海洋地質

海洋地質發展的四個階段

- 一、1872年以前
  - 主要著重在海岸及淺海地區
  - 研究的重點有四：
  - 1.海洋無脊椎動物的生物地理 (E.Forbes)
  - 2.珊瑚環礁之成因 (C.Darwin)，同時以珊瑚之分佈對古老的海洋地層作古地理的解釋 (P.M.Duncan)
  - 3.波浪及洋流對沙層的效應 (H.C.Sorby)
  - 4.海洋的環流型態及對沉積物之影響 (W.B.Carpenter)

二、挑戰者號之研究期間 (1872－1876)

- 挑戰者號 H.M.S.Challenger 在英國皇家學會及皇家海軍聯合支持下作了三年半的探測 (1872,12,21－1876,5,24) 由 G.S.Nares 船長指揮。
- 挑戰者號的測量：1.海面至各不同深度的水溫,2.採取沉積物,3.拖網收集海洋動物及植物, 4.用拖曳法在海床上採樣,5.量測水深。
- 貢獻：1.完成50大本探測研究報告,2.對大洋有規劃探測的先鋒 ,3.建立對深海海盆認識的基礎, 4.對深海沉積物之分類及觀念建立,5.對海洋微體生物之描述 ,6.對錳核之描述 ,7.對來自外太空隕石粒之描述。

三、挑戰者號以後至第二次世界大戰之間

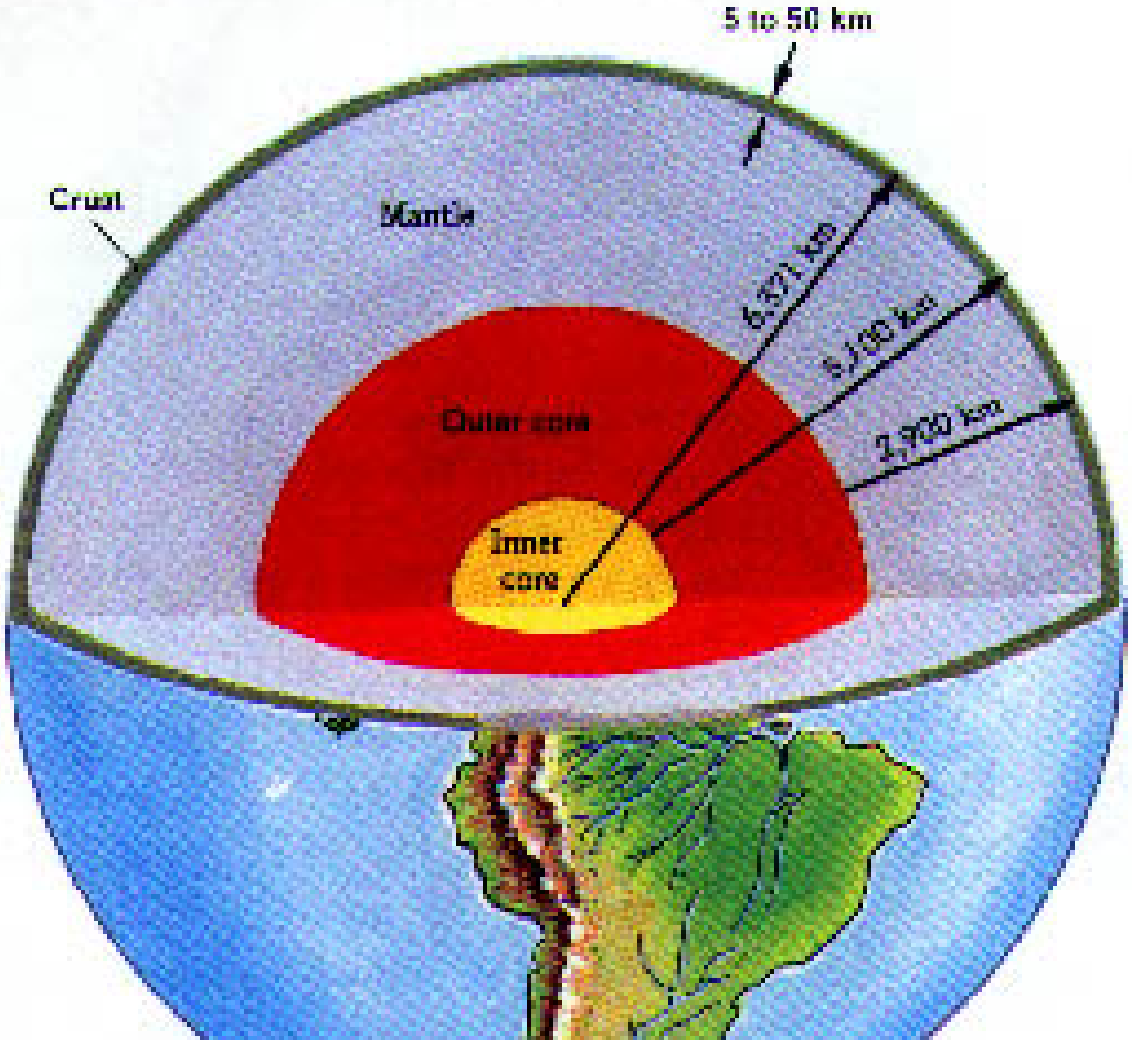
- 主要著重在有規劃的大洋探測
- 1.深海沉積物首次被德國南極探測計劃(1906－1908) 中採得。
- 2.德國流星號 (Meteor) 在1920年代於南大西洋探測中首次使用音波來測水深。
- 3.以音波所測之海床水深分佈圖首次於1939年被Veatch和Smith出版。

四、第二次世界大戰以後

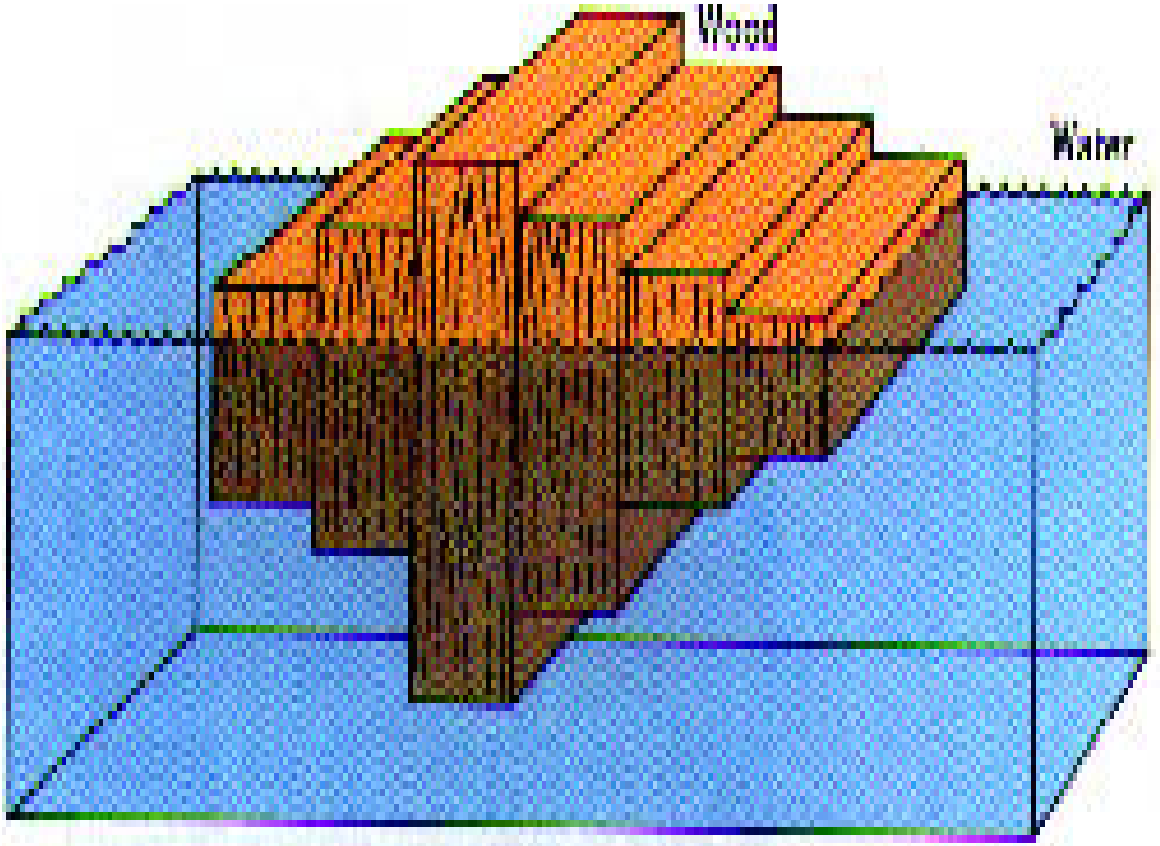
- 1.海洋地球物理急速發展 2.準確的音波測深 3.大量採集海床沉積物
- 4.板塊構造學說成立 5.開始深海鑽探計劃 6.開始國際合作
- 7.發展深海直接觀測 8.各國成立海洋研究所 9.海洋地質及地球物理之研究應用在經濟發展及外海石油探勘上

Earth's layered structure

FIGURE 3-1
Earth's layered structure, showing the thickness of each layer. (After Judson, Kauffman, and Leet, 1987.)



3-2



IGURE 3-2
sostasy is a condition of floating
quilibrium represented here by wooden
locks floating in water. The tops of the
nickest blocks stand highest above the
ater surface. (After Judson, Kauffman,
nd Leet, 1987.)

Lithosphere 3-3

FIGURE 3-3
Schematic representation of lithosphere (consisting of continental crust, oceanic crust, and upper mantle) floating on the asthenosphere. (After Judson, Kaufman, and Leet, 1987.)

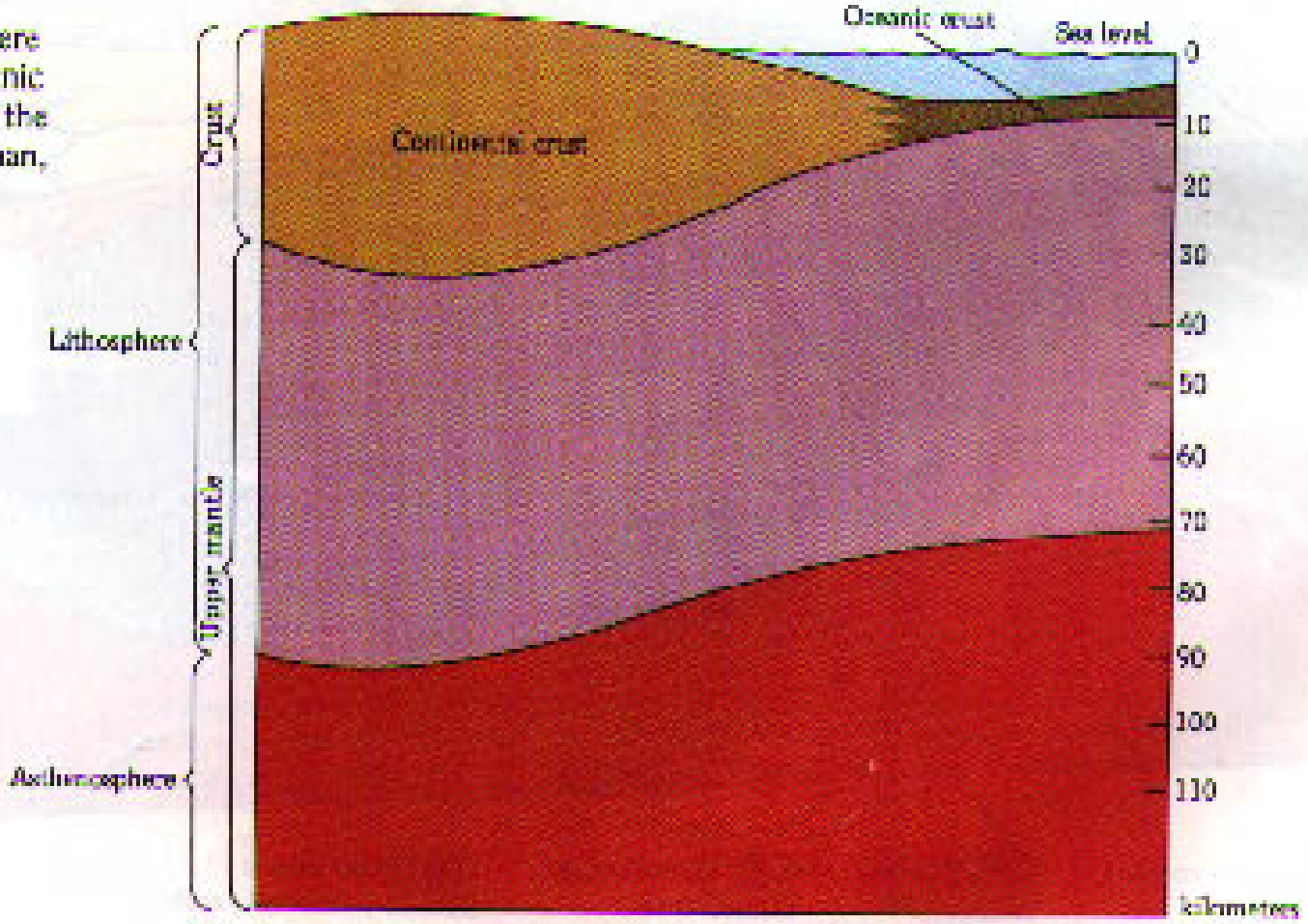
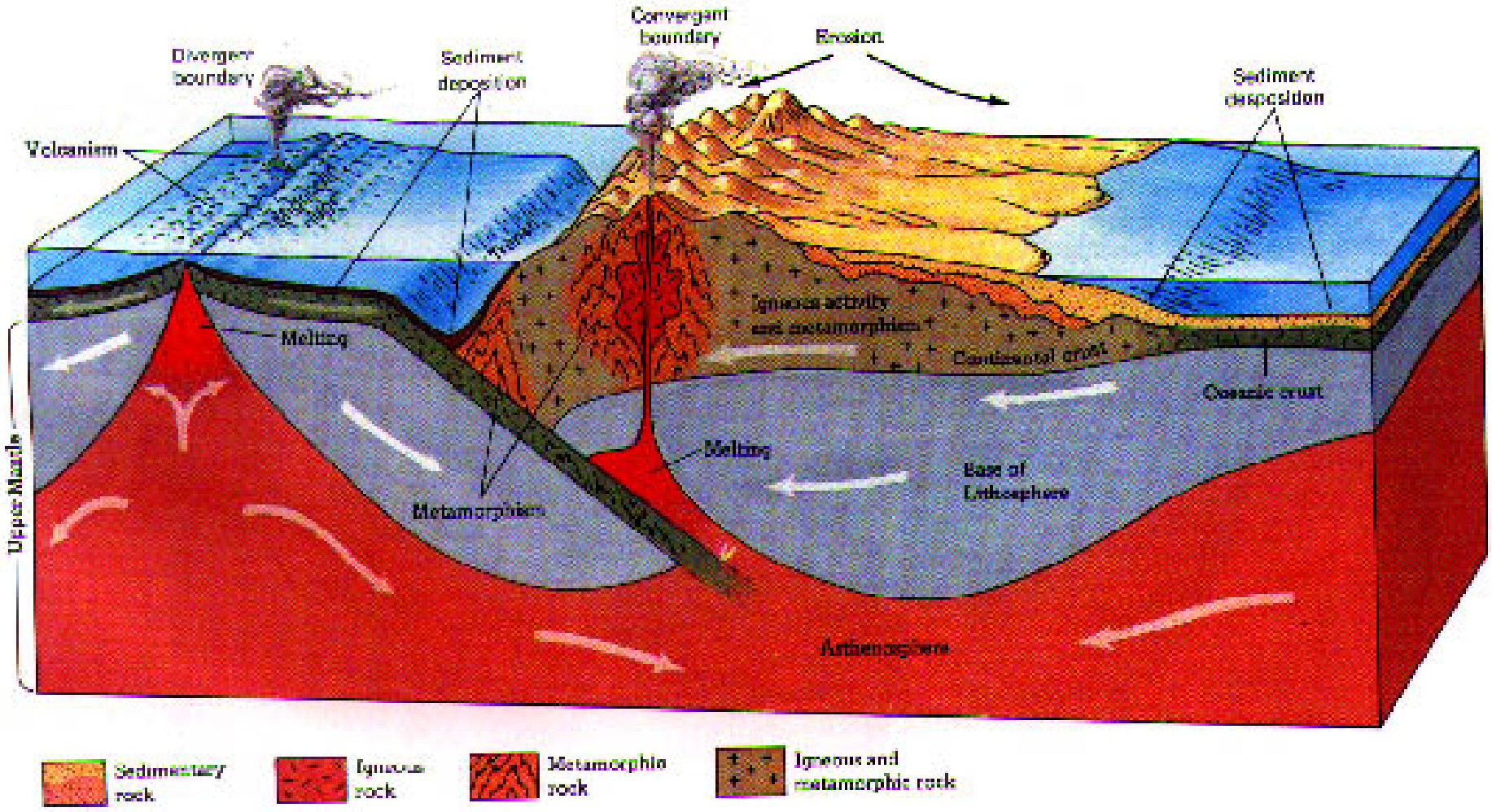


Plate tectonics 3, 4

FIGURE 3-4
Schematic representation of the major processes of plate tectonics. Convergent and divergent plate boundaries are shown. Arrows show directions of plate movements. (After Judson, Kauffman, and Leet, 1987.)



3-5

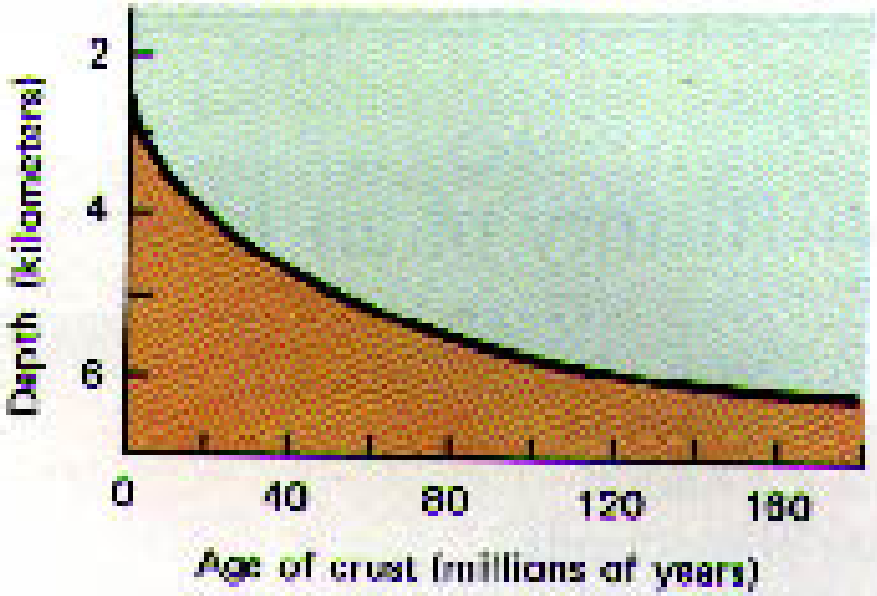
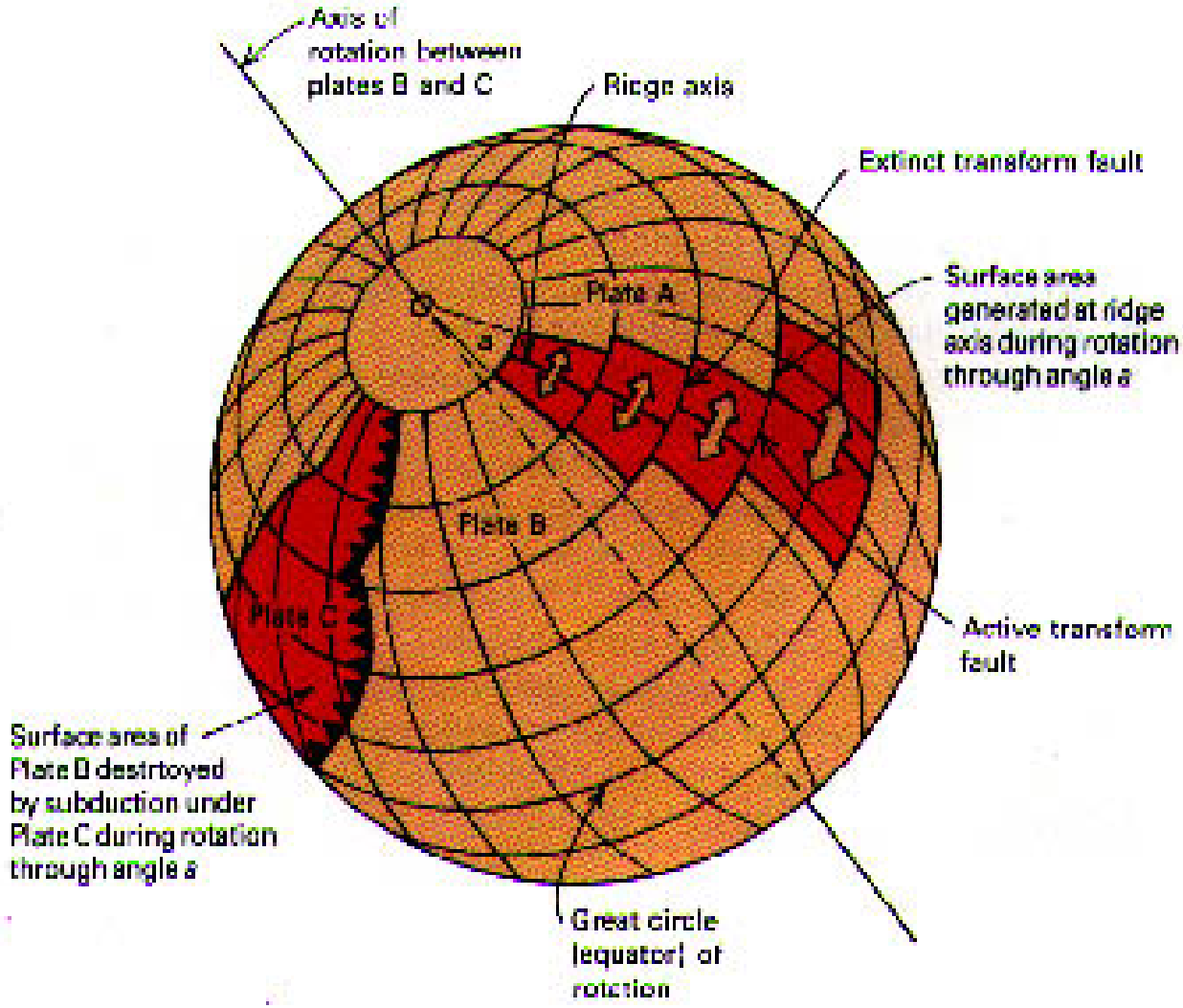


FIGURE 3-5
Ocean-bottom depths increase with age of the crust. The shallowest ocean bottom is the midocean ridges. The deepest and oldest crust occurs near land (After J. G. Sclater, R. N. Anderson, and M. L. Bell, 1971. The elevation of ridges and evolution of the central eastern Pacific. *J. Geophys. Res.* 76:7888–7915.)

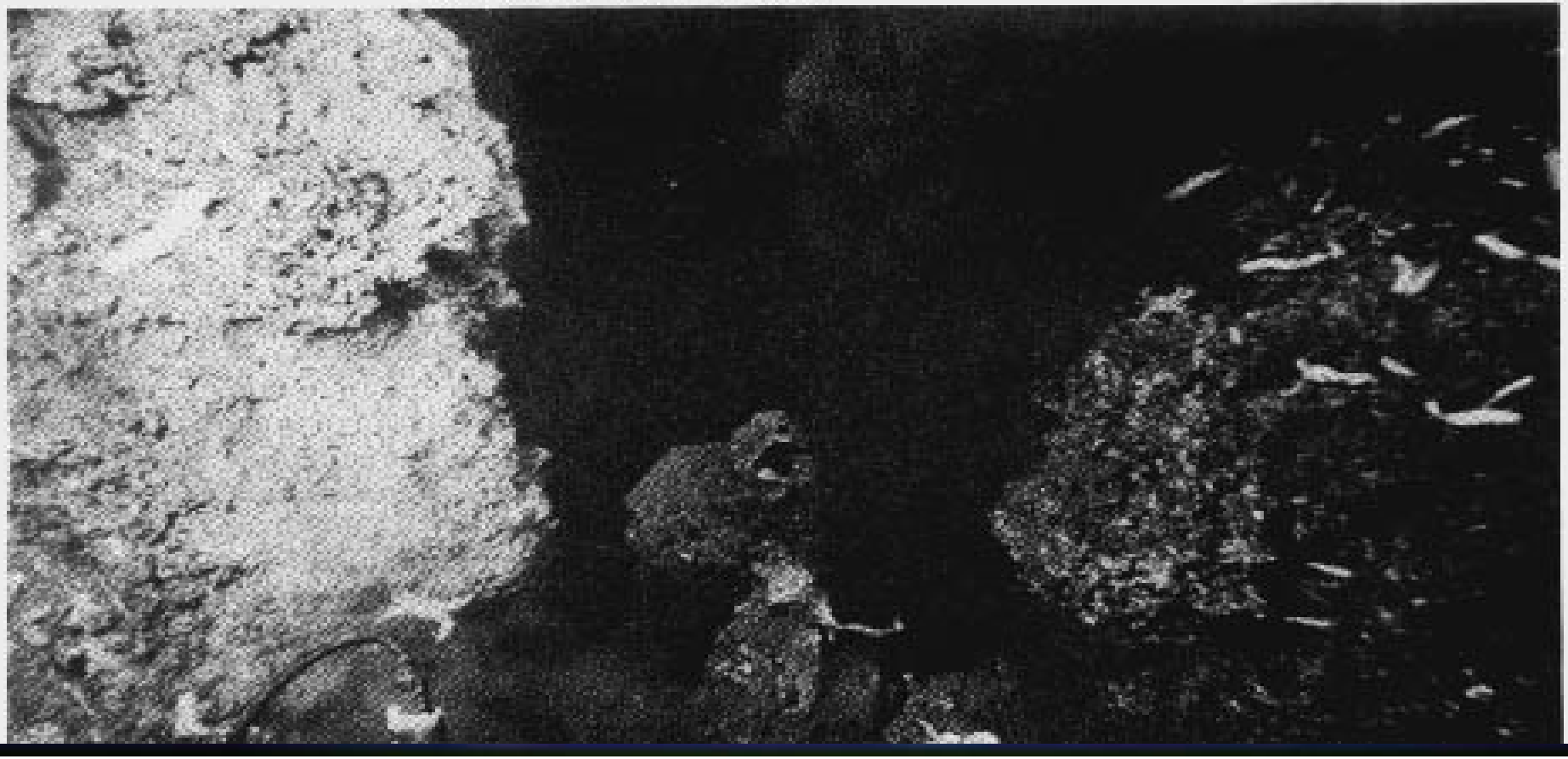
3-6

FIGURE 3-6
Representation of three rigid plates moving on the surface of a sphere. The relative rates of motion are least at the poles and greatest midway between them. Relative differences in motion are taken up along transform faults. As Plate B rotates through angle a (shown at top), new surface is added at the ridge crest. An equal amount of plate is destroyed by subduction. (After Kennett, 1982.)



3-12

FIGURE 3-12
A black smoker on the East Pacific Rise. (Photograph by Dudley Foster, courtesy Woods Hole Oceanographic Institution.)



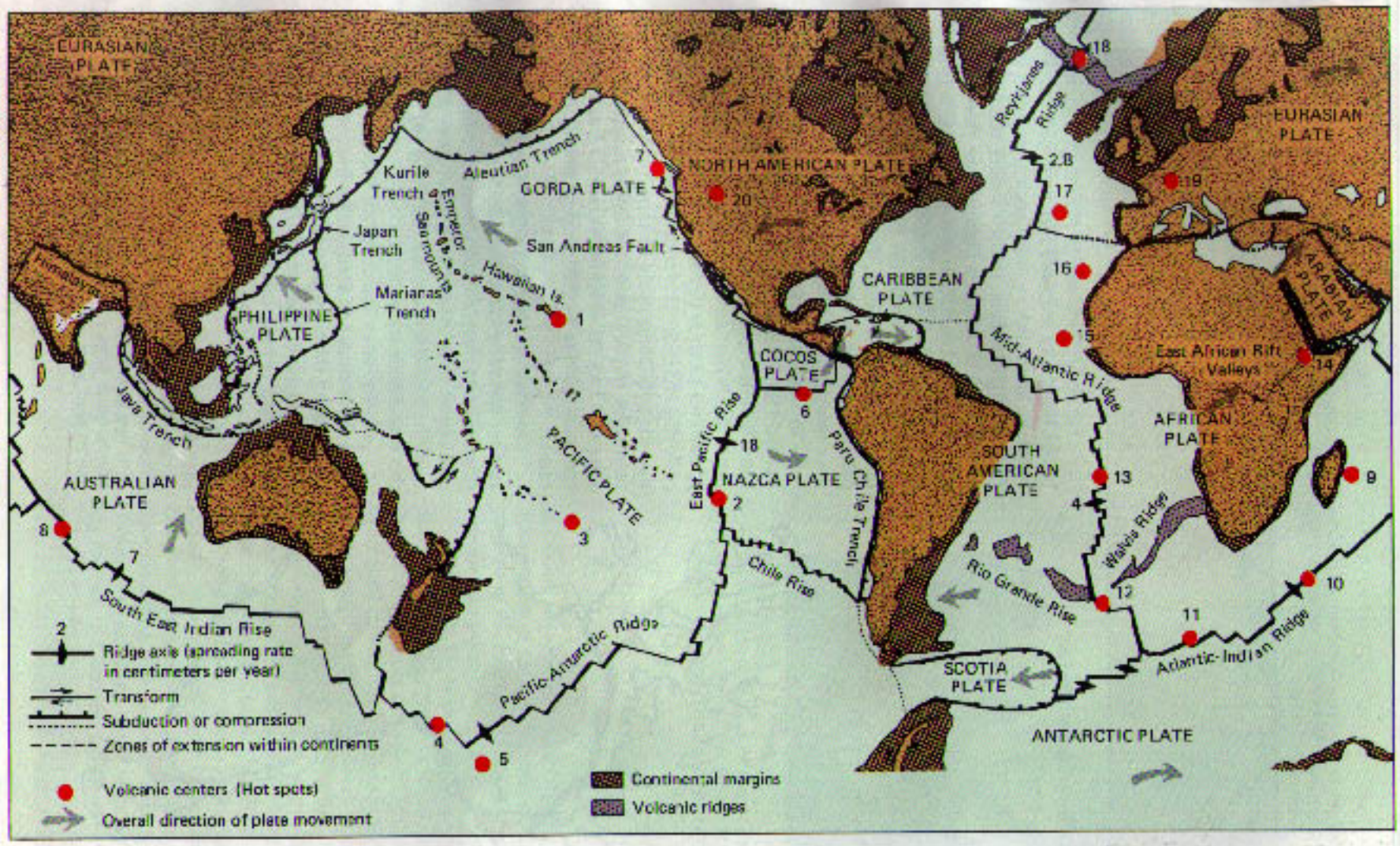


FIGURE 3-7
Major lithospheric plates and their boundaries, showing principal hot spots. Legend: 1. Hawaii, 2. Easter Island, 3. Macdonald Seamount, 4. Bellany Island, 5. Mt. Erebus, 6. Galapagos Islands, 7. Cobb Seamount, 8. Amsterdam Island, 9. Reunion Island, 10. Prince Edward Island, 11. Bouvet Island, 12. Tristan da Cunha, 13. St. Helena, 14. Afar, 15. Cape Verde Islands, 16. Canary Islands, 17. Azores, 18. Iceland, 19. Eifel, 20. Yellowstone. (After D. L. Anderson, 1971. The San Andreas Fault. *Scientific American* 225(11).)

板塊運動的主要現象

- 1.每一板塊上大陸的面積與板塊移動的速度成反比。
  - Ex.　　歐亞板塊的角速度是 0.038°/百萬年
  - 南極板塊的角速度是 0.054°/百萬年
  - 海洋地殼爲主的板塊移動速率較快
  - Ex.　　柯克斯板塊　　1.422°/百萬年
  - 太平洋板塊　　0.967°/百萬年
- 2.板塊的移動速度與板塊邊界消耗的百分比有關。隱沒作用的存在是板塊移動的主要因素。

板塊運動的主要現象(Cont)

- 3.分裂洋脊之長度與板塊移動速度無明顯的關係，板塊運動單由產生新海洋地殼的洋脊處之推動而來的。
- 4.板塊移動速度與地理緯度有關。在接近赤道之處板塊移動較快，在近極地之處則移動較慢。
- 5.板塊四周即使沒有分裂洋脊也會移動，就像菲律賓海板塊一樣。因此，洋脊上的推力並不是唯一的起動力。
- 6.即使沒有下沉的板塊邊緣相連，洋脊兩側的板塊仍會分離

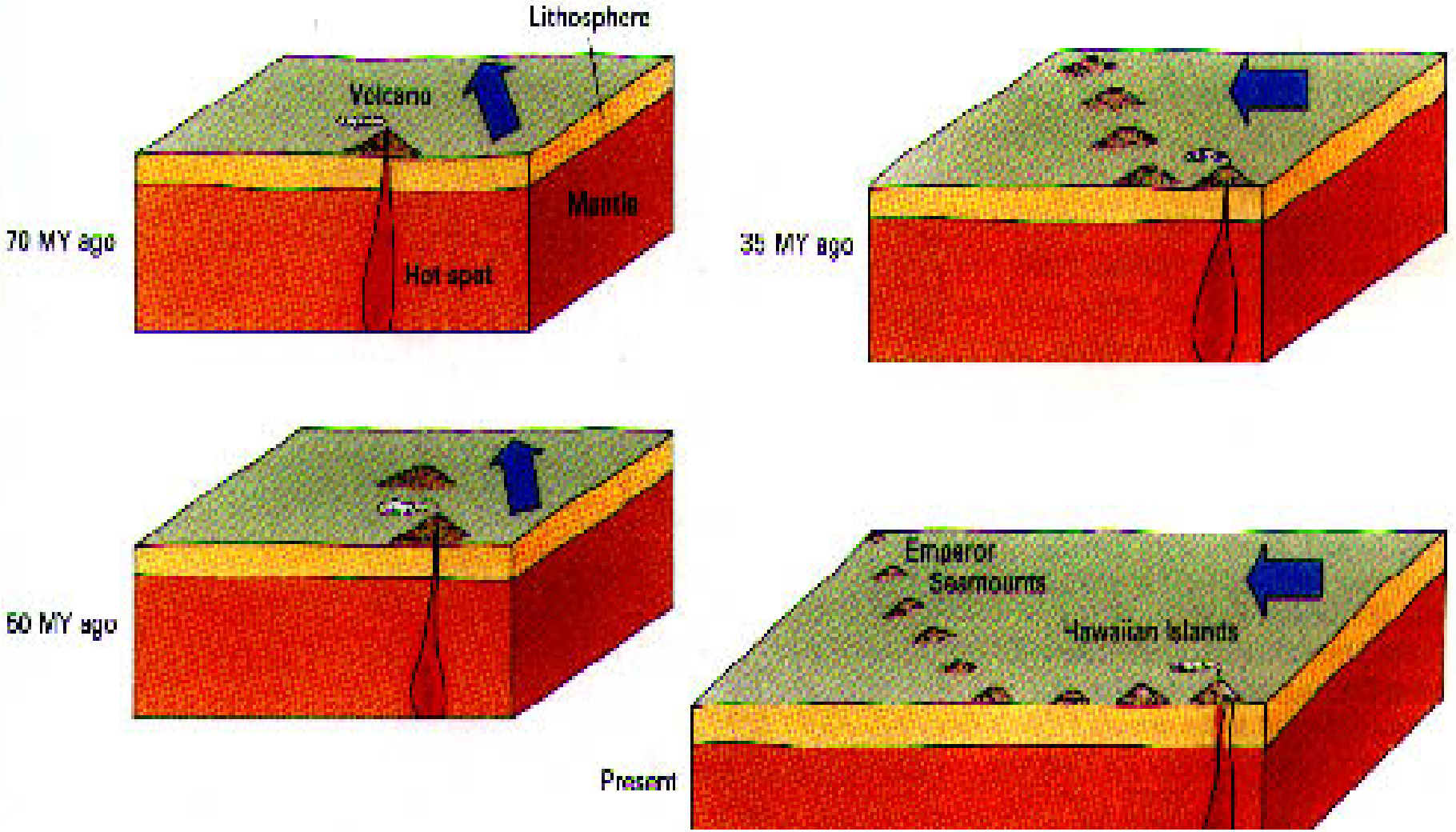
島弧區的特徵

- 1.群島的圓弧線狀分佈
- 2.顯著的火山活動
- 3.在向洋面有深的海溝，在向陸之一側有淺海
- 4.顯著的線狀磁力異常顯示離地殼均衡有大的偏差
- 5.活動性的構造運動
- 6.島弧與最近的造山帶一致
- 7.島弧之向陸面有高的熱流

FIGURE 3-8
The Hawaiian Islands and the Emperor Seamounts formed as the Pacific plate moved over a hot spot. The lines of volcanoes record the change in direction of plate movements.

noes on the youngest islands remain active while they are near the hot spot. After the crust has moved the volcano away from its source of magma, it becomes extinct. Eventually, extinct volcanoes are eroded by waves and rivers, first becoming small islands, then submerged banks, and finally seamounts.

The Hawaiian Islands are an example of such an island chain formed over a hot spot (Fig. 3-8). Volcanoes on the island of *Hawaii* are still active because they



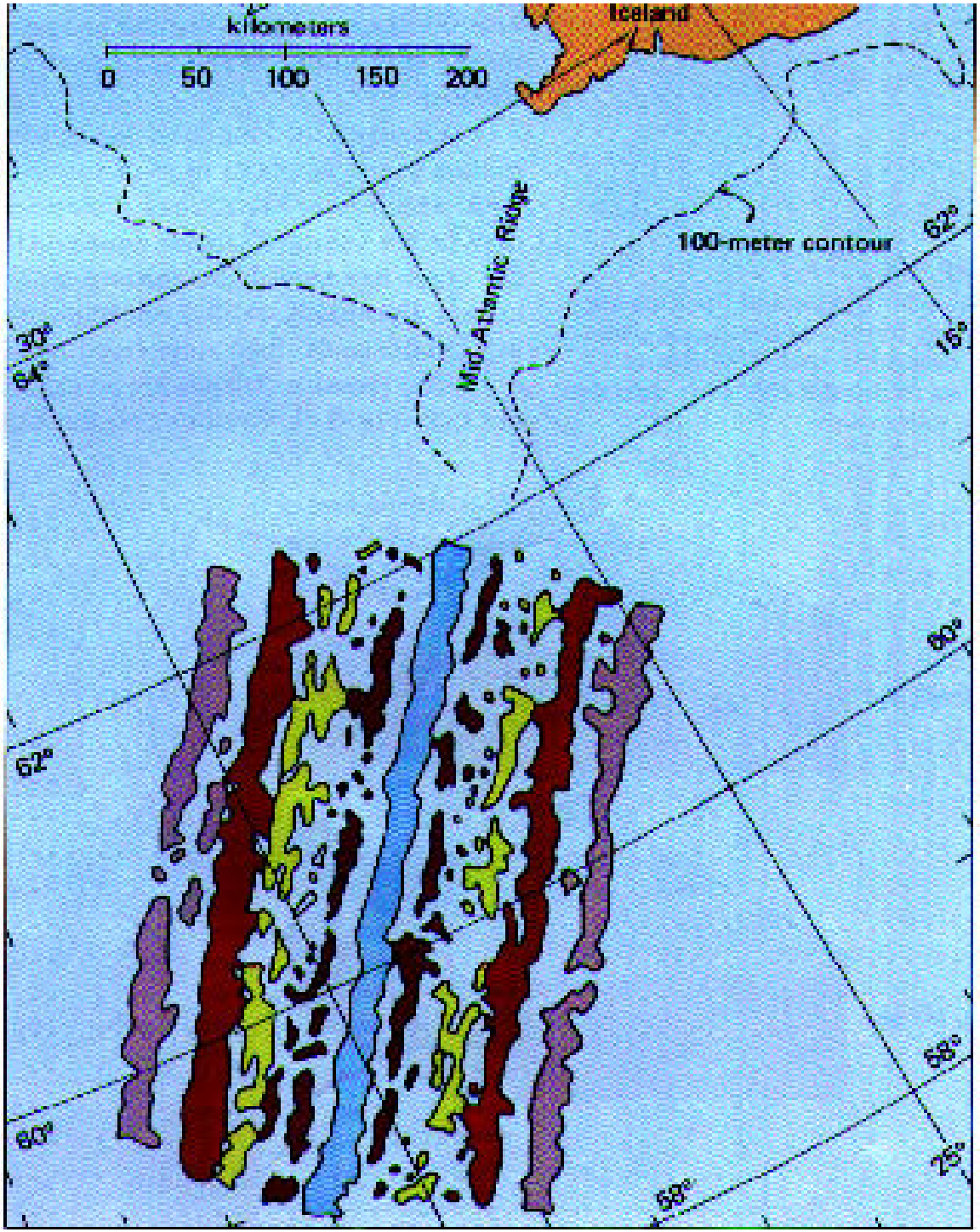


FIGURE 3-9
Magnetic anomalies on the Mid-Atlantic Ridge south of Iceland. These anomalies record the orientation of Earth's magnetic field at the time when the crust formed. Shaded areas indicate where the magnetic field is stronger than the average magnetic field of Earth. These crustal segments formed when Earth's magnetic field had the same orientation as the present field. Light areas indicate where the magnetic field is weaker. These crustal segments formed when the magnetic field was reversed from its present orientation.

Magnetic anomalies

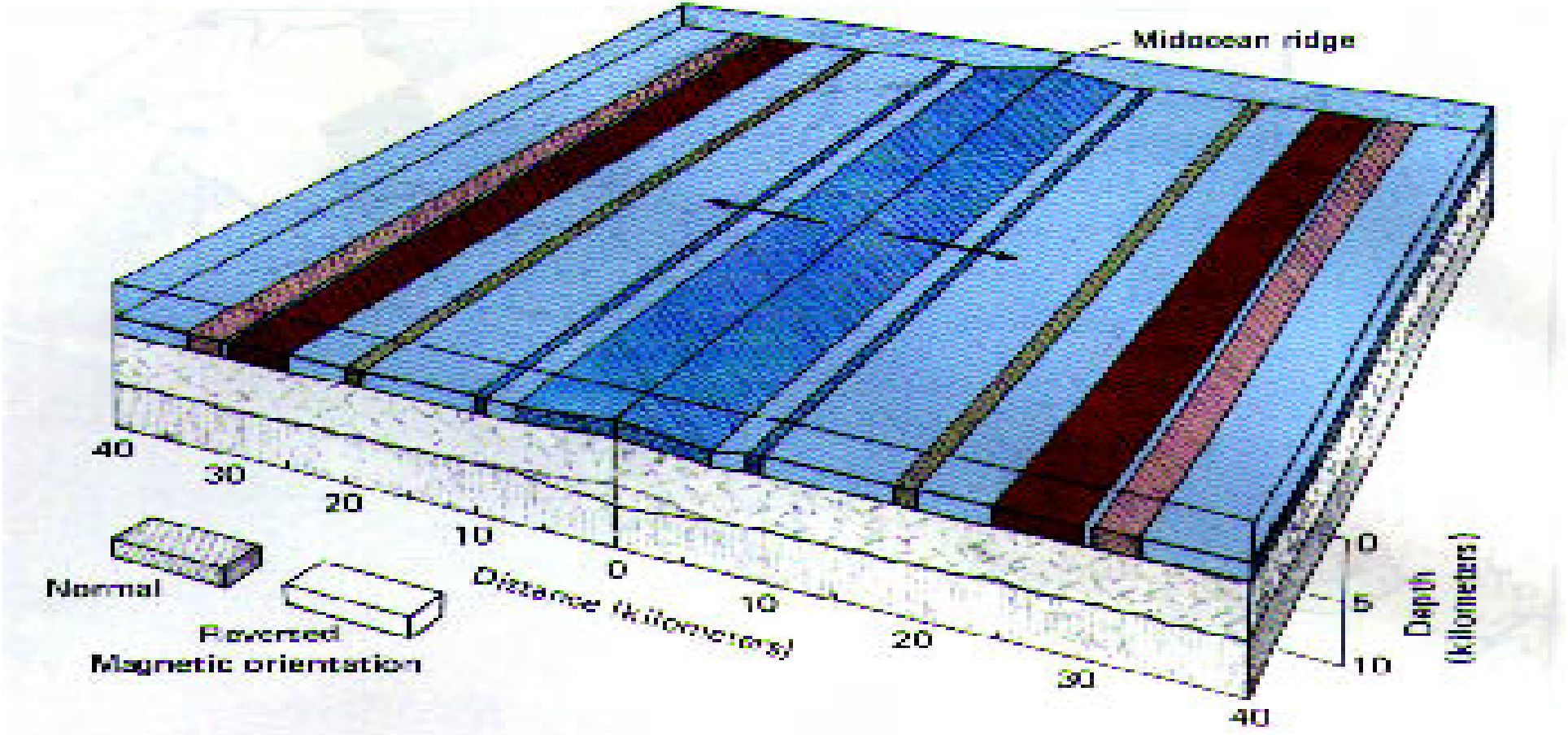
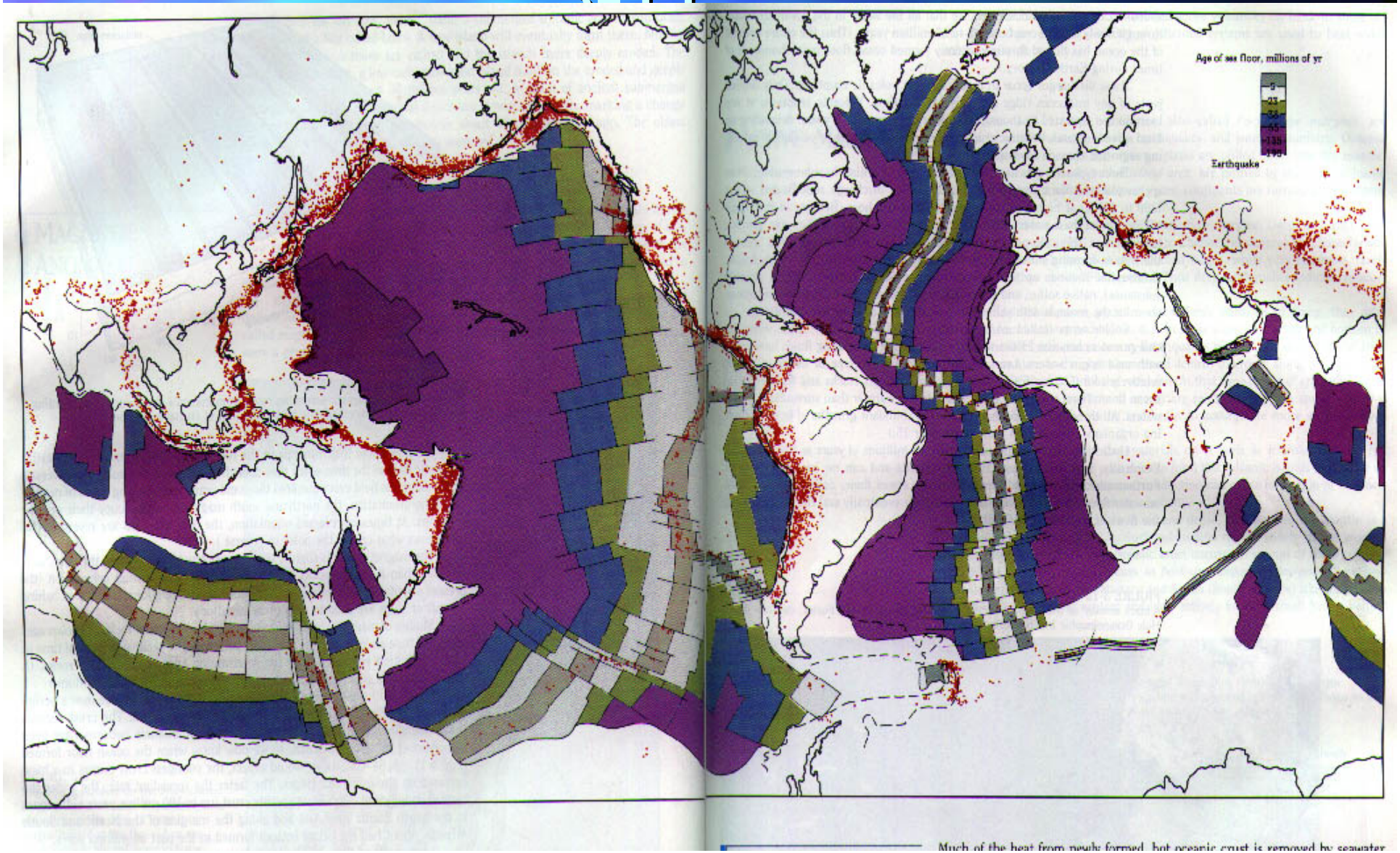


FIGURE 3-10
Striped pattern of magnetic anomalies result from minerals in oceanic crust recording the direction of Earth's magnetic field at the time of crustal formation.

3_11



Much of the heat from newly formed, hot oceanic crust is removed by seawater

Substructure 3-13

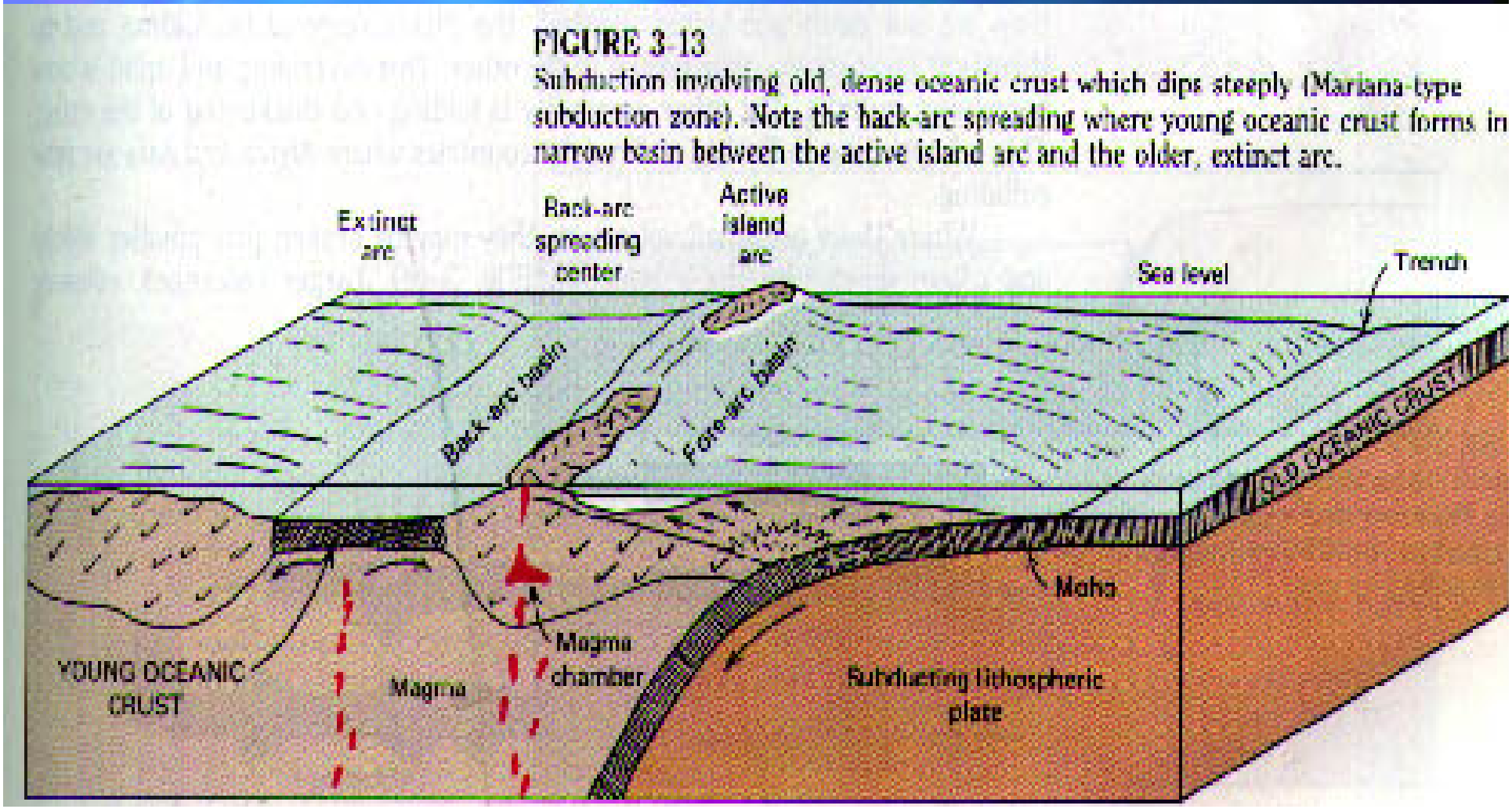


FIGURE 3-13
Subduction involving old, dense oceanic crust which dips steeply (Mariana-type subduction zone). Note the back-arc spreading where young oceanic crust forms in narrow basin between the active island arc and the older, extinct arc.

大陸地殼

- 平均波速(km/s)　　厚度(公里)
- 2.1～5.0　　1
- 6.1　　9
- 6.9　　20
- ……Conrad Discon.
- 7.1　　20
- ----------Moho
- 7.6～8.6

海洋地殼

- 平均波速(km/s)　厚度(公里)
- 第一層　1.6～3.6　不定
- 第二層　5.0　1.7
- 第三層　6.7　5.0
- ----------Moho
- 7.6～8.6
  - anisotropy

Table 3.1 Characteristics of the Earth's Layers

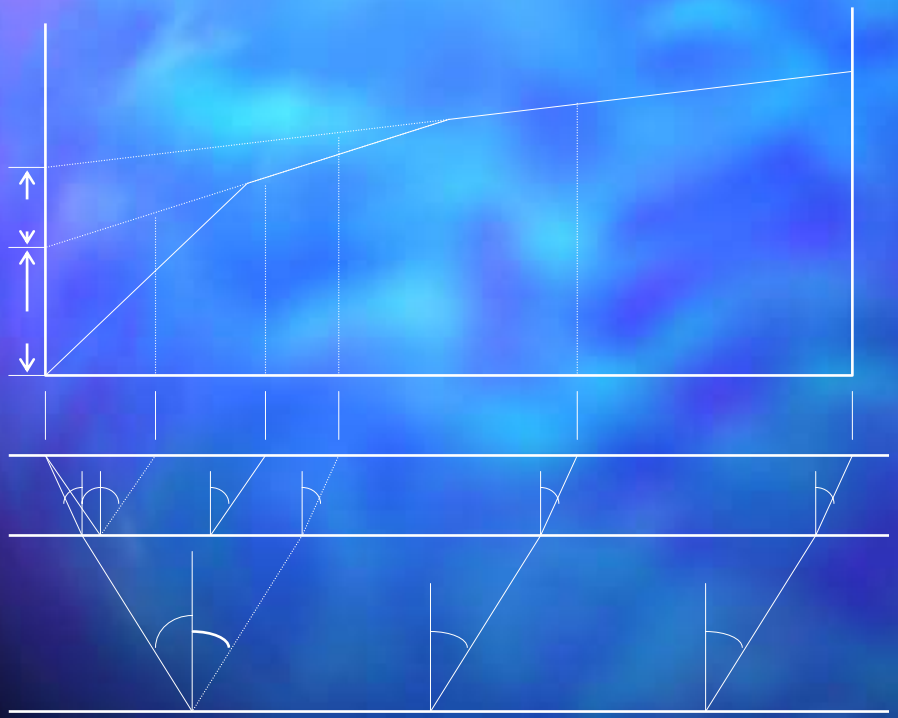
Layer	Depth from Surface	Primary Composition	Average Temperature	Average Density	Proportion of the Earth's Total Mass	Proportion of the Earth's Total Volume
Crust			~500°C (900°F)		0.4%	<1%
Continental crust	From surface to 35 km (22 mi)	Granite (aluminum silicates)		~2.7 g/cm^3		
Oceanic crust	From surface to 11 km (7 mi)	Basalt (magnesium silicates)		~2.9 g/cm^3		
Mantle	From 11 km to 2,900 km (from 7 mi to 1,800 mi)	Iron and magnesium silicates	2,500°C (4,500°F)	4.5 g/cm^3	68.1%	83%
Core					31.5%	16%
Outer core	From 2,900 km to 5,100 km (from 1,800 mi to 3,200 mi)	Liquid iron and nickel	5,000°C (9,000°F)	11.8 g/cm^3		
Inner core	From 5,100 km to 6,370 km (from 3,200 mi to 3,960 mi)	Solid iron and nickel	6,600°C (12,000°F)	16.0 g/cm^3		
Whole earth	6,370 km (3,960 mi)			5.5 g/cm^3		

Source: Kennett, 1982; Bott, 1982.

沉積層
(＞2.8 km/s折射波才測的出)

- 1a 未壓密層　1.6～2.2km/sec
- 1b 半壓密層　1.7～2.6km/sec
- 1c 完全壓密層　2.7～3.7km/sec

震测



$$t=\frac{OM}{V_1}+\frac{MP}{V_2}+\frac{PR}{V_1}=\frac{MP}{V_2}+2\frac{OM}{V_1}$$

$$=\frac{x-2z\tan\theta}{V_2}+\frac{2z}{V_1\cos\theta}$$

$$=\frac{x}{V_2}+\frac{2z}{V_1\cos\theta}(1-\frac{V_1}{V_2}\sin\theta)$$

$$=\frac{x}{V_2}+\frac{2z}{V_1\cos\theta}$$

$$\frac{\sin\theta_1}{V_1}=\frac{\sin\theta_2}{V_2}=\frac{1}{V_3}$$

$$t=\frac{OM'+R'P'}{V_1}+\frac{M'M''+P'P''}{V_2}+\frac{M''P''}{V_3}$$

$$=\frac{2z_1}{V_1\cos\theta_1}+\frac{2z_2}{V_2\cos\theta_2}+\frac{x-2z_1\tan\theta_1-2z_2\tan\theta_2}{V_3}$$

$$=\frac{x}{V_3}+\frac{2z_2}{V_2\cos\theta_2}(1-\frac{V_2}{V_3}\sin\theta_2)+\frac{2z_1}{V_1\cos\theta_1}(1-\frac{V_1}{V_3}\sin\theta_1)$$

$$=\frac{x}{V_3}+\frac{2z_2}{V_2}\cos\theta_2+\frac{2z_1}{V_1}\cos\theta_1$$

$$=\frac{x}{V_3}+t_2$$

$$t=\frac{x}{V_n}+\sum_t\frac{2z_t}{V_t}\cos\theta_t$$

$$\sin\theta=V_1/V_2$$

$$t=\frac{x}{V_2}+t_1$$

$$t_1=(2z\cos\theta)/V_1$$

$$z=\tfrac{1}{2}V_3t_1/\cos\theta$$

階　段	例　　子	山　　脈	運　動	沉　積　物	火　山　岩
孕育期	東非縱谷	塊狀山升	上　舉	很少	矽質底層玄武岩 鹼性玄武岩中心
年輕期	紅海及亞丁灣	塊狀山升	上舉及擴張	小型大陸棚 蒸　發　岩	矽質玄武岩質海床 玄武岩質島弧
成熟期	大西洋	中 洋 脊	擴　張	小型大陸棚 (次活動正地槽)	矽質玄武岩質海床 鹼性玄武岩質島弧
衰減期	太平洋	島　弧	壓　縮	島　弧 (活動正地槽)	安山岩質火山 花崗閃長岩— 片麻岩的深成岩
終點期	地中海	年輕山脈	壓縮及上舉	蒸發岩，紅土層及碎屑層	安山岩質火山 花崗閃長岩— 片麻岩的深成岩
遺留的地　縫	喜馬拉雅山 印　度　線	年輕山脈	壓縮及上舉	紅　土　層	很少，可不計

礦物的成分與結構

- 1.岩石與土壤的基本粒子
  - 礦物(細胞)：具有一定的化學和物理特性
- 2.礦物的定義
  - a.天然生成的均質固體
    - 人造寶石 ------ not
    - 水 ------ not
    - 冰 ------ yes
    - 例外：汞
  - b.無機作用生成
    - 珍珠，貝類，腎結石 ------ not
  - c.一定的結晶構造
    - 原子在礦物晶體中作規則排列, 如：NaCl
  - d. 具有一定化學成分和物理性質
    - 如：石英 Si,鉀長 KAlS , Olivine (MgFeSi

礦物的成分與結構(Cont)

- 3.結晶構造
  - a.晶體，b.習性(Habit)：結晶外形，c.同質異形(Polymorphism)，金剛石＆石墨，d.晶面＆晶面角

礦物的成分與結構(Cont)

- 4.特性： (1)晶系：以“結晶軸”相互的交角和長度來劃分成六大晶系
  - a.等軸(Cubic)：三軸垂直且等長
  - b.正方(Tetragonal)：三軸垂直，兩水平軸等長
  - c.斜方(Orthorhombic)：三軸垂直，但各不等長
  - d.單斜(Nlonoclinic)：二軸斜交，第三軸垂直此二軸，不等長
  - e.三斜(Tricline)：三軸彼此斜交，且等不長
  - f.六方(Hexagonal)：具四個晶軸，水平軸有三，彼此成60°交角，等長，另一軸垂直此三軸，不等長。

礦物的成分與結構(Cont)

- (2)習性(habit)：特殊晶體外形
- 如：pyrite ---- Cubic
- garnet ---- 正十二面體
- (3)結晶集合體：Crystal Aggregates
- 粒狀：pyrite
- 柱狀：角閃石
- :
- :

礦物的成分與結構(Cont)

- (4)硬度：min 滑石，max 金剛石
  - 1.Talc
  - 2.Gypsum
  - 3.Calcite
  - 4.Flurite
  - 5.Apatite
  - 6.Orthoclase
  - 7.石英Qtz
  - 8.Topaz
  - 9.Corundum
  - 10.Diamond

礦物的成分與結構(Cont)

- (5)解理(cleavage) ：優：雲母
- 良：Augite・・・90°
- 可：硫磺
- 劣：磷灰石
- (6)顏色

- 5.地殼礦物的成分：
  - 礦物有兩千多種，但主要的造岩礦物大約只有十種。
  - 因地殼中以矽與氧爲最常見，所以造岩礦物以矽酸鹽類爲主，約占96%以上。

B3-1-2a

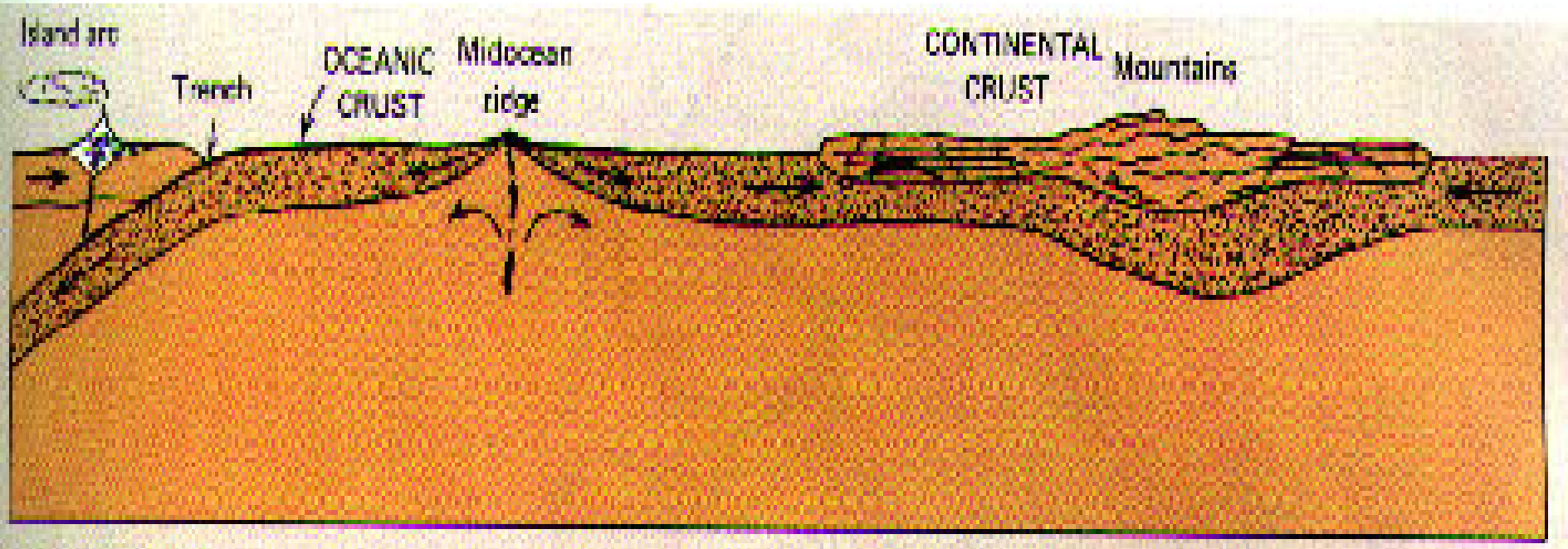
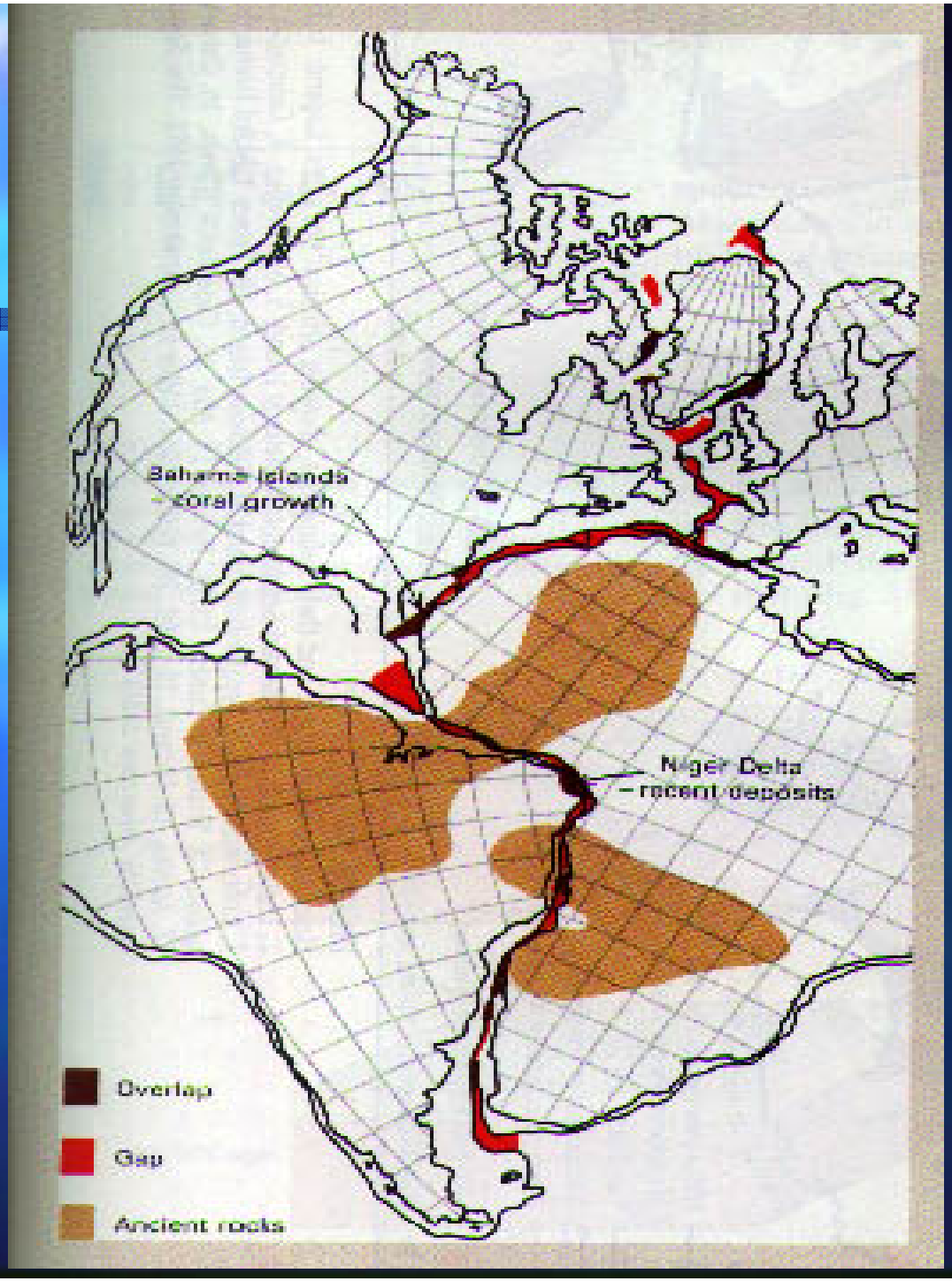


FIGURE B3-1-2
Major features of seafloor spreading postulated by Professor Hess.


Bahama Islands
– coral growth
Niger Delta
– recent deposits
Overlap
Gap
Ancient rocks