Geology

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GEOLOGY

Greek Earth The study of

Geology = The study of Earth

Geology

What is the meaning of geology ?

The meaning of geology is the science which study the minerals and chemical composition of the earth, issues of earth and the inner and outer processes which affected it , since its issue to this day.

The relationship between geology and other sciences

1. ***Physics ---------- Geophysics***

a. Gravity.

b. Magnetic.

c. Seismology.

d. Electrical.

Biology---------Paleontology (Remaining of Animals and Botanical)

Chemistry ---------- Geochemistry

Engineering ---------- Engineering geology

Geological Branches

A-Pure geology:-

1. -Crystallography .
2. -Mineralogy .
3. Petrology .
4. - Paleontology .
5. -Stratigraphy .
6. -Dynamic geology .
7. -Historical geology .

B-Connected Branches:-

1. Geochemistry .
2. Geophysics .
3. Geomorphology .
4. Structural geology .
5. Photo geology .
6. Field geology .
7. Oceanography .
8. Glacial geology .
9. Volcano logy .
10. Cosmic geology .
11. Geodesy .

C-Applied geology:-

1. Economic geology .
2. Engineering geology .
3. Petroleum geology .
4. Hydrogeology .
5. Mining geology .
6. Agricultural geology .
7. Military geology .

- در ادامه به توضیح تعدادی از موارد بالا پرداخته می شود:

1. ژئوشیمی: راجع به خواص شیمیایی زمین و ترکیب مواد تشکیل دهنده آن گفتگو می کند. در قسمتی از این رشته که به نام ژئوشیمی عملی خوانده می شود، نحوه استفاده از خواص شیمایی عناصر تشکیل دهنده ی زمین در اکتشاف منابع مورد بحث قرار می گیرد.
2. کانی شناسی: درباره مواد معدنی تشکیل دهنده زمین، طرز تشکیل و نحوه شناسایی آنها گفتگو می کند.
3. سنگ شناسی: موضوع بحث آن سنگ های زمین، تقسیم بندی و چگونگی تشکیل آنهاست.
4. هواشناسی: راجع به هوا و مشخصات آن بحث می کند.

5. آب شناسی: موضوع بحث آن درباره آبهای زمین است. این رشته خود به دو قسمت آبهای سطحی و آبهای زیرسطحی تقسیم می شود.
6. زمین شناسی ساختمانی: درباره ساختمان های طبیعی زمین بحث می کند.
7. زمین شناسی فیزیکی: درباره مشخصات طبیعی زمین بحث می کند.
8. دیرین شناسی: راجع به موجودات زنده ای که در قدیم زندگی می کردند و شرایط زندگی آنها بحث می کند. با استفاده از این رشته می توان سن طبقات مختلف زمین را محاسبه نمود
9. رسوب شناسی: راجع به رسوبات و نحوه تشکیل آنها بحث می کند.

10. چینه شناسی: موضوع بحث این بخش طبقات مختلف زمین و ارتباط آنها با یکدیگر می باشد.
11. ژئومرفولوژی: در باره عوارض زمین و طرز پیدایش پستی و بلندی بحث می کند.
12. ژئوفیزیک: درباره خواص فیزیکی زمین، نظریه جاذبه، ثقل، فشار و حرارت بحث می کند. در قسمتی از این رشته به نام ژئوفیزیک عملی، نحوه استفاده از خواص فیزیکی در اکتشاف منابع معدنی بحث می شود.
13. زمین شناسی اقتصادی: این رشته از زمین شناسی درباره آندسته از مواد زمین که ارزش اقتصادی دارند گفتگو می کند و نحوه و شرایط تشکیل آنها را مورد بررسی قرار می دهد.
14. زمین شناسی مهندسی: درباره چگونگی استفاده از اطلاعات زمین شناسی در کارهای مهندسی نظیر سد سازی، جاده سازی ونظایر آن گفتگو می کند.

15. فتوژئولوژی: این رشته قسمتی از زمین شناسی است که بر اساس آن می توان با استفاده از عکس های هوایی نقشه زمین شناسی تهیه کرد و بعضی مطالعات زمین شناسی را انجام داد.
16. زلزله شناسی: در آن زمین لرزهها مورد مطالعه قرار می گیرد.
17. آتش فشان شناسی: موضوع آن بحث در آتشفشان ها و فعالیت آتش فشانی زمین است.
18. اقیانوس شناسی: در این شاخه مضعیت اقیانوس ها مورد بررسی قرار می گیرد.
19. پالئوژئوگرافی: درباره شکل و توزیع خشکیها و دریاها زمین در ادوار گذشته زمین بحث می شود.
20. پالئوبوتانی: راجع به گیاهانی که در قدیم می زیسته اند و چگونگی شناسایی آنها گفتگو می شود.
21. دورسنجی: نحوه بررسی زمین با استفاده از ماهواره مورد بررسی قرار می گیرد.

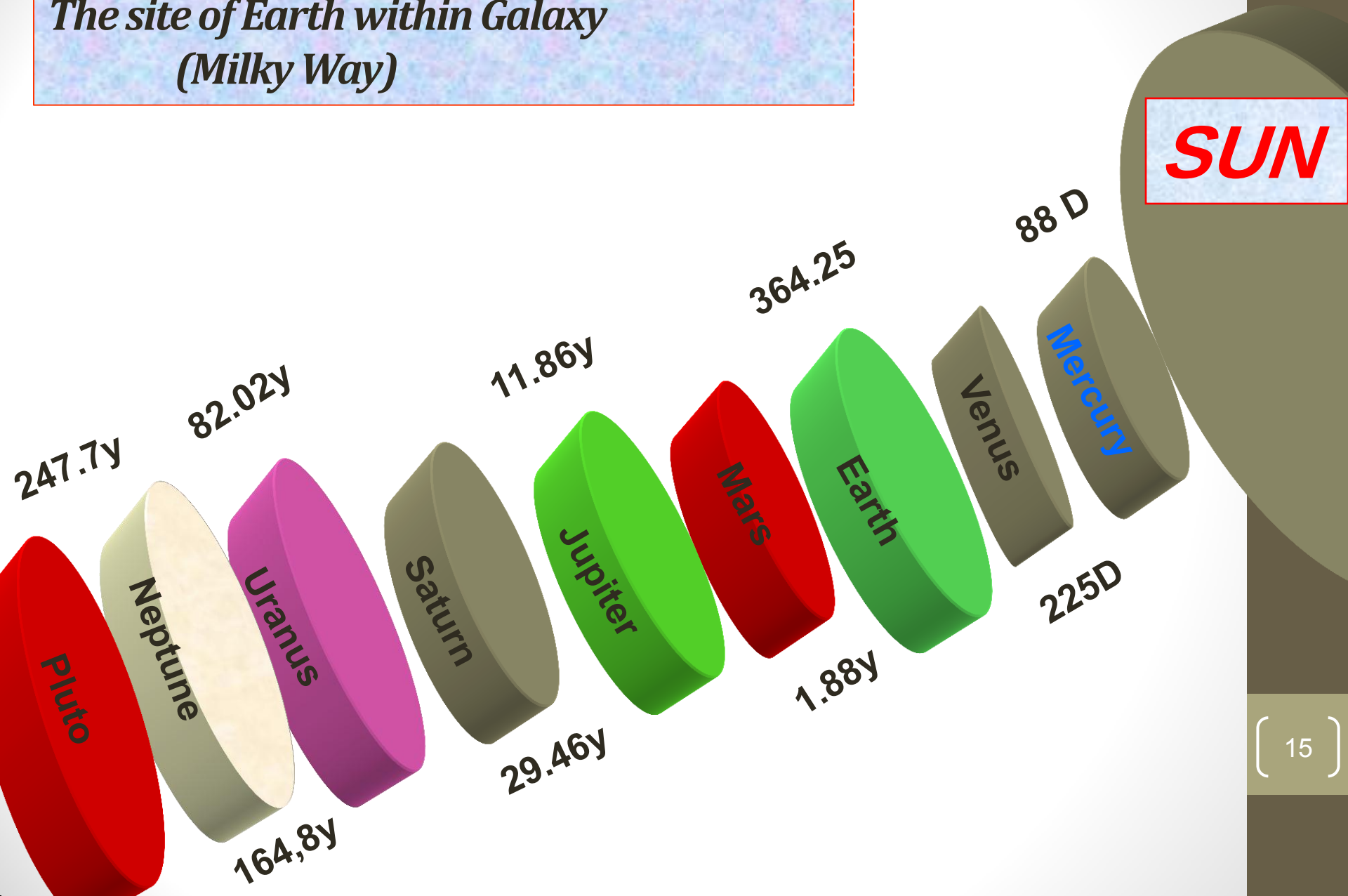
History of geology

1. ***Humorous 600 B c*** :-Thinking about the shape of Earth and he descript the earth as disc surround by water
2. ***.Aresto 384-322 B C :-***He is provided that the Earth is a ball by scientific method . by observation he notice the matter collection to the same center .
3. ***Herodotus 424-484 B c:-***The first scientist who noticed the remaining of Botany and Animals on the earth crust of mountains which prove that the present mountains were oceans surfaces in the deep past.
4. ***Khalelo 1546-1642 c :-***Pr0vided Earth motion around its axis from west to east .
5. ***William Smith 1769-1839 c*** :-He is the first scientist whose established stratigraphy and correlation by its contents of fossils and drawing a geological map for e England in 1845 .

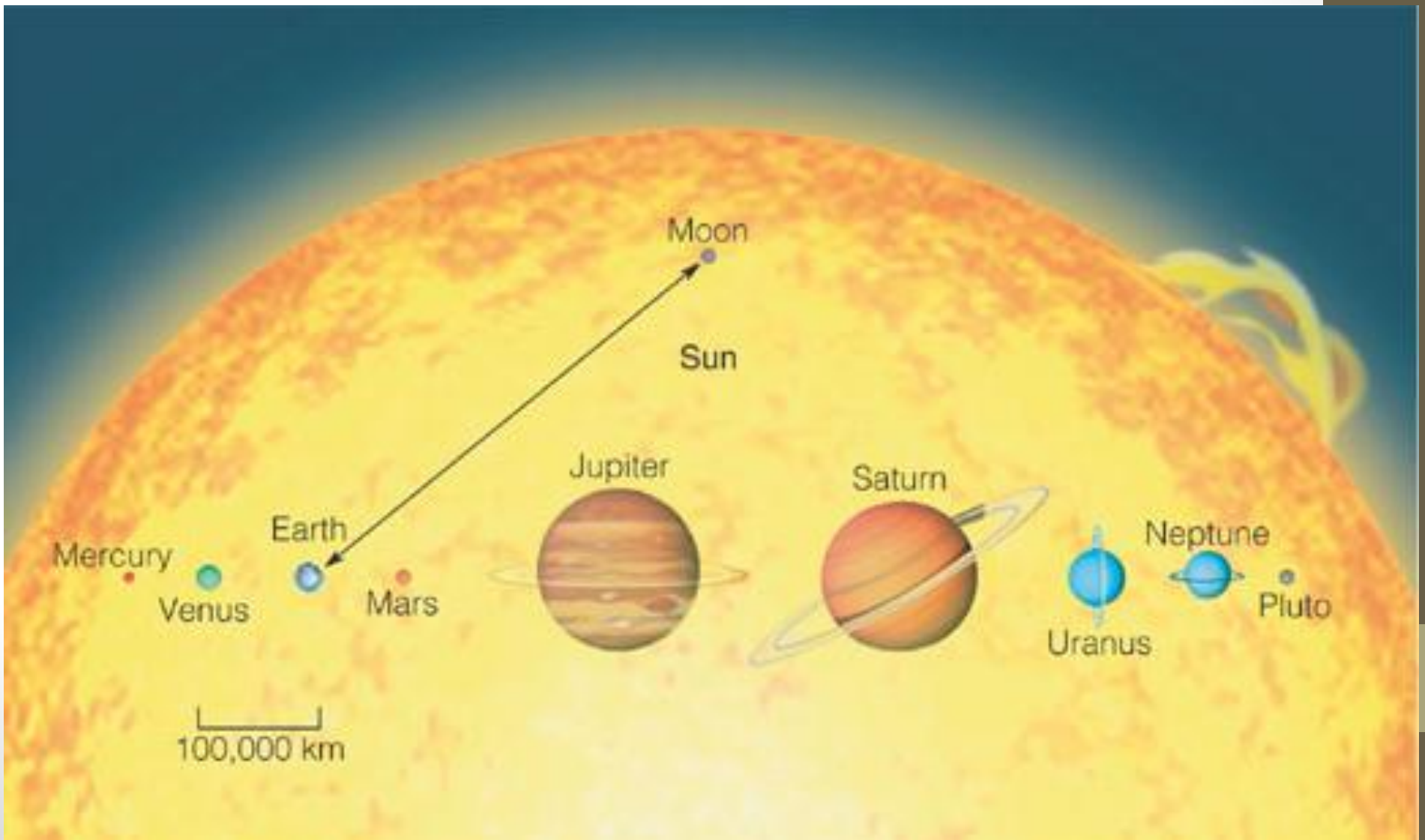
History of geology – Other scientists

1. ***Ibin Siena died 1049 :-***The first one who established the geology and also studied the minerals .
2. ***Al Bairony d 1271 :-***He described an expensive crystals minerals in scientific methods .
3. ***Alrazi d 1369*** :- Divided the minerals into six groups in his book (secrets of the secrets) .
4. ***Other scientist*** such as Jahith **Takishkhandy Sarkhasy** et .

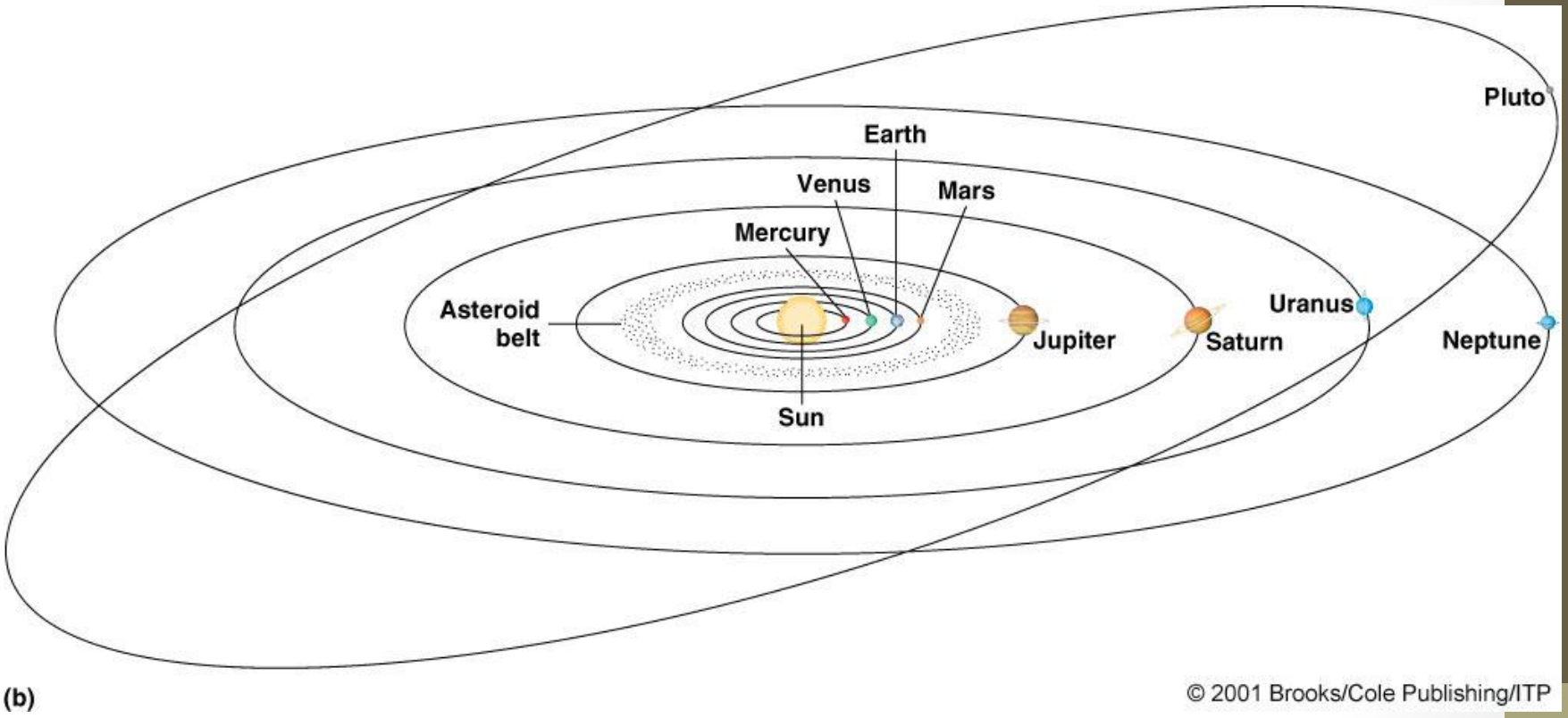
The site of Earth within Galaxy (Milky Way)



Relative Sizes of the Sun and Planets



Solar System Configuration



The Planets

- Terrestrial Planets
  - Mercury
  - Venus
  - Earth
  - Mars
- small, composed of rock, with metal cores

- Jovian Planets
  - Jupiter
  - Saturn
  - Uranus
  - Neptune
- large, composed of hydrogen, helium, ammonia, methane, relatively small rocky cores

Hypothesis issues of Earth and global system

- *Since 18th century ,the scientists were beginning searching methods about the Astronomy or cosmic geology without Church affection.*

- 1- Buffoon Ht 1707-1788 (France) :- The first scientist whose gave idea
- For the source of Earth in his book (Natural the history). The idea is the present global system is result from very hard attack between the sun and one of big solar mass, then the result were many big masses separated swimming in different distances around the sun gravity.

- 2-Kants Ht 1755 (German) :-This hypothesis proposed that the whole solar system was very much of small solid parts swimming in the global system in high speed. This parts collected together by gravity with high heating due to attachment between the parts which result very hot gases (NEBULA) rotation around together in great speed. This conditions give a gas rings and by the force out of center which result our sun system.

3-Nebular OR Lab lass Ht 1796 C(France) :-The solar system in the beginning were a (NEBULA) occupied about four sizes of our solar system. With the time ,there are heating loss ,contraction which result rotation with high speed around it s axis .at this time the force out of center makes a cycle with irregular out line which result a big masses named the solar system. later the contraction of masses due to the continuous cooling and rotation to consist the solar system.

4-Other hypothesis:-

a-Planetesimal Ht(Chamberlin-American Geologist and Moulton- Am sc 1905).

b-Gaseous Tidal Ht(Jemis and Jeffery 1929).

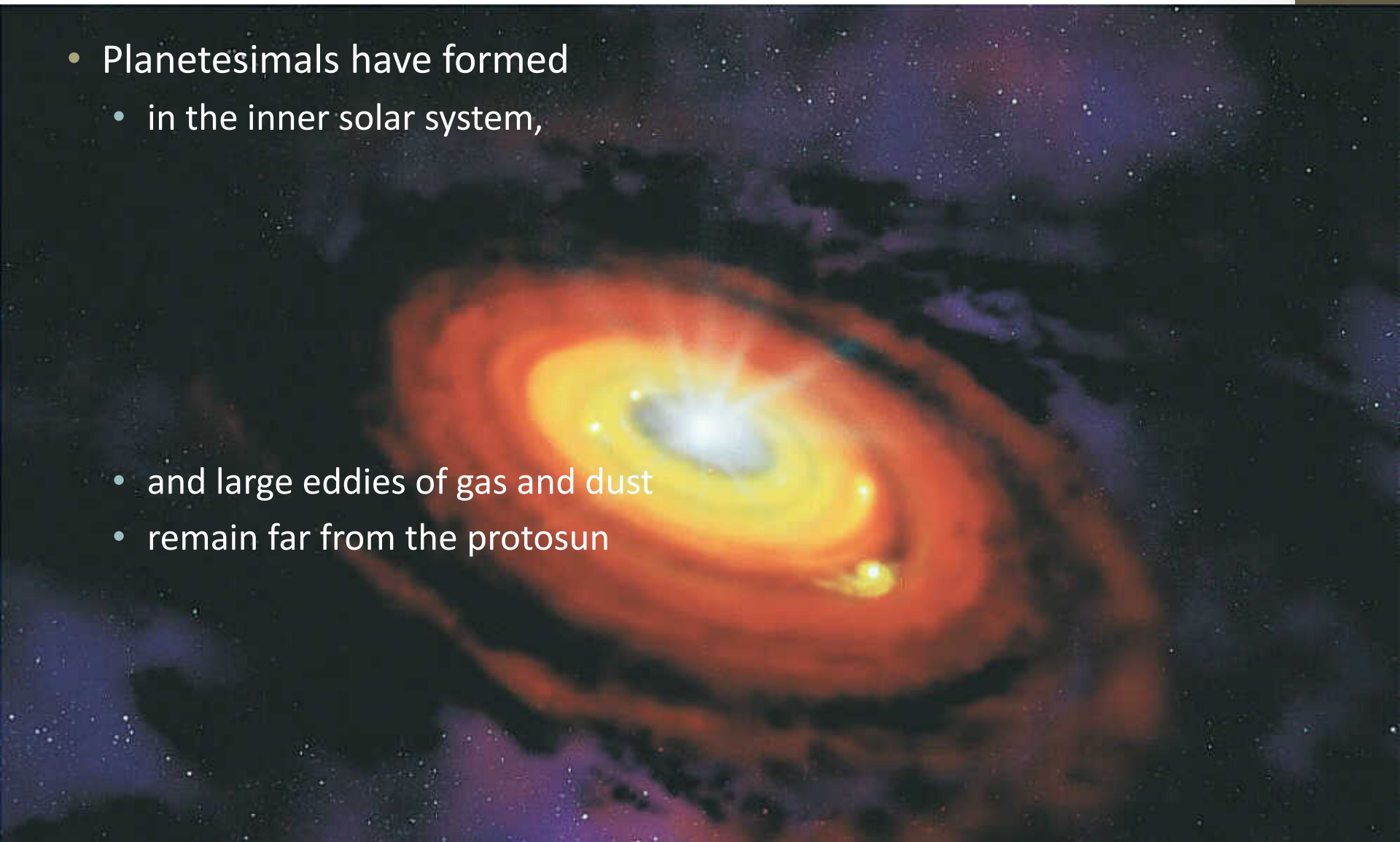
New theories in origin of solar system

1-The Nuclear Explosions Th 1931:-This Th suggests that a part of Global Space was composed of Dense Gases (Protogalaxy).

With time these gases collect together to form (Nuclear Cells). So at same time Great explosions happened for global bodies which separated it faraway from its original space and form (Global Galaxy). After that the Gases began cooling and space reduction with rotation and finally birth new solar Galaxy in space before about 13-10 Billion years ,while the Gases condensation about 250 million years ago.

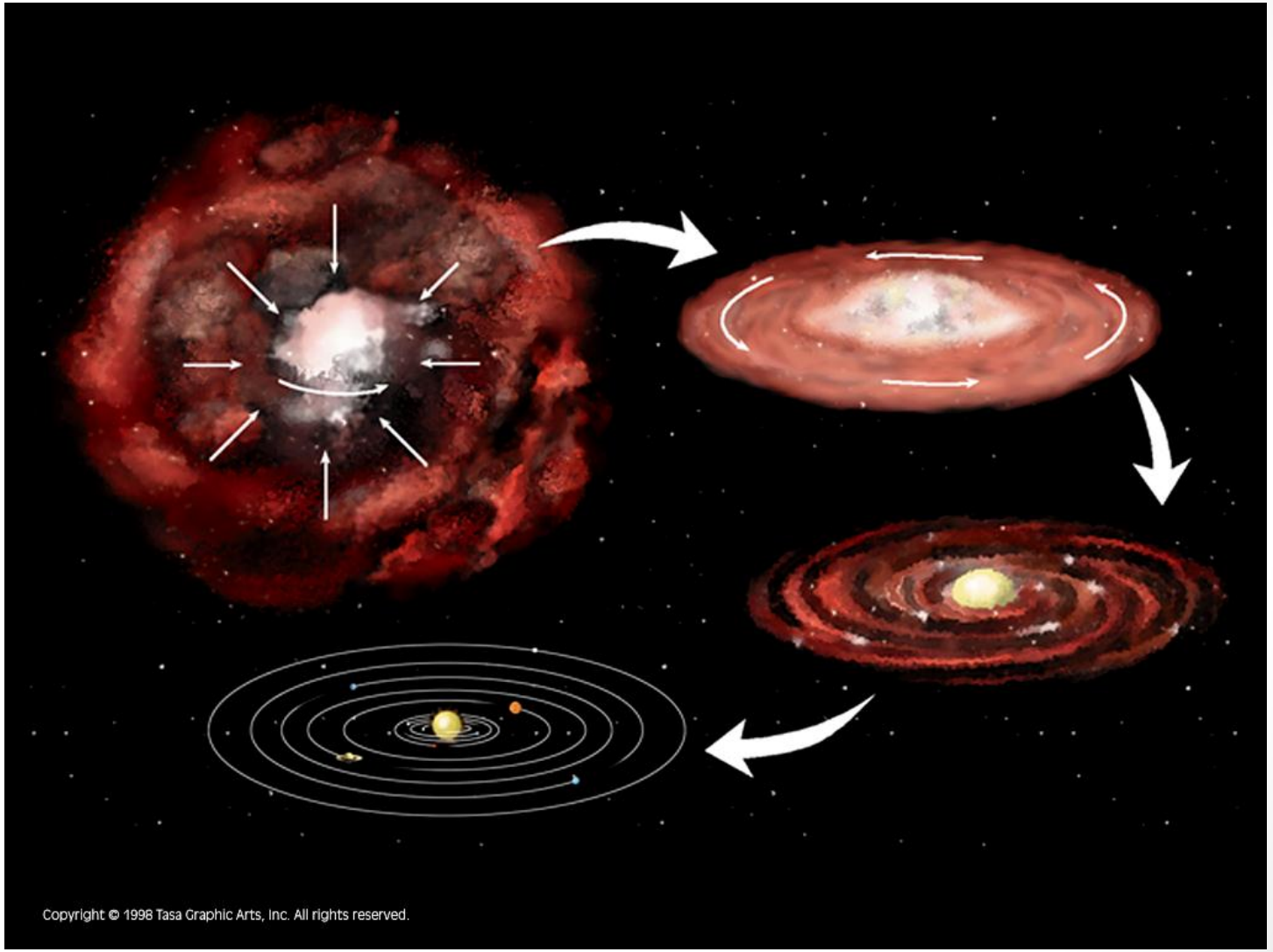
2-Great Gas Cloud Th 1942 -1948:-In the beginning the Sun and Stars were a Global cloud consist of Gases and dust which condensed under stars light pressure, dust and gases gravity forces. This conditions lead to Great rotation to form (Primary Nucles),The remain clouds stays in the center forming the Sun. Later this theory considered that Electromagnetic force played as important agent in global system.

Embryonic Sun and Rotating Clou



- Planetesimals have formed
  - in the inner solar system,
  - and large eddies of gas and dust
  - remain far from the protosun

Origin of the Earth



Evaluation of the Earth

Since 6 Billions years , the Earth was separated from Sun. So by rotation , continuous cooling ,the mass of gas became Ball-shape covered by solid crust called (Earth crust),while the inner of Earth still in Fusion state.

There are four stages at Evaluation of Earth :-

1-Anhydric Period:-In this period the elements consists Earth differentiated into three zones depend on gravity, rotation of Earth,(mass of gases and liquids) as :-

a-Silicate-Sulfides zone--------Outer part.

b-Iron- Nickel zone----------Middle part.

c-Earth crust---900-1000 million years cooling time.

2-Oceanic Period(water Basins):-This period of Rains fall due to the Temperature changes within about 300- 400 million years.

3-Contraction Period:-A big water Basins such as oceans seas as a result of continuous cooling for earth crust ,association with mountains building within about 1000 -1700 million years.

4-Continintal Drift period:-There are many evidence says the Dry part of earth(CRUST) was connect in the ancient time. By Earth agents (Hypogene Processes) the crust moves along the fusion zone of Earth which result sedimentary basins due to the big Oceanic sediment.

Conclusions:-

a-The Earth crust and air cover were buildup at first stage.

b-The water cover was buildup at second stage.

c-The ancients evidence of life is before 2500 million years.

Nature of Earth

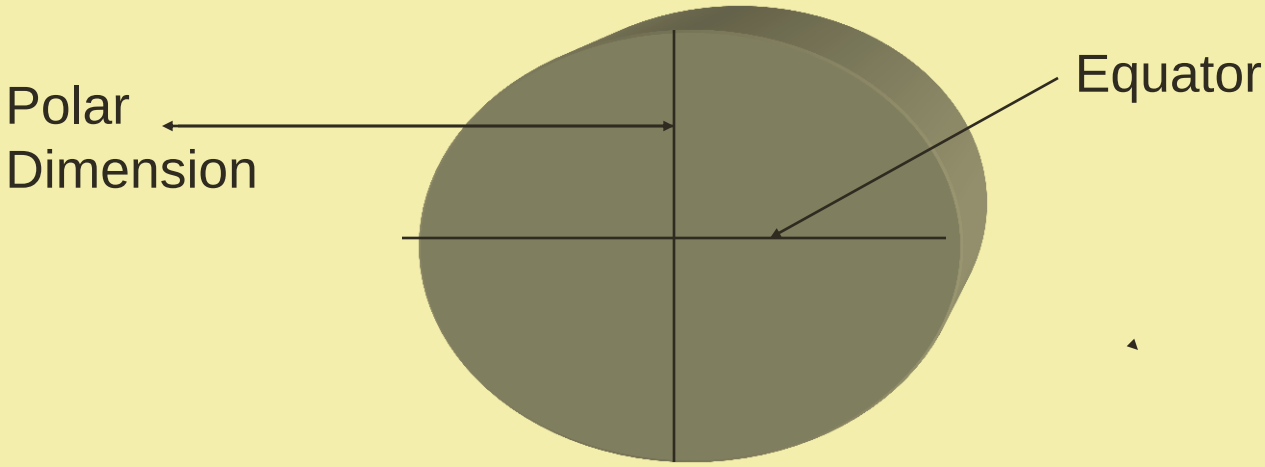
A-Dimension of Earth :-

1-The polar Radius =6357 km .

2-Equator Radius =6378 km .

3-Polar Circumference = 6357 km x 2 x 22 ÷ 7 = 40 009 km .

4-Equator Circumference = 6378 km x 2 x 22 ÷ 7 = 40 077 km .



Earth Science Literacy Principles

Earth is a complex system of interacting rock, water, air, and life.

اجزای تشکیل دهنده ی زمین

قسمت	مواد تشکیل دهنده	حالت فیزیکی	ضخامت متوسط (کیلومتر)	حجم (میلیون کیلومتر مکعب)	جرم مخصوص (گرم بر سانتی متر مکعب)	جرم کلی (گرم)	درصد جرم
هواکره	نیتروژن–اکسیژن–آب–دی اکسیدکربن و...	گازی	–	–	–	0.005E24	0.00009
آبکره	آب–نمک–برف–یخ	مایع و جامد	3.8	1370	1.03	1.41E24	0.024
پوسته	سیلیکاتهای معمولی	جامد	33	8870	2.8	25.1E24	0.4
گوشته	سیلیکاتهای بازی	جامد	2883	899000	4.5	4016E24	67.2
هسته	آهن و نیکل	قسمت خارجی جامد– قسمت داخلی مایع	3471	175000	11	1936E24	32.4
زمین			3671	1083220	5.52	5976E24	100

هوا کره

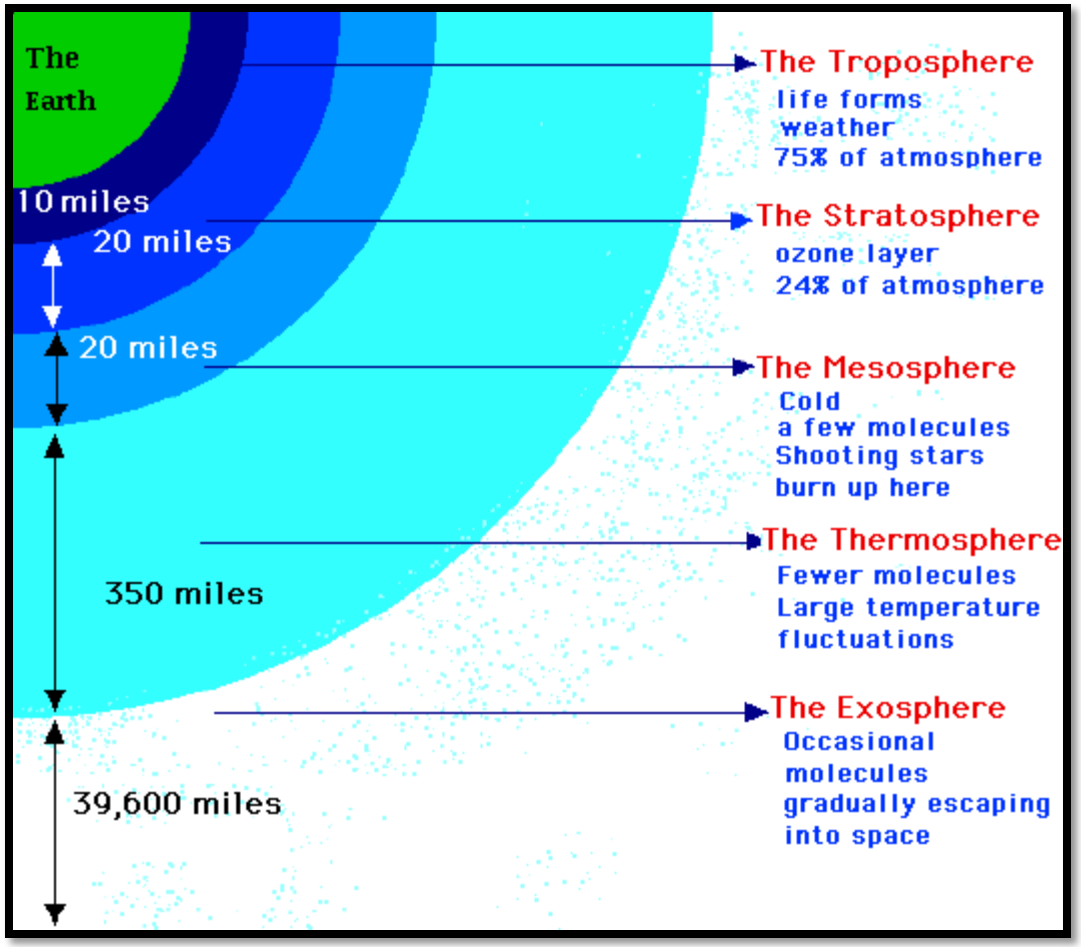
- ترکیب هوای معمولی، یعنی هوای مجاور زمین را می توان به دو دسته گازها و گرد و غبار موجود در آن تقسیم نمود.

✓ گازهای موجود در هوا: این دسته خود به سه گروه تقسیم می شود:

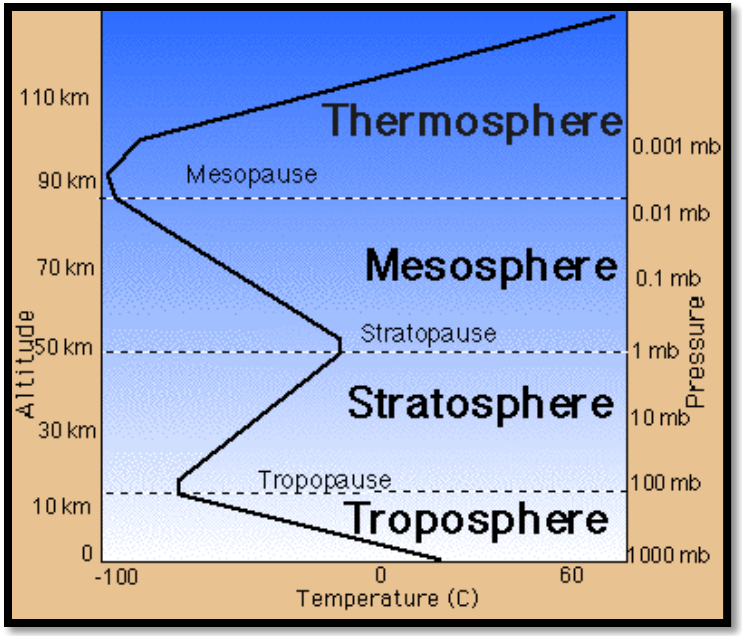
1. گازهایی که نسبن آن تقریبا ثابت است، همانند نیتروژن، اکسیژن، هیدروژن و گازهای خنثی
2. گازهایی که همیشه در هوا موجوداند ولی نسبت آن تغییر می کند. همانند بخار آب، دی اکسیدکربن
3. گازهایی که فقط در بعضی از نقاط یافت می شود، همانند اکسیدهای سولفور.

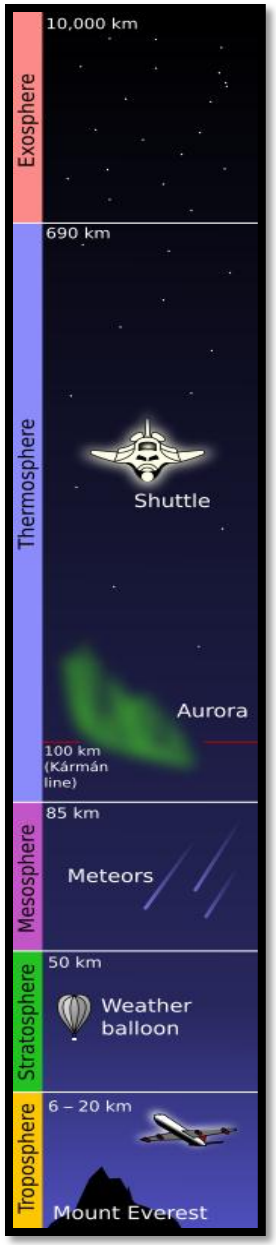
✓ گرد و غبار موجود در هوا: هوا همواره حاوی مواد بسیار ریز گرد و غبار می باشد که مقدار آن بسته به موقعیت و ارتفاع متفاوت است.

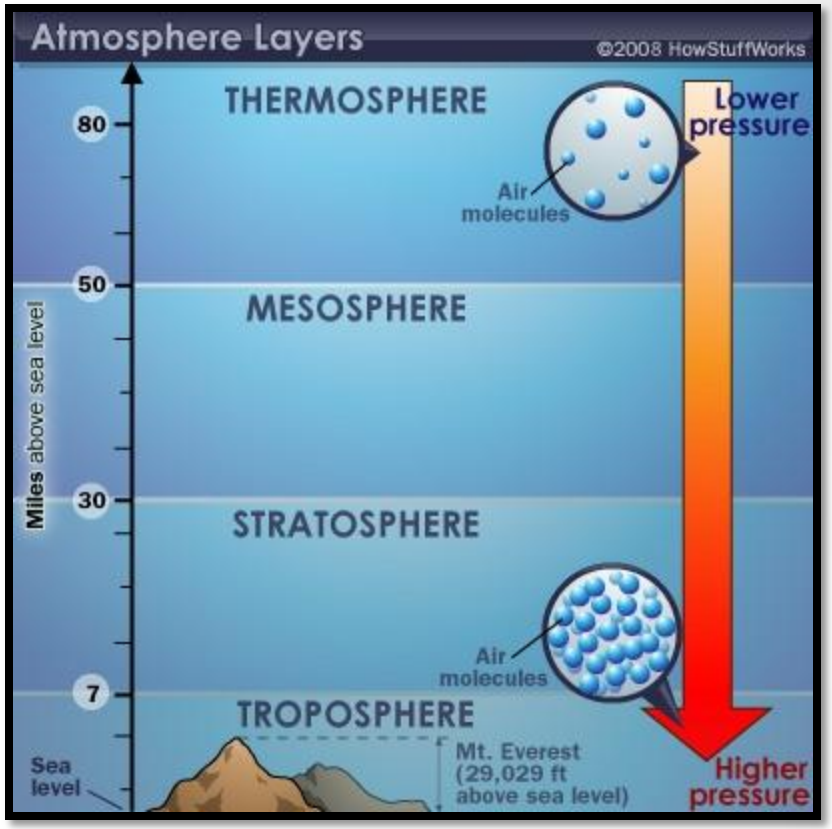
- هوایی که زمین را احاطه کرده است دارای لایه بندی هایی می باشد که در شکل زیر نشان داده شده است.



- از نظر دمایی می توان لایه های زمین را به صورت زیر تقسیم کرد.
- در این شکل با افزایش ارتفاع تا یک حد دما کاهش می یابد اما از یک ارتفاع دما مجدد افزایش می یابد که علت حضور ازون در این بخش است که با جذب اشعه ماوراء بنفش سبب افزایش دما در این بخش می شود.




Exosphere
10,000 km
Thermosphere
690 km
Shuttle
Aurora
100 km
(Kármán
line)
Mesosphere
85 km
Meteors
Stratosphere
50 km
Weather
balloon
Troposphere
6 – 20 km
Mount Everest


Atmosphere Layers
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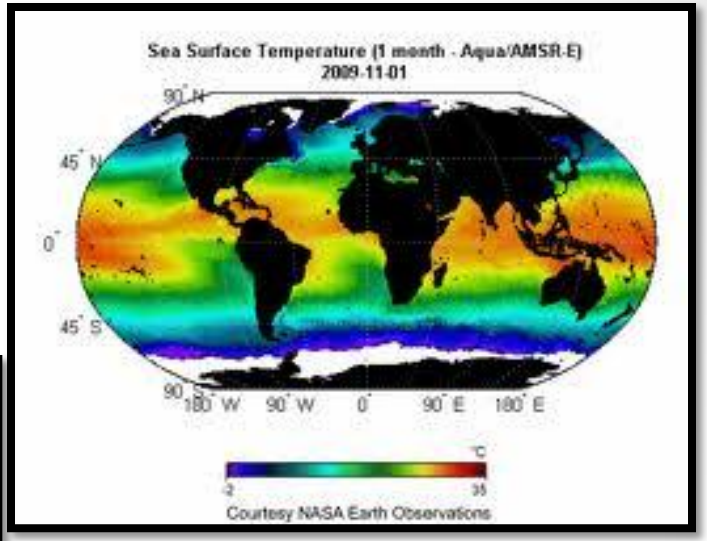
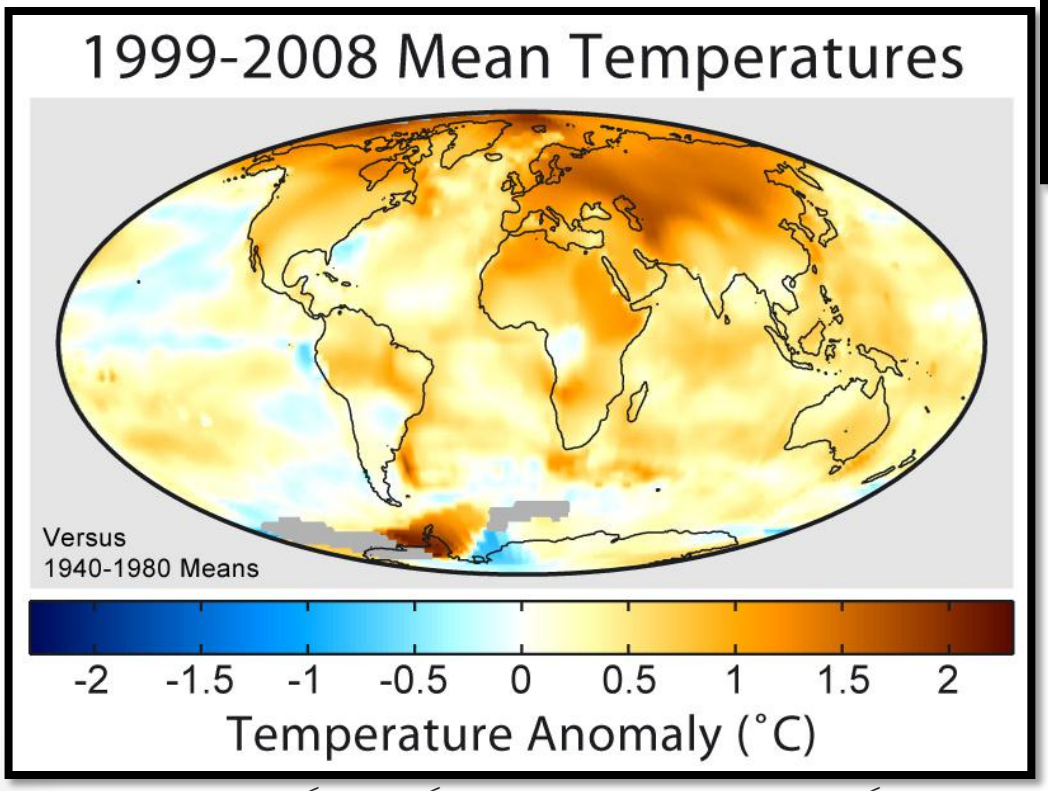
THERMOSPHERE
MESOSPHERE
STRATOSPHERE
TROPOSPHERE
80
50
30
7
Miles above sea level
Lower
pressure
Air
molecules
Air
molecules
Sea
level
Mt. Everest
(29,029 ft
above sea level)
Higher
pressure



میانگین دما در سطح کره زمین



گرم شدن زمین در اثر افزایش گازهای گلخانه ای

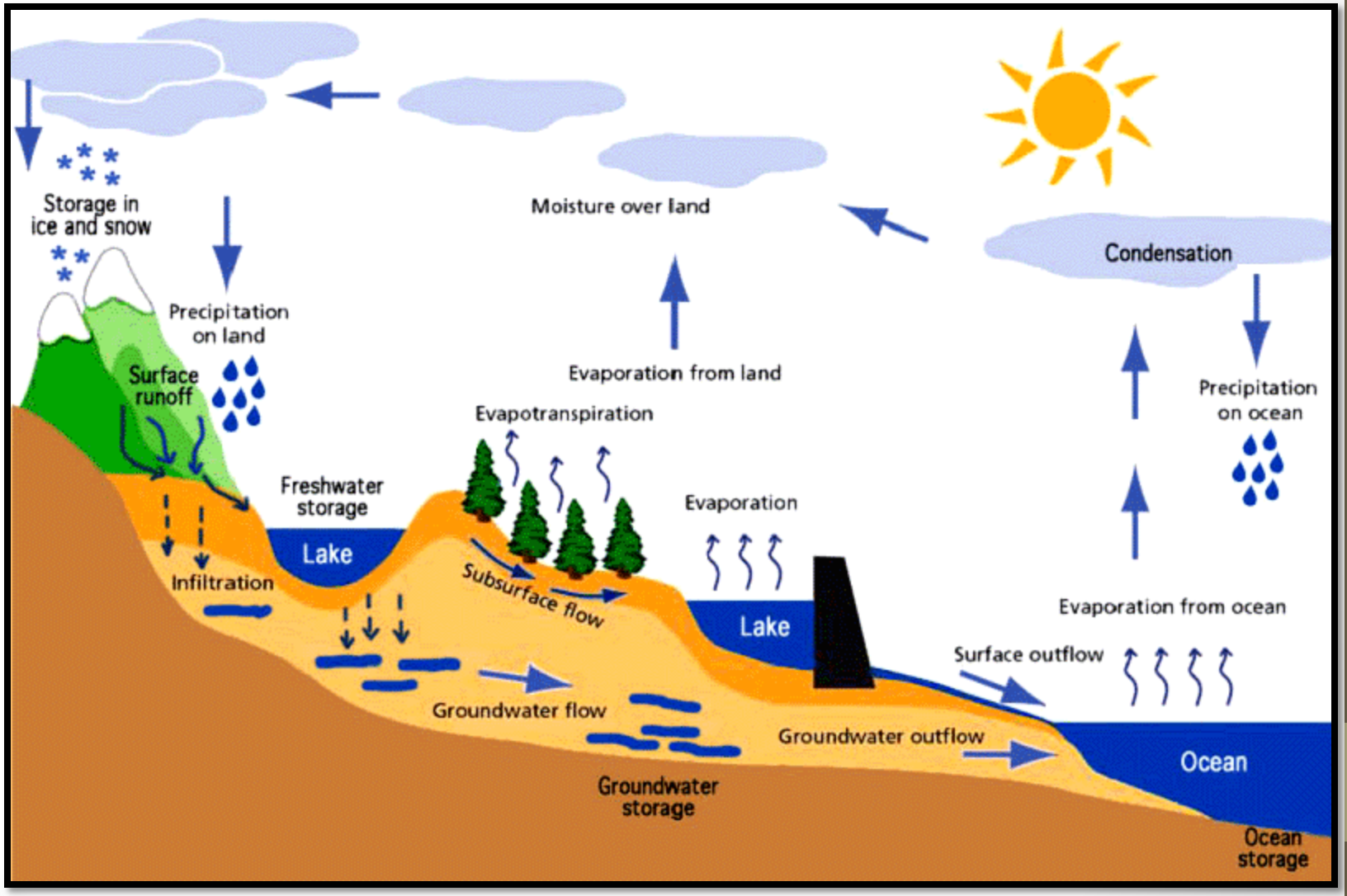
آبکره

- آبکره شامل تمام آبهای زمین است که می توان آن را به رودخانه ها و جویبارها، اقیانوس ها و دریاها، دریاچه ها و مردابها، آب های زیرزمینی و یخچالهای طبیعی تقسیم کرد.
- به طور کلی می توان گفت که بیش از ۹۷ آبکره را آبهای اقیانوس ها و دریاها و ۳ درصد باقی سایر موارد می باشد.
- علت اینکه در این بحث یخچال ها جزء آبکره به حساب آمد این ی باشد که همیشه بین یخچال ها و اقیانوس ها تعادل بر قرار است، بدین گونه که با افزایش دما مقداری از یخچال ها آب شده و به آب اقیانوس ها اضافه می شود و بلعکس، با کاهش دما اقیانوس ها به یخچال تیدیل می شوند.

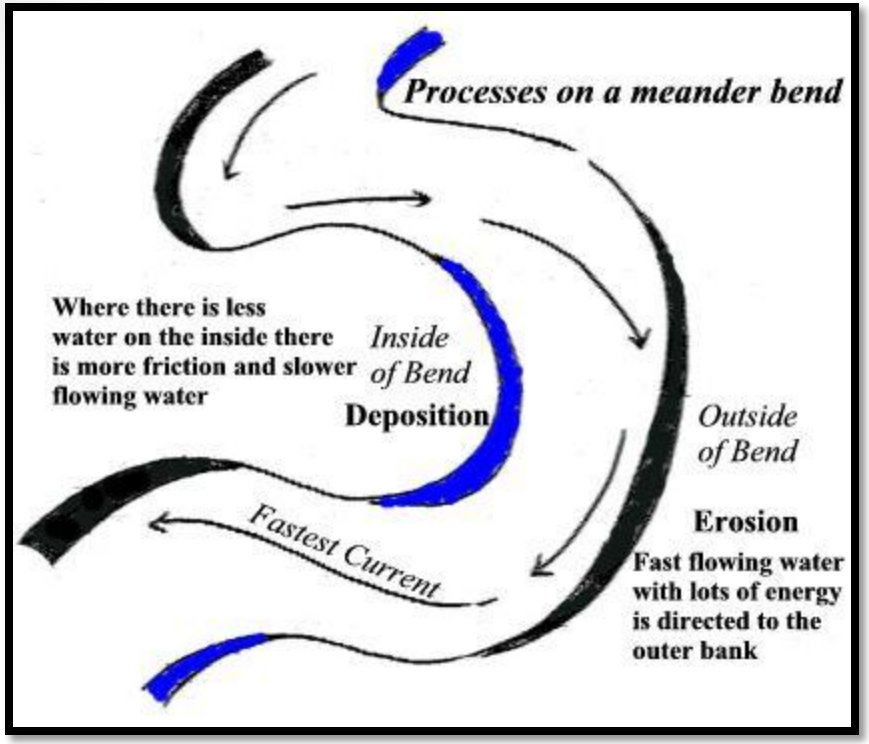
واحد های مهم آبکره

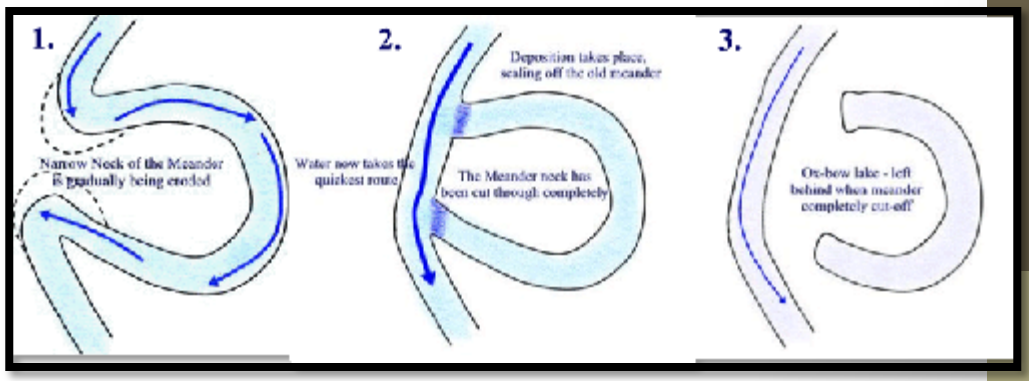
شرح	واحد	مقدار
وزن آب اقیانوس ها و دریاها	تن	1410E15
وزن آبهای شیرین	تن	0.51E15
وزن یخچال های طبیعی	تن	20-50 E15
وزن آب موجود در رسوبات	تن	200E15
وزن بخار آب موجود در هوا	تن	0.013E15

در زیر چرخه آبکره را مشاهده می نمایید.



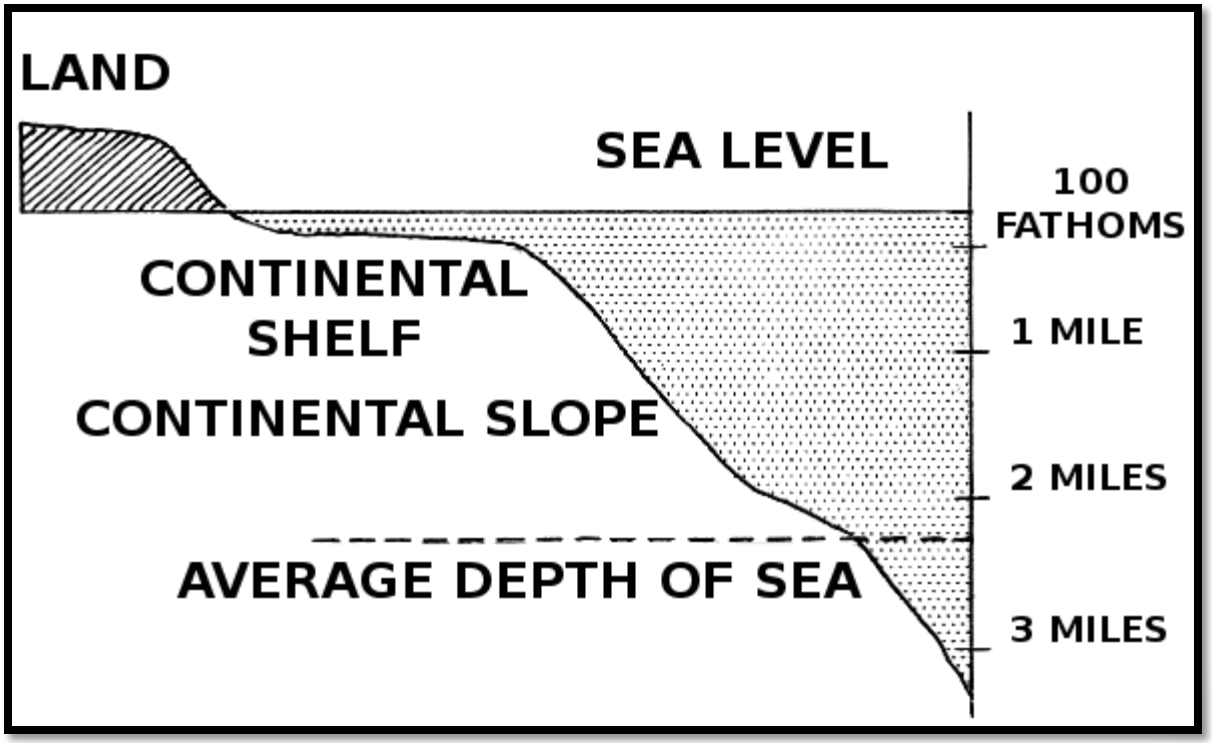
- مئاندر:
- یکی از مشخصات رودخانه ها پیچ و خم ها مسیر آن است. در مناطقی که سرعت حرکت رودخانه کم است همانند نواحی نزدیک دریا یا دریاچه، مسیر رودخانه به آسانی عوض می شود. مثلا اگر مانعی در سر راه مسیر قرار گیرد و یا اینکه شاخه فرعی رودخانه با سرعتی بیش از سرعت شاخه اصلی به آن بپیوندد، باعث تغییر مسیر حرکت رودخانه می شود. این پیچ و خمهای مسیر به نام مئاندر خوانده می شود.
- مئاندرها پس از تشکیل، کم کم وسیع می شوند و بالا وقتی ابتدا و انتهای یک منحنی مئاندر به هم رسید، این قسمت منحنی کم کم متروک شده و ارتباط آن با رودخانه قطع می شود و اگر این قسمت دارای آب باشد، دریاچه کوچکی به وجود می آید که به شکل قوس دایره است و به نام شاخ گاو خوانده می شود.

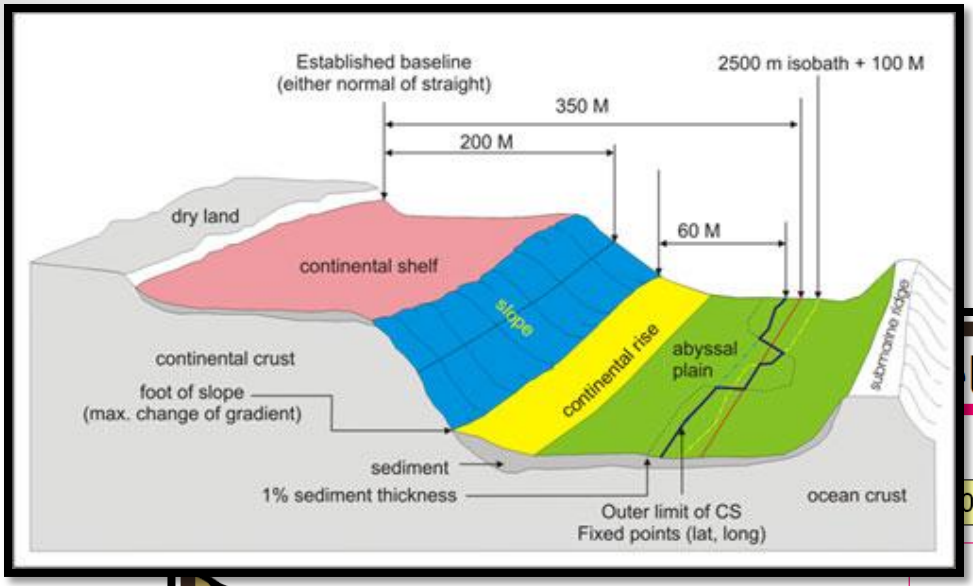

Processes on a meander bend
Where there is less water on the inside there is more friction and slower flowing water
Inside of Bend
Deposition
Outside of Bend
Erosion
Fast flowing water with lots of energy is directed to the outer bank
Fastest Current


1.
Narrow Neck of the Meander is gradually being eroded
2.
Deposition takes place, sealing off the old meander
Water now takes the quickest route
The Meander neck has been cut through completely
3.
Ox-bow lake - left behind when meander completely cut-off

شیب قاره

- محل برخورد اقیانوس با قاره ها را شیب قاره می گویند.





lf

cut off line is 350 NM or

100 NM beyond 2500-meter isobath

0NM from FoS

or

Sediment Thickness/Distance from FoS = 1%

Sedimentary layers

Basement

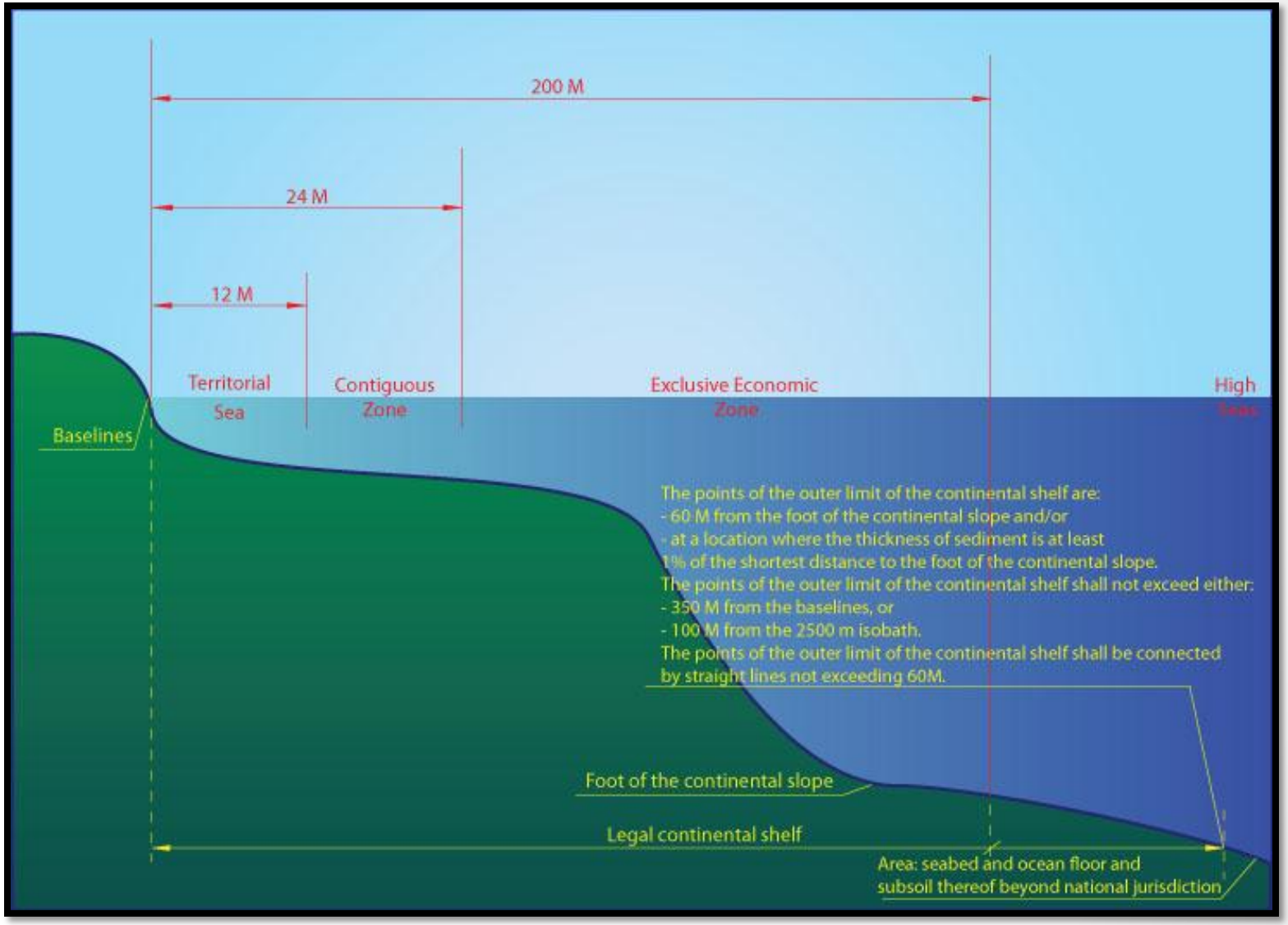
Baseline

(Low-Water Line, Straight Baseline, etc.)

Foot of Slope (FoS) = Maximum change of gradient

EEZ

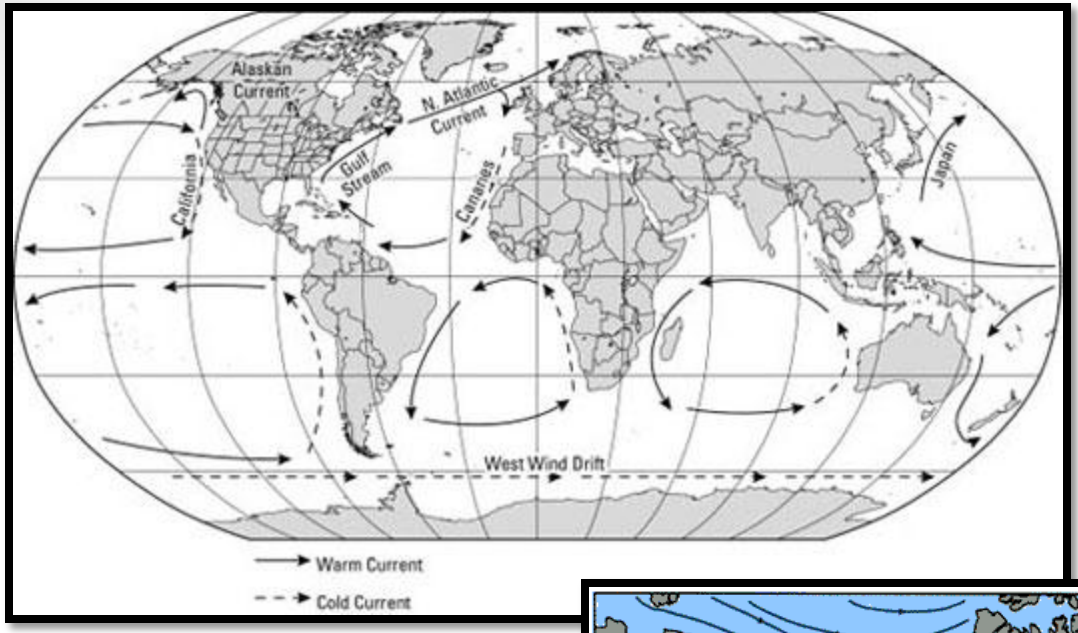
Continental Shelf

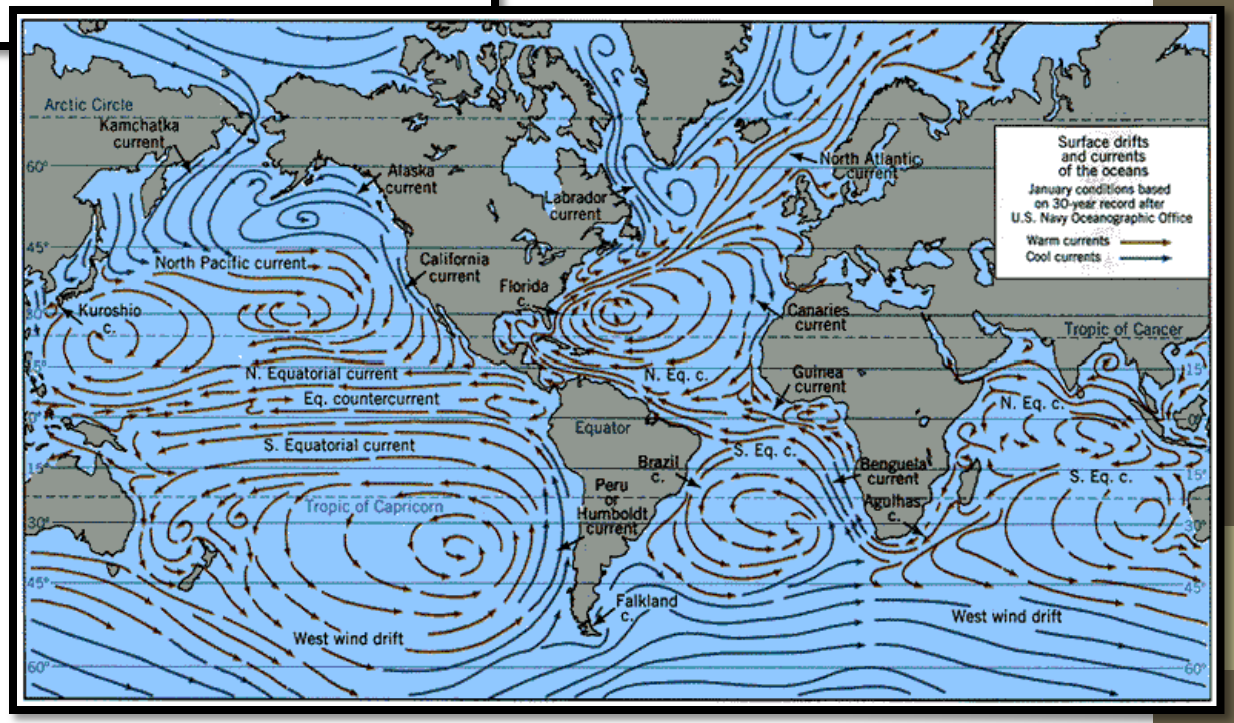

200 M
24 M
12 M
Territorial Sea
Contiguous Zone
Exclusive Economic Zone
High Seas
Baselines
The points of the outer limit of the continental shelf are:
- 60 M from the foot of the continental slope and/or
- at a location where the thickness of sediment is at least 1% of the shortest distance to the foot of the continental slope.
The points of the outer limit of the continental shelf shall not exceed either:
- 350 M from the baselines, or
- 100 M from the 2500 m isobath.
The points of the outer limit of the continental shelf shall be connected by straight lines not exceeding 60M.
Foot of the continental slope
Legal continental shelf
Area: seabed and ocean floor and subsoil thereof beyond national jurisdiction

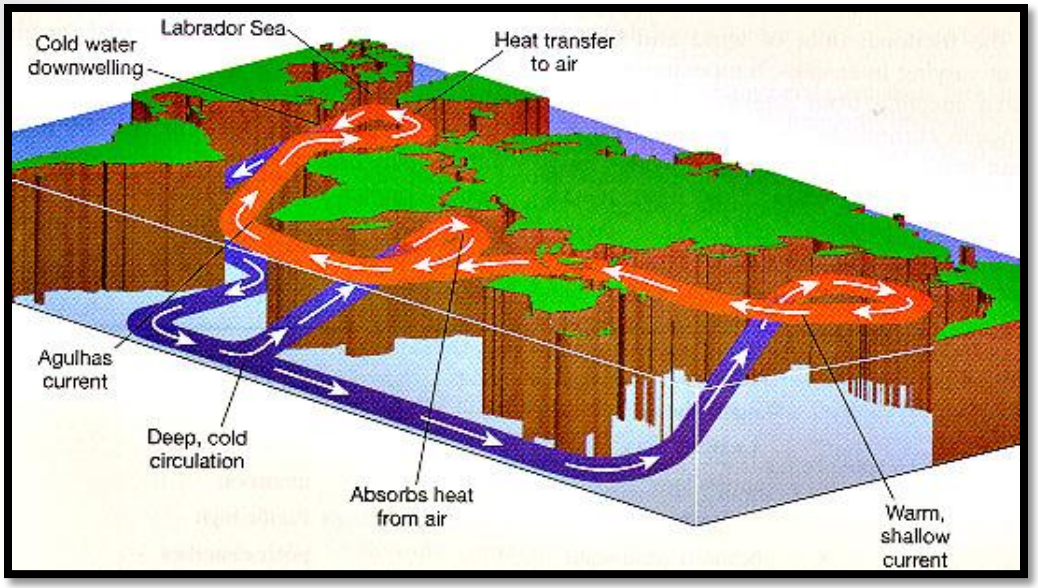
جریان های اقیانوسی

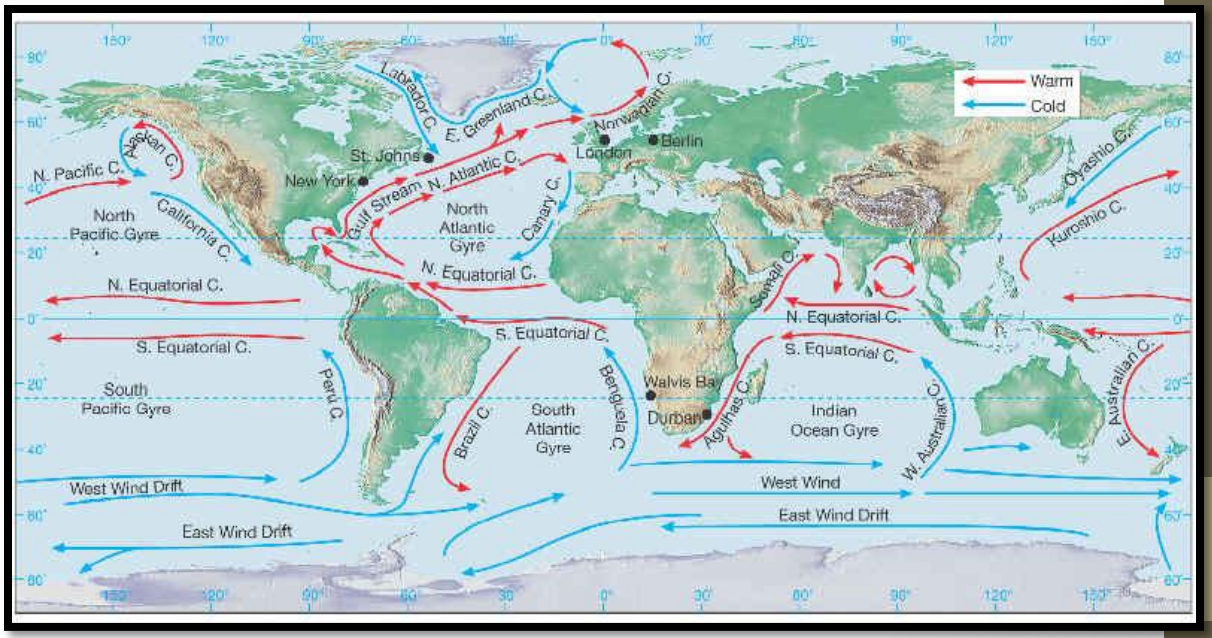
- جریان های اقیانوسی حاصل دو منشا می باشند.

1. جریان ها: اختلاف دما بین خشکی و دریا سبب ایجاد باد های شدیدی می شود، ورزش این باد باعث ایجاد جریان های آب از دریا به ساحل می شود(در بعضی از موارد موقعیت برعکسی ایجاد بدین گون که جهت باد از خشک به دریا می باشد)
2. آب های حاصل از ذوب شدن یخ ها موجود در یخچال ها، این آبها به علت اینکه دمای پایینی دارند سنگین بوده و سبب ایجاد جریان هایی در کف اقیانوس ها می شوند.


Alaskan Current
N. Atlantic Current
California
Gulf Stream
Canaries
Japan
West Wind Drift
Warm Current
Cold Current


Arctic Circle
Kamchatka current
Alaska current
Labrador current
North Atlantic current
Surface drifts and currents of the oceans
January conditions based on 30-year record after U.S. Navy Oceanographic Office
Warm currents
Cool currents
North Pacific current
California current
Florida c.
Kuroshio c.
Canaries current
Tropic of Cancer
N. Equatorial current
Eq. countercurrent
N. Eq. c.
Guinea current
Equator
S. Equatorial current
S. Eq. c.
Brazil c.
Benguela current
Peru or Humboldt current
Agulhas c.
Tropic of Capricorn
Falkland c.
West wind drift
West wind drift

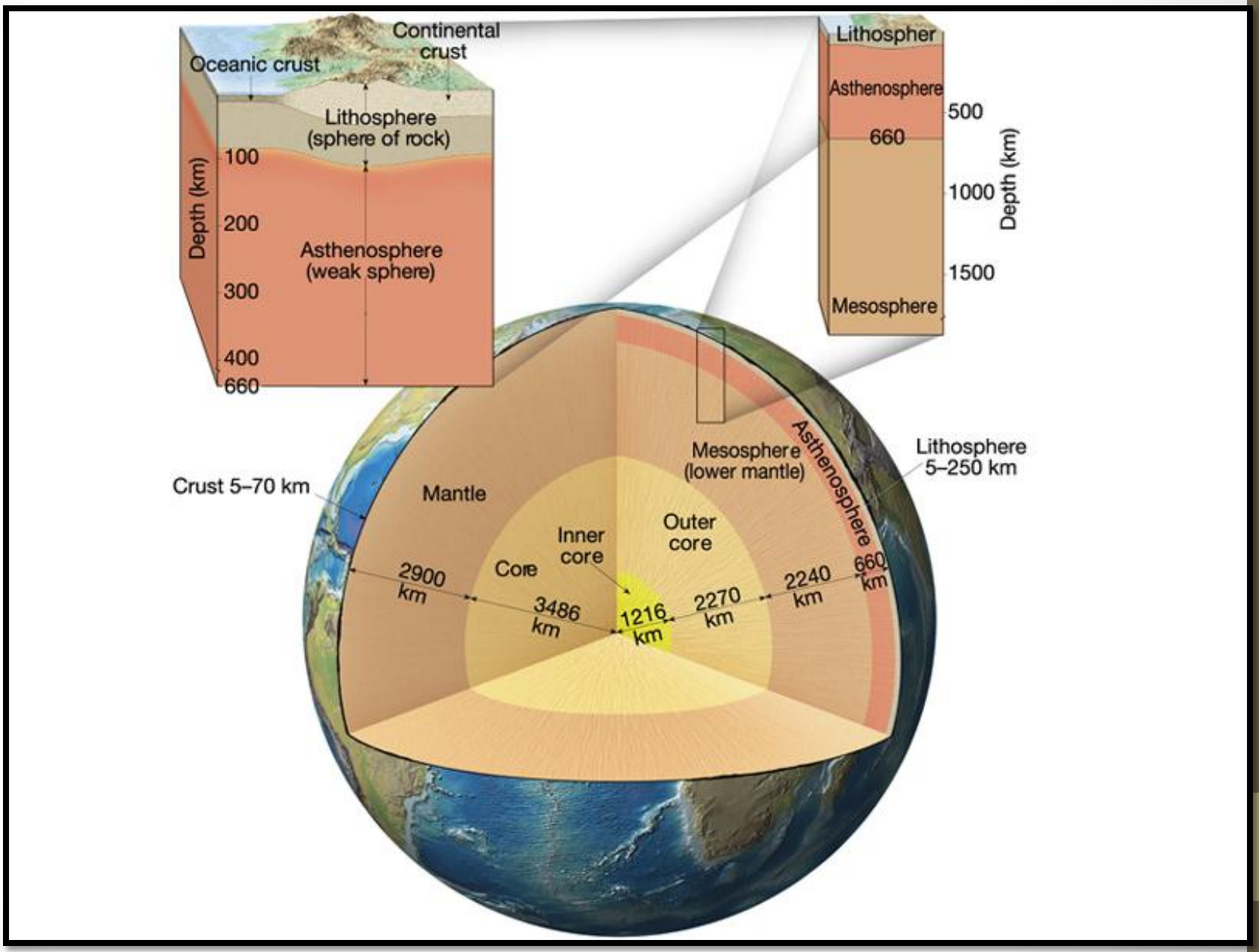

Cold water downwelling
Labrador Sea
Heat transfer to air
Agulhas current
Deep, cold circulation
Absorbs heat from air
Warm, shallow current

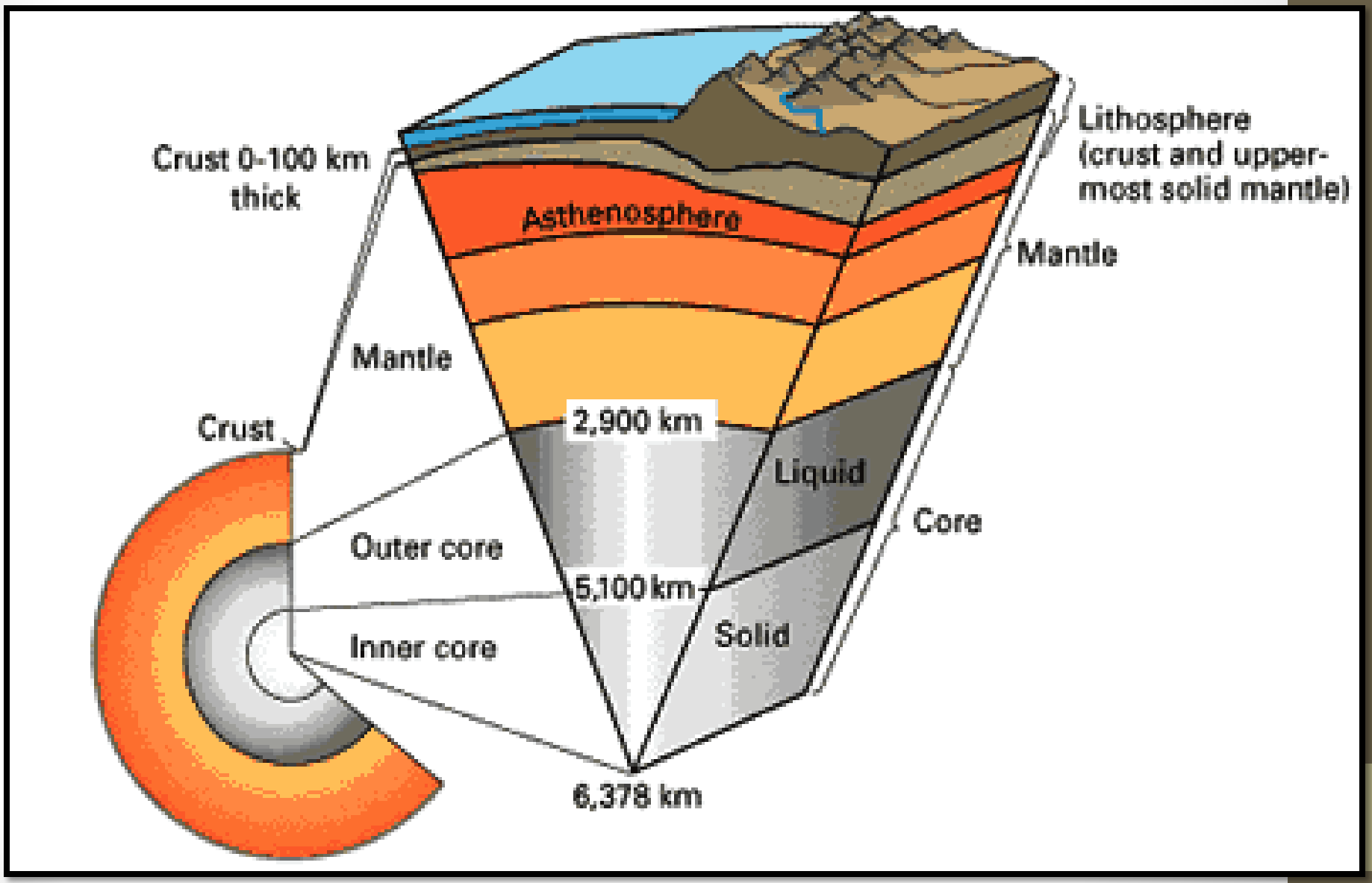

Warm
Cold
Labrador C.
E. Greenland C.
Norwegian C.
St. Johns
London
Berlin
New York
N. Pacific C.
Alaskan C.
Gulf Stream
N. Atlantic C.
Canary C.
North Pacific Gyre
California C.
North Atlantic Gyre
Oyashio C.
Kuroshio C.
N. Equatorial C.
Somali C.
S. Equatorial C.
Peru C.
Brazil C.
Benguela C.
Walvis Bay
Durban
Agulhas C.
South Pacific Gyre
South Atlantic Gyre
Indian Ocean Gyre
W. Australian C.
E. Australian C.
West Wind Drift
West Wind
East Wind Drift

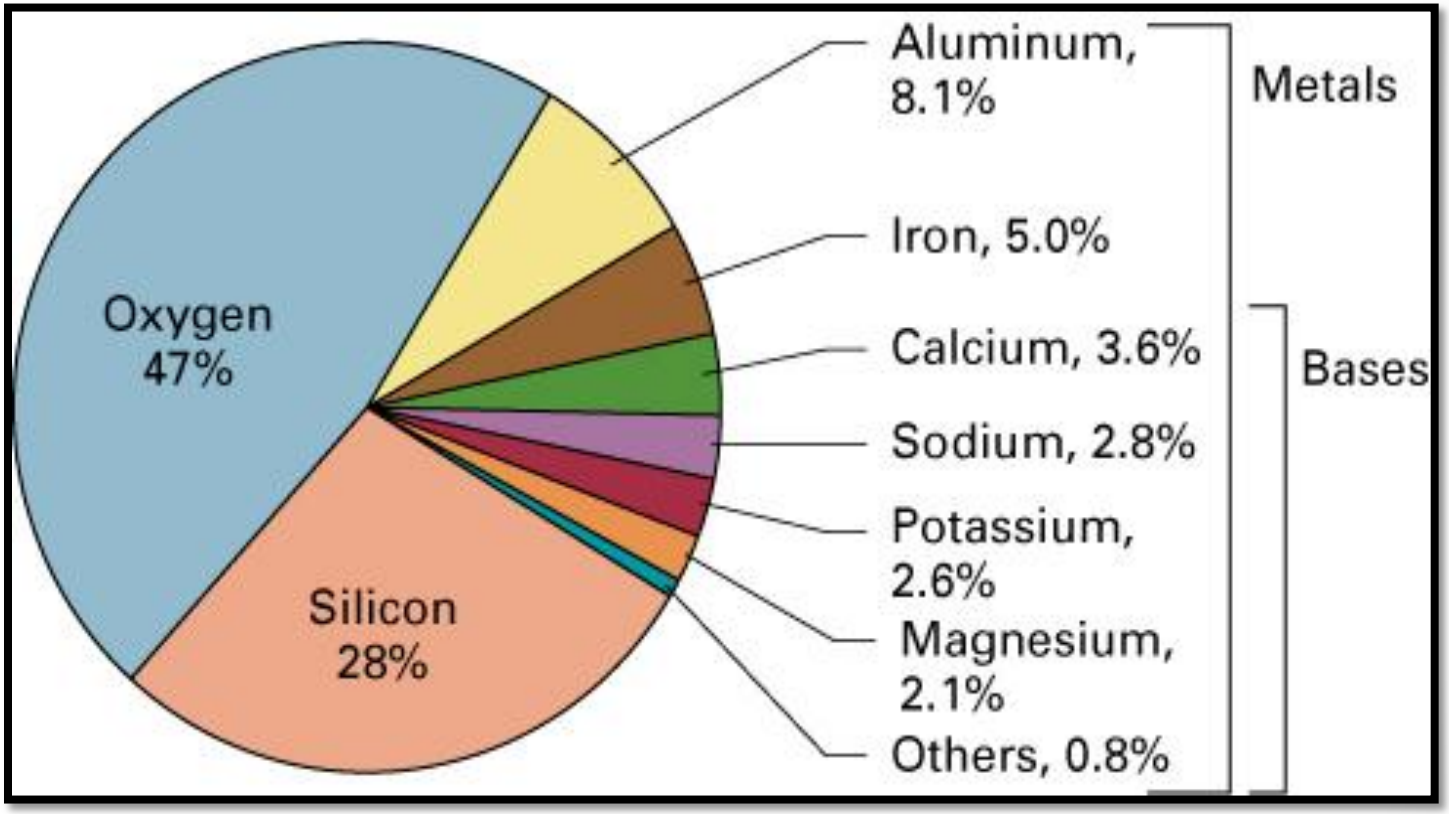
سنگ کره

- قسمت سنگی مهمترین قسمت زمین از نظر حجم و وزن می باشد، که دارای سه بخش می باشد.

1. پوسته زمین: این بخش سرتا سر زمین را(در قاره ها و زیر اقیانوس ها) می پوشاند و ضخامت متوسط ان ۳۳ کیلومتر است.
2. گوشته زمین: زیر پوسته زمین و تا عمق ۲۹۰۰ کیلومتری گسترش دارد و خود به بخش های کوچکتری تقسیم می شود.
3. هسته زمین: از عمق ۲۹۰۰ کیلومتری تا مرکز زمین توسعه دارد و خود به دو قسمت خارجی و داخلی تقسیم می شود.


Continental crust
Oceanic crust
Lithosphere (sphere of rock)
Depth (km)
100
200
300
400
660
Asthenosphere (weak sphere)
Lithospher
Asthenosphere
660
500
1000
1500
Depth (km)
Mesosphere
Crust 5–70 km
Mantle
Mesosphere (lower mantle)
Asthenosphere
Lithosphere 5–250 km
Inner core
Outer core
Core
2900 km
3486 km
1216 km
2270 km
2240 km
660 km

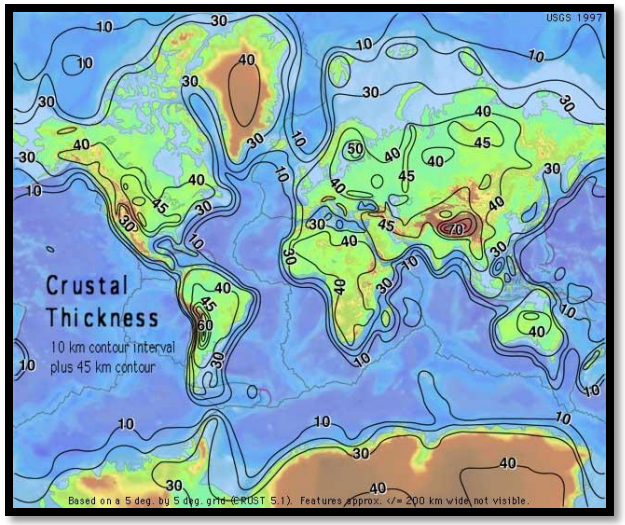

Crust 0-100 km thick
Asthenosphere
Lithosphere (crust and upper-most solid mantle)
Mantle
Mantle
Crust
2,900 km
Liquid
Core
Outer core
5,100 km
Inner core
Solid
6,378 km



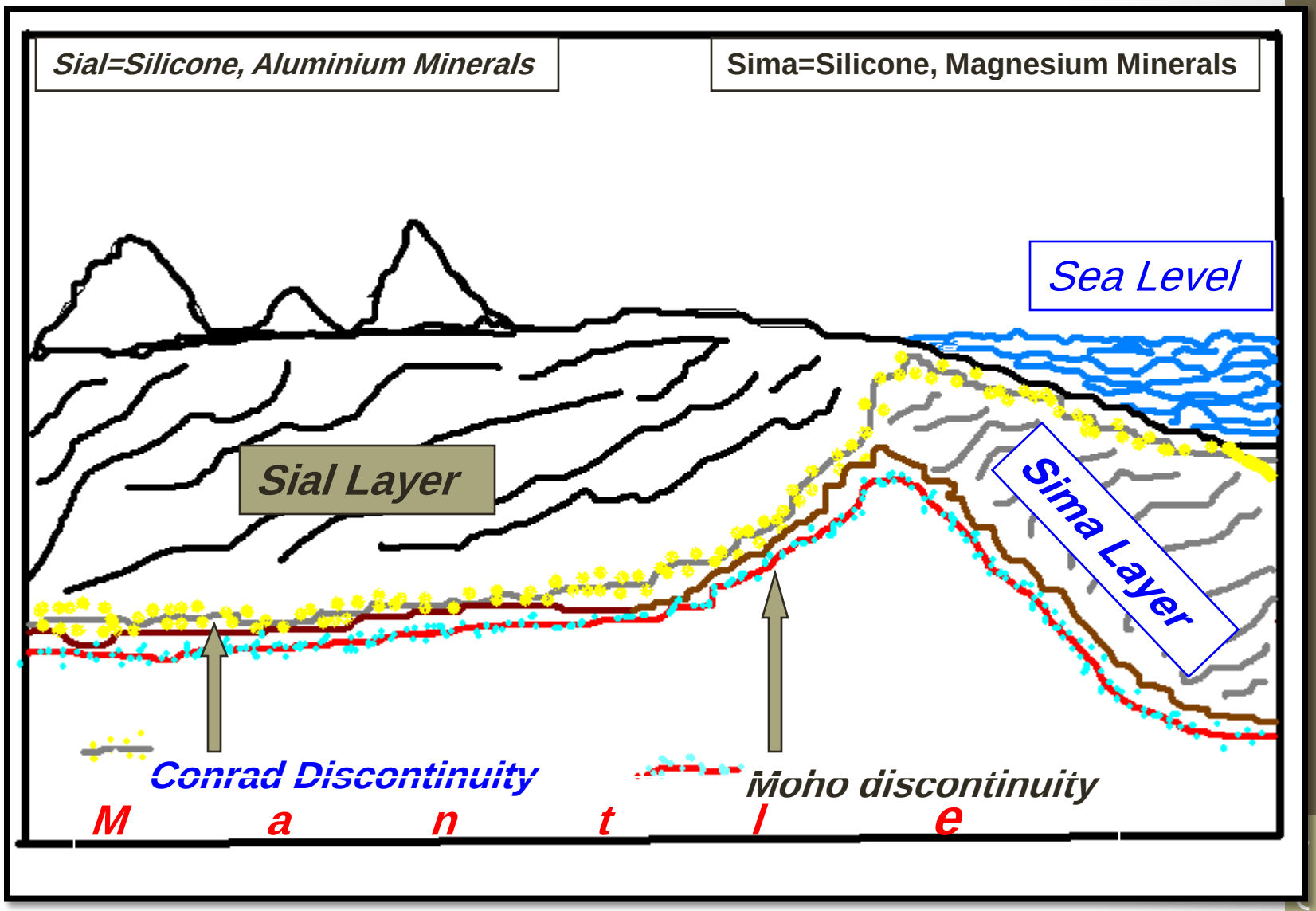
ترکیبات پوسته

پوسته زمین

- ضخامت متوسط پوسته زمین در حدود ۳۳ کیلومتر می باشد، ضخامت پوسته در زیر اقیانوس ها به مراتب کمتر از قاره ها می باشد به صورتی که پوسته از حداقل ضخامتی برابر ۱۰ کیلومتر در زیر دریاها و حداکثر ٦۰ کیلومتر در زیر قاره ها و کوهها دارد.

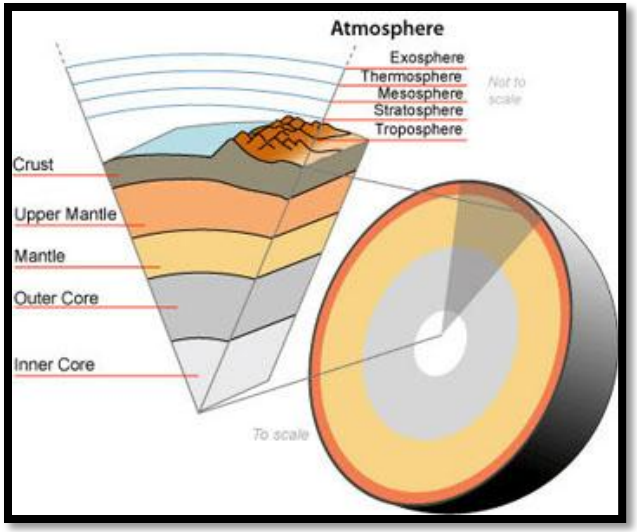


- از نظر ترکیب شیمیایی می توان پوسته را به دو قسمت بالایی و پایینی تقسیم کرد.
- قشر بالایی پوسته از سنگهای گرانیتی و گرانودیوریت تشکیل شده است که به علت دارا بودن مقدار زیادی سیلیسیم و آلومینیم به نام ***سیال*** نیز خوانده می شود.
- قشر زیرین پوسته بیشتر از سنگ هایی با ترکیب بازالت تشکیل شده و به علت دارا بودن مقدار زیادی سلیسیم و منیزیم به نام سیما معروف است.
- جرم مخصوص پوسته زمین در قسمت های مختلف یکسان نیست و امروزه فرض بر این است که جرم مخصوص در زیر اقیانوس ها کمی بیش از جرم مخصوص آن در زیر قاره ها است(نظریه ایزوستازی) ولی می توان مقدار متوسط آن را ۲.۷ الی ۲.۸ در نظر گرفت.


Sial=Silicone, Aluminium Minerals
Sima=Silicone, Magnesium Minerals
Sea Level
Sial Layer
Sima Layer
Conrad Discontinuity
Moho discontinuity
M a n t l e

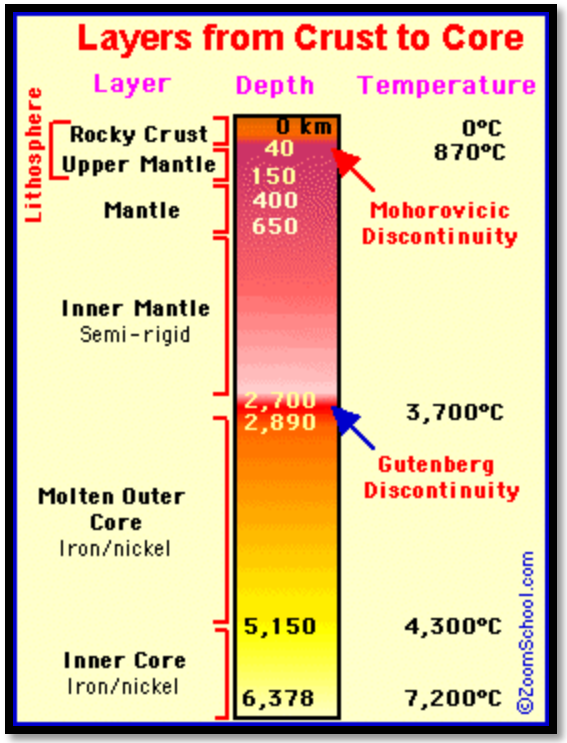
گوشته زمین

- قسمتی از زمین که بین دو انفصال موهورویچ و گوتنبرگ قرار دارد گوشته زمین خوانده می شود. به این ترتیب قسمتی از زمین که بین ۳۳ تا ۲۹۰۰ کیلومتری گسترش دارد گوشته است.



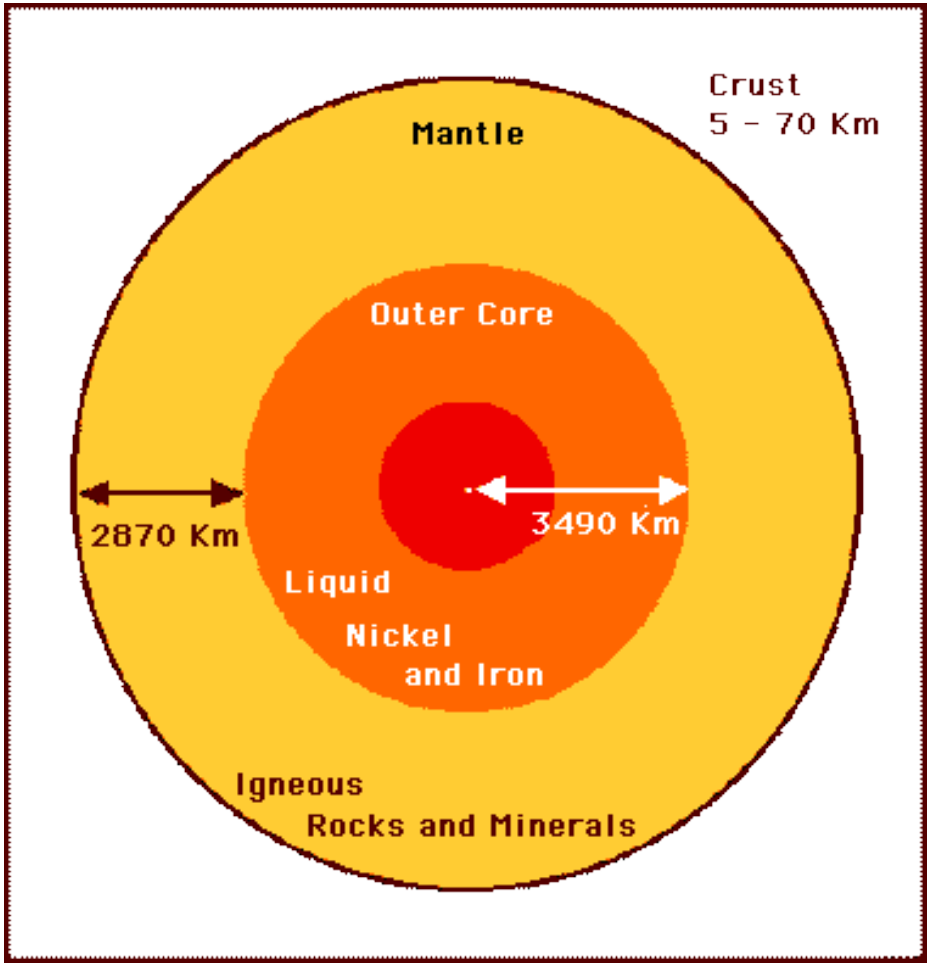
- گوشته بالایی: مطالعات نشان داده است که منشا بسیاری از پدیده های زمین شناسی مثل فعالیت ماگمایی، زلزله های عمیق، تغییر مکان قاره ها، مسبب اش گوشته بالایی می باشد.
- مطالعات نشان داده که در گوشته بالایی احتمالا سه سنگ دونیت، پریدوتیت و اکلوژیت سبب ایجاد خاصیت ارتجاعی شده اند.
- جرم مخصوص این بخش از گوشته در حدود ۳.۹ گرم بر سانتی متر مکعب می باشد.

- گوشته پایینی: این قسمت از کوشته بین اعماق ۹۸٤ الی ۲۹۰۰ کیلومتری قرار دارد، این قسمت از زمین متجانس به نظر می رسد و سیلیکاتهای منیزیم و آهن و اکسیدهایی مثل کریندن، رتیل و اسپینل تشکیل شده است.



هسته زمین

- هسته زمین از عمق ۲۹۰۰ کیلومتری تا مرکز زمین گسترش دارد و ضخامت کلی آن ۳٤۷۱ کیلومتر است.
- مطالعات نشان داده است که در عمق تقریبی ۵۱۲۰ کیلومتری، یک انفصال در خواص الاستیک هسته وجود دارد که بر مبنای آن می توان هسته را به دو قسمت خارجی و داخلی تقسیم کرد.
- هسته خارجی از نظر خواص الاستیک حالت مایع و هسته داخلی حالت جامد دارد.
- هسته زمین(خارجی و داخلی) از جنس نیکل و آهن تشکیل شده است.
- جرم مخصوص هسته خارجی بین ۸.۵ تا ۱۱.۵ گرم بر سانتی متر مکعب و جرم مخصوص هسته داخلی در حدود ١٤ تا ١٨ گرم بر سانتی مترمکعب و جرم مخصوص هسته به طور کلی در حدود ۱۱ گرم بر سانتی متر مکعب می باشد.


Crust
5 - 70 Km
Mantle
Outer Core
2870 Km
3490 Km
Liquid
Nickel
and Iron
Igneous
Rocks and Minerals

کانی ها

- Identification
- Classification
- Formation

} of common minerals & rocks

Minerals and Rocks

Definition:

- Highly-ordered crystalline atomic structure
- Definite chemical composition
- (Naturally occuring) homogeneous solid

Not minerals: coal
glass

Polymorphs: diamond (C)
graphite (C)

Crystallography

A vast and hideously complicated subject . . .

- 32 crystal classes by symmetry elements:
  - *rotation symmetry*
  - *rotoinversion symmetry*
  - *mirror symmetry*
  - *combinations of above*

- Classes grouped into 6 crystal systems:
  - *triclinic*
  - *monoclinic*
  - *orthorhombic*
  - *tetragonal*
  - *hexagonal*
  - *isometric*

Common Minerals to Learn

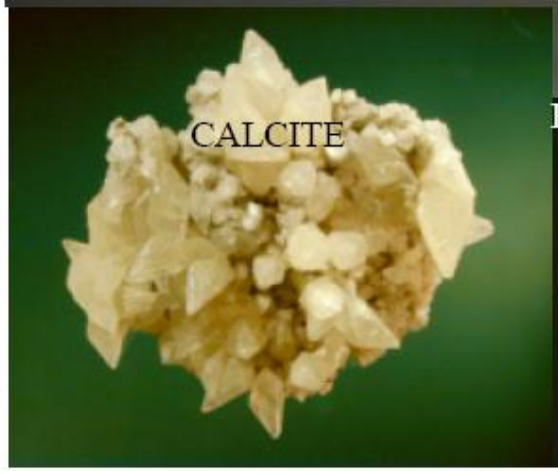
Olivine		(Mg,Fe,Ca) Silicate
Pyroxene		(Mg,Fe,Ca) Silicate
Amphibole		(Mg,Fe,Ca) Silicate + OH
Feldspar		(K,Na,Ca) Al-Silicate
Quartz		Silica
Mica	Biotite, Muscovite	(K,Mg) Al-Silicate + OH
Clay	Kaolinite, Montmorillonite	Al-Silicate + OH
Chlorite		(Mg,Fe) Al-Silicate + OH
Serpentine		Mg Silicate + OH
Calcite & Dolomite		$CaCO_3$ & $(Ca,Mg)CO_3$
Gypsum		Calcium Sulphate + H_2O
Hematite & Magnetite		Iron Oxide
Pyrite		Iron Sulphide

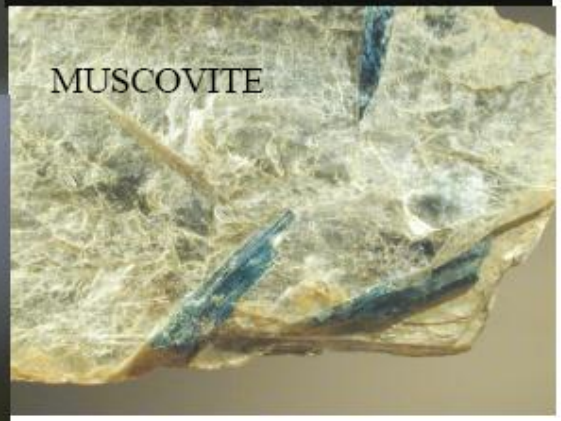
Identifying Common Minerals

1. Colour
2. Streak
3. Lustre
4. Transparency
5. Habit
6. Cleavage
7. Density
8. Hardness

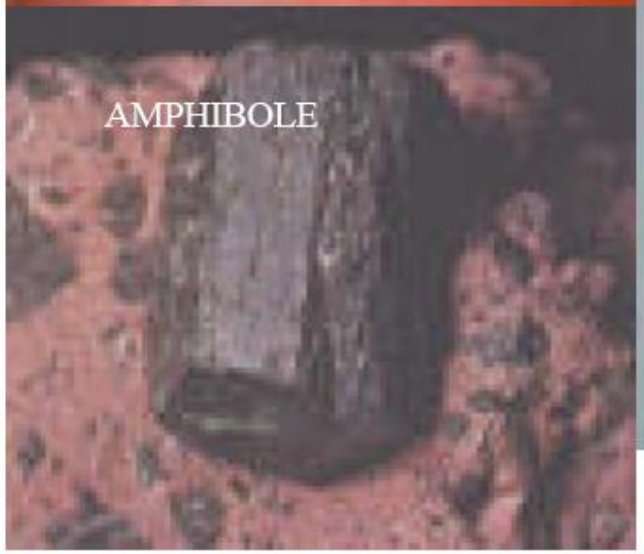
Checklist of properties

Identifying Minerals: *Colour - White/Pale*





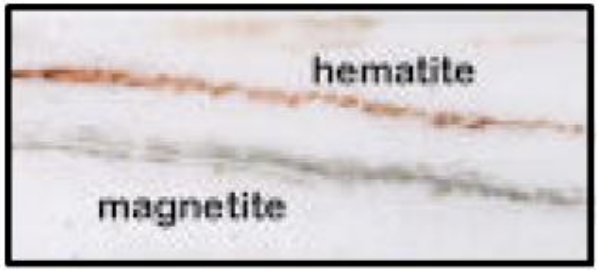
Identifying Minerals: *Colour - Dark*



Identifying Minerals: *Colour - Green*

Identifying Minerals: *Streak*

Hematite Fe_2O_3
Magnetite Fe_3O_4



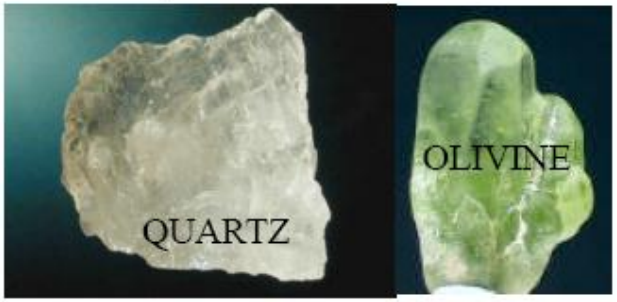
Streak: *scratch the mineral on the back of a ceramic tile and note the colour*

Identifying Minerals: *Lustre*

Dull, Earthy

Milky white

Glassy



Irridescent, Pearly

Adamantine

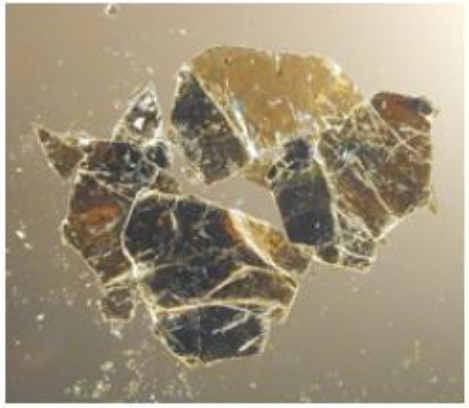
Identifying Minerals: *Habit*

Characteristic crystal shape; Related to crystallography

Cubic
e.g. Pyrite

Laths
e.g. Feldspar

Sheets
e.g. Micas



Fibrous
e.g. Asbestos

Identifying Minerals: *Form*

Characteristic form of crystals

Euhedral . . . . . Subhedral . . . . . Anhedral

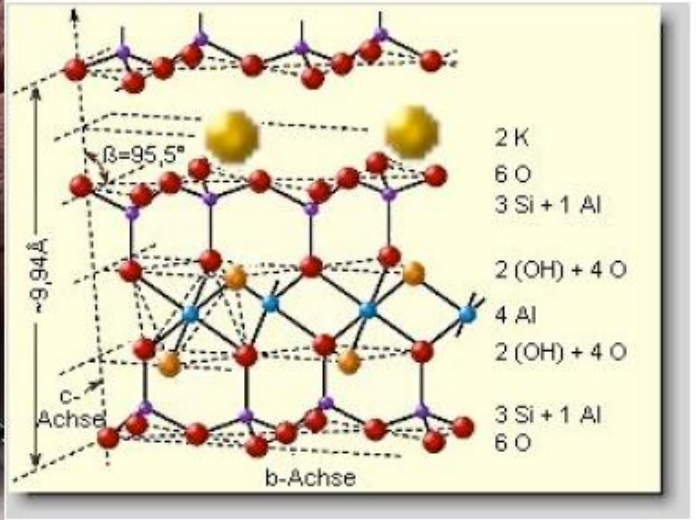
Quartz

Olivine

Quartz

Identifying Minerals: *Cleavage*

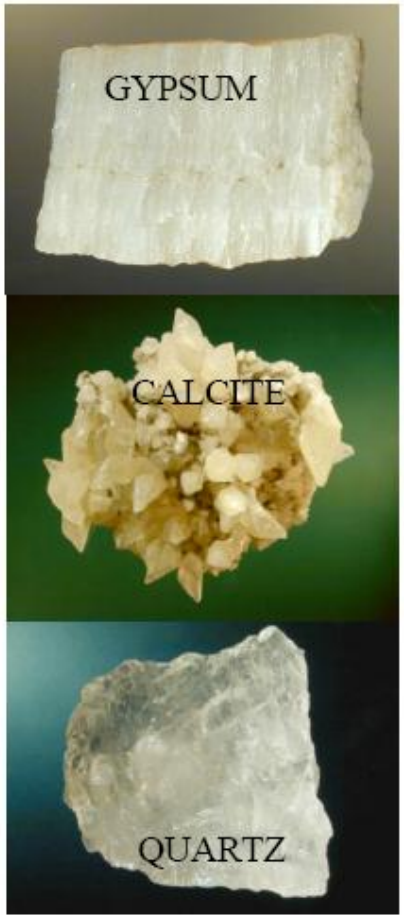
Planes of weakness within crystal lattice



Identifying Minerals: *Hardness*

Moh's Scale of Hardness

1. Talc
2. Gypsum
3. Calcite
4. Fluorite
5. Apatite
6. Orthoclase
7. Quartz
8. Topaz
9. Corundum
10. Diamond



2.5 Fingernail

3. Copper coin

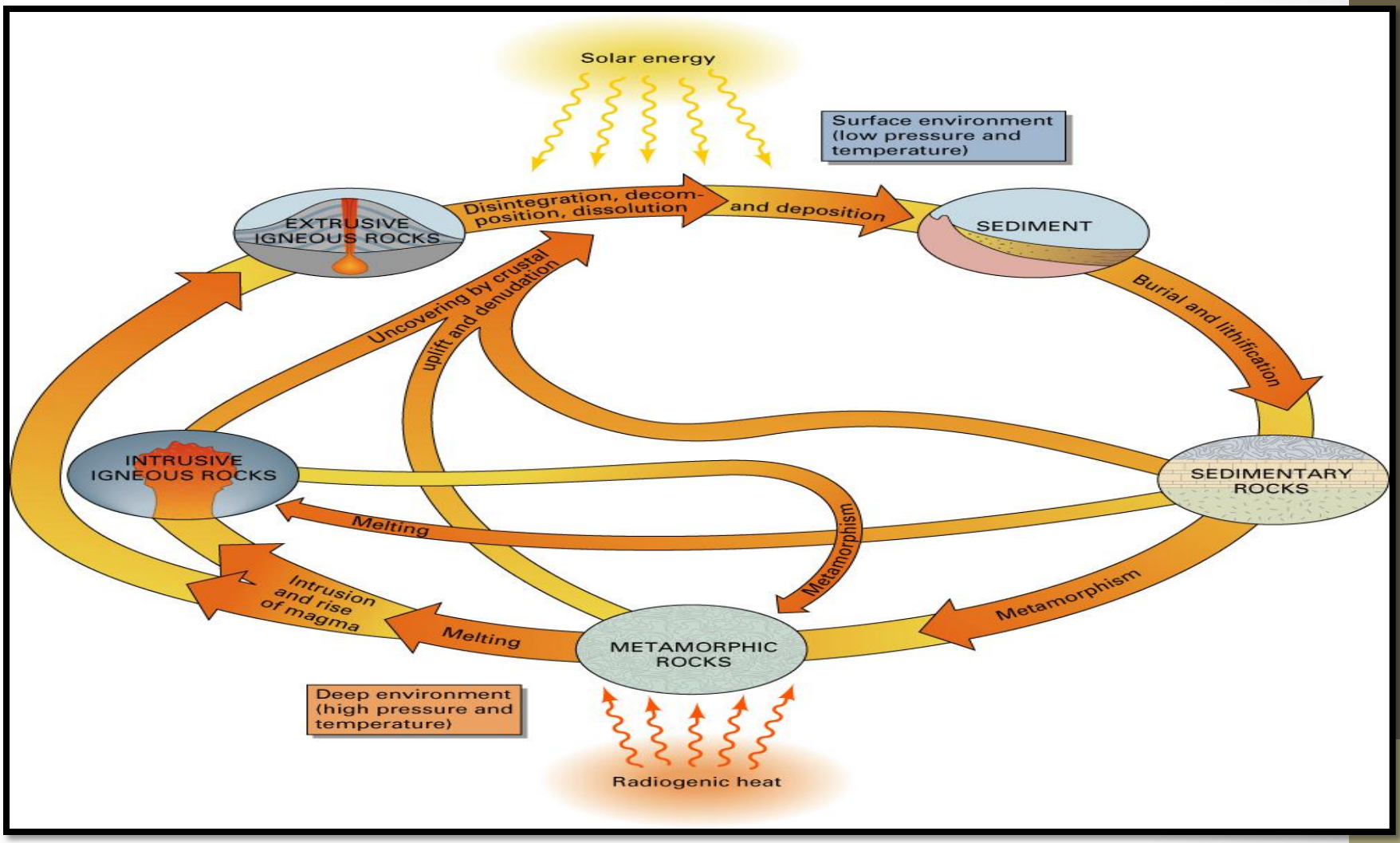
5.5 Pocket knife

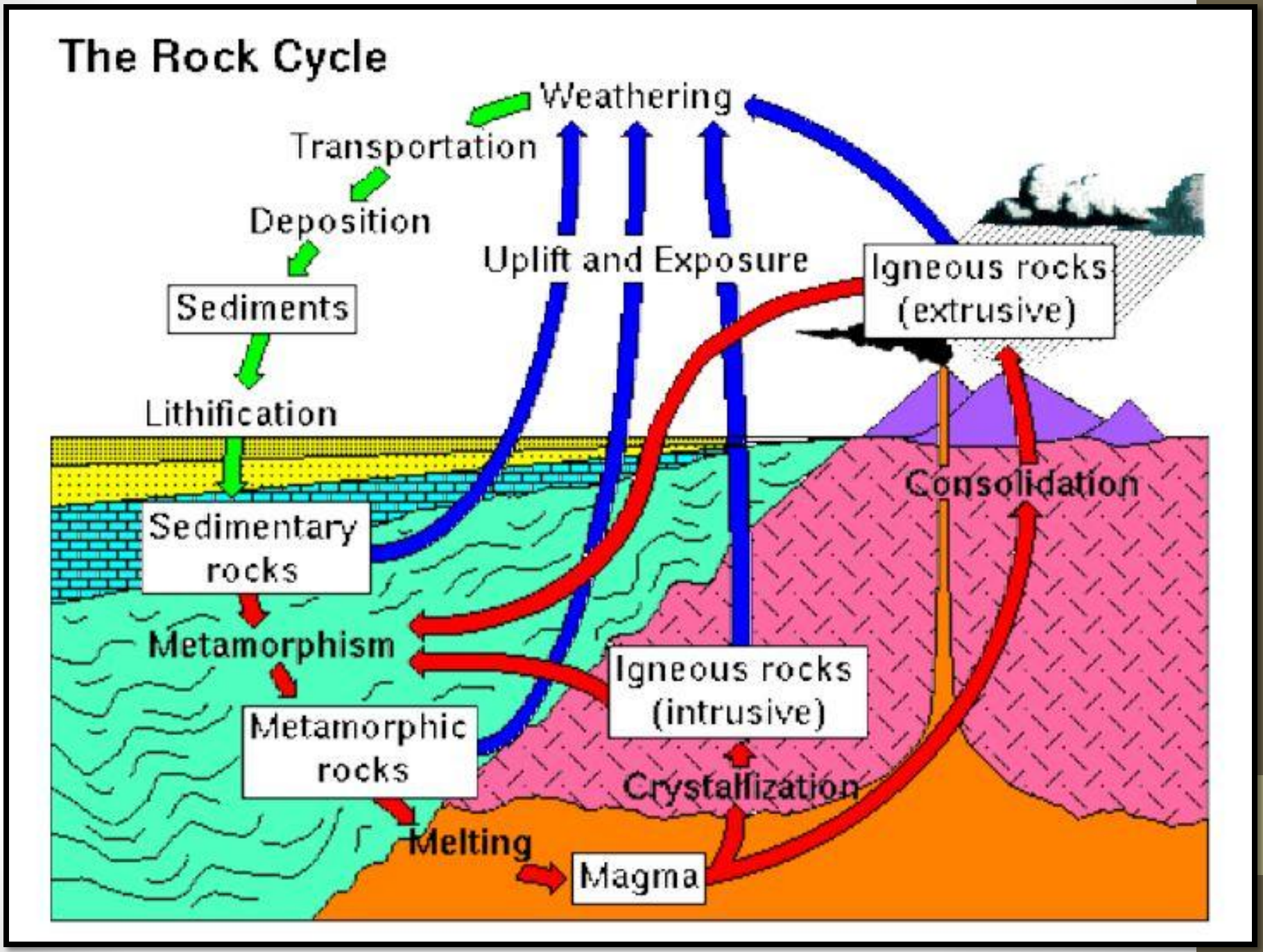
سنگها

- سنگهای اجسام طبیعی هستند که از مجموعه ای از یک یا چند کانی تشکیل شده است. سنگهای موجود در زمین را می توان به سه گروه تقسیم نمود.

1. سنگهای آذرین: این نام به سنگ هایی اطلاق می شود که از انجماد ماگما و یا سرد شدن یک سال داغ نتیجه شده اند.
2. سنگهای رسوبی: سنگهای رسوبی در نتیجه رسوب موادی که ز فرسایش قسمتهای مختلف زمین حاصل شده تولید می شوند.
3. سنگهای دگرگونی: اگر سنگهای رسوبی و یا آذرین تحت تاثیر یک یا چند عامل از سه عامل فشار، دما و محلول های گرمایی قرار گیرند، به سنگهای دگرگونی تبدیل می شوند.

- در اسلاید بعد چرخه سنگ ها در کره زمین را مشاهده می نمایید


Solar energy
Surface environment (low pressure and temperature)
EXTRUSIVE IGNEOUS ROCKS
Disintegration, decomposition, dissolution
and deposition
SEDIMENT
Burial and lithification
Uncovering by crustal uplift and denudation
INTRUSIVE IGNEOUS ROCKS
SEDIMENTARY ROCKS
Melting
Metamorphism
Intrusion and rise of magma
Melting
METAMORPHIC ROCKS
Metamorphism
Deep environment (high pressure and temperature)
Radiogenic heat


The Rock Cycle
Weathering
Transportation
Deposition
Sediments
Lithification
Uplift and Exposure
Igneous rocks (extrusive)
Consolidation
Sedimentary rocks
Metamorphism
Igneous rocks (intrusive)
Metamorphic rocks
Crystallization
Melting
Magma

Igneous Rocks

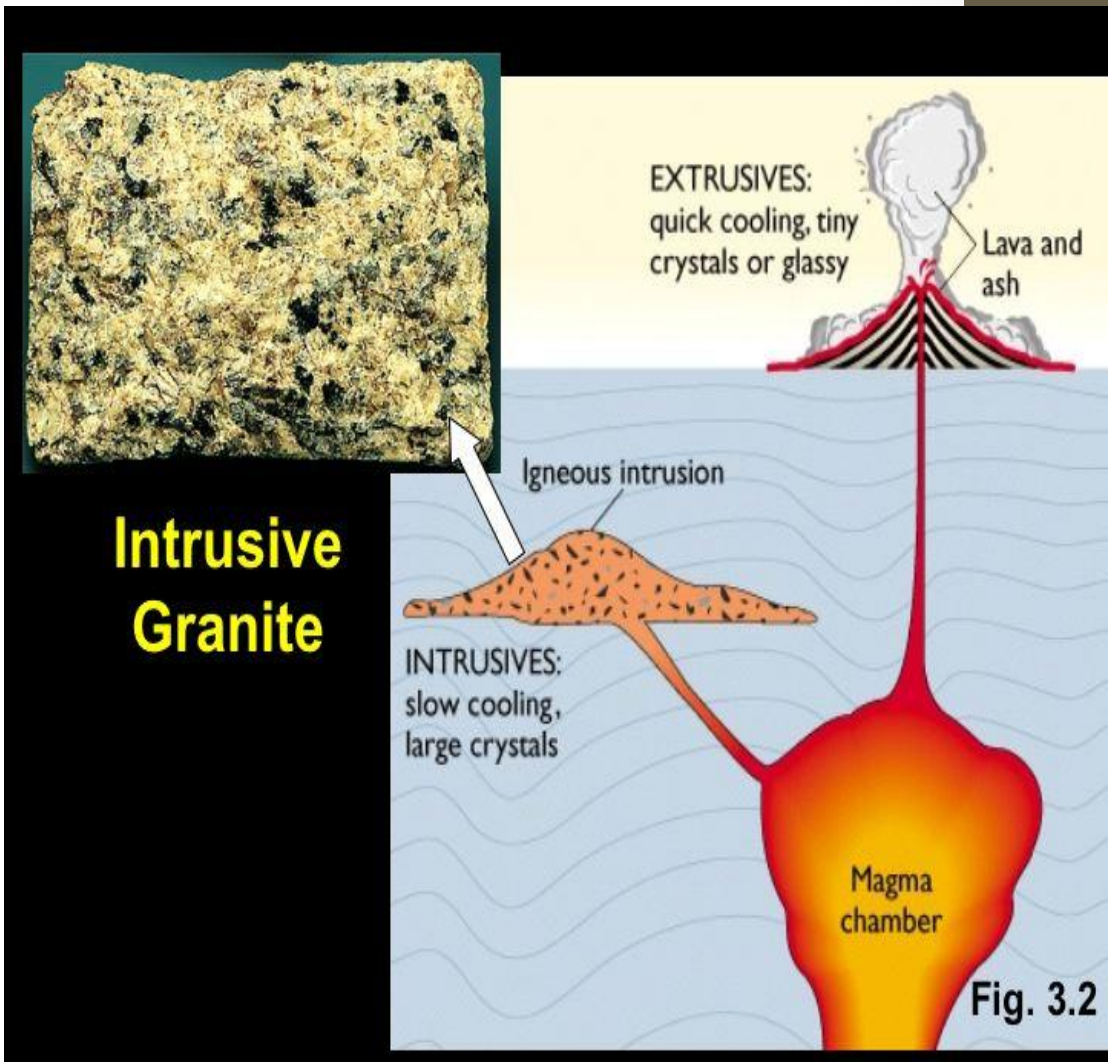
Igneous rocks form when liquid molten material cools and solidifies

- **Two types:**
  1. **Intrusive igneous rocks**
  2. **Extrusive igneous rocks**

Magma Vs Lava

Intrusive Igneous Rocks

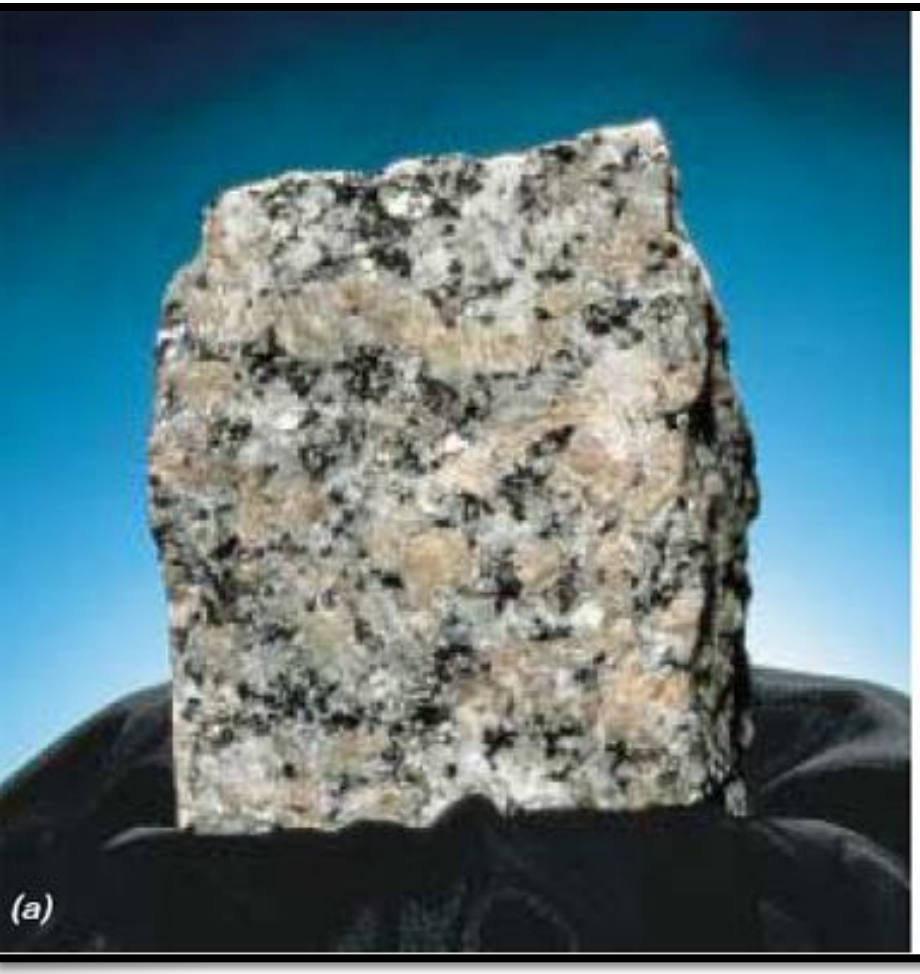
- ✓Magma solidifies <u>below</u> the Earth's surface
- ✓They cool slowly and therefore develop larger mineral crystals visible to the eye
- ✓Coarse-textured



Intrusive Igneous

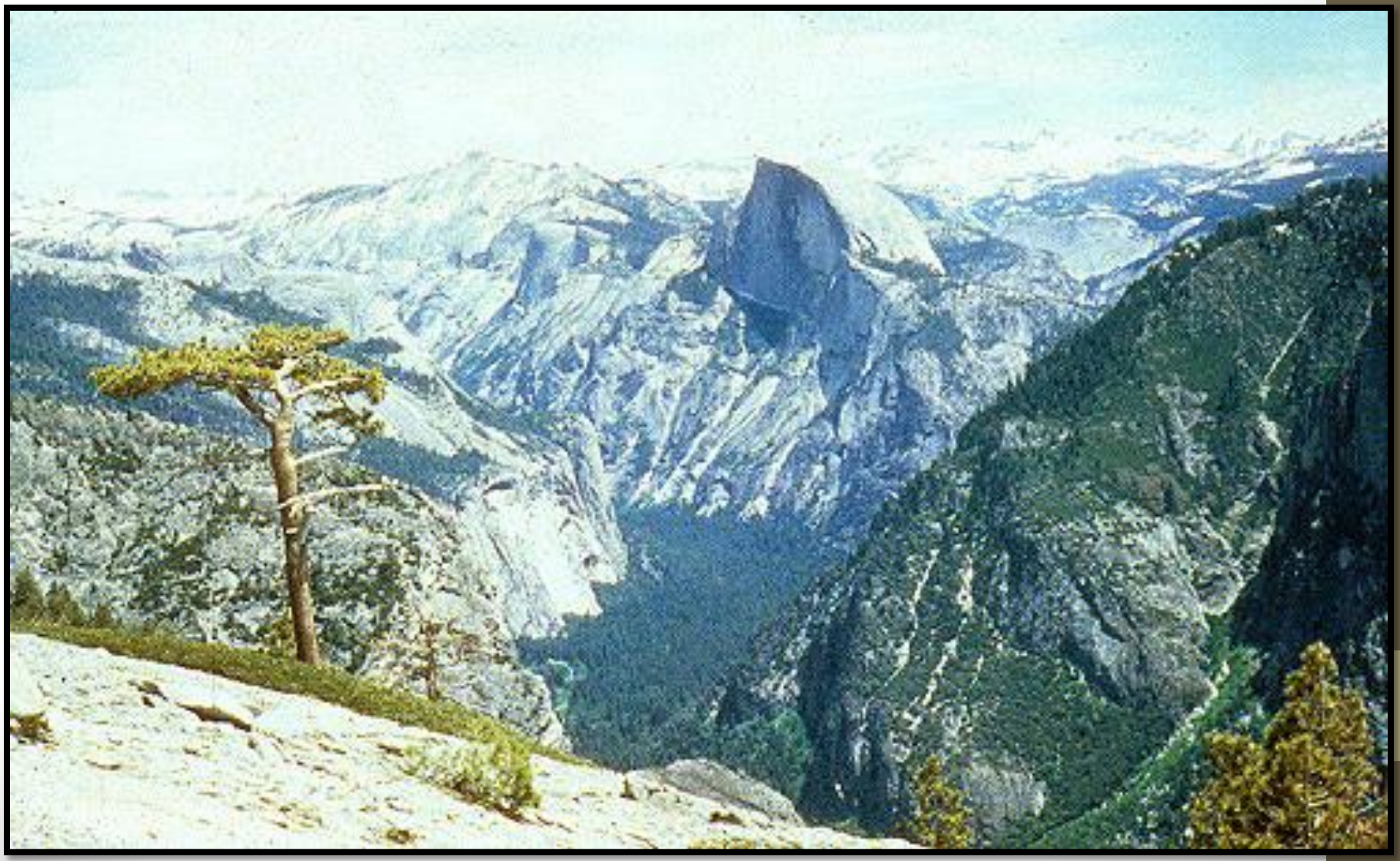
- very durable, resistant to erosion

Granite



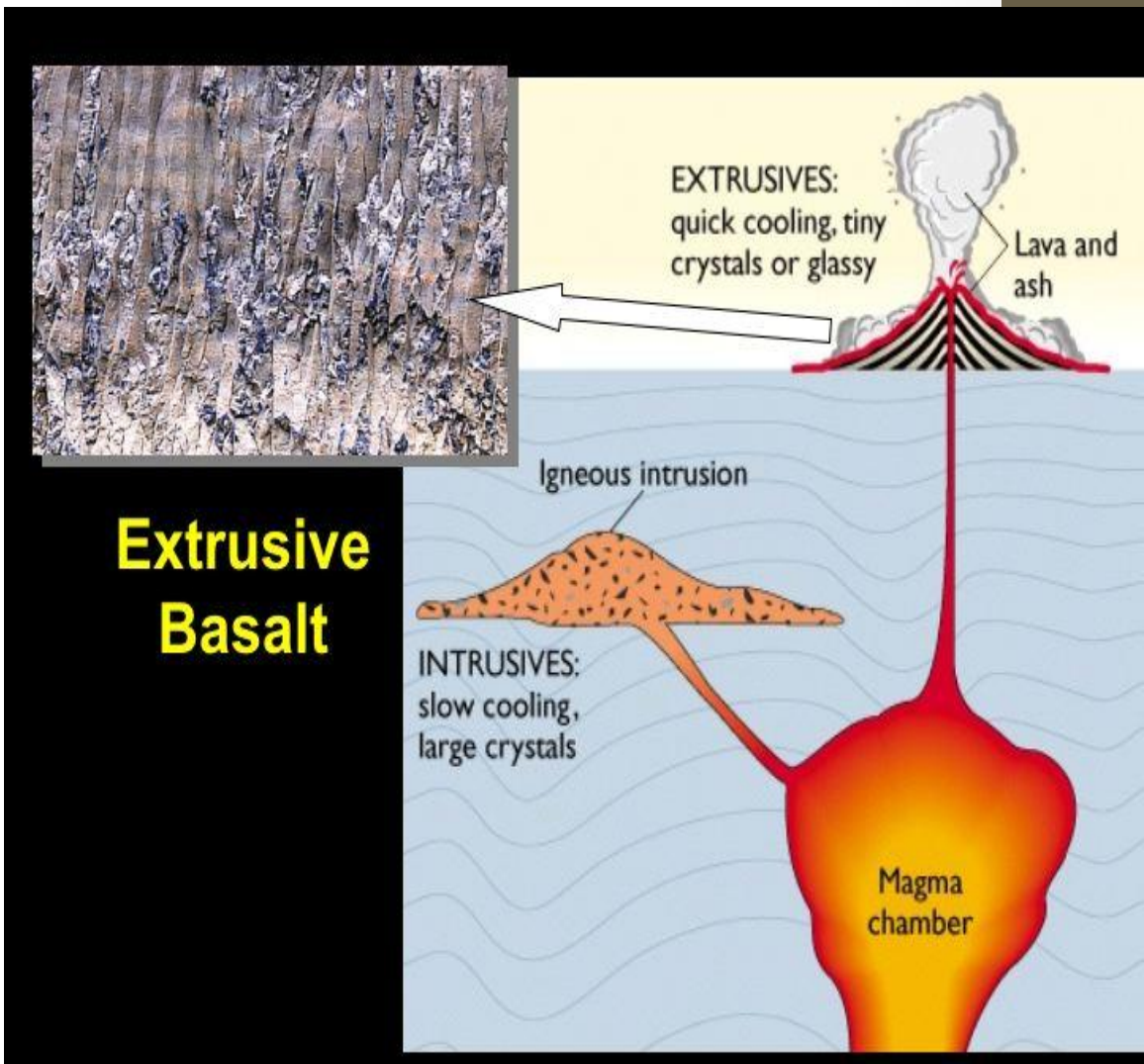
Diorite

Intrusive Igneous: The Sierra Nevada Mountains



Extrusive (volcanic)Igneous Rocks

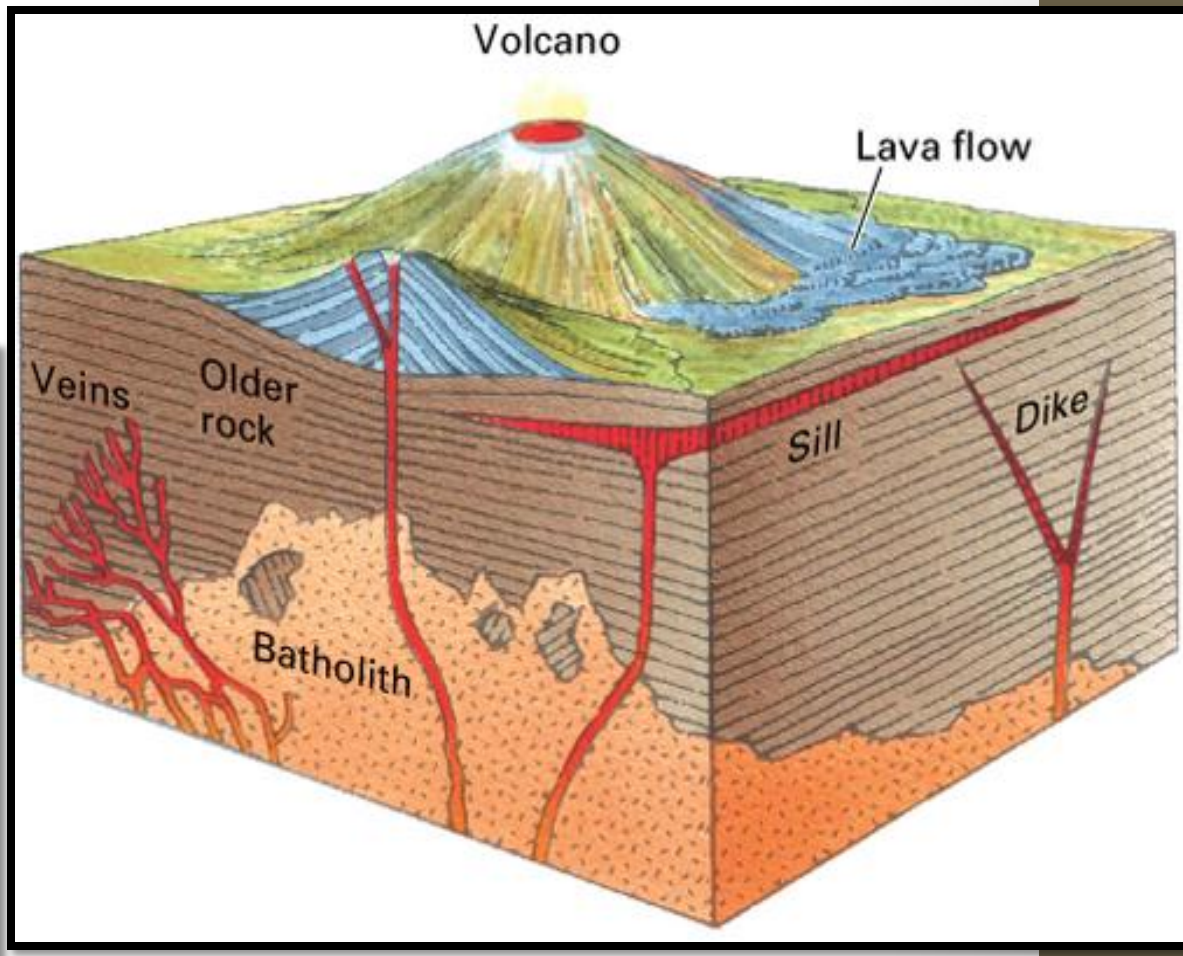
- ✓ Lava Solidifies above ground
- ✓ Cool very rapidly
- ✓ Develop smaller, microscopic size crystals
- ✓ Fine textured



Extrusive Igneous

Igneous Rocks

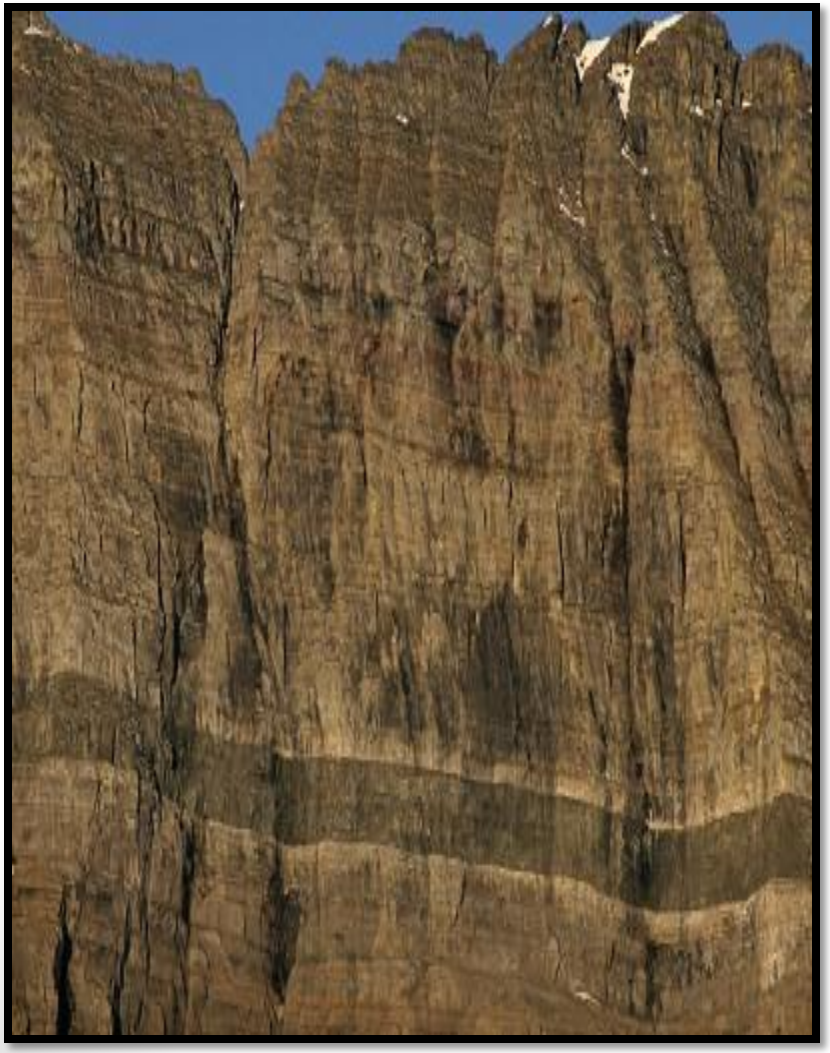
A body of intrusive igneous rock is called a pluton

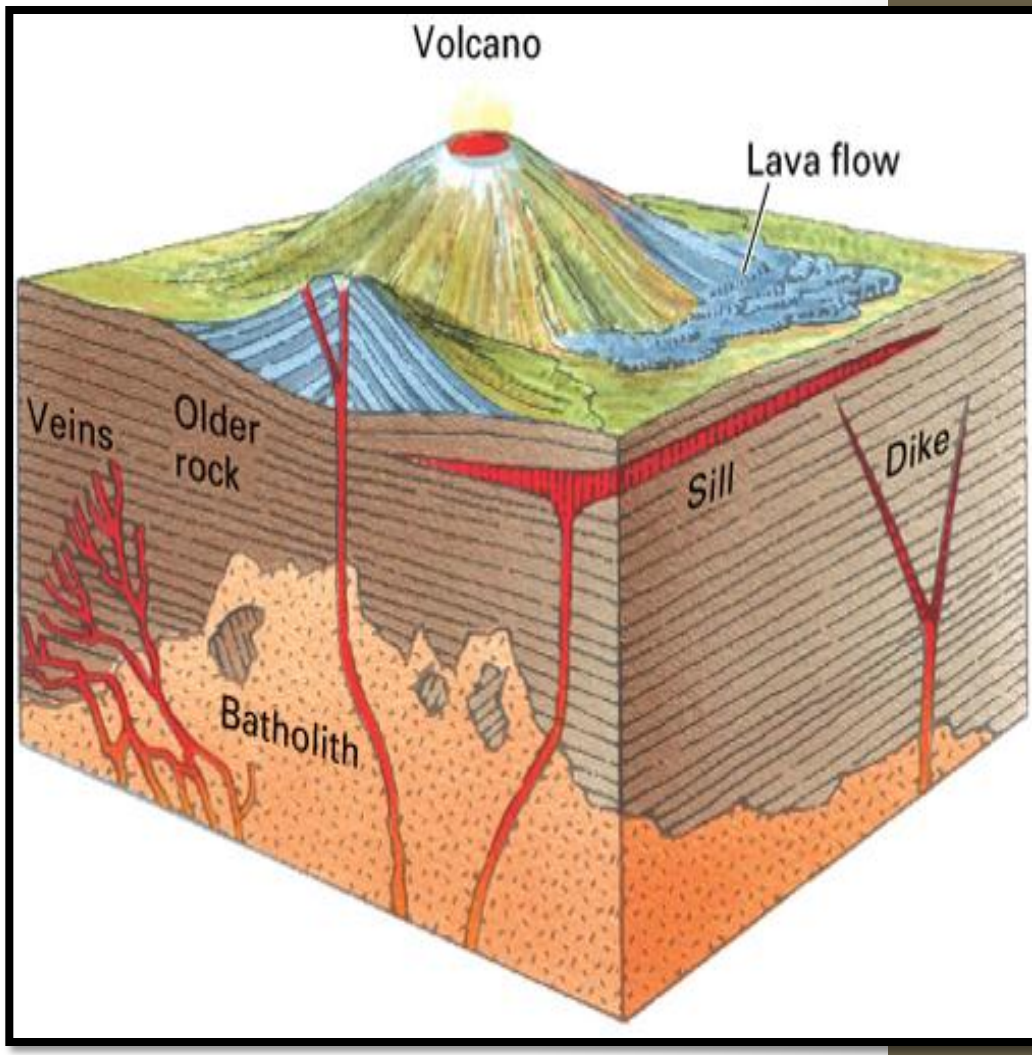


Granite accumulates in enormous plutons, called *batholiths* an area of several thousand square kilometers

Igneous Rocks

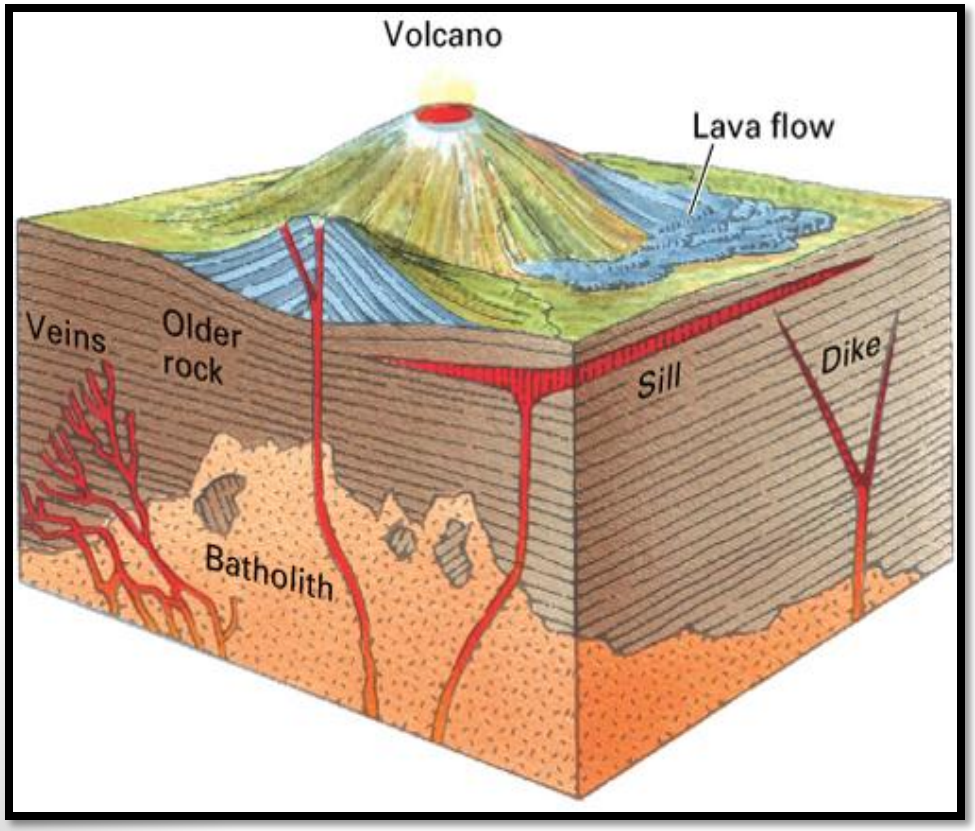
A *sill is* a plate-like pluton formed when magma forces its way between two preexisting rock layers





Igneous Rocks

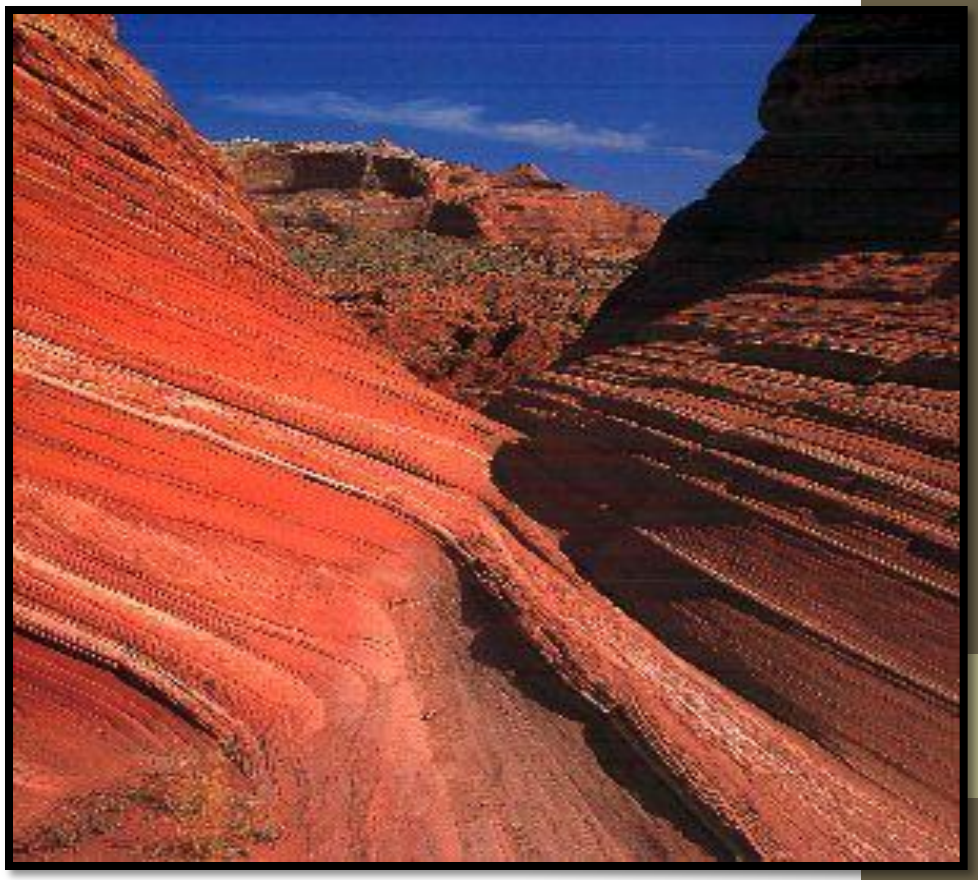
A *dike is* a wall-like pluton formed when a vertical rock fracture is forced open by magma



Sedimentary rocks

Sedimentary rocks are formed when sediments are bonded together through compaction and cementation

- Only rocks that contain fossils
- Have layers/bands and break or crumble easily

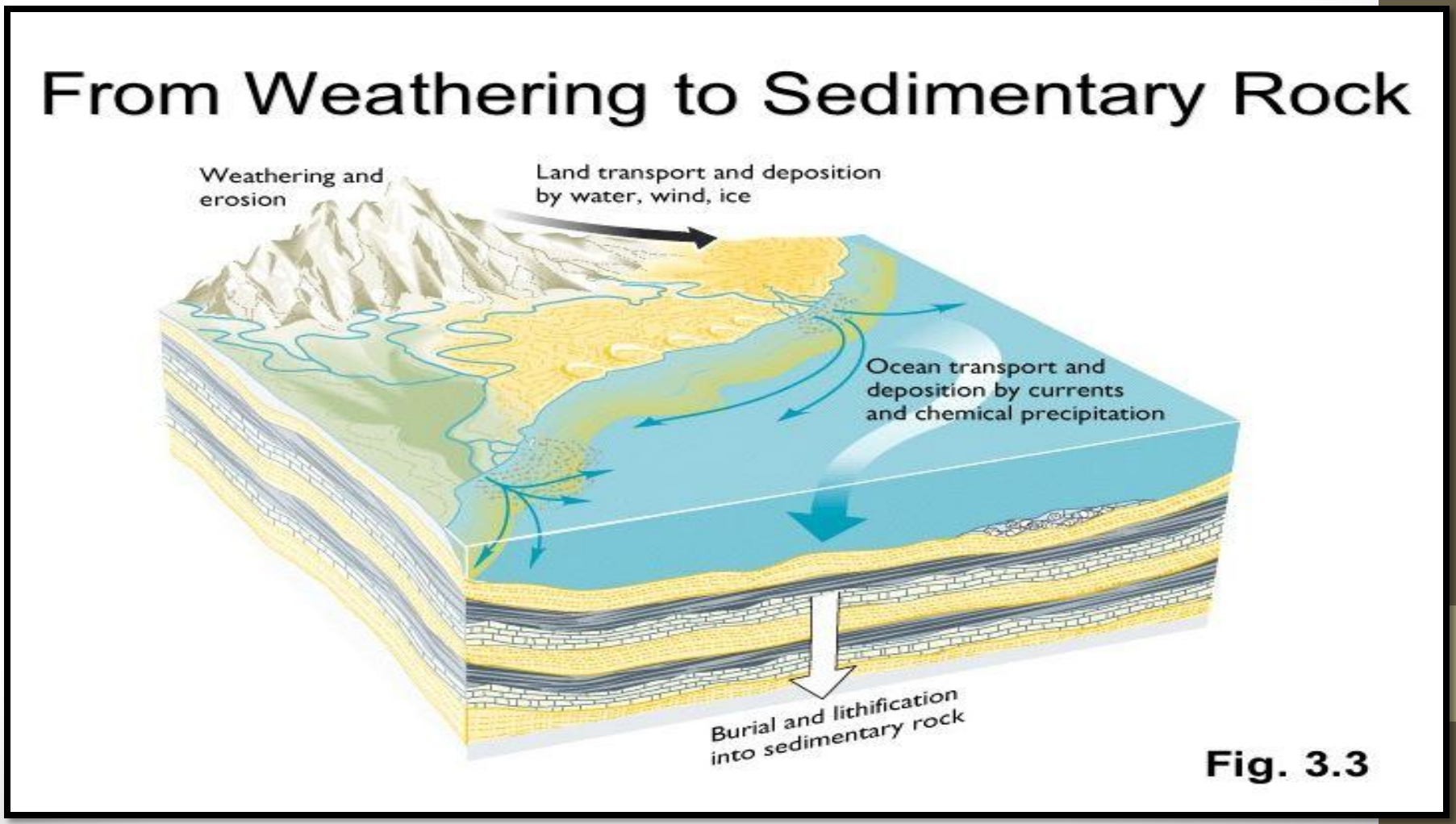


Sedimentary Rock Process

1. **Pieces of earth are weathered (broken down/worn away by wind and water or through chemical decomposition)**

2. **Weathered pieces are washed downstream where they settle on the bottom of the rivers, lakes, and oceans.**

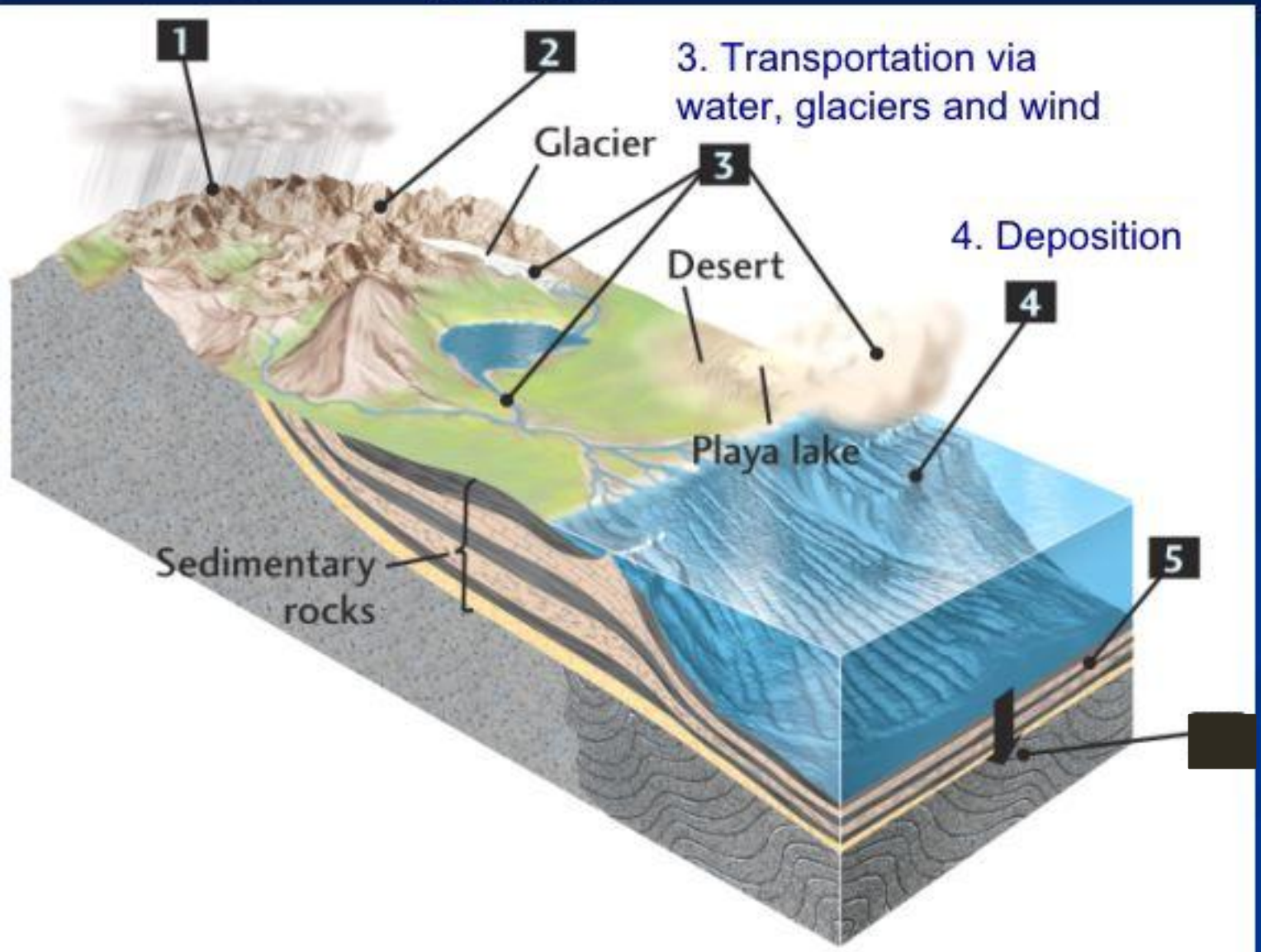
3. Over time they are layered and pressed down more and more through time, until the bottom layers slowly turn into rock.



Sediment stages

1. Weathering

2. Erosion



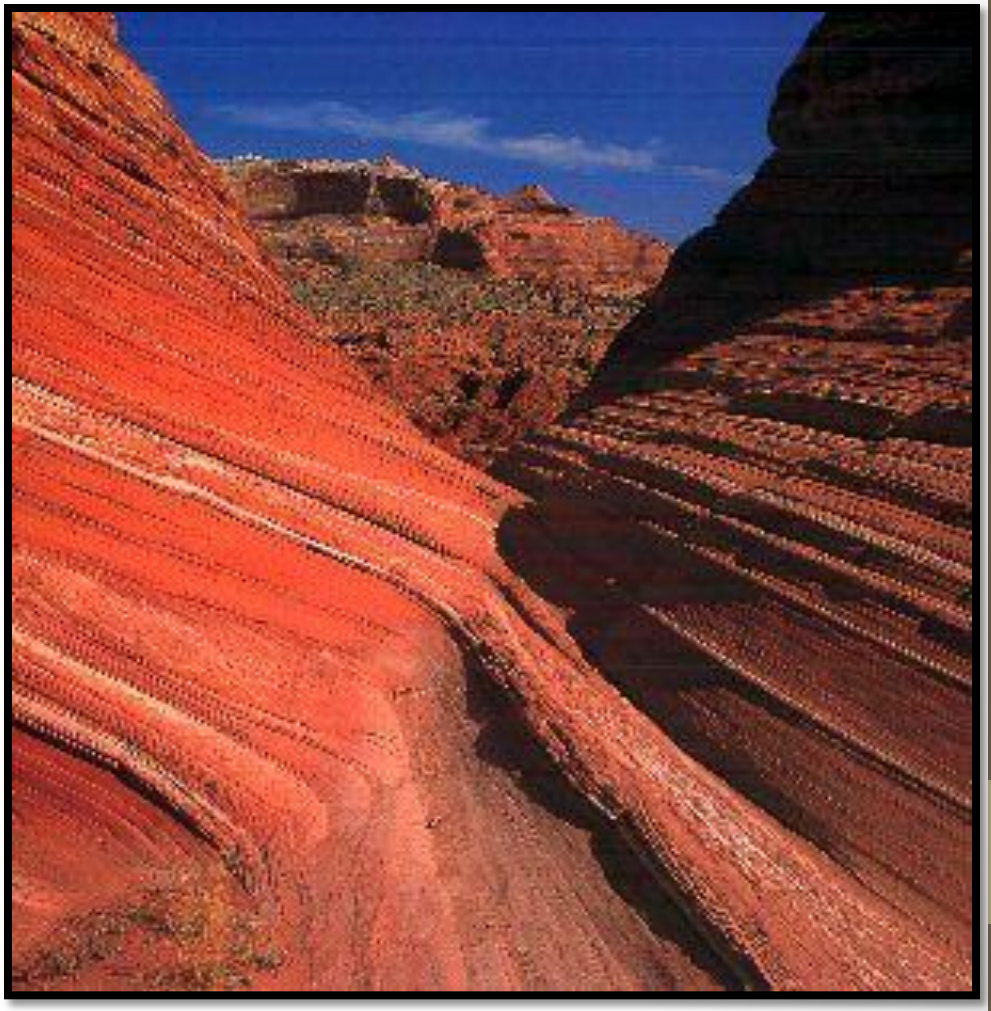
5. Burial and compaction

Sediments and Sedimentary Rocks

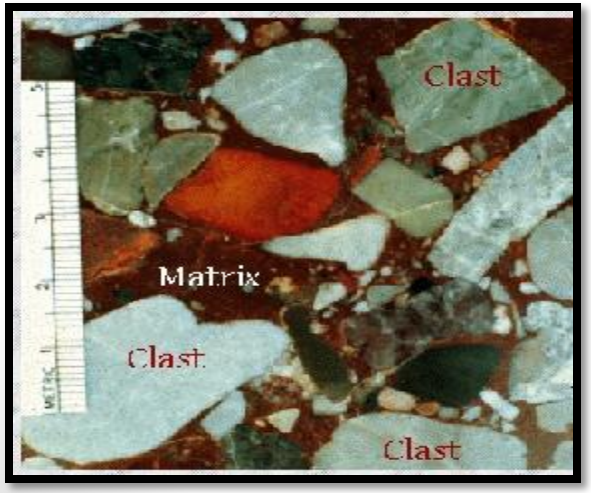
Sediment accumulates in more-or less horizontal layers, called strata **(**beds)

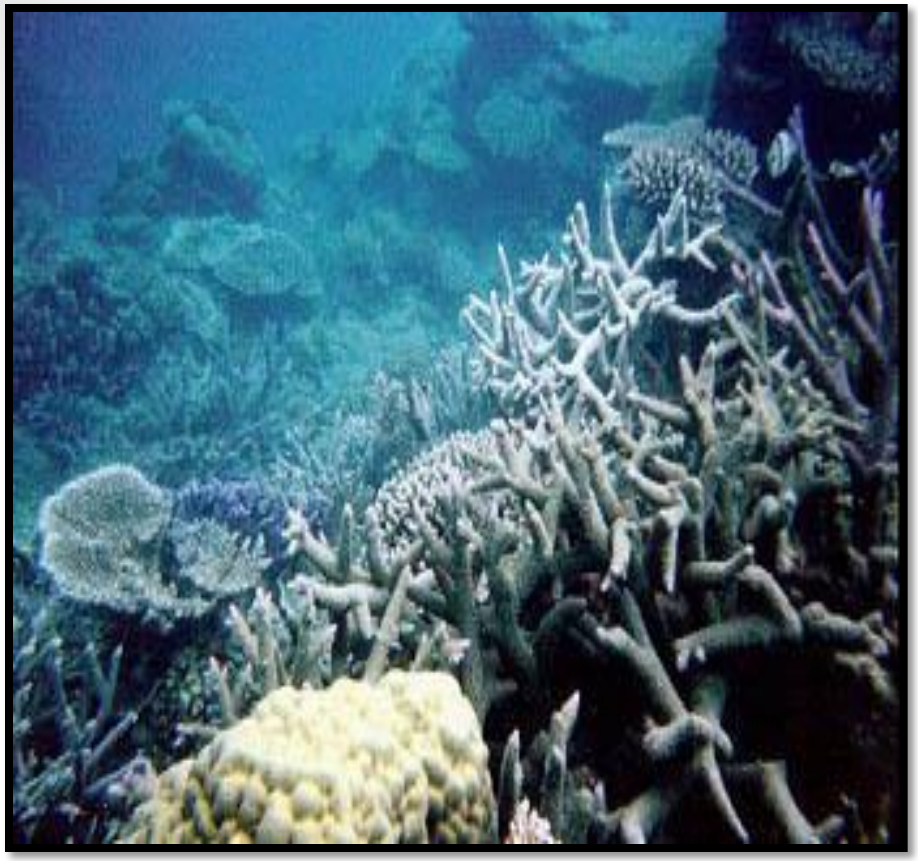
3 Types of sedimentary rocks

1. Clastic
2. Organic
3. Chemical



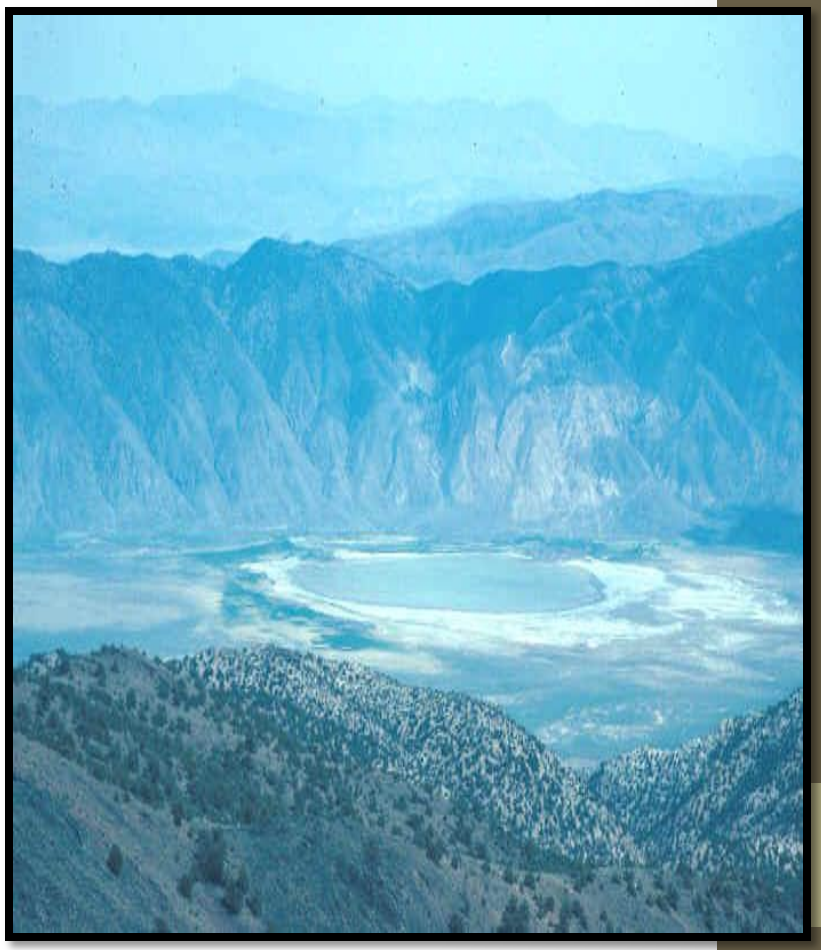
1. Clastic: Pieces of other rocks that have been cemented or compressed together



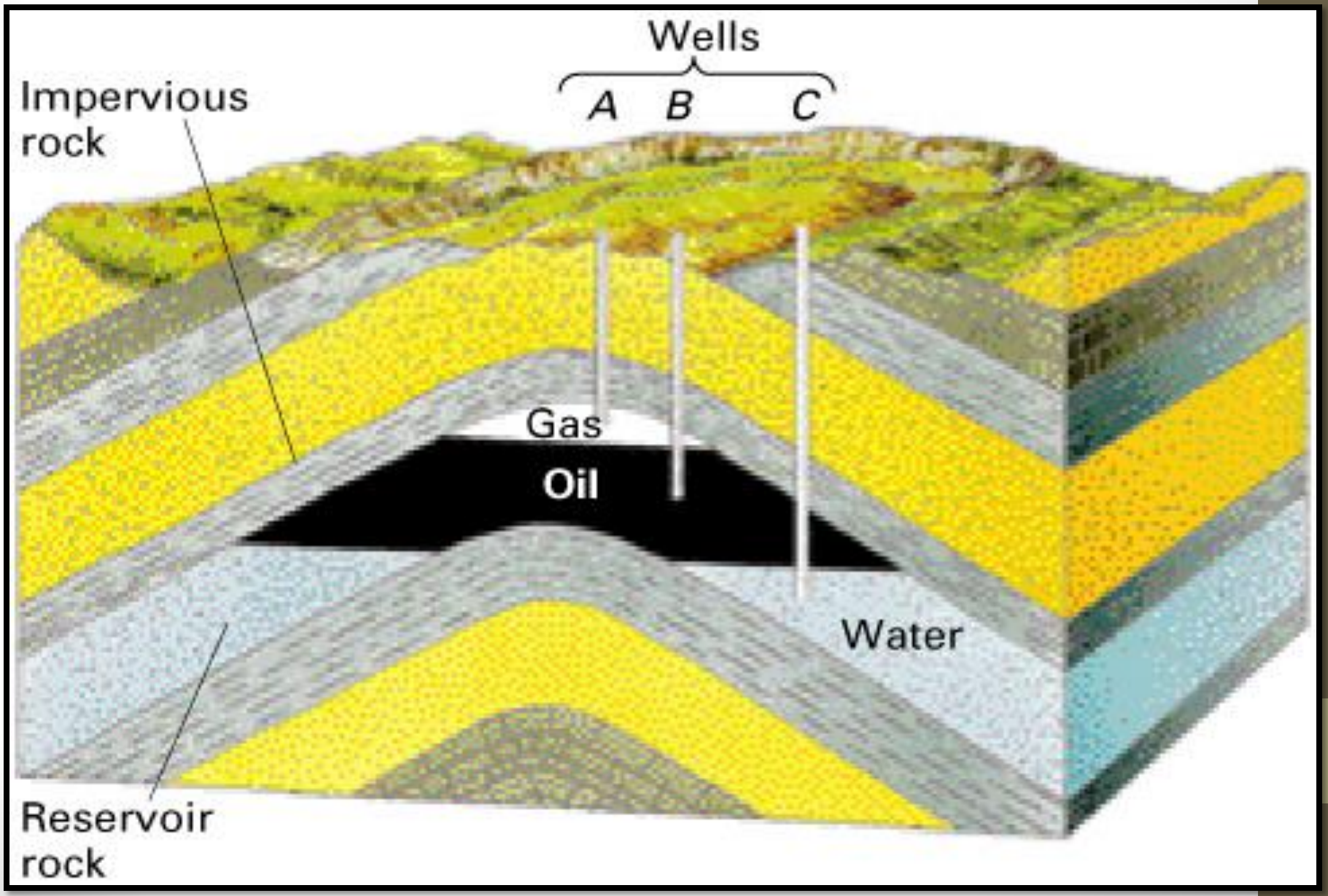


2. Organic: Rocks that form as a direct result of something that was once alive

3. Chemical: rocks that form as a direct result of some chemical process

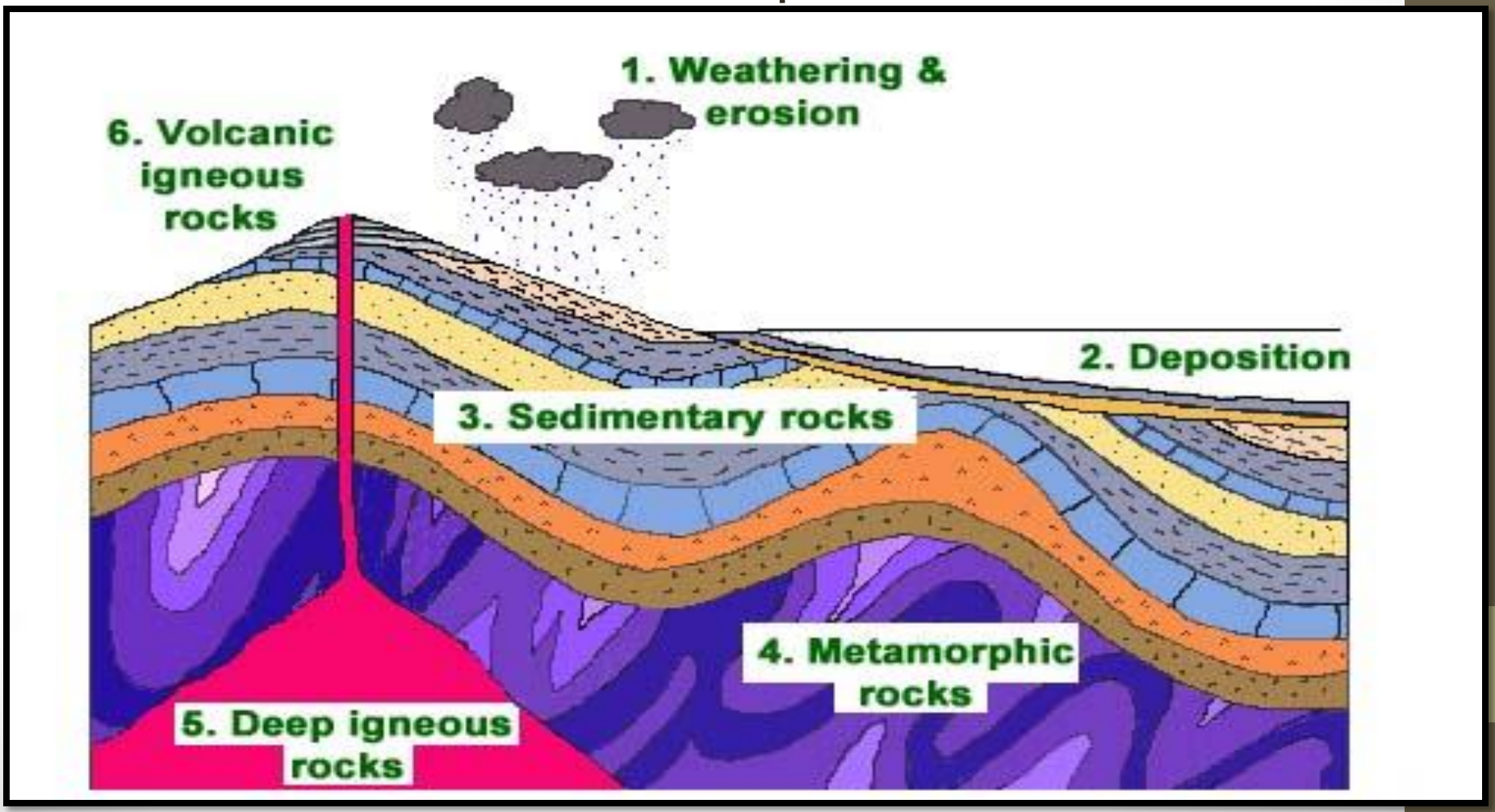


Sedimentary rocks create reservoirs for fossil fuel storage

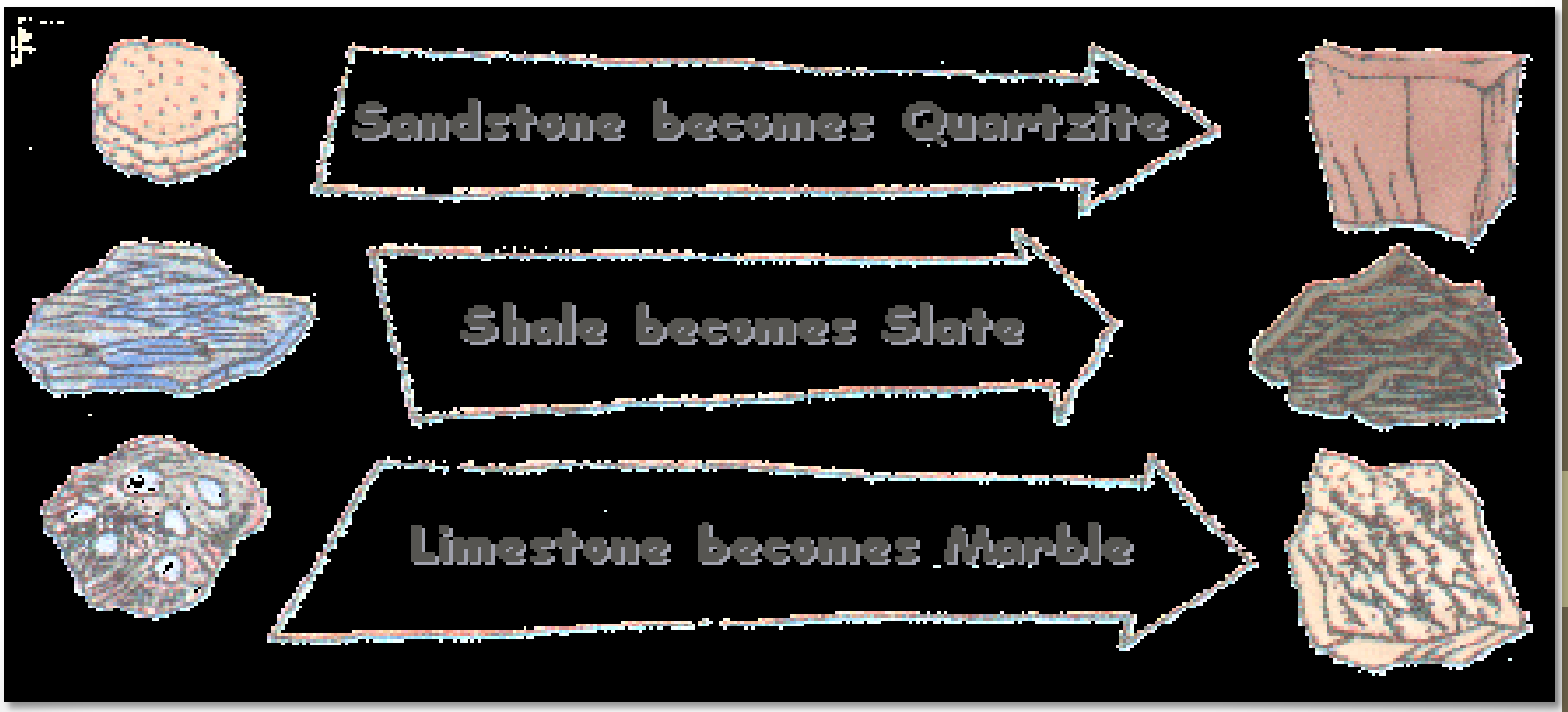


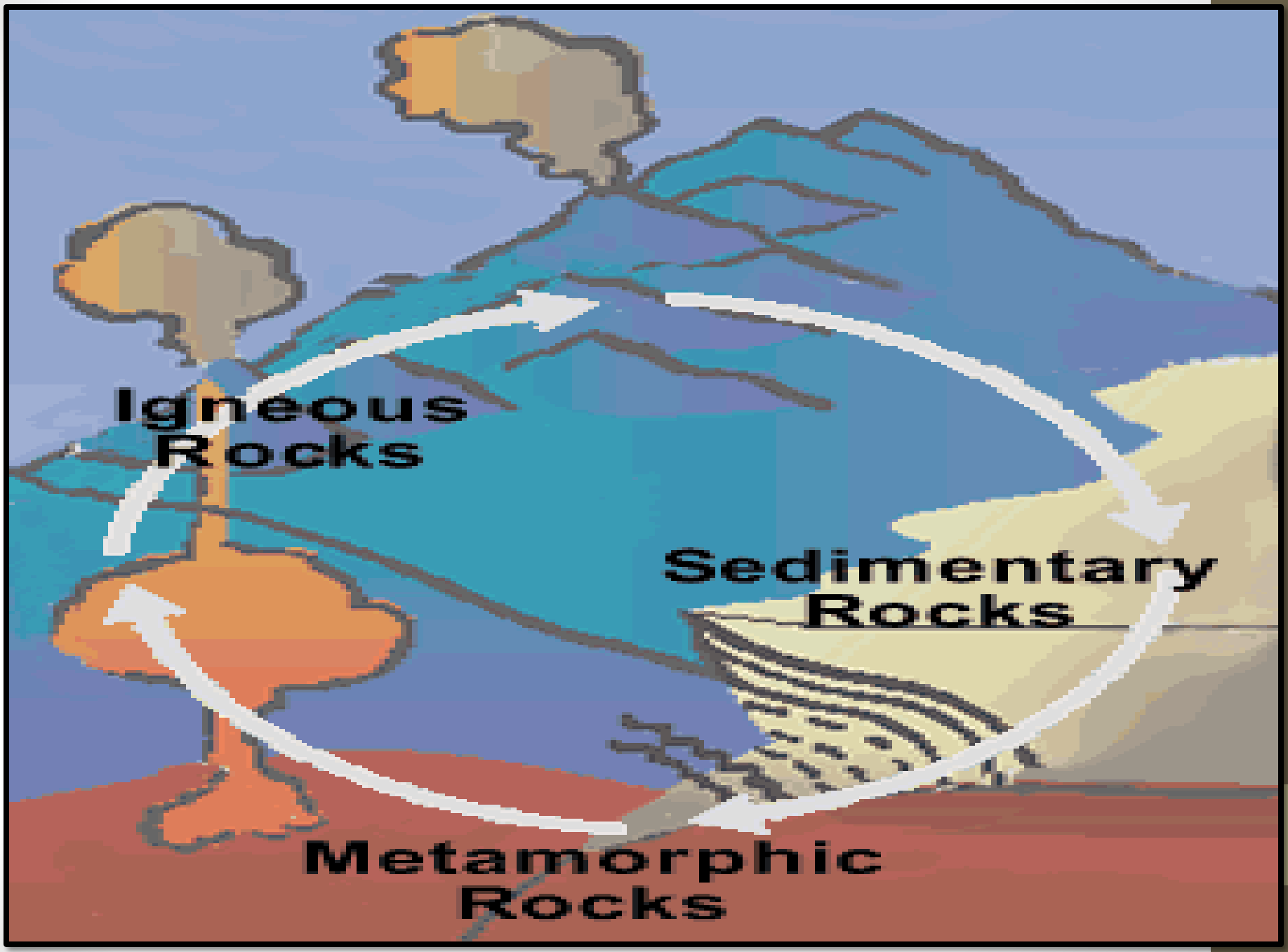
Metamorphic Rocks

Metamorphic rocks are formed from preexisting rocks by intense heat and pressure, which alter rock structure and chemical composition



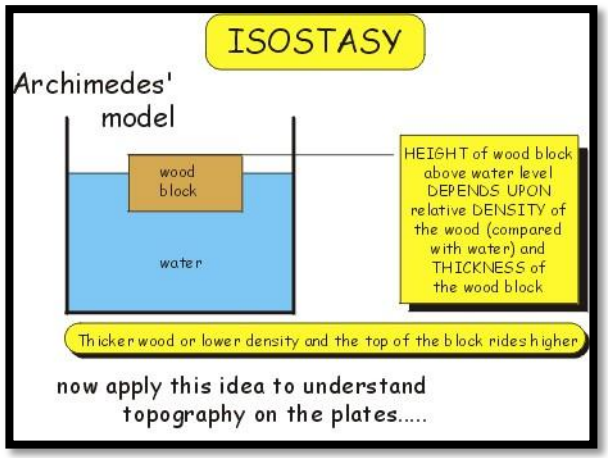
Metamorphic Rocks

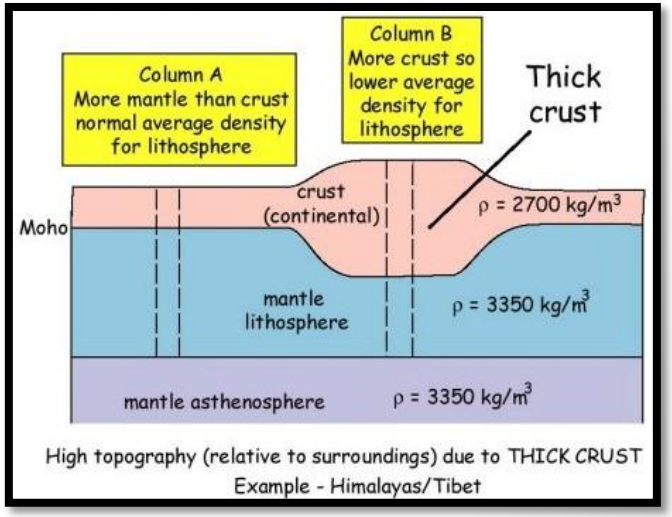



Igneous Rocks
Sedimentary Rocks
Metamorphic Rocks

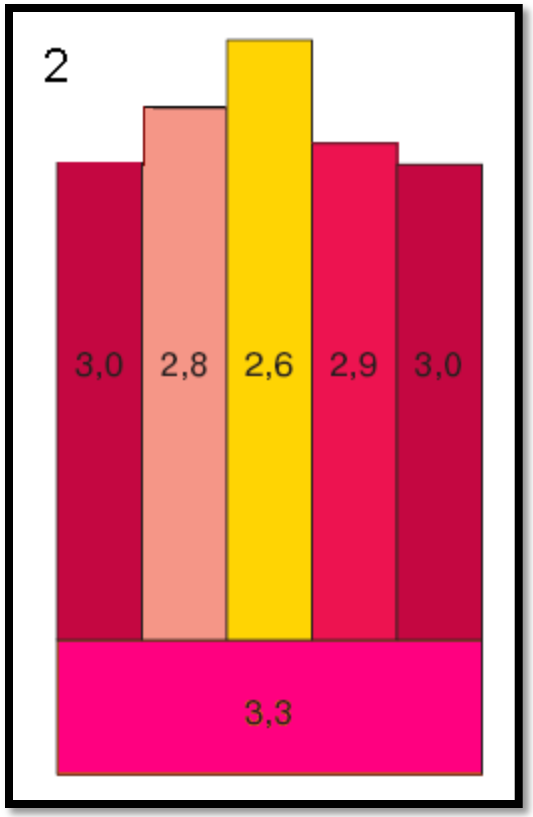
ایزوستازی

- بر اساس این نظریه، عوارض سطحی زمین روی قسمت های زیرین در حال تعادل اند و در عمق معینی موسوم به عمق خنثی شدن، فشار موثر بر زمین در همه جا مساوی است.





- نظریه پرات: بر اساس این نظریه، پوسته زمین در زیر دریاها ضخامت یکنواختی دارد. جرم مخصوص زمین در هر قسمت نیز به ارتفاع آن قسمت بستگی دارد و هر چقدر ارتفاع زیادتر باشد، به همان نسبت جرم مخصوص کمتر می شود.
- این نظریه بر اساس قرار گیری اجسام جامد با وزن یکسان و جرم مخصوص متفاوت که دارای جرم مخصوص کمتری از مایع می باشند در روی سطح مایع می باشد. در این حالت قسمت زیرین تنام اجسام در یک عمق قرار می گیرد و هر چقدر جرم مخصوص کمتر باشد مقدار بیشتری از آن خارج ز مایع قرار می گیرد.
- بر اساس این نظریه چون ضخامت پوسته زمین در زیر دریاها کمتر از قاره های است، بایستی جرم مخصوص آن زیادتر با شد تا بتواند کمبود ضخامت را با افزایش جرم مخصوص جبران کند.



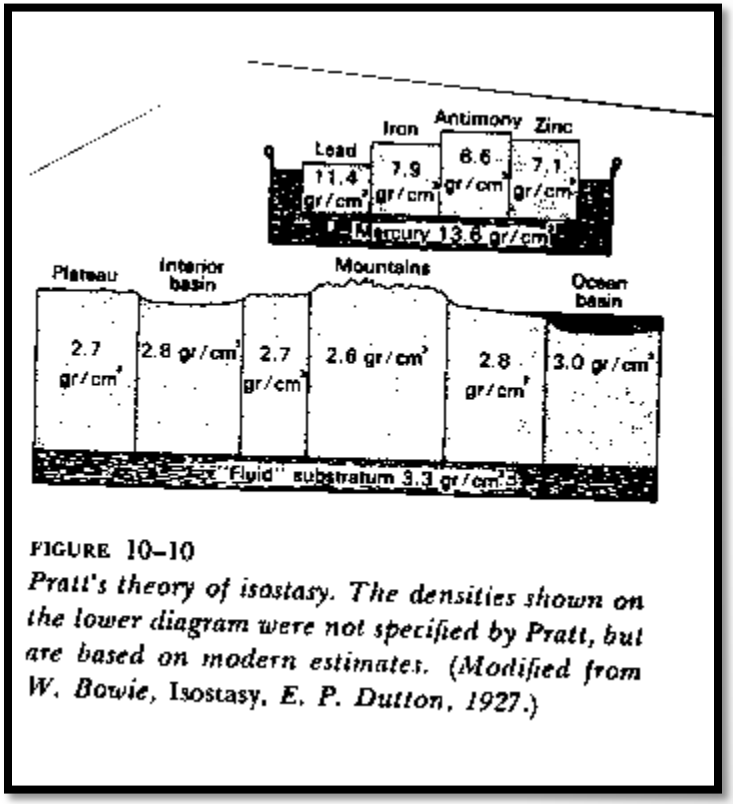
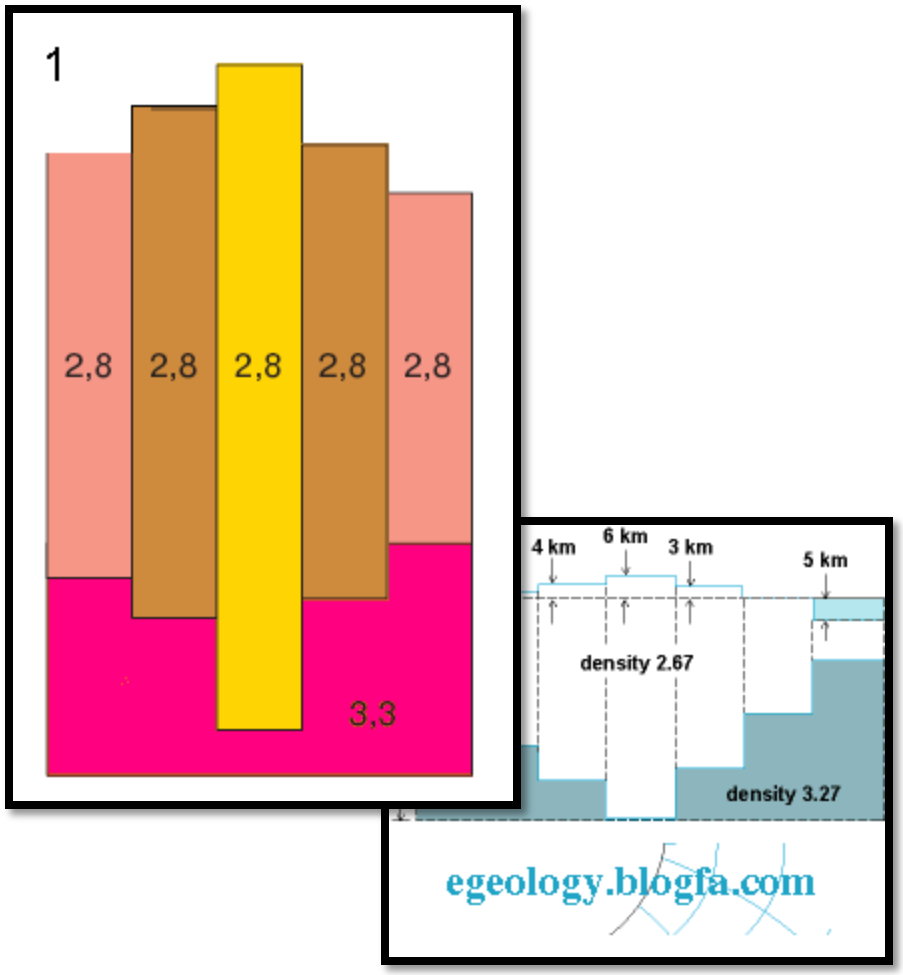
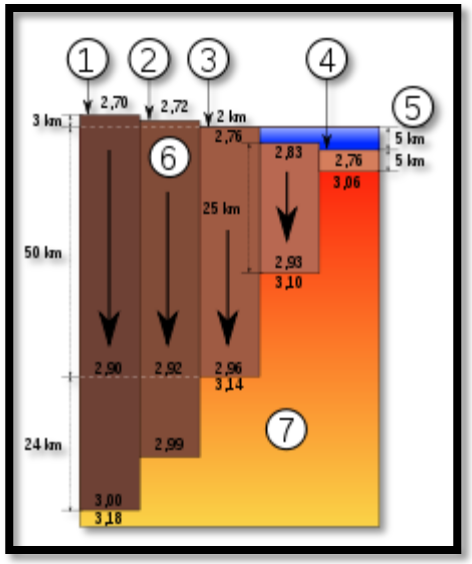


FIGURE 10–10
Pratt's theory of isostasy. The densities shown on the lower diagram were not specified by Pratt, but are based on modern estimates. (Modified from W. Bowie, Isostasy, *E. P. Dutton, 1927.)*

- نظریه آیری: مطابق نظریه آیری، جرم مخصوص پوسته زمین در همه جا یکسان است و پوسته روی قسمتهای داخلی زمین، که جرم مخصوص بیشتری دارند، قرار گرفته است. در زیر کوهها پوسته زمین بیش از زیر اقیانوس ها به داخل قسمتهای داخلی نفوذ کرده و در نتیجه به حالت تعادل در آمده است.
- برای توجیه این نظریه می توان شناوری منشورهای مختلف از جسم واحدی مثلا مس را در روی جیوه در نظر گرفت. مطابق این آزمایش هر چقدر طول جسم زیادتر باشد، طول بیشتری از آن از جیوه بیرون می ماند و مقدار زیادتری نیز در داخل جیوه فرو می رود.
- بر اساس این نظریه هر چقدر کوه مرتفع تر باشد قسمت عمقی آن یا به اصطلاح ریشه کوه نیز بزرگ تر است.

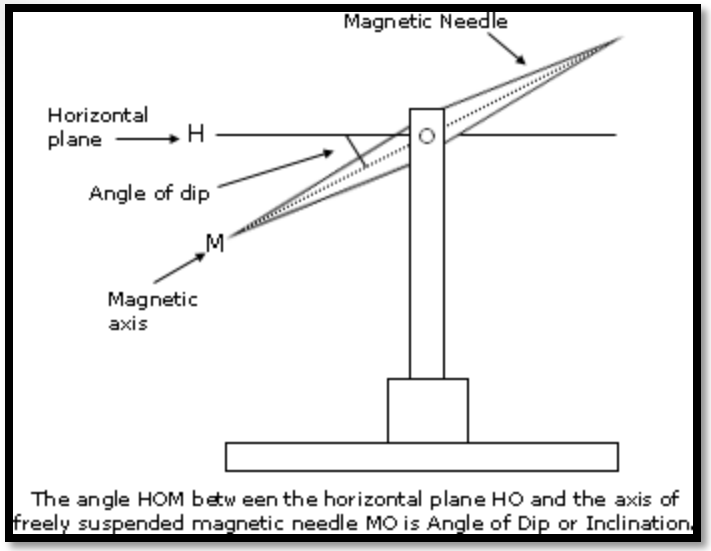

1
2,8
2,8
2,8
2,8
2,8
3,3
4 km
6 km
3 km
5 km
density 2.67
density 3.27
egeology.blogfa.com

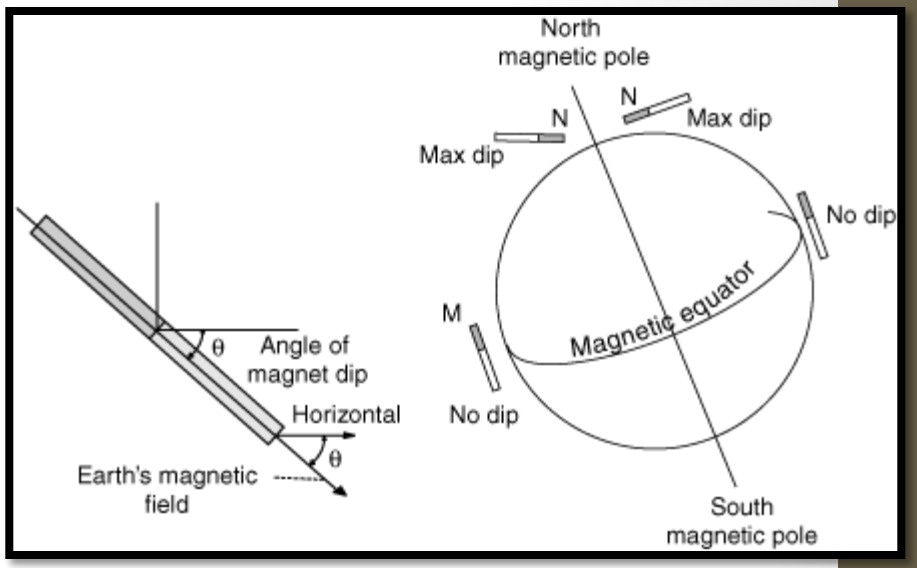
- نظریه هیزکانن: این نظریه در حقیقت تلفیقی از دو نظریه قبلی است و بر اساس آن هم جرم مخصوص پوسته در زیر قاره ها و دریا ها متفاوت است و هم کوهها نسبت به قسمت های دیکر ریشه طویل تر دارند.
- این نظریه می تواند اختلاف جرم مخصوص زیر دریاها و قاره ها، و نیز ضخیم تر بودن پوسته را در زیر ارتفاعات توضیح دهد.

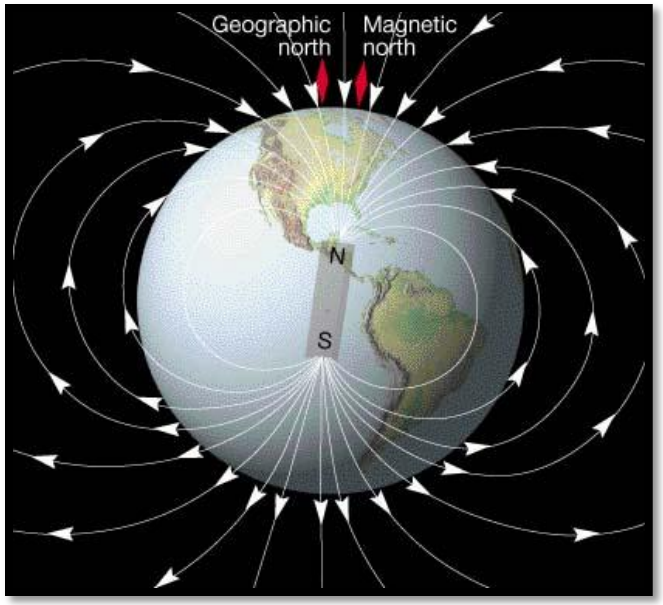


مغناطیس زمین

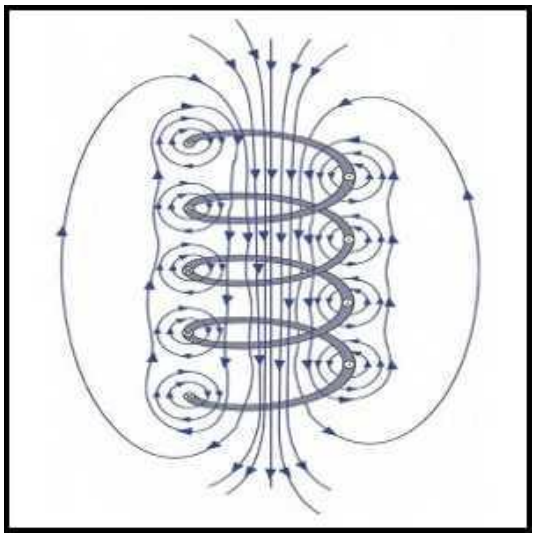
- هرگاه یک عقربه مغناطیسی را روی پایه دون اصطحکاک قرار دهیم، پس از نوسانات متعدد، در امتدادی می ایستد که آن را امتداد شمال جنوب مغناطیسی می گویند. این امتداد معمولا با امتداد شمال جنوب جغرافیایی منطبق نیست، بلکه با ان زاویه می سازد که آن را زاویه انحراف مغناطیسی زمین می خوانند. همچنین عقربه به حالت به حالت افقی قرار نمی گیرد بلکه با افق زاویه ای می سازد که به نام زاویه میل مغناطیسی خوانده می شود.

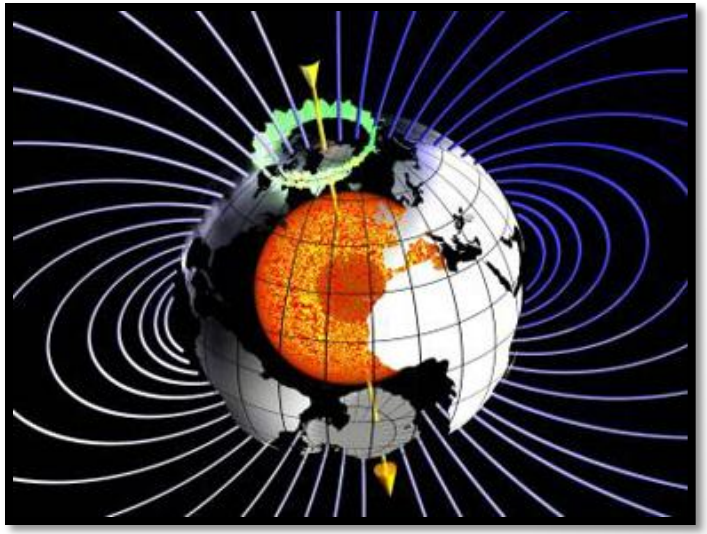

Magnetic Needle
Horizontal plane
H
O
Angle of dip
M
Magnetic axis
The angle HOM between the horizontal plane HO and the axis of freely suspended magnetic needle MO is Angle of Dip or Inclination.


θ
Angle of magnet dip
Horizontal
θ
Earth's magnetic field
North magnetic pole
N
N
Max dip
Max dip
No dip
M
Magnetic equator
No dip
South magnetic pole


Geographic north
Magnetic north
N
S

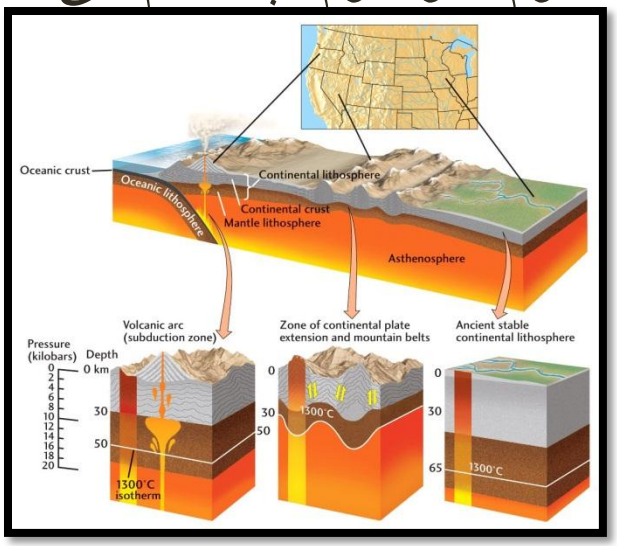
- برای تشریح مغناطیس زمین نظریه های مختلفی ارائه شده که از آنها می توان گفت که علت اصلی مغناطیس بودن زمین در داخل آن است.
- میدان مغناطیسی داخل زمین به وسیاه جریان الکتریکی که مربوط به حرکت مواد در درون آن است تولید می شود.





حرارت زمین

- همانطور که می دانیم، با افزایش عمق دما افزایش می یابد.
- در ابتدا تصور می شد که زمین حرارت خود را از زمان تشکیل خود حفظ کرده است. اما امروزه منشا حرارت زمین را فعل و انفعالات رادیواکتیو نظیر اورانیوم، توریوم، پتاسیم می دانند.



سن زمین

Geologic Time

By examining layers of sedimentary rock, geologists developed a time scale for dividing up earth history.

Earlier in the 20th century, radiometric-dating techniques allowed scientists to put absolute dates on divisions in the geologic time scale.

In this segment, we will learn how geologists:

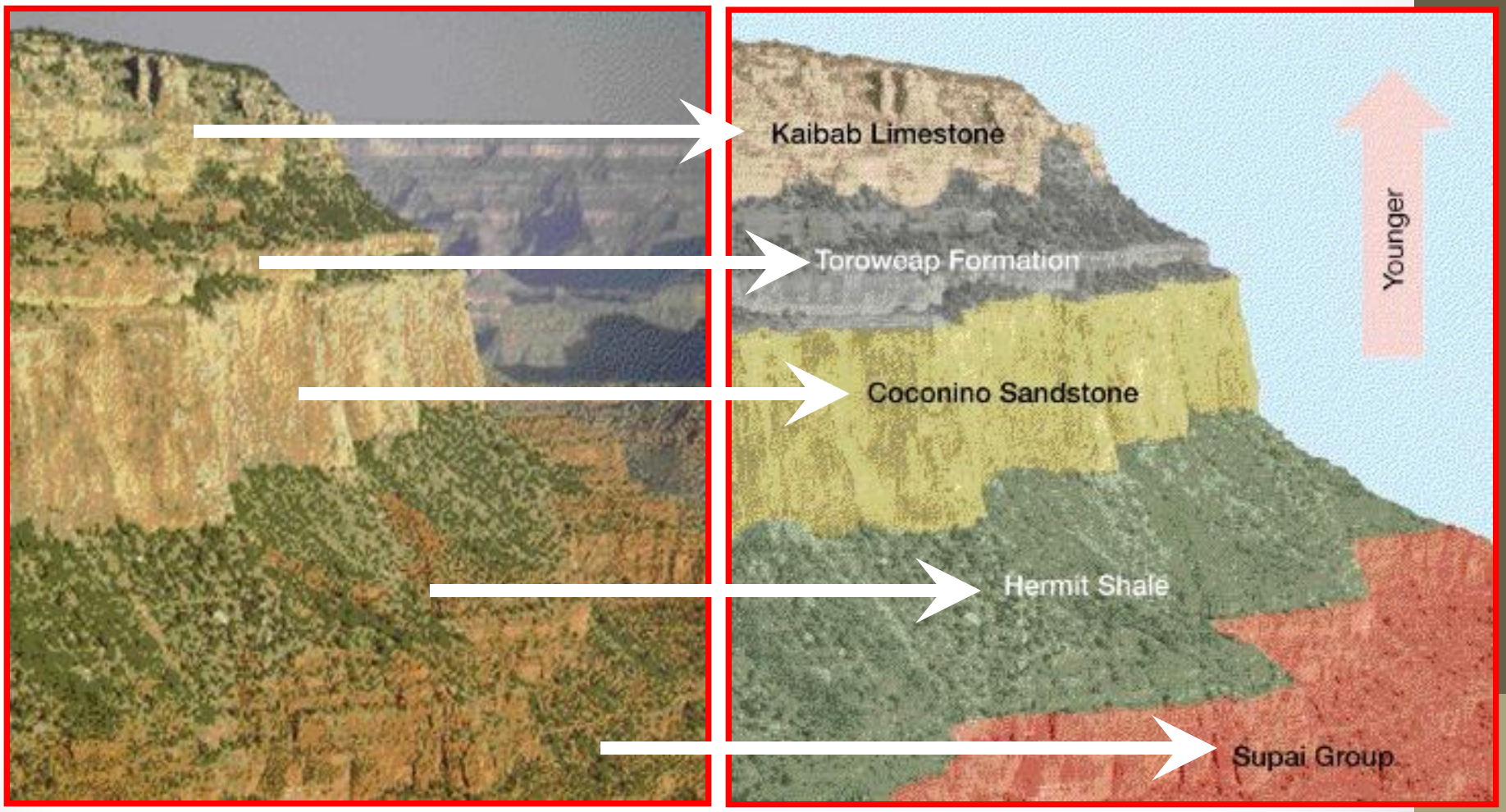
- determine the relative ages of rock units,
- determine the divisions of the geologic time scale, and
- how radiometric techniques can be used to date some rocks.

How do geologists determine how old rocks are?

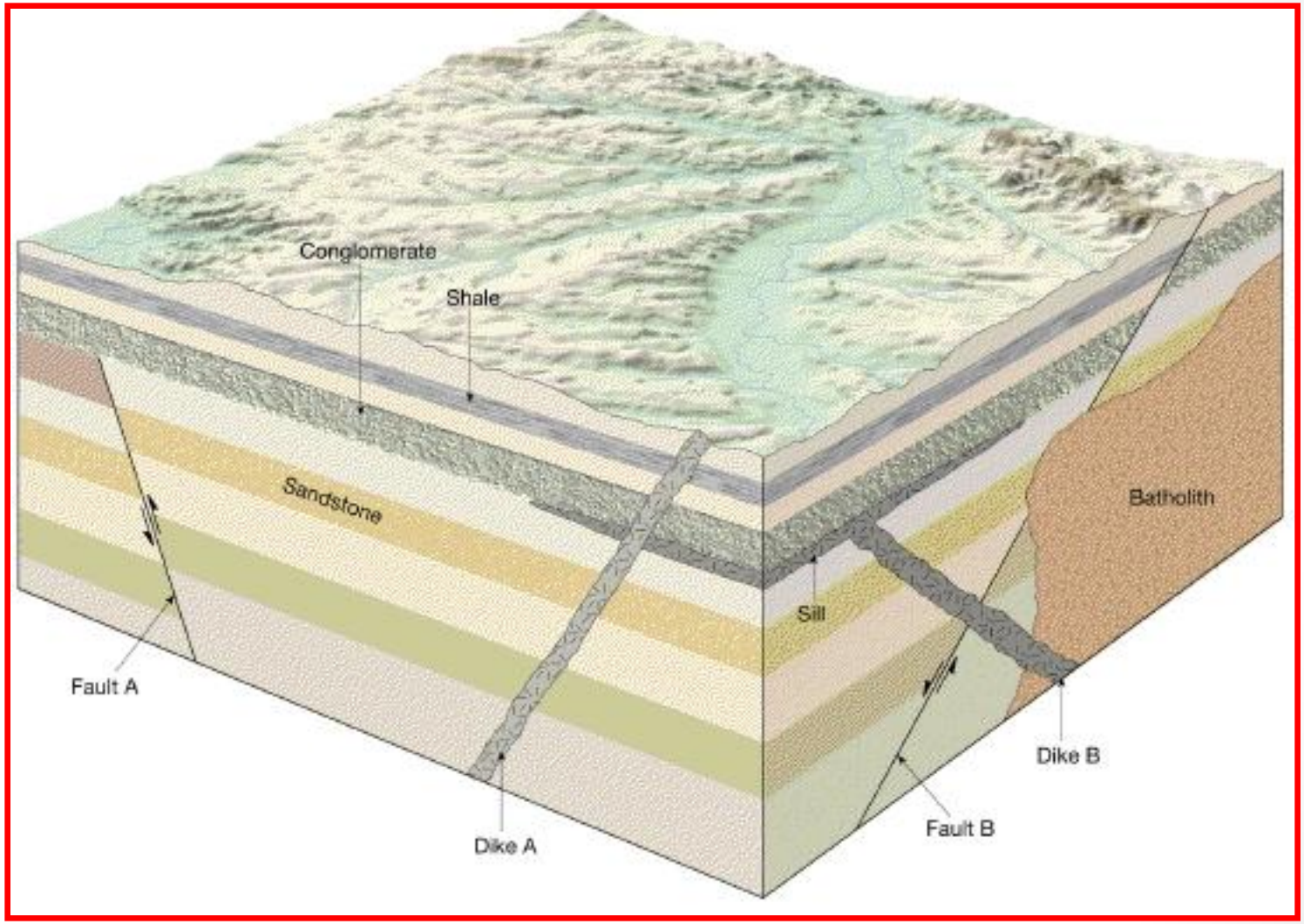
1. ***Relative dating*** -- determine whether the rock is older or younger than other rocks
2. ***Absolute dating*** -- use radiometric dating techniques to determine how long ago the rock formed in the exact number of years

*Not all rocks can be dated absolutely, so combinations of techniques are used.

Example of Relative Age Dating and Correlation



Relative Age Dating



Absolute Dating:

- Radiometric Dating Techniques
- Use naturally-occurring radioactive isotopes
- **Isotope** -- form of an element that has additional neutrons
- **Radioisotope** -- isotope that spontaneously decays, giving off radiation

Rate of Radioactive Decay

- Radioisotopes decay at a constant rate.
- Rate of decay is measured by half-life
- **Half-life** -- time it takes for one-half of the radioactive material to decay.

Decay products

- Radioisotopes may decay to form a different isotope or a stable isotope.
- May be a series of radioactive decays before a stable isotope is formed.
- Stable isotope is called the "**daughter**" formed from decay of radioactive "**parent**"

Radiometric Age Dating

Radioisotopes are trapped in minerals when they crystallize.

Radioisotopes decay through time, and stable isotopes are formed.

Determining the **ratio** of parent isotope to daughter product reveals the number of half-lives that has elapsed.

Common isotopes used in age dating

U-Pb -- half-life of U-238 is 4.5 b.y.

K-Ar -- half-life of K-40 is 1.3 b.y.

Rb-Sr -- half-life of Rb-87 is 47 b.y.

Carbon 14 -- half-life of C-14 is 5730 yrs

Absolute Dating Example

Thus, by using the appropriate radioactive isotope (knowing its half-life time), and measuring the quantity of the isotope present in the rock, one can deduce how long it has taken to decay down to the present amount in the rock.

Example: A rock has 0.5 (one-half) of the original carbon 14 material in it. One can deduce that knowing the half-life of carbon 14 is 5730 years, the rock must have decayed (lost) 50% of its original carbon 14 material and is now 5730 years old. In a period of 5730 years from now, the rock will contain .25 (25%) of its original carbon 14 material. Theoretically, there will always be some trace of carbon 14 present in the rock…it will never decay totally.

Interpreting the rock record:

Prior to geologic principles, Archbishop James Ussher calculated the age of the Earth at 6000 years. He noted that calculations were made based on the books of the Bible (namely Genesis) and pinpointed the origin of the Earth to be October 26, 4004 B.C. at 9:00 a.m.

Principle of ***Uniformitarianism***:

James Hutton, late 1700s – (considered to be "Father of Geology")

Hutton realized that most sedimentary layers were deposited from gradual, day-to-day processes. He realized that it took a long time to form these rocks. This was far different from what others believed prior to this time.

"Present is the key to the past" -- whatever processes are occurring today (plate tectonics, volcanism, mountain building, earthquakes, sedimentation) also occurred in the past and probably at the same (or very comparable) rates.

Principles associated with Relative Dating

The comparing of rock units to decipher their age relative to one another

- **Principle of *Superposition***

  Rock layer above is younger than the ones below it. (Oldest on bottom, youngest on top)

  May not apply to rocks that have been folded (can get turned upside-down).

- **Principle of *Original Horizontality***

  Sedimentary layers are deposited in approximately horizontal sheets.

  If layers are folded, episode of deformation must have occurred after rocks formed. Age of folding is younger than youngest deformed rock unit.

- **Principle of *Crosscutting Relationships***

  Any feature (e.g. fault or intrusion) that cuts across rocks is younger than the youngest rock that is cut.

- **Principle of *Faunal Succession***

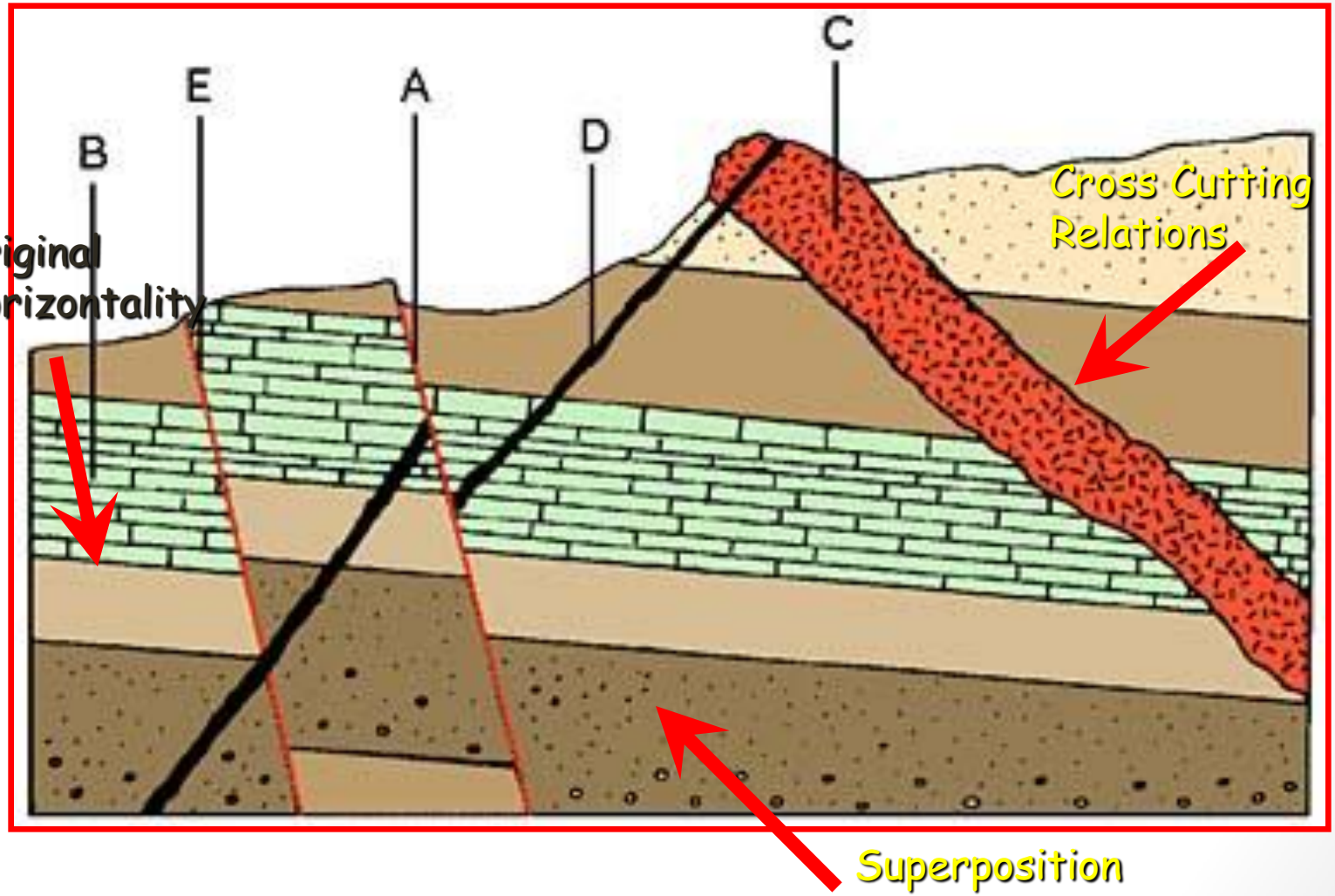
  Organisms have evolved and gone extinct through time

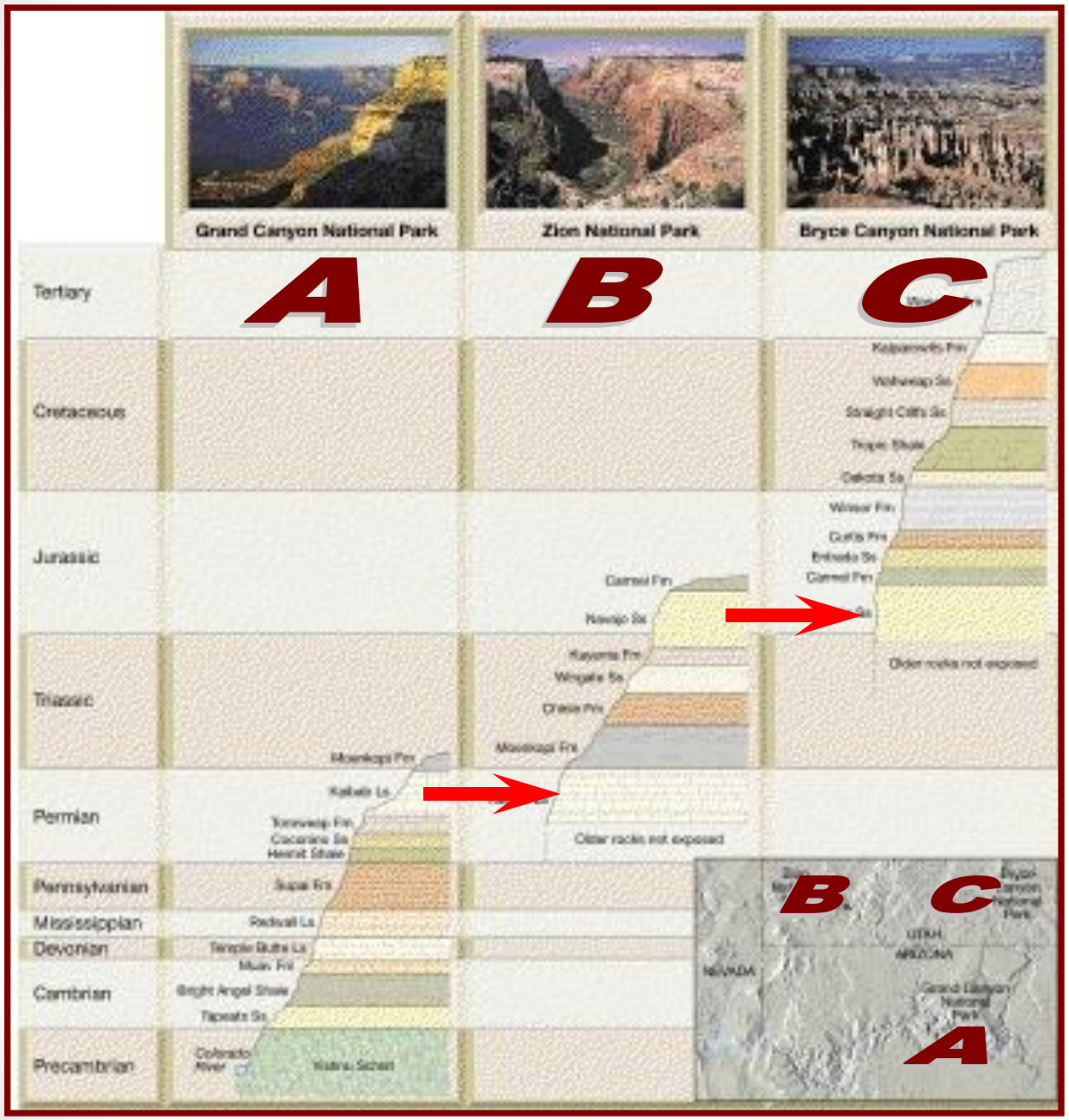
  Fossil content of rock changes in a systematic way, reflecting evolutionary changes

  Fossil content can be used to help determine age of rock and correlate rocks.

  Paraphrased as "Organisms within rock units change with time".

Illustration of Relative Age Principles

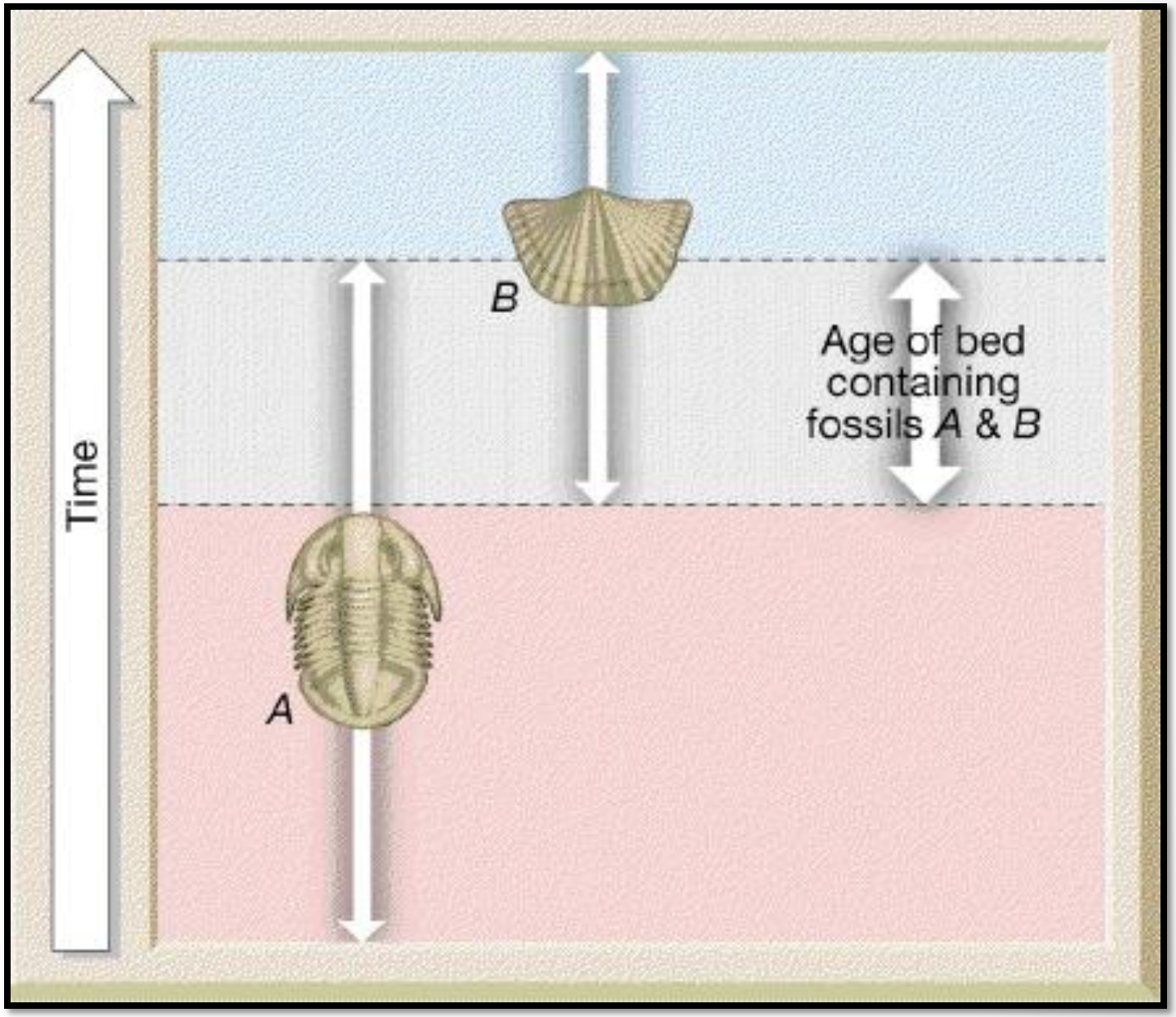




Correlation

Correlation is determining that rocks are the same formation (may mean rocks are the same age)

Illustration of Principle of Faunal Succession



Unconformities

Unconformities are surfaces in rock that represent periods of erosion or non-deposition. In other words, time has been left out of the physical geologic rock record.

There are three (3) principal types of unconformities:

1. ***Angular Unconformity***

   Rocks above and below unconformity have different orientations. Shows that there was a period of deformation, followed by erosion, and then renewed deposition. Easiest of the three types to recognize because the units are at an angle truncated with the units above them.

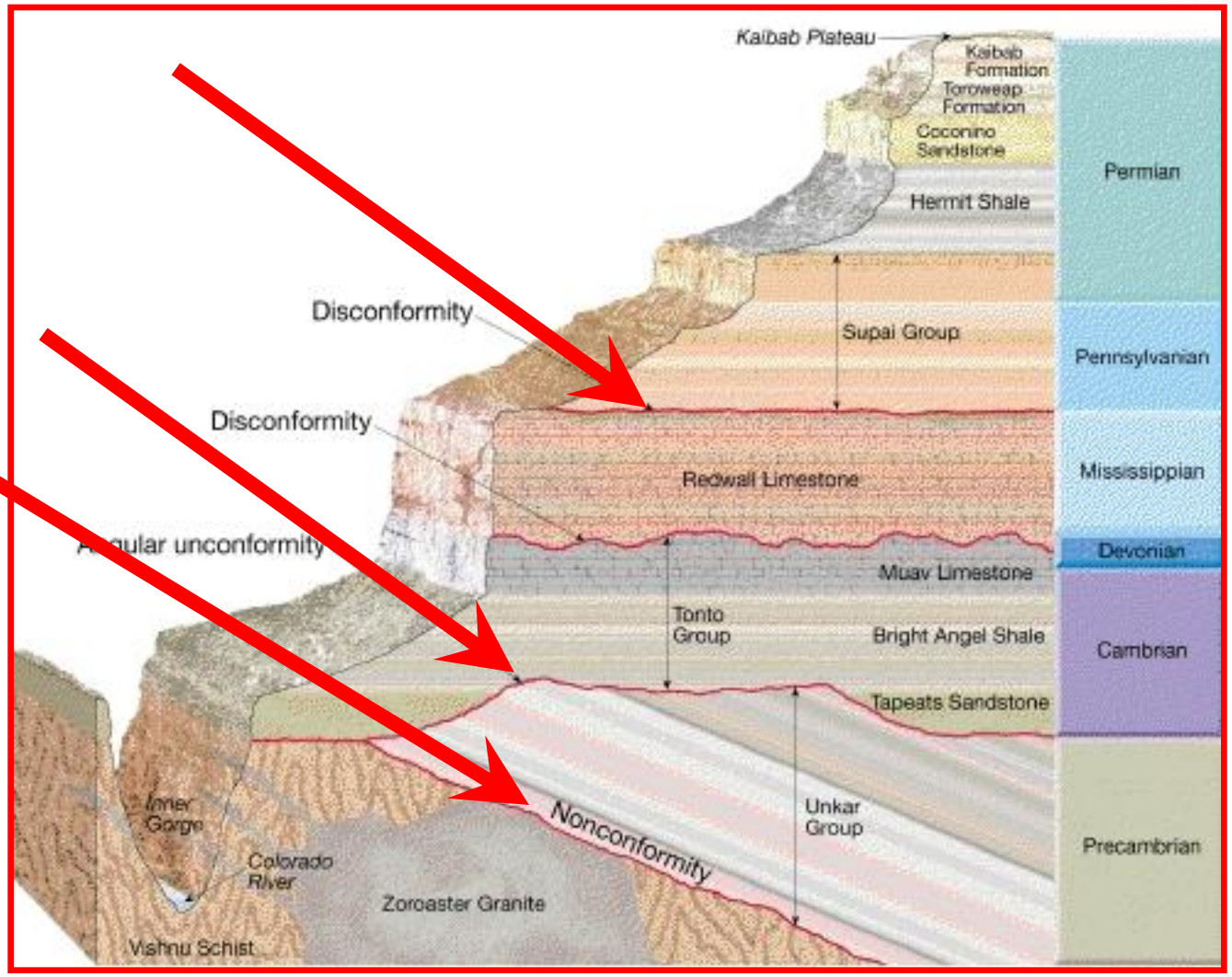
2. ***Nonconformity***

   Rocks in a horizontal fashion were eroded down to igneous bedrock material at which time subsequent deposition of sedimentary layers commenced. Shows that there was a period of deformation, followed by erosion, and then renewed deposition. Represents the greatest amount of time left out of the geologic rock record.

3. ***Disconformity***

   Rocks in a nearly horizontal fashion were eroded and an erosional profile remains covered by subsequent sedimentary deposition. Shows that there was a period of erosion and then renewed deposition in nearly horizontal layers. Most difficult to recognize because the units are nearly horizontal and only a small discontinuous layer can be observed (rubble zone or soil profile).

Unconformity Types Using Grand Canyon as Example



Geologic Time Scale

Developed in 1800s from relative dating of rocks

More recently, radiometric techniques have allowed us to determine ages of units in years before present.

Many of the names relate back to localities in England (Ex: Devonian from Devonshire)

Divisions of Geologic Time Scale:

Eons →Eras:

Paleozoic -- Mesozoic -- Cenozoic

Oldest ----------> Youngest

Periods of the Phanerozoic: Paleozoic Era

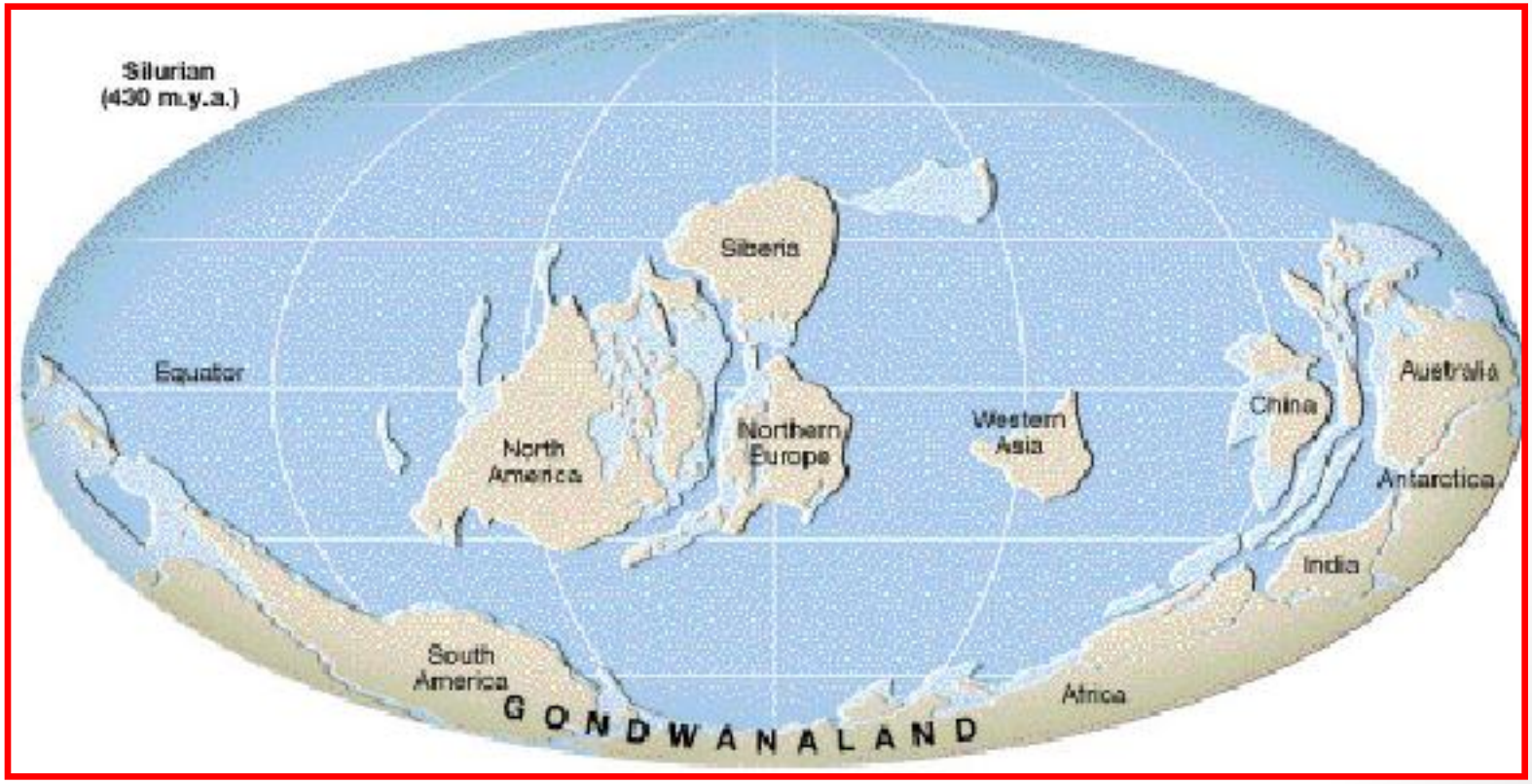
Permian (youngest)

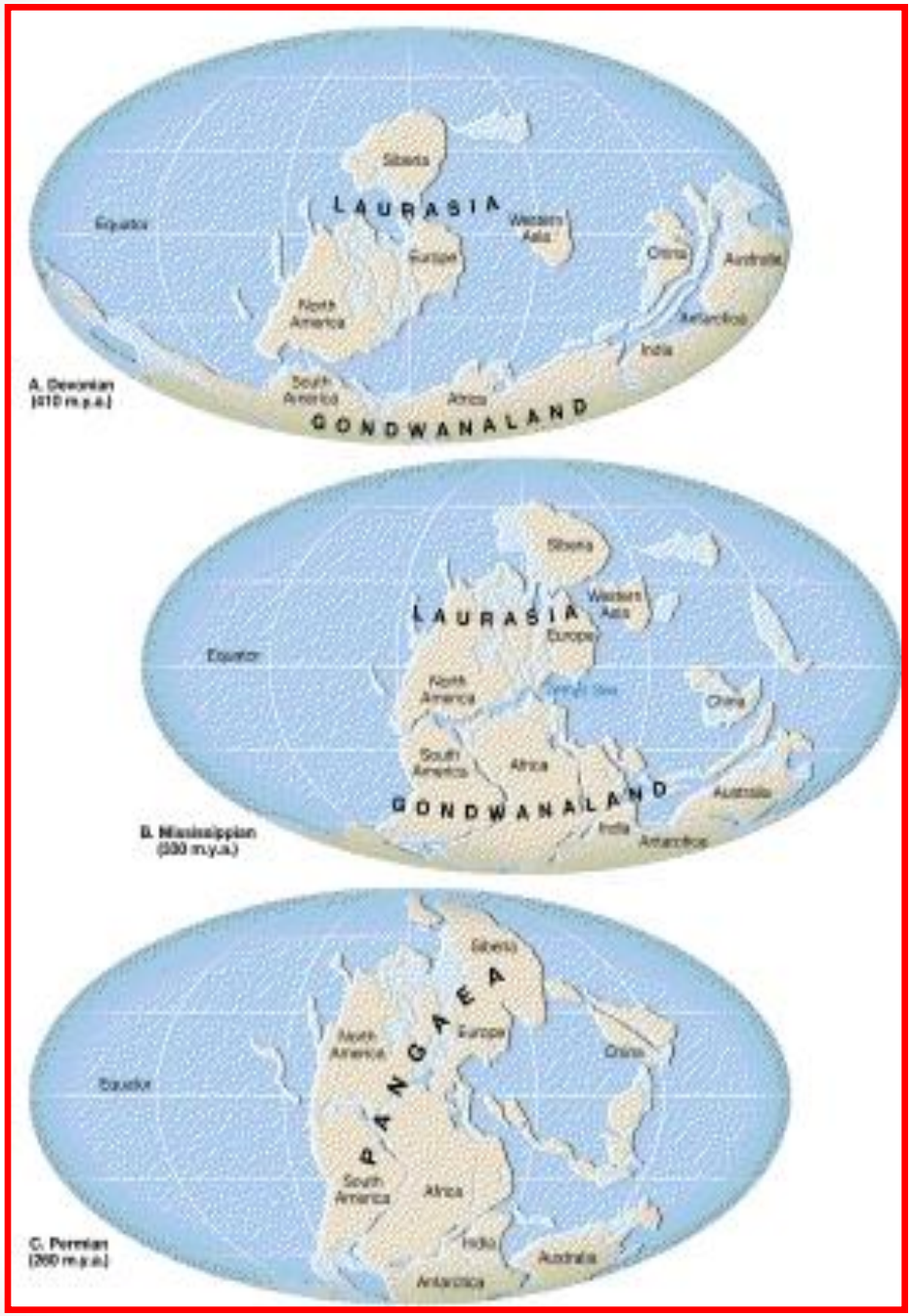
Pennsylvanian together with Mississippian are called "Carboniferous" in Great Britain

Epochs of Tertiary and Quaternary

Paleocene→Eocene→Oligocene→Miocene→Pliocene→Pleistocene

Earth During the Silurian (430+ million years ago)



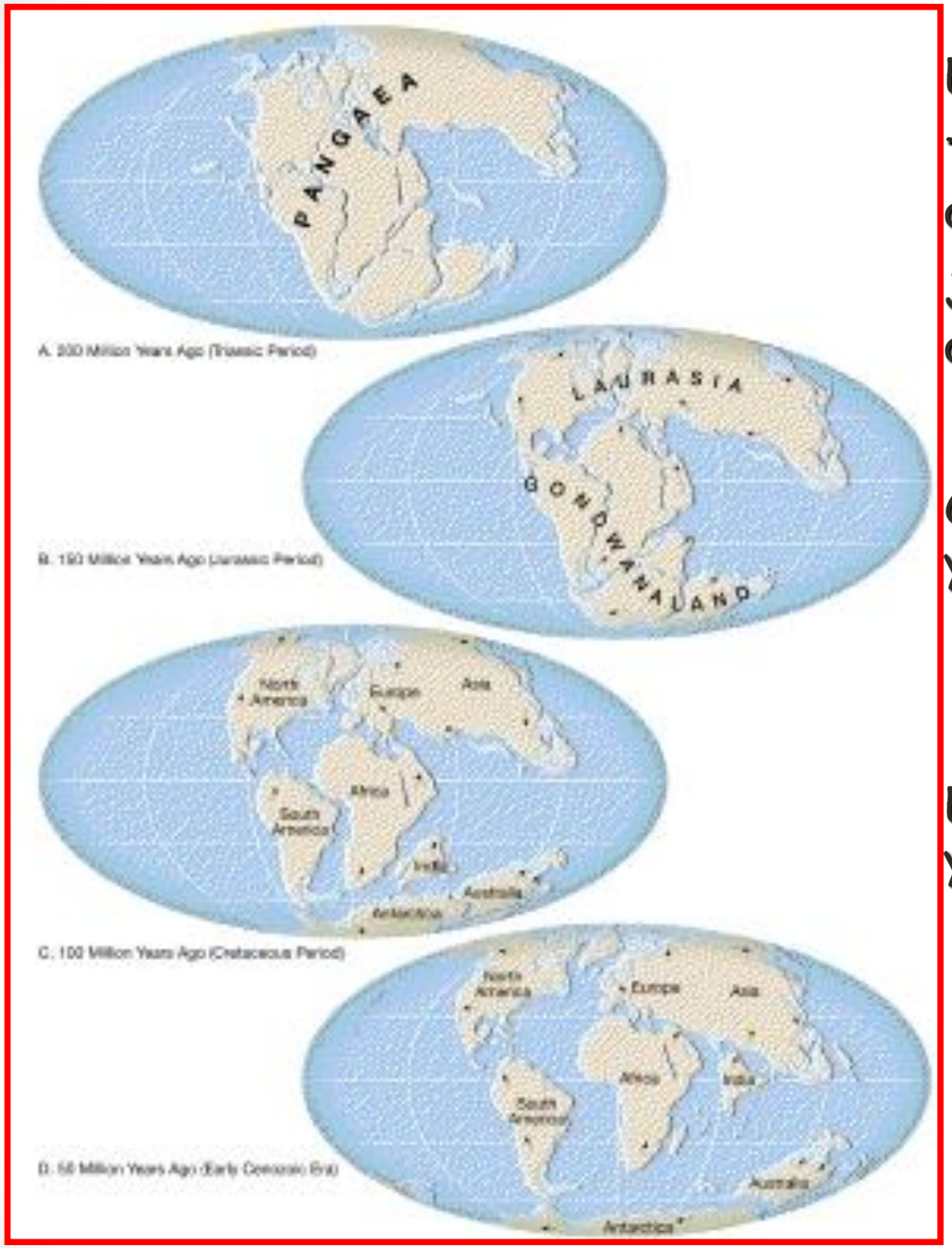


Earth during:

Devonian ~410 million years ago

Mississippian ~330 million years ago

Permian ~250 million years ago



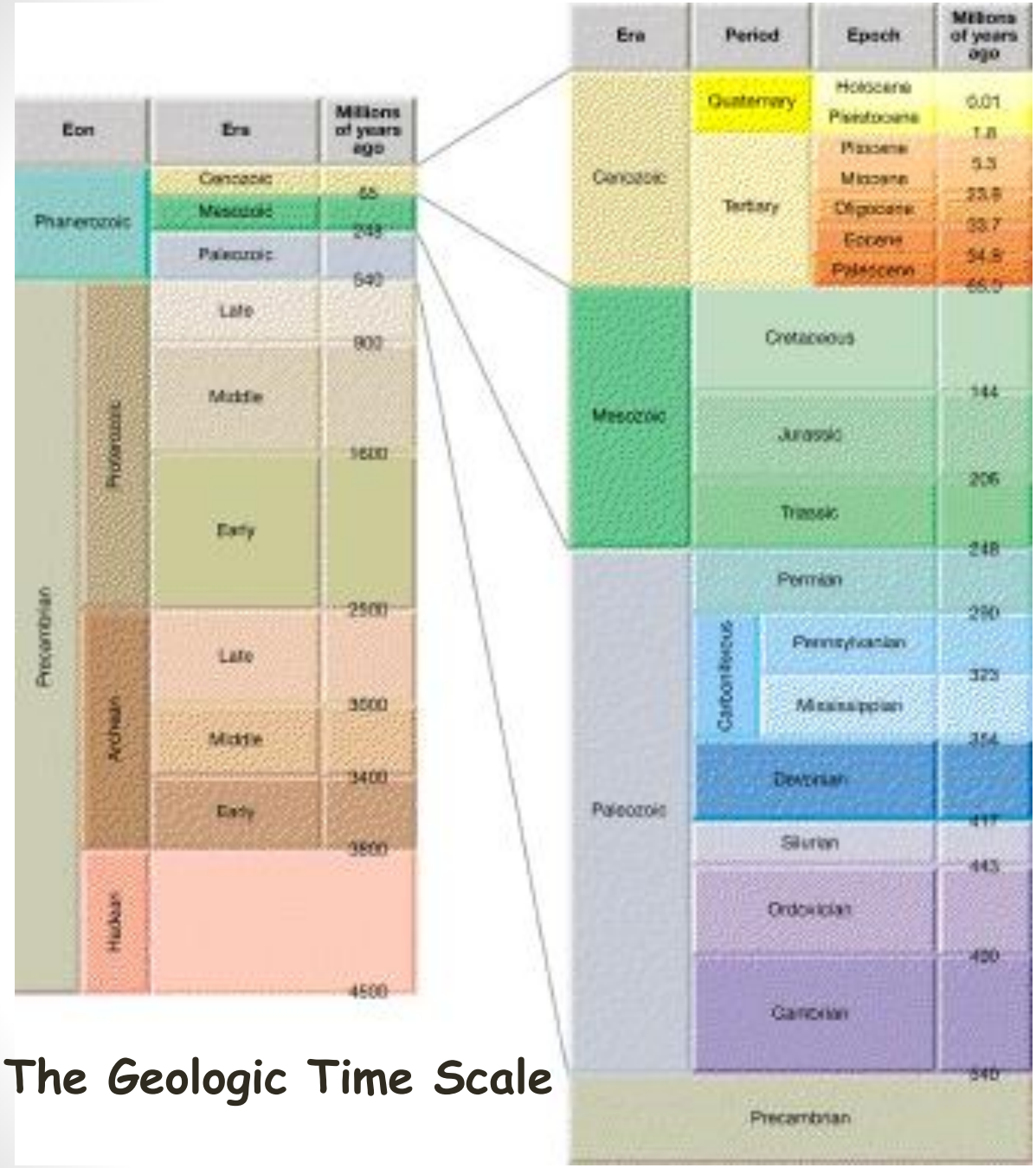
Earth during:

Triassic ~ 200 million years ago

Jurassic ~190 million years ago

Cretaceous ~100 million years ago

Early Cenozoic ~50 million years ago



The Geologic Time Scale

Most recent "Ice Age" "Humans" arrive

Major Mass Extinction

Age of Dinosaurs

Major Mass Extinction

Age of Coal Formation

Age of Fishes

First multi-celled organisms

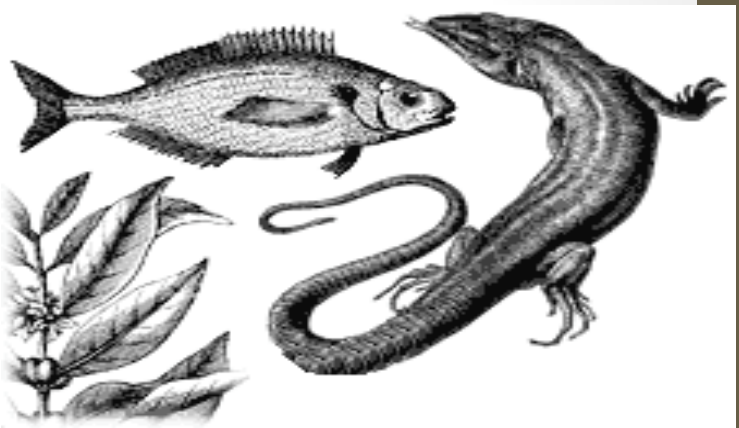
Origin of the Earth 4.55 Billion years

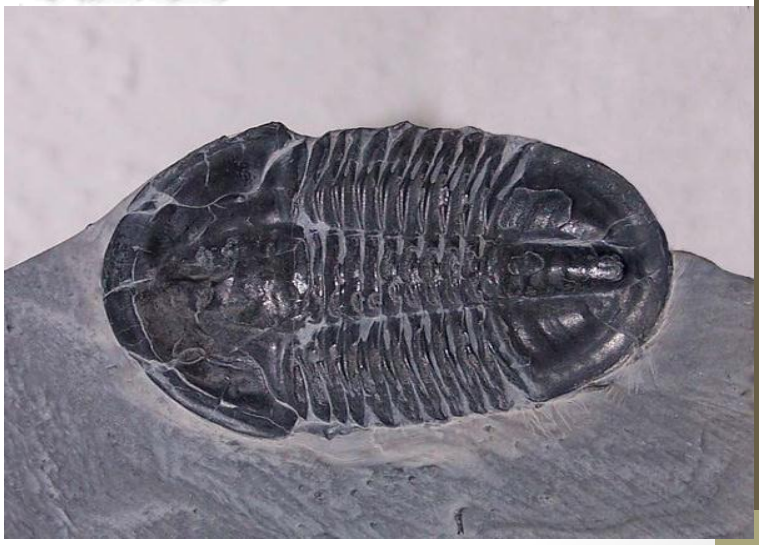
Precambrian Time

- 4.6 billion years before present to 544 million years before present
- Longest era with a sparse fossil record
- Origin of earth's crust, first atmosphere, and first seas
- Earliest fossils of cyanobacteria use photosynthesis to produce oxygen
- Ozone layer in the atmosphere is formed from oxygen

Paleozoic era

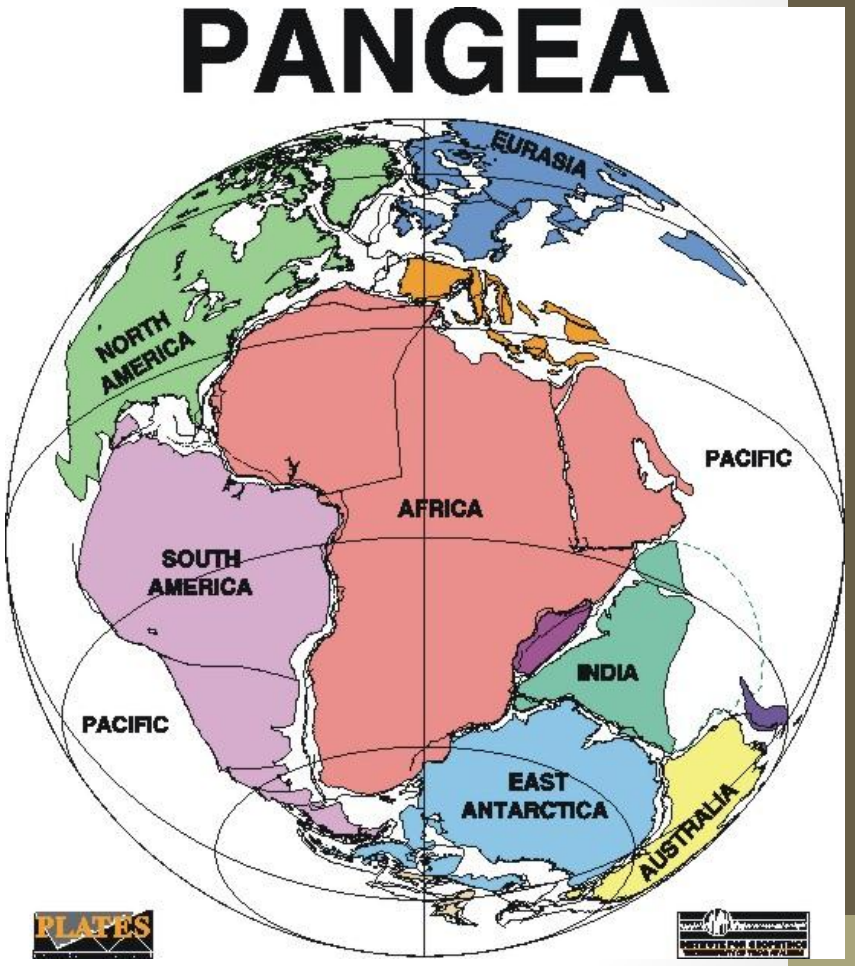
- 544 million years before present to 245 million years before present
- Marine communities flourish
- Early fishes develop
- Origin of amphibians, insects & reptiles
- Recurring ice ages/ Appalachians mountains form
- Spore-bearing plants dominate





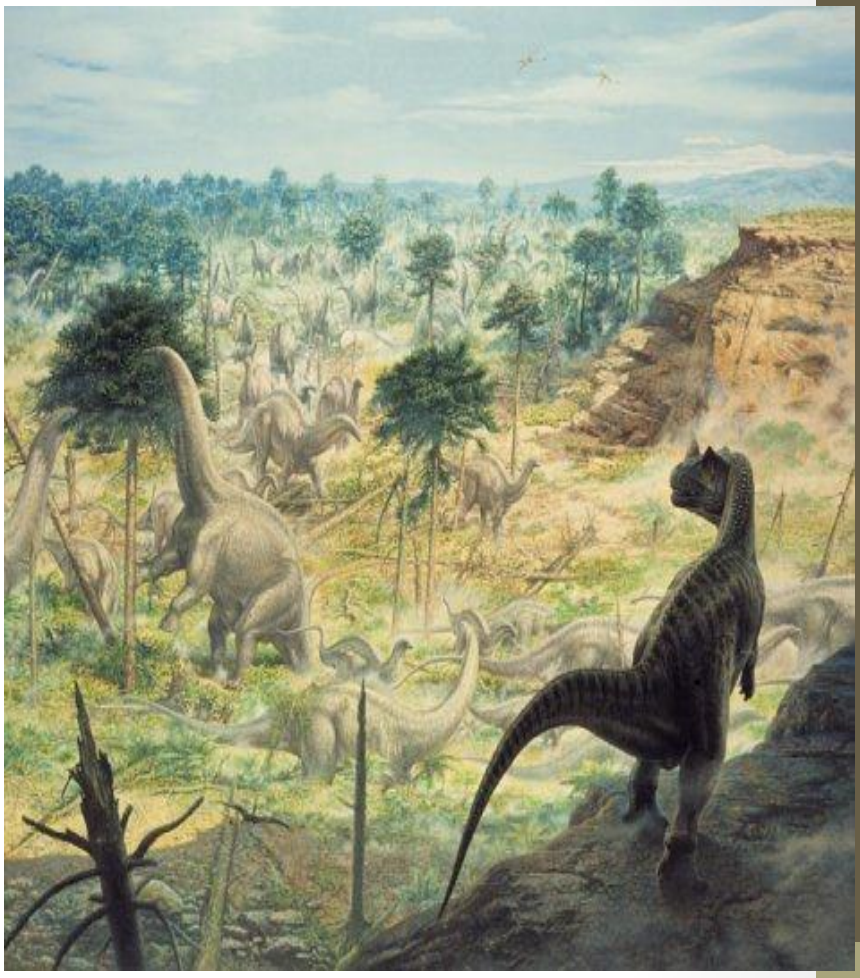
Paleozoic era (continued)…

- 286 - 248 million years before present: Supercontinent of Pangea forms
- 248 million years before present: MASS EXTINCTION- 90 % of all known families lost!



Mesozoic Era

- 245 million years before present - 65 million years before present
- The age of the dinosaurs!
- Gymnosperms dominate land plant/ origin of angiosperms - flowering plants
- Origin of mammals & birds
- 145 million years before present - asteroid impact? MASS EXTINCTION
- Pangea begins to separate/ Rocky mountains form

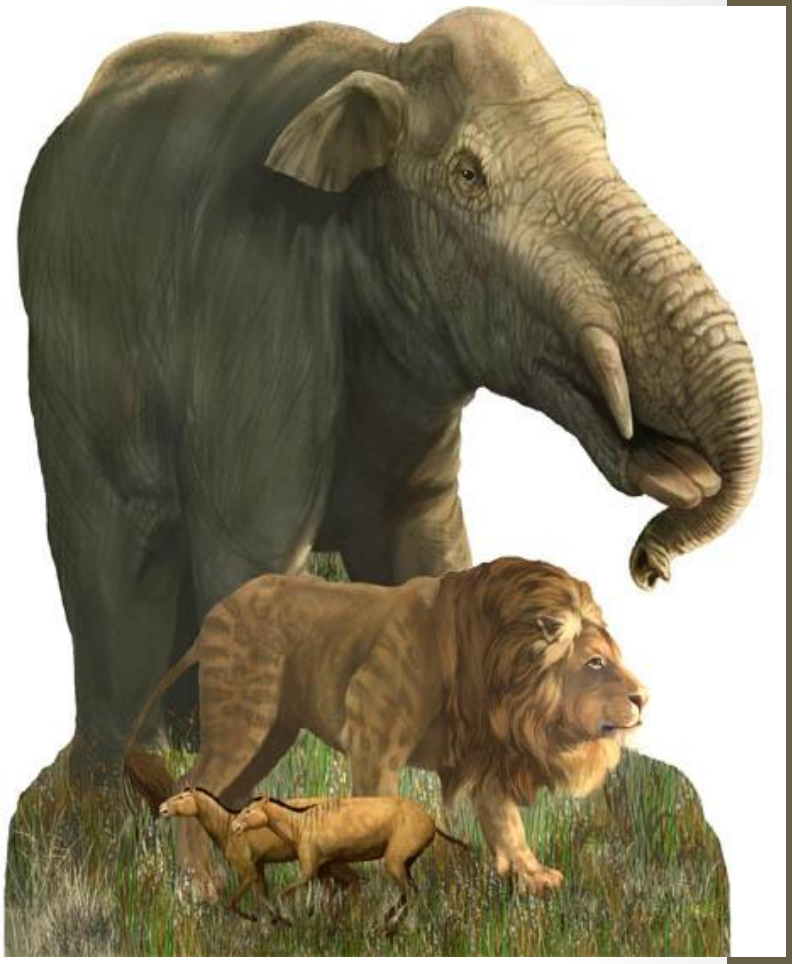


65 million years before present….

- ASTEROID IMPACT!
- Mass extinction of ALL dinosaurs and many marine organisms
- End of the Mesozoic era

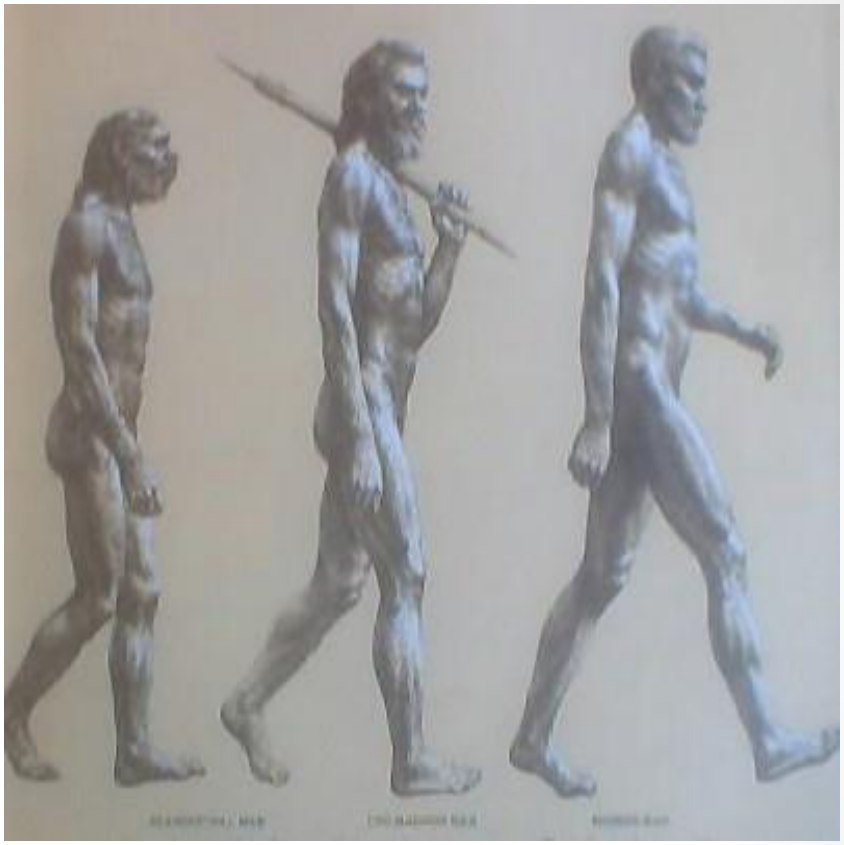
Cenozoic Era

- 65 million years before present - today
- Present era we live in
- Continued evolution and adaptations of flowering plants, insects, birds, mammals
- Mammals dominant
- Major crustal movements & mountain building (Alps & Himalayan mountains form)



And during the Cenozoic era…

- The most primitive hominid (human ancestor) evolves - approximately 4.4million years before present
- The first modern humans (homo sapiens) evolved approximately 100,000 years before present



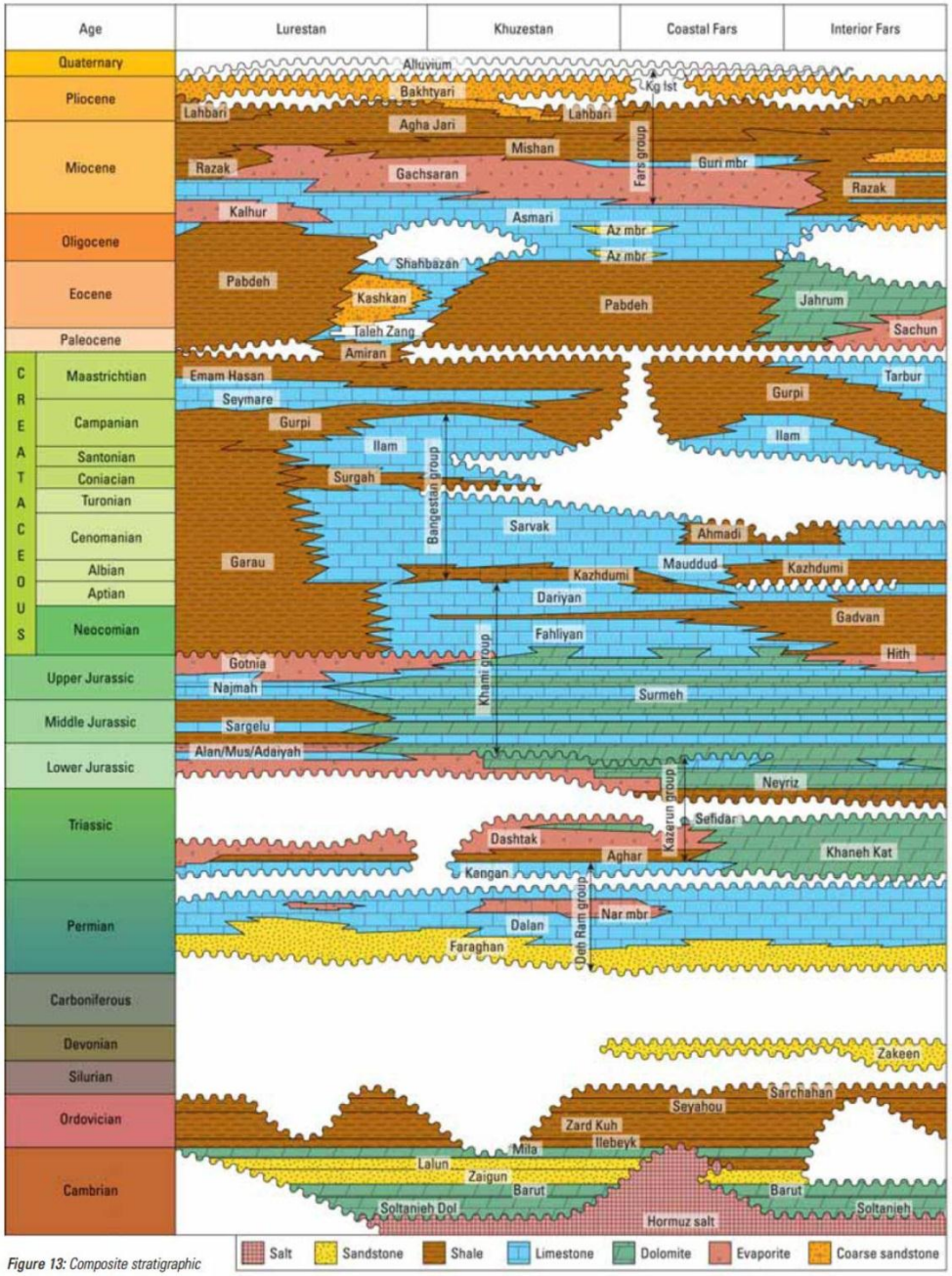


Figure 13: Composite stratigraphic column for the Zagros basin, Iran

1890

Still the same rock.

1910

Still the same rock.

1920

Still the same rock.

1970

Still the same rock, but where did it go?

1990

Weathering

Mechanical Weathering - processes that break a rock or mineral into smaller pieces without altering its composition

Chemical Weathering - processes that change the chemical composition of rocks and minerals

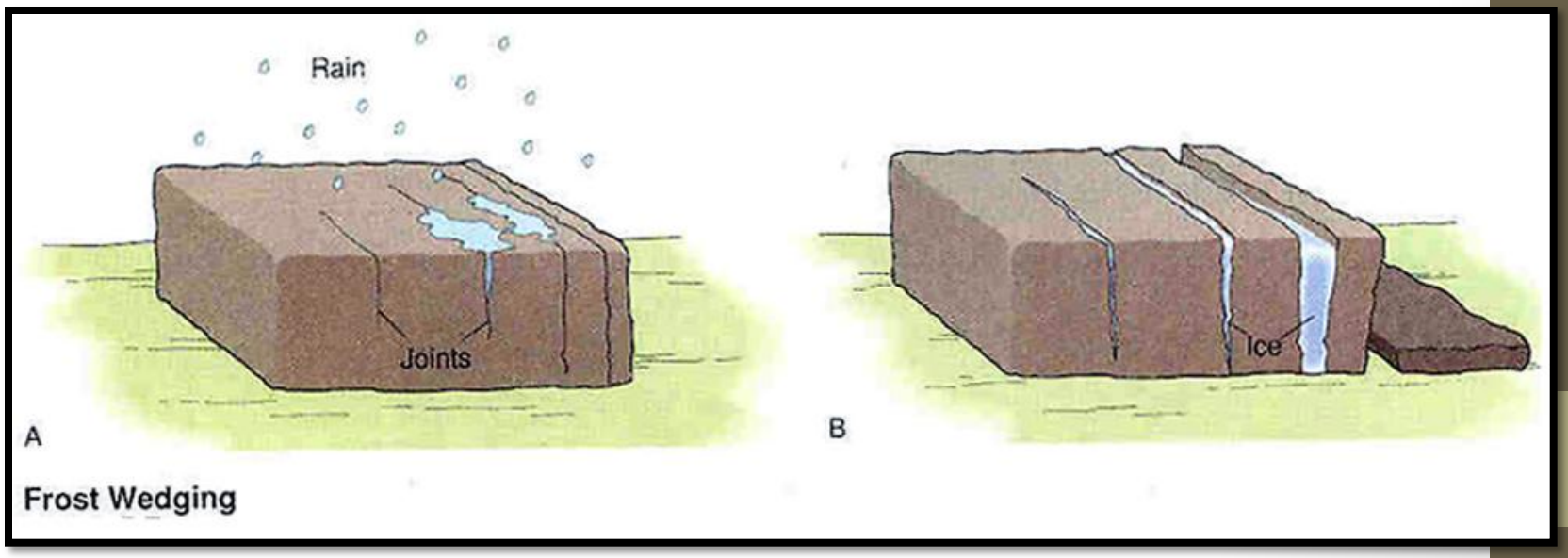
Processes and Agents of Mechanical Weathering

These are actions or things that break down Earth materials

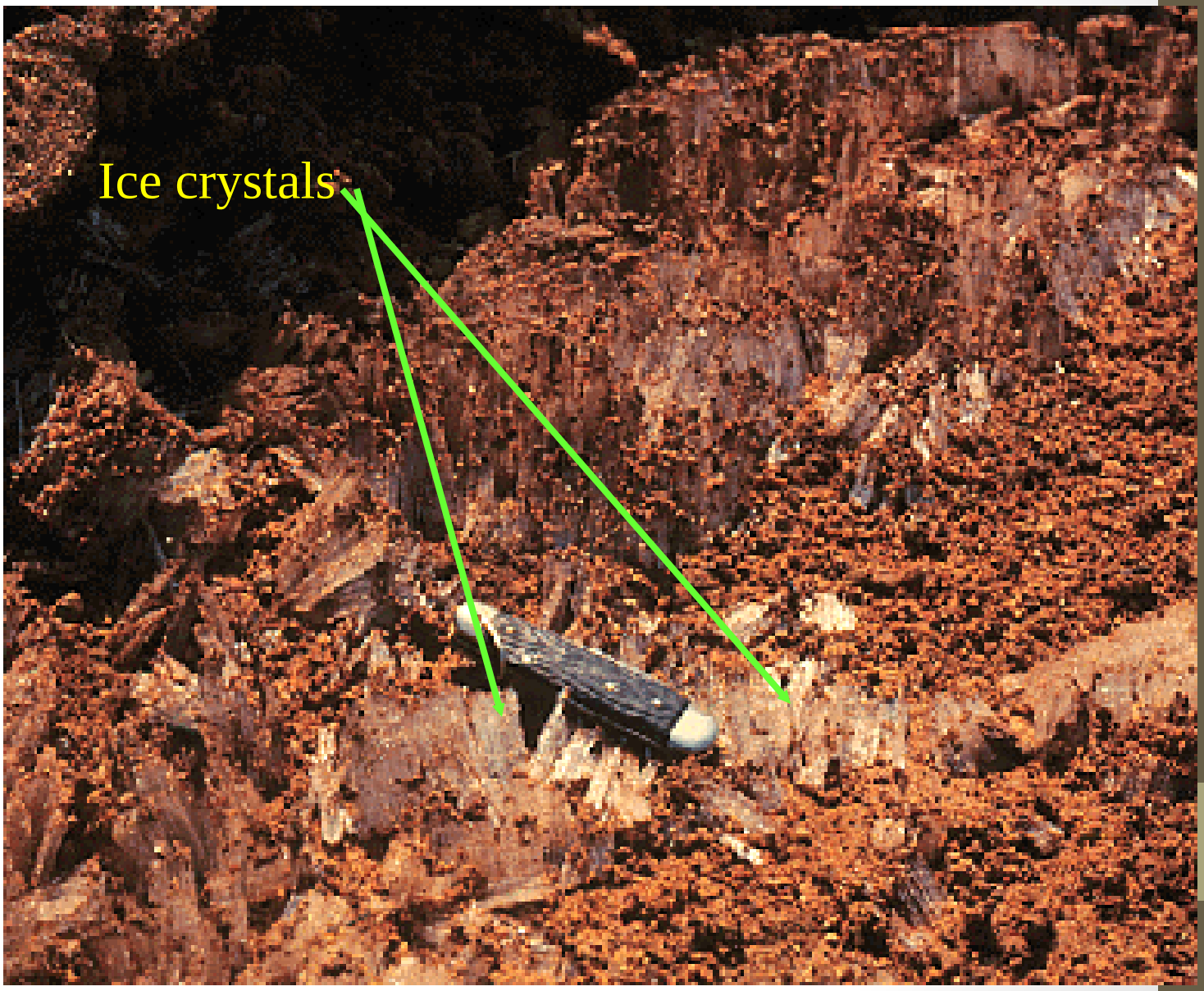
- frost wedging
- thermal expansion and contraction
- mechanical exfoliation
- abrasion by wind, water or gravity
- plant growth

Processes and Agents of Mechanical Weathering

- Frost Wedging – cracking of rock mass by the expansion of water as it freezes in crevices and cracks



Frost Wedging (in soil)



Processes and Agents of Mechanical Weathering

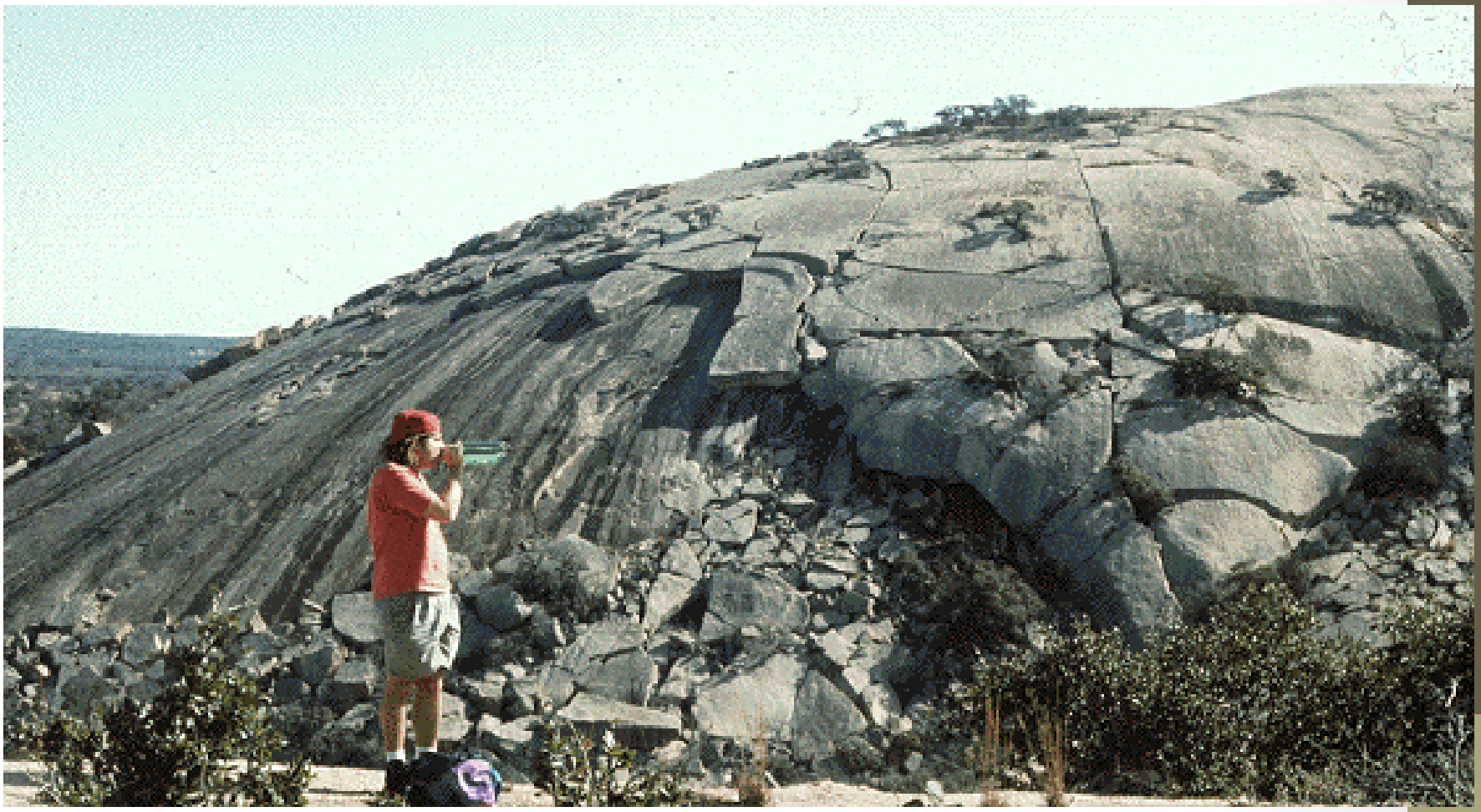
- Thermal expansion and contraction –

  repeated heating and cooling of materials cause rigid substances to crack and separate

Processes and Agents of Mechanical Weathering

- Exfoliation – As underlying rock layers are exposed, there is less pressure on them and they expand. This causes the rigid layers to crack and sections to slide off (similar to peeling of outer skin layers after a sunburn). The expanding layers often form a dome.

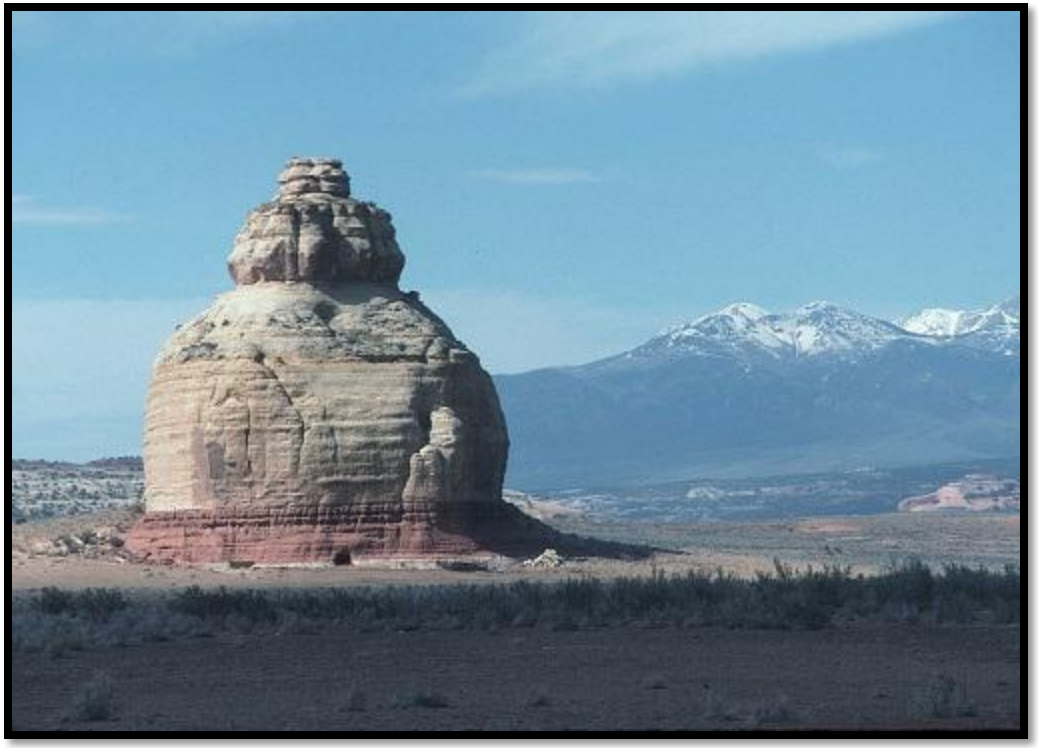
Dome Exfoliation



Processes and Agents of Mechanical Weathering

- Abrasion – Moving sediments or rock sections can break off pieces from a rock surface they strike. The sediments can be moved by wind or water and the large rock sections by gravity.

Wind Abrasion



Wind and Water Abrasion

Processes and Agents of Mechanical Weathering

- Plant Growth – As plants such as trees send out root systems, the fine roots find their way into cracks in the rocks. As the roots increase in size, they force the rock sections apart, increasing the separation and weathering.

Plant Wedging

Plant Wedging

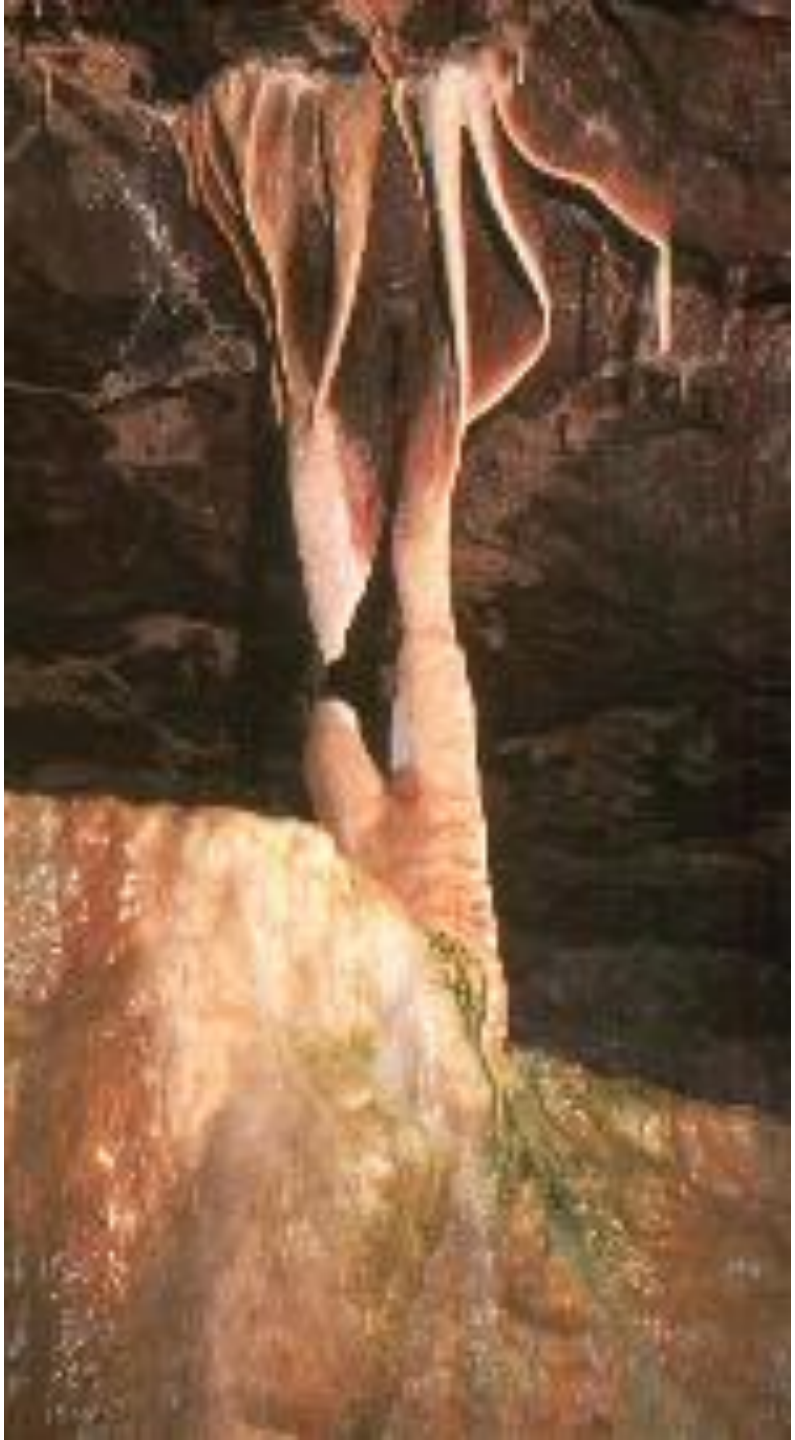
Processes of Chemical Weathering

- dissolving (dissolution)
- oxidation
- hydrolysis

Processes of Chemical Weathering

Dissoalving (dissolution)

Water, often containing acid from dissolved carbon dioxide, will dissolve minerals from a rock body leaving cavities in the rock. These cavities may generate sinkholes or cave features such as stalactites and stalagmites.



Limestone cave feature

result of dissolution

Processes of Chemical Weathering

Oxidation

Minerals may combine with oxygen to form new minerals that are not as hard. For example, the iron-containing mineral pyrite forms a rusty-colored mineral called limonite.

Pyrite Oxidation

Pyrite

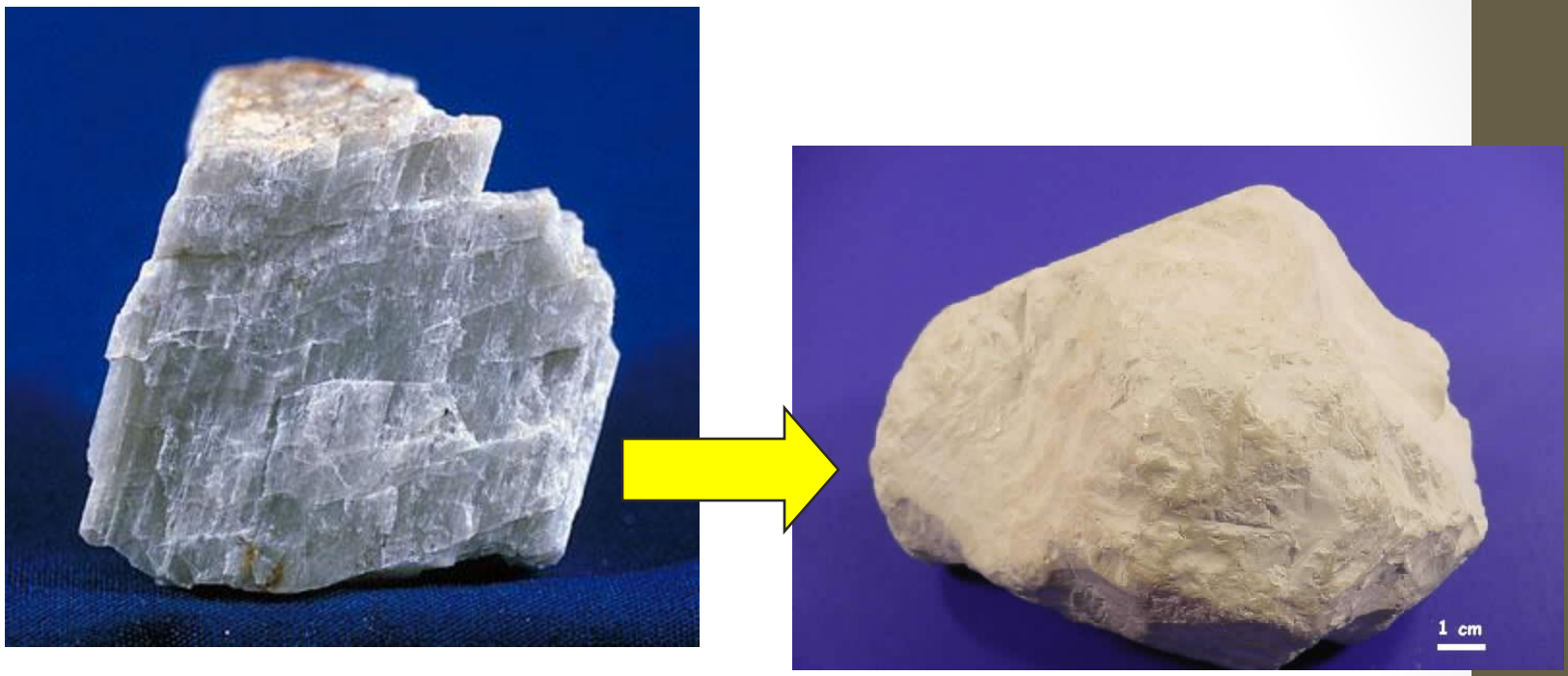
Limonite

Processes of Chemical Weathering

Hydrolysis

Minerals may chemically combine with water to form new minerals. Again these are generally not as hard as the original material.

Feldspar Hydrolysis



Feldspar → Kaolinite (clay)

Factors in Chemical Weathering

- Climate – wet and warm maximizes chemical reactions
- Plants and animals – living organisms secrete substances that react with rock
- Time – longer contact means greater change
- Mineral composition – some minerals are more susceptible to change than others

Weathering and Erosion

Weathering produces regolith (“rock blanket”) which is composed of small rock and mineral fragments.

When organic matter is mixed into this material it is called soil.

Erosion Transport Agents or Forces

- Water
    - rain
        - streams and rivers
        - ocean dynamics
        - ice in glaciers
- Wind
- Gravity

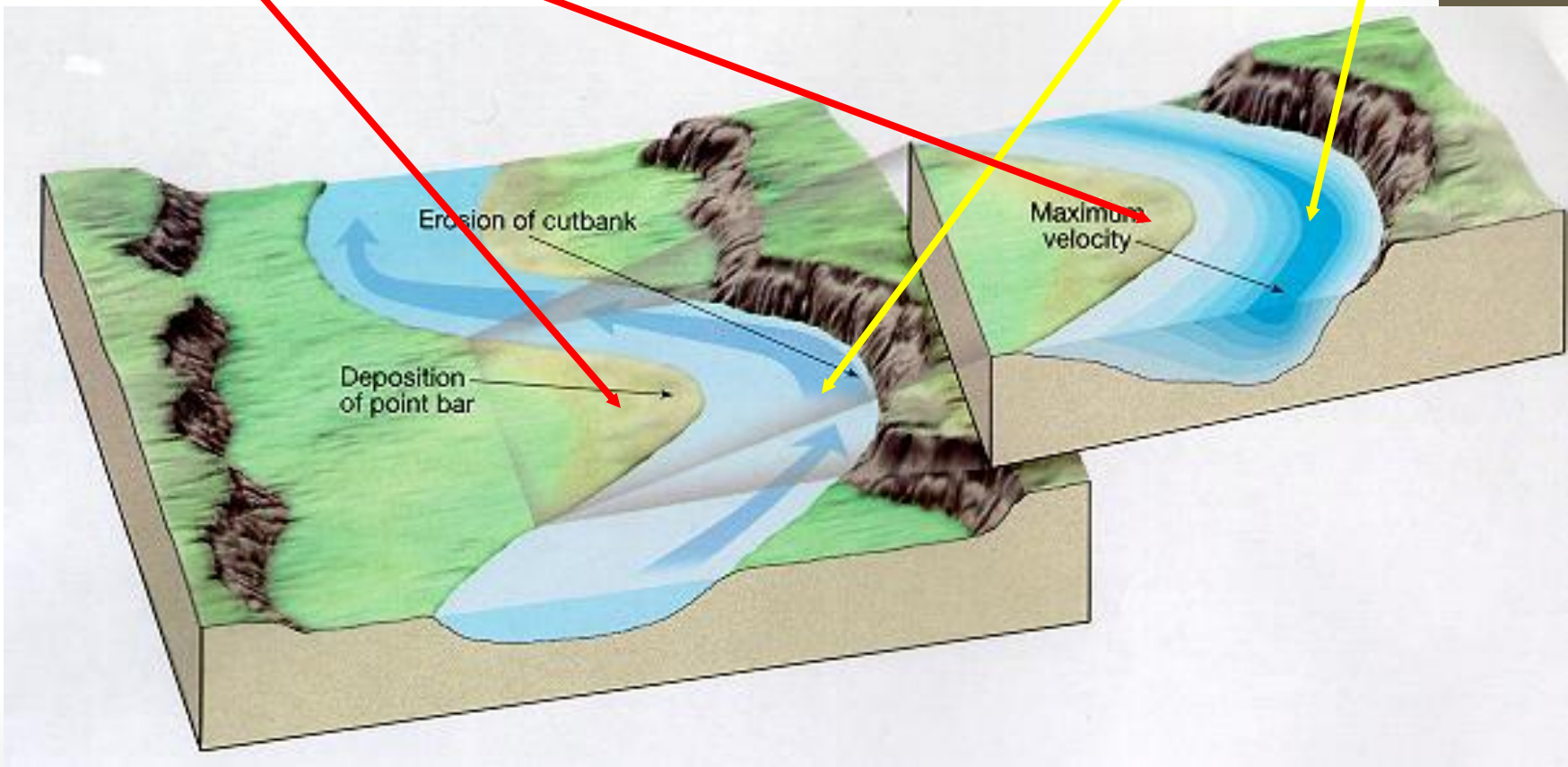
Streams

Flowing water will lift and carry small sediments such as silt and sand.

Stream Erosion and Deposition

Where water moves more swiftly there will be more erosion.

Where the water slows down, sediments will be deposited.



Ocean Dynamics

- Tidal action and waves carry away weathered materials.

Glaciers

Glaciers are large ice fields that slowly flow downhill over time.

Glaciers

Glacial ice drags rocky material that scours the surface it flows over . The glacier deposits debris as it melts.

Wind Transport of Sediments

Wind will carry fine, dry sediments over long distances.

Wind Transport of Dust

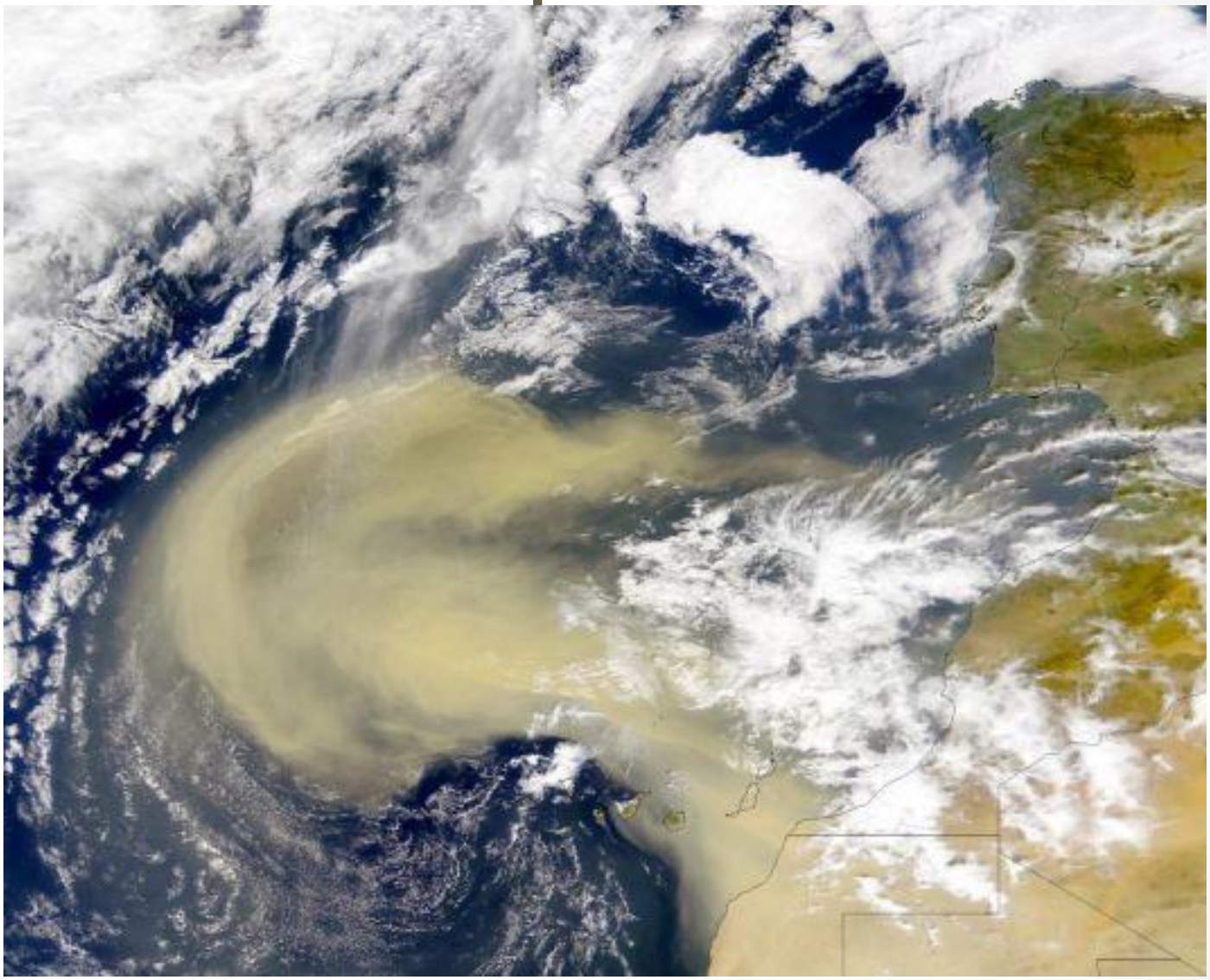


Photo shows Sahara Desert sand being transported over the Atlantic Ocean.

Transport by Gravity

When sediments are weathered they may be transported downward by gravity. The general term for this is mass wasting.

http://en.wikipedia.org/wiki/Mass_wasting

Transport by Gravity

When sediments are weathered they may be transported downward by gravity as a slump.

http://new.filter.ac.uk/database/image.php?id=594

Transport by Gravity

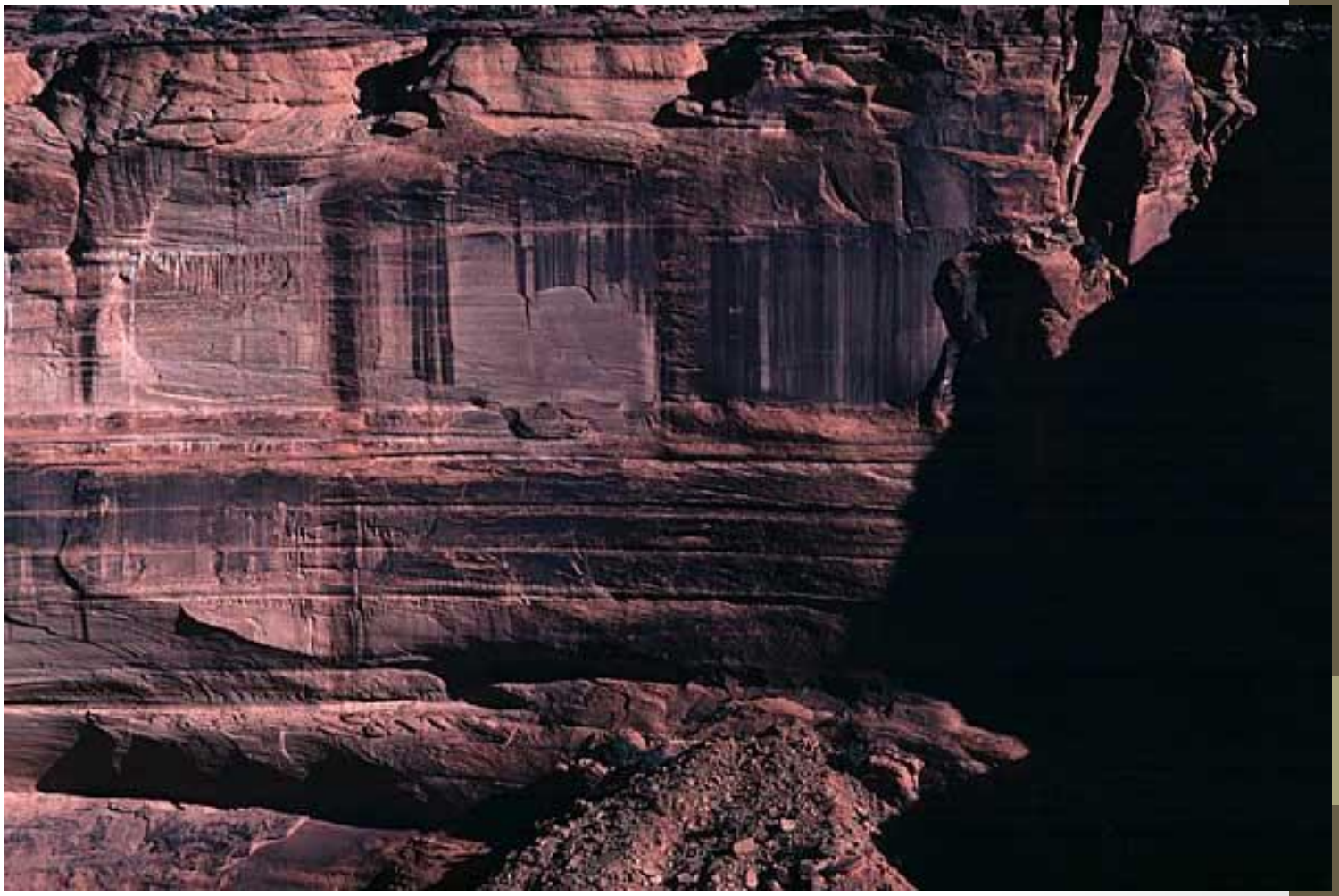
Loose sediments transported by gravity are called scree.

http://www.dave-stephens.com/scrambles/banff/aylmer/aylmer013.jpg

Deposition Formation

Transported sediments are deposited in layers and generate strata like those found in the Grand Canyon.

Deposition Formation



Volcanic eruptions

- Factors that determine the violence of an eruption
  - Composition of the magma
  - Temperature of the magma
  - Dissolved gases in the magma
- Viscosity of magma
  - Viscosity is a measure of a material's resistance to flow

Volcanic eruptions

- Viscosity of magma
  - Factors affecting viscosity
    - Temperature (hotter magmas are less viscous)
    - Composition (silica content)
      - High silica – high viscosity (e.g., rhyolitic lava)
      - Low silica – more fluid (e.g., basaltic lava)
    - Dissolved gases (volatiles)
      - Mainly water vapor and carbon dioxide
      - Gases expand near the surface

Volcanic eruptions

- Viscosity of magma
  - Factors affecting viscosity
    - Dissolved gases (volatiles)
      - Provide the force to extrude lava
      - Violence of an eruption is related to how easily gases escape from magma
        - Easy escape from fluid magma
        - Viscous magma produces a more violent eruption

Materials associated with volcanic eruptions

- Lava flows
  - Basaltic lavas are more fluid
  - Types of lava
    - Pahoehoe lava (resembles braids in ropes)
    - Aa lava (rough, jagged blocks)
- Gases
  - One to five percent of magma by weight
  - Mainly water vapor and carbon dioxide

Materials associated with volcanic eruptions

- Pyroclastic materials
  - "Fire fragments"
  - Types of pyroclastic material
    - Ash and dust – fine, glassy fragments
    - Pumice – from "frothy" lava
    - Lapilli – "walnut" size
    - Cinders – "pea-sized"
    - Particles larger than lapilli
      - Blocks – hardened lava
      - Bombs – ejected as hot lava

Volcanoes

- General features
  - Conduit, or pipe, carries gas-rich magma to the surface
  - Vent, the surface opening (connected to the magma chamber via a pipe)
  - Crater
    - Steep-walled depression at the summit
    - Caldera (a summit depression greater than 1 km diameter)

Volcanoes

- General features
  - Parasitic cones
  - Fumaroles
- 3 Types of volcanoes
  - Shield volcano
    - Broad, slightly domed
    - Primarily made of basaltic (fluid) lava
    - Generally large size
    - e.g., Mauna Loa in Hawaii

Volcanoes

- Types of volcanoes
  - Cinder cone
    - Built from ejected lava fragments
    - Steep slope angle
    - Rather small size
    - Frequently occur in groups

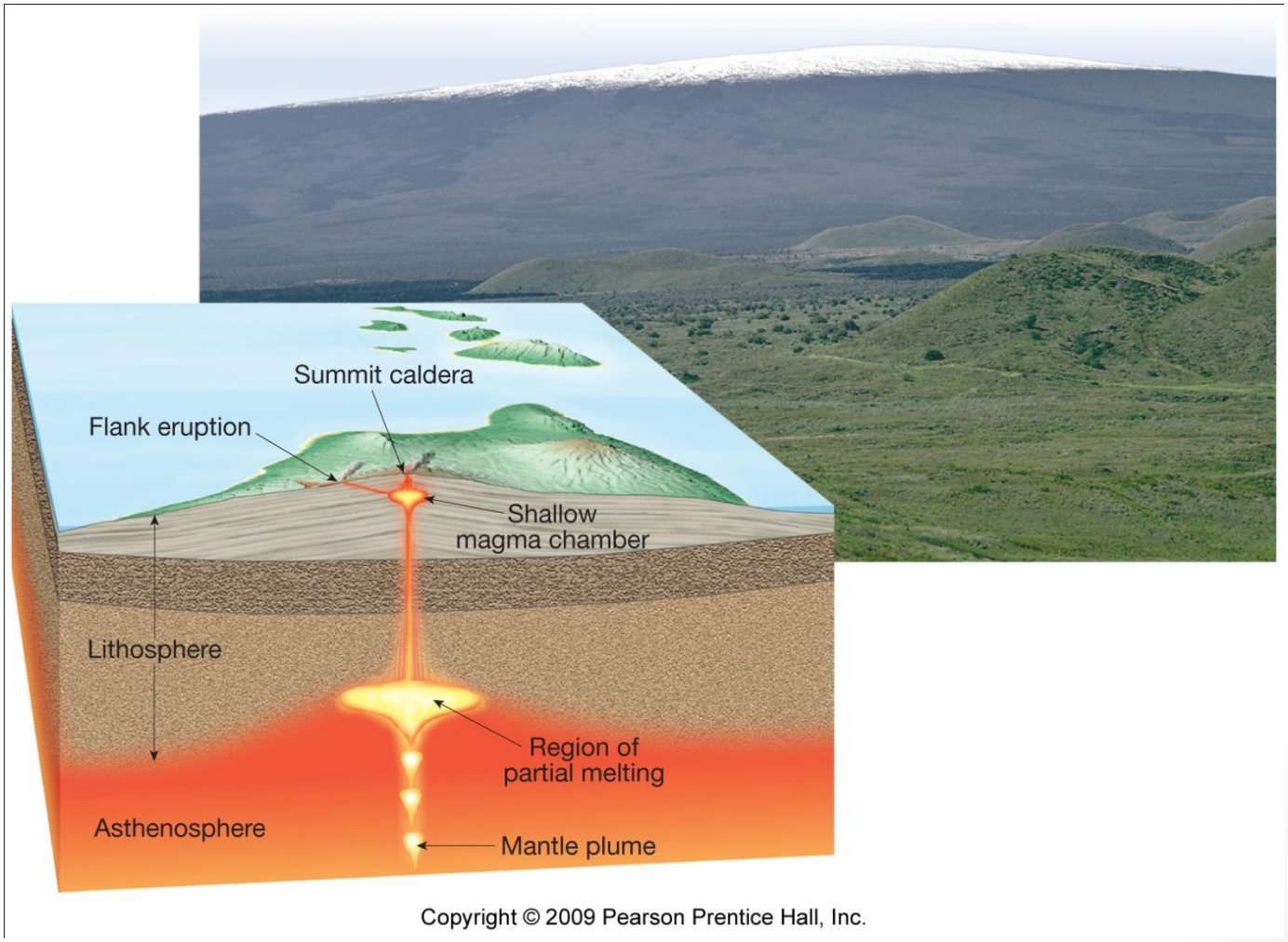
Volcanoes

- Types of volcanoes
  - Composite cone (or stratovolcano)
    - Most are adjacent to the Pacific Ocean (e.g., Mt. Rainier)
    - Large size
    - Interbedded lavas and pyroclastics
    - Most violent type of activity

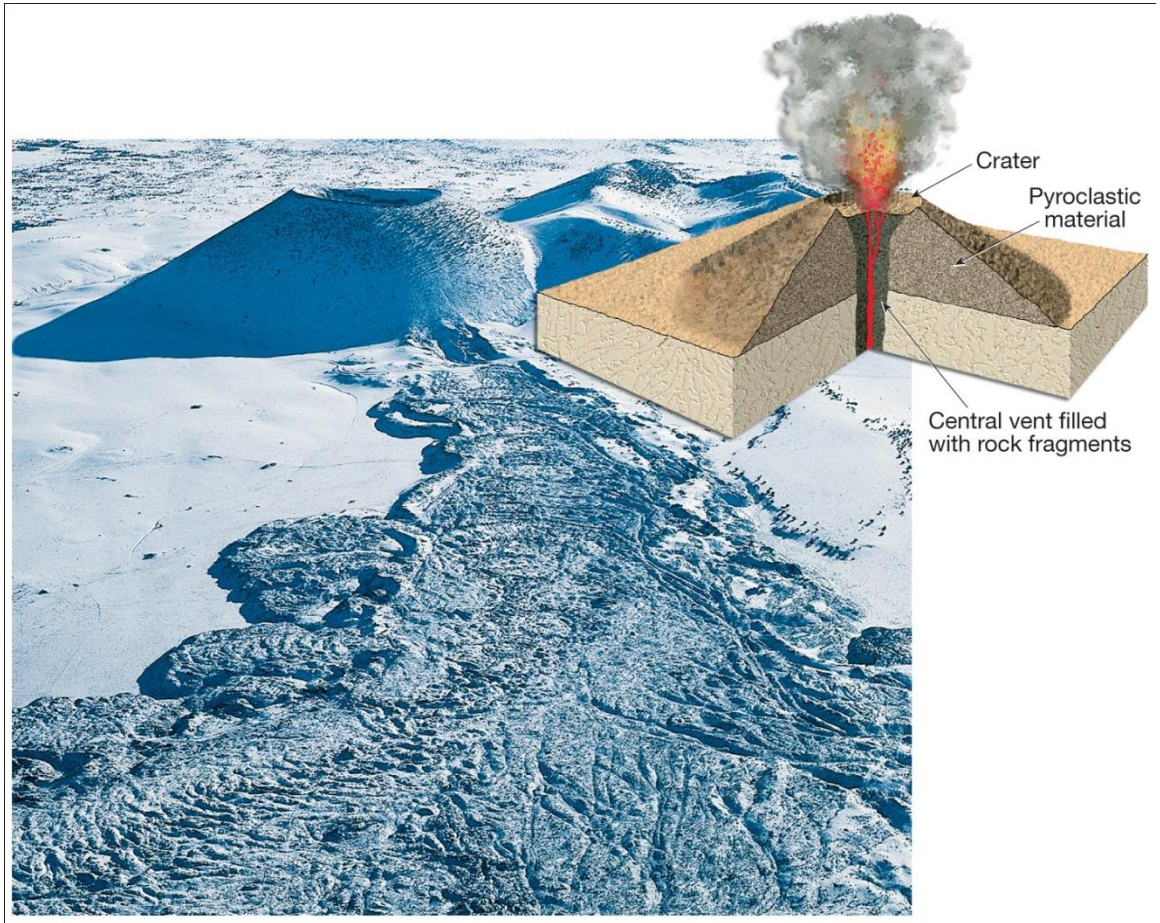
Volcanoes

- Types of volcanoes
  - Composite cone (or stratovolcano)
    - Often produce nuée ardente
      - Fiery pyroclastic flow made of hot gases infused with ash
      - Flows down sides of a volcano at speeds up to 200 km (125 miles) per hour
    - May produce a lahar – volcanic mudflow

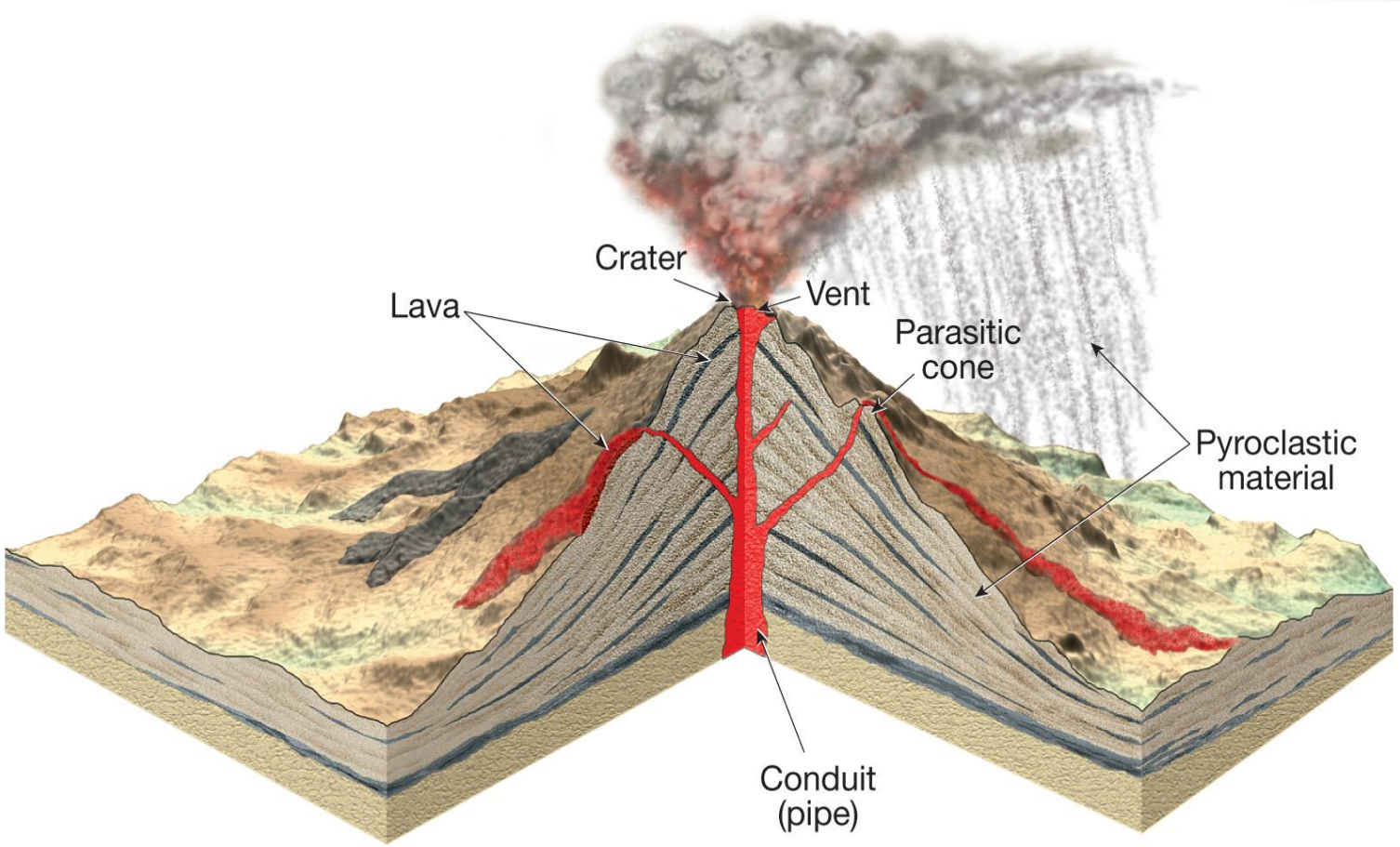
Shield volcano



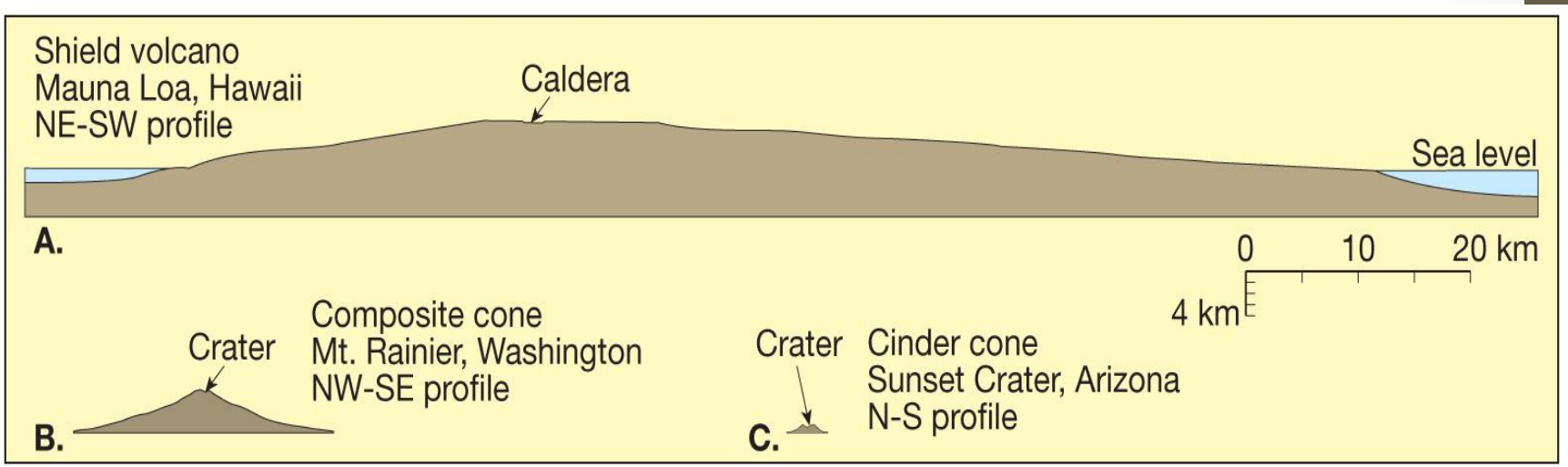
A cinder cone near Flagstaff, Arizona



Composite volcano



A size comparison of the three types of volcanoes



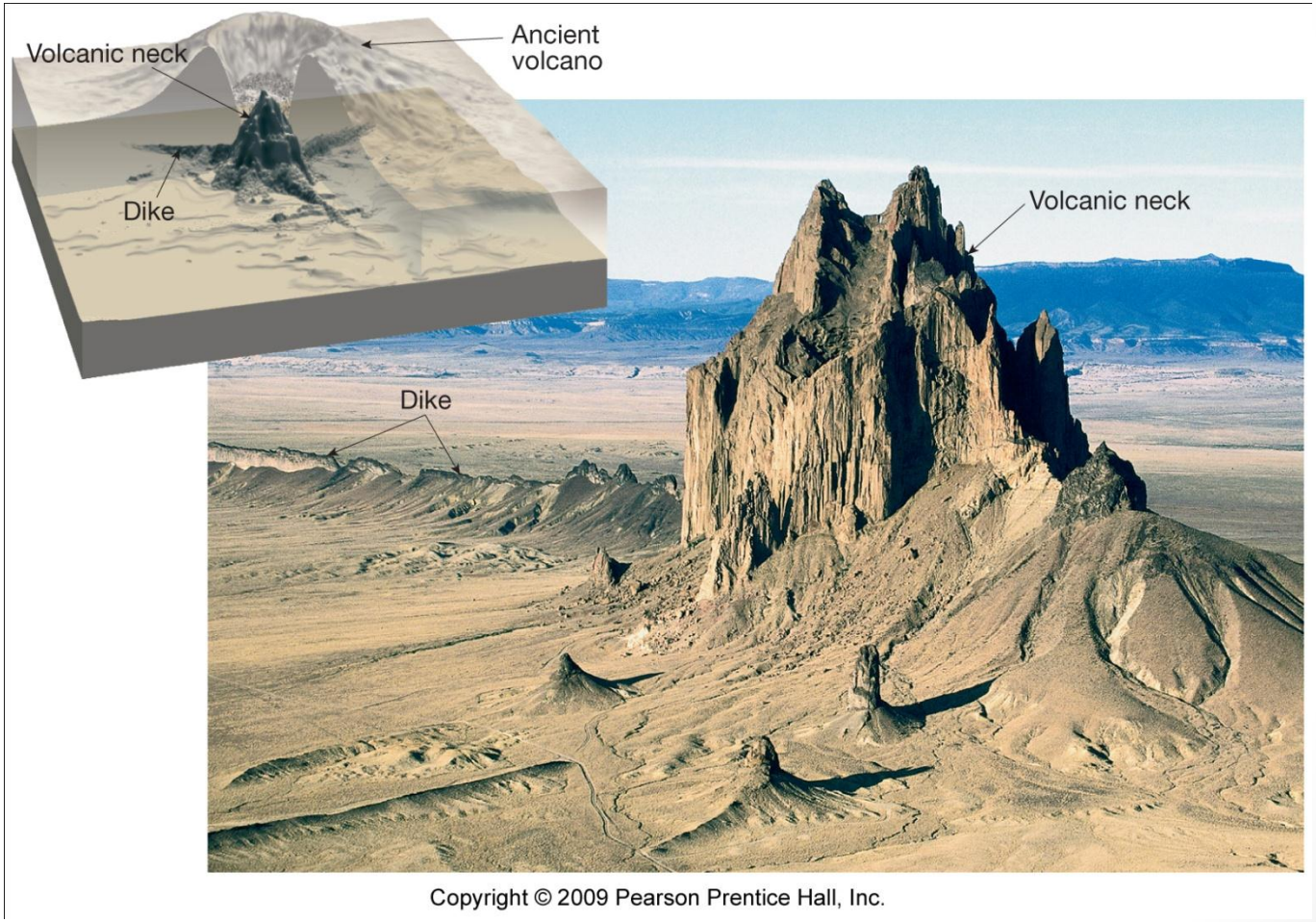
Other volcanic landforms

- Calderas
  - Steep-walled depression at the summit
  - Formed by collapse
  - Nearly circular
  - Size exceeds 1 kilometer in diameter
- Fissure eruptions and lava plateaus
  - Fluid basaltic lava extruded from crustal fractures called fissures
  - e.g., Columbia Plateau

Other volcanic landforms

- Volcanic pipes and necks
  - Pipes are short conduits that connect a magma chamber to the surface
  - Volcanic necks (e.g., Ship Rock, New Mexico) are resistant vents left standing after erosion has removed the volcanic cone

Formation of a volcanic neck



Intrusive igneous activity

- Most magma is emplaced at depth
- An underground igneous body is called a pluton
- Plutons are classified according to
  - Shape
    - Tabular (sheetlike)
    - Massive

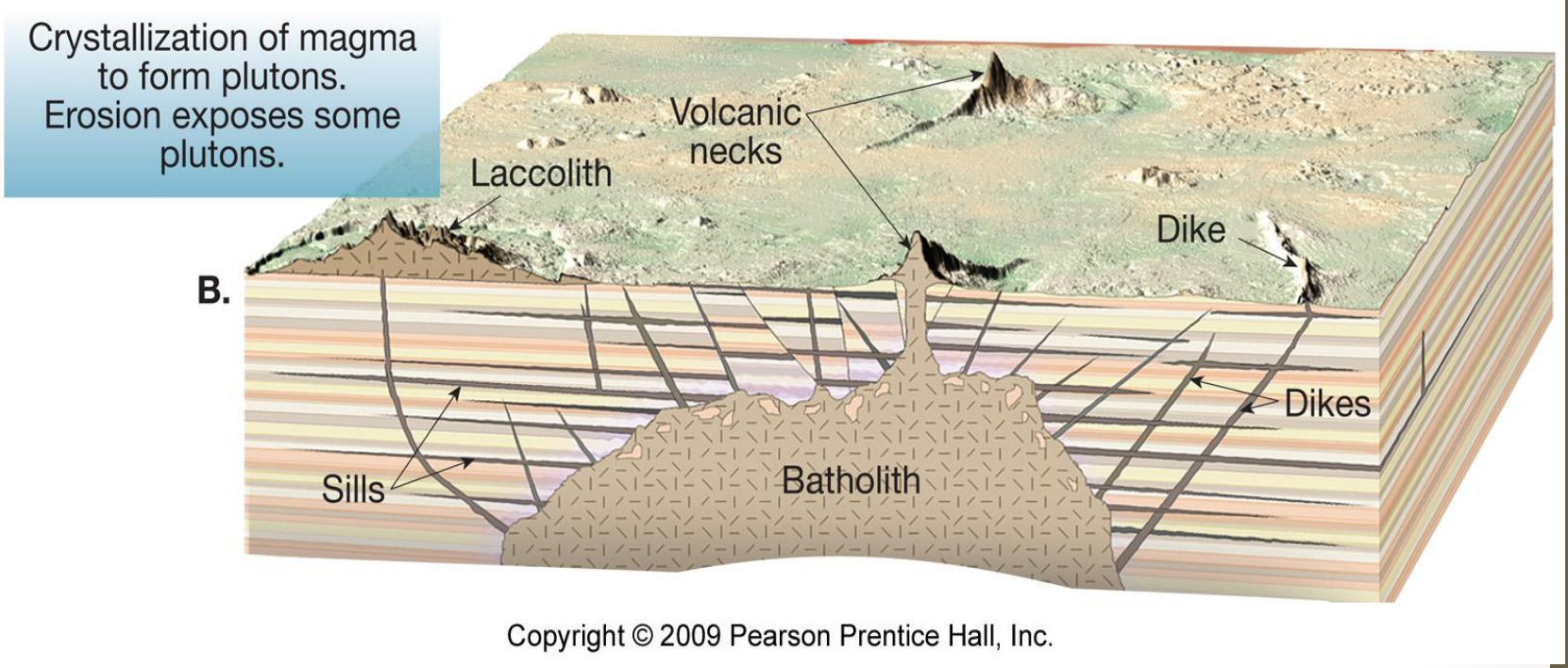
Intrusive igneous activity

- Plutons are classified according to
  - Orientation with respect to the host (surrounding) rock
    - Discordant – cuts across existing structures
    - Concordant – parallel to features such as sedimentary strata

Intrusive igneous activity

- Types of igneous intrusive features
  - Dike, a tabular, discordant pluton
  - Sill, a tabular, concordant pluton
    - e.g., Palisades Sill, NY
    - Resemble buried lava flows
    - May exhibit columnar joints
  - Laccolith
    - Similar to a sill

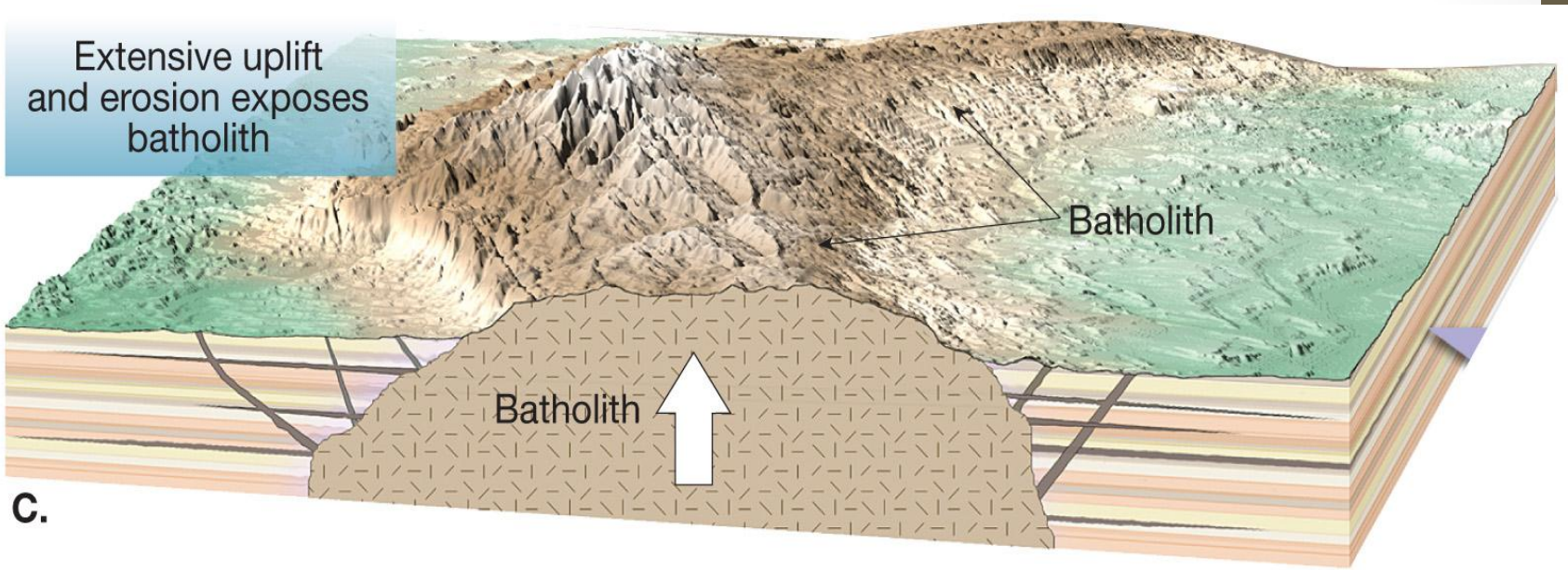
Intrusive igneous structures exposed by erosion



Intrusive igneous activity

- Types of igneous intrusive features
  - Laccolith
    - Lens-shaped mass
    - Arches overlying strata upward
  - Batholith
    - Largest intrusive body
    - Often occur in groups
    - Surface exposure 100+ square kilometers (smaller bodies are termed stocks)
    - Frequently form the cores of mountains

A batholith exposed by erosion



Origin of magma

- Magma originates when essentially solid rock, located in the crust and upper mantle, melts
- Factors that influence the generation of magma from solid rock
  - Role of heat
    - Earth's natural temperature increases with depth (geothermal gradient) is not sufficient to melt rock at the lower crust and upper mantle

Origin of magma

- Factors that influence the generation of magma from solid rock
  - Role of heat
    - Additional heat is generated by
      - Friction in subduction zones
      - Crustal rocks heated during subduction
      - Rising, hot mantle rocks

Origin of magma

- Factors that influence the generation of magma from solid rock
  - Role of pressure
    - Increase in confining pressure causes an increase in melting temperature
    - Drop in confining pressure can cause decompression melting
      - Lowers the melting temperature
      - Occurs when rock ascends

Origin of magma

- Factors that influence the generation of magma from solid rock
  - Role of volatiles
    - Primarily water
    - Cause rock to melt at a lower temperature
    - Play an important role in subducting ocean plates

Origin of magma

- Factors that influence the generation of magma from solid rock
  - Partial melting
    - Igneous rocks are mixtures of minerals
    - Melting occurs over a range of temperatures
    - Produces a magma with a higher silica content than the original rock

Plate tectonics and igneous activity

- Global distribution of igneous activity is not random
  - Most volcanoes are located on the margins of the ocean basins (intermediate, andesitic composition)
  - Second group is confined to the deep ocean basins (basaltic lavas)
  - Third group includes those found in the interiors of continents

Locations of some of Earth's major volcanoes

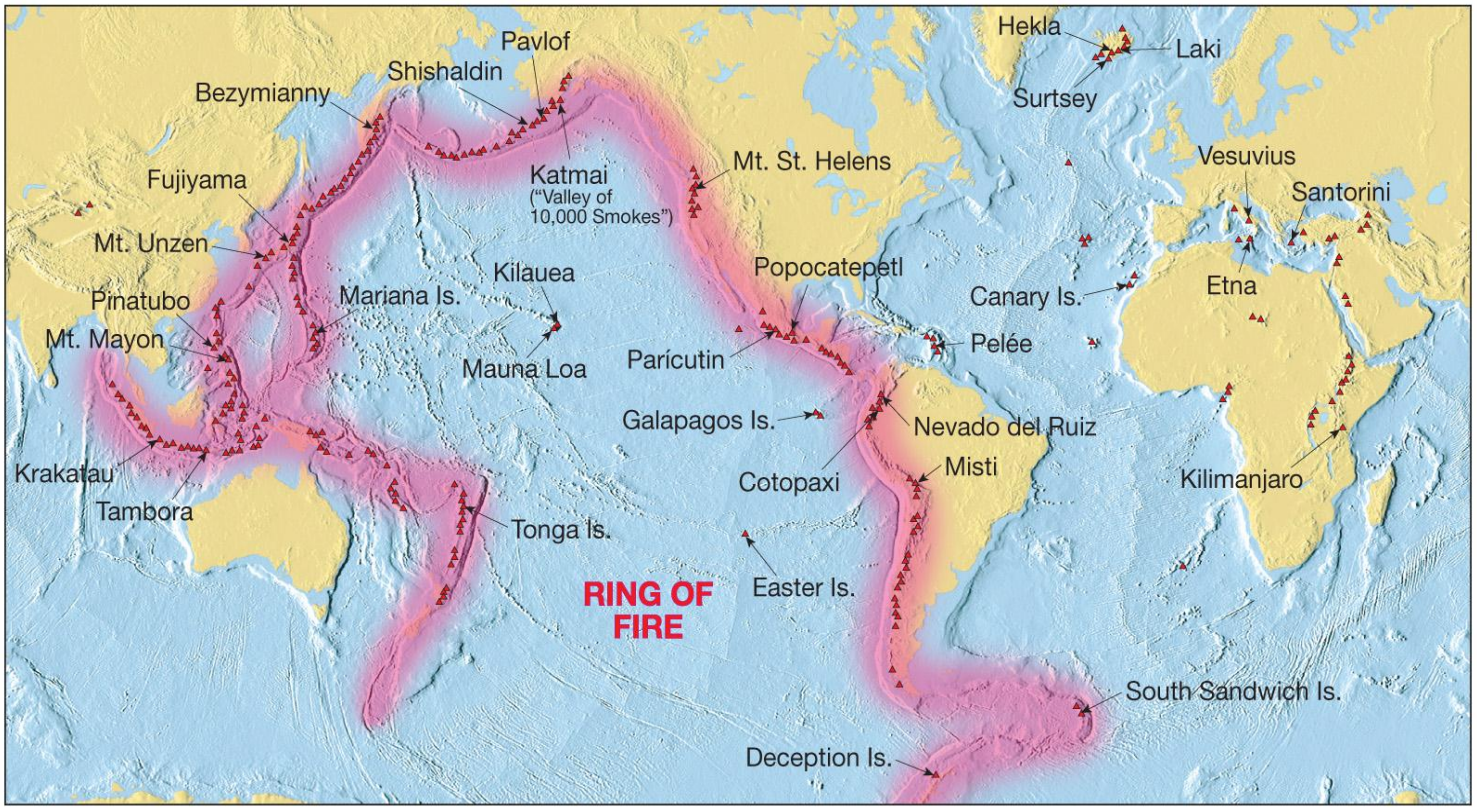


Plate tectonics and igneous activity

- Plate motions provide the mechanism by which mantle rocks melt to form magma
  - Convergent plate boundaries
    - Descending plate partially melts
    - Magma slowly rises upward
    - Rising magma can form
      - Volcanic island arcs in an ocean (Aleutian Islands)
      - Continental volcanic arcs (Andes Mountains)

Plate tectonics and igneous activity

- Plate motions provide the mechanism by which mantle rocks melt to form magma
  - Divergent plate boundaries
    - The greatest volume of volcanic rock is produced along the oceanic ridge system
      - Lithosphere pulls apart
      - Less pressure on underlying rocks
      - Partial melting occurs
      - Large quantities of fluid basaltic magma are produced

Plate tectonics and igneous activity

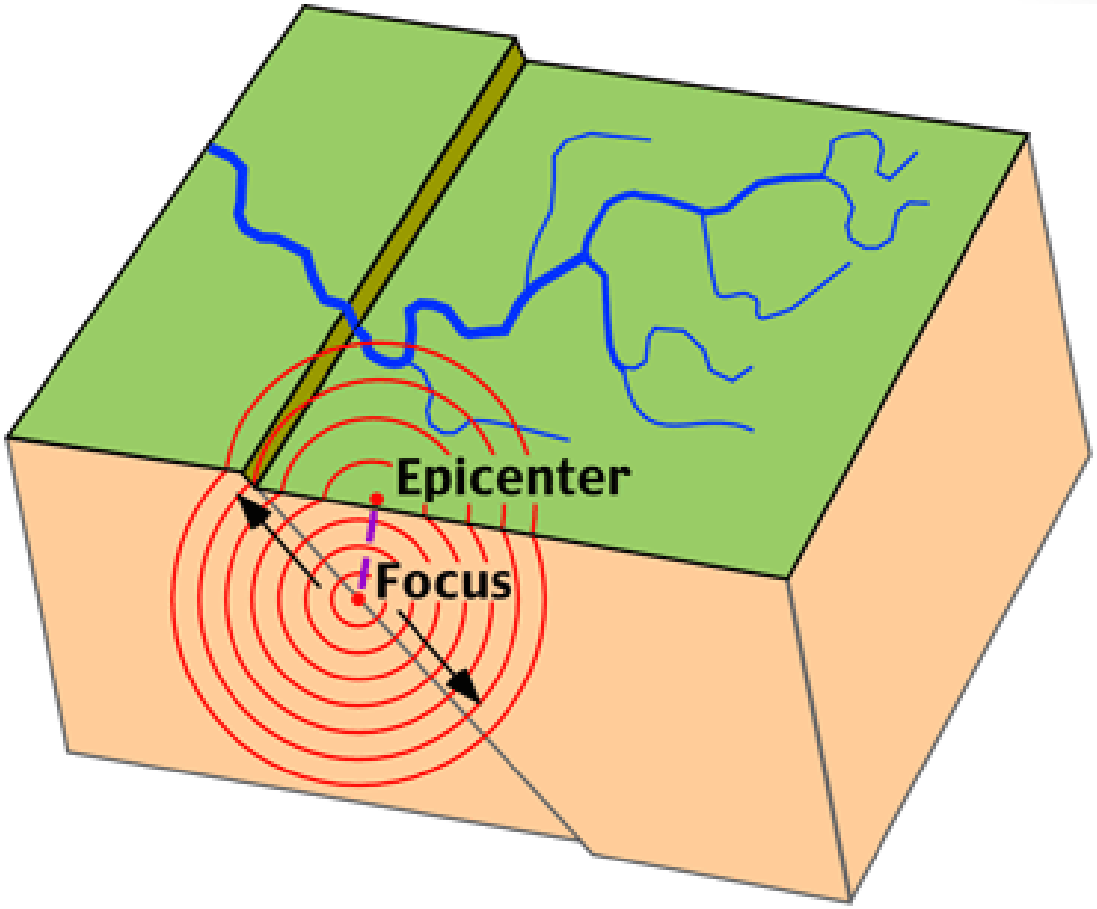
- Plate motions provide the mechanism by which mantle rocks melt to form magma
  - Intraplate igneous activity
    - Activity within a rigid plate
    - Plumes of hot mantle material rise
    - Form localized volcanic regions called hot spots
    - Examples include the Hawaiian Islands and the Columbia River Plateau in the northwestern United States

Earthquakes!!

Results of plate movements

Results of Plate Movements - Earthquakes

- An earthquake is a **sudden vibration or trembling** in the Earth.
- Earthquake motion is caused by the quick release of stored potential energy. Most earthquakes are produced along faults, **tectonic plate boundary zones, or along the mid-oceanic ridges**.
- At these areas, large masses of rock that are moving past each other can become locked due to friction. Friction is overcome when the accumulating stress has enough force to **cause a sudden slippage of the rock masses.**
- This produces shock waves called **Seismic waves** into the surrounding rocks.



- During an earthquake, motions are transmitted from the point of sudden energy release, **the earthquake focus**, as spherical **seismic waves** that travel in all directions outward.
- The point on the Earth's surface directly above the focus is termed the **epicenter.**
- Two different kinds of seismic waves exist: **P-waves (primary waves) and S-waves (secondary waves).**

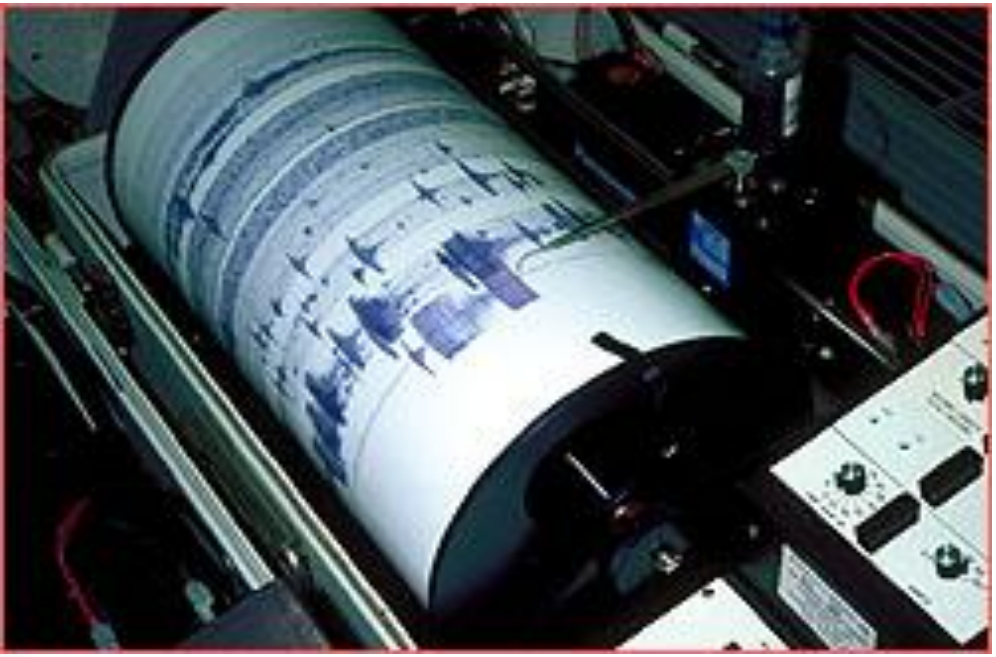
Measuring the Intensity of Seismic vibrations

- Earthquake waves are detected by an instrument called **Seismograph**

- The intensity of seismic vibrations is measured on an **0-9 scale** developed by **Charles F. Richter** called **Richter Scale**
- a) Magnitudes **3 - 4 minor quakes**,
- b) Magnitudes **5 - 6 moderate quakes**

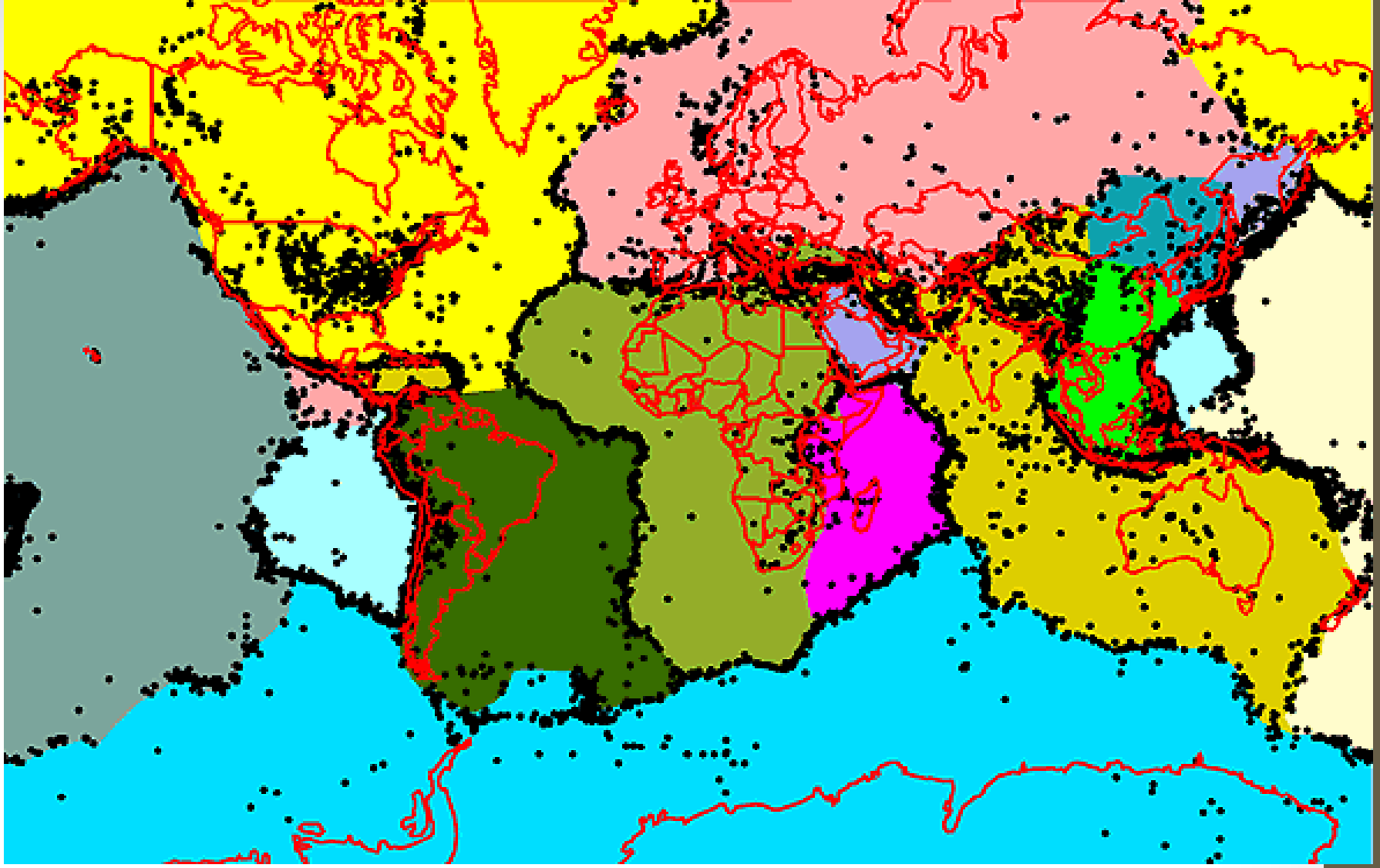
  c) Magnitudes **7 - 8 devastating quakes**

Seismograph: drum & record

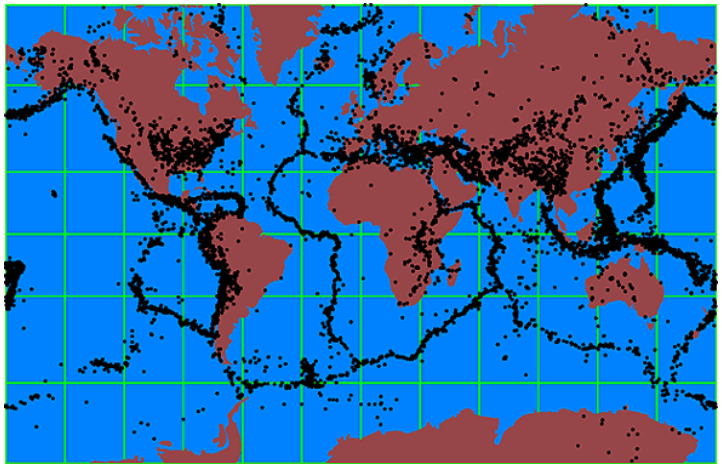


Earthquake Distribution

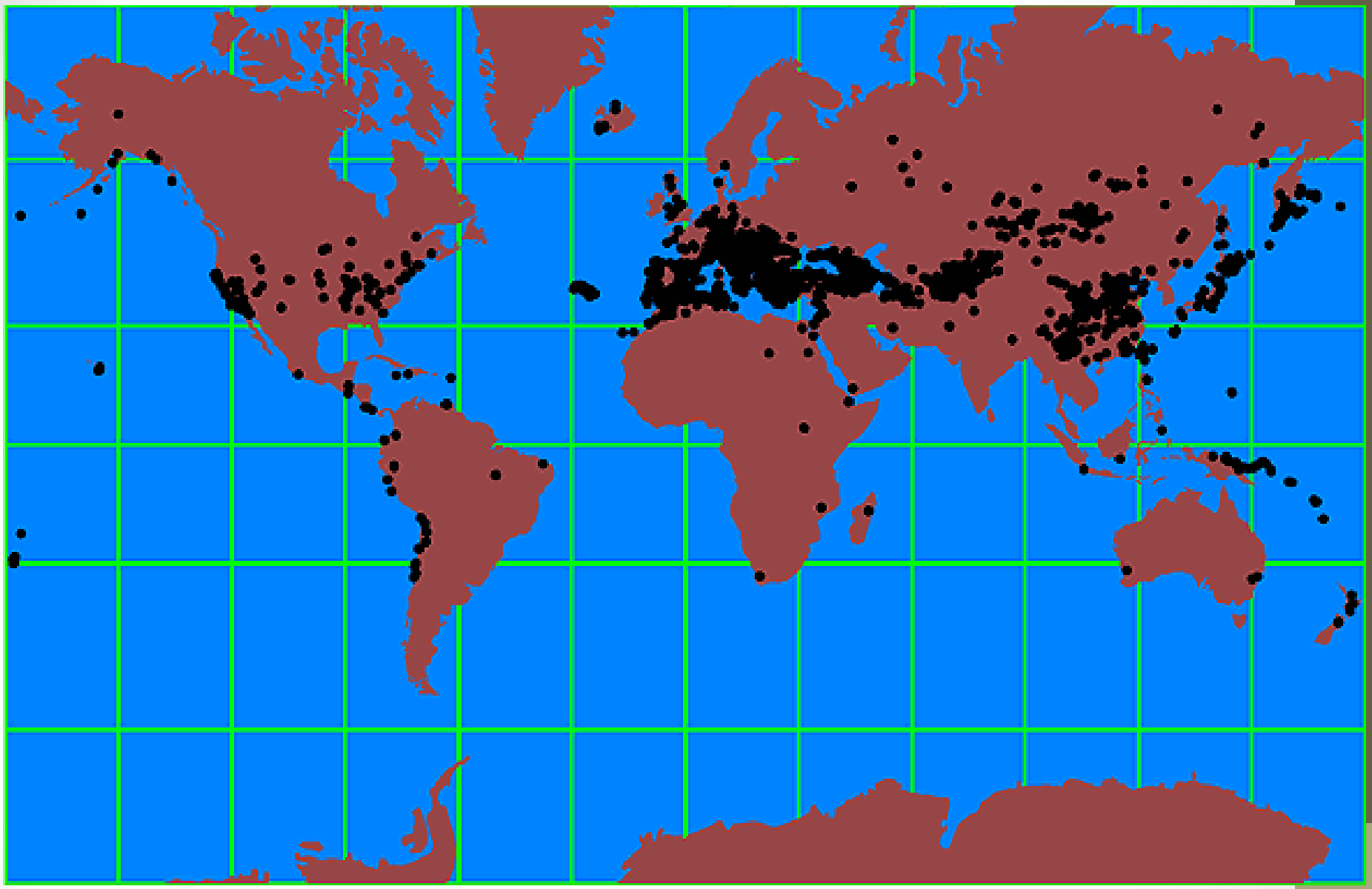
- 80% occur on the **Circumference of the Pacific Belt** (Pacific Plate and Nazca Plate – **"ring of fire")**
- Also **Trans-Eurasian Belt**
- Fewer still at **Mid-ocean ridges**
- Intraplate Earthquakes (very few and poorly understood)



Distribution of earthquakes with a magnitude less than **5.0**. Each tectonic plate has been given a unique color. This illustration indicates that the majority of small **earthquakes** occur along **plate boundaries**.

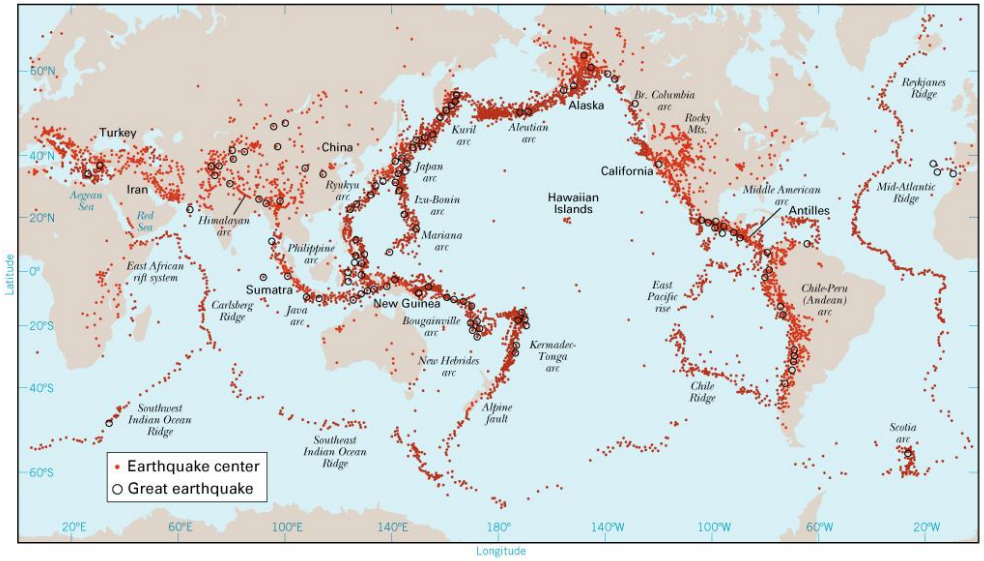


Distribution of earthquakes with a magnitude less than **5 on the Richter Scale**

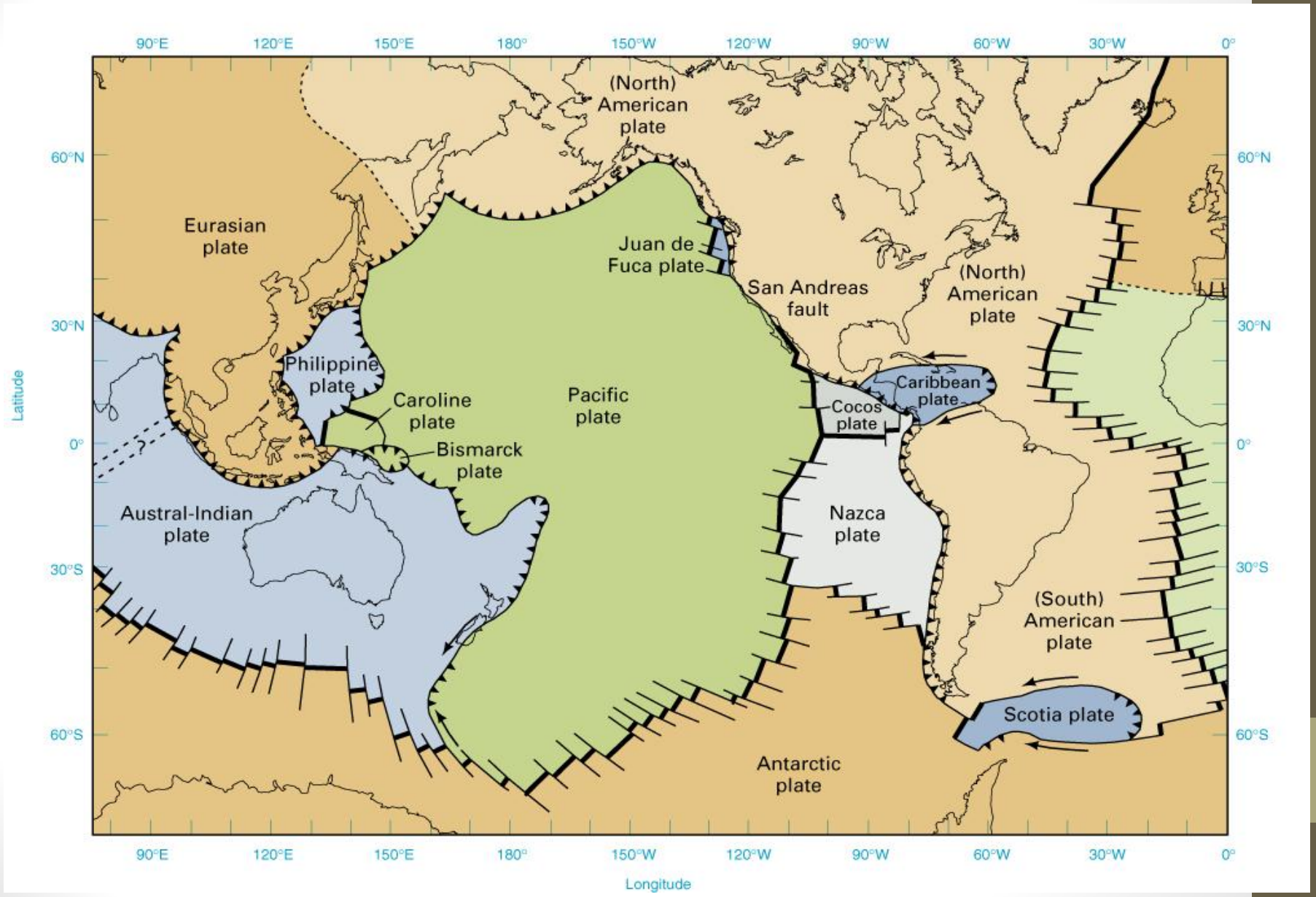


Distribution of earthquakes with a magnitude **greater than 7 on the Richter Scale**

Distribution of Earthquakes



Pacific Rim "The Ring of fire"



Earthquake Damage & Destruction

- Structurally **damaging buildings**, bridges and dwellings,
- Starting off **fires,**
- Causing strong tides called **tsunamis**
- Triggering **mass wasting** (slides, rock falls)
- Earthquakes can also take **human lives**

Tsunamis

- great sea wave generated by an earthquakes when the epicenter is located on the ocean floor
- Tsunamis displace a large mass of water which in turn creates a high open water wave with large horizontal dimensions, but little vertical height.
- Waves pile up (vertically) when they reach shallow coastal margins and **may reach a speed of 1000 km per hr** with reached heights in excess of 65 meters.

Earthquake Damage – Factors - 1

- **Time of day:** Higher losses of life tend to occur on weekdays between the hours of 9:00 AM to 4:00 PM. During this time of day many people are in large buildings because of work or school.
- **Magnitude of the earthquake:** and duration of the event. The longer the duration the more deadly.
- **Distance form the earthquake's focus:** The strength of the shock waves diminish with distance from the focus.
- **Geology of the affected area:** Some rock types transmit seismic wave energy more readily. Buildings on solid bedrock tend to receive less damage.

Earthquake Damage – Factors - 2

- **Type of soil:** Unconsolidated rock and soil sediments have a tendency to increase the amplitude and duration of the seismic waves increasing the potential for damage. Some soil types when saturated become liquefied.

- **Type of building construction**: Some building materials and designs are more susceptible to earthquake damage.

- **Population density**: More people often means greater chance of injury and death.

A view of a parking lot on the campus of California State University. Columns of reinforced concrete failed after the 1994 Northridge earthquake (**Source:** National Geophysical Data Center

The following image looks at downtown Kobi, Japan at about noon on the day of the 1995 earthquake. Many areas of downtown Kobi were **on fire** and there was no water pressure to put out the flames. (**Source:** **National Geophysical Data Center**, *NOAA*).

The Guatemala earthquake of February 4, 1976 had a magnitude of 7.5. This earthquake killed about 23,000 people, injured 76,000, and caused a number of **landslides**. Source: **National Geophysical Data Center**, *NOAA*).

The earthquake of March 27, 1964, in the Gulf of Alaska generated a **tsunami**. This photo shows a beached fishing boat that was carried landward by the tsunami wave. (**Source:** Image provided by the **National Geophysical Data Center**, *NOAA*).

Earthquake of June 16, 1964 in Niigata, Japan had a magnitude of 7.4. **Liquefaction of some soils** in the area caused large apartment buildings to tip over on their sides. (**Source:** **National Geophysical Data Center**, *NOAA*).

Plate Tectonics

Theory of Plate Tectonics

Plate Tectonics

Plate Boundaries

Causes of Plate Tectonics

What is Plate Tectonics

- The Earth's crust and upper mantle are broken into sections called plates
- Plates move around on top of the mantle like rafts


North American
Eurasian
Eurasian
Juan de Fuca
Philippine
Caribbean
Cocos
African
Arabian
Nazca
Australian
Pacific
South American
Scotia
Antartica
Tectonic Plate Boundary Types:
Extensional
Compressional
Transform (sliding) or Undefined

What is the Lithosphere?

- The crust and part of the upper mantle = lithosphere
  - 100 km thick
  - Less dense than the material below it so it “floats”

What is the Asthenoshere?

- The plastic layer below the lithosphere = asthenosphere
- The plates of the lithosphere float on the asthenosphere

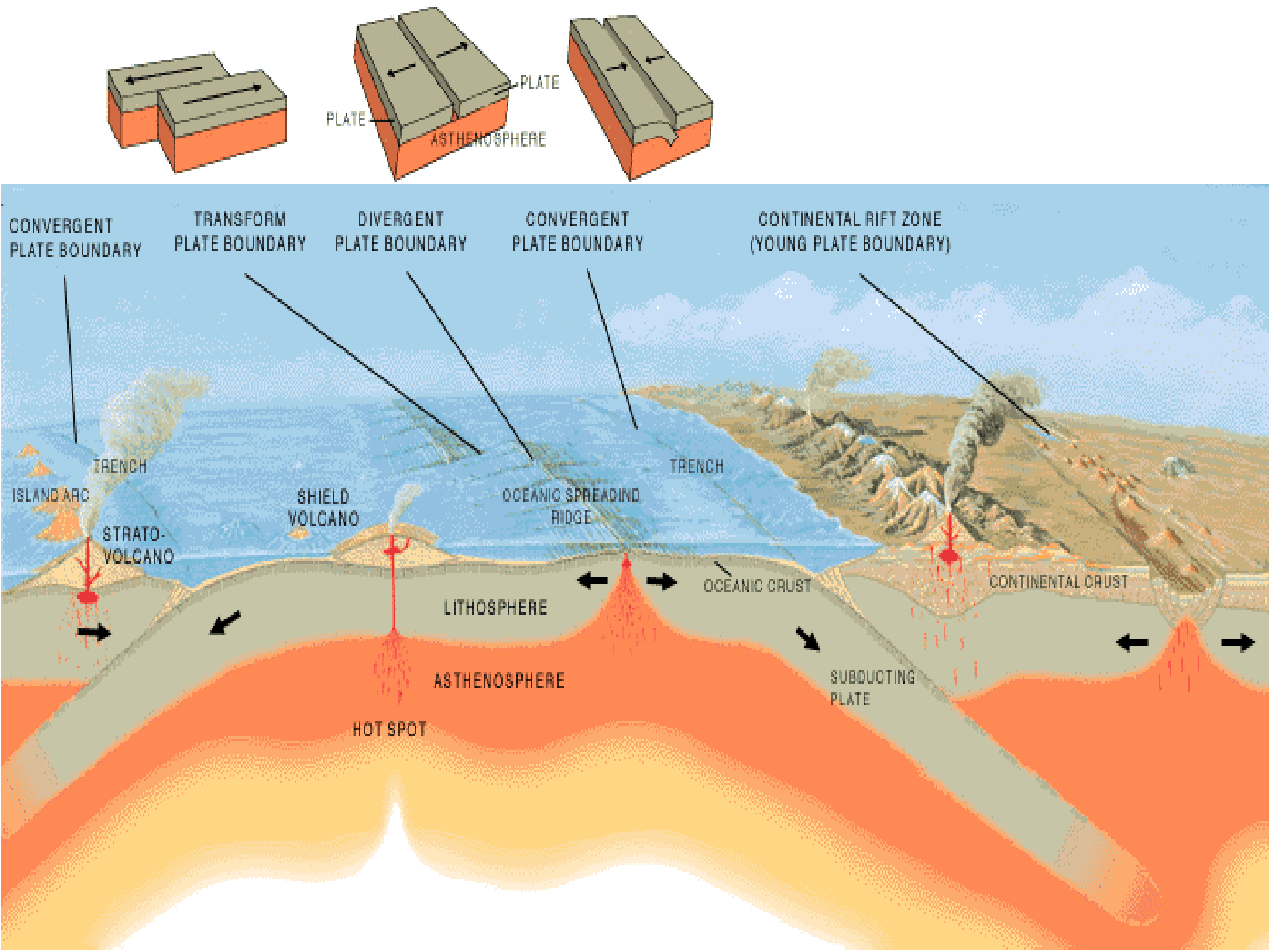


PLATE
PLATE
ASTHENOSPHERE
CONVERGENT PLATE BOUNDARY
TRANSFORM PLATE BOUNDARY
DIVERGENT PLATE BOUNDARY
CONVERGENT PLATE BOUNDARY
CONTINENTAL RIFT ZONE (YOUNG PLATE BOUNDARY)
TRENCH
ISLAND ARC
STRATO-VOLCANO
SHIELD VOLCANO
OCEANIC SPREADING RIDGE
TRENCH
OCEANIC CRUST
CONTINENTAL CRUST
LITHOSPHERE
ASTHENOSPHERE
SUBDUCTING PLATE
HOT SPOT

2 Types of Plates

- Ocean plates - plates below the oceans
- Continental plates - plates below the continents

Plate Boundaries

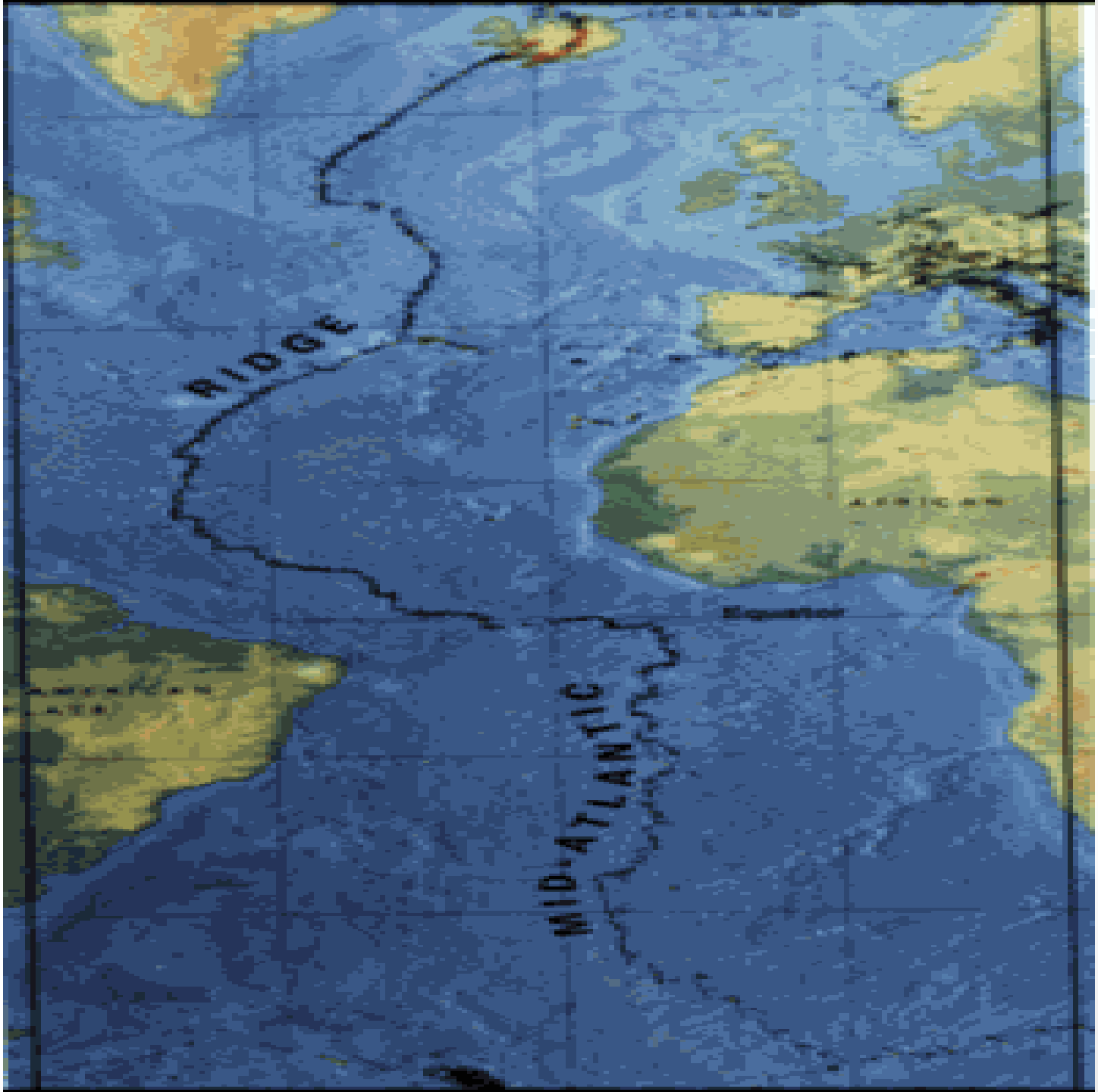
Divergent Boundaries

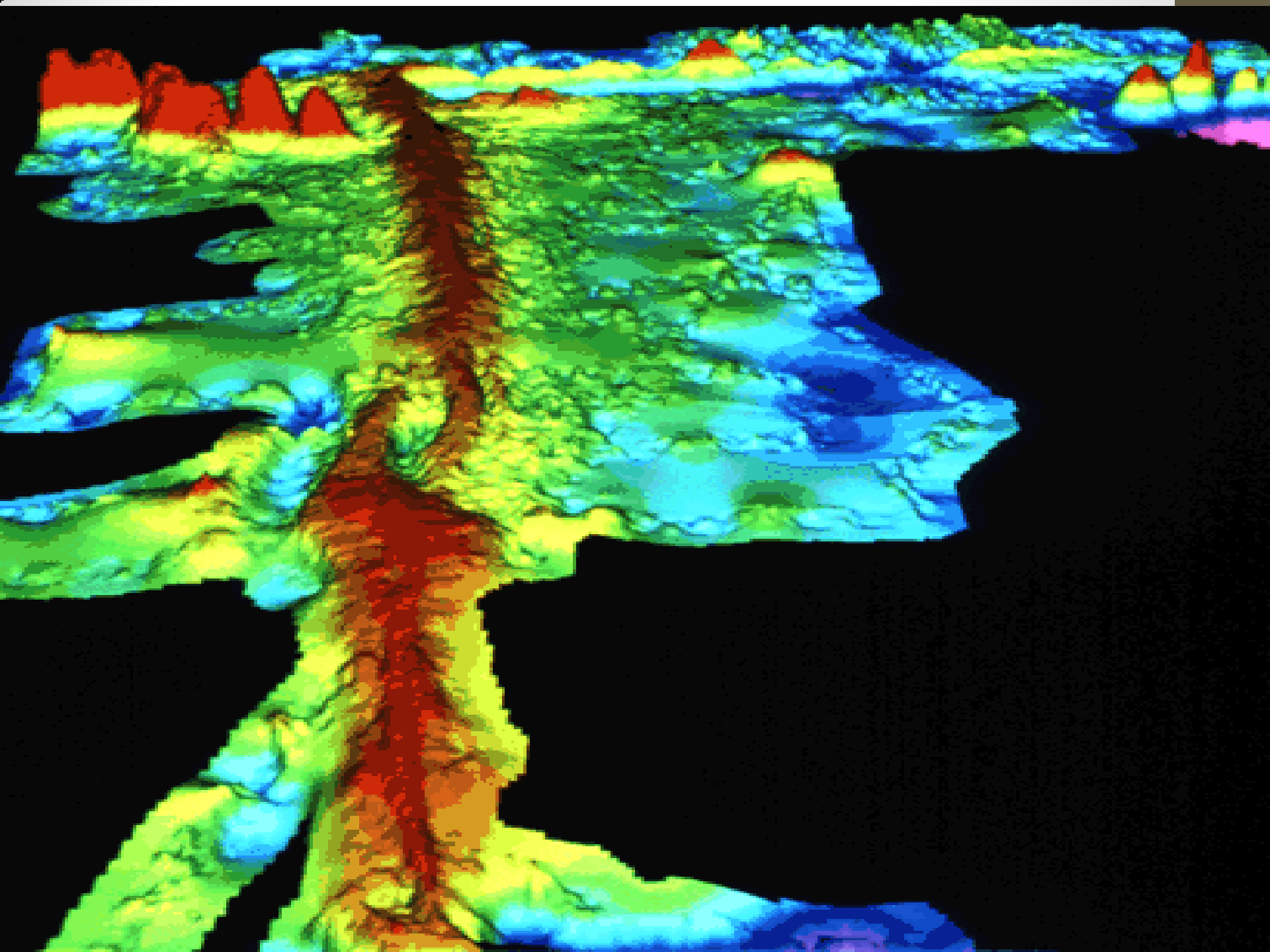
- Boundary between two plates that are moving apart or rifting

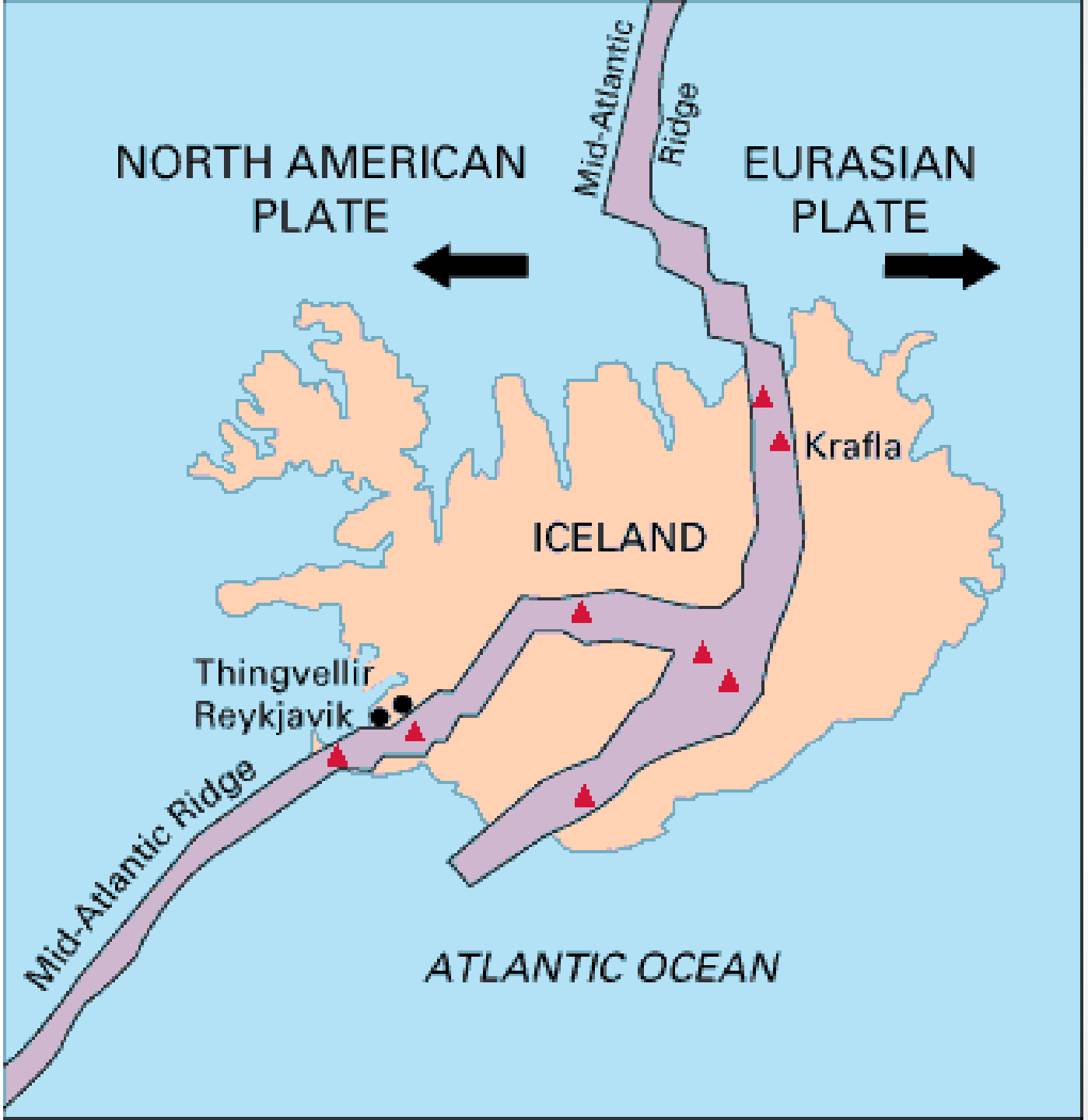
- RIFTING causes SEAFLOOR SPREADING

Features of Divergent Boundaries

- Mid-ocean ridges
- rift valleys
- fissure volcanoes


RIDGE
MID-ATLANTIC




NORTH AMERICAN PLATE
Mid-Atlantic Ridge
EURASIAN PLATE
Krafla
ICELAND
Thingvellir
Reykjavik
Mid-Atlantic Ridge
ATLANTIC OCEAN

Convergent Boundaries

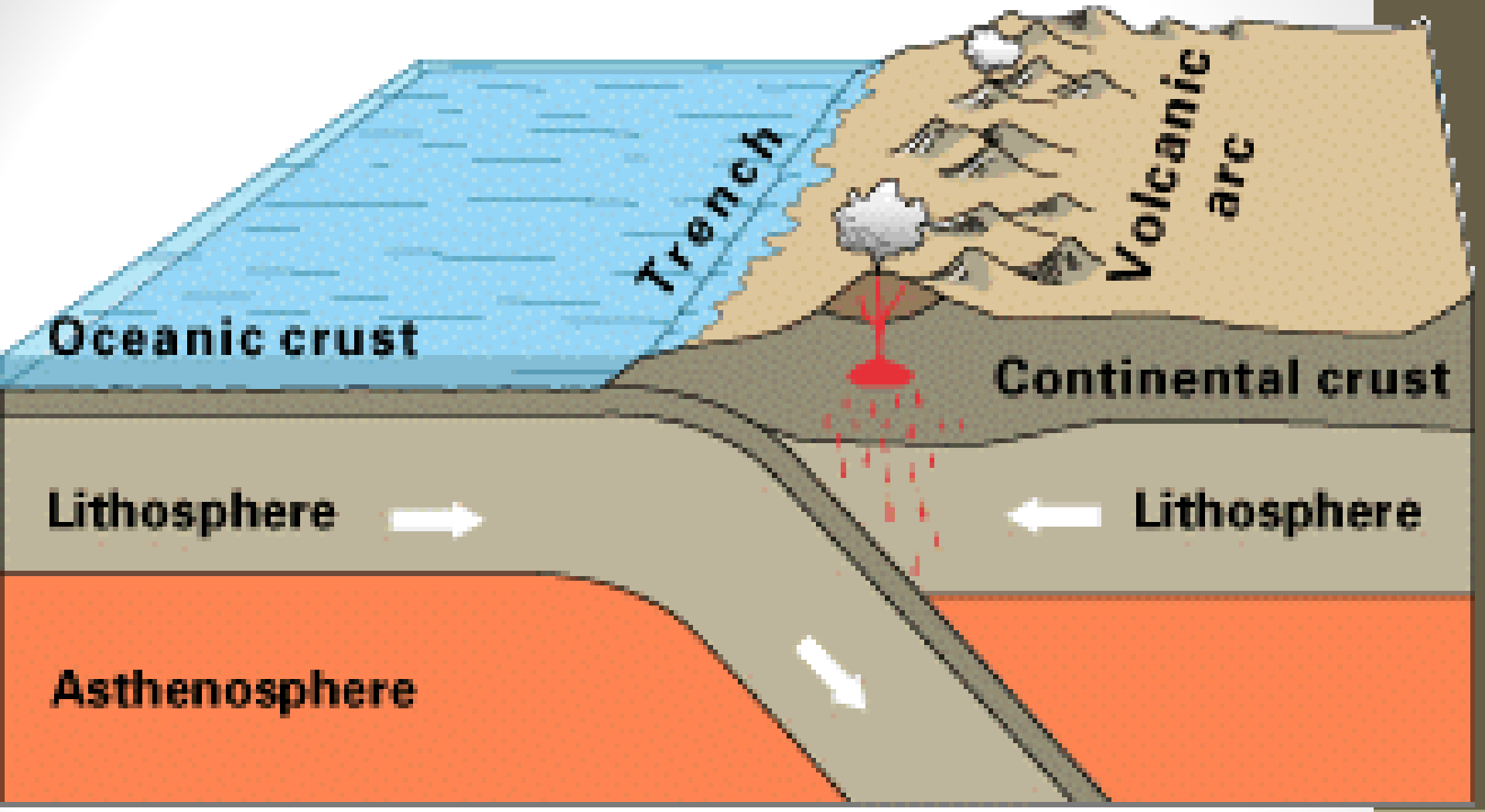
- Boundaries between two plates that are colliding

→ ←

- There are 3 types…

Type 1

- Ocean plate colliding with a less dense continental plate
- Subduction Zone: where the less dense plate slides under the more dense plate
- VOLCANOES occur at subduction zones

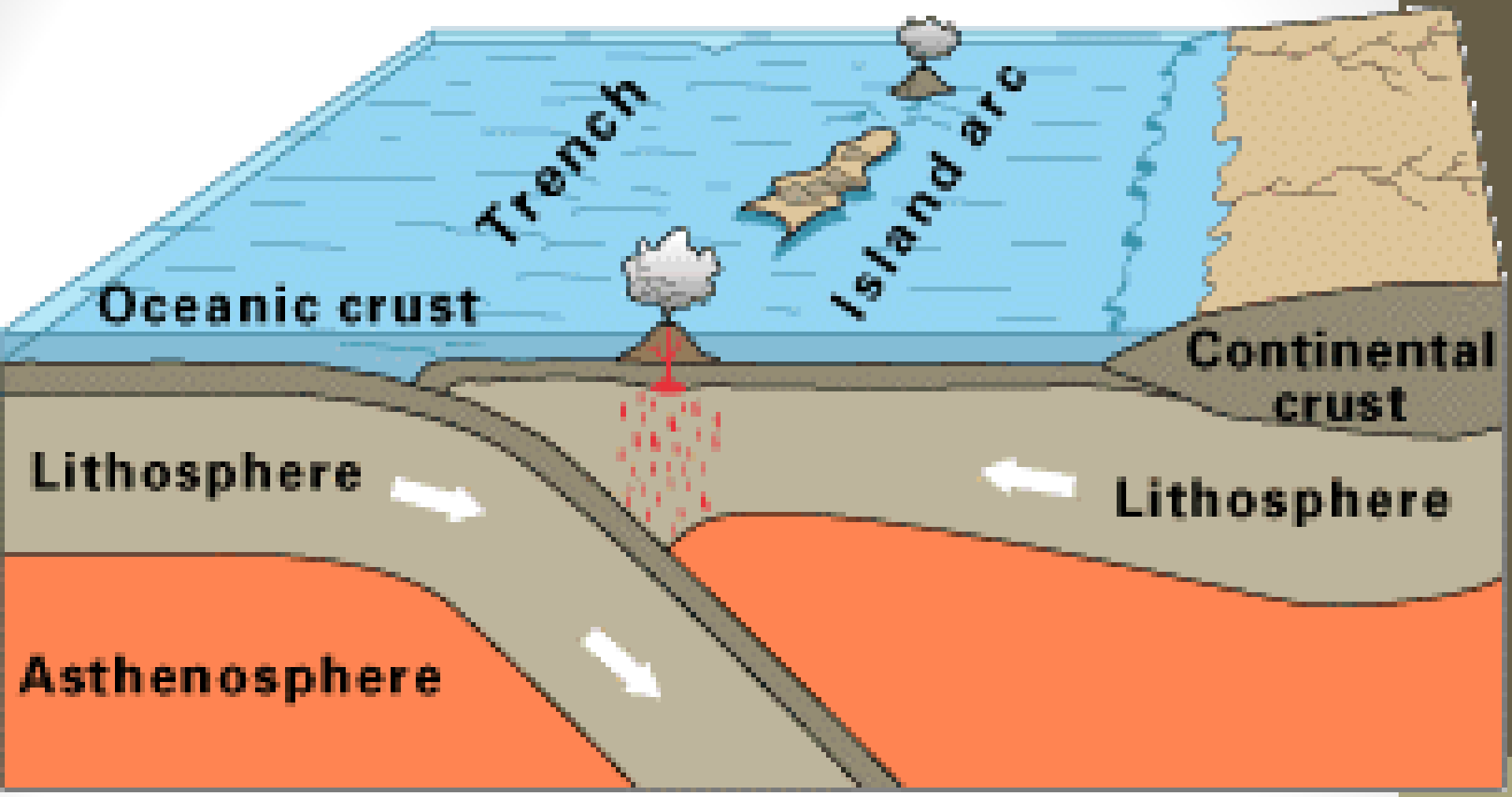


Oceanic-continental convergence

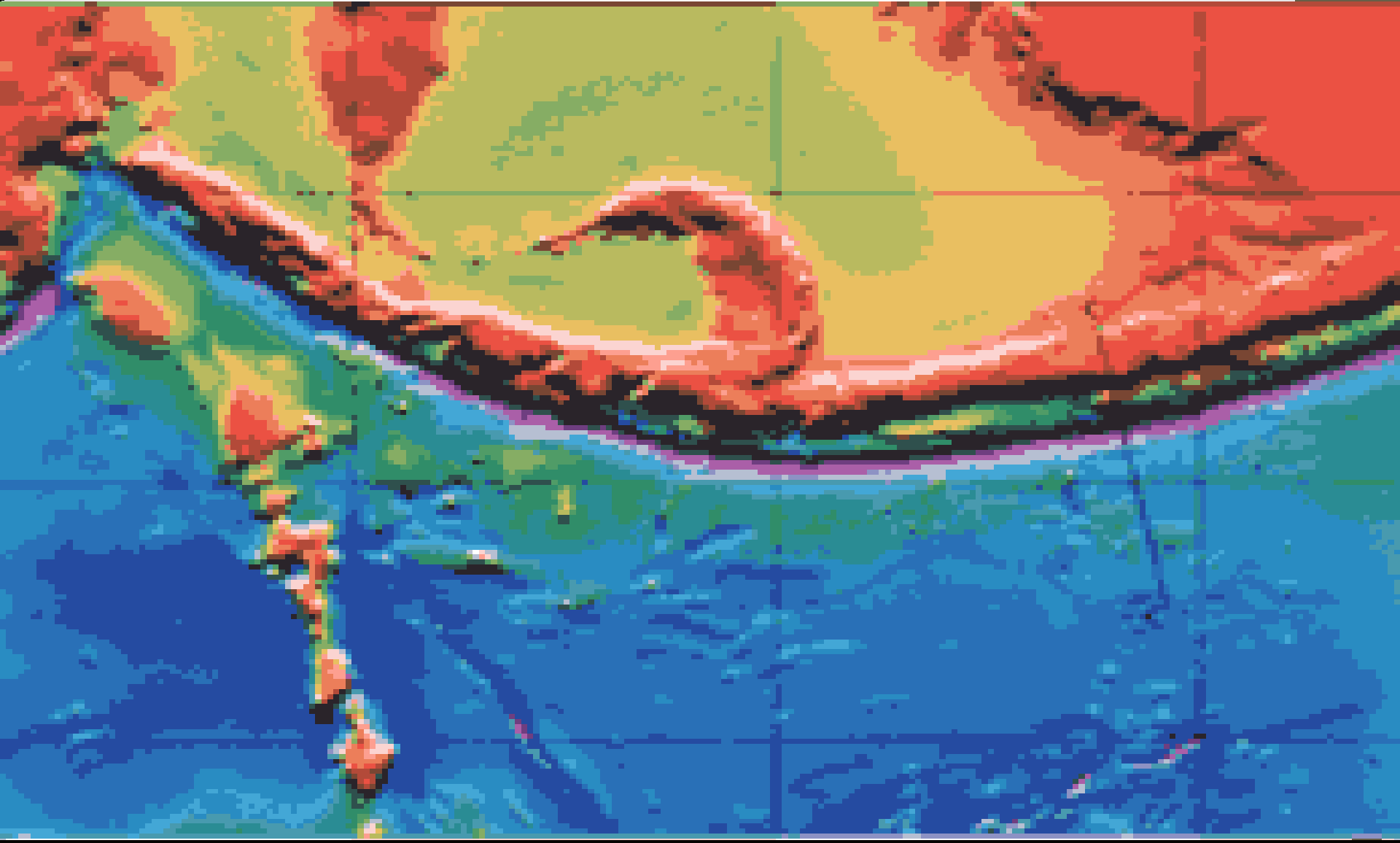
Andes Mountains, South America

Type 2

- Ocean plate colliding with another ocean plate
- The less dense plate slides under the more dense plate creating a subduction zone called a TRENCH



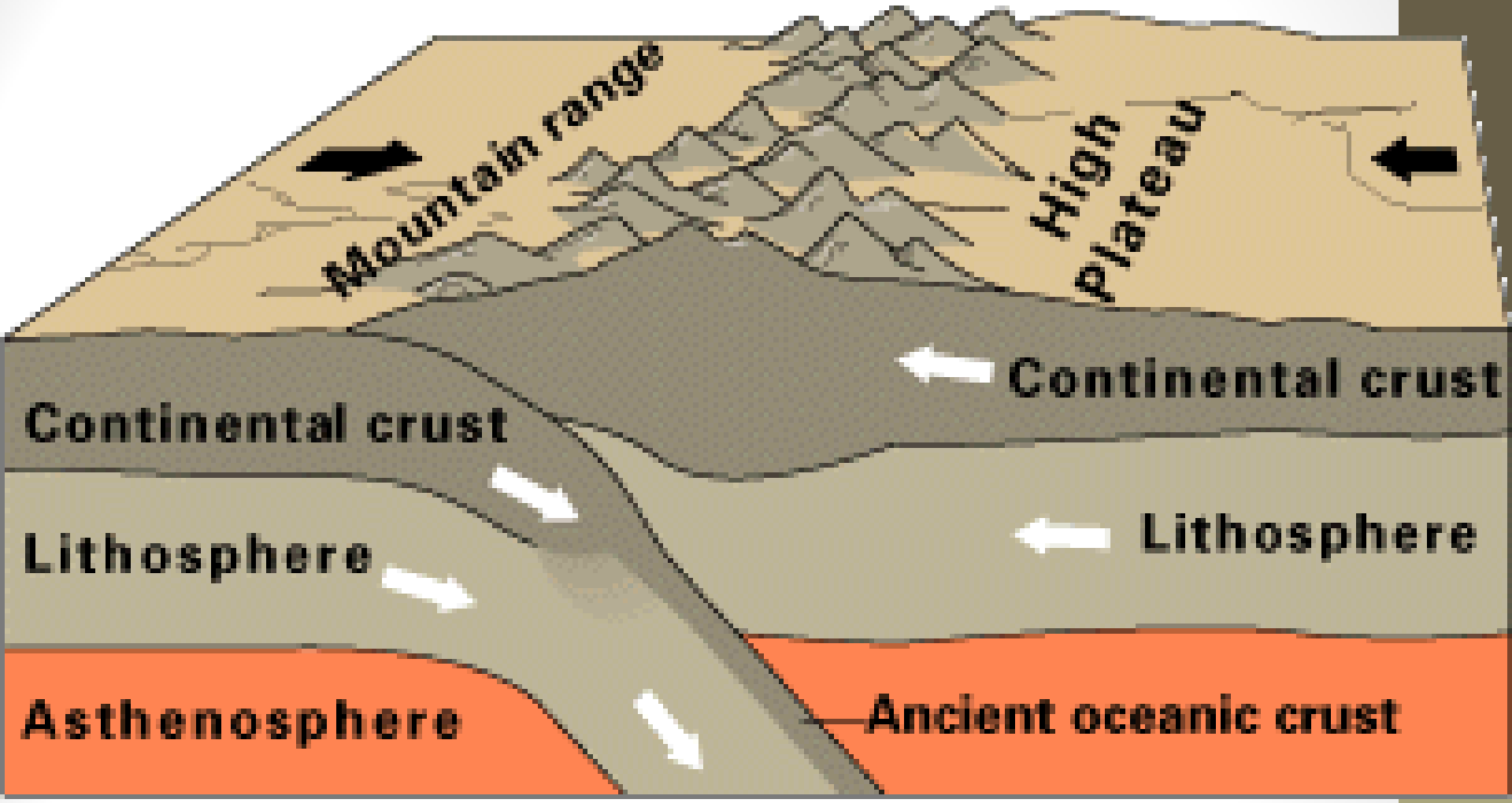
Oceanic-oceanic convergence



Aleutian Islands, Alaska

Type 3

- A continental plate colliding with another continental plate
- Have Collision Zones:
  - a place where folded and thrust faulted mountains form.

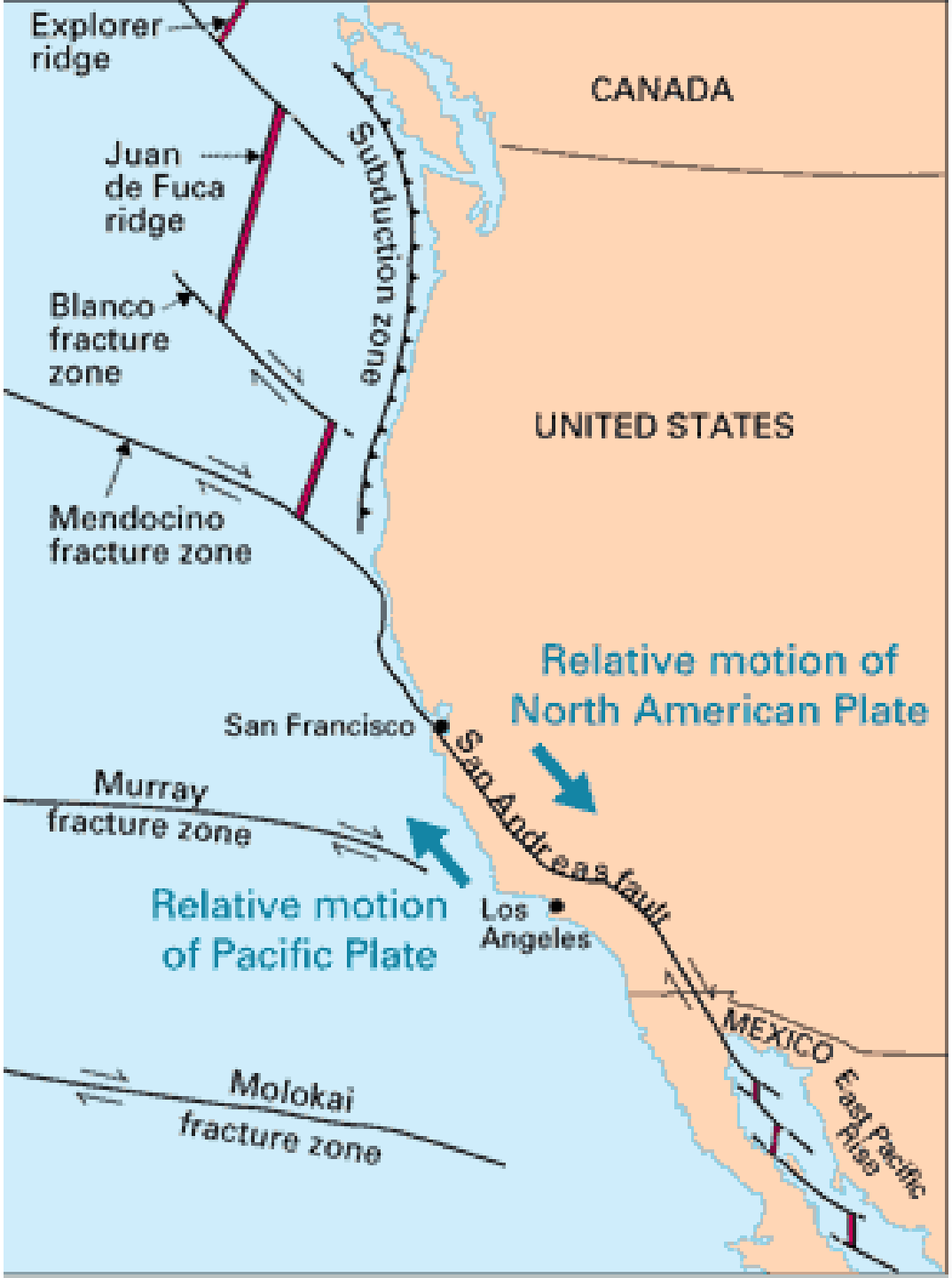


Continental-continental convergence


EURASIAN
PLATE
Tibetan
Plateau
Himalayas
Ganges Plain
Mt. Everest
INDIAN
PLATE
INDIAN OCEAN

Transform Fault Boundaries

- Boundary between two plates that are sliding past each other
- EARTHQUAKES along faults


Explorer ridge
Juan de Fuca ridge
Blanco fracture zone
Mendocino fracture zone
Subduction zone
CANADA
UNITED STATES
Relative motion of North American Plate
San Francisco
San Andreas fault
Murray fracture zone
Relative motion of Pacific Plate
Los Angeles
MEXICO
East Pacific Rise
Molokai fracture zone

San Andreas Fault, CA

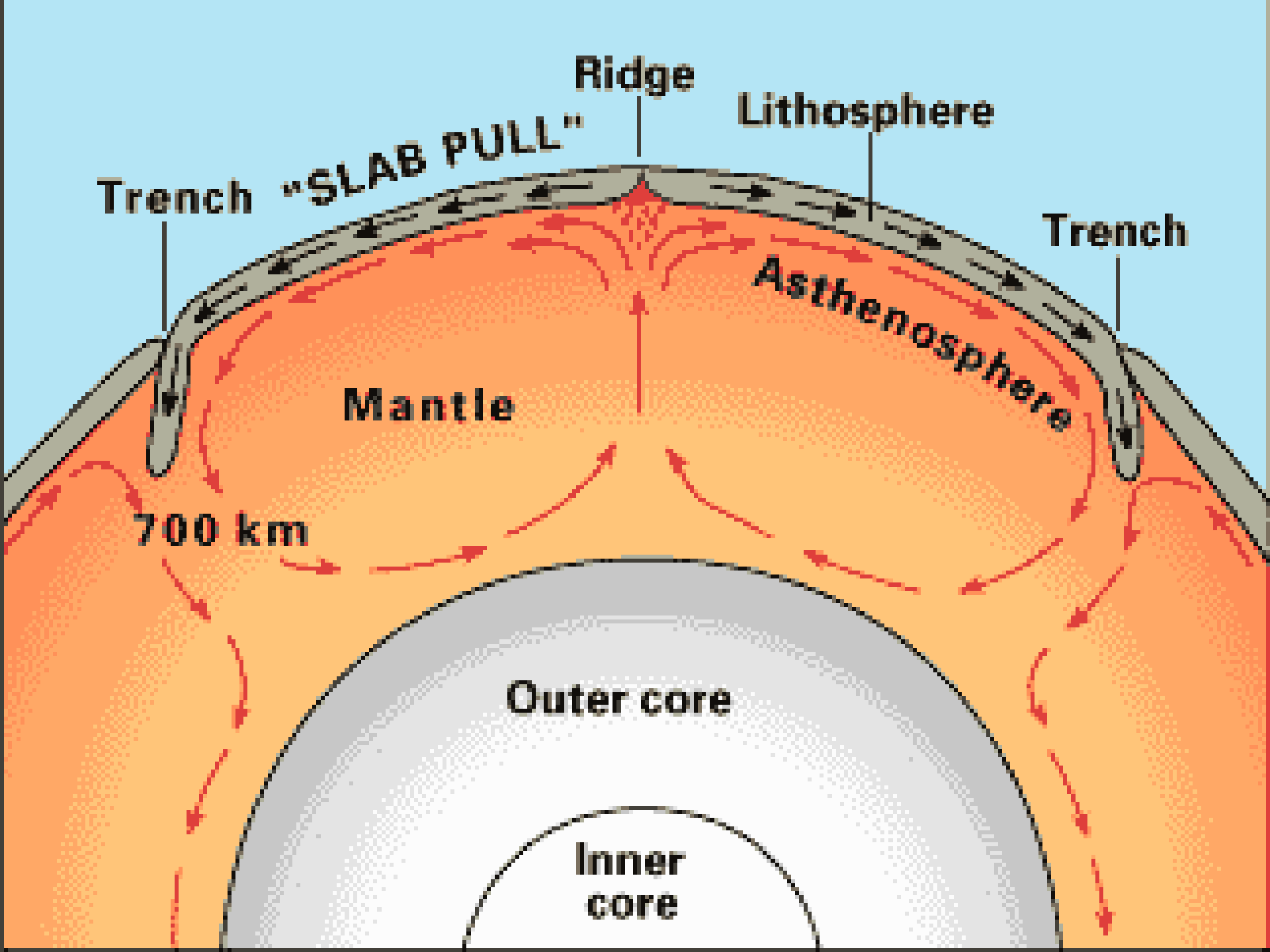
Questions…

- What are the three types of boundaries?
- What direction do plates go for each?
- Which boundary has a subduction zone…what occurs at a subduction zone?

Causes of Plate Tectonics

Convection Currents

- Hot magma in the Earth moves toward the surface, cools, then sinks again.
- Creates convection currents beneath the plates that cause the plates to move.


Ridge
Lithosphere
Trench
"SLAB PULL"
Trench
Asthenosphere
Mantle
700 km
Outer core
Inner
core