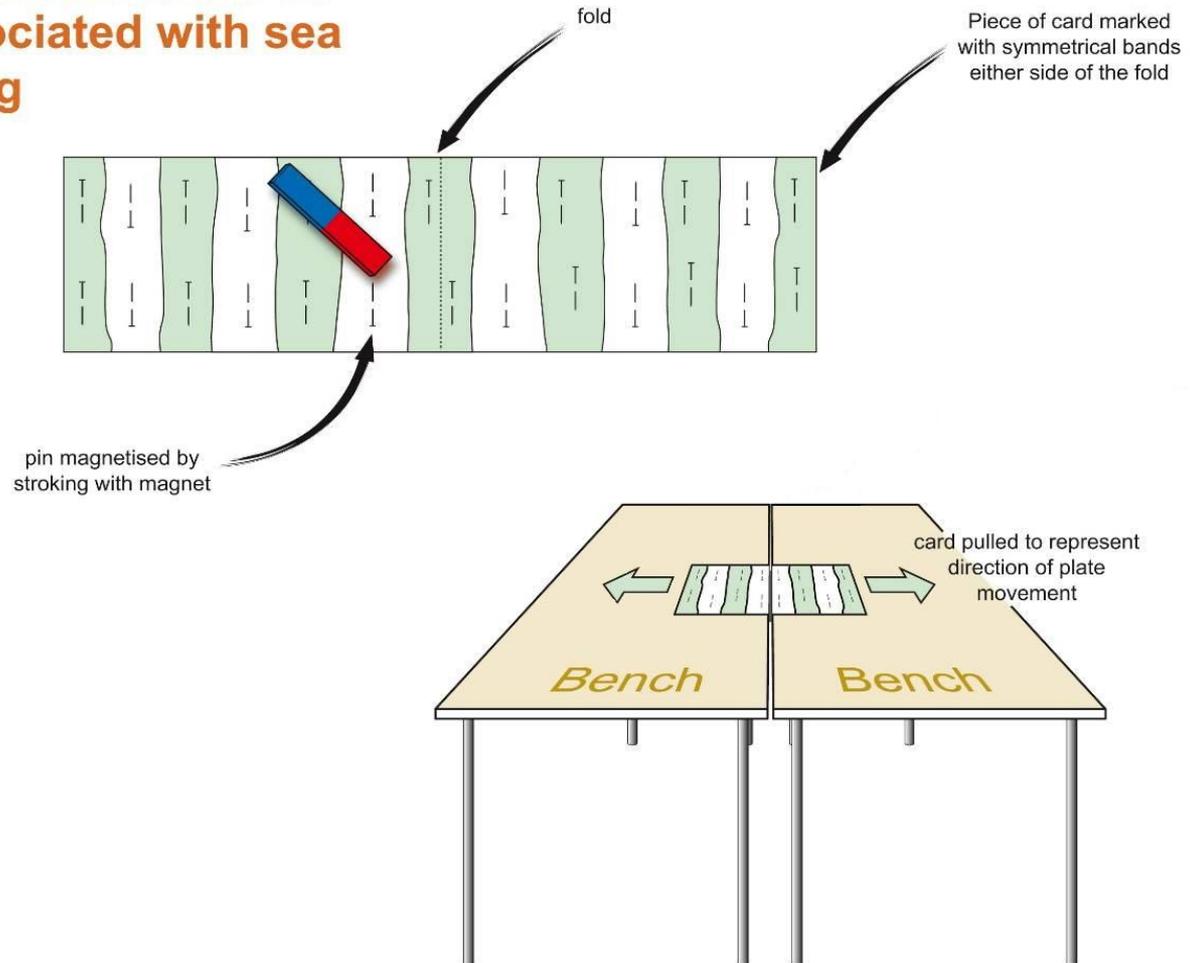
Meanwhile, it had been found from sequences of volcanic lava flows that the Earth's magnetic field had 'flipped' many times in the geological past



Magnetisation preserved in rocks – like the petri dish wax magnetic field – but reversed at intervals because of magnetic pole flips

The plate tectonic story

Classroom demonstration of concepts associated with sea floor spreading



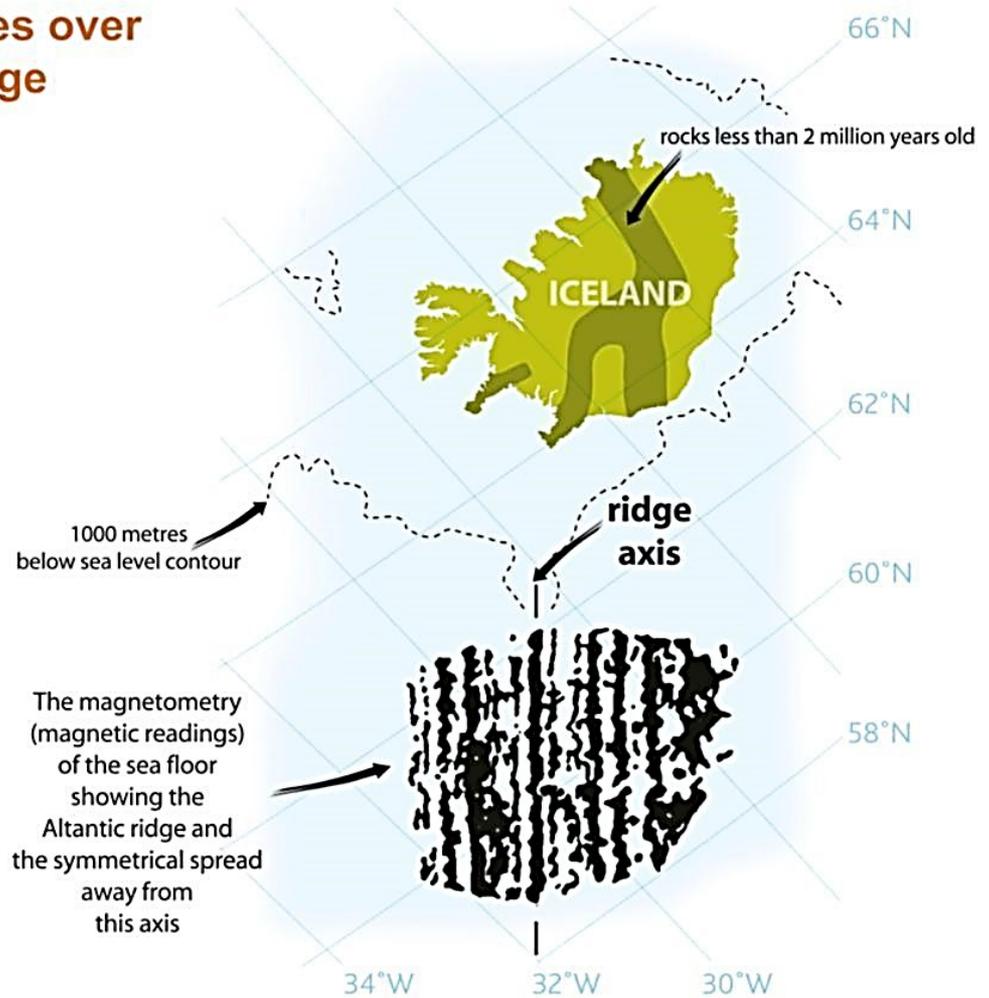
The plate tectonic story

Magnetic anomalies over the Reykjanes Ridge

Black = positive anomaly
White = negative anomaly



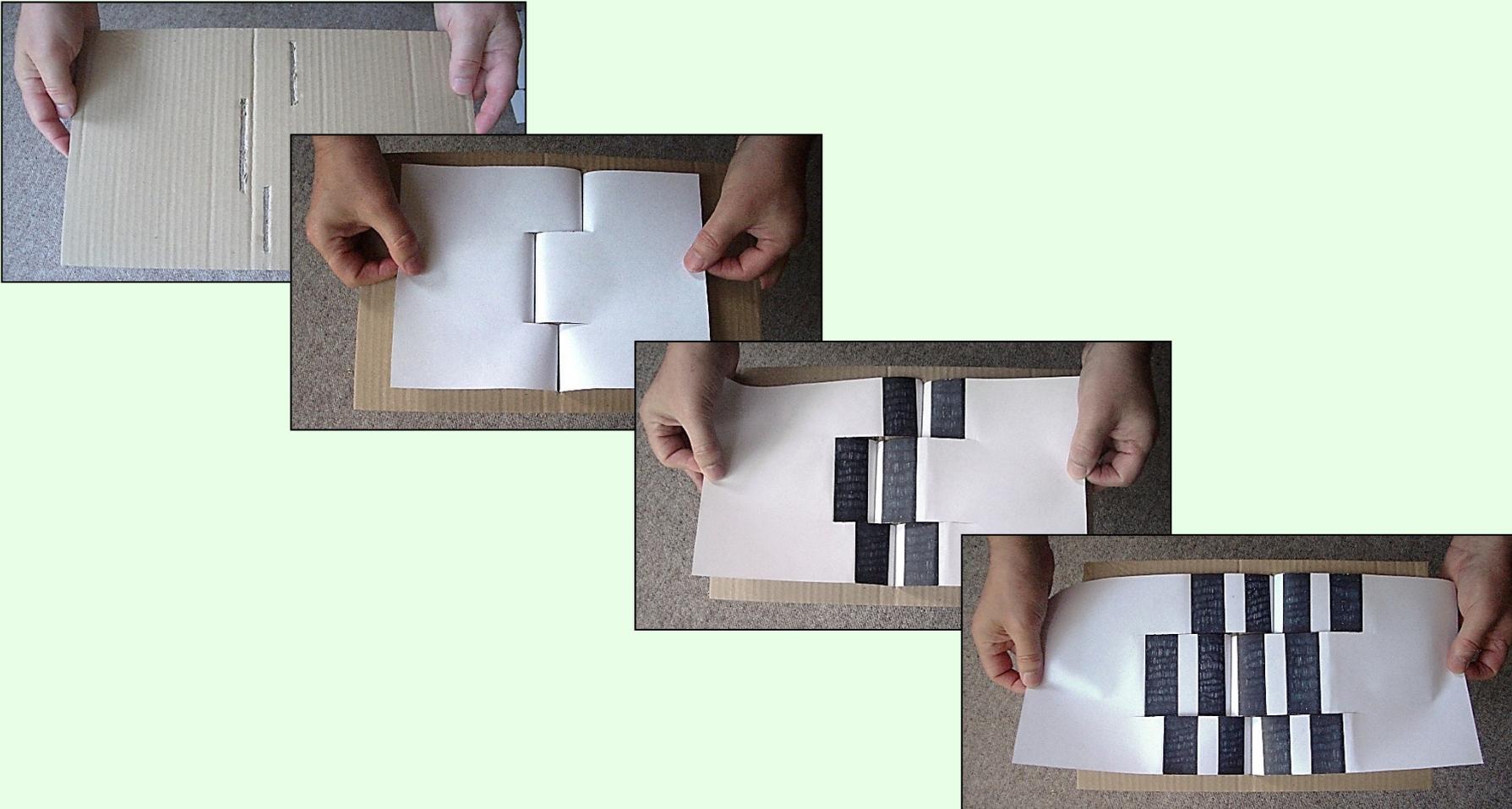
The equipment used to show magnetic anomalies © Peter Kennett



Magnetic anomalies over the Reykjanes Ridge © Geoscience, redrawn by ESEU

The plate tectonic story

The magnetic stripes are offset by transform faults – conservative or sliding plate margins



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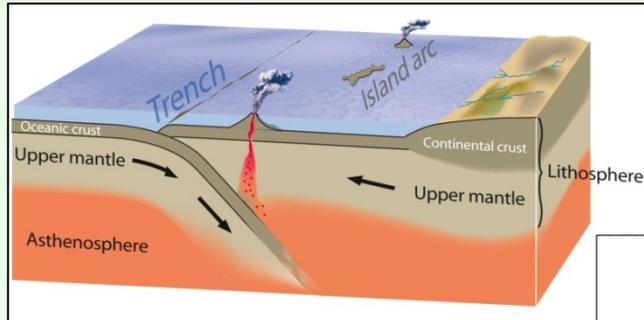
The plate tectonic story

- **Convergent margins**

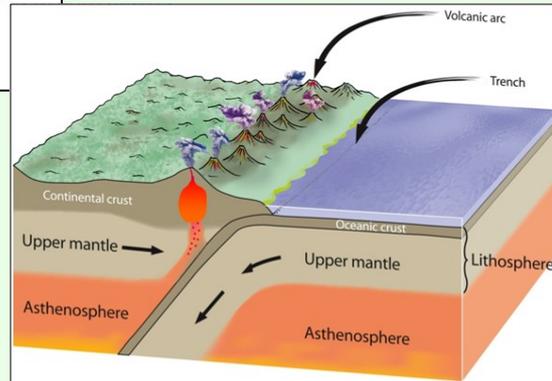
Go to: https://www.earthlearningidea.com/Video/V31_Convergent_margins.html
hyperlink

The plate tectonic story

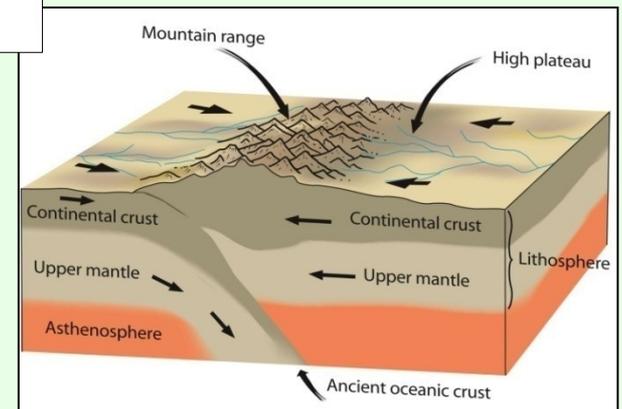
Convergent plate margins - recycling material



Continental plate collision zone. Reproduced with kind permission of USGS, redrawn by ESEU



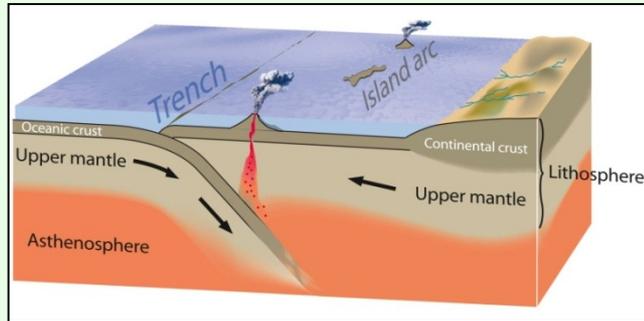
Subduction zone ('partially melts and volcanoes are produced' 'molten rock cools down below the surface') - reproduced with kind permission of USGS, redrawn by ESEU



Continental plate collision zone. Reproduced with kind permission of USGS, redrawn by ESEU

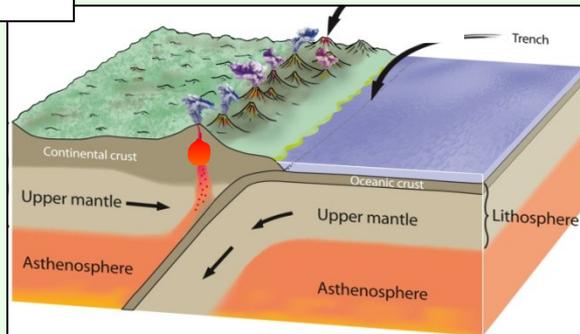
The plate tectonic story

Convergent plate margins - recycling material

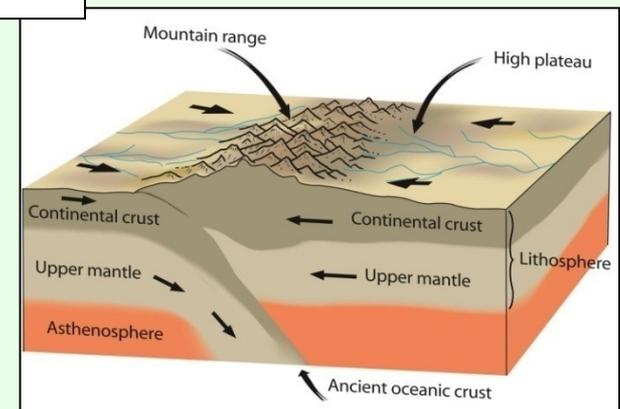


**Ocean v ocean
convergent plate margin**
– one oceanic plate
subducted beneath another

**Ocean v continent
convergent plate margin**
– an oceanic plate
subducted beneath a
continental plate



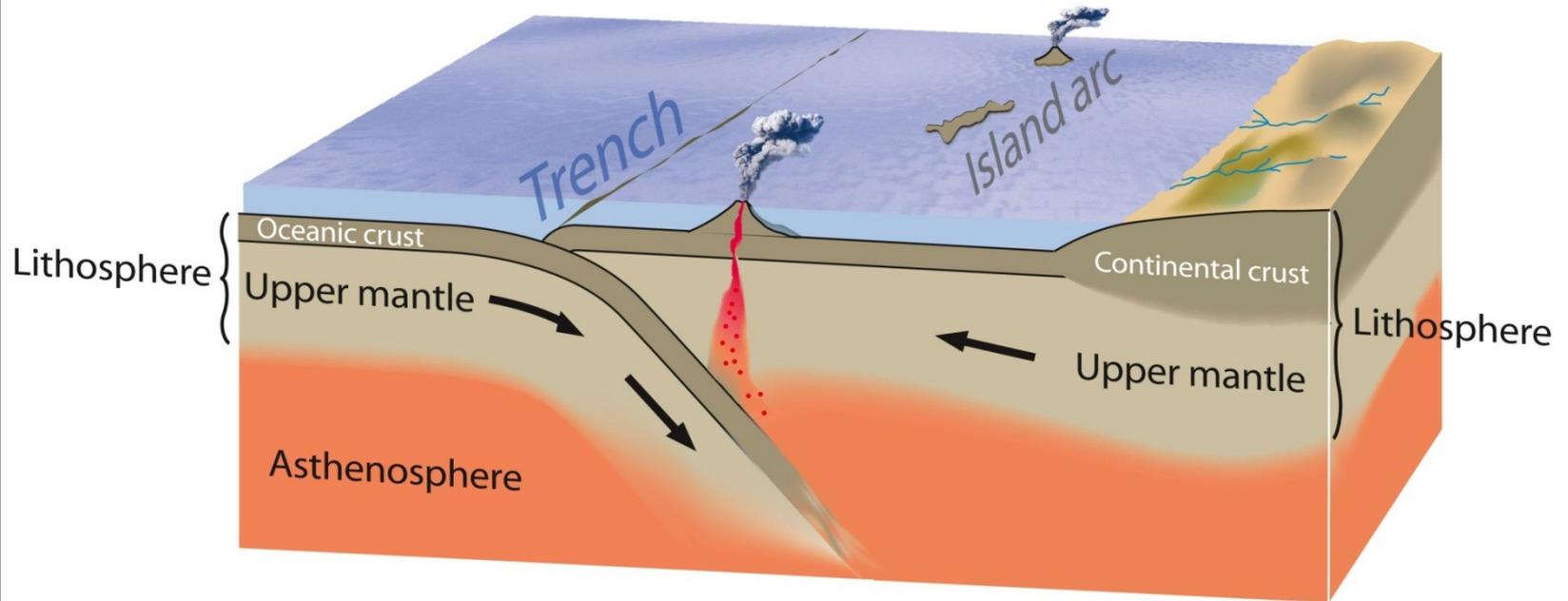
**Continent v continent
convergent plate margin**
– two continental plates
colliding



The plate tectonic story

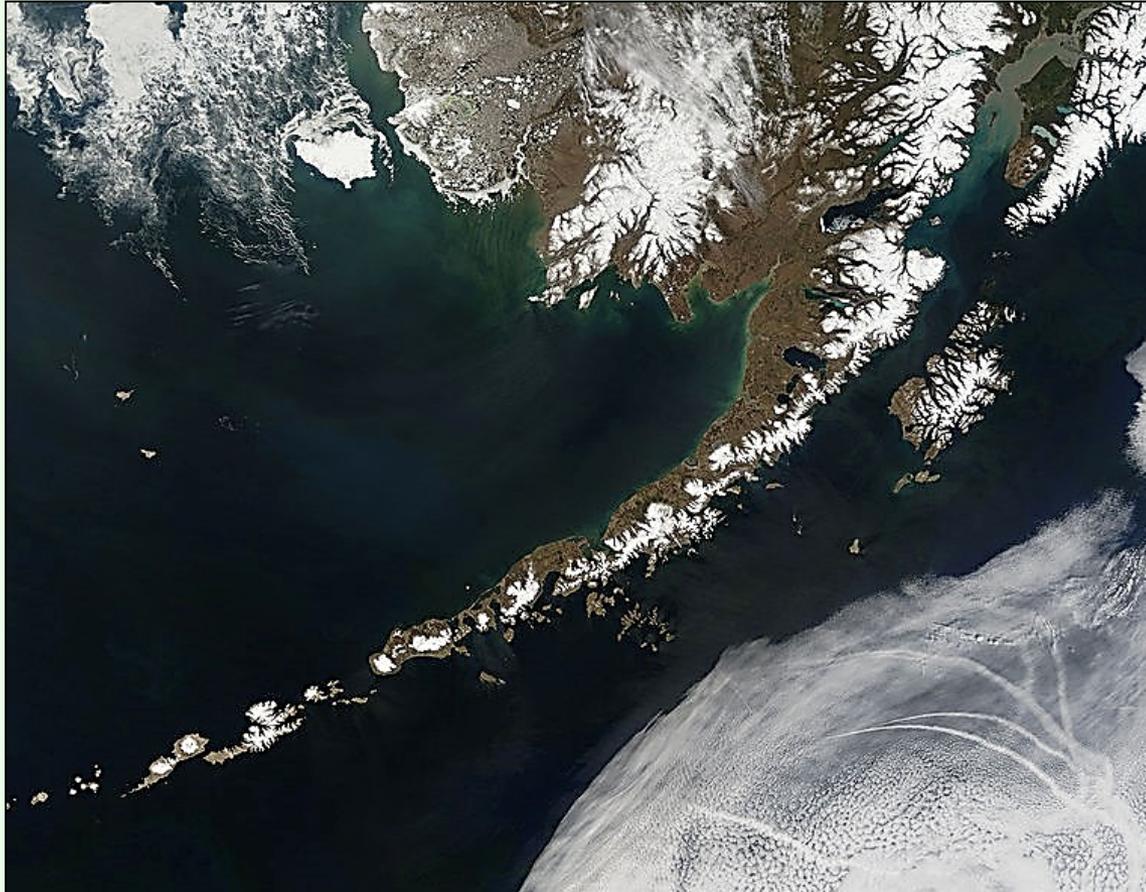
Ocean-ocean convergence

Two oceanic plates meet in the open ocean. The denser plate is subducted into the mantle. Partial melting produces magma which rises to form an island arc.



The plate tectonic story

Convergent plate margins:
where plate material is recycled



'A satellite view of the Aleutian Islands, Pacific Ocean' by NASA (public domain)

The plate tectonic story

Island arc volcanism

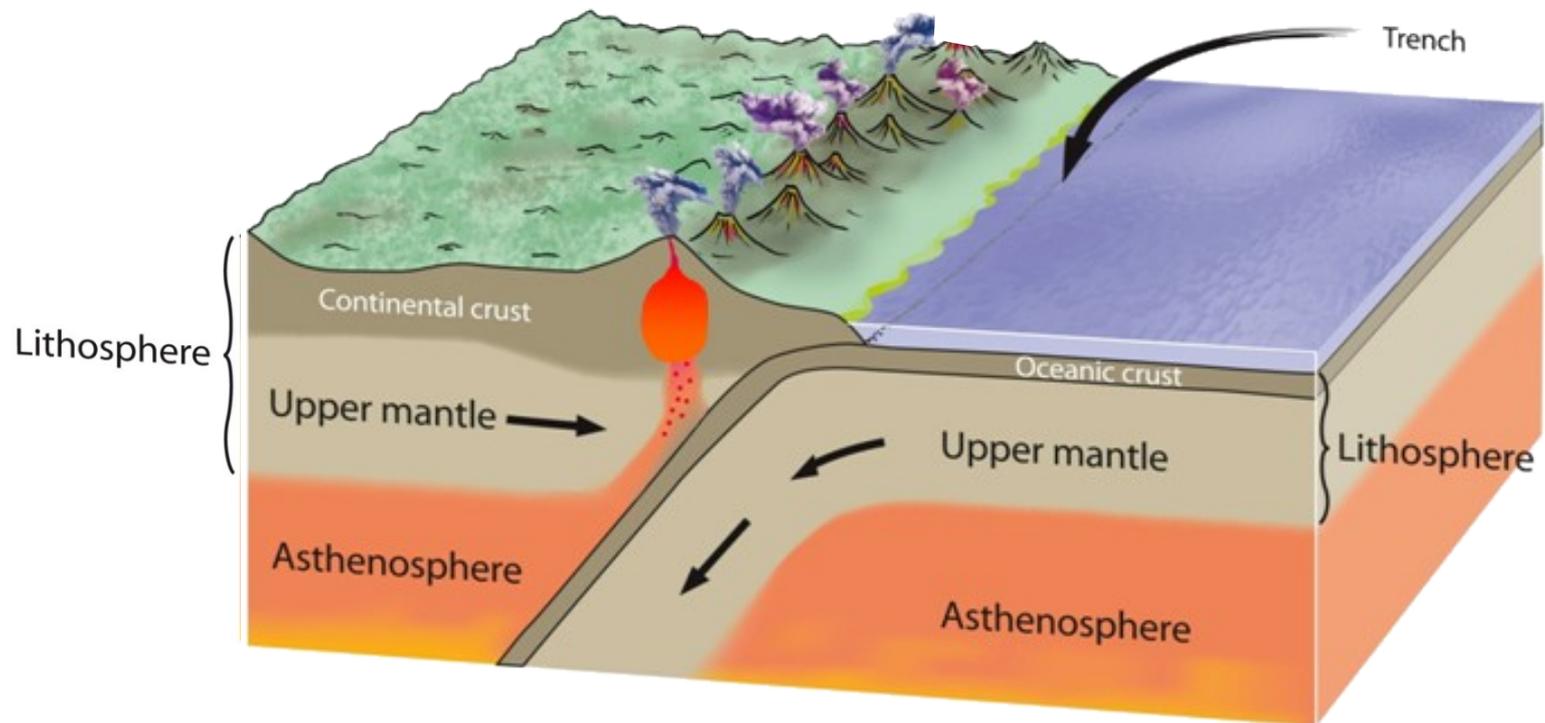


Zavodovski Island, South Sandwich Island, South Atlantic (Peter Kennett)

The plate tectonic story

Ocean-continent convergence

The dense oceanic plate descends below the lighter continental one. Partial melting of the basaltic rocks of the ocean floors produces magma which rises. It is richer in silica than basalt and erupts in a more violent way.



Subduction zone ('partially melts and volcanoes are produced' 'molten rock cools down below the surface')
- reproduced with kind permission of USGS, redrawn by ESEU

The plate tectonic story

Ocean-continent convergence: Mount St Helens

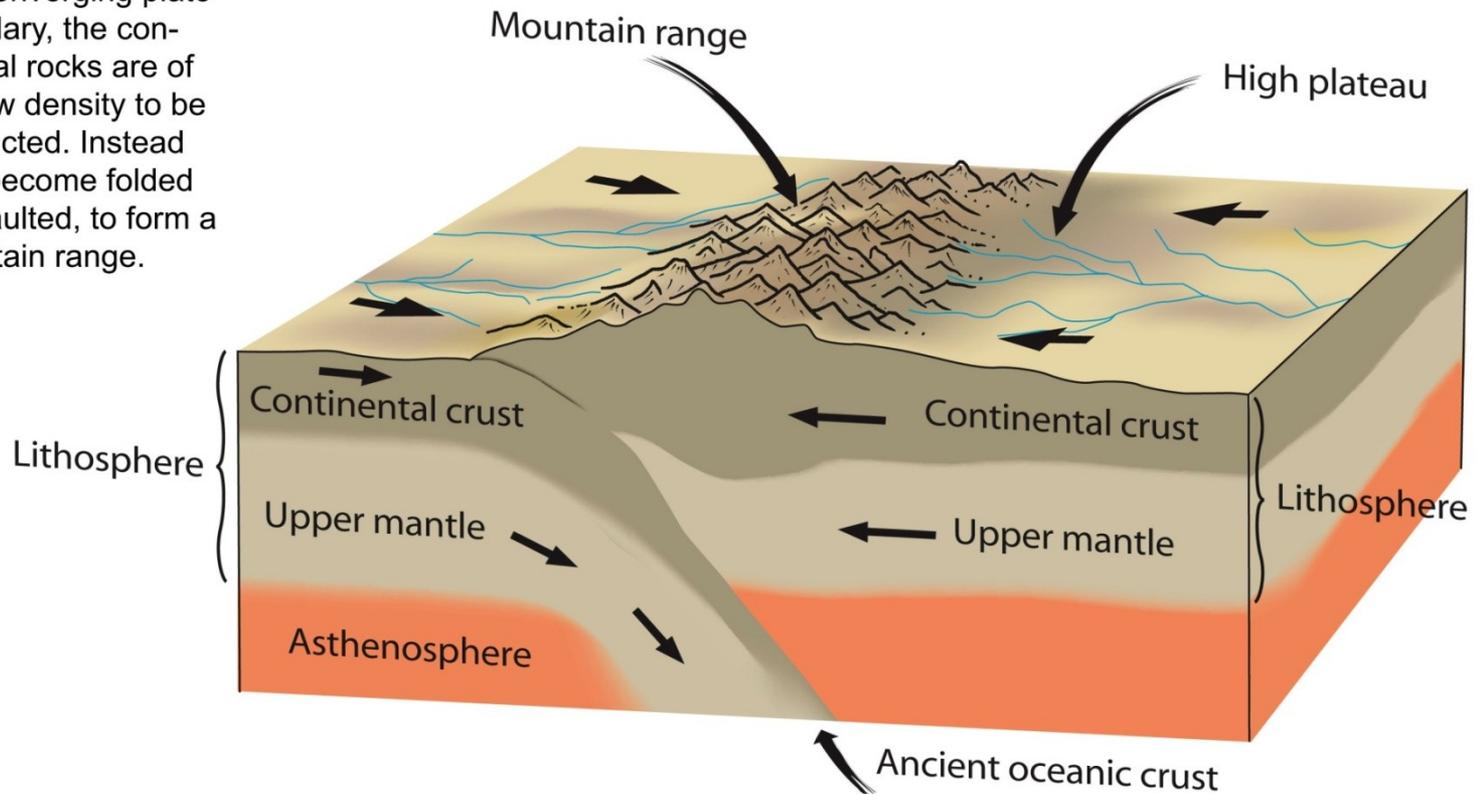


Mount St Helens © USGS/Cascades Volcano Observatory

The plate tectonic story

Continent-continent convergence

When two continents are brought together at a converging plate boundary, the continental rocks are of too low density to be subducted. Instead they become folded and faulted, to form a mountain range.



The plate tectonic story

Plates in motion – cardboard replica
A working model of how colliding continents
produce mountain chains – like this one



'The Tibetan Plateau, Himalayas' by NASA – image in the public domain 'The Tibetan Plateau, Himalayas' by NASA (public domain)

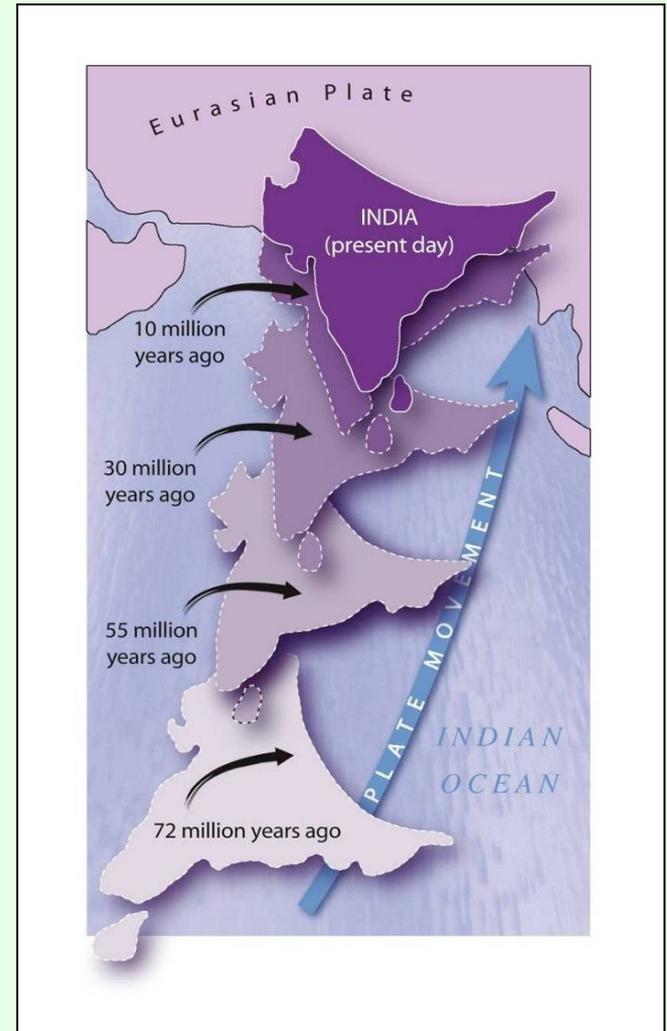
The plate tectonic story

Continent-continent convergence

The rapid northward drift of the Indian plate (at 15-40cm per year) produced the Himalayas and Tibetan Plateau when it collided with the Eurasian plate.



Folds at Lhotse (Himalayas) by Michael Searle © University of Oxford



Eurasian Plate (India's movement) © This Dynamic Earth: the Story of Plate Tectonics, USGS, redrawn by ESEU

The plate tectonic story

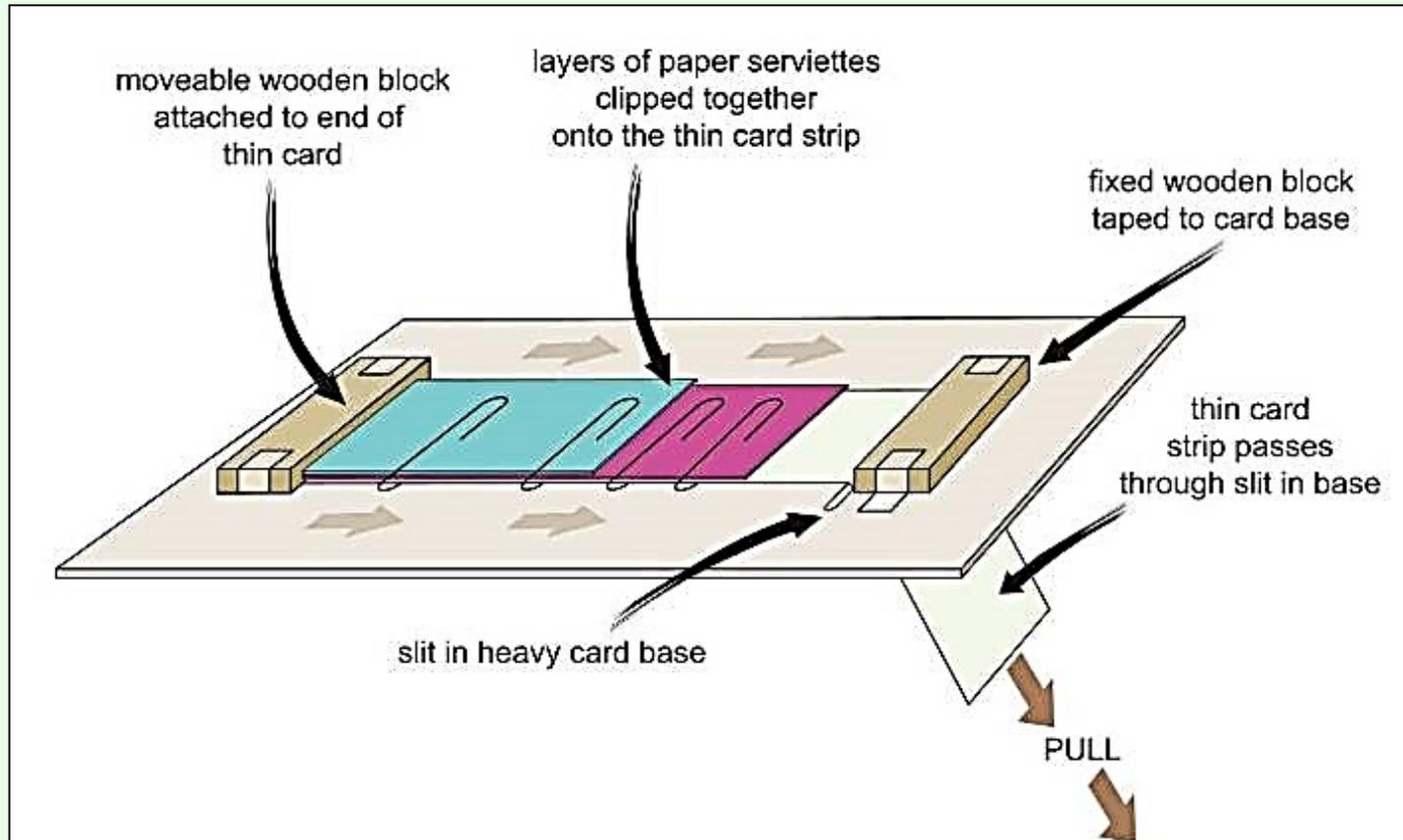
Plates in motion:
cardboard replica plates in motion



Cardboard replica of plates in motion (photograph) © ESEU

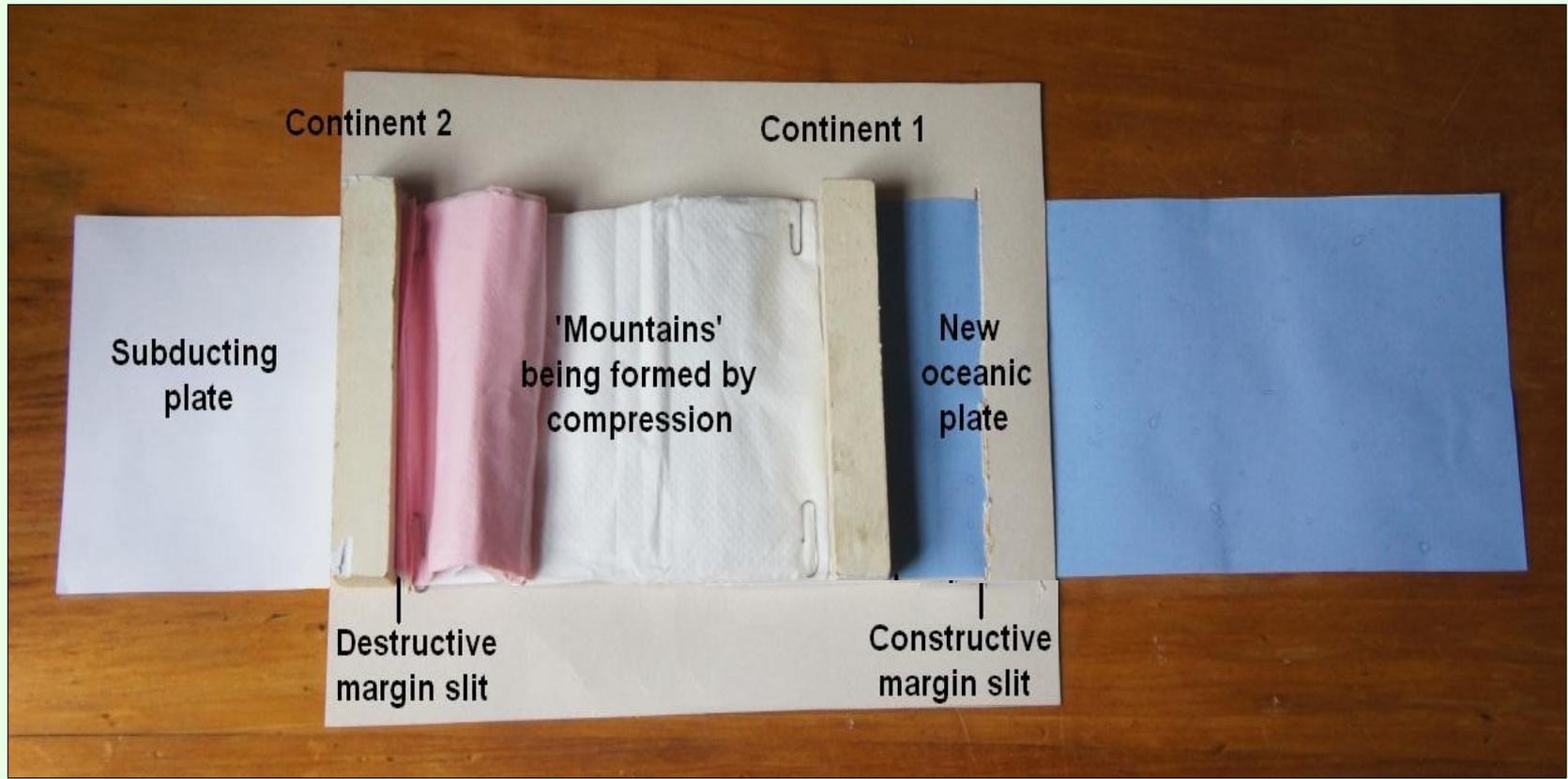
The plate tectonic story

Plates in motion:
cardboard replica plates in motion



The plate tectonic story

Plates in motion:
cardboard replica plates in motion



Photograph of plates in motion © Chris King

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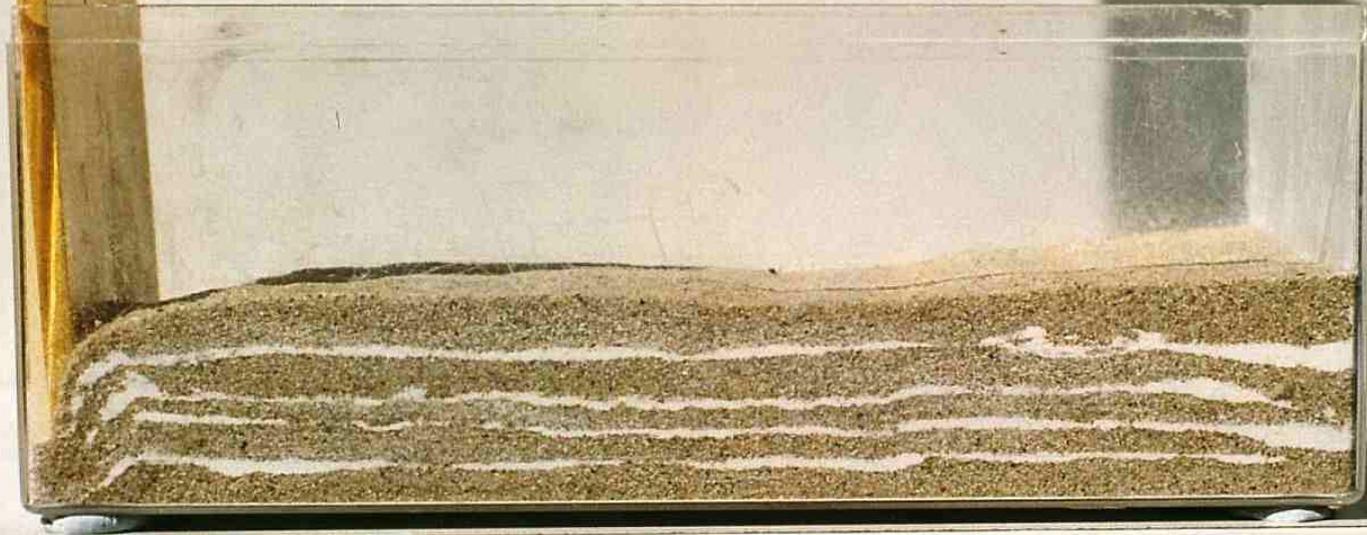
The plate tectonic story

- **Deformation**

Go to: https://www.earthlearningidea.com/Video/V31_Deformation2.html hyperlink

The plate tectonic story

Deformation – make your own folds and faults



The Himalayas in 30s...

The plate tectonic story

Deformation – make your own folds and faults



The Himalayas in 30s

The plate tectonic story

Deformation – make your own folds and faults



The Himalayas in 30s

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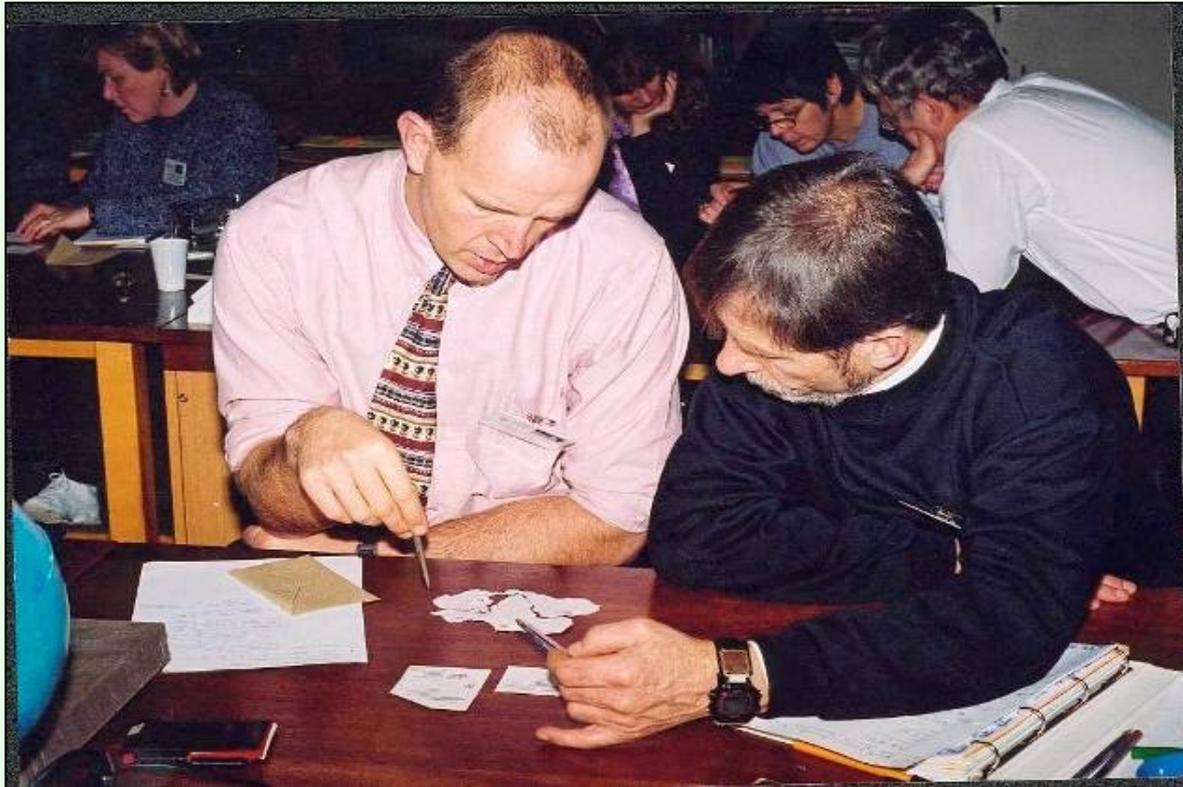
The plate tectonic story

- **Continental jigsaw puzzles**

Go to: https://www.earthlearningidea.com/Video/V32_Jigsaw_puzzles.html hyperlink

The plate tectonic story

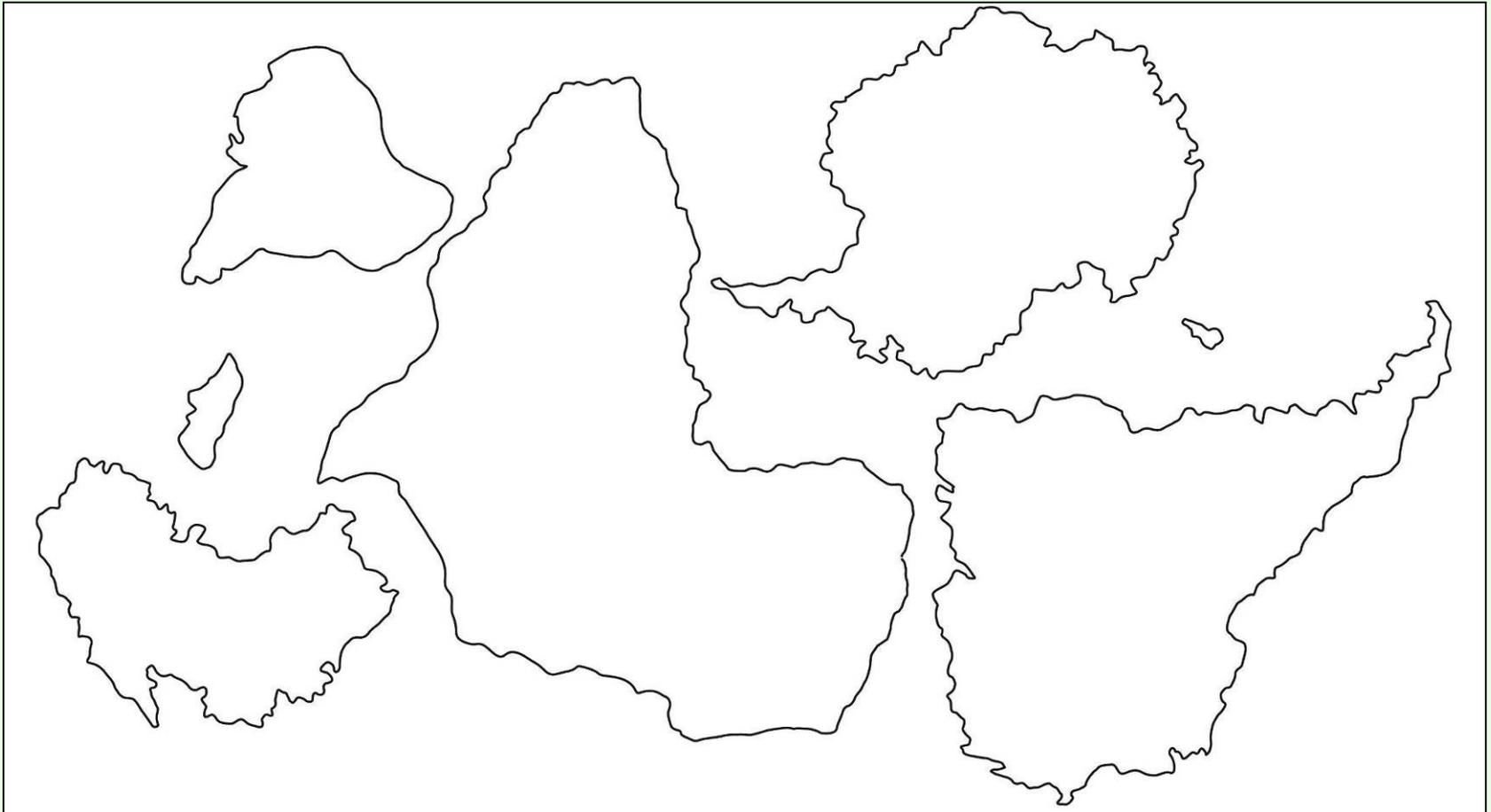
Continental jigsaw puzzles - the 'matching' evidence



Debating the reconstruction of the supercontinent of 'Gondwana' © Peter Kennett

The plate tectonic story

The continental jigsaw puzzles (the outlines of the Gondwana continents)

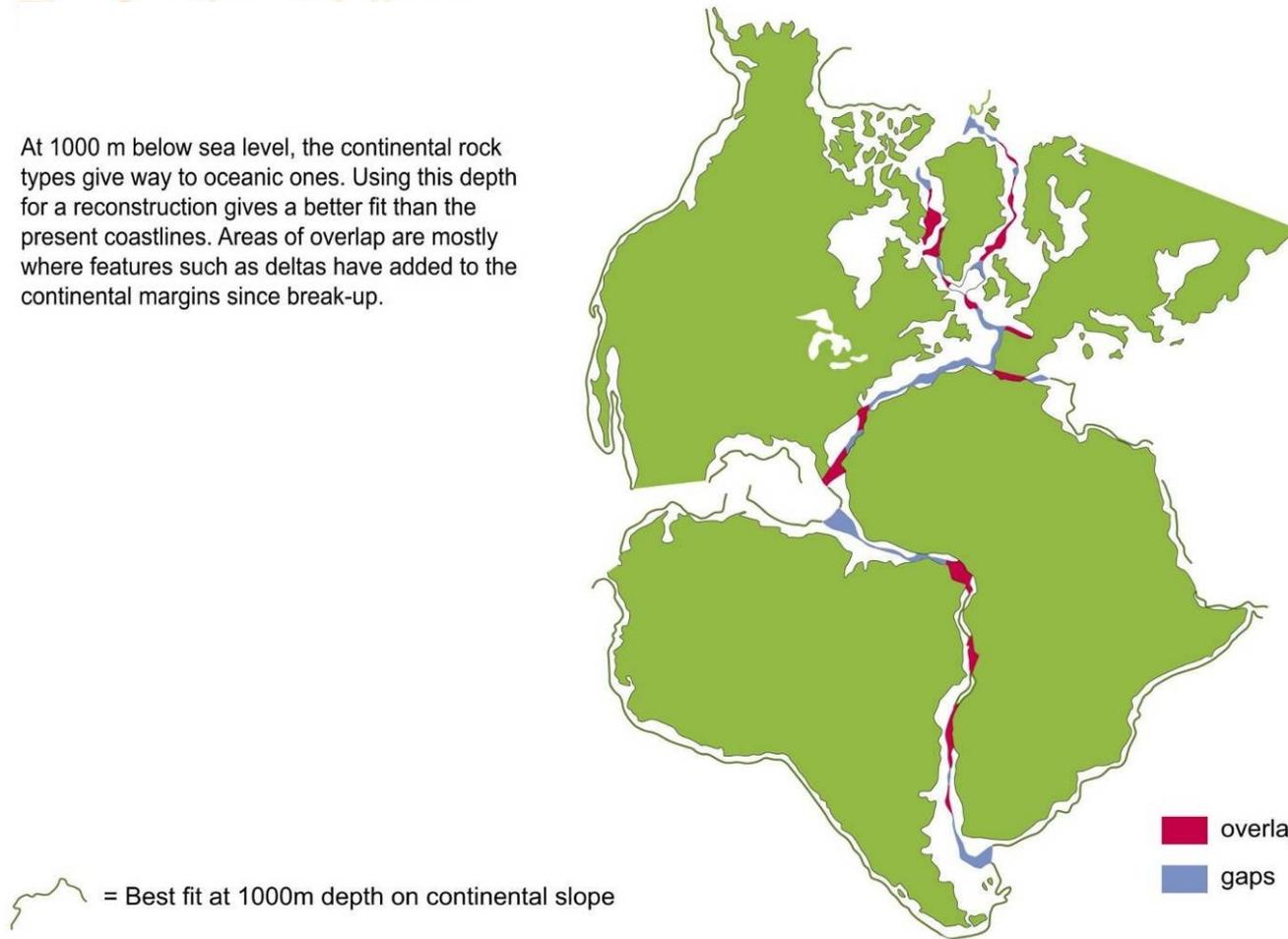


The continental jigsaw puzzle (the outlines of the Gondwana continents) © Author/origin unknown – redraw by Peter Kennett

The plate tectonic story

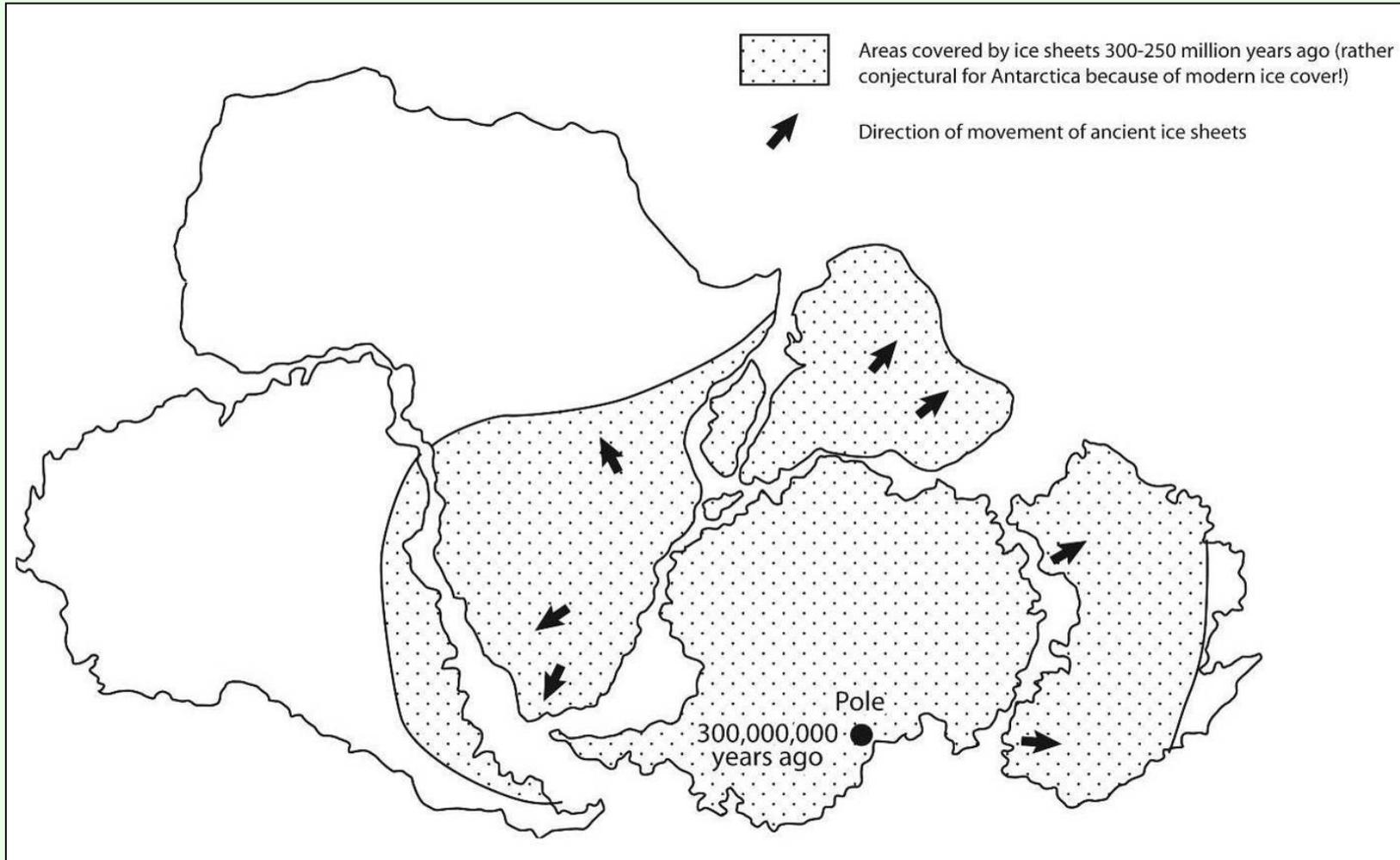
The continental jigsaw puzzles (continental shelf match at 1000m depth below sea level)

At 1000 m below sea level, the continental rock types give way to oceanic ones. Using this depth for a reconstruction gives a better fit than the present coastlines. Areas of overlap are mostly where features such as deltas have added to the continental margins since break-up.



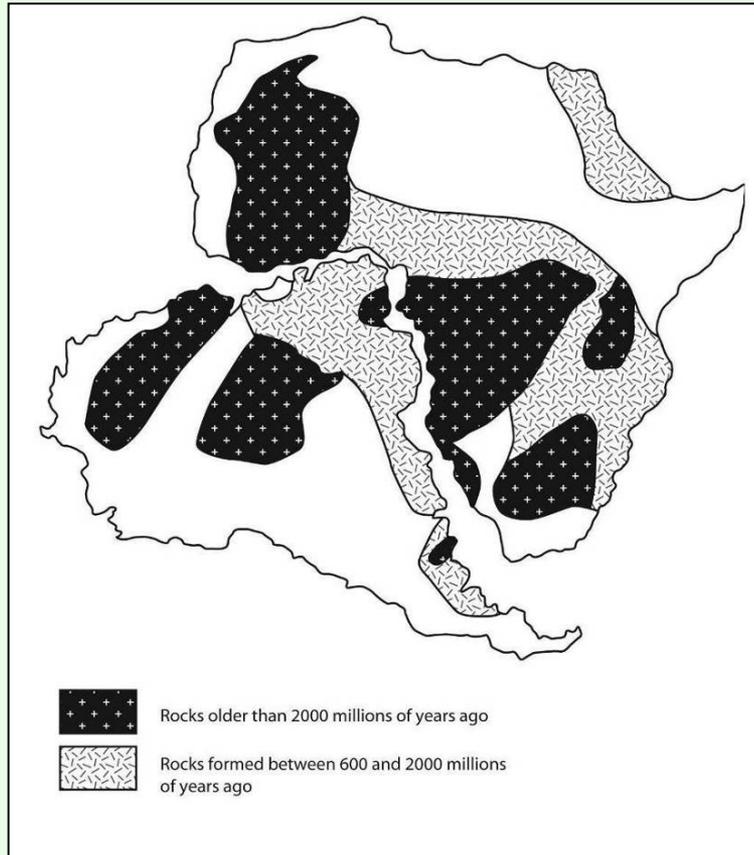
The plate tectonic story

The continental jigsaw puzzles (former distribution of ice across the Gondwana continents)

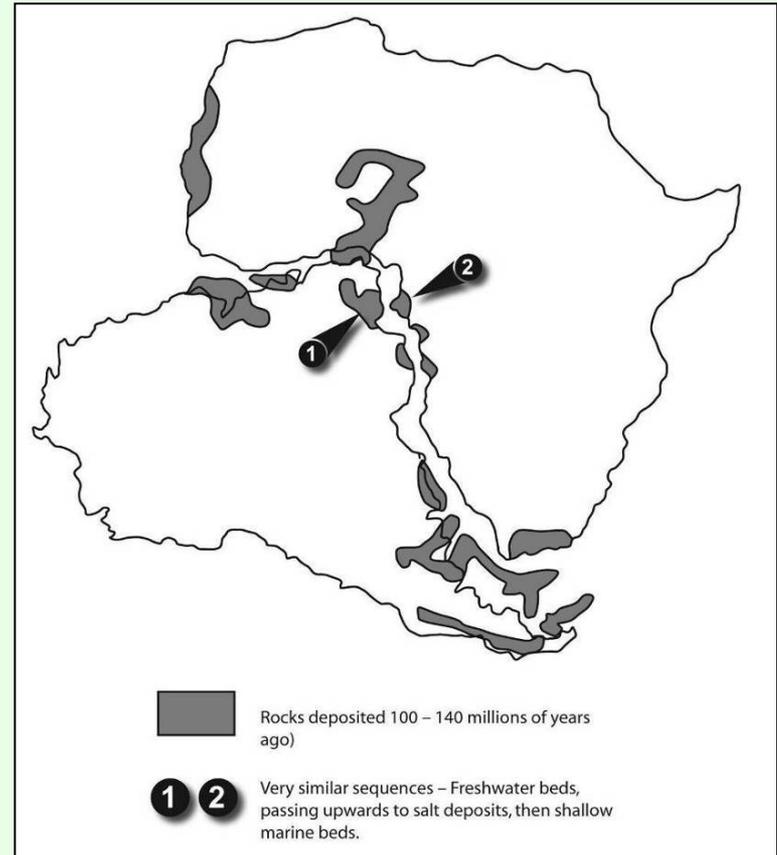


The plate tectonic story

The continental jigsaw puzzles (matching ancient rock distributions)



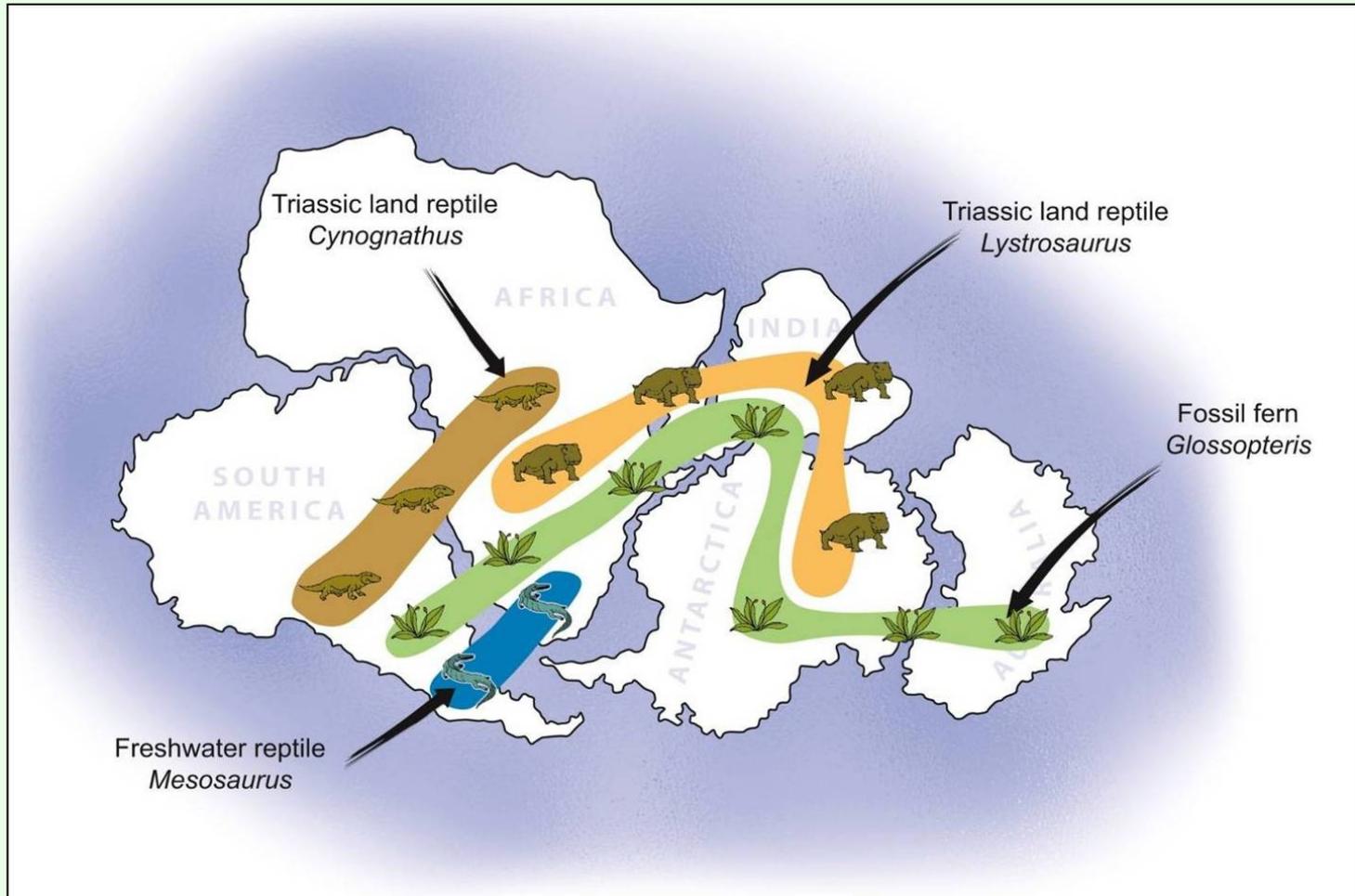
The distribution of ancient rocks across South America and Africa
© Andrew McLeish in 'Geological Science'



The distribution of younger rocks across South America and Africa up to the beginning of the continental split. Source unknown, redrawn by ESEU

The plate tectonic story

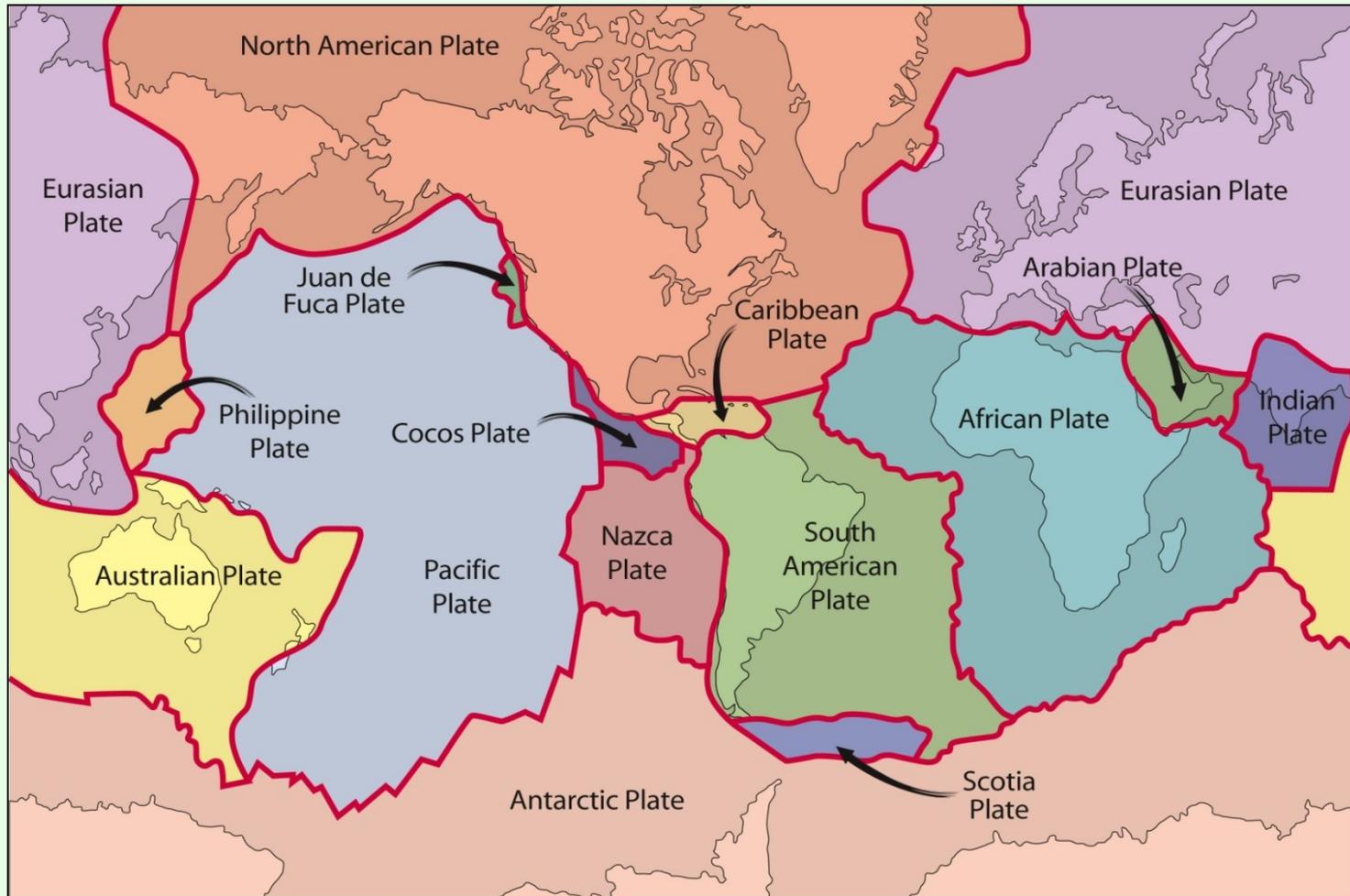
The continental jigsaw puzzles (distribution of land/freshwater animals and plants in the continents of 'Gondwana')



The continental jigsaw puzzles fossil distribution evidence, reproduced with kind permission of USGS

The plate tectonic story

Map of plates and continental distributions today



Map of plates © This Dynamic Earth: the Story of Plate Tectonics, USGS, redrawn by ESEU

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Brickquake

Go to: https://www.earthlearningidea.com/Video/V33_Brickquake.html hyperlink

The plate tectonic story

Brickquake – can earthquakes be predicted?

How earthquakes work –
and how difficult they are to predict



Ground deformation after an earthquake ©
National Geophysical Data Center (NGDC)



Brickquake (ESEU)

The plate tectonic story

Brickquake – can earthquakes be predicted?

How earthquakes work –
and how difficult they are to predict

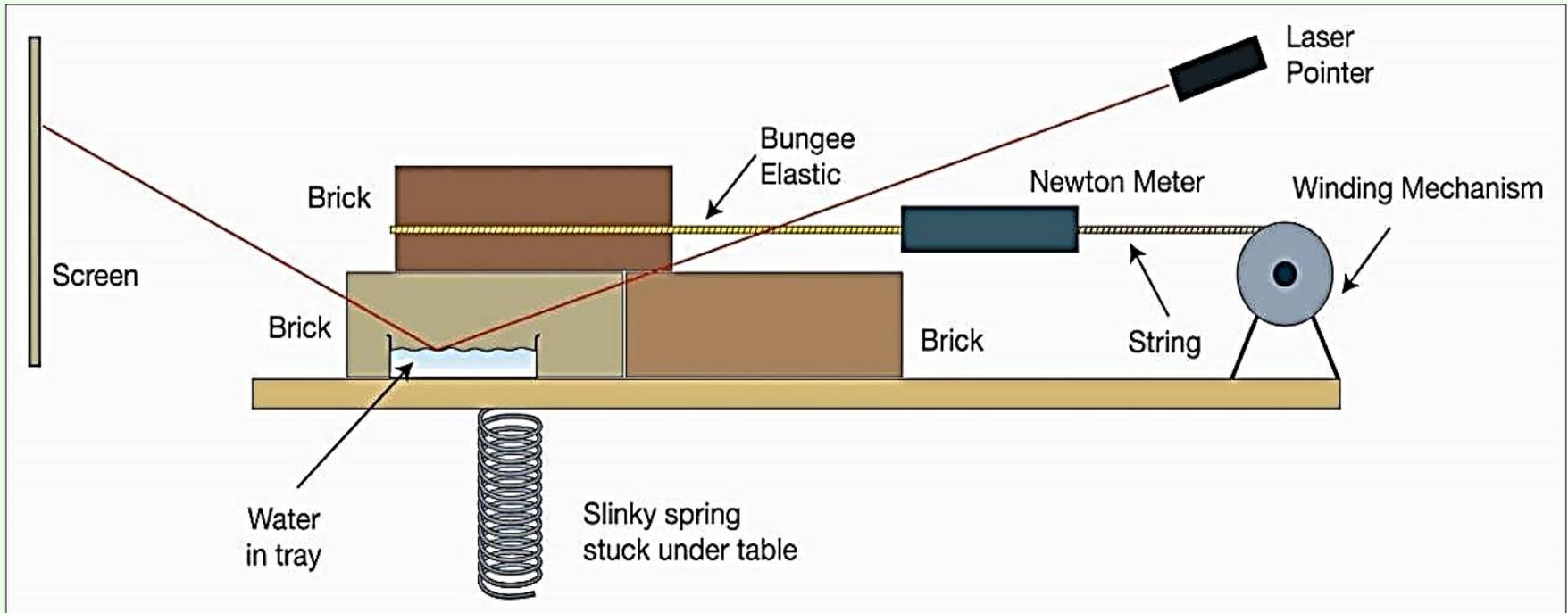


Brickquake (ESEU)

The plate tectonic story

Brickquake – can earthquakes be predicted?

How earthquakes work –
and how difficult they are to predict



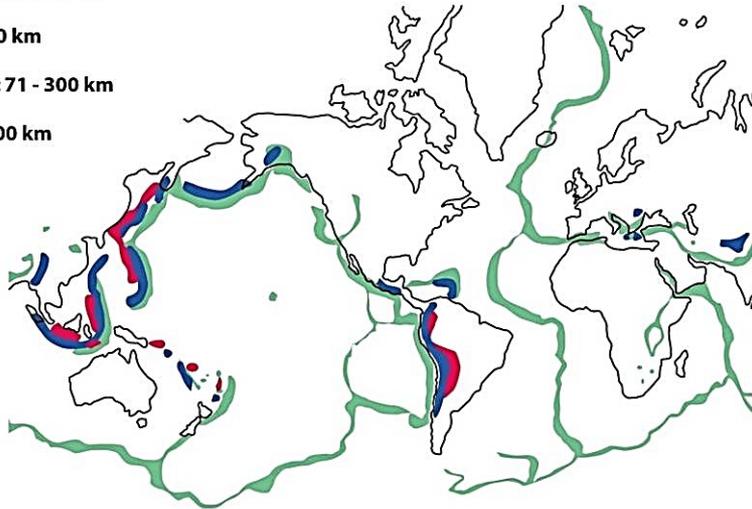
Brickquake – can earthquakes be predicted (diagram) © ESEU

The plate tectonic story

Distribution of earthquakes

Depth of focus of earthquake

- Shallow: 0 - 70 km
- Intermediate: 71 - 300 km
- Deep: 301 - 700 km



Distribution of earthquakes – source unknown, redrawn by ESEU

'Brickquake' results

Distance moved (cm)	Force (Newtons)	Relative energy released
2	15	30
7.5	45	337.5
3.5	35	122.5
4	25	100

'Brickquake' – can earthquakes be predicted?



Brickquake (ESEU)

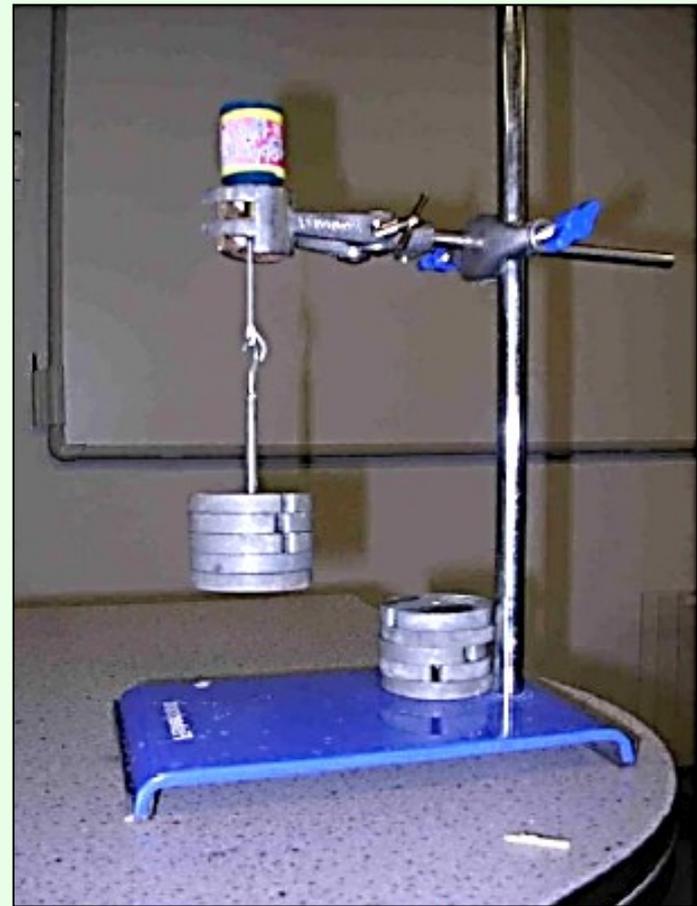
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Party popper eruption

Go to: https://www.earthlearningidea.com/Video/V34_Party_poppers.html
hyperlink

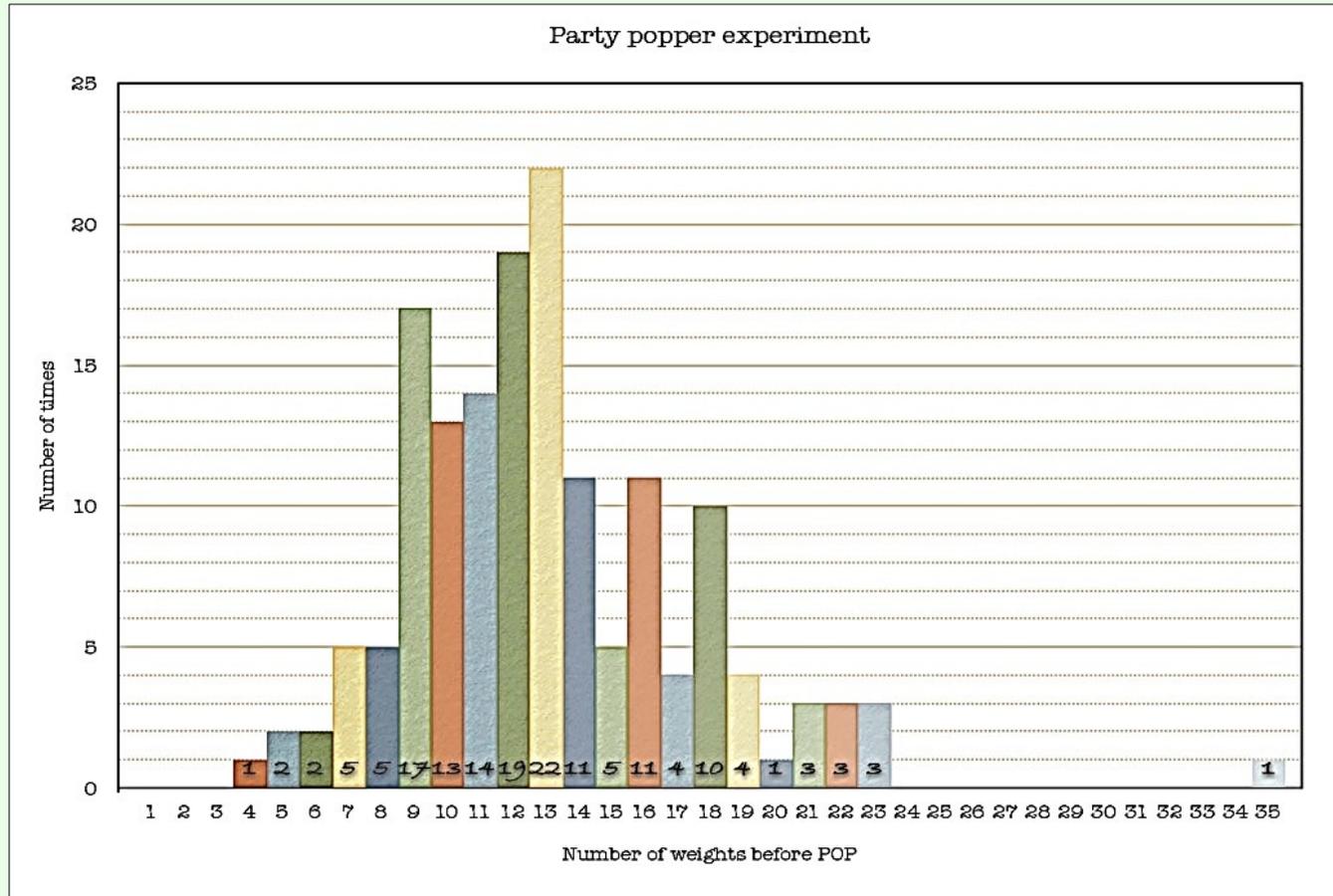
The plate tectonic story

How predictable are volcanic eruptions?
– party popper simulation



The plate tectonic story

How predictable are volcanic eruptions? – party popper simulation – the result of 156 attempts



The plate tectonic story

How predictable are volcanic eruptions?
– party popper simulation

Party
popper
eruption
'chance'
cards



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The plate tectonic story

- **Plate plenary**

Go to: https://www.earthlearningidea.com/Video/V35_Plate_plenary.html hyperlink

The plate tectonic story

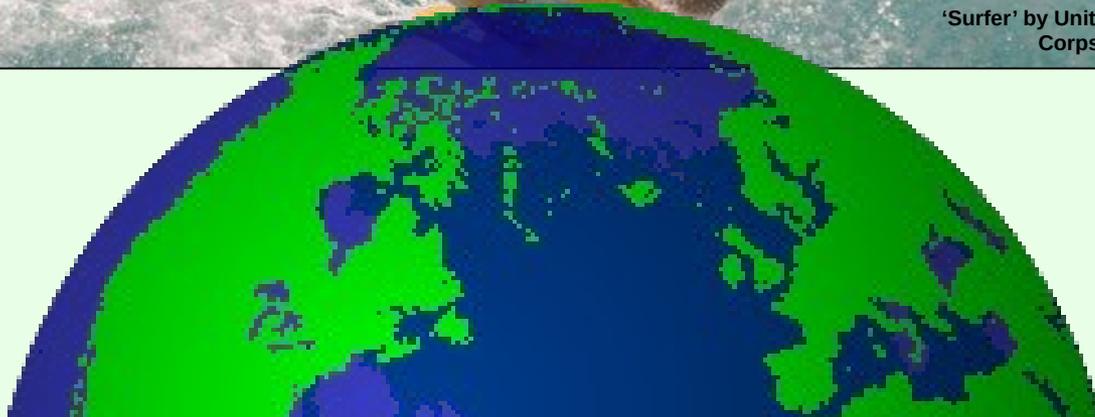
What am I doing?



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balancing on rails jeh.jpg*

The plate tectonic story

Plate-riding



The plate tectonic story

Plate-riding

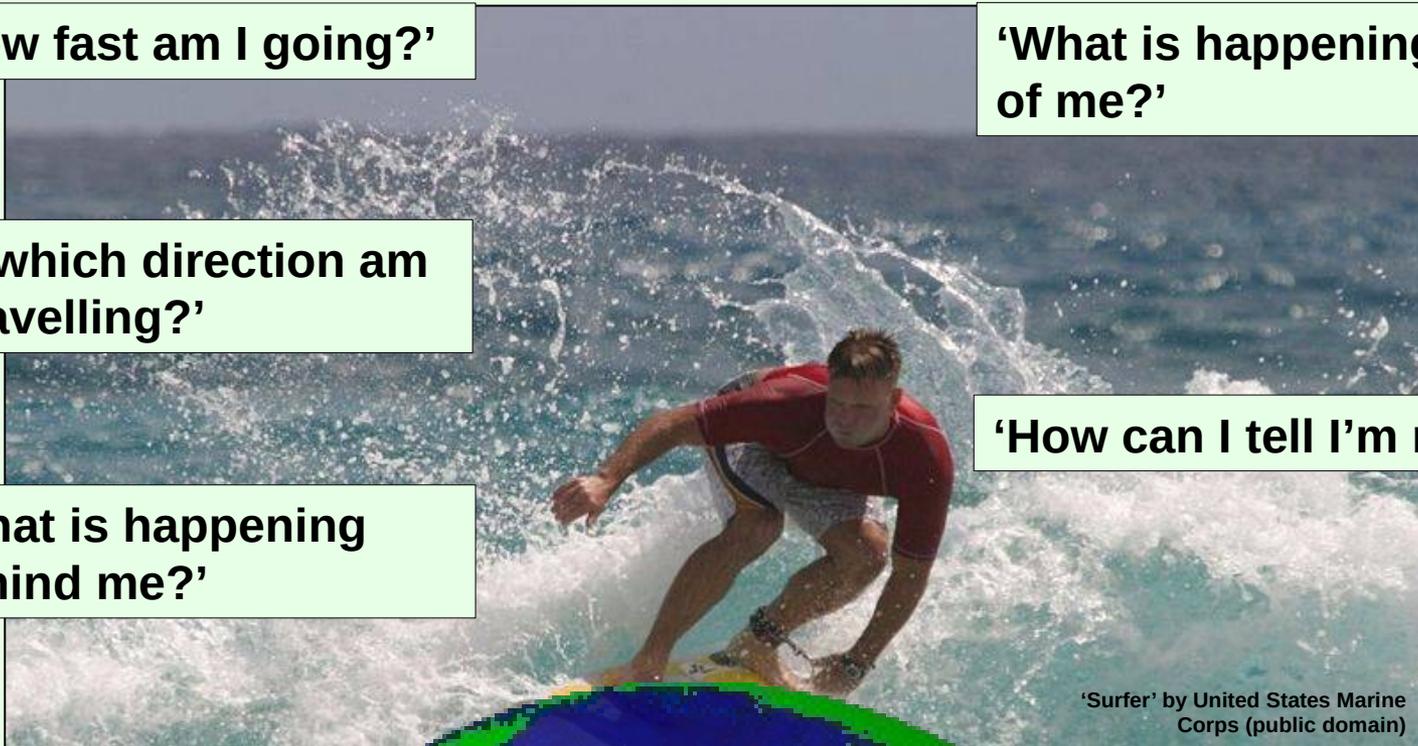
'How fast am I going?'

'What is happening in front of me?'

'In which direction am I travelling?'

'How can I tell I'm moving?'

'What is happening behind me?'



'Surfer' by United States Marine Corps (public domain)

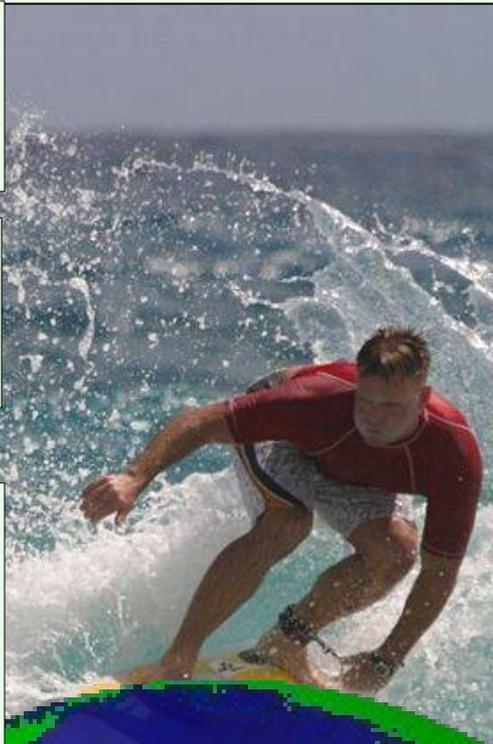
The plate tectonic story

Plate-riding

'How fast am I going?'
*(as fast as our
fingernails grow)*

**'In which direction am
I travelling?'**
(towards the East)

**'What is happening
behind me?'**
*(new plate material is
being formed, as in
Iceland)*



**'What is happening in front
of me?'**
*(I'm heading towards the
Japanese subduction zone,
with its earthquakes,
volcanoes and mountains)*

'How can I tell I'm moving?'
*(GPS measurements over
several years, magnetic
stripe evidence, age of the
sea floor evidence)*

Surfer by United States Marine
Corps (public domain)

The plate tectonic story

Model the five different types of plate margin with your hands
Possible answers include:

divergent margin



ocean v ocean



ocean v continent



continent v continent



conservative (transform)



The plate tectonic story

Workshop outcomes

The workshop and its activities provide the following outcomes:

- an introduction to plate tectonics;
- distinction between the 'facts' of plate tectonics and the evidence used to support plate tectonic theory;
- a survey of some of the evidence supporting plate tectonic theory;
- explanation of some of the hazards caused by plate tectonic processes - earthquakes and eruptions;
- methods of teaching the abstract concepts of plate tectonics, using a wide range of teaching approaches, including practical and electronic simulations;
- approaches to activities designed to develop the thinking and investigational skills of students;
- an integrated overview of the concepts involved in teaching the processes of plate tectonics.

The plate tectonic story

Copyright

Making a 'brickquake' x 3 © ESEU

Marking the points and direction of magnetism using cocktail sticks © ESEU

Set-up for the party popper activity © Peter Kennett, ESEU

Classroom demonstration of concepts associated with sea floor spreading © ESTA redrawn by ESEU

Oceanic ridge © ESTA, redrawn by ESEU

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The upper part of the mantle and the crust © Chris King and Dee Edwards, redrawn by ESEU

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Mid ocean ridge © Press & Siever, redrawn by ESEU

Map of plates - reproduced with kind permission of USGS, redrawn by ESEU

Galunggung eruption by USGS – image in the public domain

Photograph, 'North All Trucks' © USGS

Battleship grid for Geobattleships © Dave Turner

Distribution of earthquakes - source unknown, redrawn by ESEU

Picture of a plate © Peter Kennett

The Structure of the Earth – from the seismic evidence – reproduced with kind permission of USGS, redrawn by ESEU

Graph of 'Velocities of P and S waves as they travel into the Earth © ESTA, redrawn by ESEU

The Internal structure of the Earth - reproduced with kind permission of USGS, redrawn by ESEU

The lithosphere, asthenosphere and below © ESEU

Ice photographs © Peter Kennett

Student pulling Potty Putty™ © ESEU

Photographs of potty putty™ x 3 © Peter Kennett

Skateboard x 2 © Peter Kennett, ESEU

Theoretical driving mechanisms of plate movement © Pete Loader

The plate tectonic story

Copyright continued...

Slab pull x 2 © David Bailey

Petri-dish magnetic field preserved in iron filings in wax © Michèle Bourne, ESEU

Model magnetic Earth (ESEU)

Magnetic inclination plotted against latitude (graph) © Chris King

Model of the Earth's magnetic field (drawing) © ESEU

The pattern of heat flow out of the ocean floor and the upper part of the mantle and the crust © Chris King and Dee Edwards, redrawn by ESEU

Underwater basalt lava at a divergent margin in the public domain by Vintei

'Ancient pillow lava' by US National Oceanic & Atmospheric Administration – image in the public domain

Photograph of 'The Geological Map of the World' © Open University

Black Smoker © This Dynamic Earth: the Story of Plate Tectonics, USGS

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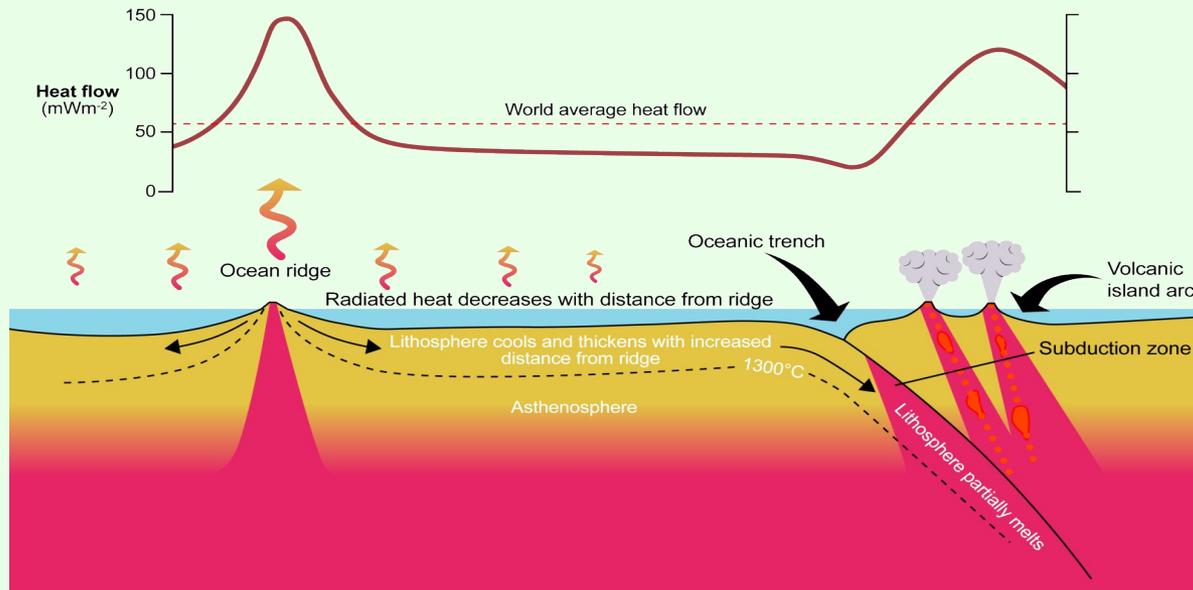
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Part 2

Earth Science for science and geography – video workshop



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