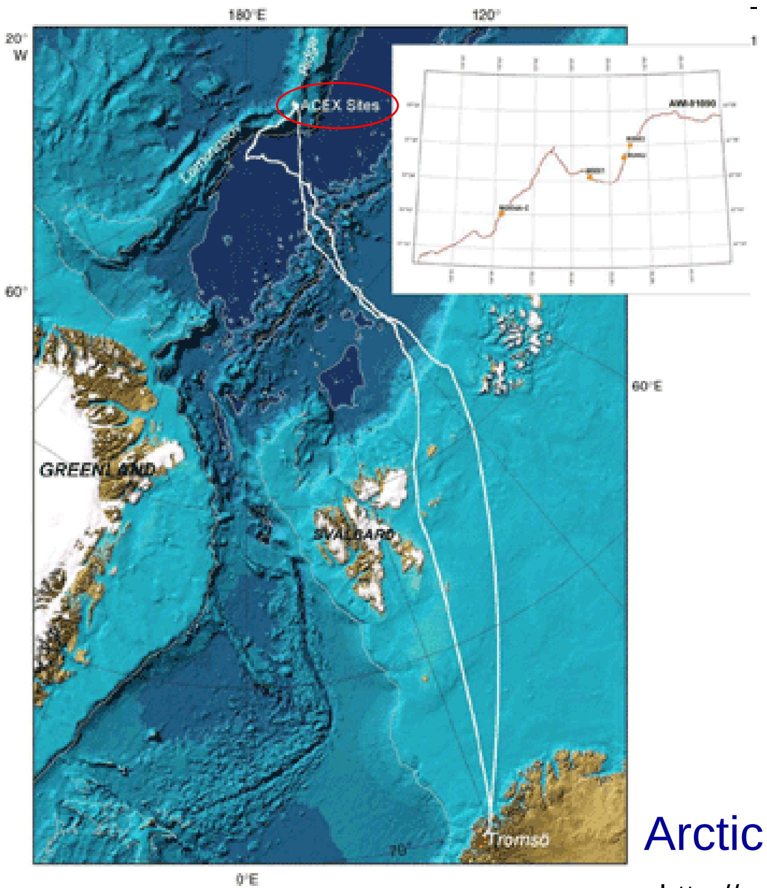
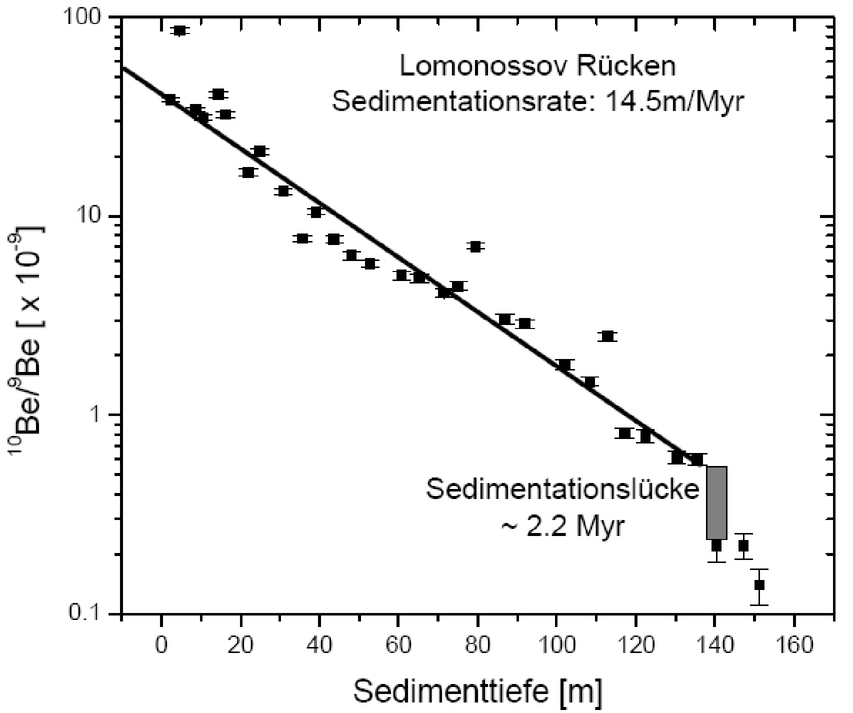
6. Sedimentation rates

The down-core decrease of $^{10}Be/^{9}Be$ yields an average sedimentation rate of 14.5 ± 1 m/Ma and a gap in sedimentation between 9.4 and 11.6 Ma





Frank et al. 2008

Arctic Coring Expedition 2004

http://www.eso.ecord.org/expeditions/302/302.htm

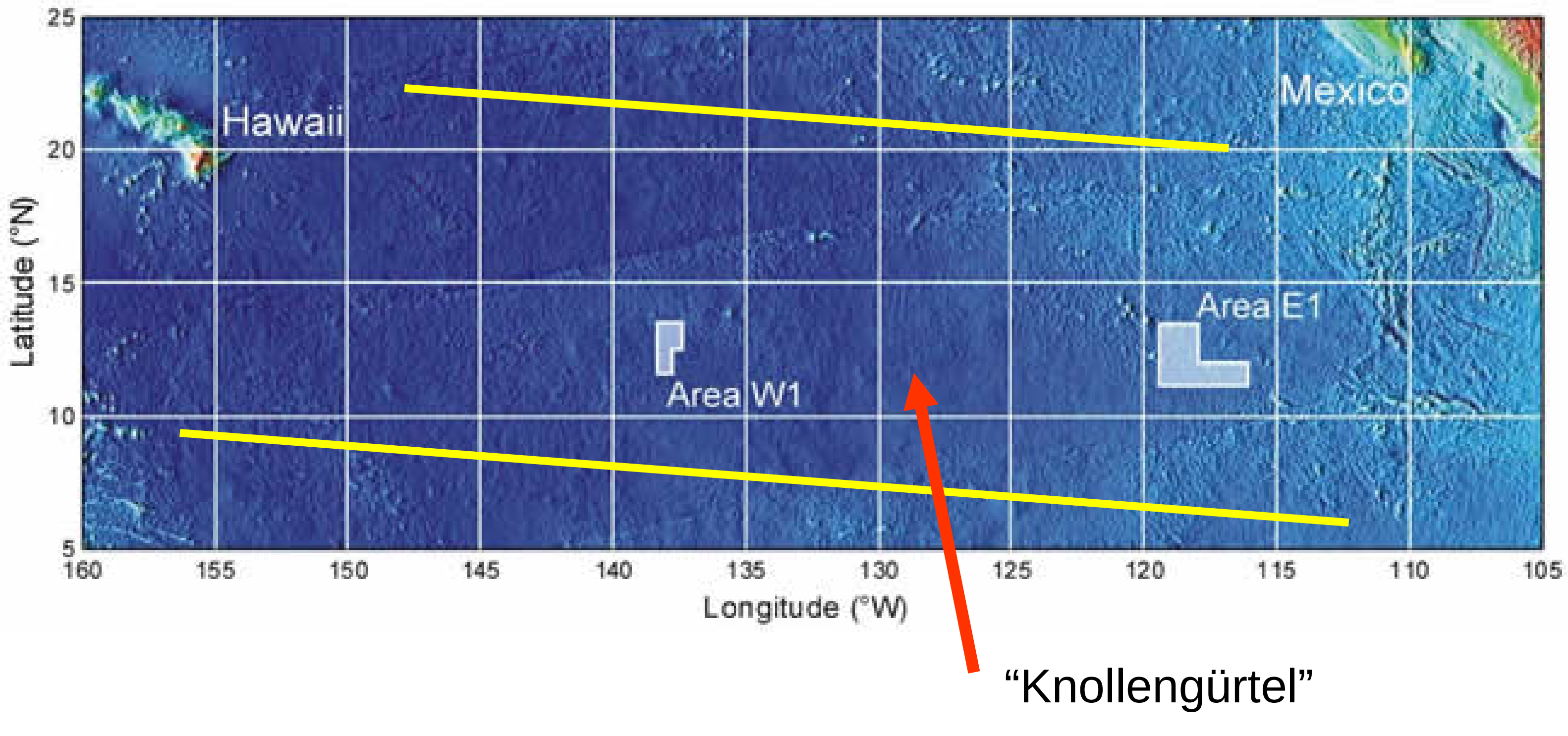
6. Sedimentation and growth rates

BGR Pressemitteilung 17.7.2006:

Deutschland steckt Claim im Pazifik ab

„Manganknollen sollen Buntmetallversorgung der Zukunft sichern“

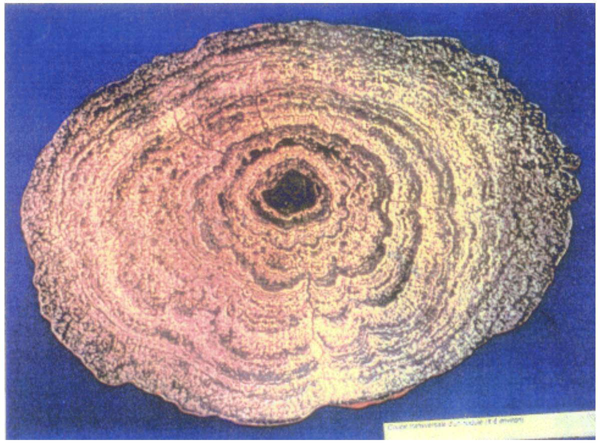
Lage der beiden deutschen Lizenzgebiete im Pazifik

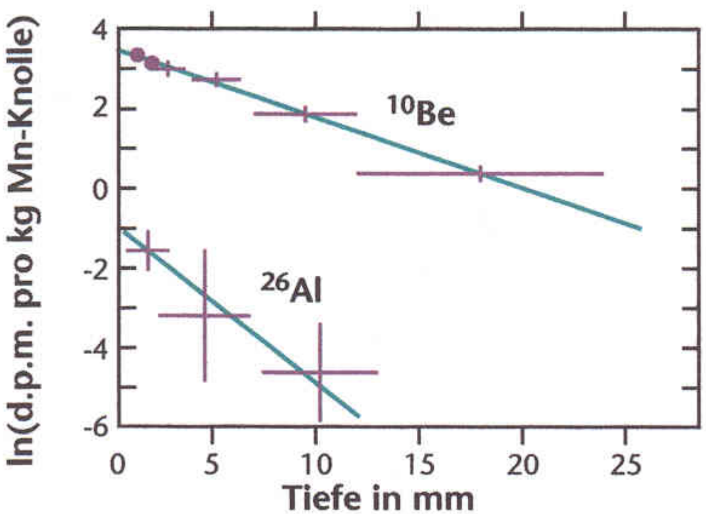


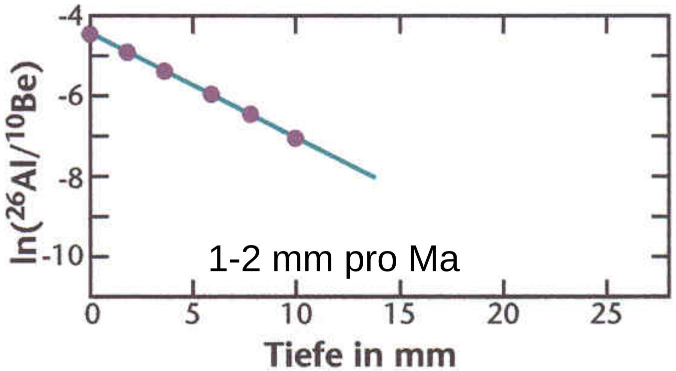
Manganese nodules are dark, potato-shaped little balls where metals and other minerals have accumulated around a core over a few million years. They contain a relatively high percentage of metals, i.e. **Nickel, Copper, Cobalt, Manganese** and **Iron** and are mostly found in water depths of 4000-6000 metres a few thousand km from the closest continent shores. Their growth rate can be dated with the help of cosmogenic nuclides.

6. Sedimentation and growth rates

Manganese nodules







Guichard et al. (1978) Nature 272

7. Water dating – Tritium

- Tritium forms in the atmosphere by the interaction of ^{14}N with cosmic-ray neutrons:
  $^{14}N + {}^{1}n \rightarrow {}^{12}C + {}^{3}H$

- Tritium rapidly combines with oxygen, forming water (HTO). Then it mixes with all other water

- Tritium decays to Helium-3; $T_{1/2}$ = 12.3 years

- Low activity ~1 part in 10^{18} (varies by region)

- Used to trace water sources; age of „recent“ materials

- Sources directly fed by rainwater will contain the same tritium levels as rainwater

- Trapped aquifers will have no tritium

- Slow travelling aquifers will have a reduced amount

Reported in units of tritium units (TU):
1 TU = 1 atom of tritium per 10^{18} atoms of hydrogen

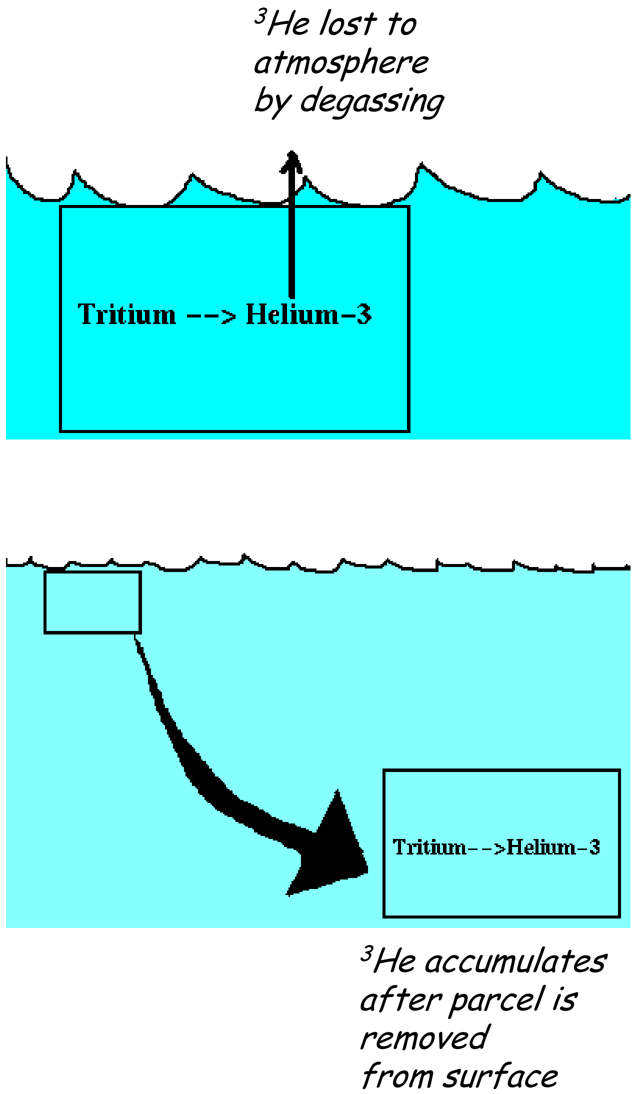
7. Water dating – Tritium

Tritium /^{3}He age

The tritium/^{3}He age is an **apparent age**

Advantage: It is independent of the initial tritium concentration of the water sample.

Potential problem: tritium/^{3}He age is affected by mixing and dispersion

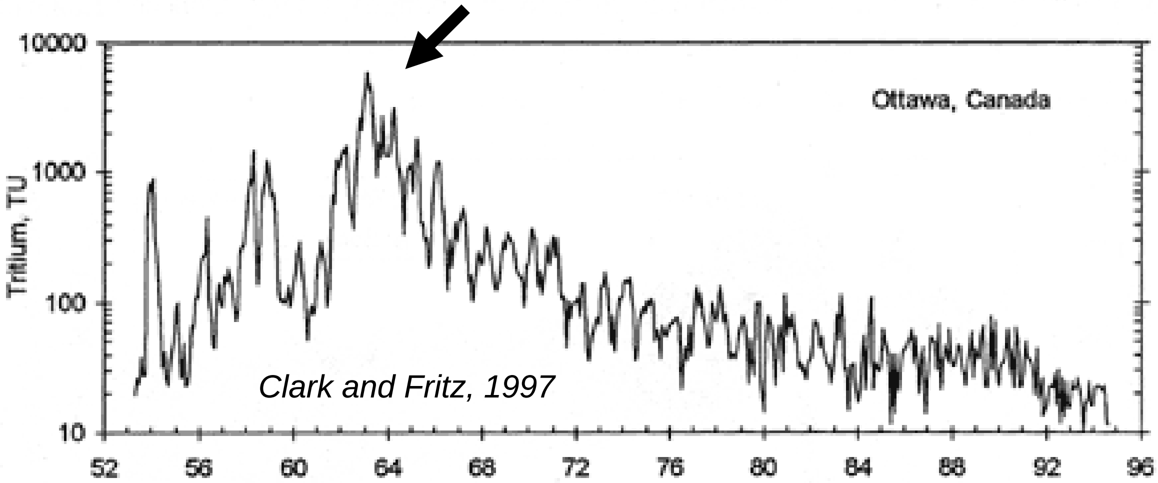


7. Water dating – Tritium

Bomb Tritium

Most of the tritium in the world today was produced by atmospheric testing of nuclear devices that began in 1952 and reached a maximum in 1963/1964.
The bulk of this tritium was released in the northern hemisphere, and entered the oceans.

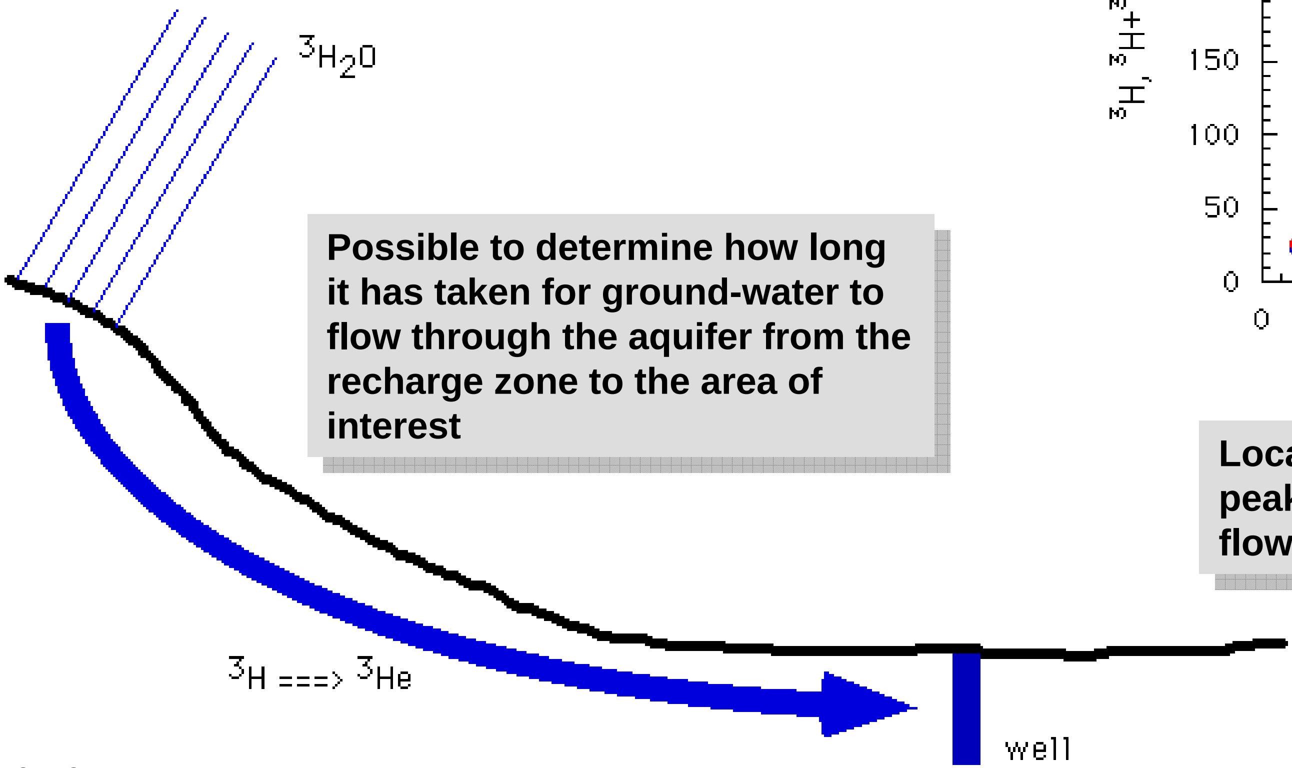
bomb spike



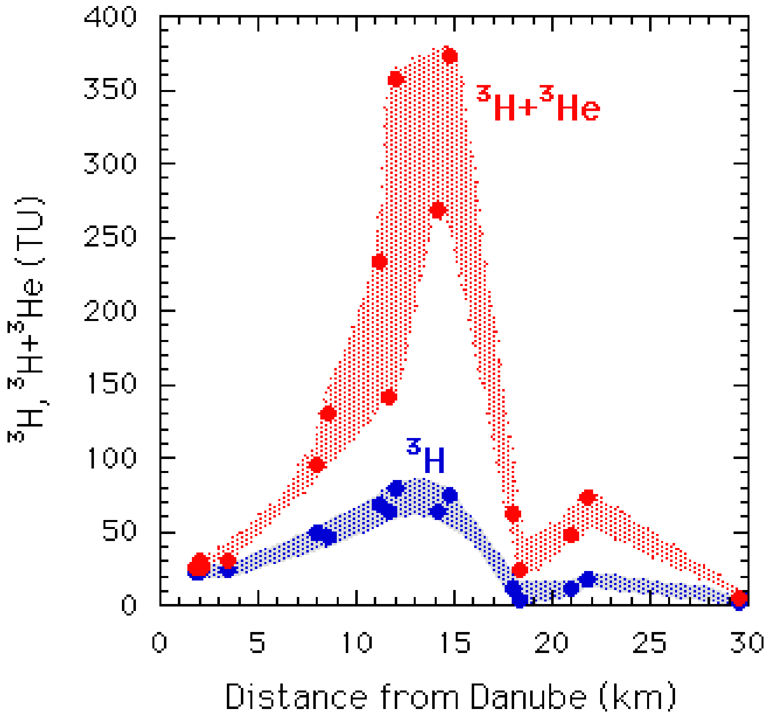
rainfall tritium concentrations

7. Ground water dating – Tritium

Assumptions:
(1) tritium of water was in equilibrium with atmospheric levels
(2) decrease in tritium levels is only due to radioactive decay



Possible to determine how long it has taken for ground-water to flow through the aquifer from the recharge zone to the area of interest

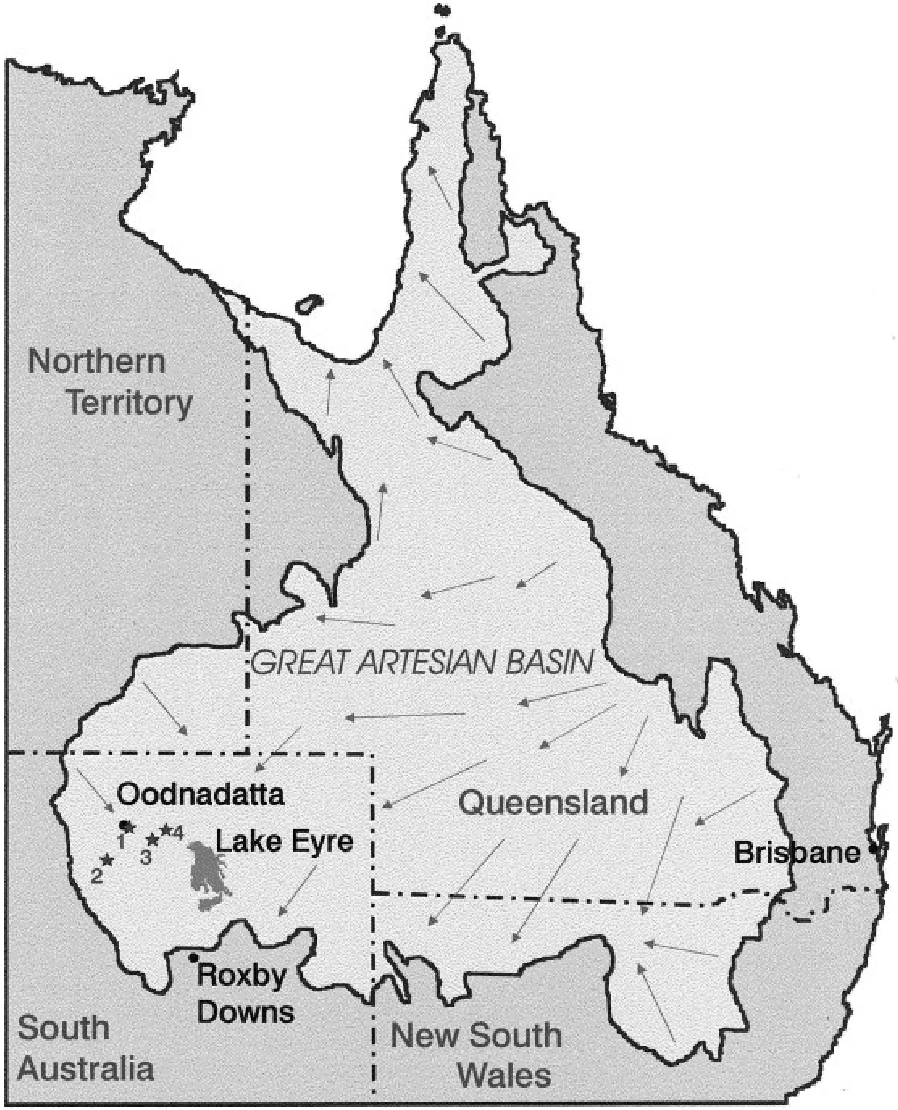


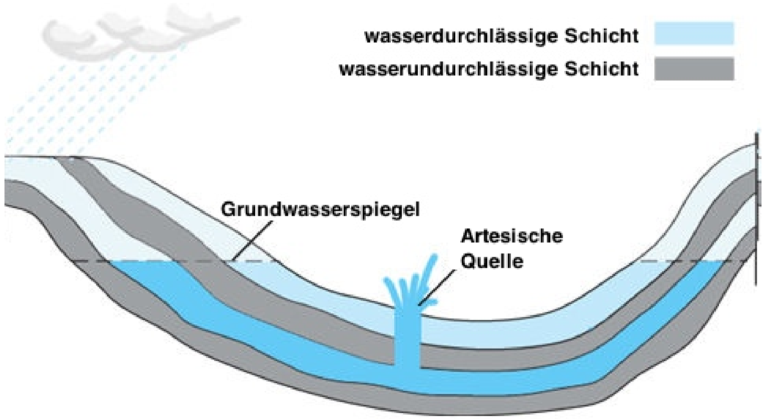
Location of the mid-1960s bomb peak provides information on the flow velocity

$^3H/^3He$ age is defined as the time elapsed since the water was isolated from the atmosphere

7. Ground water dating – ^{36}Cl

Great Artesian Basin (Eastern Australia)

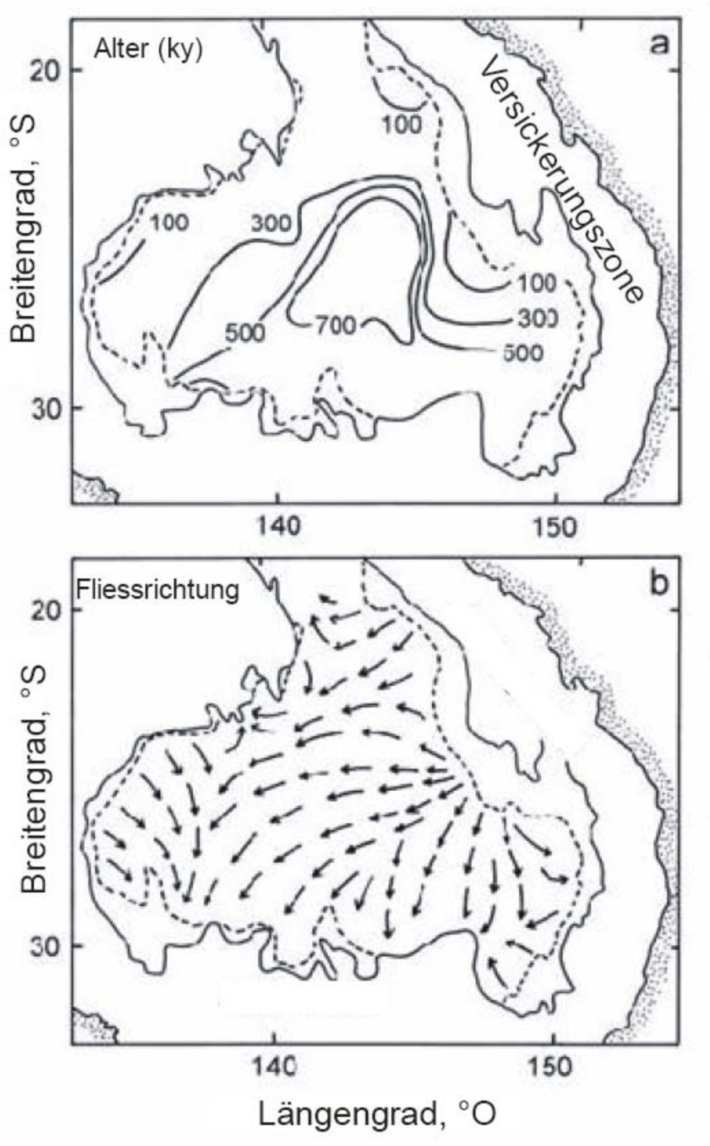




Collon et al. (2000)

7. Ground water dating – ^{36}Cl

Great Artesian Basin (Eastern Australia)



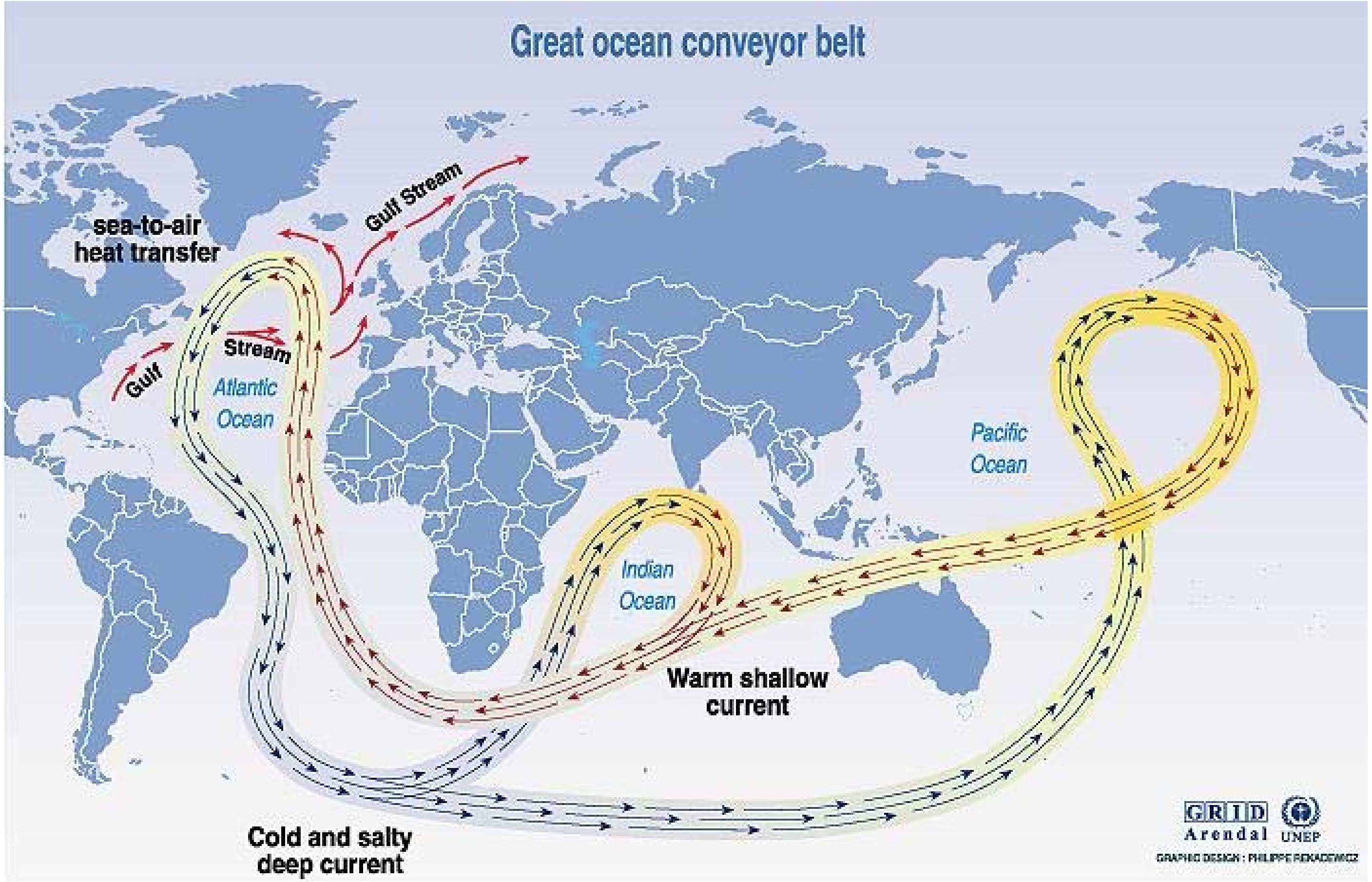
a) ^{36}Cl ground water dating (ages in 10^3 years)

b) reconstructed ground water flow

Torgersen et al. (1991), Love et al. (2000)

8. Sea water dating – ^{14}C

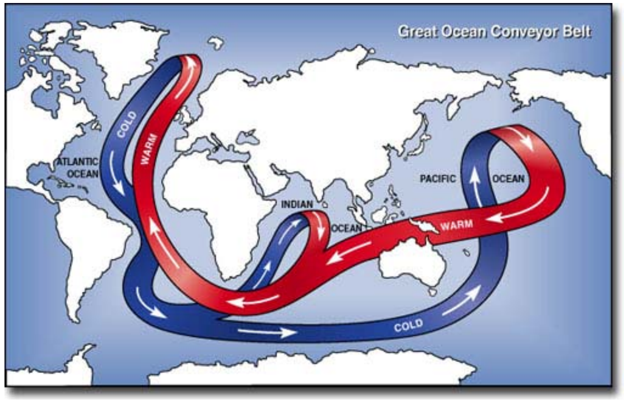
Great Ocean Conveyor



Source: Broecker, 1991, in Climate change 1995, Impacts, adaptations and mitigation of climate change: scientific-technical analyses, contribution of working group 2 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996.

8. Sea water dating – ^{14}C

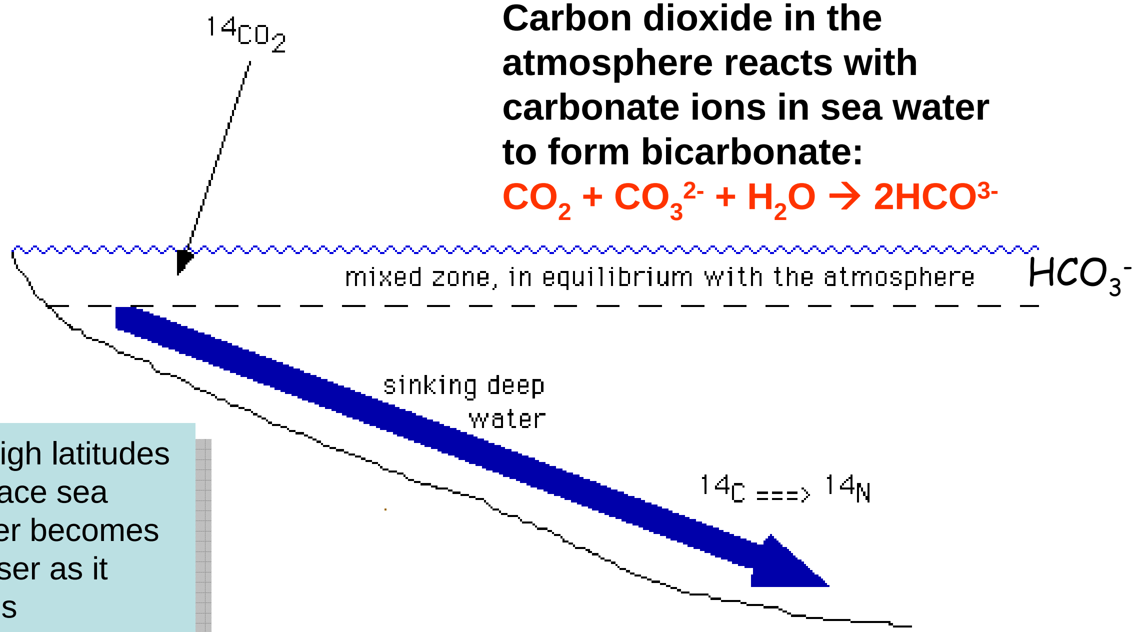
Great Ocean Conveyor



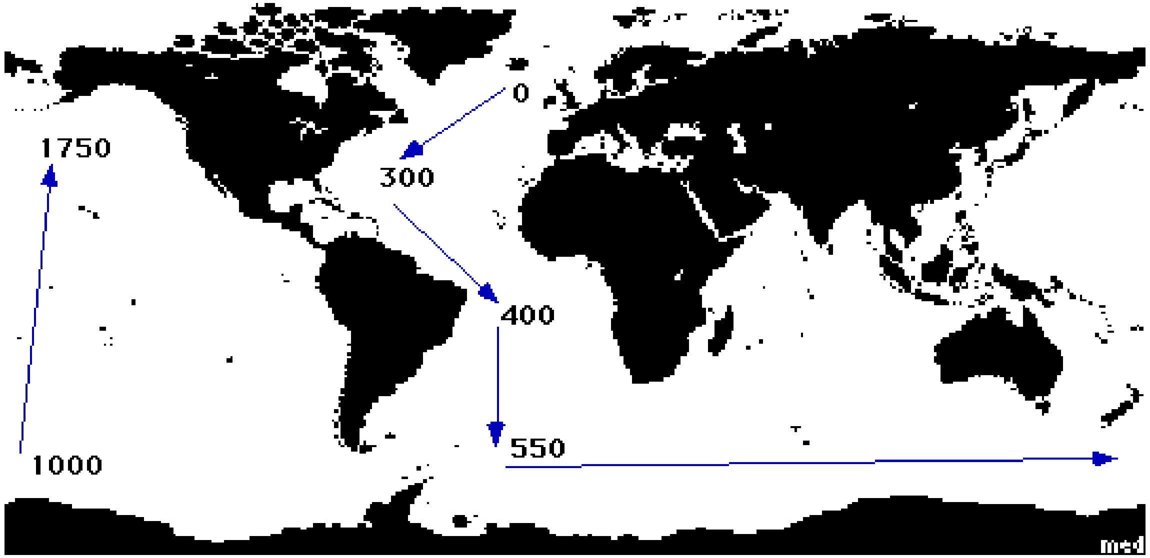
At high latitudes surface sea water becomes denser as it cools

Carbon dioxide in the atmosphere reacts with carbonate ions in sea water to form bicarbonate:

$CO_2 + CO_3^{2-} + H_2O \rightarrow 2HCO^{3-}$

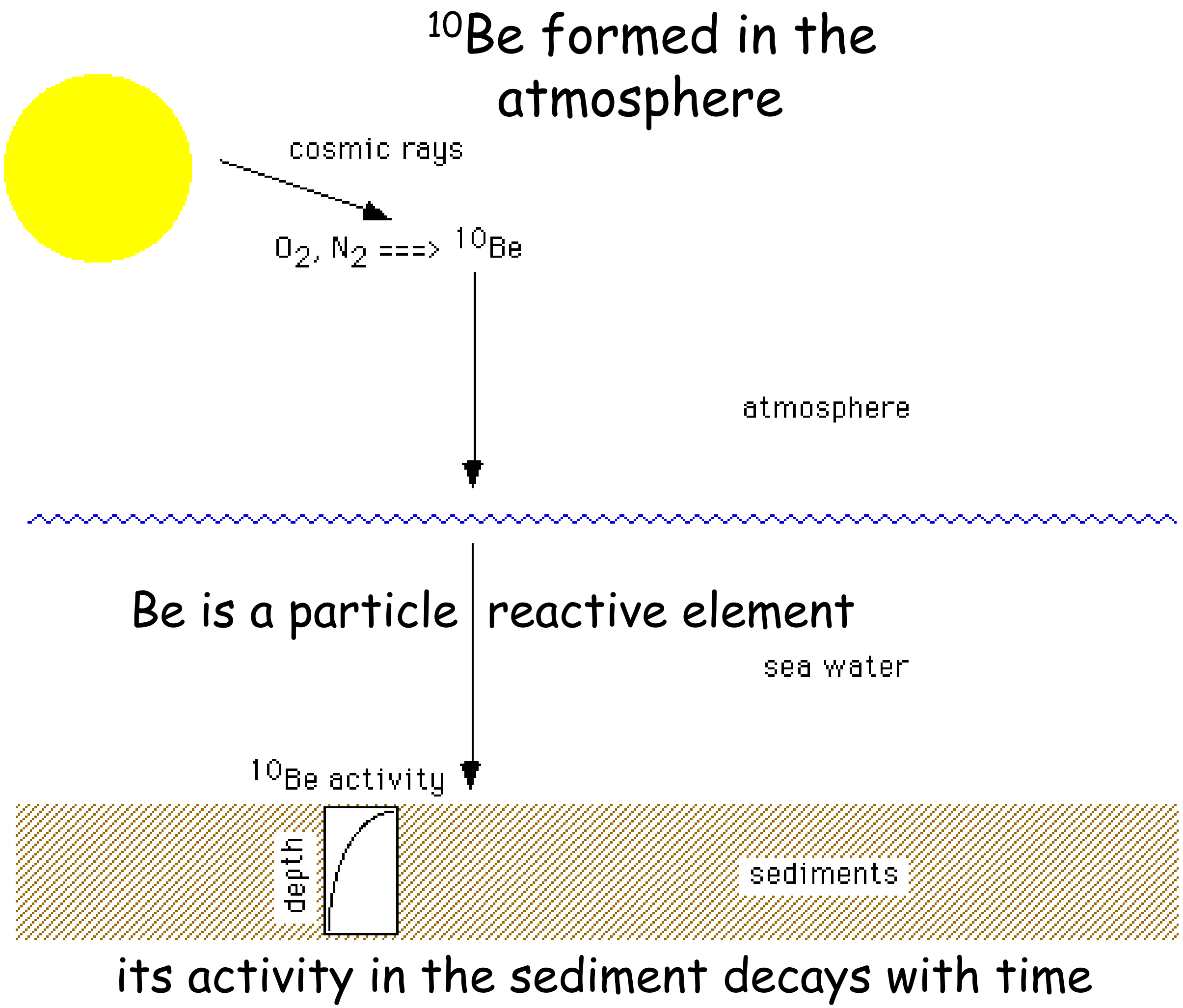


The major source of this bottom water is in the North Atlantic



9. Crustal recycling processes – ^{10}Be

• ^{10}Be is produced by reactions of high energy cosmic ray protons with O_2 and N_2 in the atmosphere and at the surface of minerals exposed to atmosphere

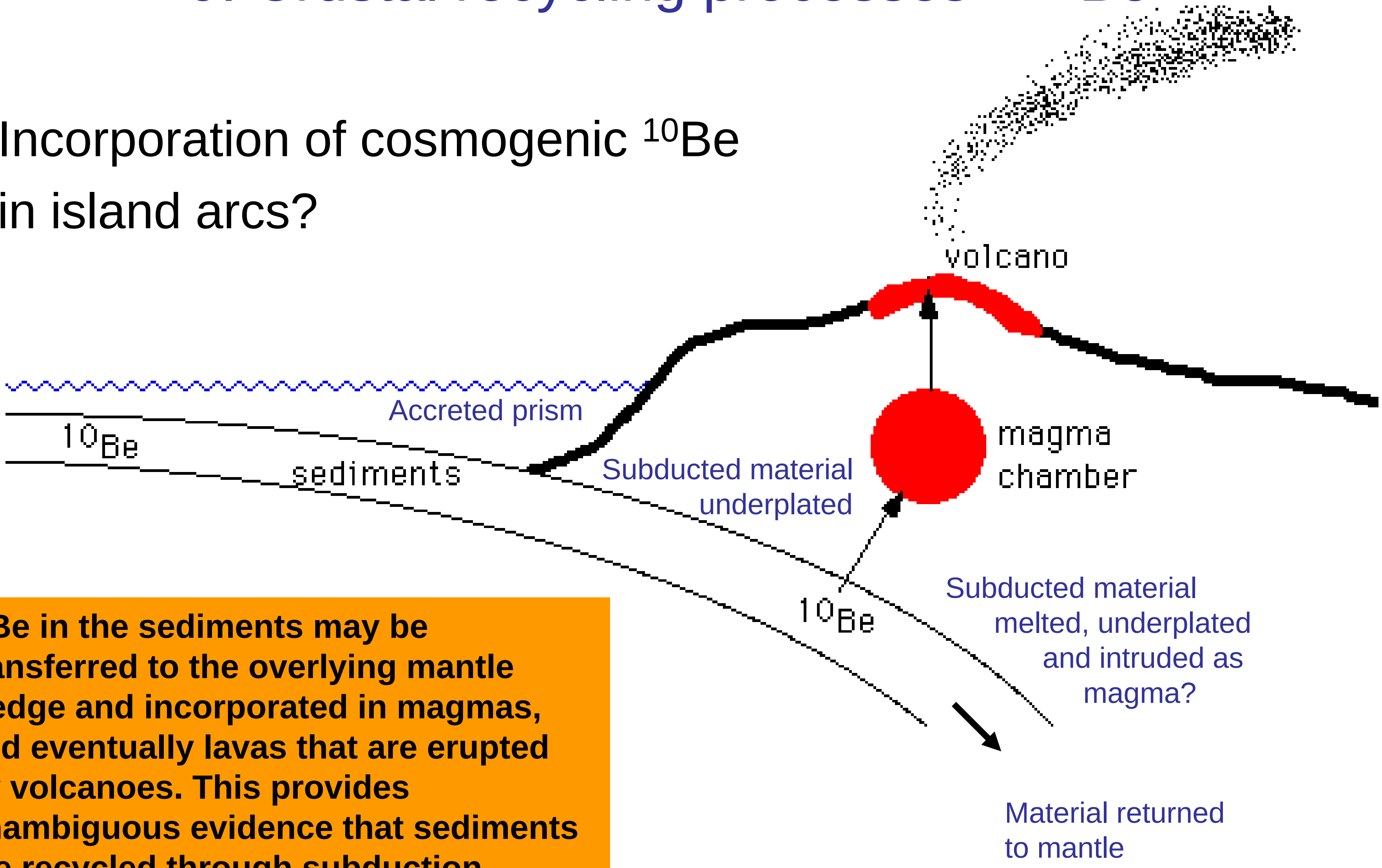


• ^{10}Be then undergoes decay to ^{10}B with a half-life of about 1.5 Ma

• ^{10}Be can be used to derive sedimentation rates

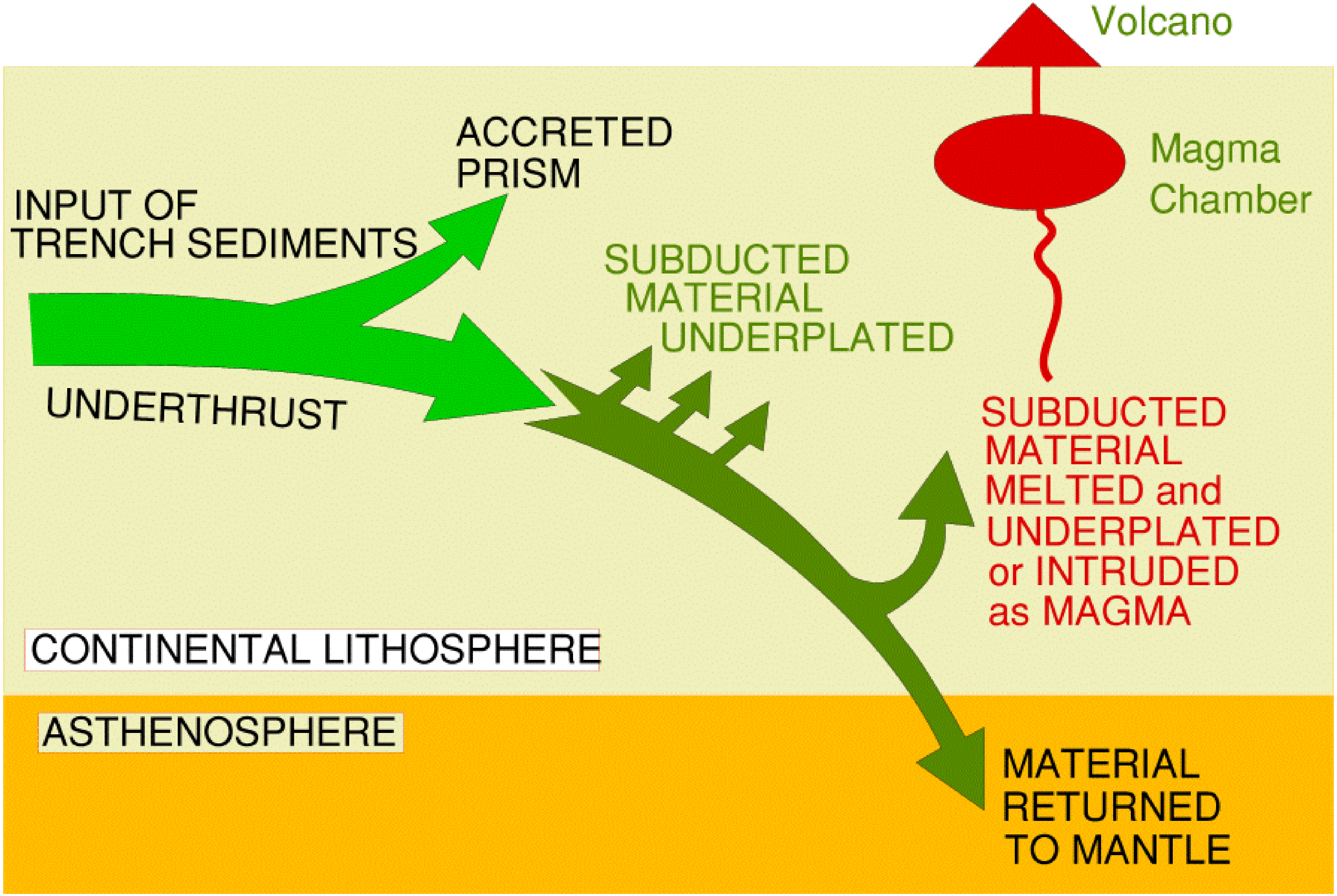
9. Crustal recycling processes – ^{10}Be

Incorporation of cosmogenic ^{10}Be in island arcs?

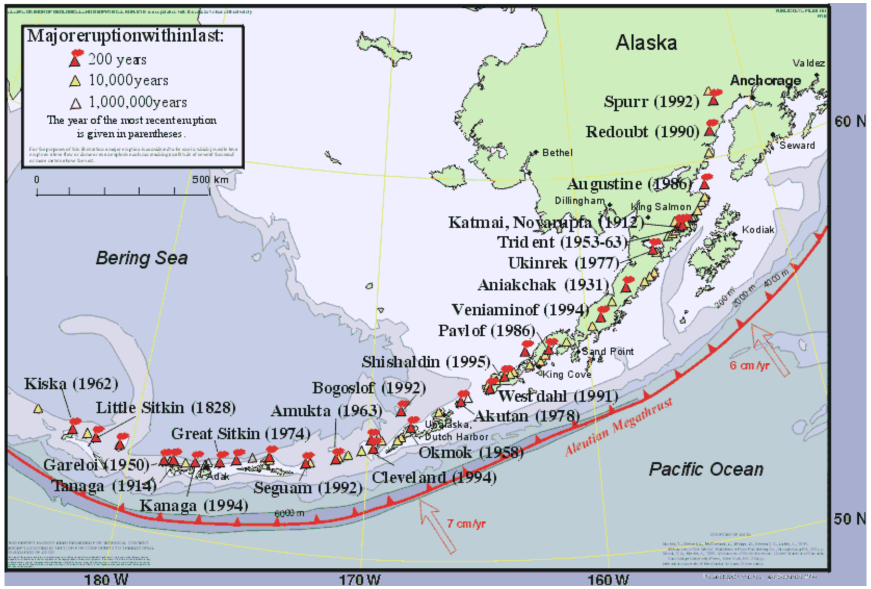


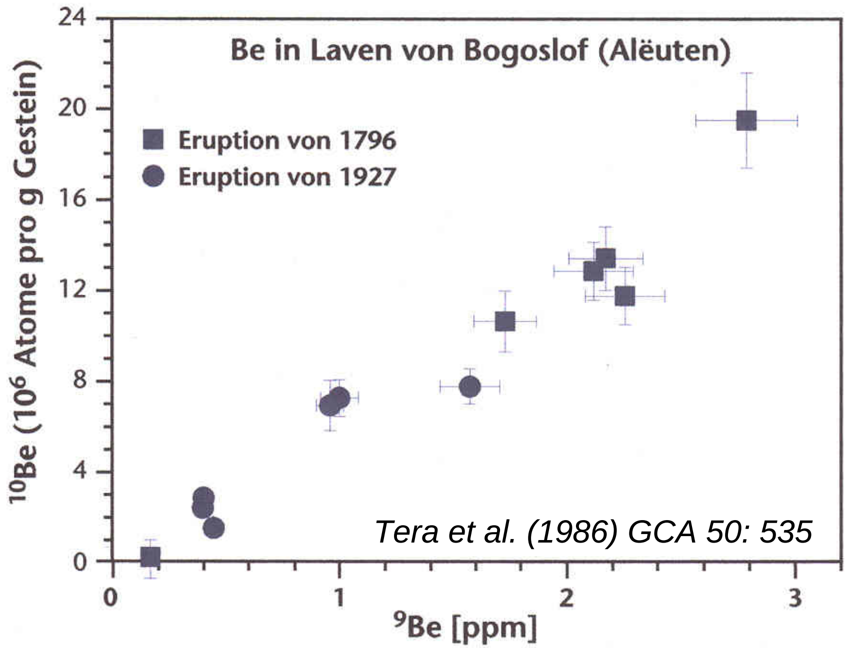
^{10}Be in the sediments may be transferred to the overlying mantle wedge and incorporated in magmas, and eventually lavas that are erupted by volcanoes. This provides unambiguous evidence that sediments are recycled through subduction zones, as the half life of ^{10}Be is too short for it to be still present in the mantle.

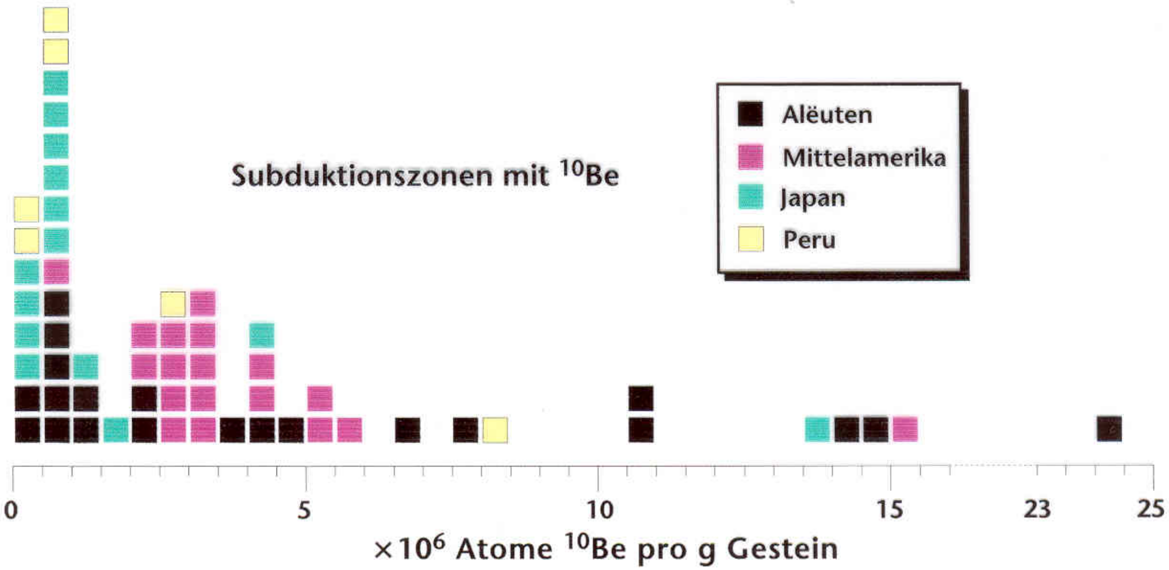
9. Crustal recycling processes – ^{10}Be



9. Crustal recycling processes – ^{10}Be

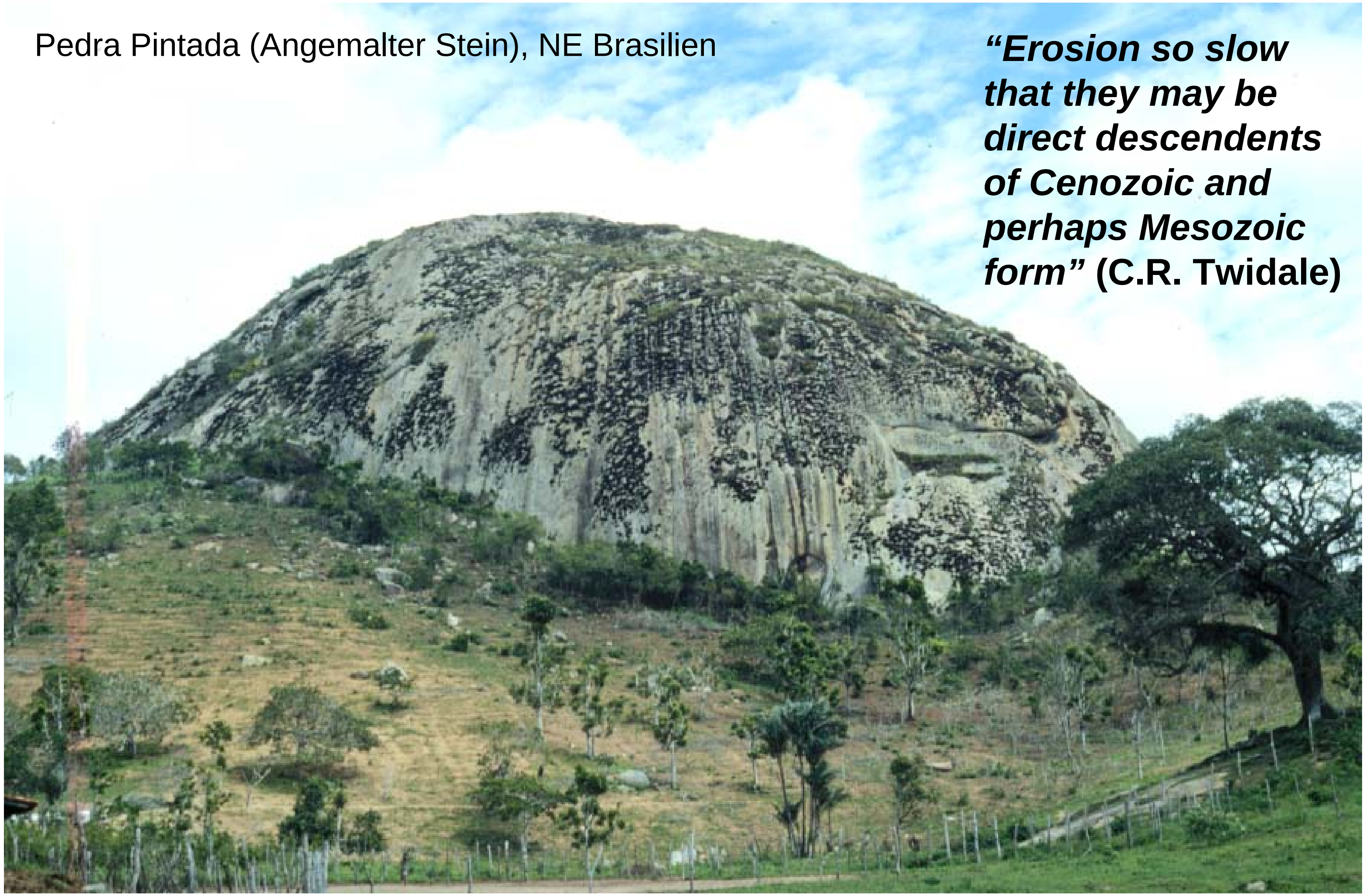






10. Age of landscapes

Tropical inselbergs



10. Age of landscapes

Arid environments

Inselbergs in the central Namib desert:
mean denudation rate of the order of 5 m/m.y.
(Cockburn et al., 1999)

Atacama desert, Chile:
~2 m/m.y. to <0.2 m/m.y.
(Caffee, 2005)