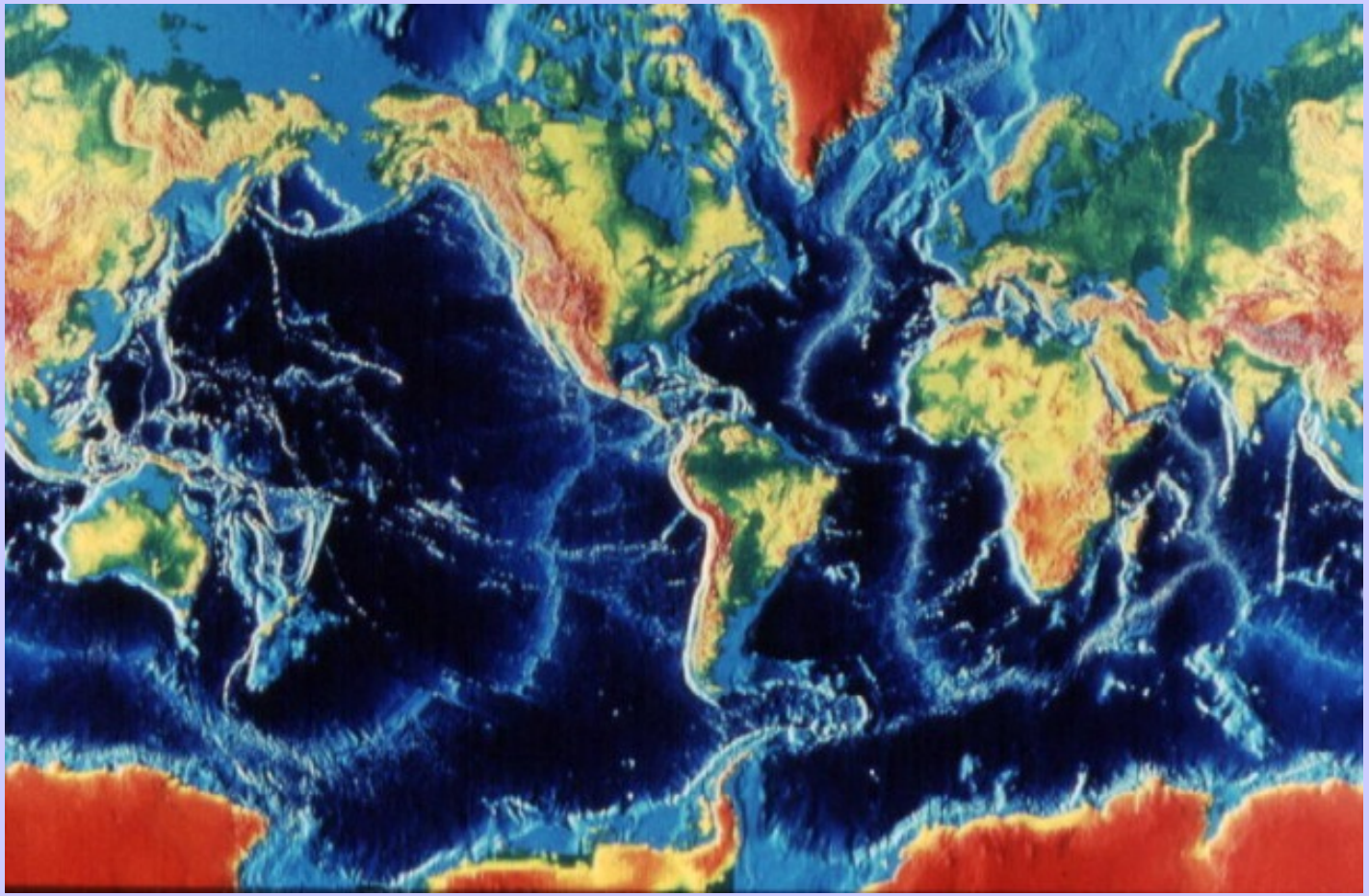
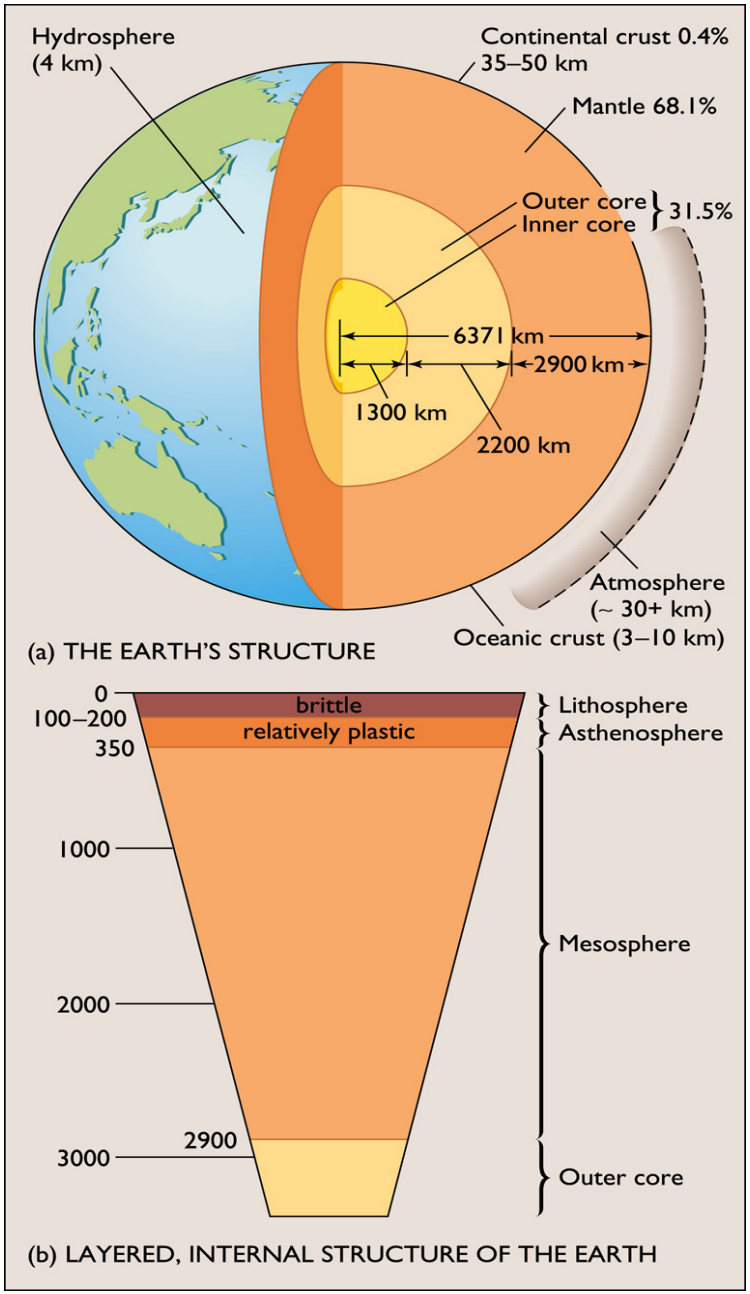
A origem das bacias oceânicas

- Introdução
- A estrutura interna da Terra
- Fisiografia do assoalho oceânico
- Provincias batimétricas: Métodos Sísmicos marinhos
- Diferenças geológicas entre Continentes e Bacias oceânicas
- Balanço de massa e isostasia

A ORIGEM DAS BACIAS OCEÂNICAS

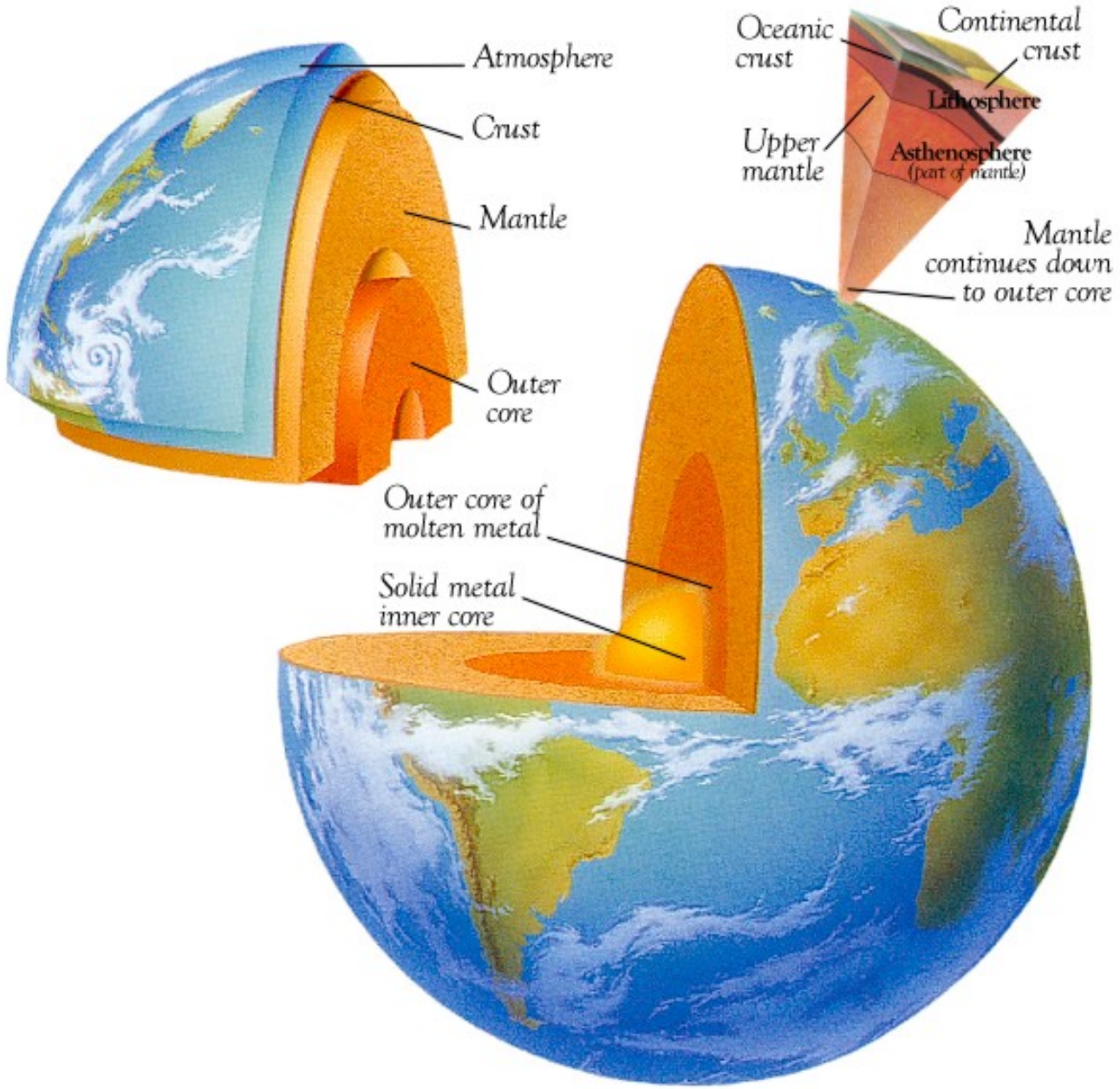


Com base em métodos
Indiretos: geofísicos.



Composição e
Estrutura: crosta
Manto e núcleo
Diferenciação
Primária-densidade

Com base no estado
Rigidez ou viscosidade

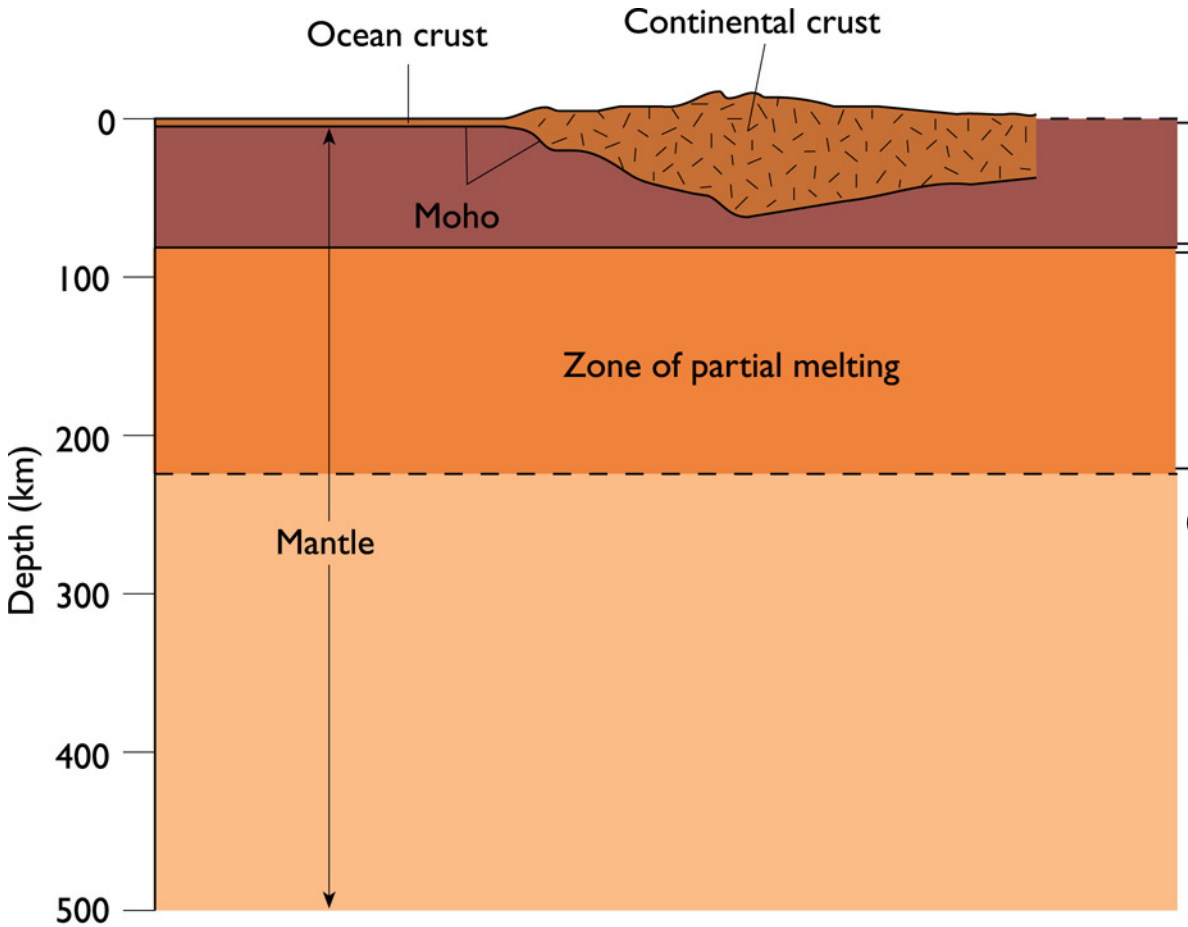

Atmosphere
Crust
Mantle
Outer core
Outer core of molten metal
Solid metal inner core
Oceanic crust
Continental crust
Lithosphere
Upper mantle
Asthenosphere
(part of mantle)
Mantle continues down to outer core

Estrutura da Terra

- C/base em composição e estrutura: crosta, manto e núcleo (diferenciação primária: densidade. Entretanto...composição não é o único fator que controla as características físicas das rochas no interior da Terra. ***Temperatura e pressão aumentam com a profundidade afetando as propriedades das rochas.***
- Pressão aumenta a temperatura de fusão das substâncias. Assim aumentando a pressão num material, este precisa ser aquecido a uma temperatura maior que o normal para fundir.
- Ex. conversão da liga ferro-níquel fundida do núcleo externo para liga ferro-níquel sólida do núcleo interno. No núcleo externo, a temperatura é maior que o ponto de fusão da liga, mesmo naquela alta pressão—consequentemente o núcleo externo está em fusão. Mas em maior profundidade, onde as pressões são muito maiores a temperatura permanece abaixo do ponto de fusão da liga----resultando num núcleo sólido interno composto pela mesma liga. Efeitos semelhantes ocorrem no manto.

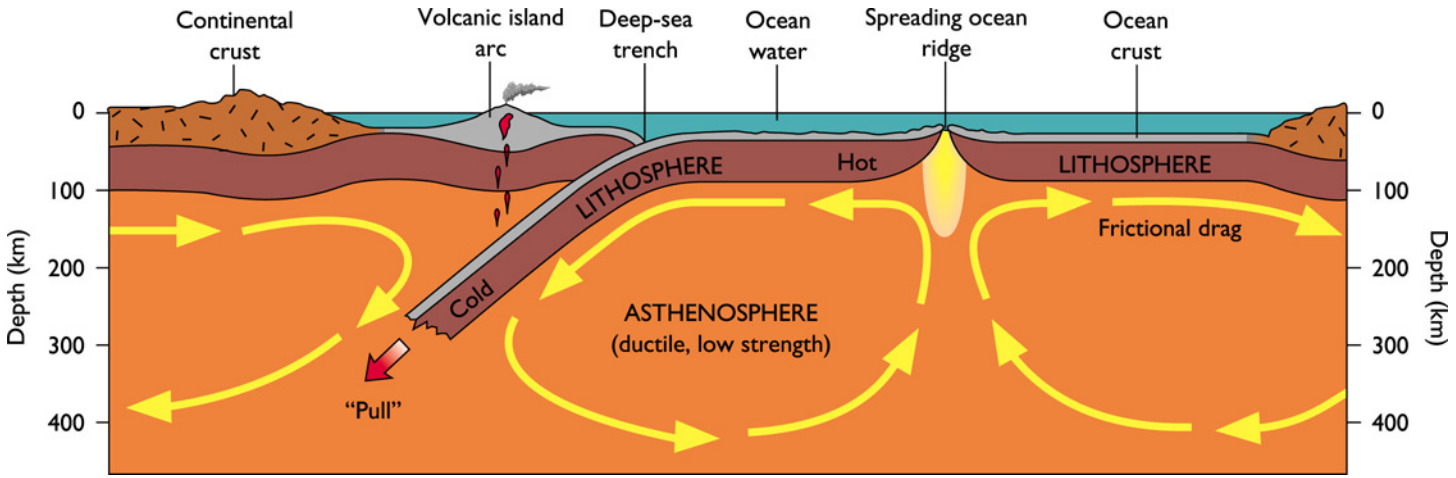
- c/base no estado: (rigidez ou viscosidade) litosfera, astenosfera e mesosfera.

- Sob a litosfera composição das rochas do manto não muda, mas o estado físico sim. Ali a temperatura sobrepuja a pressão causando com que uma porção muito fina do manto (menos que 1%) se funda, na verdade num estado de fusão parcial---as rochas não são rígidas e quebradiças mas relativamente fracas e fluem plasticamente de uma maneira análoga ao asfalto---é a astenosfera. Depois a astenosfera inferior fica gradualmente mais rígida a medida que a pressão aumenta com a profundidade e a temperatura de fusão das rochas aumenta. A plasticidade das rochas do manto desaparece ao redor de 350 Km abaixo da superficie terrestre sendo aí considerada a base da astenosfera
- Então: litosfera—inclui a crosta externa e a parte superior do manto até 100 e 200 Km; a astenosfera inclui o manto parcialmente fundido até 350 Km. Abaixo disso até o núcleo externo é a Mesosfera.



(b) THE LITHOSPHERE AND THE ATHENOSPHERE

Obs: base
Da astenosfera
Pode ir até 350 Km


Continental crust
Volcanic island arc
Deep-sea trench
Ocean water
Spreading ocean ridge
Ocean crust
0
100
200
300
400
Depth (km)
LITHOSPHERE
Hot
LITHOSPHERE
Cold
Frictional drag
ASTHENOSPHERE
(ductile, low strength)
"Pull"

Morfologia das bacias oceânicas

- Batimetria (topografia submarina)
- Províncias batimétricas: três grandes províncias fisiográficas : margens continentais, fundo de bacia oceânica e cordilheira meso-oceânica
- Margem continental: plataforma, talude e elevação continental
- Fundo de bacia oceânica: planícies abissais, colinas abissais, montanhas submarinas, fossas
- Cordilheiras Meso-oceânicas: rift valley , falhas de transformação, zonas de fratura.

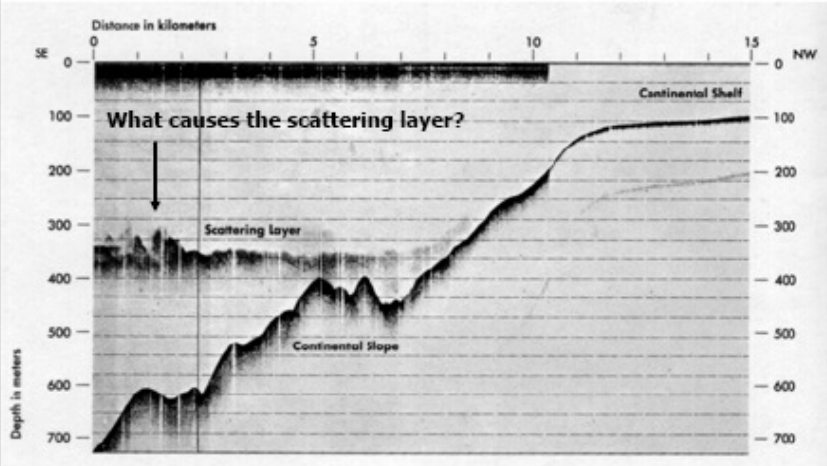
If you measure how long it takes between when the sound was released and when it returns, and you know the speed of sound, then you know the depth:

Depth = V x (T / 2)

Speed of sound (1507 meters per sec)

Time

If the time of travel was 20 seconds
How deep is the water?

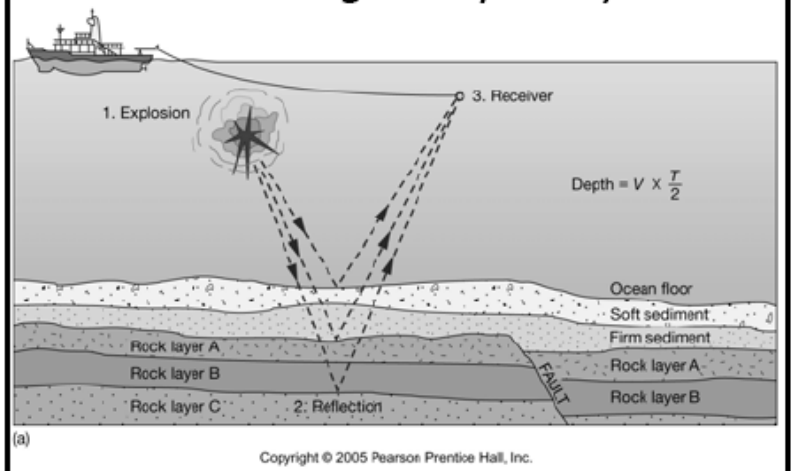


Copyright © 2005 Pearson Prentice Hall, Inc.

Measuring bathymetry

- Precision depth recorder (PDR) 1950s
  - Focused beam, high frequency
- Multibeam echo sounders
- Side-scan sonar (sound navigation and ranging) **swath**
- More detailed "picture" of the sea floor
- Satellite measurements
- Seismic reflection profiles looks at ocean structure beneath sea floor

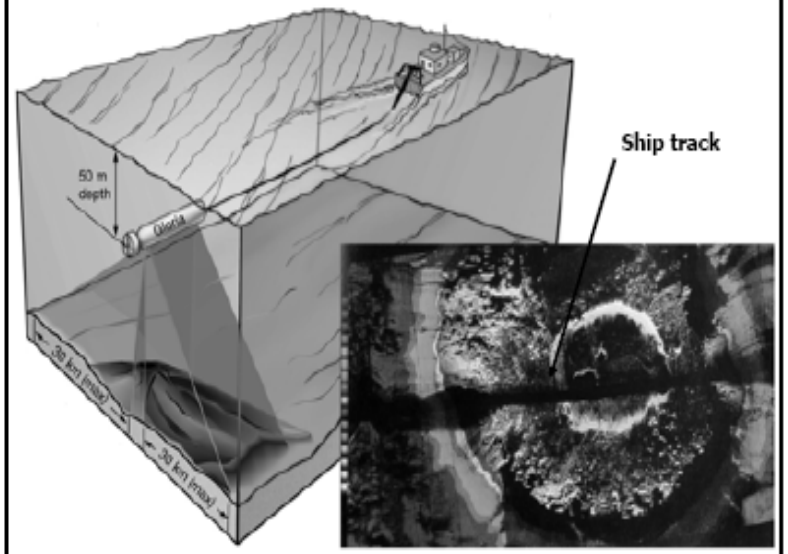
Measuring bathymetry



Copyright © 2005 Pearson Prentice Hall, Inc.

Seismic Profiling – good for determining subsurface properties

Side scan sonar, mapping broad swaths of seafloor



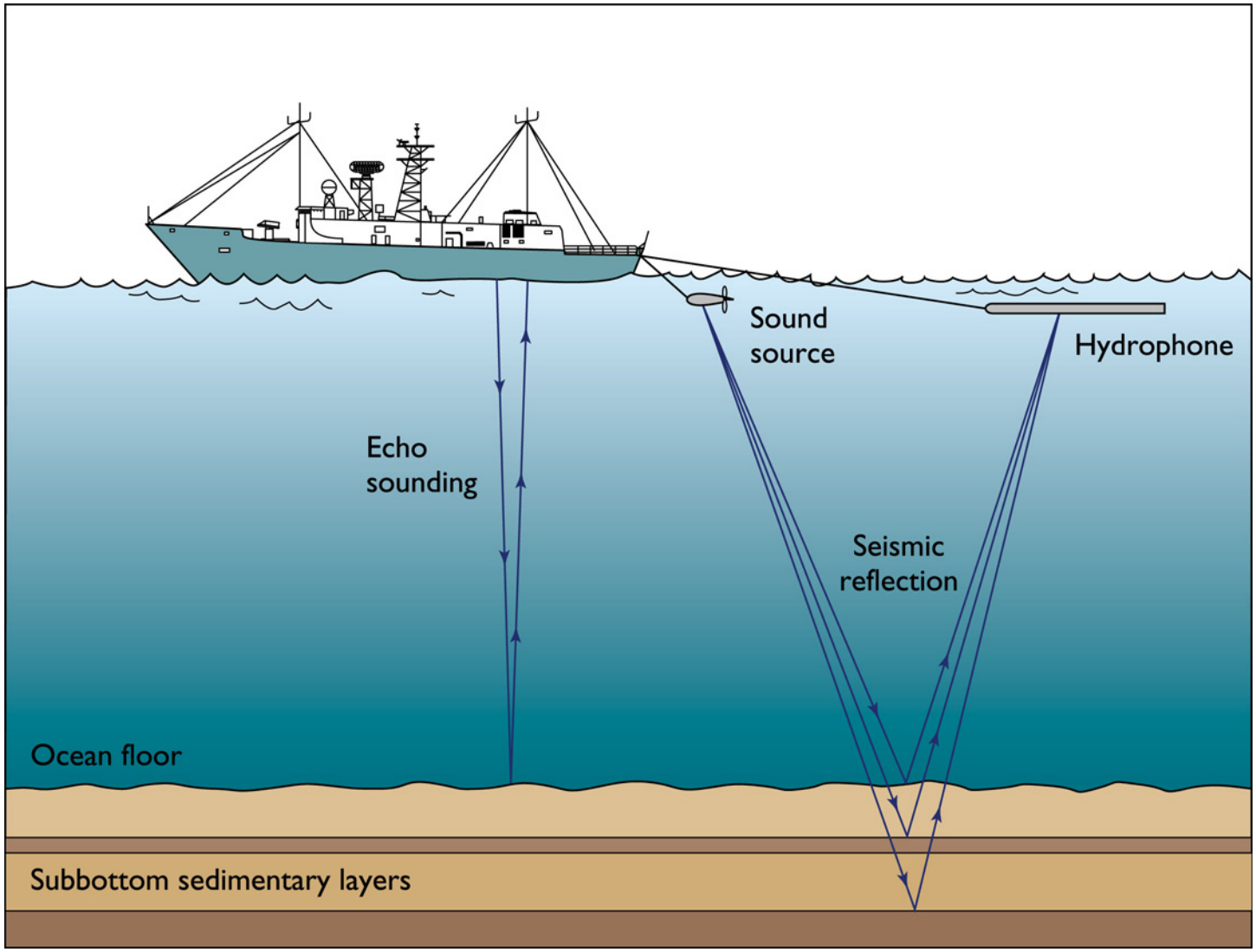
Copyright © 2005 Pearson Prentice Hall, Inc.

Like mowing the lawn

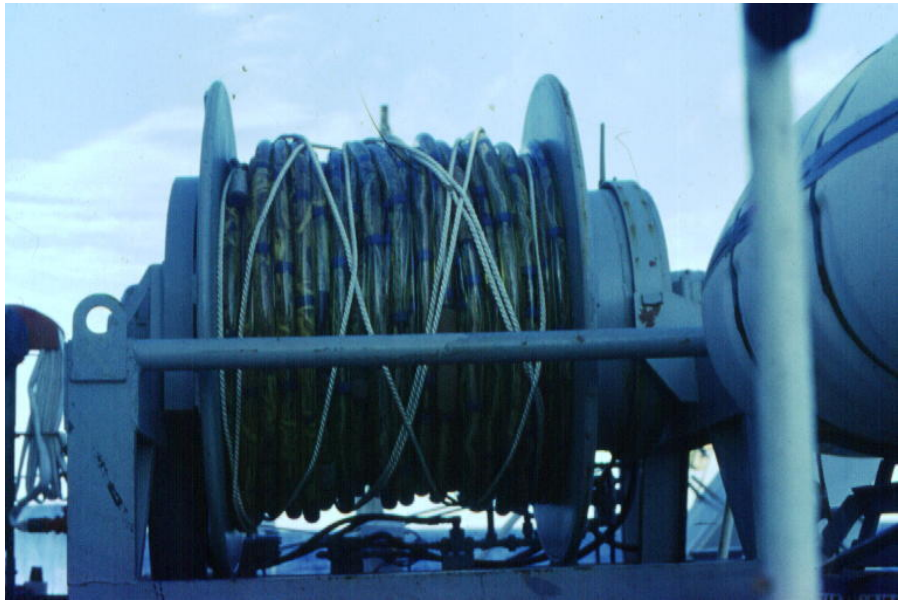
Sea floor mapping with satellites

- Don't directly measure the seafloor
- Measures small differences in surface elevation due to gravitational differences caused by sea-floor objects
- Bigger the object, the bigger the mass, the bigger the gravity. So big objects Ilike seamounts) pull water around them

- Plataforma: interna, externa, quebra da plataforma
- Talude continental: canyons submarinos
- Elevação continental—em direção ao mar por mais de 500 Km da base do talude continental—depósitos de dezenas de Km de sedimentos.
- Planícies abissais---as áreas mais planas do planeta (menos de 1 m por Km)

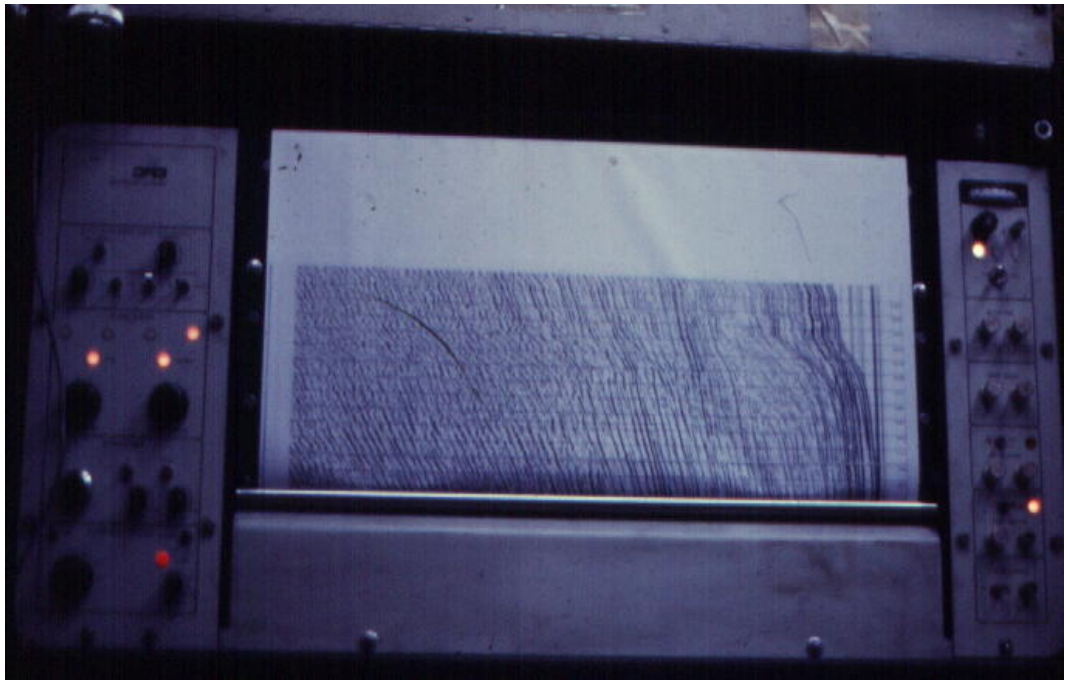


Sísmica de reflexão no mar

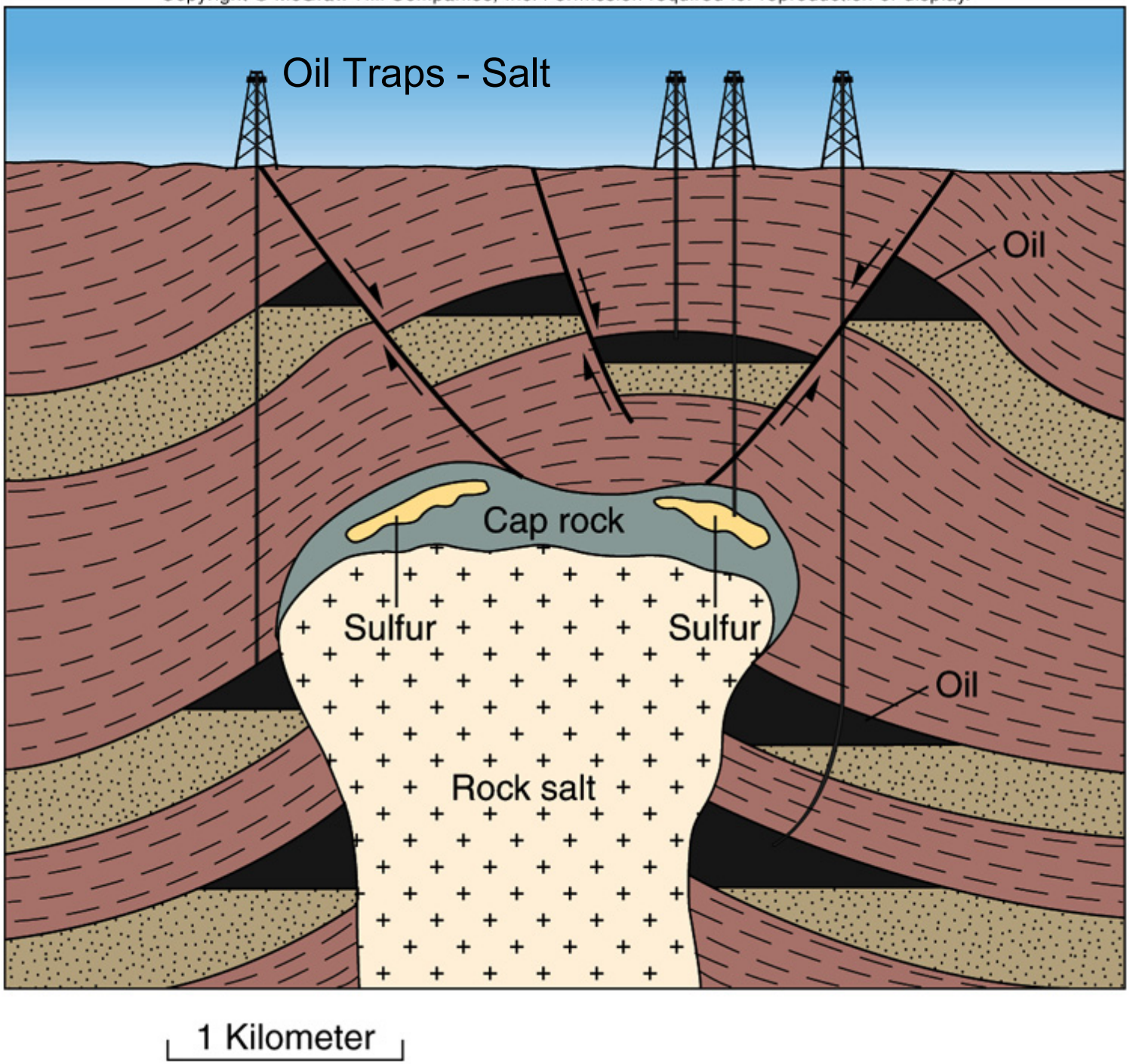


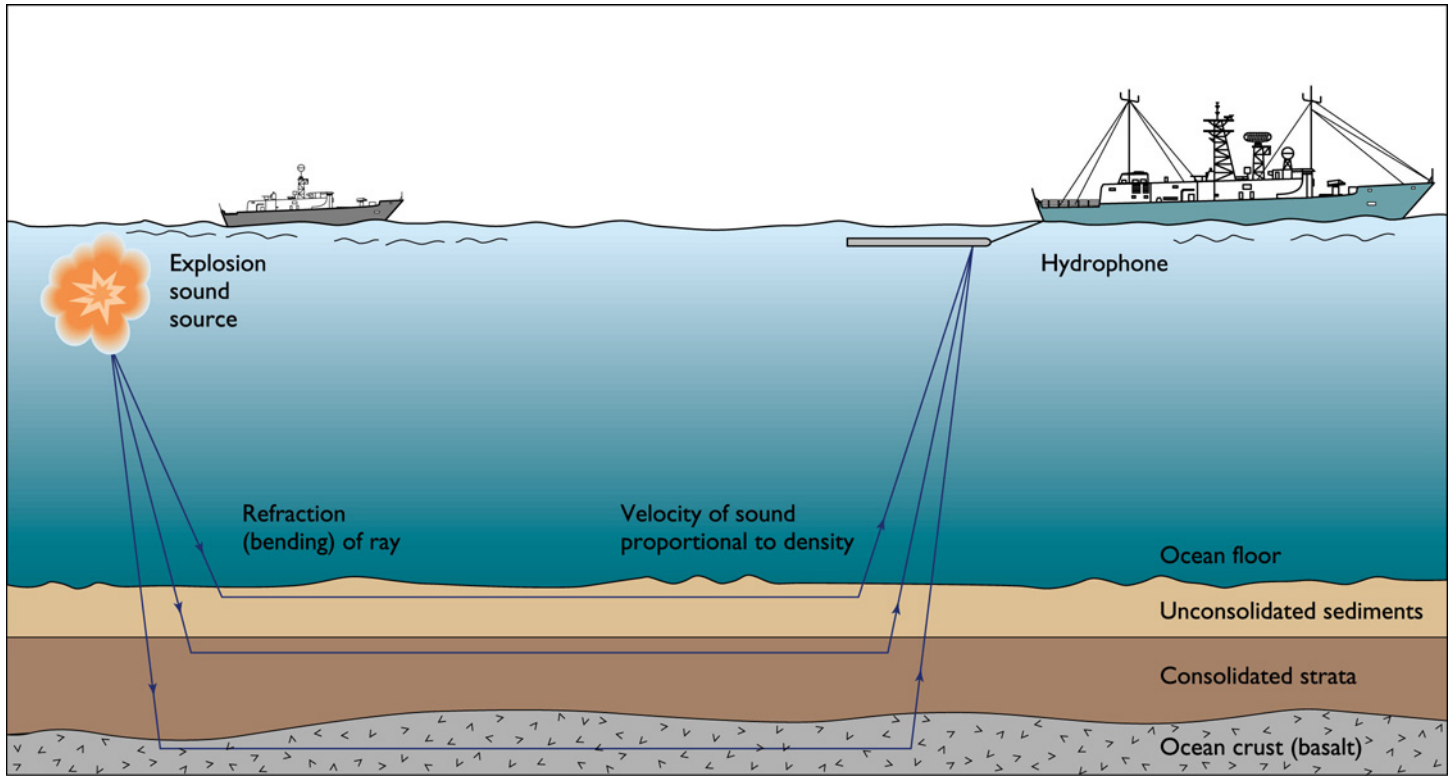
Sensores: cabos com hidrofones

Registro sísmico

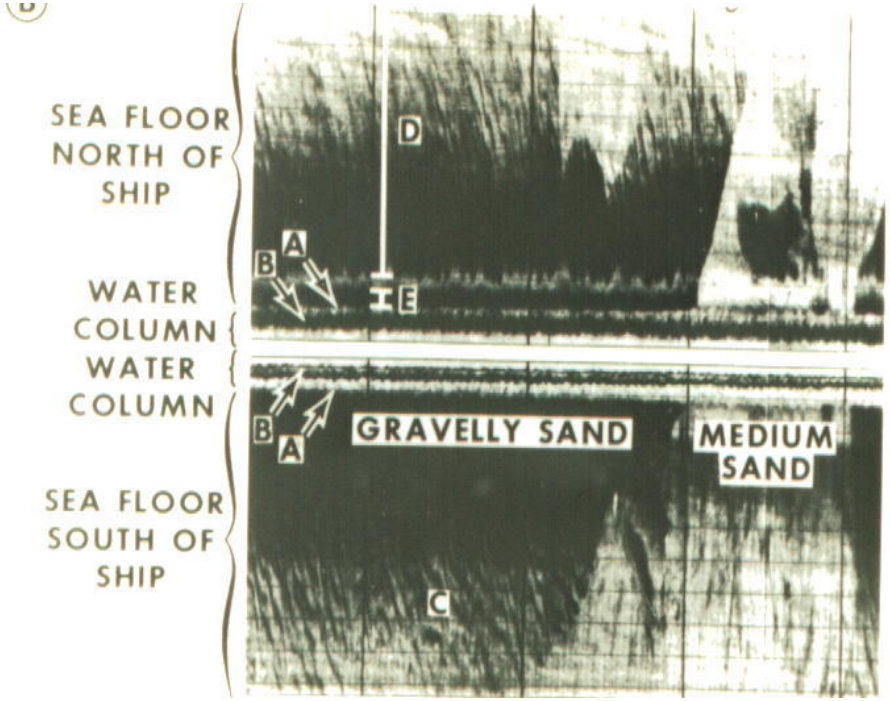


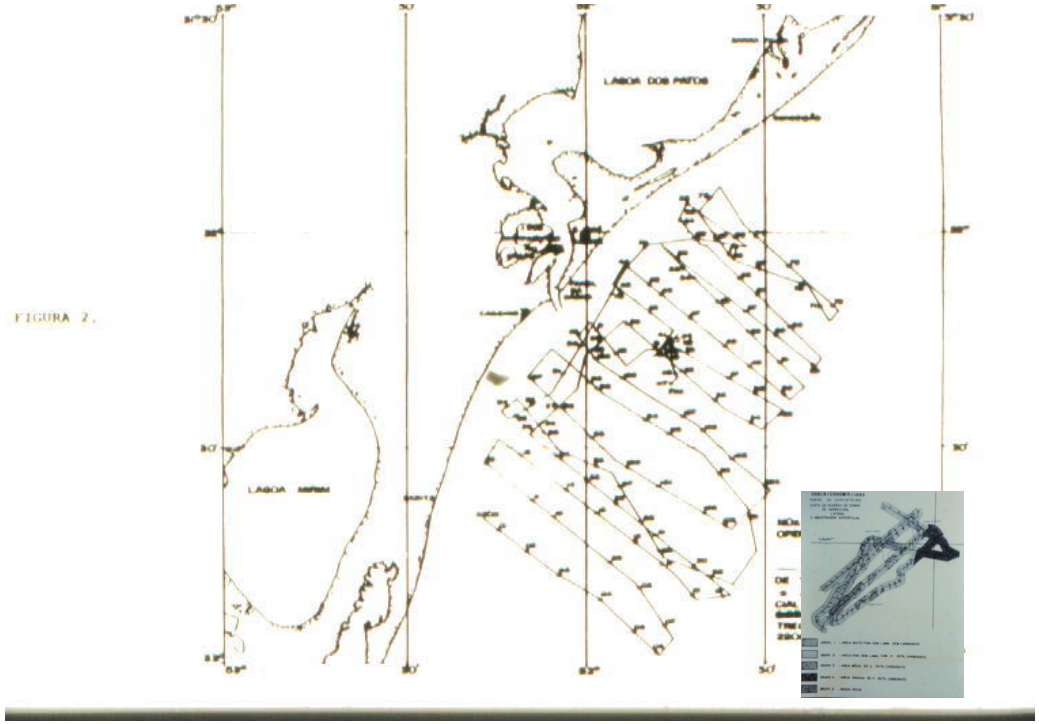
Copyright © McGraw-Hill Companies, Inc. Permission required for reproduction or display.



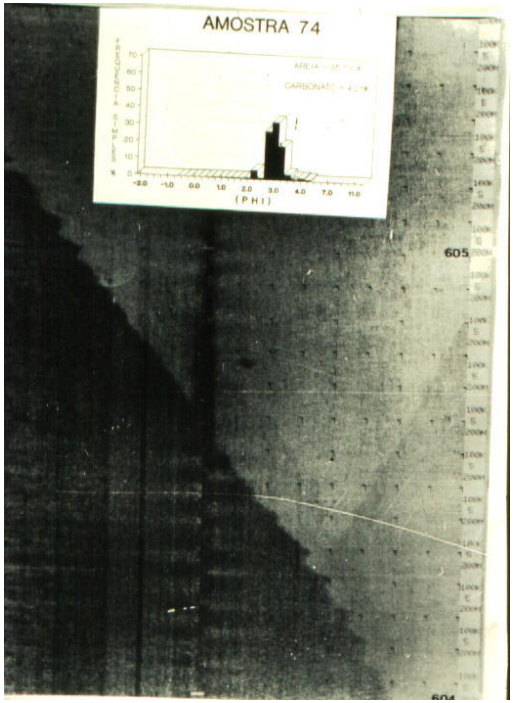

Explosion
sound
source
Hydrophone
Refraction
(bending) of ray
Velocity of sound
proportional to density
Ocean floor
Unconsolidated sediments
Consolidated strata
Ocean crust (basalt)

- 3 -

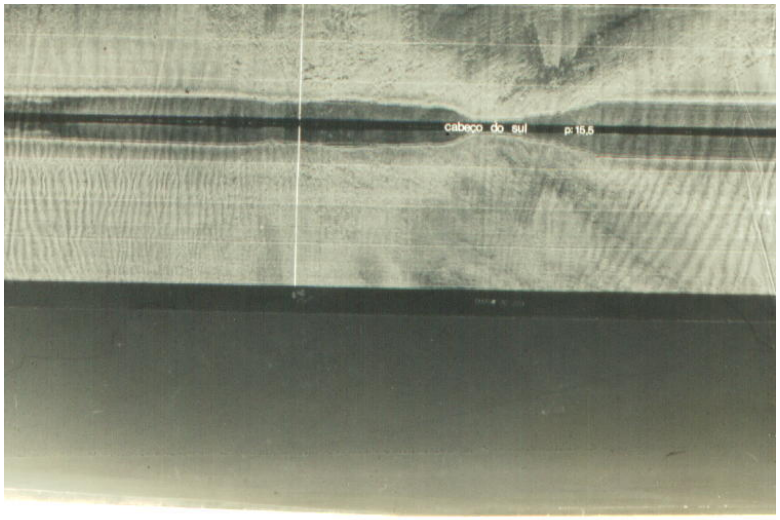

SEA FLOOR NORTH OF SHIP
WATER COLUMN
WATER COLUMN
SEA FLOOR SOUTH OF SHIP
D
A
B
E
B
A
GRAVELLY SAND
MEDIUM SAND
C



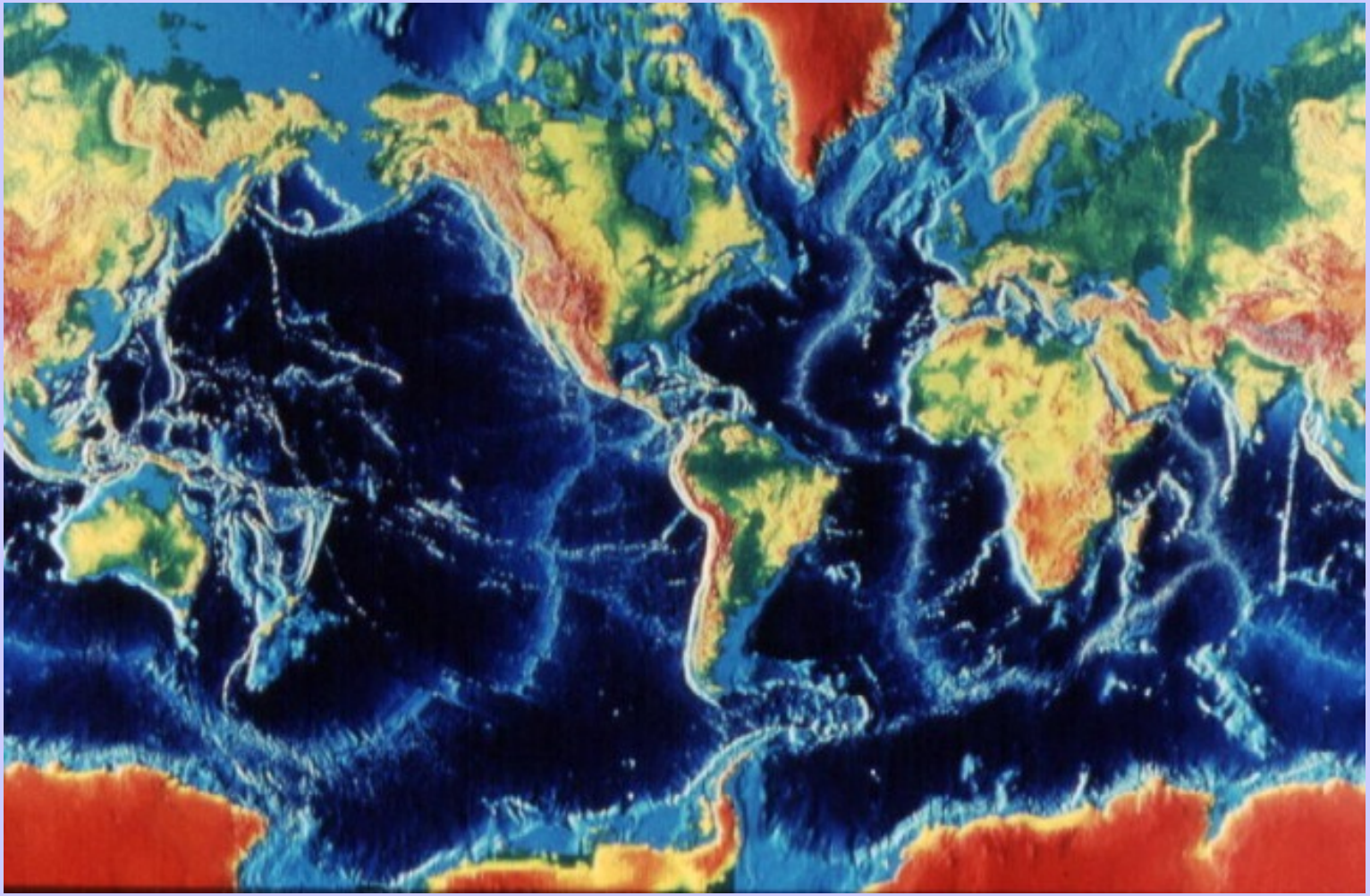
Geocosta Sul (1984)



Parcel do Carpinteiro


cabeço do sul
p: 15,5

AMOSTRA 70
AREIA = 33.56 %
CARBONATO = 66.4 %
(PHI)
576



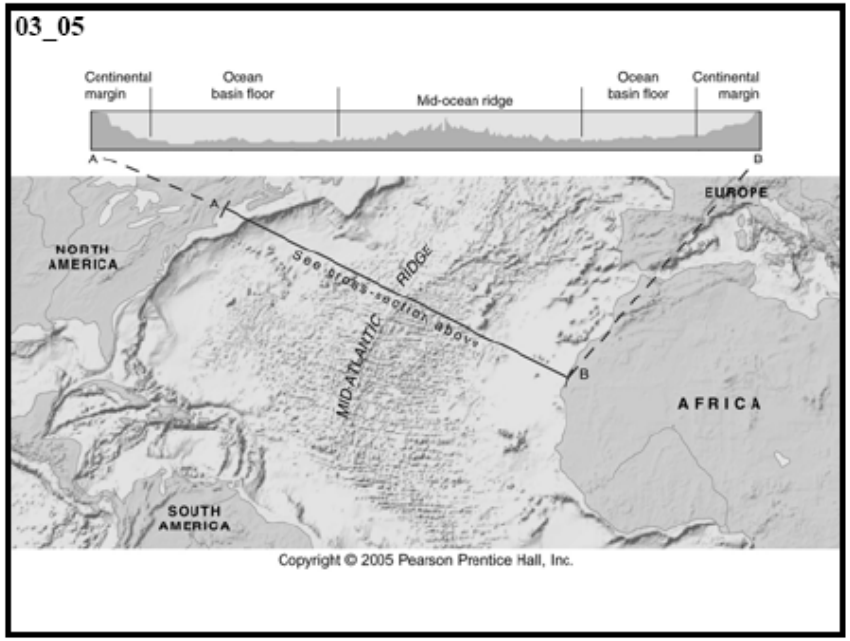
Fisiografia do fundo oceânico:

3 Províncias principais

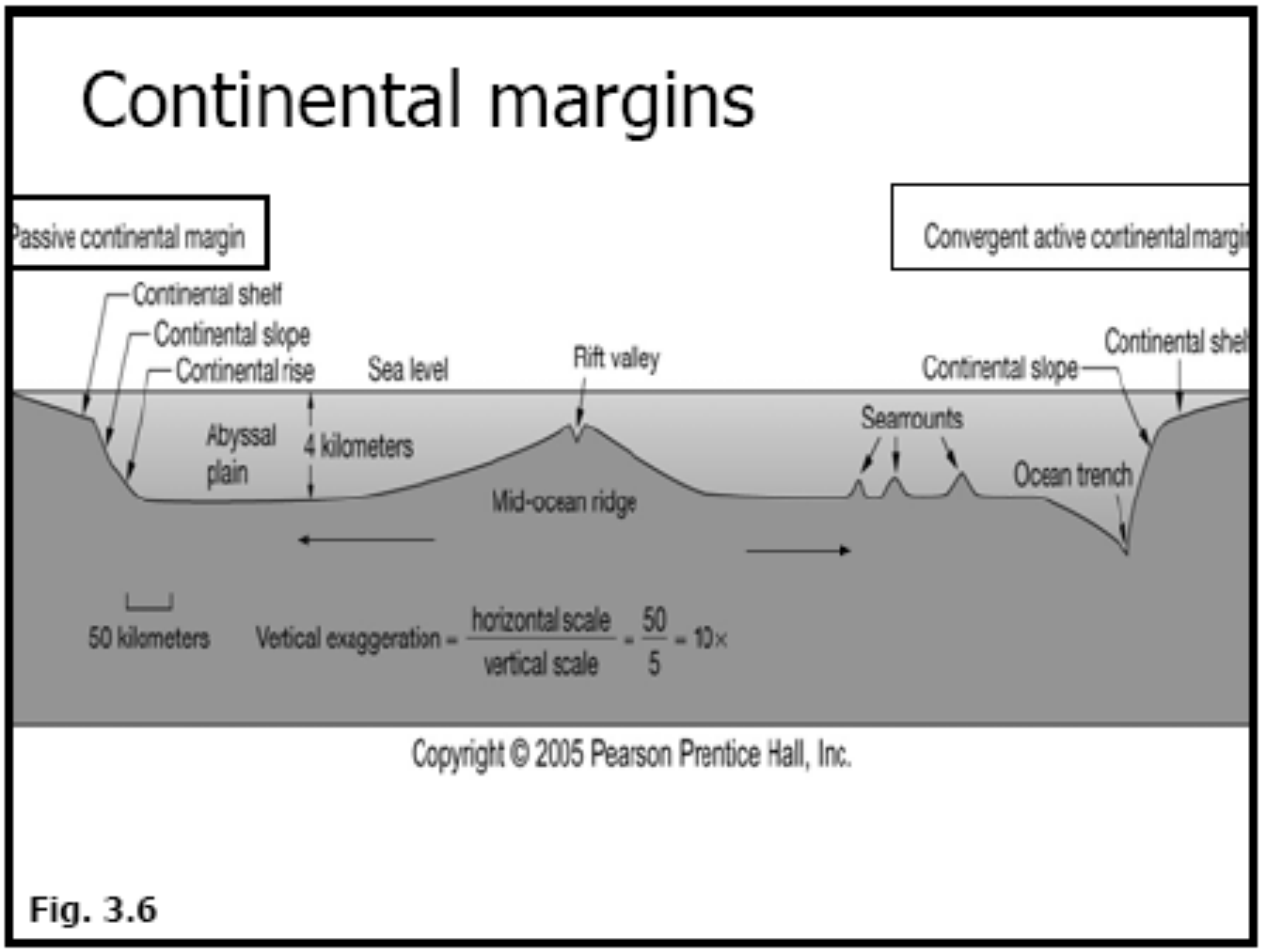
- Margem continental: Plataforma, talude e elevação continental (obs: dois tipos de margens continentais: Atlântica e Pacífica, ou Passiva e Ativa (função dos limites ou margens de placas---como veremos mais adiante).
- Fundo de Bacia Oceânica: Planícies abissais, Colinas abissais, montanhas submarinas, fossas profundas.
- Cordilheira Meso-Oceânica: P.Cristas, P. Flancos,Falhas de transformação,zonas de fratura.

Ocean provinces

- 3 major provinces
- Continental margins
  - Shallow-water areas close to shore
- Deep-ocean basins
  - Deep-water areas farther from land
- Mid-ocean ridge
  - Submarine mountain range



Continental margins

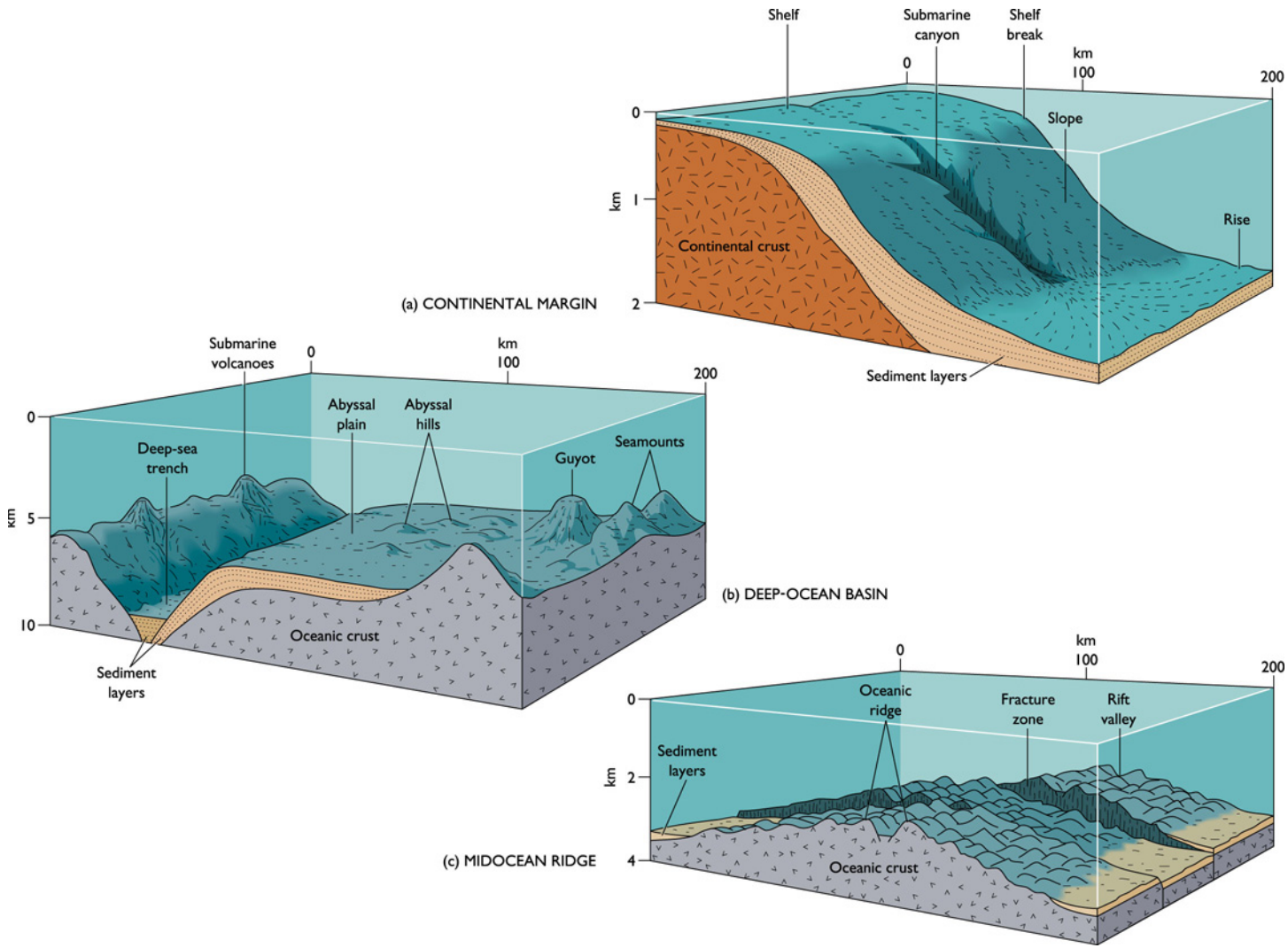


Copyright © 2005 Pearson Prentice Hall, Inc.

Fig. 3.6

that the break-of-slope is caused by wave abrasion related to a sea-level lowered

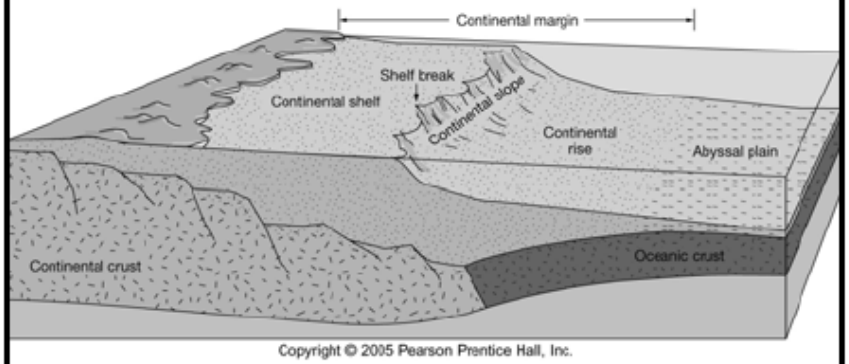
For example, the depth of the shelf-break is approximately the same on the windward and the leeward side of islands which is in agreement with the concept of the break being formed at the depth of vigorous abrasion, but is in disagreement with the concept of wave base.


Shelf
Submarine canyon
Shelf break
0
km
100
200
0
Slope
km
1
Rise
Continental crust
2
Sediment layers
(a) CONTINENTAL MARGIN
Submarine volcanoes
0
km
100
200
0
Abyssal plain
Abyssal hills
Deep-sea trench
Guyot
Seamounts
km
5
10
Oceanic crust
Sediment layers
(b) DEEP-OCEAN BASIN
0
km
100
200
0
Oceanic ridge
Fracture zone
Rift valley
Sediment layers
km
2
4
Oceanic crust
(c) MIDOCEAN RIDGE

Continental shelf

- Extends from shoreline to shelf break
- Shallow, low relief, gently sloping (almost flat)
- Average width 70 km (43 m) but can extend to 1500 km (930 m)
- Average depth of shelf break 135 m (443 ft) Remember what the shelf break represents?

Continental margin

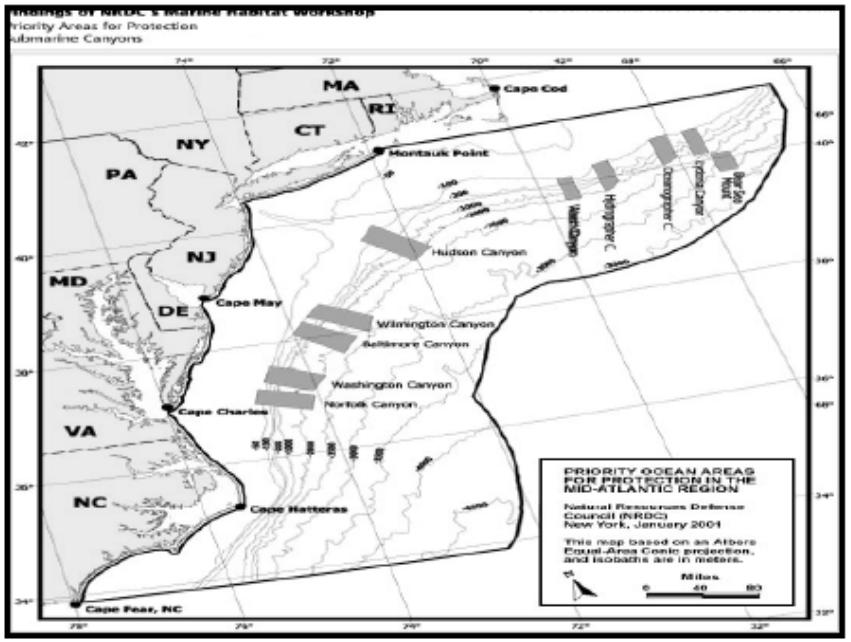


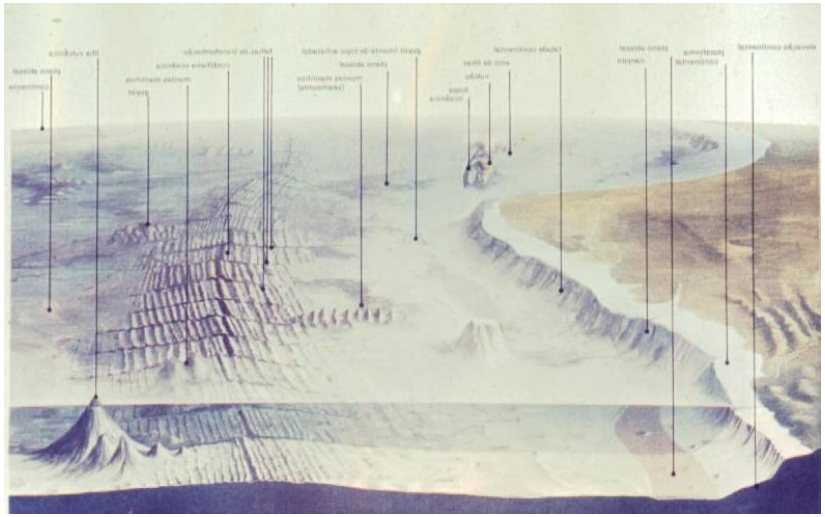
Copyright © 2005 Pearson Prentice Hall, Inc.

Fig. 3.7

Continental slope

- Change in gradient from shelf
- Average gradient 4°
- Submarine canyons
  - **Great place to fish**
  - Orignally thought to be from rivers at low-stand sea level
  - Some are too deep and not near rivers



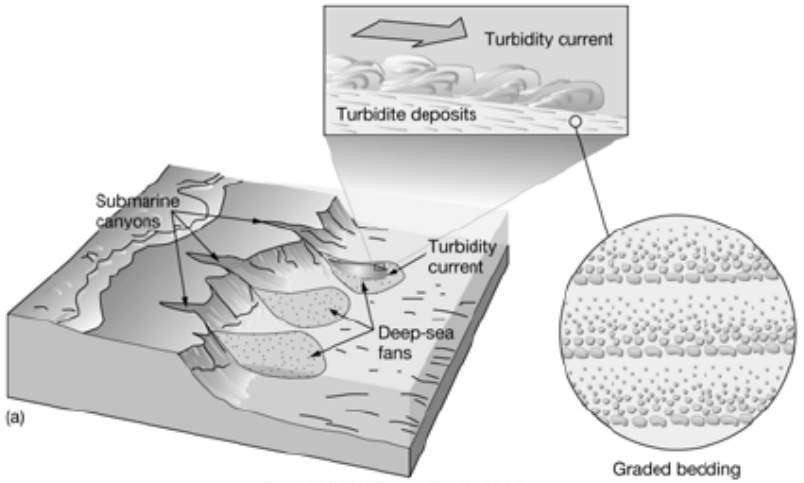


Tripoli
Cairo
Jerusalem
Tehran
Baghdad
New Delhi
ARABIA
Riyad
THAR DESERT
Bombay
Khartoum
N'Djamena
AFRICA
Douala
Kinshasa
Luanda
Lusaka
Nairobi
KALAHARI DESERT
LENA GUYOT
HEARD

Turbidity currents cut submarine canyons

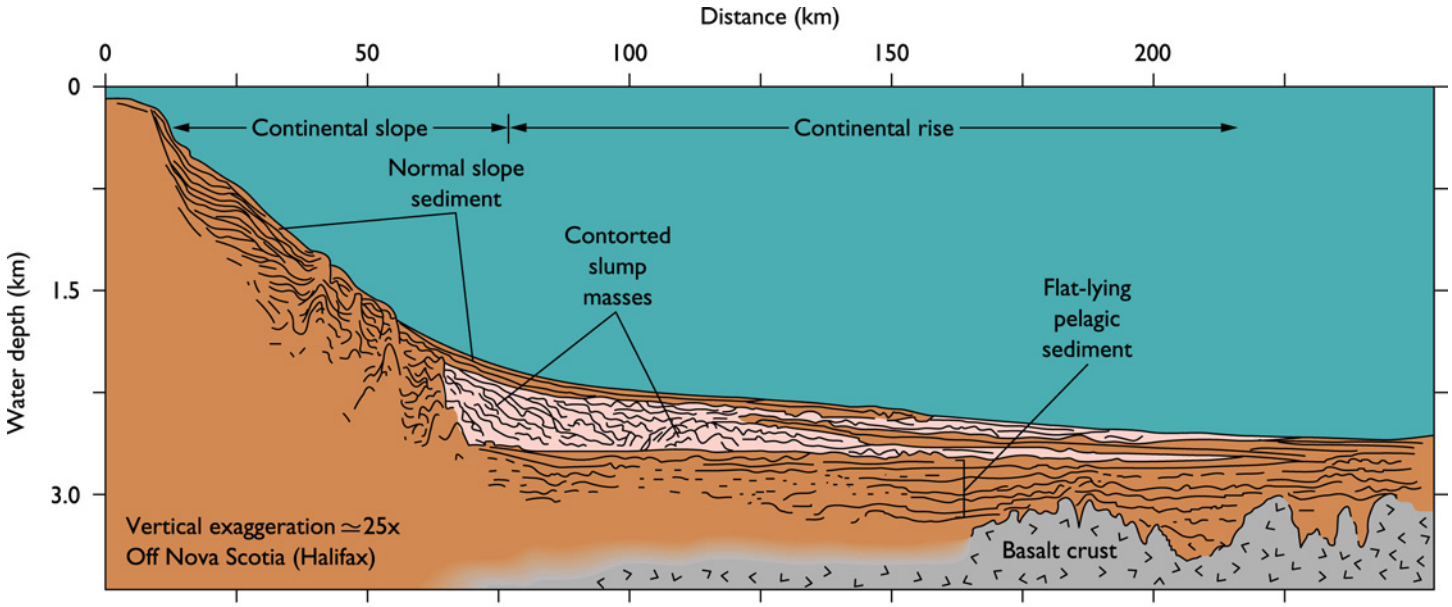
- **Underwater Avalanche**
- **Mixture of seawater and sediments**
- **Move under influence of gravity**
- **Erode canyons**
- **Deposit sediments at base of slope**

Continental slope and submarine canyons

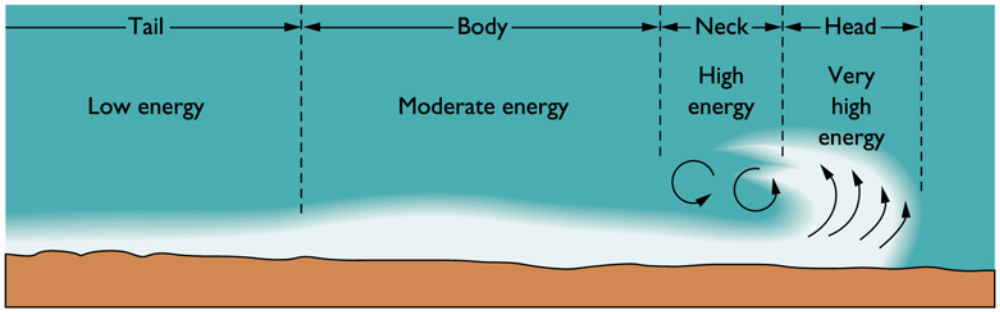


Copyright © 2005 Pearson Prentice Hall, Inc.

Fig. 3.8a



(a) SEISMIC-REFLECTION PROFILE

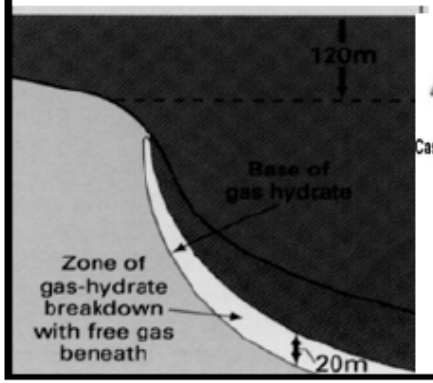


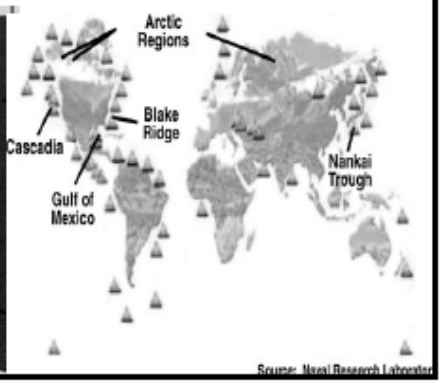
(b) TURBIDITY CURRENT

One feature that sometimes exists at the base of the continental slope is methane hydrates

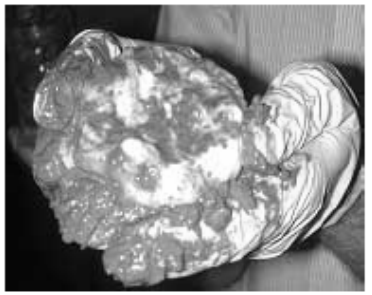
-slumped sediments trap methane (natural gas)

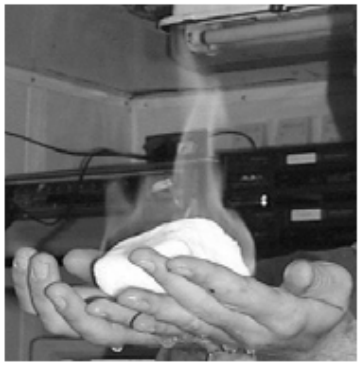
-high pressure and low temperature forms it into a solid





Its Ice!

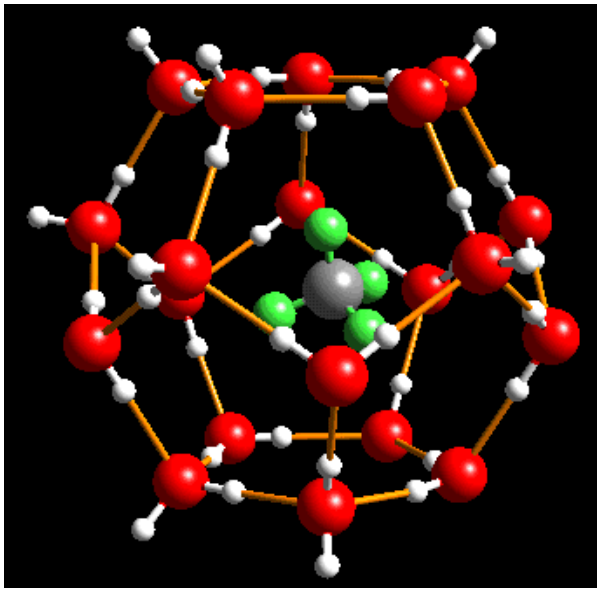




and Fire!

What are Gas Hydrates ?

- Gas hydrates are cages of water molecules that surround and trap methane and other low molecular weight gaseous molecules
- Three Structure Types: I, II, and H

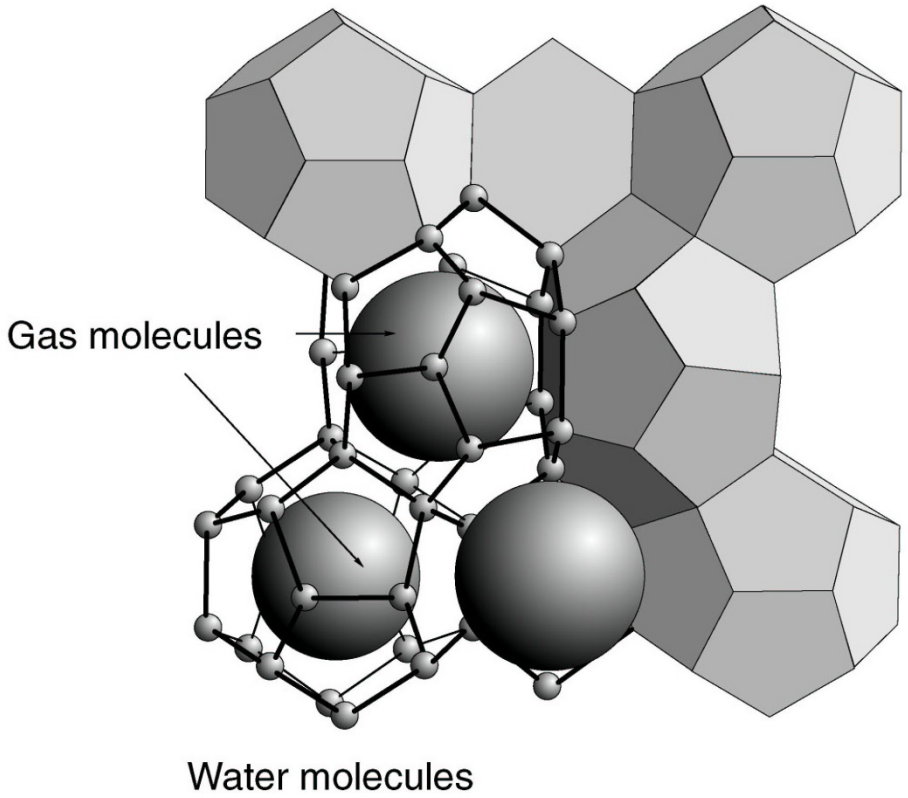


A portion of the gas hydrate core recovered in 1981 by the *Glomar Challenger*. This was the first sub-sea hydrate known to have been recovered intact for surface analysis. DOE's Morgantown Energy Technology Center, now part of the Federal Energy Technology Center, was one of 6 laboratories selected to study the sample in 1982.

Gas Hydrate Structure I

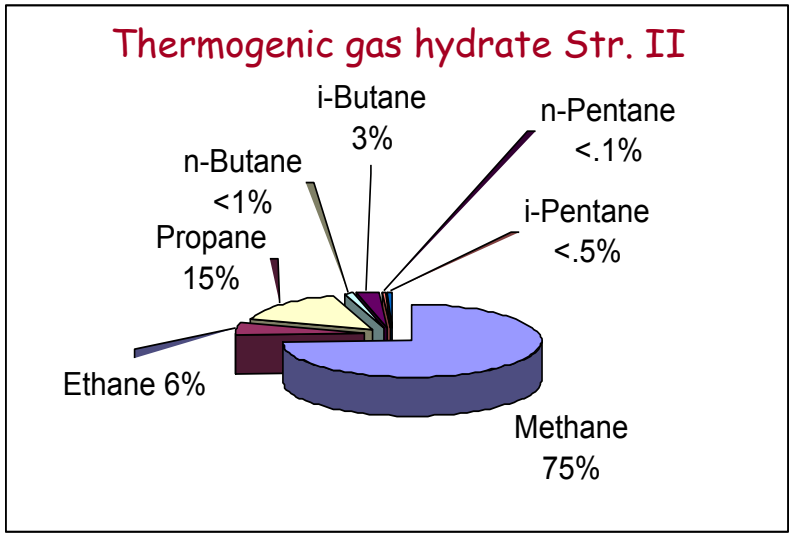
- Structure I Gas Hydrate Crystal - Cubic Lattice
- Can hold only small molecules (5.2 angstroms or less) such as ethane(C_2H_6) and methane(CH_4)
- Biogenic in origin

Figure 1. *Gas hydrate of type I structure. Small spheres are tetrahedrally-linked water molecules which comprise the cages; large spheres are gas molecules. Four (5^{12})-cages are shown, one at each corner composed of twelve five-sided polygons known as pentagonal dodecahedra, and two ($5^{12}6^2$)-cages in the center facing each other, composed of twelve five-sided and two six-sided polygons. The (5^{12})-cages are present in all three gas hydrate structure types.*



Gas Hydrate Structure II

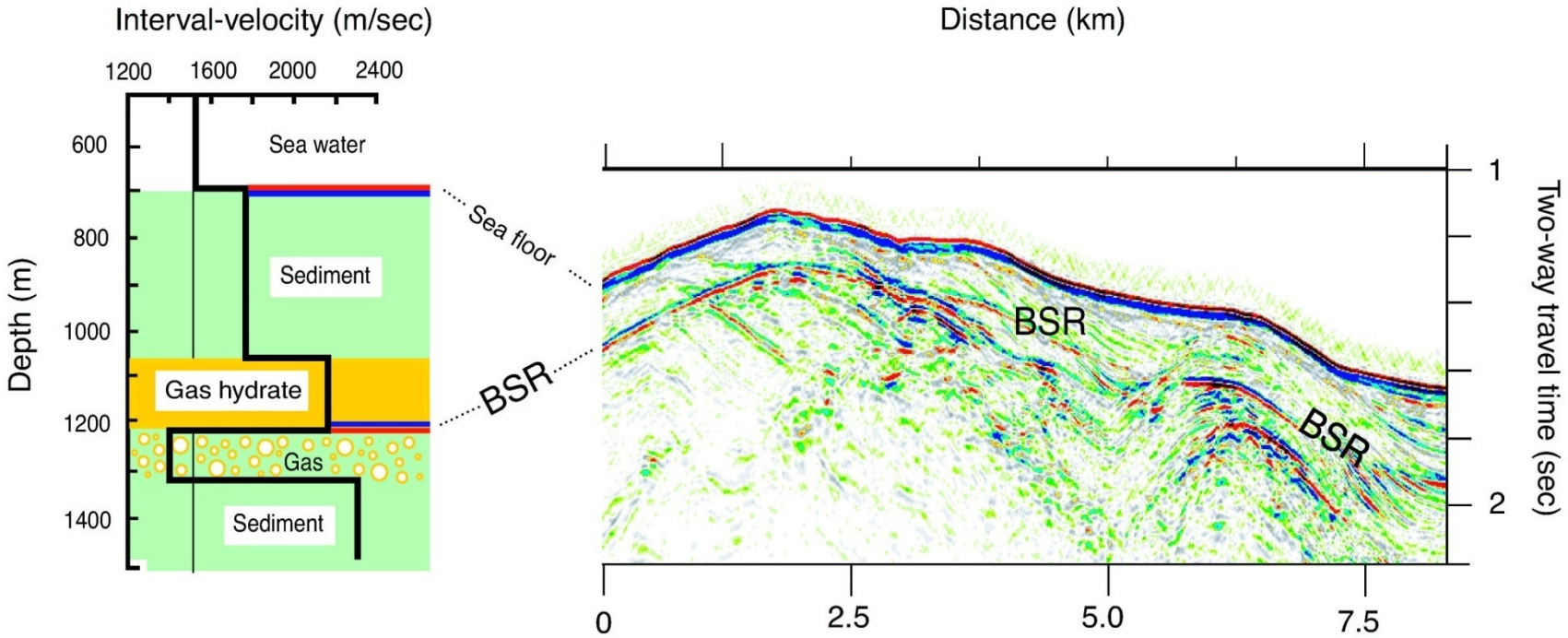
- Structure II Gas Hydrate Crystal - Diamond Lattice
- May contain larger molecules (5.9-6.9 angstroms) such as propane (C_3H_8) or isobutane (C_4H_{10})
- Thermogenic in origin



Locating Gas Hydrates in Marine Systems

The presence of gas hydrates is usually identified from bottom-simulating seismic reflection (BSR)

Figure 3. *Schematic seismic velocity distribution of subseafloor strata (left) and seismic profile across hydrate and gas-containing strata showing layered and folded structures with crosscutting bottom simulating reflection (BSR; right). Red = large positive amplitude p-waves, and blue = large negative amplitude p-waves. BSR with negative polarity comes from the contrast between high acoustic impedance of hydrate-filled sediment (>2000 m/sec) and free gas-containing sediment (<1500 m/sec). Sea floor reflection shows positive polarity from contrast between sea water seismic velocity (1500 m/sec) and sediment velocity (about 1800 m/sec).*



Deep ocean basin features

- Abyssal plains
- Volcanic peaks
- Ocean trenches
- Volcanic arcs

Abyssal plains

- Very flat depositional surfaces from base of continental rise
- 4500 – 6000 meters deep
- Next to trenches they are the deepest parts of the ocean
- Suspension settling of very fine particles
- Sediments cover ocean crust irregularities so it looks flat…like snow
- Well-developed in Atlantic and Indian oceans

Abyssal plains

- Mostly in Atlantic and Indian Oceans
- Off of passive margins because trenches act as gutters for sediments
- Less in Pacific because of abundant active margins and large size

Abyssal plains

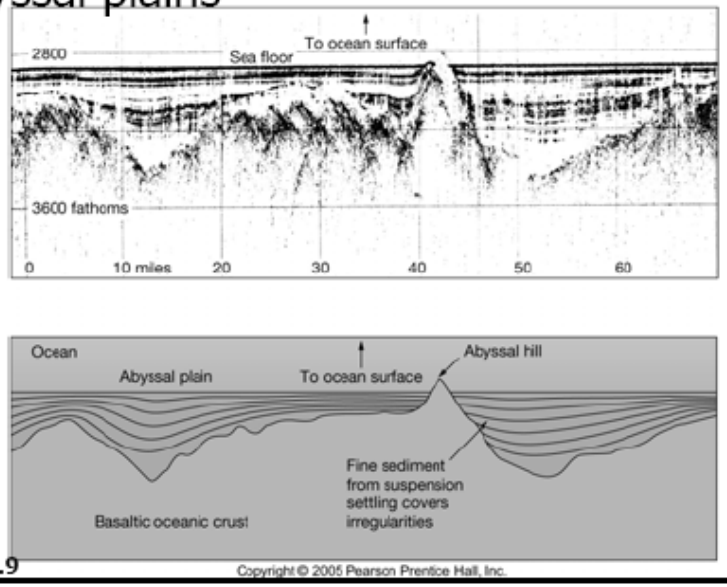
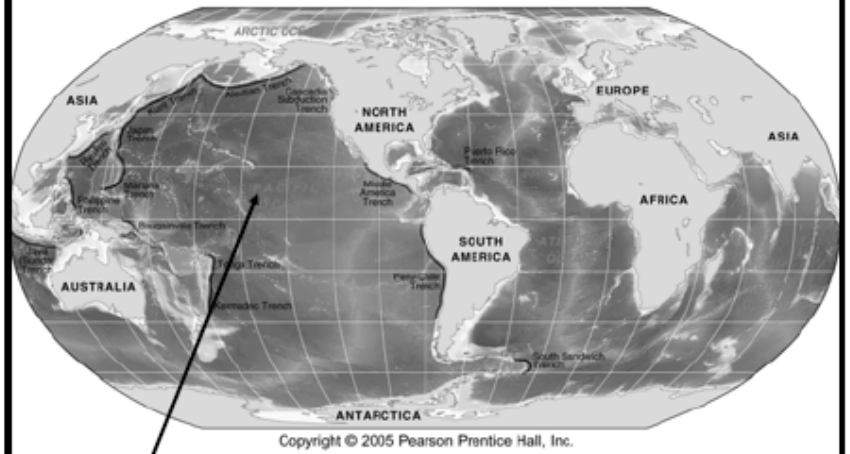


Fig. 3.9

Copyright © 2005 Pearson Prentice Hall, Inc.

Ocean trenches

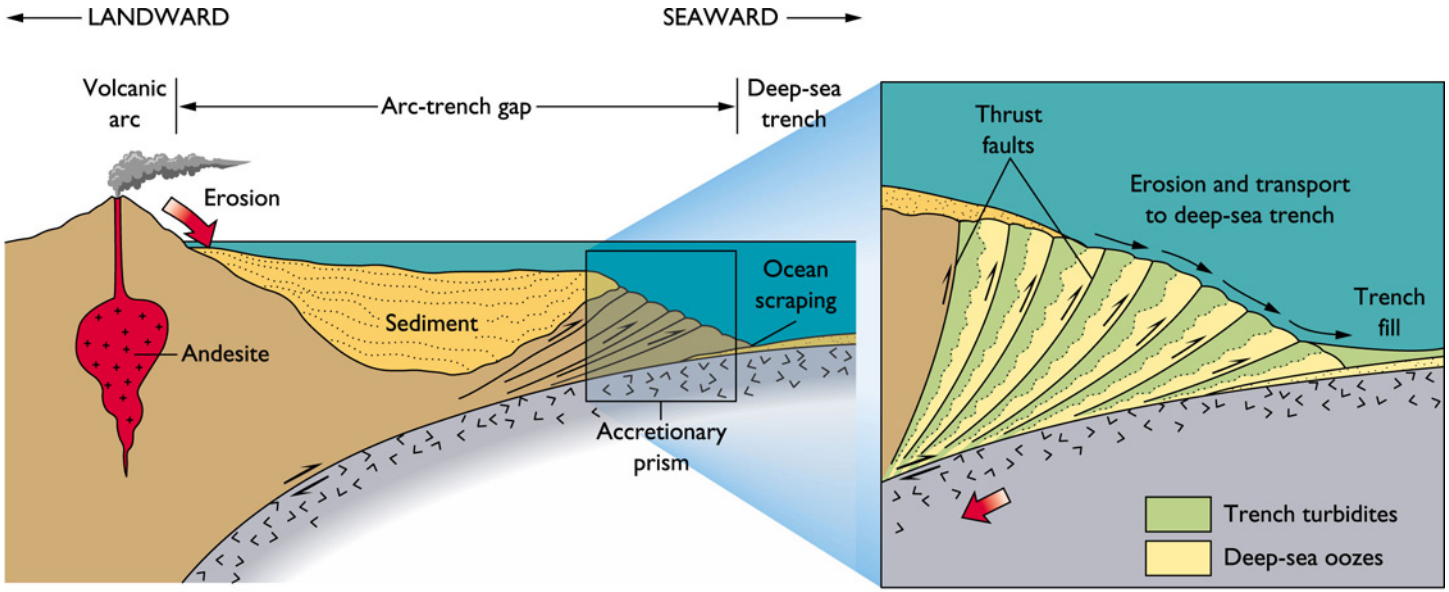


Copyright © 2005 Pearson Prentice Hall, Inc.

The Pacific Ring of Fire

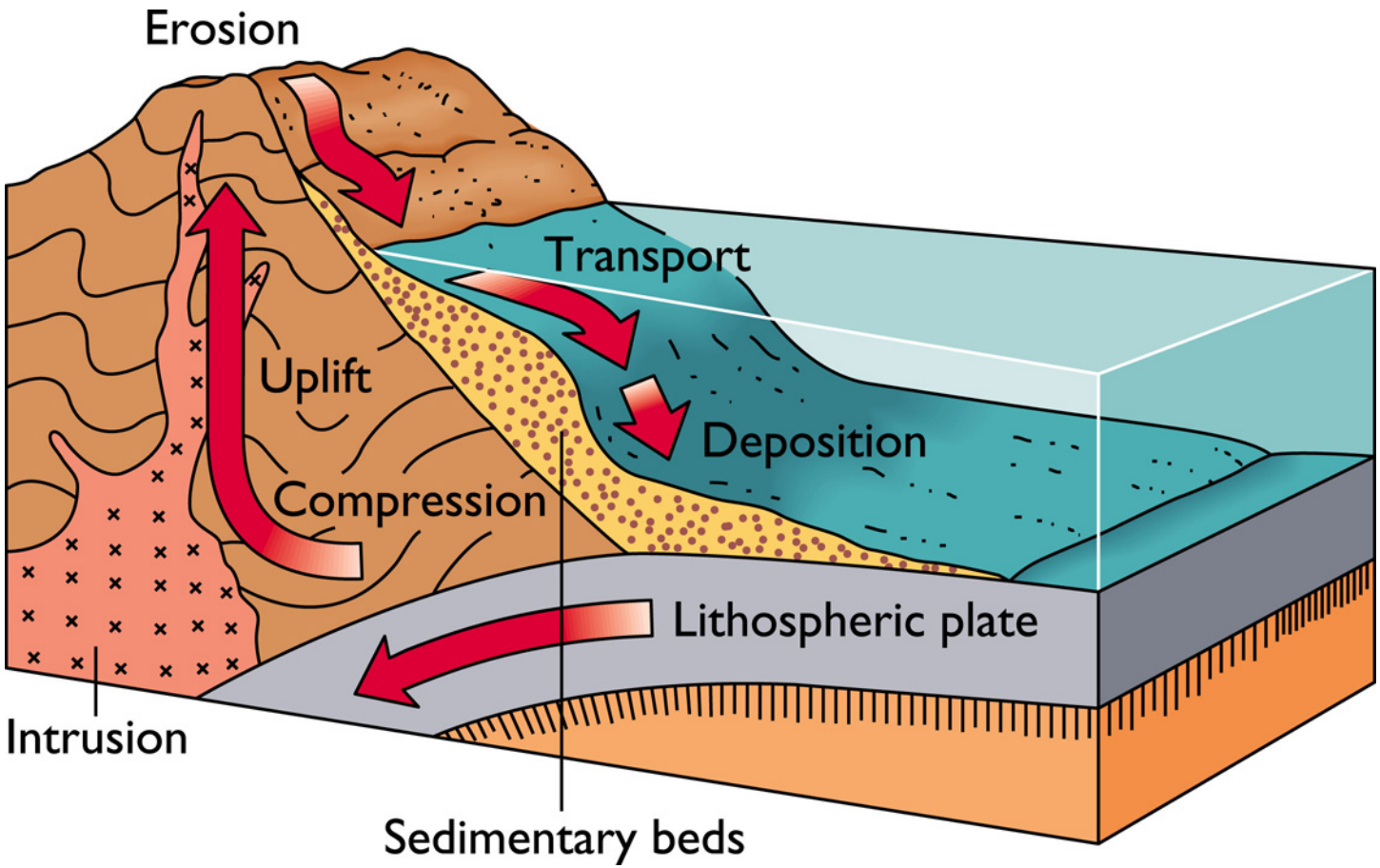
Volcanic arcs

- Landward side of ocean trench
- Island arc
  - Chain of islands, e.g., Japan
- Continental arc
  - Volcanic mountain range, e.g., Andes Mountains



(a) VOLCANIC ARC-TRENCH SYSTEM

(b) ACCRETIONARY PRISM


Erosion
Transport
Uplift
Deposition
Compression
Lithospheric plate
Intrusion
Sedimentary beds

Volcanic peaks

- Poke through sediment cover
- Below sea level:
  - Seamounts, tablemounts or guyots at least 1 km (0.6 m) above seafloor
  - Abyssal hills or seaknolls are less than 1 km
- Above sea level:
  - Volcanic islands

Ocean trenches

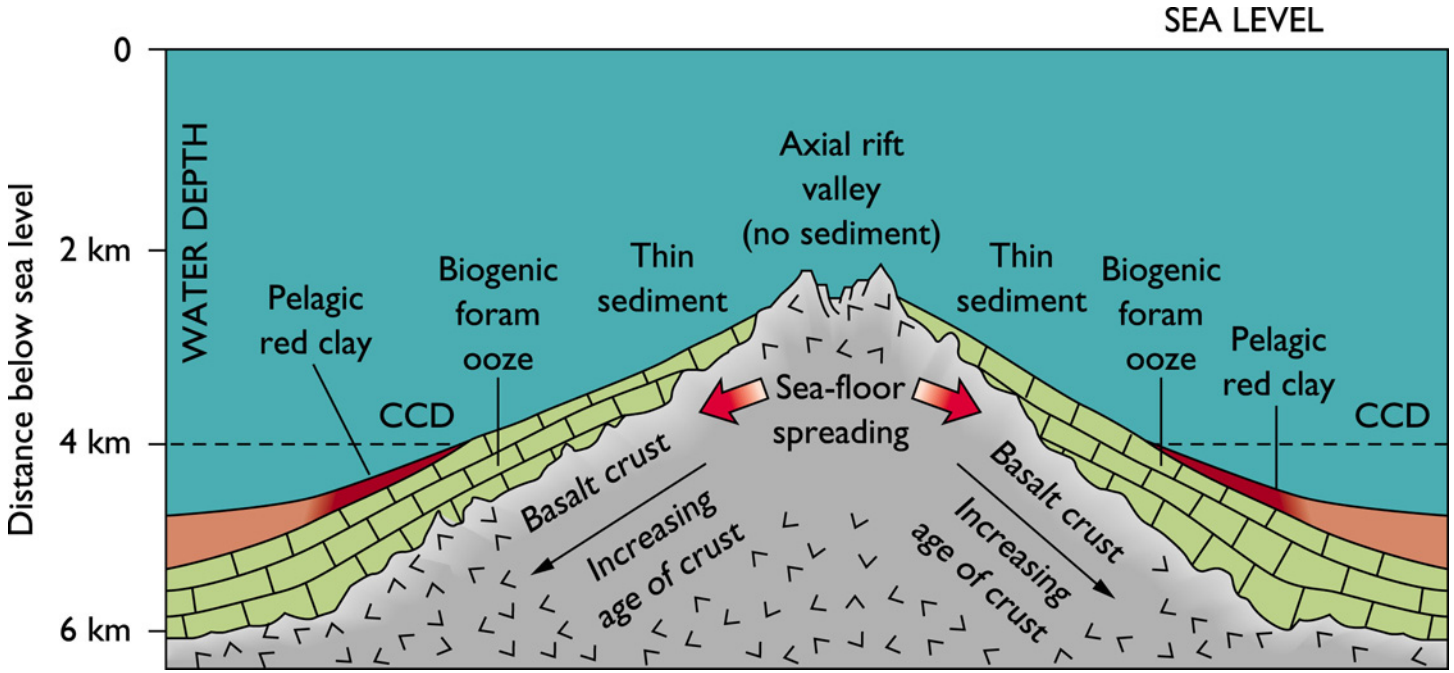
- Linear, narrow, steep-sided
- Associated with subduction zones
- Deepest parts of ocean
  - Mariana Trench, 11,022 m (36,161 ft)
- Majority in Pacific Ocean

Mid-ocean ridge

- Longest mountain chain
- On average, 2.5 km (1.5 miles) above surrounding sea floor
- Wholly volcanic
  - 80% of earth's volcanic activity takes place underwater
- Basaltic lava
- Divergent plate boundary

Mid-ocean ridge features

- Central rift valley, faults and fissures
- Seamounts
- Pillow basalts
- Hydrothermal vents
  - Deposits of metal sulfides
  - Unusual life forms
- Fracture zones and transform faults


SEA LEVEL
0
2 km
4 km
6 km
Distance below sea level
WATER DEPTH
Axial rift valley (no sediment)
Thin sediment
Thin sediment
Biogenic foram ooze
Biogenic foram ooze
Pelagic red clay
Pelagic red clay
CCD
CCD
Sea-floor spreading
Basalt crust
Basalt crust
Increasing age of crust
Increasing age of crust

Rift valley, faults and fissures

- Downdropped rift valley at central crest
- Cracks (fissures) and faults common

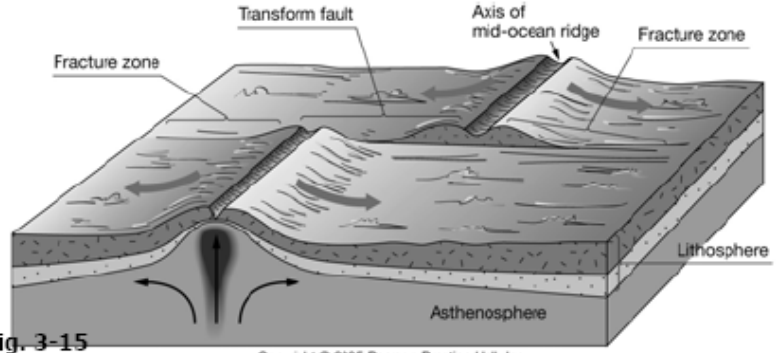
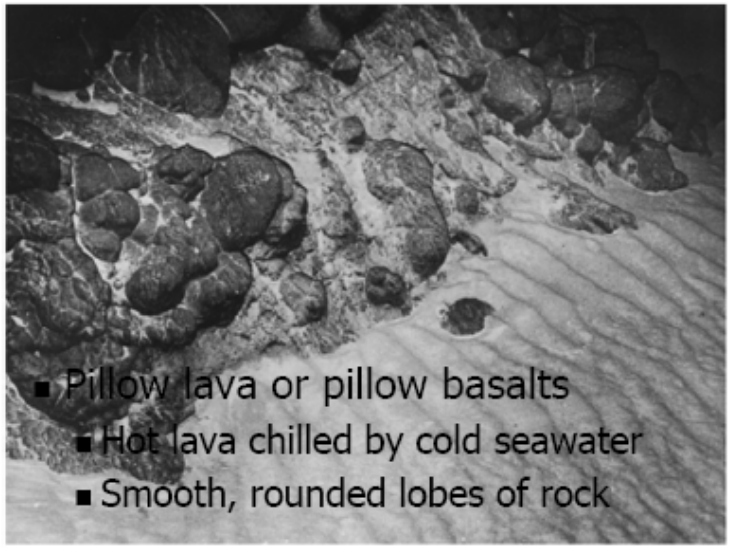


Fig. 3-15

Copyright © 2005 Pearson Prentice Hall, Inc.



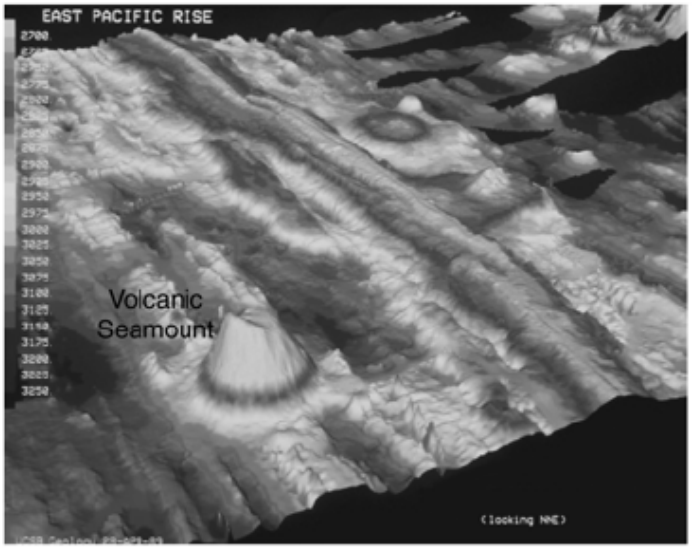
- Pillow lava or pillow basalts
- Hot lava chilled by cold seawater
- Smooth, rounded lobes of rock

(b)

Copyright © 2005 Pearson Prentice Hall, Inc.

Mid-ocean ridge features

- Oceanic ridge
  - Prominent rift valley
  - Steep, rugged slopes
  - Example: Mid-Atlantic Ridge
- Oceanic rise
  - Gentler, less rugged slopes
  - Example: East Pacific Rise



(a)

Copyright © 2005 Pearson Prentice Hall, Inc.

Volcanic features of mid-ocean ridge

- Hydrothermal vents
  - Heated subsurface seawater migrates through cracks in ocean crust
    - Warm-water vents <30°C or 86°F
    - White smokers >30°C <350°C or 662°F (white because of barium sulfide)
    - Black smokers > 350°C
      - **(black because of metal sulfides; Fe, Ni, Zn)**
    - Important for maintaining the supply of metals to the ocean

Hydrothermal vents

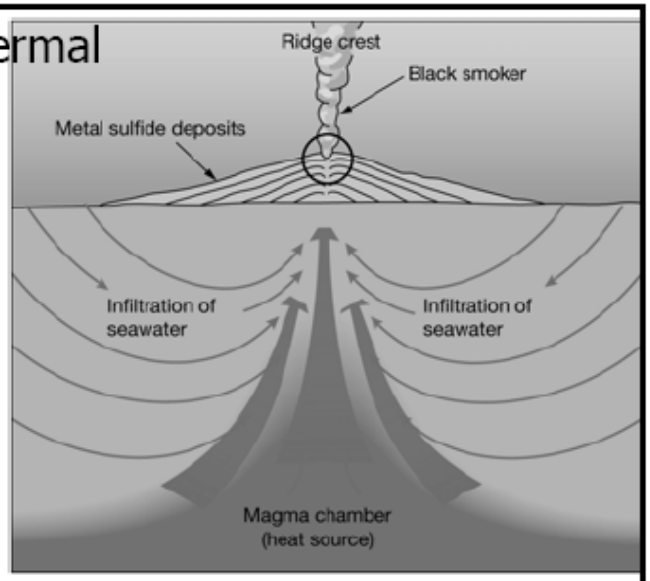
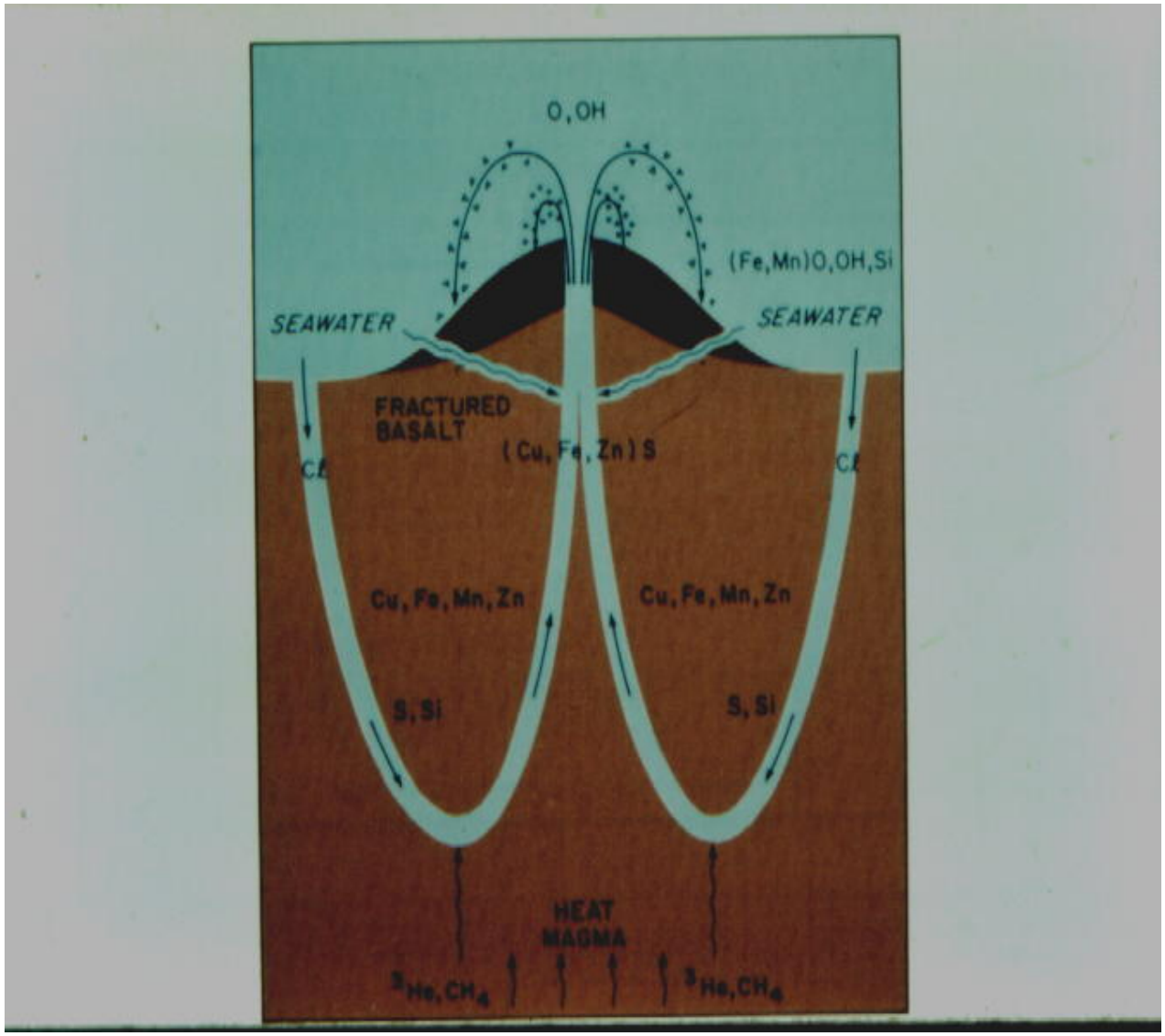


Fig. 3.14

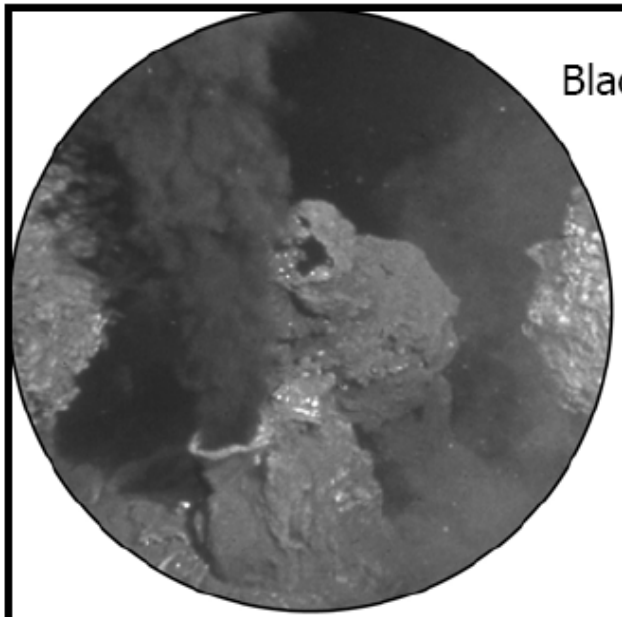
Copyright © 2005 Pearson Prentice Hall, Inc.

A água do mar muda de
Levemente alcalina e
Oxidada para uma solução
Ácida reduzida altamente
Enriquecida em Si,Ca,Fe,
Mn,Cu, todos lixiviados do
Basalto.
A água do mar perde Mg que
É adquirido pelas rochas
A medida que a água do mar
Circula torna-se enriquecida
Em S parcialmente devida a
Percolação e a redução dos
Ions sulfatos da água do mar

Estas condições favorecem a
Combinação do S com outros
Metais (Cu,Fe,Pb e Zn).



HIDROTERMAIS



Black Smoker

Copyright © 2005 Pearson Prentice Hall, Inc.

Hydrothermal vents

- Dissolved metals precipitate to form metal sulfide deposits
- Unusual biological communities
  - Able to survive without sunlight
  - Archaeons and bacteria oxidize hydrogen sulfide gas to provide food

White Smoker

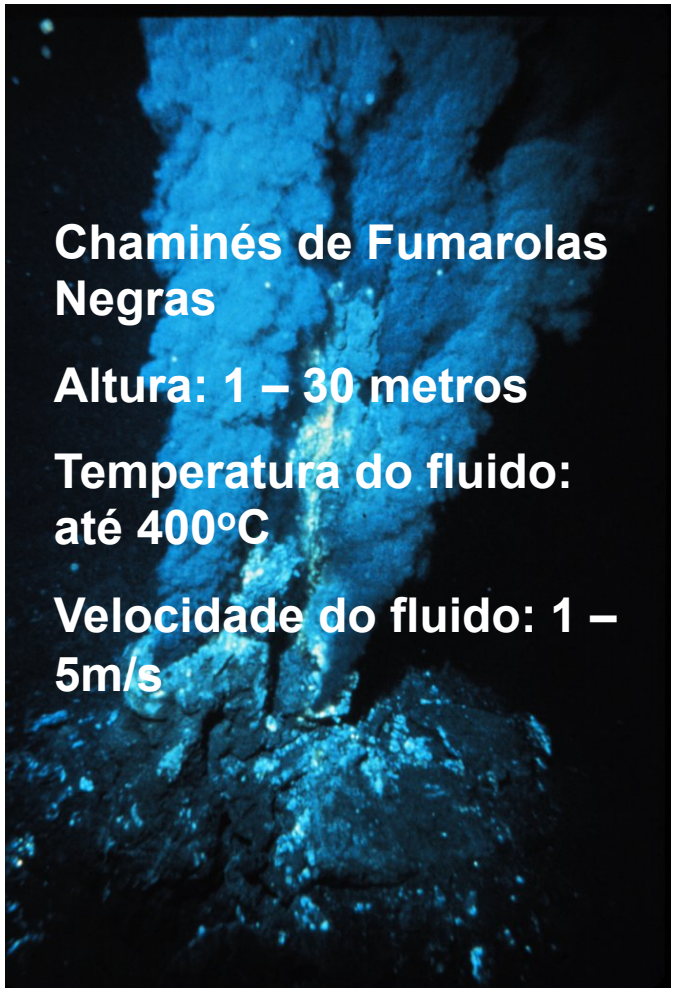
b)

Copyright © 2005 Pearson Prentice Hall, Inc.

Fracture zones and transform faults at ridges

- Long linear zones of weakness offset axes of mid-ocean ridge, at right angles to the ridge valley
- Transform faults: movement in opposite directions, (active...seismic)
- Fracture zones: extensions of fracture zones (aseismic)...old transform fault scars that used to be moving in opposite directions that are now moving in the same direction

Depósitos de sulfetos metálicos no fundo dos oceanos



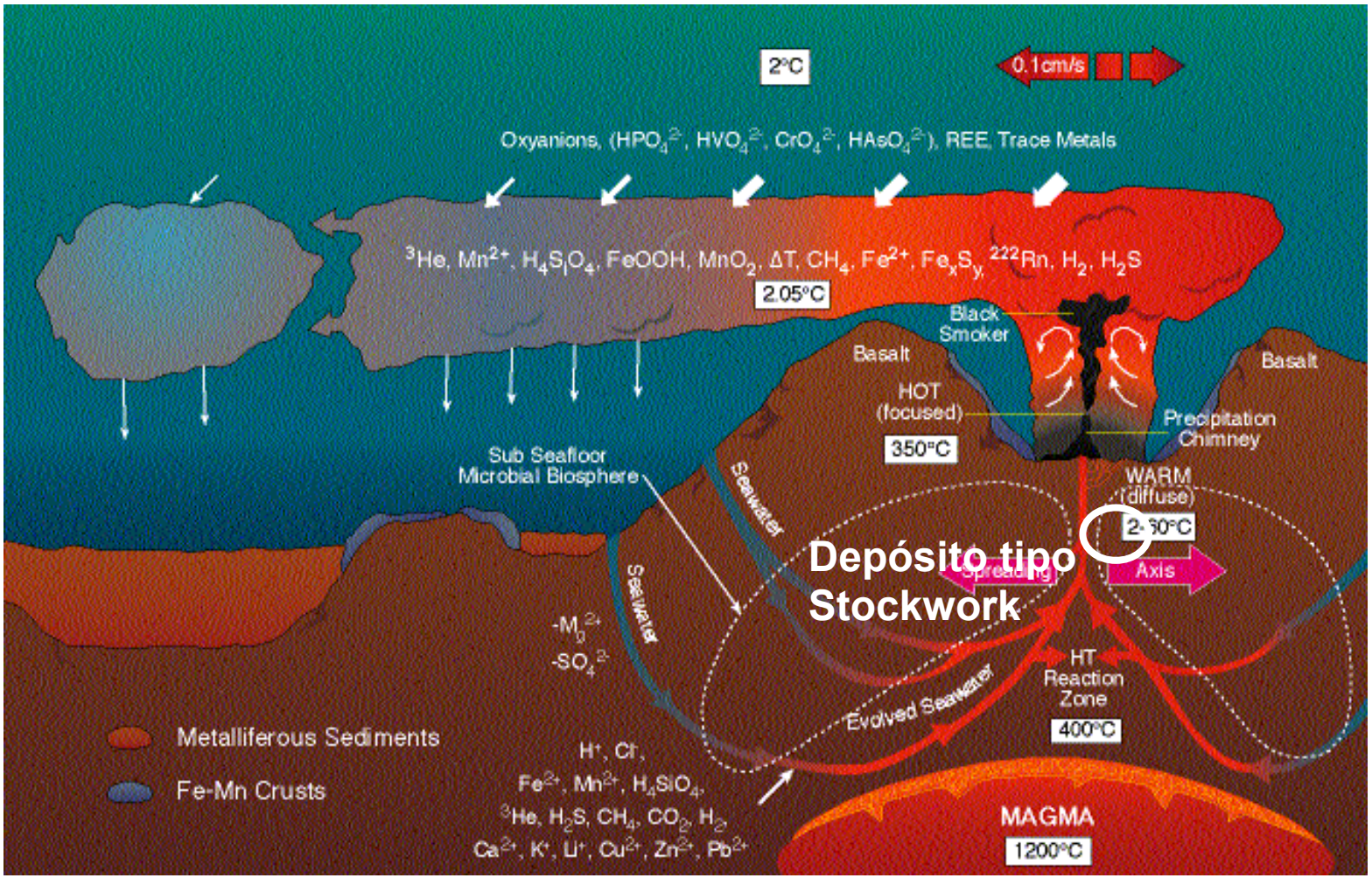
Fluido hidrotermal quente, ácido (pH 2) e rico em H_2S ascende rapidamente e encontra águas frias, alcalinas e oxigenadas do fundo oceânico (Barreira Geoquímica A/D)

Precipitam sulfetos metálicos (Me_nS) e óxidos minerais

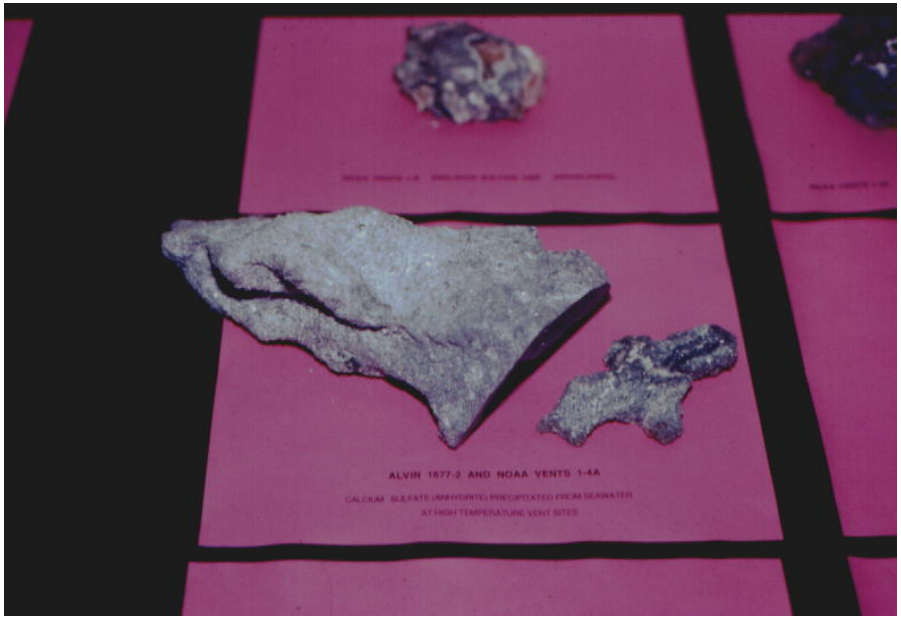
Precipitação contínua de sulfetos e óxidos em torno de respiradouros termais forma chaminés (Black Smoker Chimneys – foto)

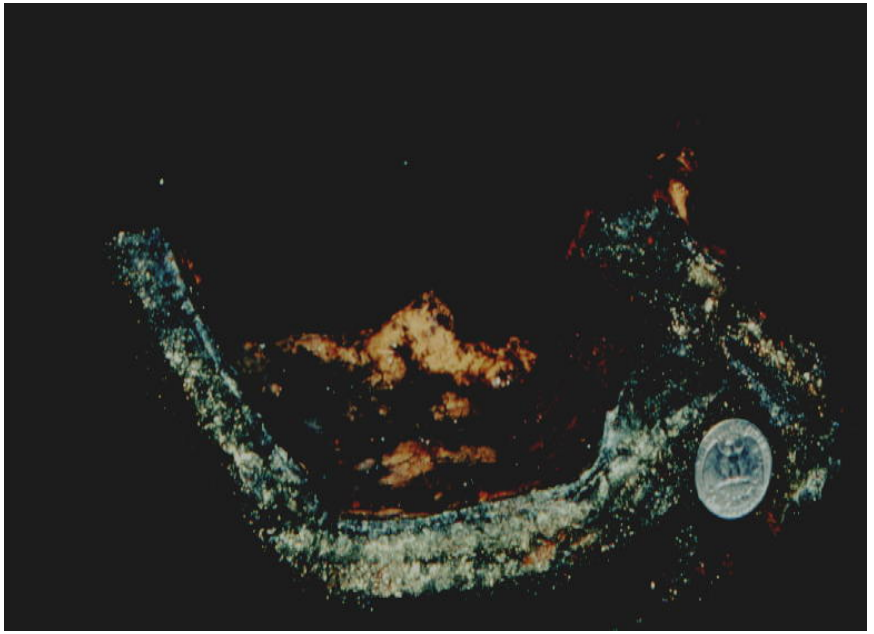
Depósitos de sulfetos metálicos no fundo dos oceanos

Depósitos de sulfetos metálicos no fundo dos oceanos

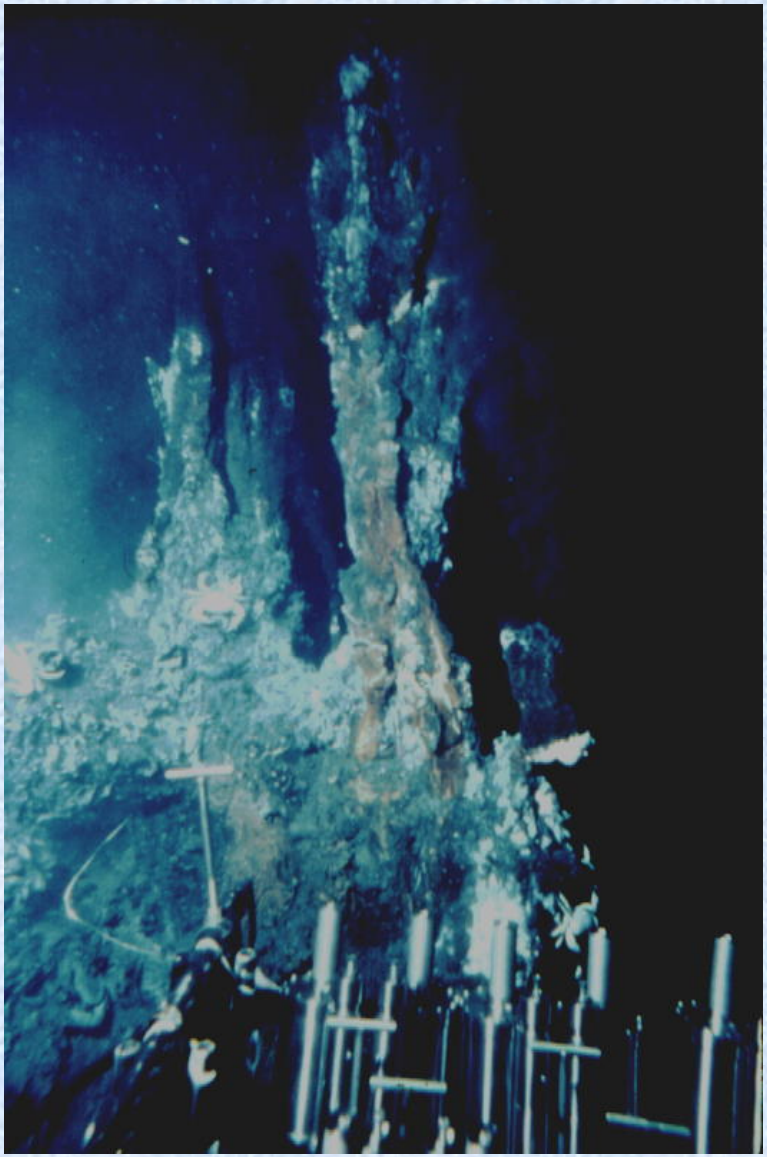


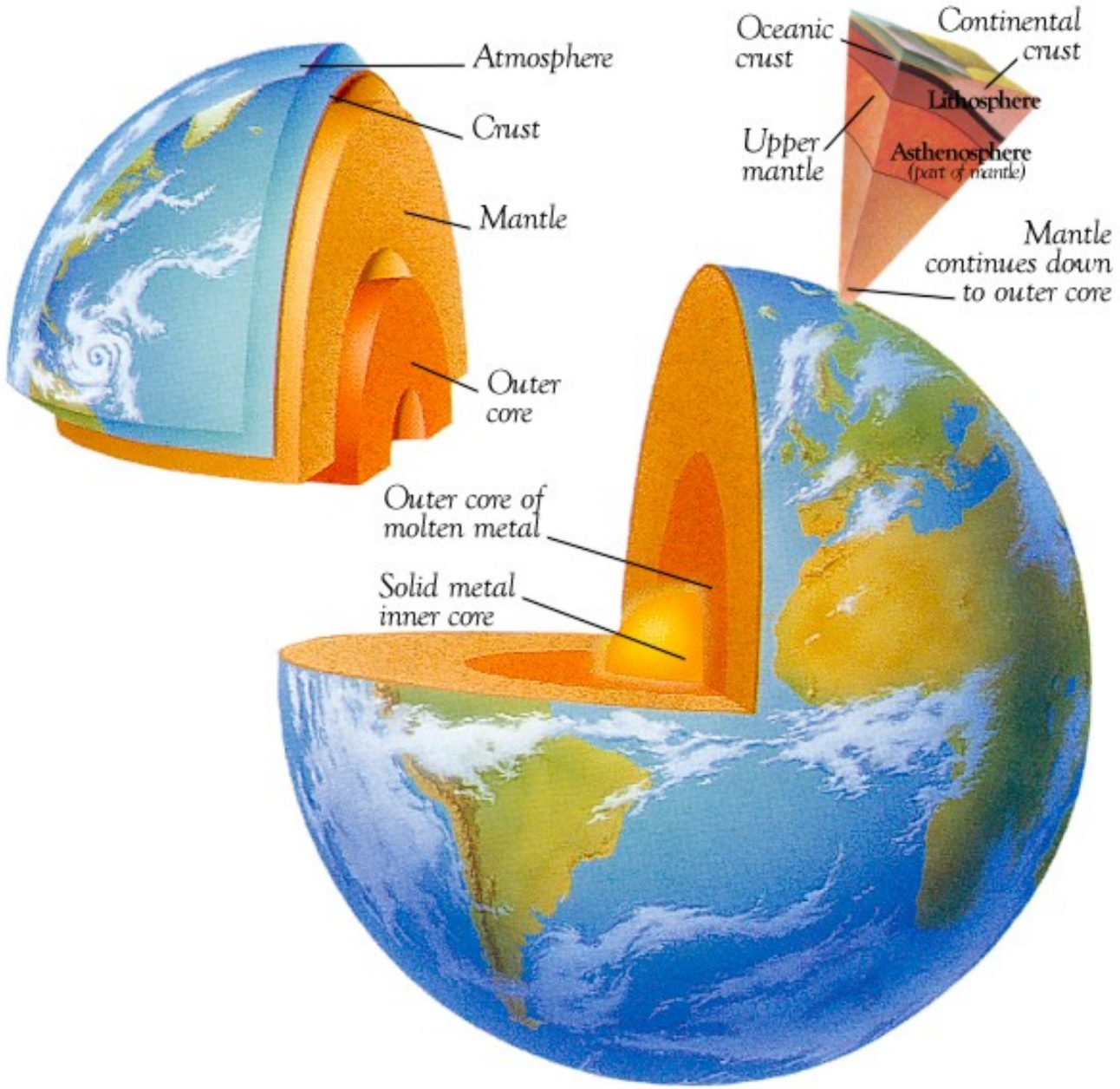
Stockwork: O Corpo da rocha encaixante intensamente cortado por veios mineralizados que se entrecruzam, que o conjunto pode ser explorado, merecendo A designação de minério.

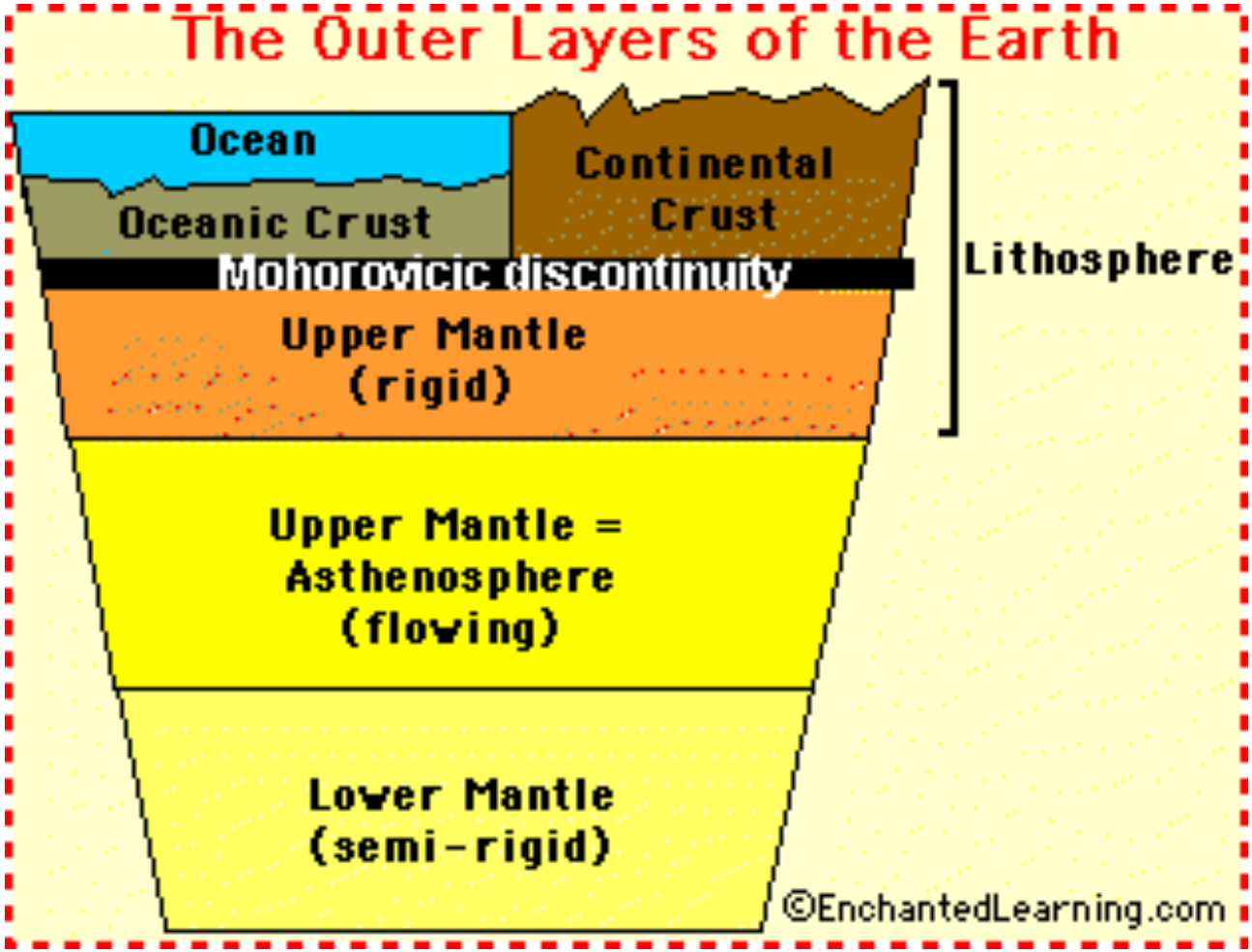

ALVIN 1677-2 AND NOAA VENTS 1-4A

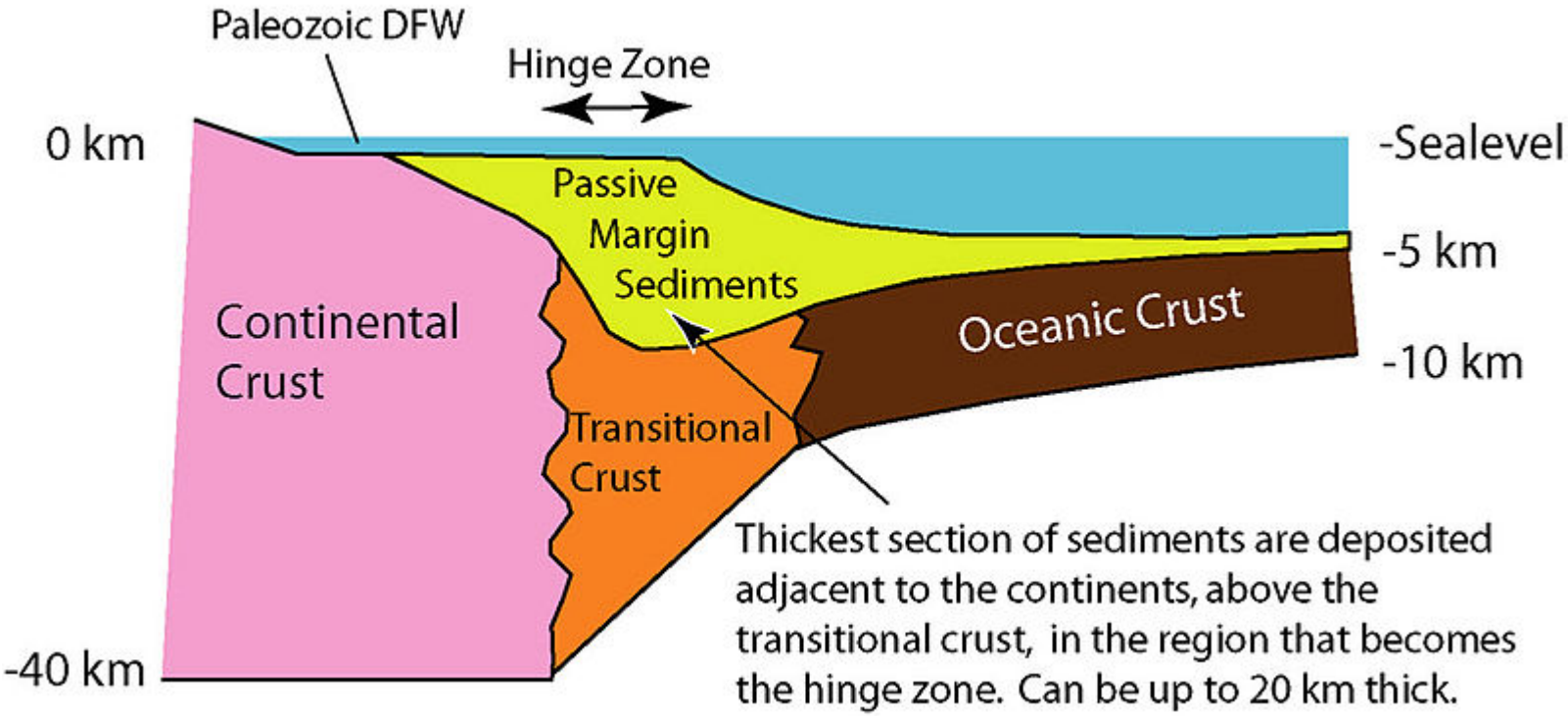


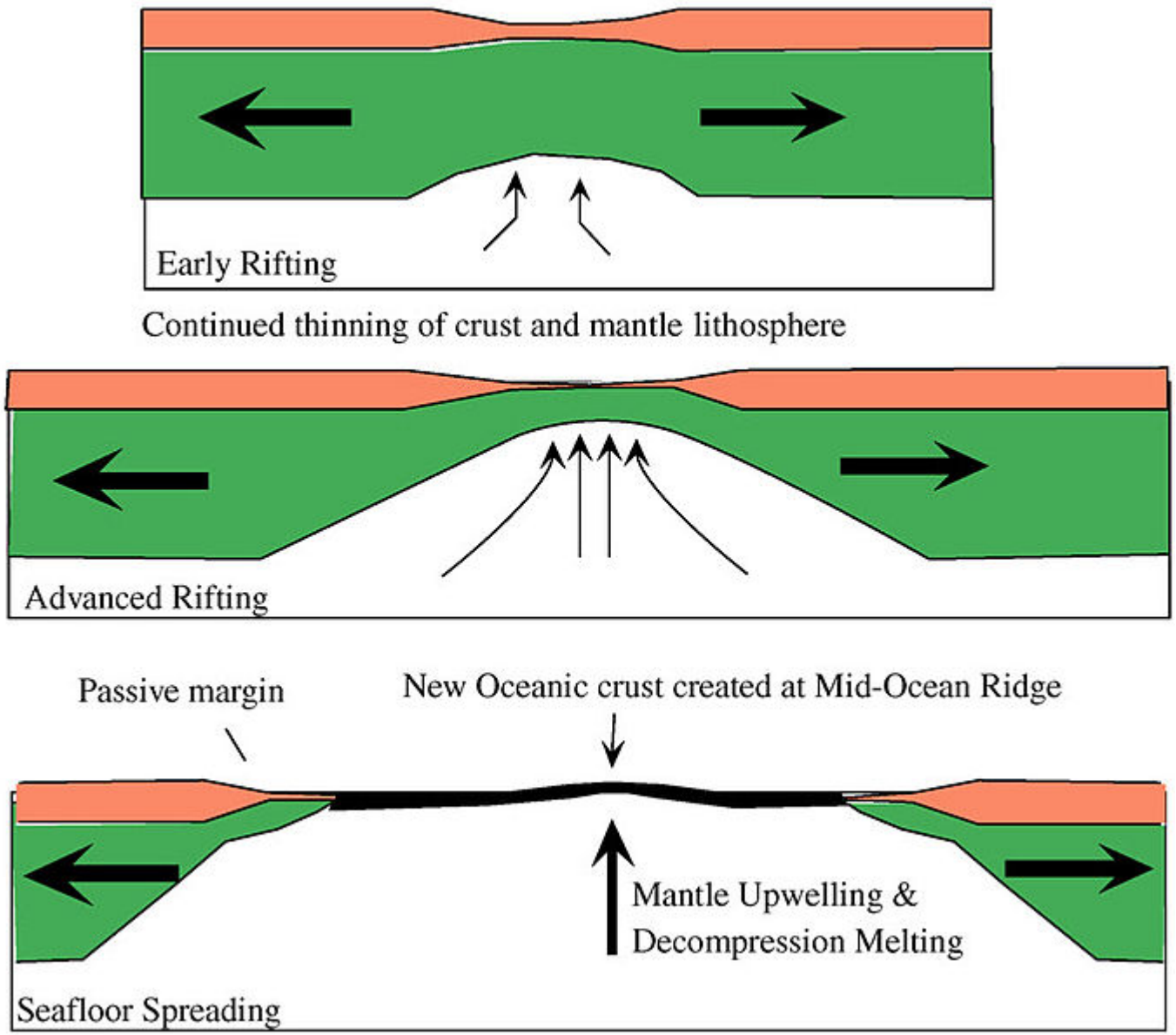
East Pacific Rise

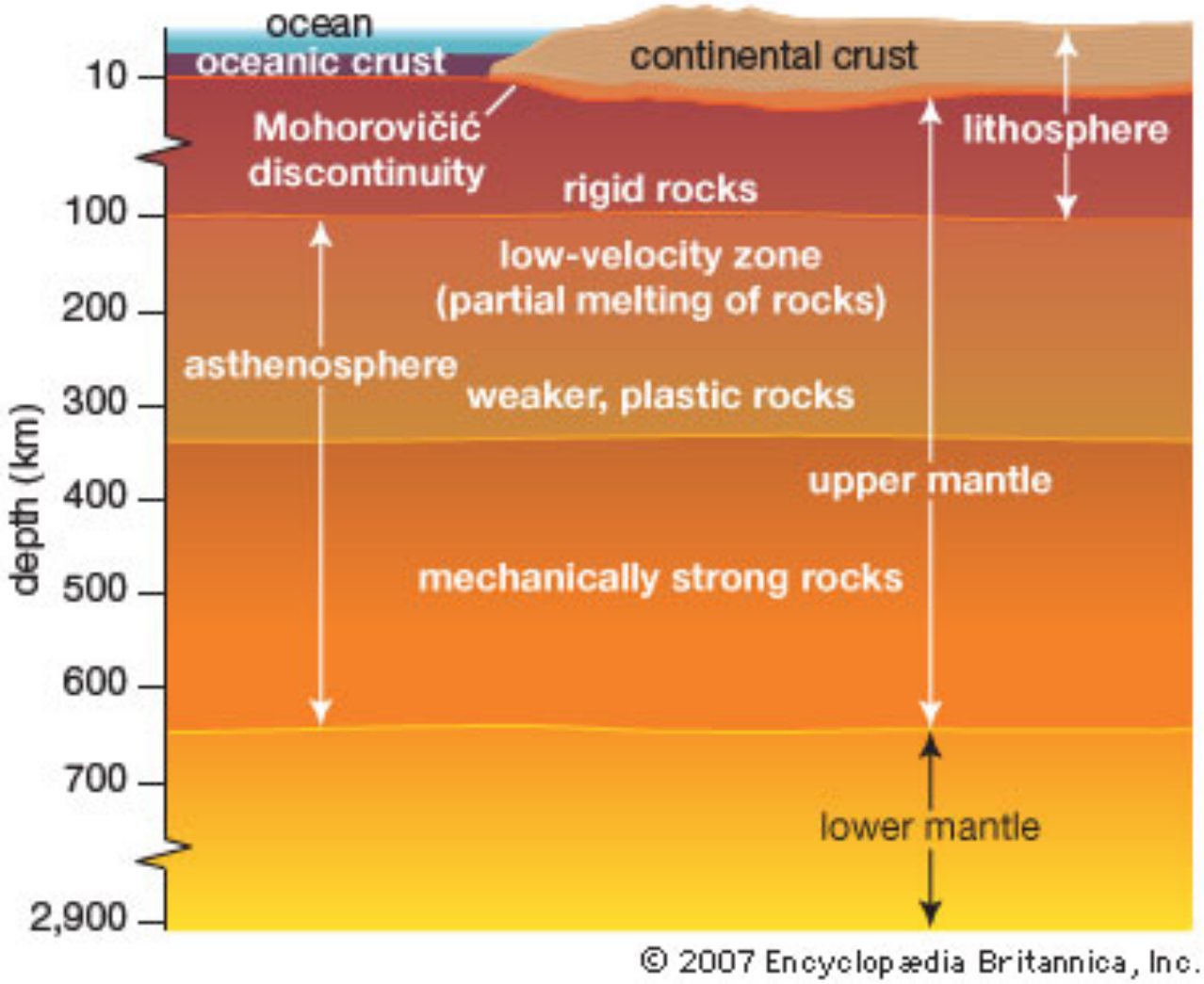



Atmosphere
Crust
Mantle
Outer core
Outer core of molten metal
Solid metal inner core
Oceanic crust
Continental crust
Lithosphere
Upper mantle
Asthenosphere
(part of mantle)
Mantle continues down to outer core

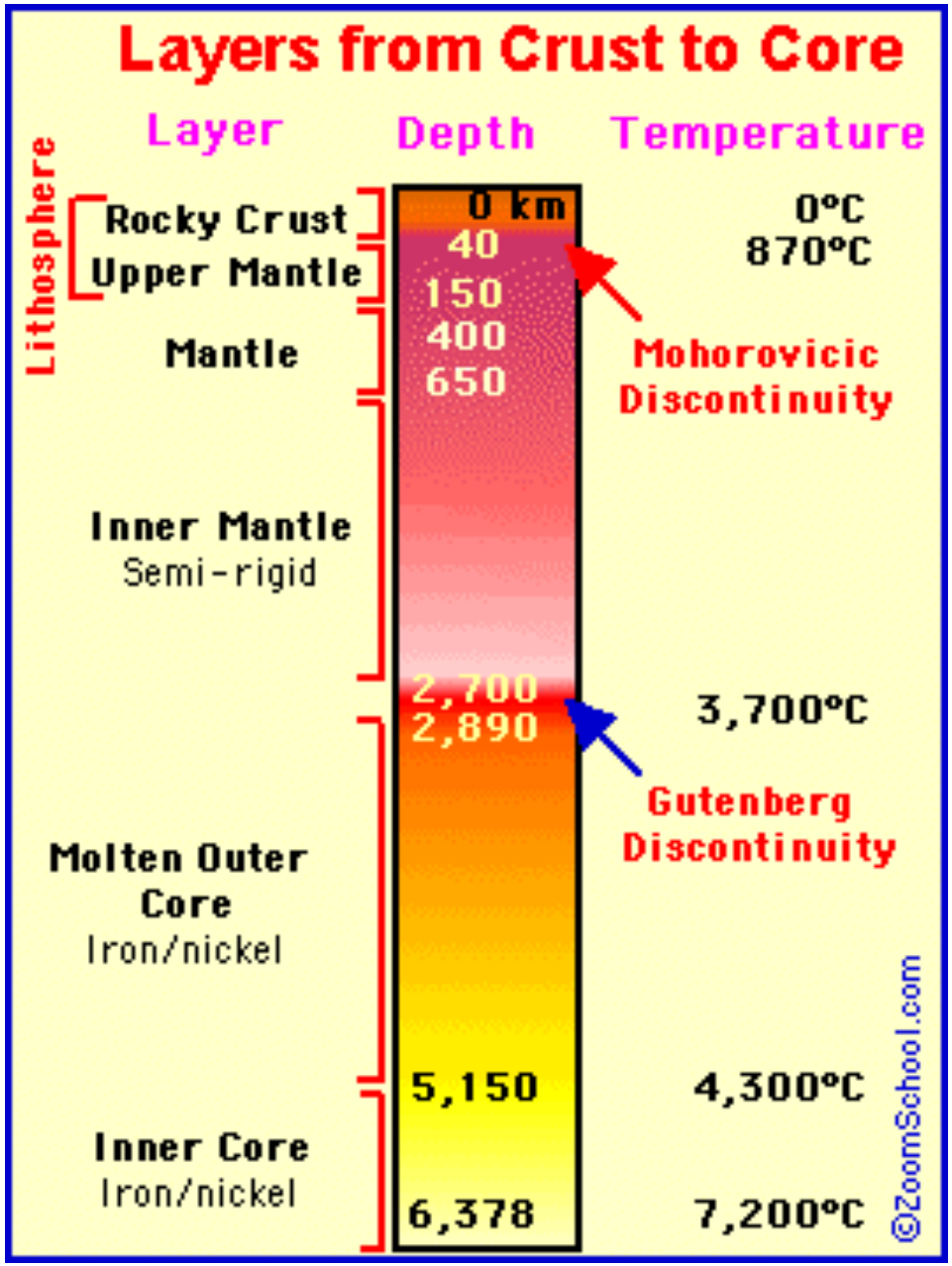

The Outer Layers of the Earth
Ocean
Continental Crust
Oceanic Crust
Mohorovicic discontinuity
Lithosphere
Upper Mantle (rigid)
Upper Mantle = Asthenosphere (flowing)
Lower Mantle (semi-rigid)
©EnchantedLearning.com


Paleozoic DFW
Hinge Zone
0 km
-Sealevel
Passive
Margin
Sediments
-5 km
Continental
Crust
Oceanic Crust
-10 km
Transitional
Crust
-40 km
Thickest section of sediments are deposited
adjacent to the continents, above the
transitional crust, in the region that becomes
the hinge zone. Can be up to 20 km thick.


Early Rifting
Continued thinning of crust and mantle lithosphere
Advanced Rifting
Passive margin
New Oceanic crust created at Mid-Ocean Ridge
Mantle Upwelling &
Decompression Melting
Seafloor Spreading



© 2007 Encyclopædia Britannica, Inc.

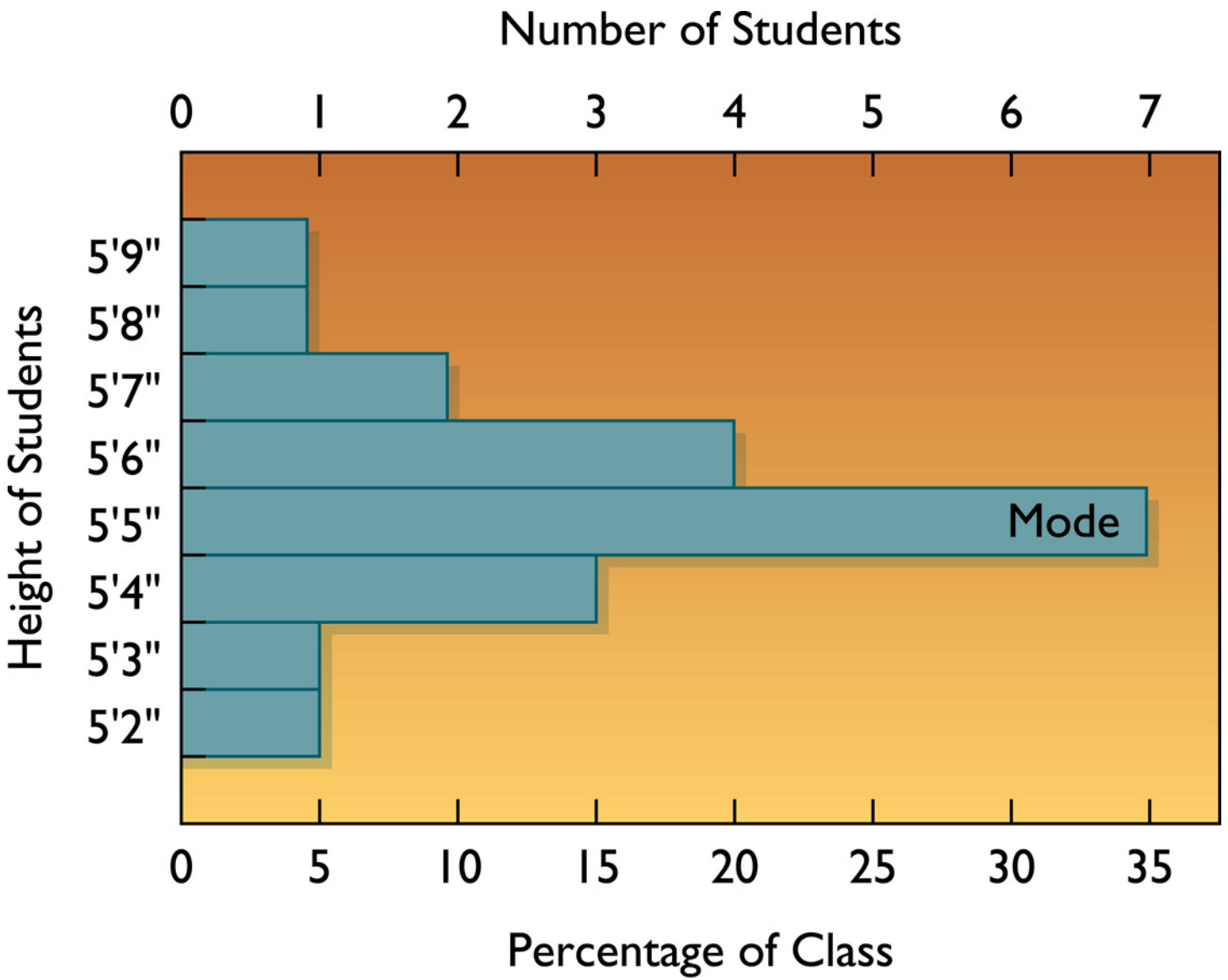

Layers from Crust to Core
Layer
Depth
Temperature
Lithosphere
Rocky Crust
Upper Mantle
Mantle
Inner Mantle
Semi-rigid
Molten Outer Core
Iron/nickel
Inner Core
Iron/nickel
0 km
40
150
400
650
2,700
2,890
5,150
6,378
0°C
870°C
Mohorovicic Discontinuity
3,700°C
Gutenberg Discontinuity
4,300°C
7,200°C
©ZoomSchool.com

- Então: crosta continental, espessa, baixa densidade,granítica: crosta oceânica, fina de alta densidade, basáltica---ambas em contato com rochas mais densas do manto.

- ASSIM, AGORA QUE TEMOS ESSAS IDÉIAS EM MENTE,VAMOS CONSIDERAR UMA TEORIA SIMPLES E VERIFICAR UMA EXPERIÊNCIA ELEMENTAR QUE VAI NOS AJUDAR A RESPONDER A QUESTÃO INICIAL *PORQUE MASSAS CONTINENTAIS E BACIAS OCEÂNICAS EXISTEM ?*

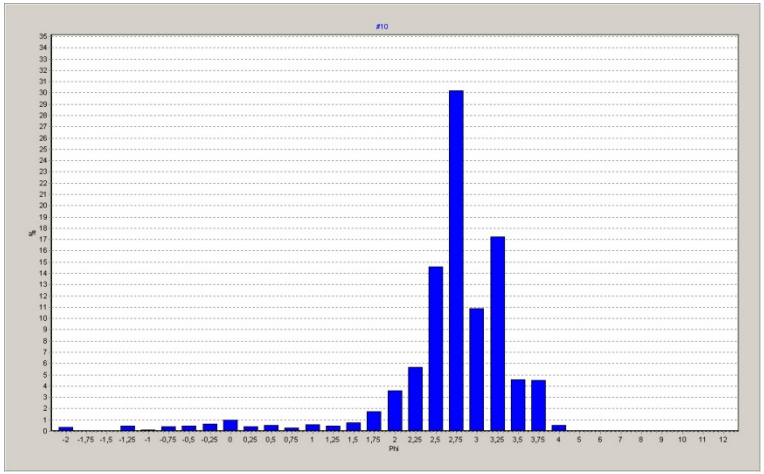
Diferenças geológicas entre continentes e bacias oceânicas

- Uma questão fundamental sobre a crosta terrestre: Exceto pelo contraste óbvio em elevação, a geologia das bacias oceânicas é fundamentalmente diferente da geologia das massas continentais ?
- A resposta para essa pergunta requer medidas detalhadas das elevações terrestres, profundidade e composição das rochas da crosta continental e oceânica

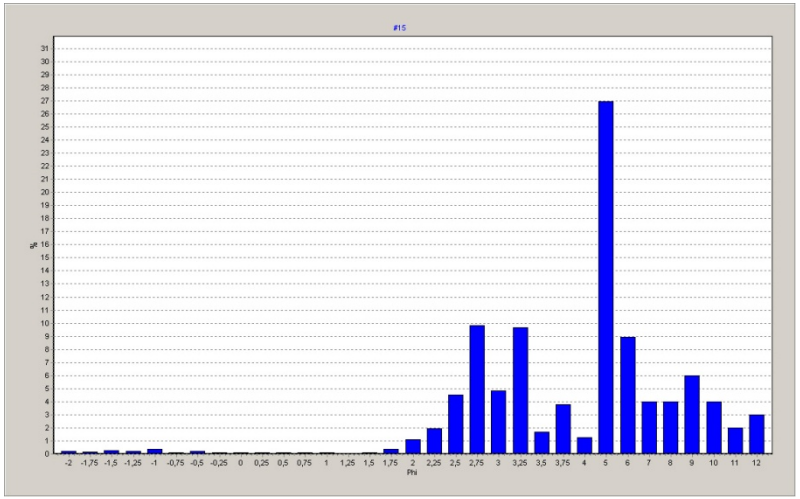


(a) FREQUENCY OF THE HEIGHT OF CLASSMATES

Amostras da ante-praia ao sul do naufrágio do Navio Altair

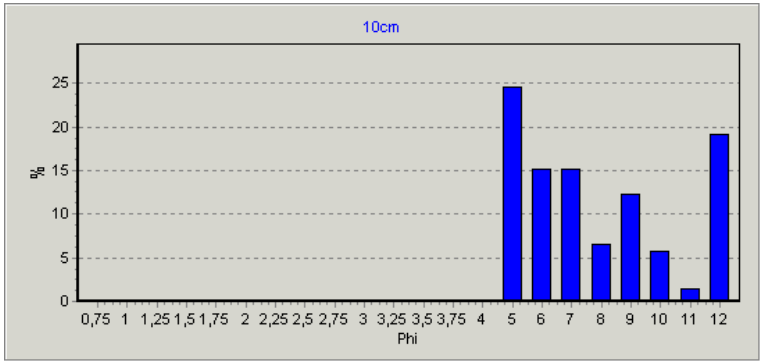


Fundo arenoso- unimodal

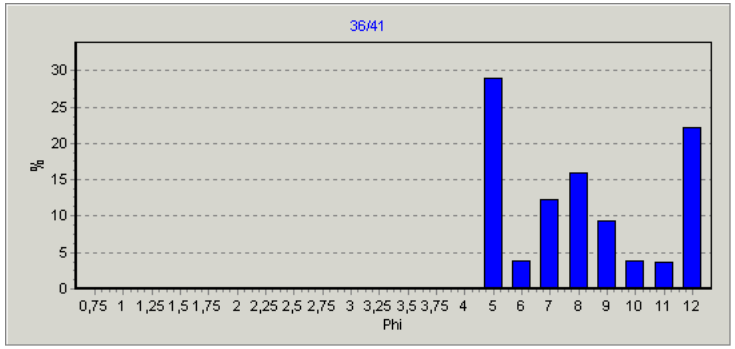


Fundo siltico-areno bimodal

T.9 Topo



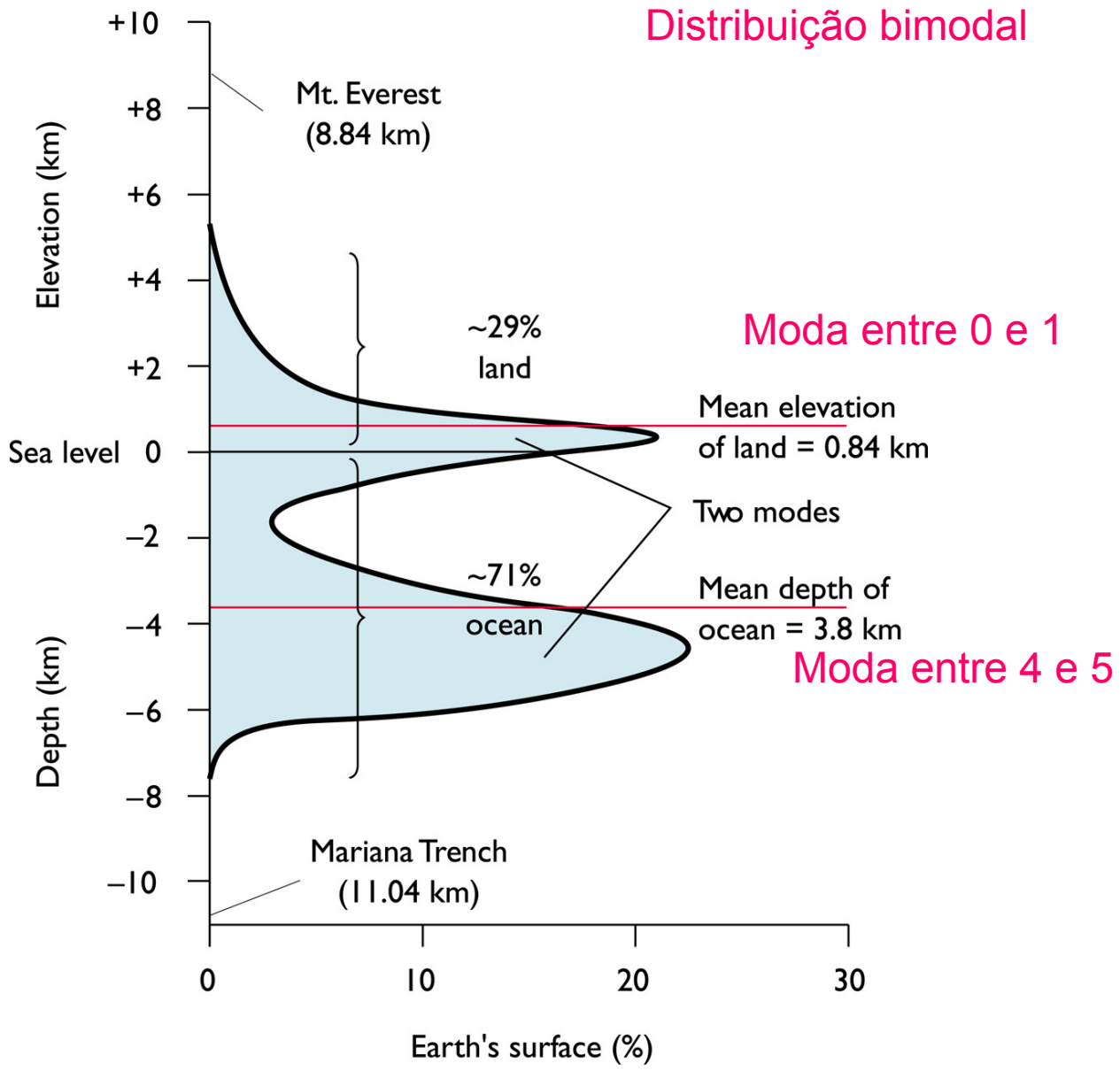
T9(10cm)
Density=1,2786g/cm3
Porosity=0,8413g/cm3
%H2O=60,5%
%Organic Matter=0,67%



T9(36-41cm)
Density=1,3283g/cm3
Porosity=0,8108g/cm3
%H2O=52,9%
%Organic Matter=3,6%

T.9(2) Topo

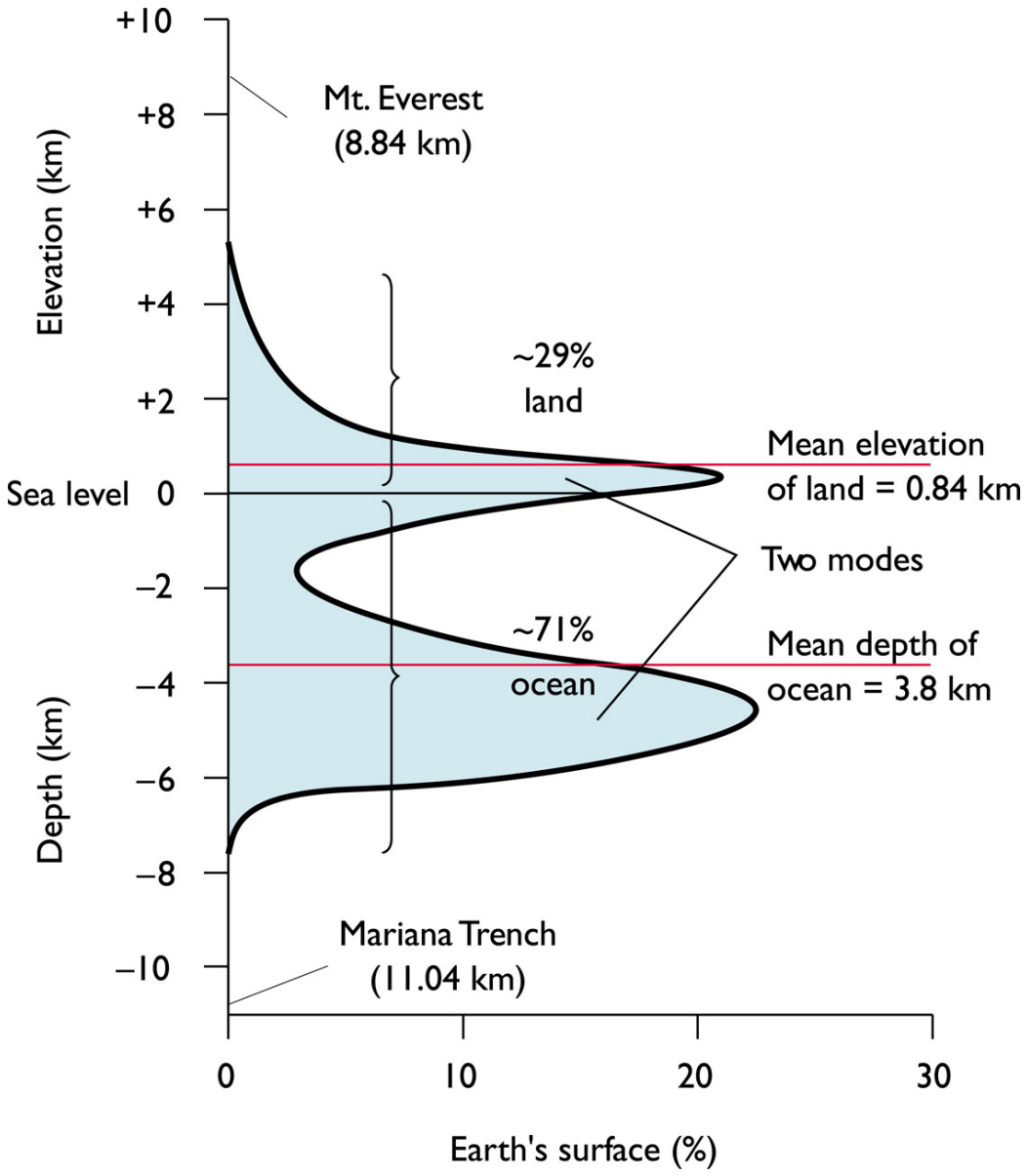
Profundidade 8 m



(b) FREQUENCY PLOT OF TOPOGRAPHY AND BATHYMETRY

- Análise de distribuição de frequência da altura da terra acima do nivel do mar (topografia) e da profundidade abaixo do nivel (batimetria)
- O grafico de frequência mostra que:
- somente cerca de 29% da crosta terrestre se projeta acima do nível do mar
- Montanhas e fossas profundas são feições incomuns independente do seu tamanho.
- A distribuição de frequências é bimodal (lembrar que a moda é o valor mais frequente de ocorrência da variável).Então a distribuição tem duas modas: Uma moda associada com a terra (0 a 1 Km acima do nível do mar) e uma moda associada com a água (4 a 5 Km abaixo do nível do mar).
- Se fosse feita um histograma para altura de colegas numa classe também teríamos uma distribuição bimodal porque haveria uma moda para a altura dos homens e uma moda para a altura das mulheres, então a distribuição de altura é dependente do Sexo. O mesmo raciocínio se aplica para o nossos dados de elevação e profundidade----implica que a CROSTA DOS CONTINENTES E OCEANOS são FUNDAMENTALMENTE DIFERENTES senão a distribuição seria Unimodal.---

- **Basalto e granito: Basalto rocha de coloração escura, vulcânica rica em Oxigênio, Silica e *Magnésio.* Granito---rica em oxigênio, silica e *alumínio.*—O basalto da crosta é significativamente mais denso do que o granito 2,9 g/cm^3 versus 2,7 g/ cm^3 ambas recobrindo rochas do manto que são mais densas (3,3 g/cm^3)---o limite entre a crosta e o manto superior---descontinuidade de Mohorovicic— mais profunda nos continentes do que nos oceanos devido a diferença de espessura (30 a 40 Km no continente e 4 a 10 Km no oceano**



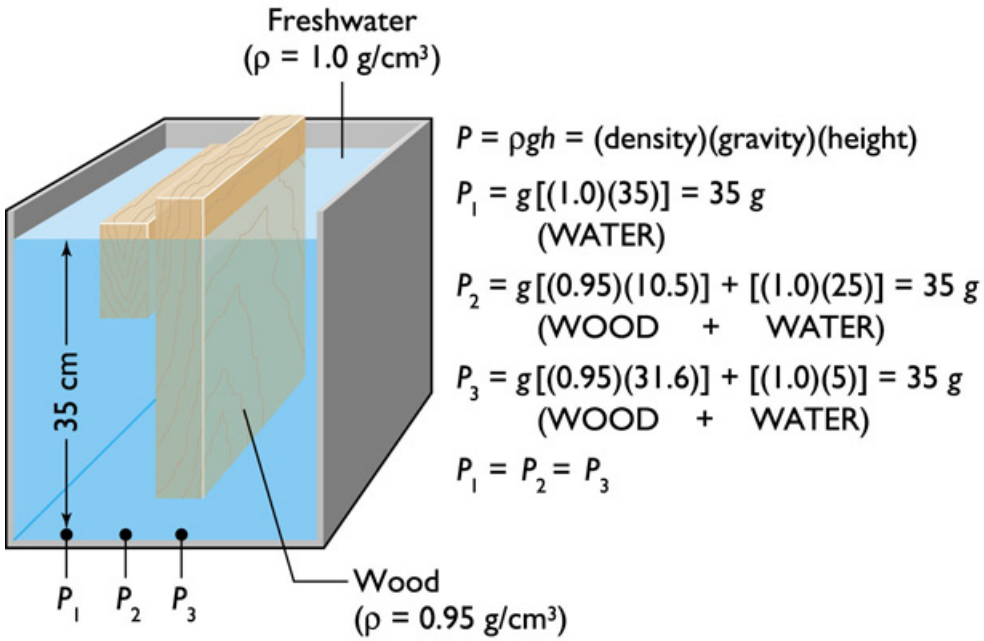
(b) FREQUENCY PLOT OF TOPOGRAPHY AND BATHYMETRY

Balanço de massa e Isostasia

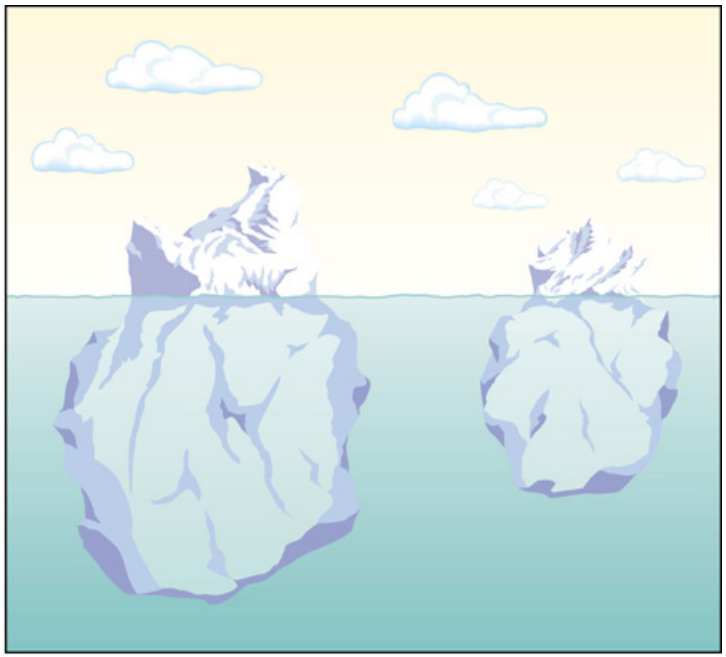
Só água:

A menos que a água seja perturbada, a água parada exerce pressão igual em qualquer lugar do fundo senão,haveria fluxo para igualar a pressão de áreas de pressão mais alta para mais baixa. A pressão no fundo pode aumentar desde que adicionemos mais água ou a resfriamos.Se removermos a água (h) a altura diminui e a pressão decresce

Se mantermos h constante e aumentarmos a densidade resfriando a água a pressão exercida no fundo pela água irá aumentar—A pressão no fundo pode aumentar, desde que aumentemos a altura ou resfriamos a água.

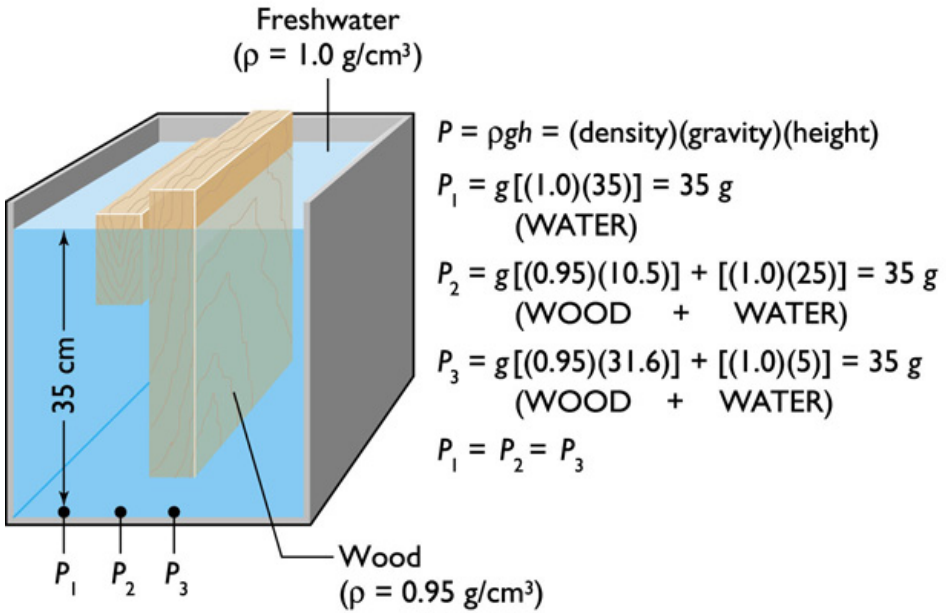


(a) BUCKET EXPERIMENT

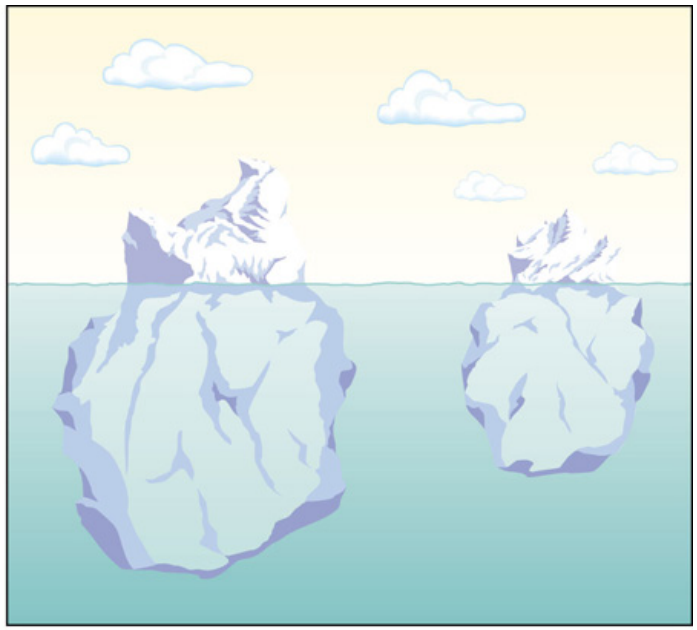


(b) ICEBERGS

A pressão P_1 no fundo do recipiente é proporcional a altura (h), densidade (ρ) da água e força da gravidade (g)



(a) BUCKET EXPERIMENT



(b) ICEBERGS

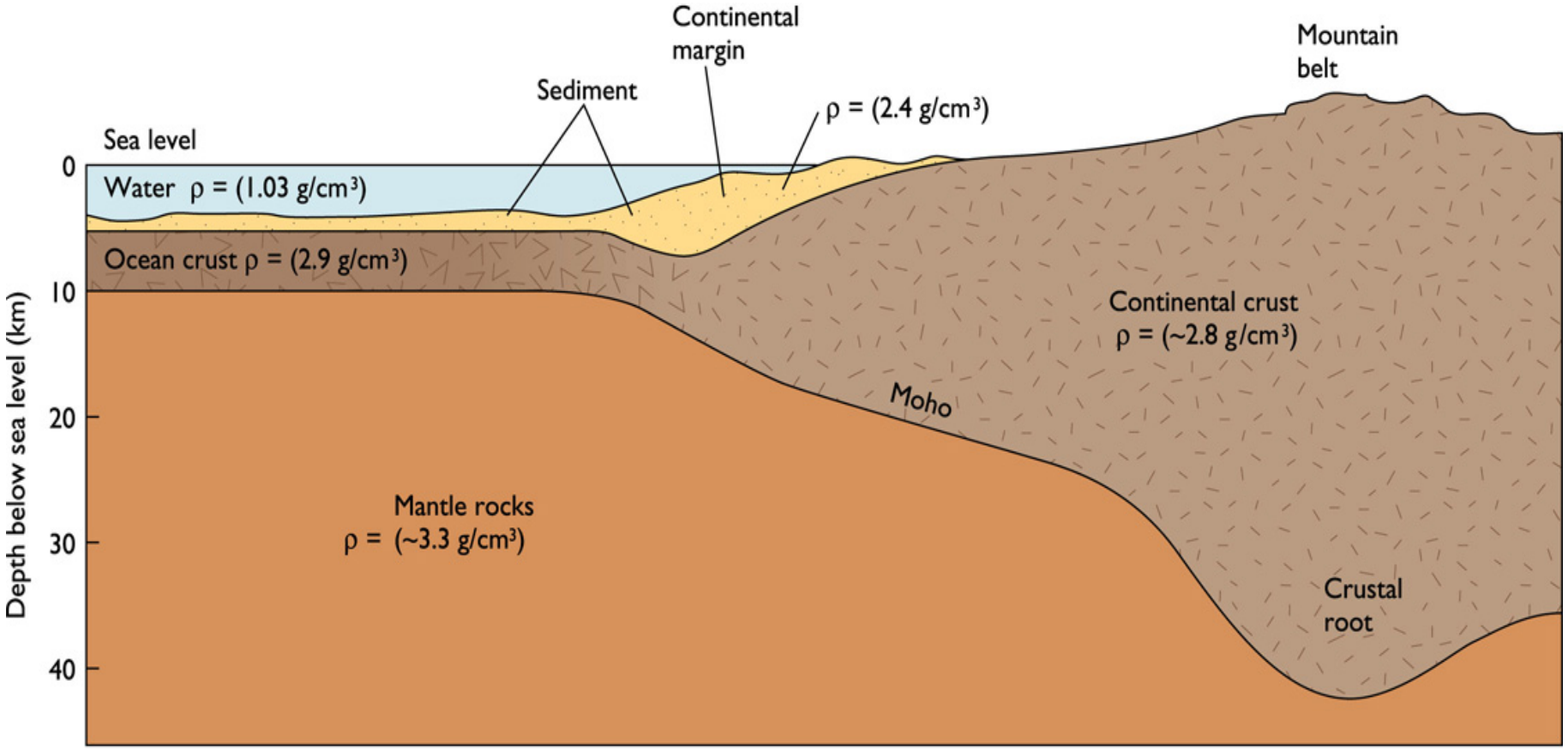
Quanto mais alto o iceberg está do
Nível do mar mais ele mergulha na água para
Manter equilibrio isostático

Colocando um bloco de madeira quebra o balanço de massa, porque a adição de madeira flutuante causa um aumento localizado em pressão no fundo sob o bloco. Sendo um fluído a água flui instantaneamente da área sob o bloco em resposta ao aumento de pressão.Eventualmente o bloco para de descer e subir , a água para de fluir e tudo fica imóvel. Isso significa que a pressão no fundo do recipiente é igual em todos os lugares inclusive sob o bloco independentemente do mesmo se elevar acima da superficie da água.

Verificando a fórmula, uma P constante em todos os lugares significa que onde **h é maior**, (como é no caso do bloco flutuando) **a densidade deve ser menor** (A variável h nesse caso representa a combinação da altura da madeira e da água ($h = h_{madeira} + h_{água}$ Esta é a única maneira para existir o equilibrio porque a gravidade não muda. A DENSIDADE MÉDIA DA COLUNA COM O BLOCO DE MADEIRA é MENOR (MADEIRA DE DENSIDADE MENOR) do que em qualquer lugar no fundo. O aparente excesso de massa de madeira elevando-se acima da superficie da água é compensado pela parte submersa que tem menor densidade. Quanto mais alto for o bloco mais alto ficará sobre a água e mais fundo deve penetrar para haver o equilibrio de massa **-----**

ISOSTASIA É ESSE BALANÇO DE MASSA.

- O principio da ISOSTASIA tem uma aplicação direta na natureza crustal dos continentes e oceanos.
- Podemos explicar a notável distribuição bimodal da topografia terrestre em termos do experimento dos blocos de madeira flutuando na água
- Podemos assim imaginar a crosta continental e oceânica como duas massas rochosas flutuando no manto plástico mais denso. Além disso esses dois tipos de rochas granito nos continentes e basalto nos oceanos tem suas próprias modas características de elevação: Granito 840 m acima do nível do mar e basalto 3.800 m abaixo.
- **ANALOGIA COM O EXPERIMENTO: GRANITO E BASALTO VÃO SER EQUIVALENTES A DOIS BLOCOS DE DIFERENTES TIPOS DE MADEIRA FLUTUANDO NA ÁGUA (EQUIVALENTE AO MANTO)AOS NÍVEIS APROPRIADOS A SUA DENSIDADE**
- OS CONTINENTES ELEVAM-SE ACIMA DO OCEANO DEVIDO A SUA CROSTA GRANÍTICA LEVE E ESPESSA E AS BACIAS OCEÂNICAS SÃO BAIXAS DEVIDO A SUA CROSTA FINA E DENSA.
- Descontinuidade de Mohorovicic (MOHO)---3 a 4 vezes mais profundo sob os continentes do que sob as bacias oceânicas.



(c) OCEANIC CRUST VERSUS CONTINENTAL CRUST

Isostasy (Greek isos = "equal", stásis = "standstill") is a term used in geology to refer to the state of gravitational equilibrium between the earth's lithosphere and asthenosphere such that the tectonic plates "float" at an elevation which depends on their thickness and density. This concept is invoked to explain how different topographic heights can exist at the Earth's surface.