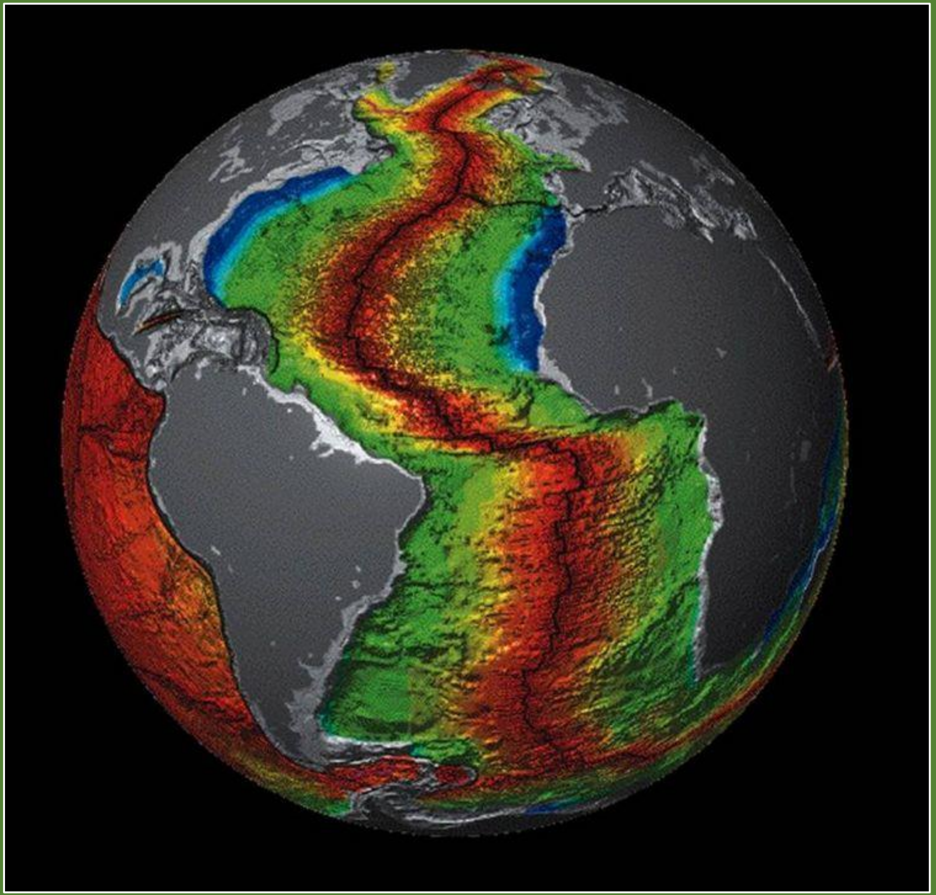
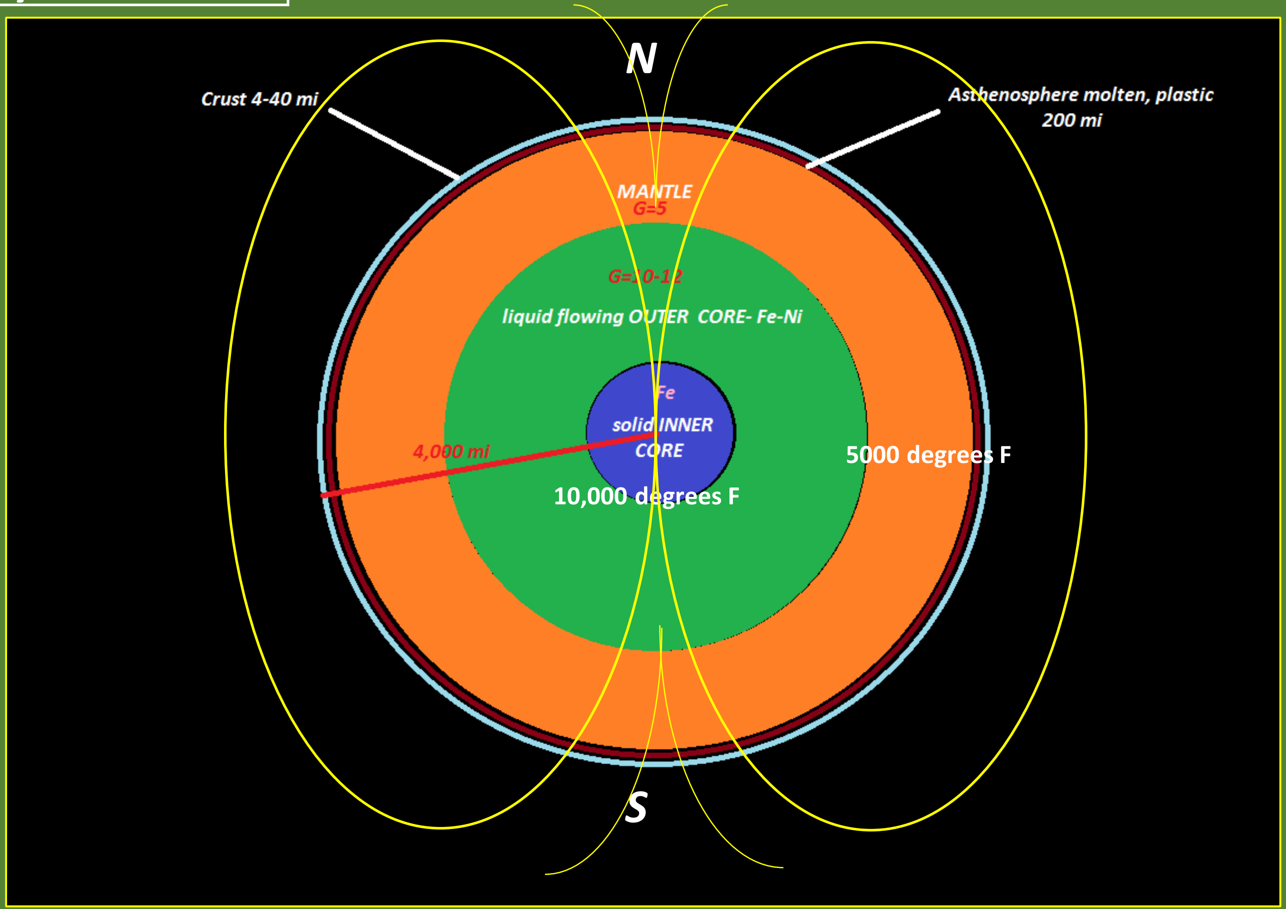
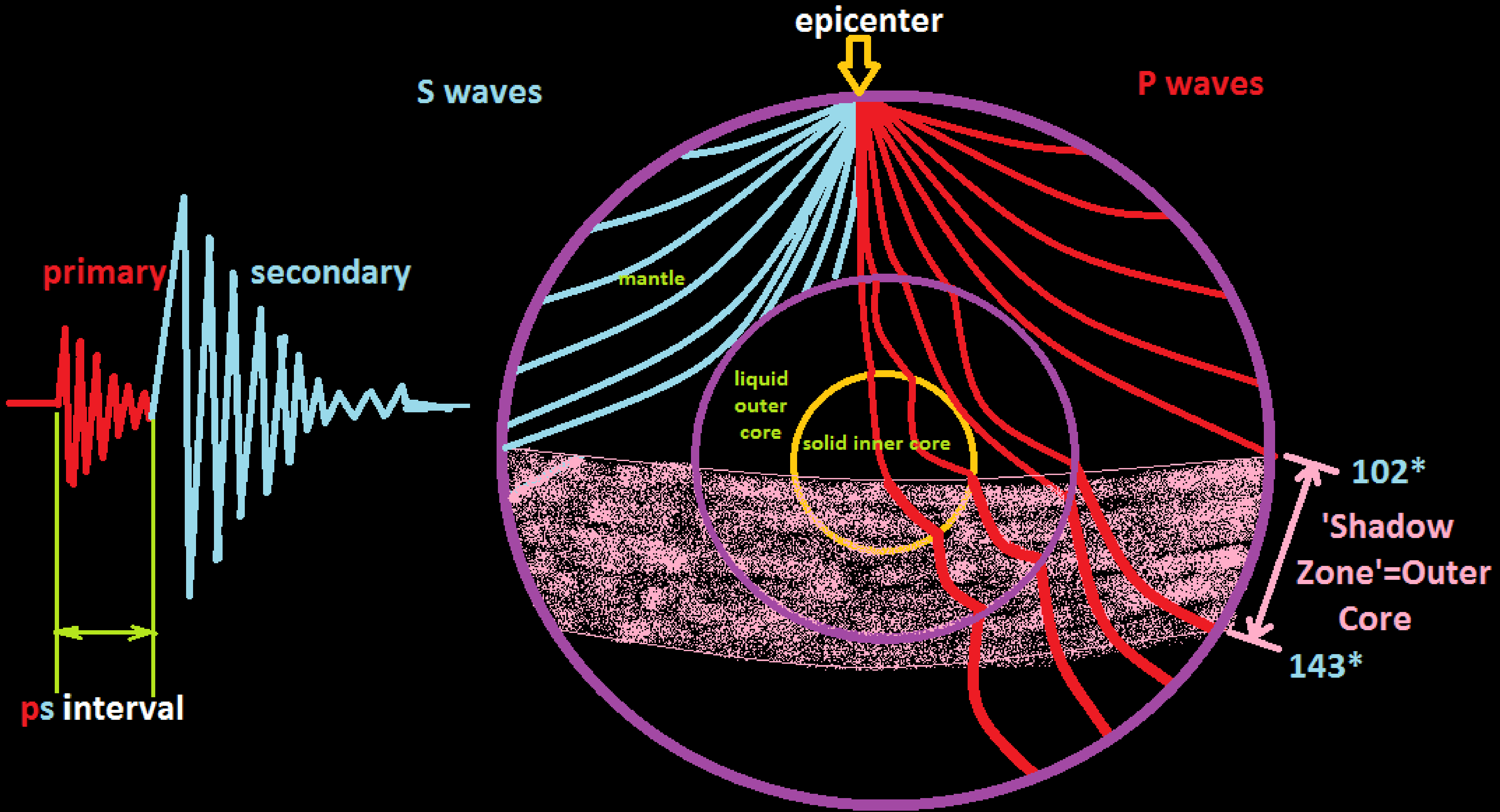
Introduction
To Minerals and Rocks

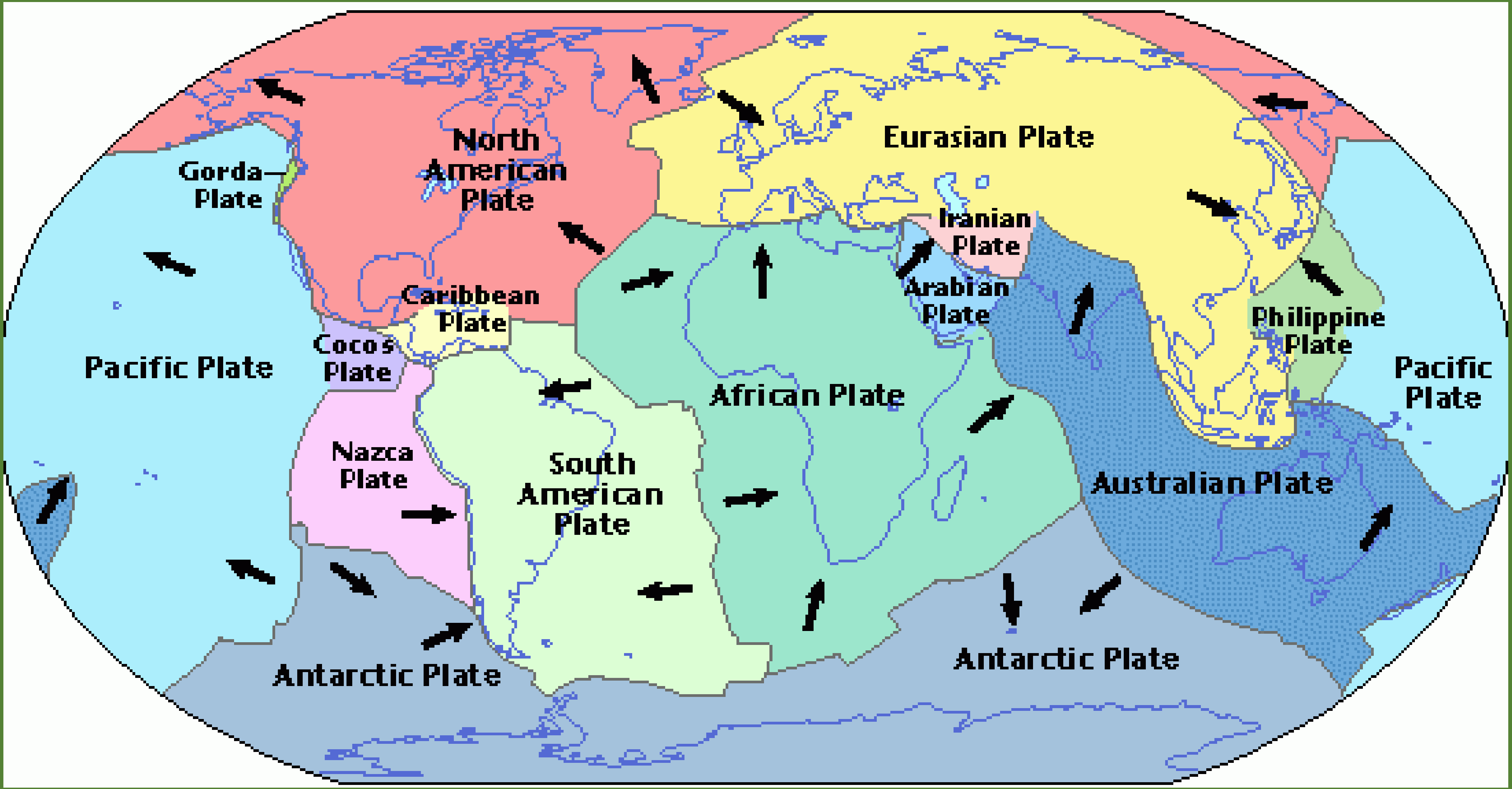
The story in the rocks



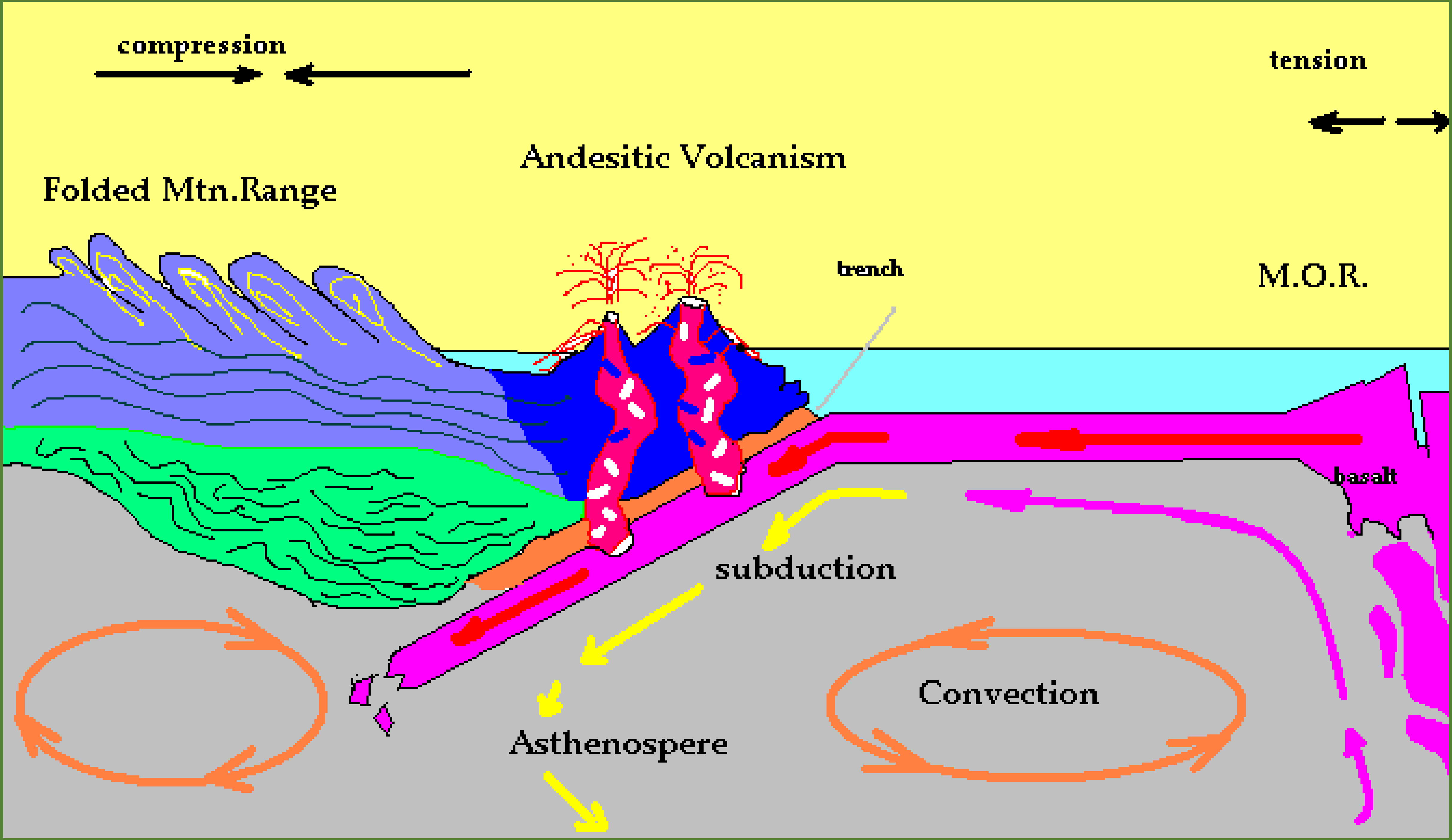




Earthquake waves tell us about the interior of the earth, like a 'cat'-scan of the body



https://www.youtube.com/watch?v=UwWWuttntio


compression
tension
Andesitic Volcanism
Folded Mtn.Range
trench
M.O.R.
basalt
subduction
Convection
Asthenospere


USGS


Geologic Map of the State of Florida
by Thomas M. Scott, P. G. #99, Kenneth M. Campbell, Frank R. Rupert, Jonathan D. Arthur,
Thomas M. Missimer, Jacqueline M. Lloyd, J. William Yon, and Joel G. Duncan
20 0 20 40 60 80 Miles
20 0 20 40 60 80 Kilometers
Scale 1:750,000
Albers Conic Equal-Area Projection
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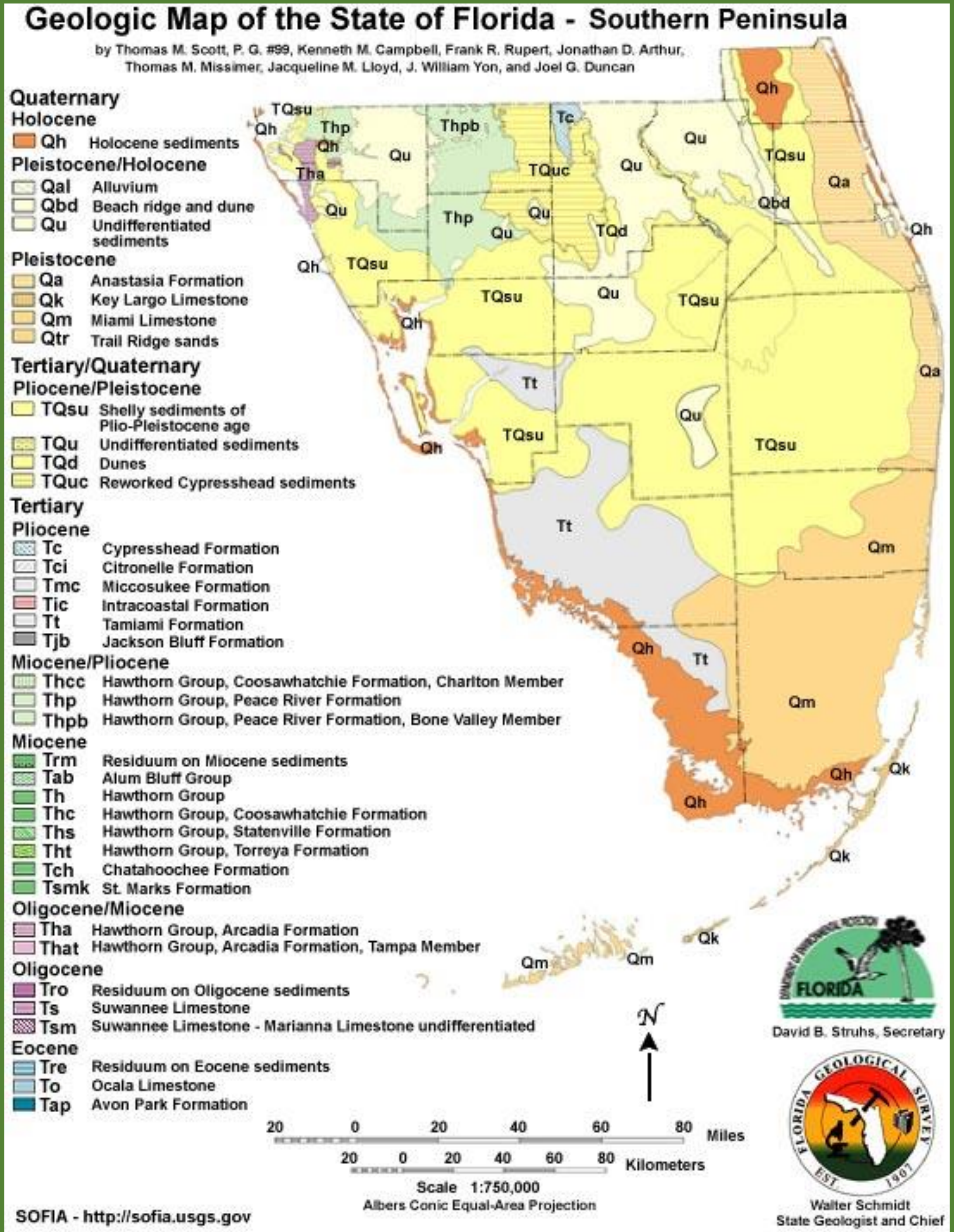
Walter Schmidt
State Geologist and Chief
FLORIDA
David B. Struhs, Secretary
SOFIA - http://sofia.usgs.gov


Geologic Map of the State of Florida - Southern Peninsula
by Thomas M. Scott, P. G. #99, Kenneth M. Campbell, Frank R. Rupert, Jonathan D. Arthur,
Thomas M. Missimer, Jacqueline M. Lloyd, J. William Yon, and Joel G. Duncan
Quaternary
Holocene
Qh Holocene sediments
Pleistocene/Holocene
Qal Alluvium
Qbd Beach ridge and dune
Qu Undifferentiated sediments
Pleistocene
Qa Anastasia Formation
Qk Key Largo Limestone
Qm Miami Limestone
Qtr Trail Ridge sands
Tertiary/Quaternary
Pliocene/Pleistocene
TQsu Shelly sediments of Plio-Pleistocene age
TQu Undifferentiated sediments
TQd Dunes
TQuc Reworked Cypresshead sediments
Tertiary
Pliocene
Tc Cypresshead Formation
Tci Citronelle Formation
Tmc Miccosukee Formation
Tic Intracoastal Formation
Tt Tamiami Formation
Tjb Jackson Bluff Formation
Miocene/Pliocene
Thcc Hawthorn Group, Coosawhatchie Formation, Charlton Member
Thp Hawthorn Group, Peace River Formation
Thpb Hawthorn Group, Peace River Formation, Bone Valley Member
Miocene
Trm Residuum on Miocene sediments
Tab Alum Bluff Group
Th Hawthorn Group
Thc Hawthorn Group, Coosawhatchie Formation
Ths Hawthorn Group, Statenville Formation
Tht Hawthorn Group, Torreya Formation
Tch Chatahoochee Formation
Tsmk St. Marks Formation
Oligocene/Miocene
Tha Hawthorn Group, Arcadia Formation
That Hawthorn Group, Arcadia Formation, Tampa Member
Oligocene
Tro Residuum on Oligocene sediments
Ts Suwannee Limestone
Tsm Suwannee Limestone - Marianna Limestone undifferentiated
Eocene
Tre Residuum on Eocene sediments
To Ocala Limestone
Tap Avon Park Formation
20 0 20 40 60 80 Miles
20 0 20 40 60 80 Kilometers
Scale 1:750,000
Albers Conic Equal-Area Projection
N
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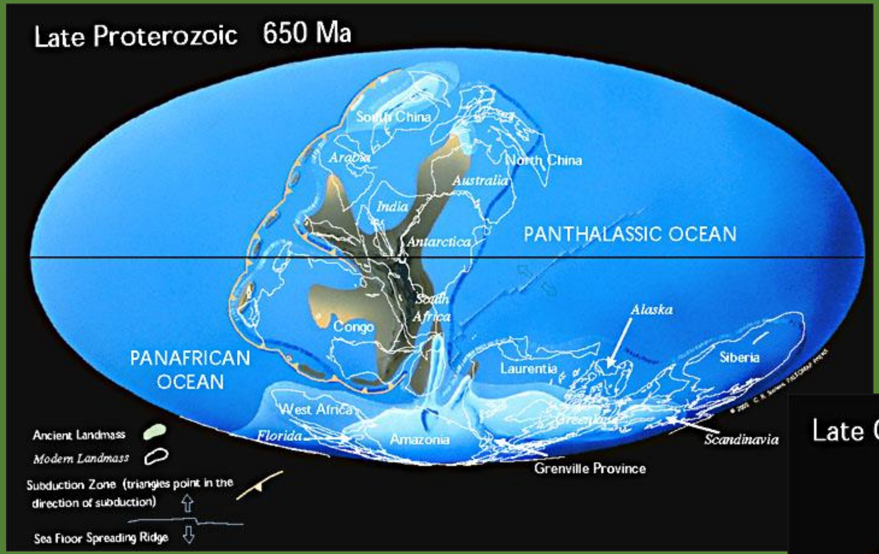
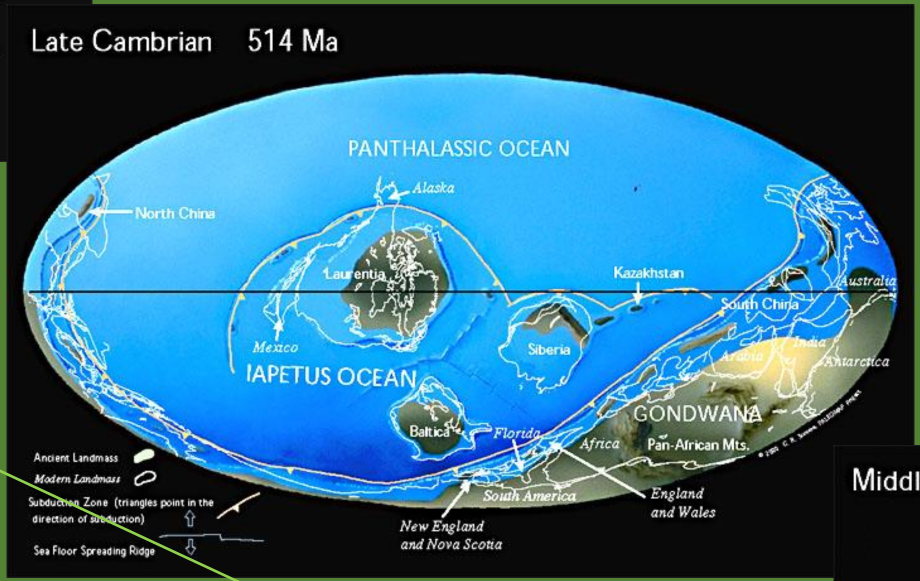
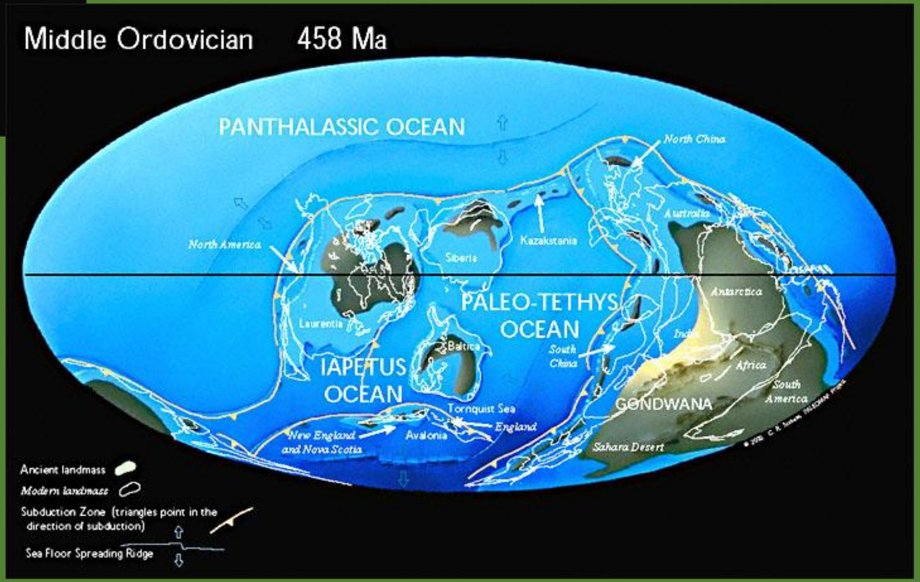
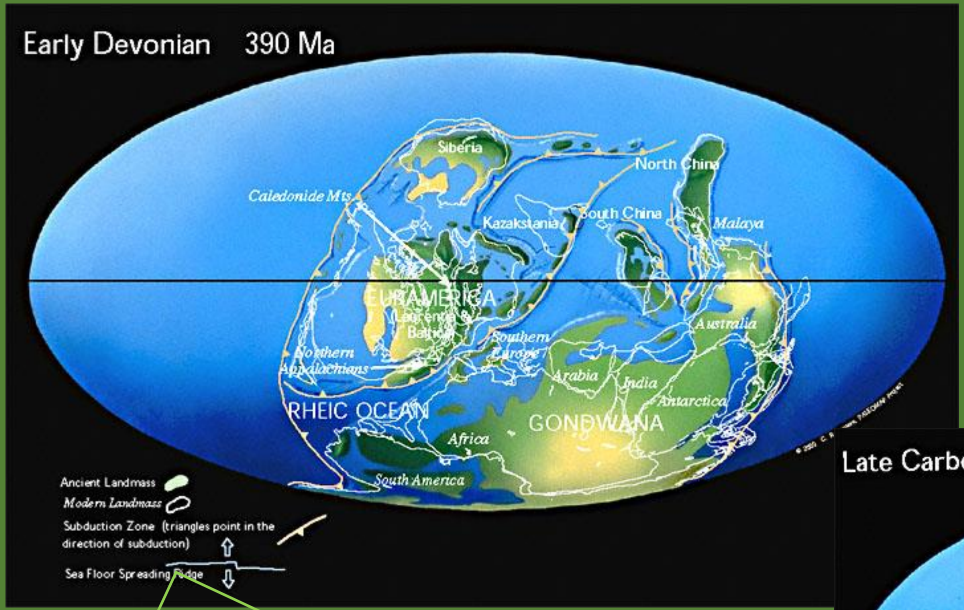
Christopher Scotese

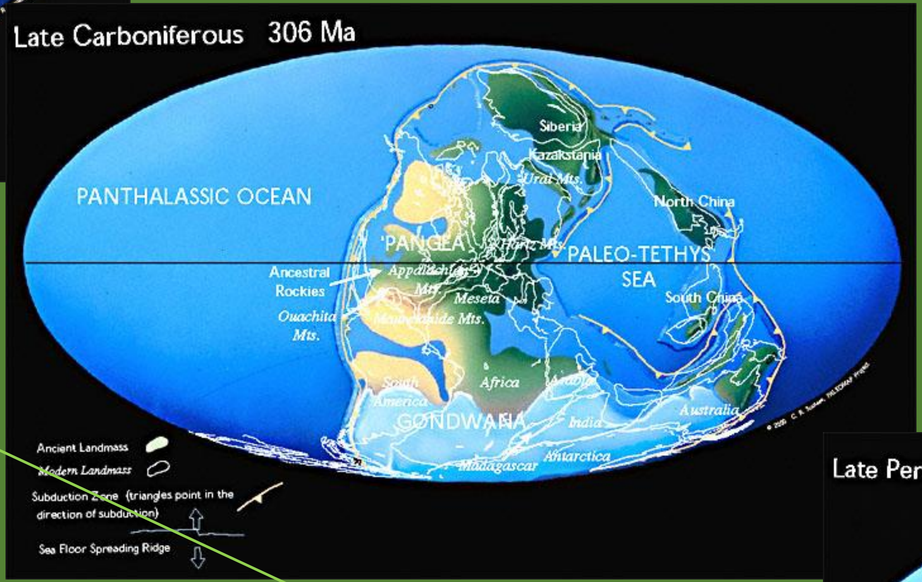


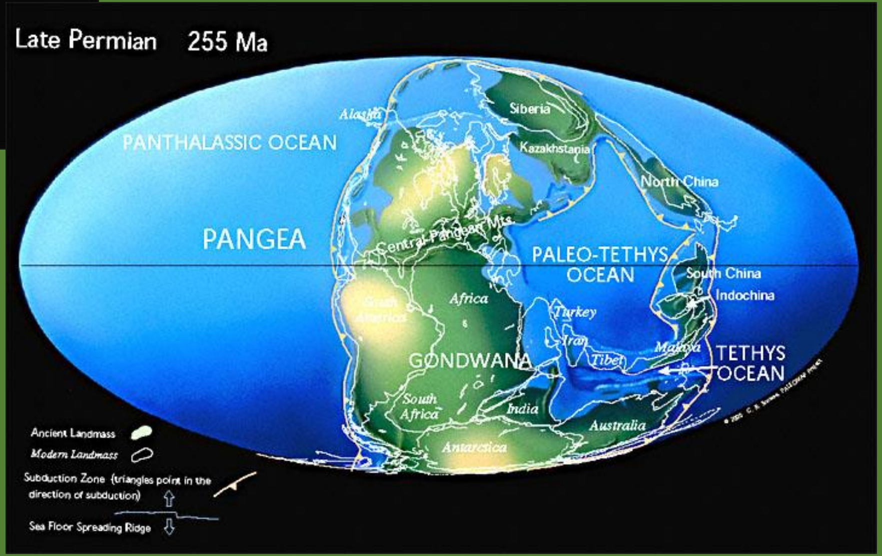




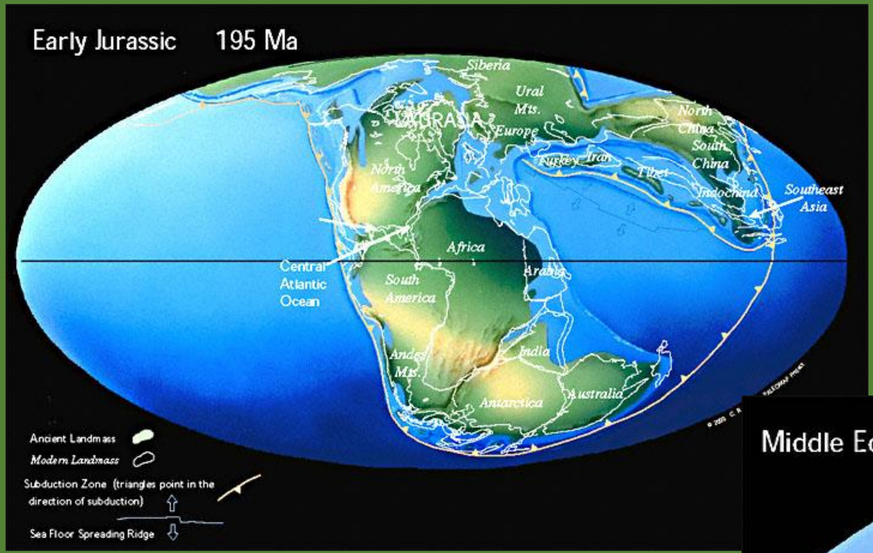
Christopher Scotese

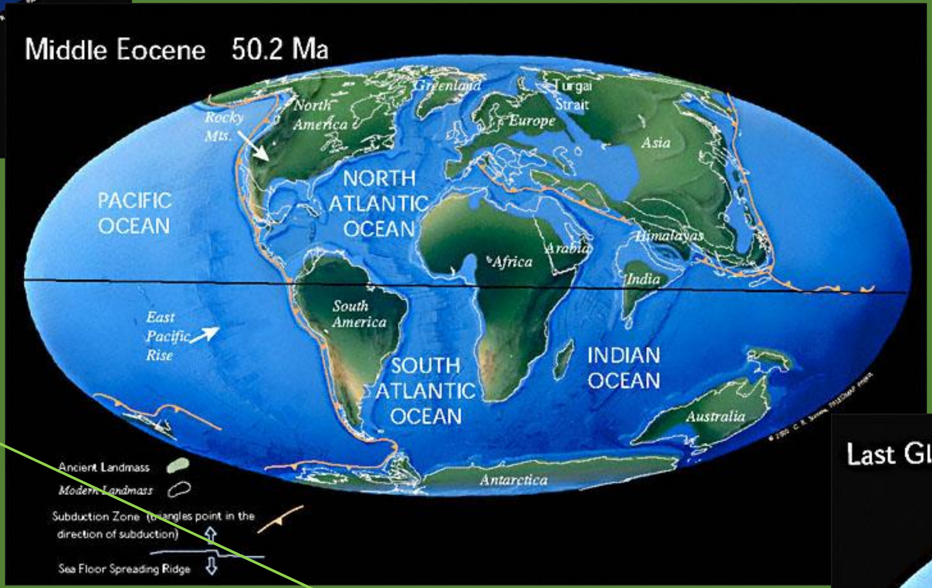


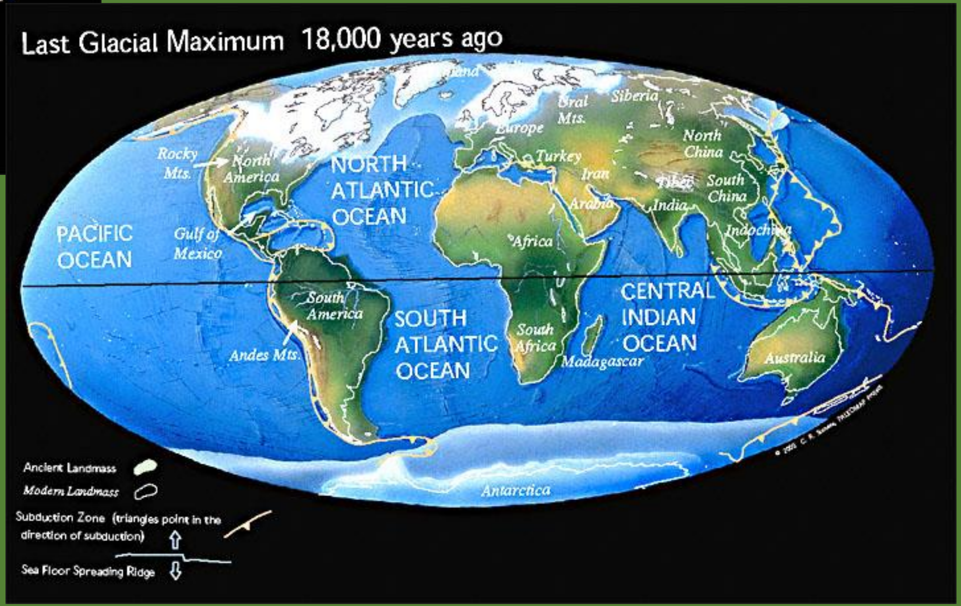




Christopher Scotese







Learning outcomes:

Geology is the scientific study of the earth.

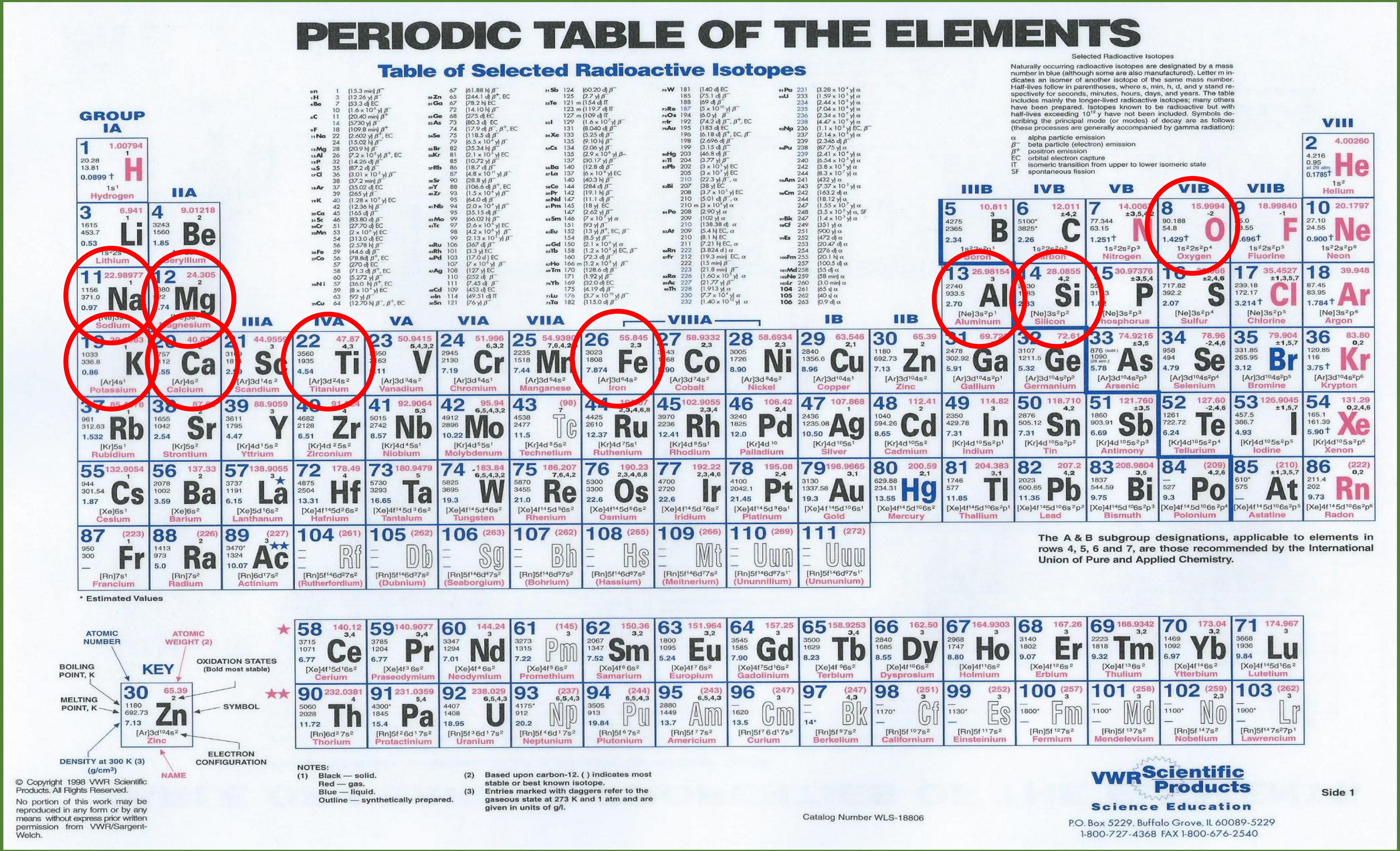
The science of Geology allows us to understand earthquakes, volcanoes, glaciers and climate, how ocean basins and continents form and change, the economic minerals and rocks that are the building blocks of our civilization; the age and history of the earth.

The cement blocks and mortar in your house are derived from the limestones of the State. The iron nails in the wood are from iron deposits up North that have been melted by coal and formed into the nails; the tar on your roof and its shingles are from oil in the ground and the electricity in you house comes from natural gas. The glass in you windows is from melted quartz sand.

Other branches of earth science are meteorology, paleontology (fossils), astronomy (the Solar System and Universe), oceanography and mineralogy, and petrology.

J. Hutton, 1795: the guiding rule of Geology is " the present is the key to the past " (**Uniformitarianism**)

Minerals



PERIODIC TABLE OF THE ELEMENTS
Table of Selected Radioactive Isotopes
Selected Radioactive Isotopes
Naturally occurring radioactive isotopes are designated by a mass number in blue (although some are also manufactured). Letter m indicates an isomer of another isotope of the same mass number. Half-lives follow in parentheses, where s, min, h, d, and y stand respectively for seconds, minutes, hours, days, and years. The table includes mainly the longer-lived radioactive isotopes; many others have been prepared. Isotopes known to be radioactive but with half-lives exceeding 10¹² y have not been included. Symbols describing the principal mode (or modes) of decay are as follows (these processes are generally accompanied by gamma radiation):
α alpha particle emission
β⁻ beta particle (electron) emission
β⁺ positron emission
EC orbital electron capture
IT isomeric transition from upper to lower isomeric state
SF spontaneous fission
GROUP IA
IIA
IIIA
IVA
VA
VIA
VIIA
VIIIA
IB
IIB
IIIB
IVB
VB
VIB
VIIB
VIII
1 H Hydrogen
2 He Helium
3 Li Lithium
4 Be Beryllium
5 B Boron
6 C Carbon
7 N Nitrogen
8 O Oxygen
9 F Fluorine
10 Ne Neon
11 Na Sodium
12 Mg Magnesium
13 Al Aluminum
14 Si Silicon
15 P Phosphorus
16 S Sulfur
17 Cl Chlorine
18 Ar Argon
19 K Potassium
20 Ca Calcium
21 Sc Scandium
22 Ti Titanium
23 V Vanadium
24 Cr Chromium
25 Mn Manganese
26 Fe Iron
27 Co Cobalt
28 Ni Nickel
29 Cu Copper
30 Zn Zinc
31 Ga Gallium
32 Ge Germanium
33 As Arsenic
34 Se Selenium
35 Br Bromine
36 Kr Krypton
37 Rb Rubidium
38 Sr Strontium
39 Y Yttrium
40 Zr Zirconium
41 Nb Niobium
42 Mo Molybdenum
43 Tc Technetium
44 Ru Ruthenium
45 Rh Rhodium
46 Pd Palladium
47 Ag Silver
48 Cd Cadmium
49 In Indium
50 Sn Tin
51 Sb Antimony
52 Te Tellurium
53 I Iodine
54 Xe Xenon
55 Cs Cesium
56 Ba Barium
57 La Lanthanum
72 Hf Hafnium
73 Ta Tantalum
74 W Tungsten
75 Re Rhenium
76 Os Osmium
77 Ir Iridium
78 Pt Platinum
79 Au Gold
80 Hg Mercury
81 Tl Thallium
82 Pb Lead
83 Bi Bismuth
84 Po Polonium
85 At Astatine
86 Rn Radon
87 Fr Francium
88 Ra Radium
89 Ac Actinium
104 Rf (Rutherfordium)
105 Db (Dubnium)
106 Sg (Seaborgium)
107 Bh (Bohrium)
108 Hs (Hassium)
109 Mt (Meitnerium)
110 Uun (Ununnilium)
111 Uuu (Unununium)
The A & B subgroup designations, applicable to elements in rows 4, 5, 6 and 7, are those recommended by the International Union of Pure and Applied Chemistry.
* Estimated Values
58 Ce Cerium
59 Pr Praseodymium
60 Nd Neodymium
61 Pm Promethium
62 Sm Samarium
63 Eu Europium
64 Gd Gadolinium
65 Tb Terbium
66 Dy Dysprosium
67 Ho Holmium
68 Er Erbium
69 Tm Thulium
70 Yb Ytterbium
71 Lu Lutetium
90 Th Thorium
91 Pa Protactinium
92 U Uranium
93 Np Neptunium
94 Pu Plutonium
95 Am Americium
96 Cm Curium
97 Bk Berkelium
98 Cf Californium
99 Es Einsteinium
100 Fm Fermium
101 Md Mendelevium
102 No Nobelium
103 Lr Lawrencium
KEY
ATOMIC NUMBER
ATOMIC WEIGHT (2)
OXIDATION STATES (Bold most stable)
BOILING POINT, K
MELTING POINT, K
SYMBOL
DENSITY at 300 K (3) (g/cm³)
NAME
ELECTRON CONFIGURATION
30 Zn Zinc
NOTES:
(1) Black — solid. Red — gas. Blue — liquid. Outline — synthetically prepared.
(2) Based upon carbon-12. ( ) indicates most stable or best known isotope.
(3) Entries marked with daggers refer to the gaseous state at 273 K and 1 atm and are given in units of g/l.
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Side 1

The Rocks of the Earth are made of Minerals:

MINERALS: 1. Naturally occurring; not man made

2. Solid: ice is a mineral, liquid water is not

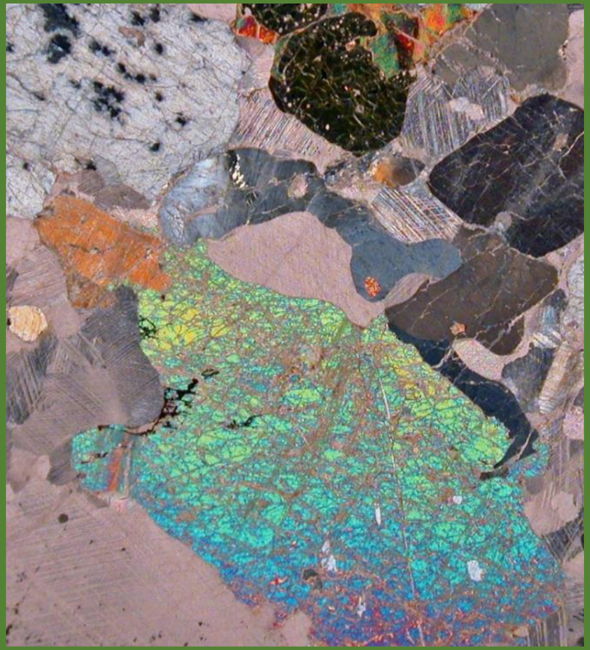
3. Crystalline structure – atoms and/or molecules are arranged in a geometric structure that fall into 6 crystal systems

4. Not organic (from life) = INORGANIC

5. Definite PHYSICAL & CHEMICAL properties: a) Specific gravity (G) (Heft), how Dense

b) HARDNESS (H –Moh's Scale from 1-10)

1 talc, 2.5 fingernail, 3.5 penny, 5.5 steel knife or nail, feldspar 6, quartz 7, 10 diamond.



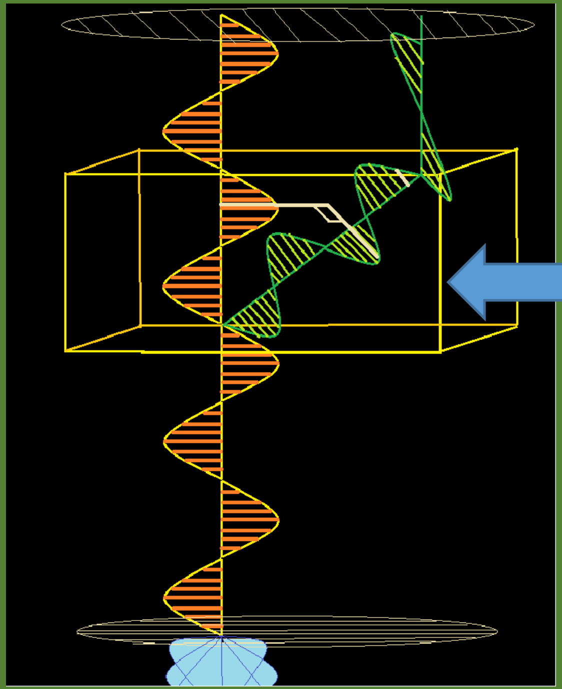
c) CLEAVAGE (may easily split along parallel planes

d) STREAK on a porcelain tile

e) COLOR may or may not be important

f) FRACTURE (example: *conchoidal*)

g) TASTE salt



h) DOUBLE REFRACTION Split Light in two

I) MAGNETIC is or is attracted to a magnet (Fe rich)

J) RADIOACTIVE- Geiger counter

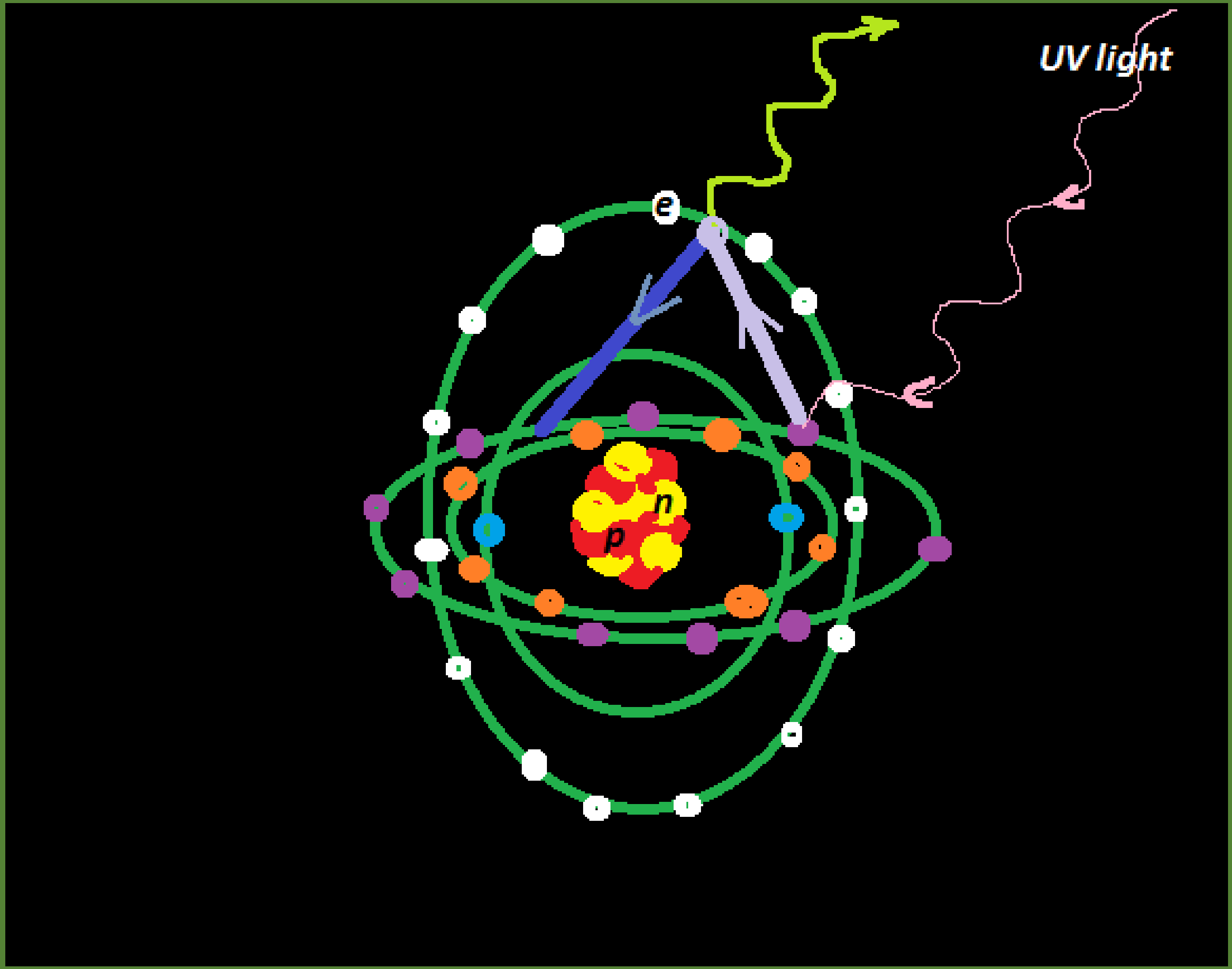
k) FLUORESCENCE with UV light see above

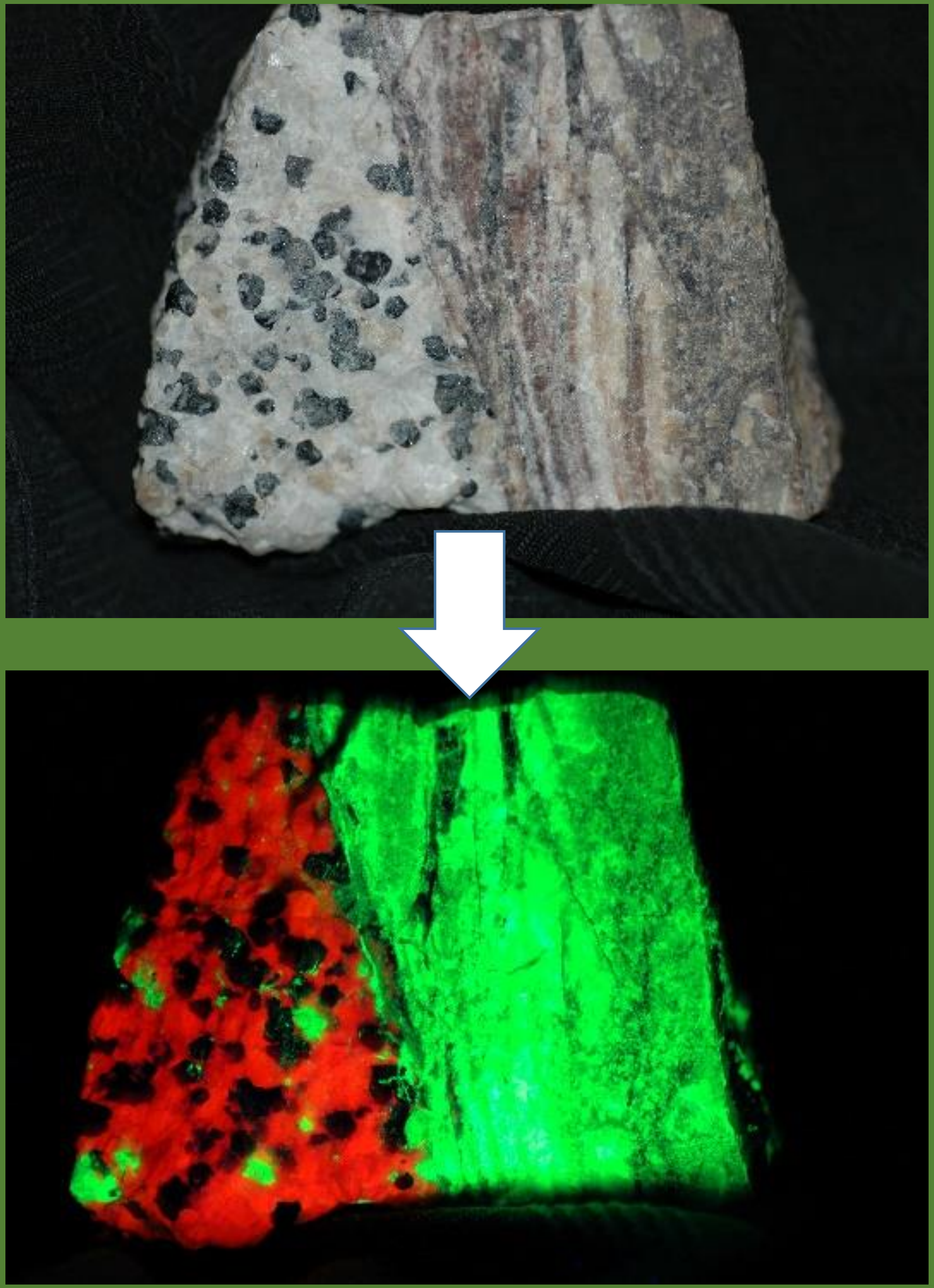
l) a *Chemical Formula*; NaCl salt, SiO_2 quartz, Fe_3O_4 Magnetite, $CaCO_3$ Calcite

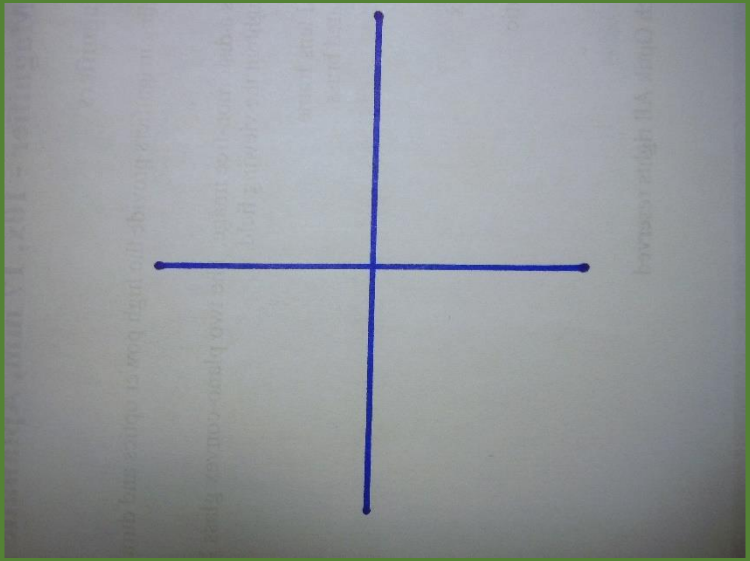
m) May EFFORVESCE or Fizz with acid

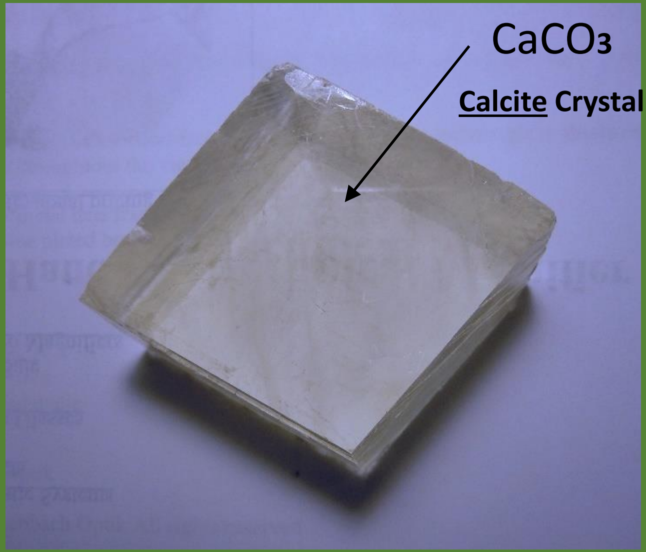
n) LUSTER the shine: metallic or nonmetallic

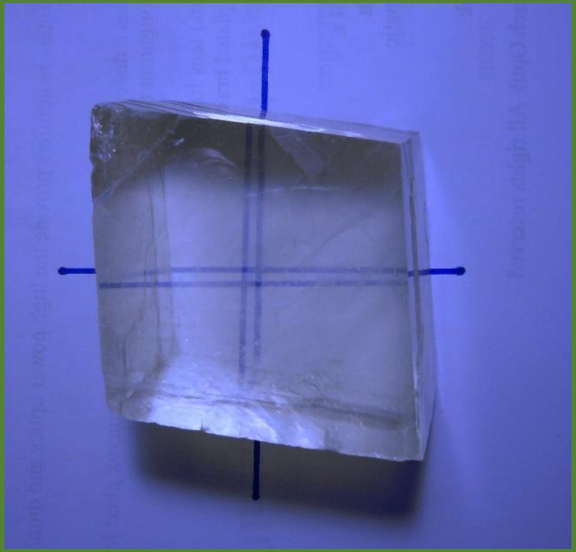
Fluorescence



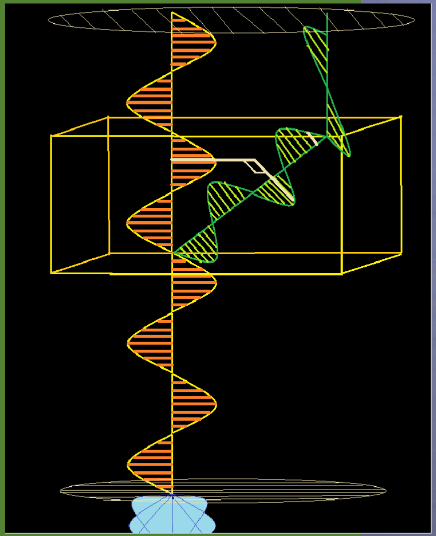


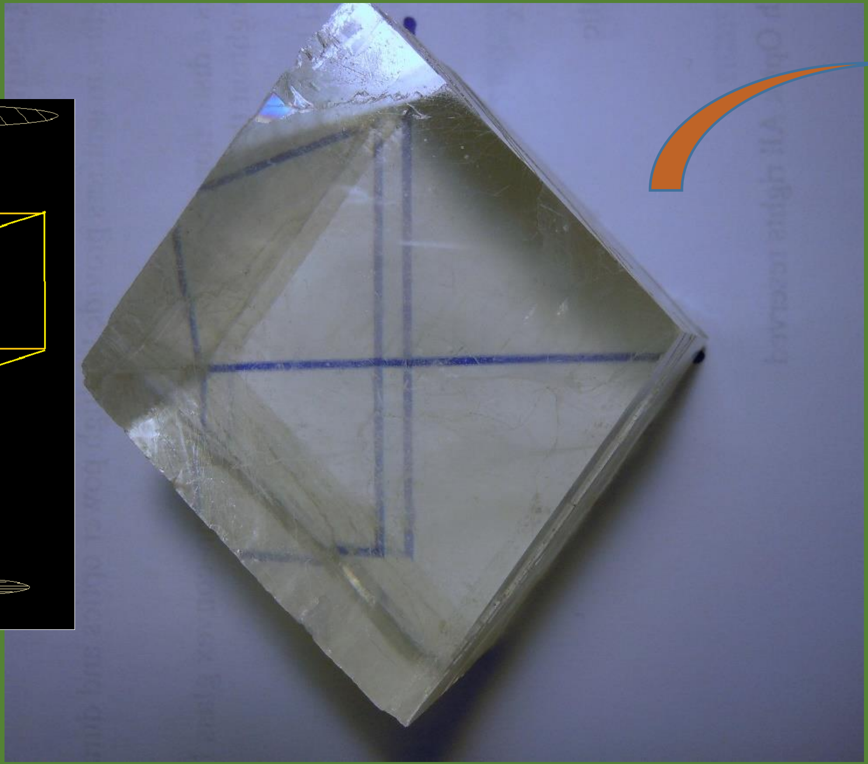


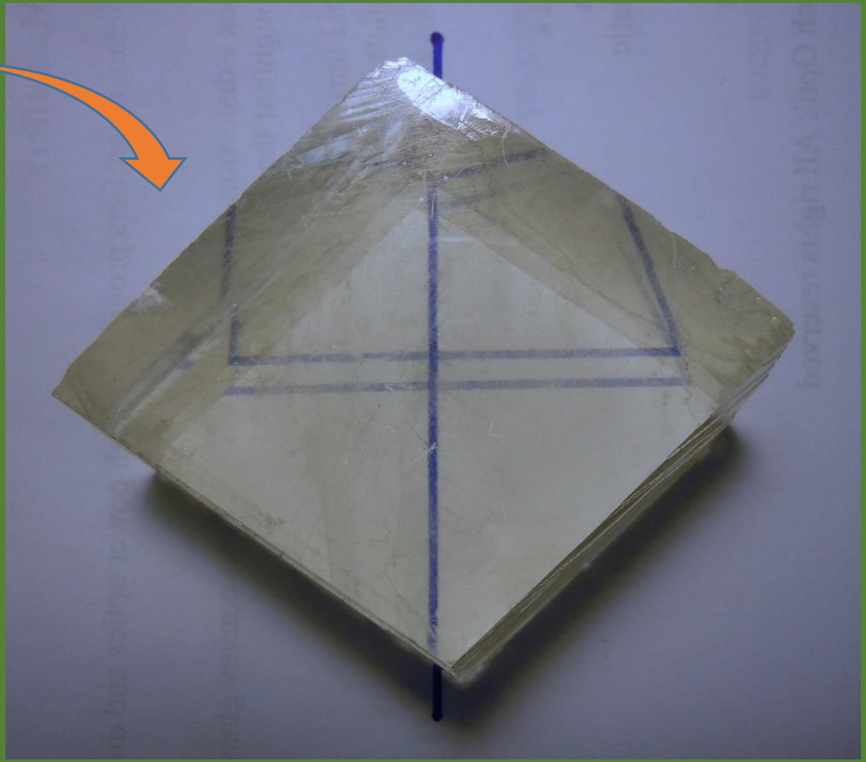




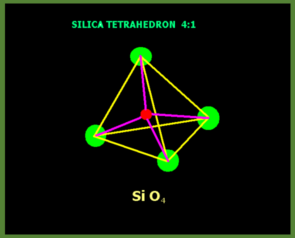
DOUBLE REFRACTION: light passing through a crystal will be split in two







MINERAL FAMILIES



1 – SILICATES some combination of Silicon (Si) 3and Oxygen (O-) *Olivine, Quartz, Feldspar, Garnet, Beryl, Mica*

2 – OXIDES some combination of a *Metal* like Iron (Fe+) or aluminum (AL+) and Oxygen(O-) Limonite, *Hematite, Magnetite, Corundum, Ruby*

3 – SULFIDES some combination of Sulfur (S-) and a metal (Fe+, Cu+) *Pyrite (fools 'gold')*

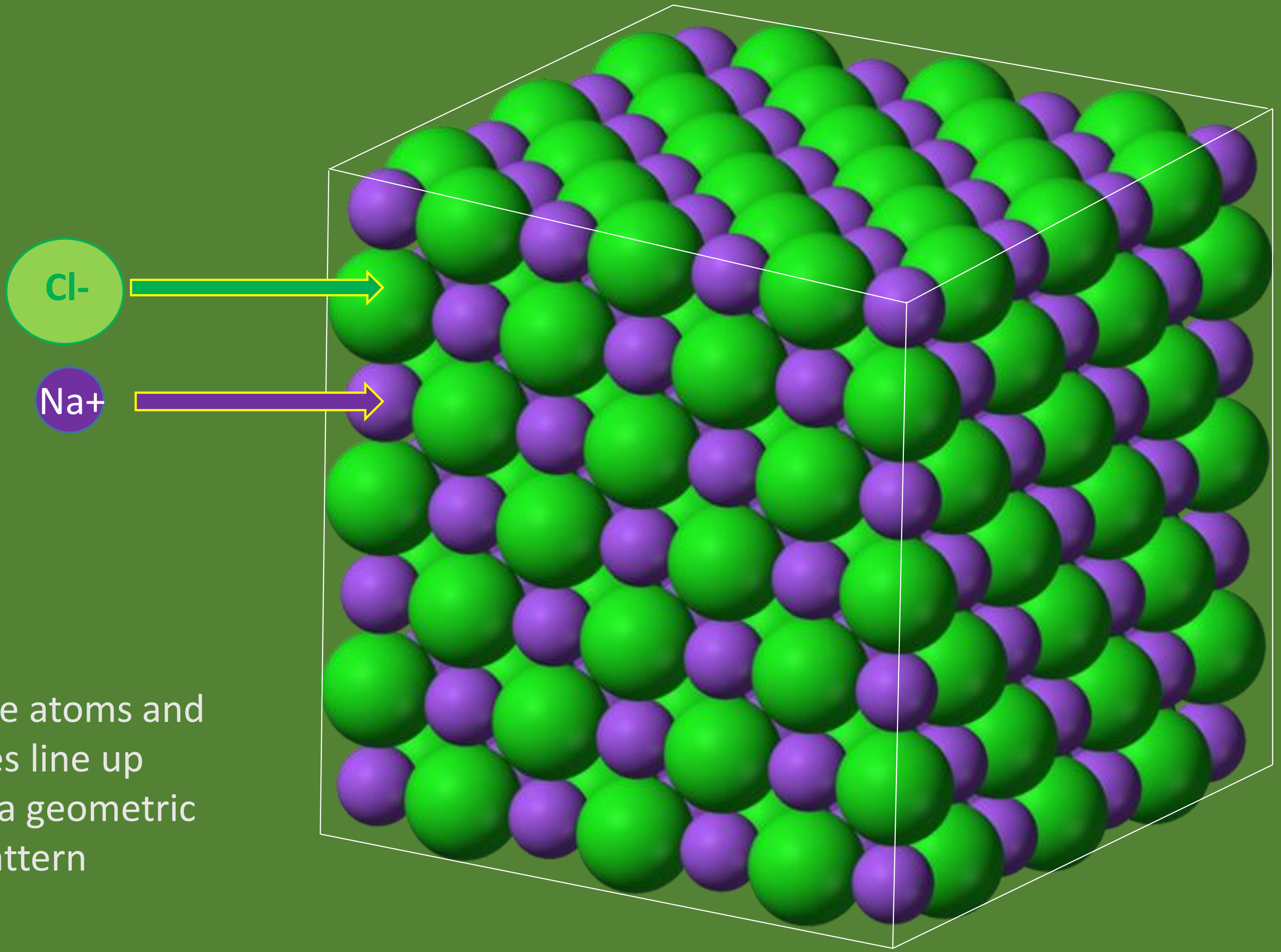
4 – SULFATES some combination of SO_{4-} and a metal *Gypsum*

5 – CARBONATES some combination of CO_{3-} and a metal *Calcite, Dolomite*

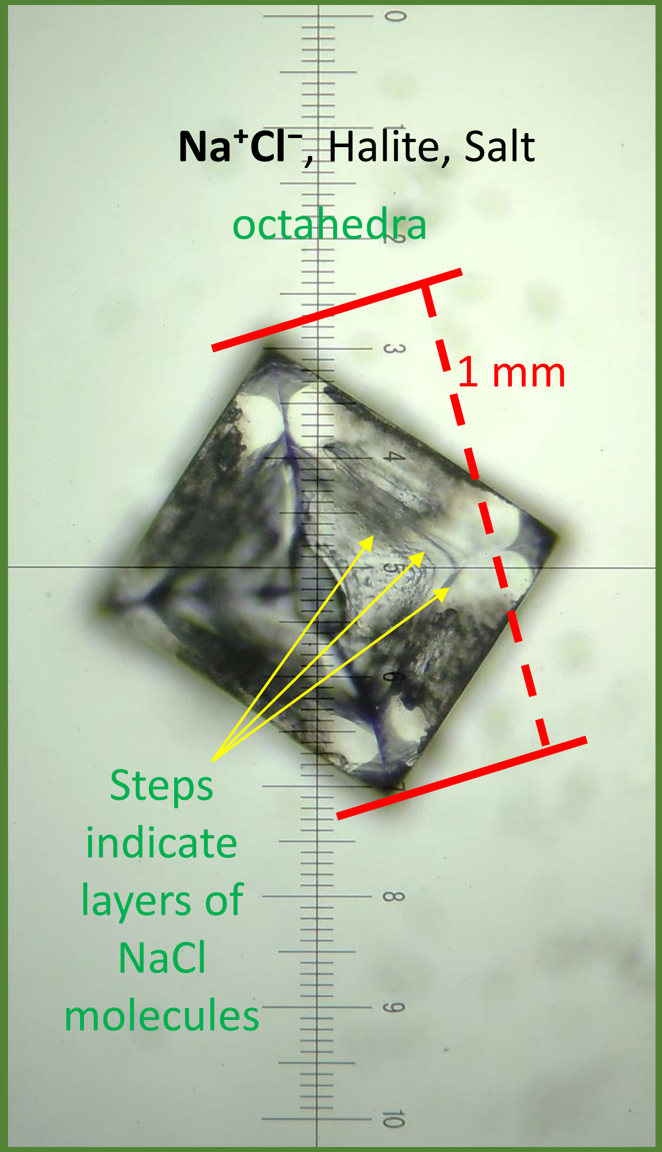
6 – HALIDES some combination of Fluorine-, Chlorine-, Bromine-, or Iodine- and a metal *Halite, Fluorite*

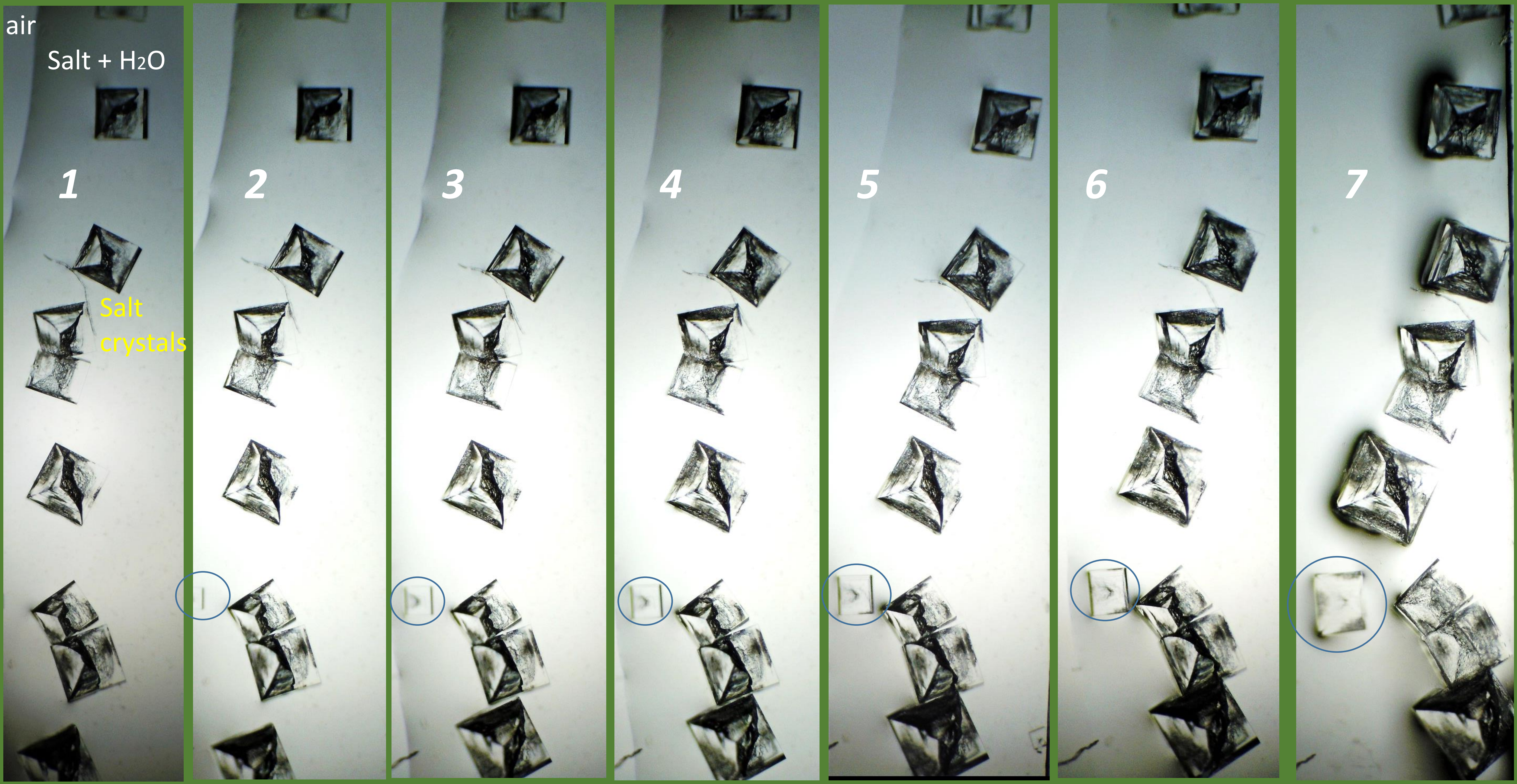
7 – NATIVE ELEMENTS - rare: *Gold, Silver, Copper, Sulfur, Graphite, Diamond*

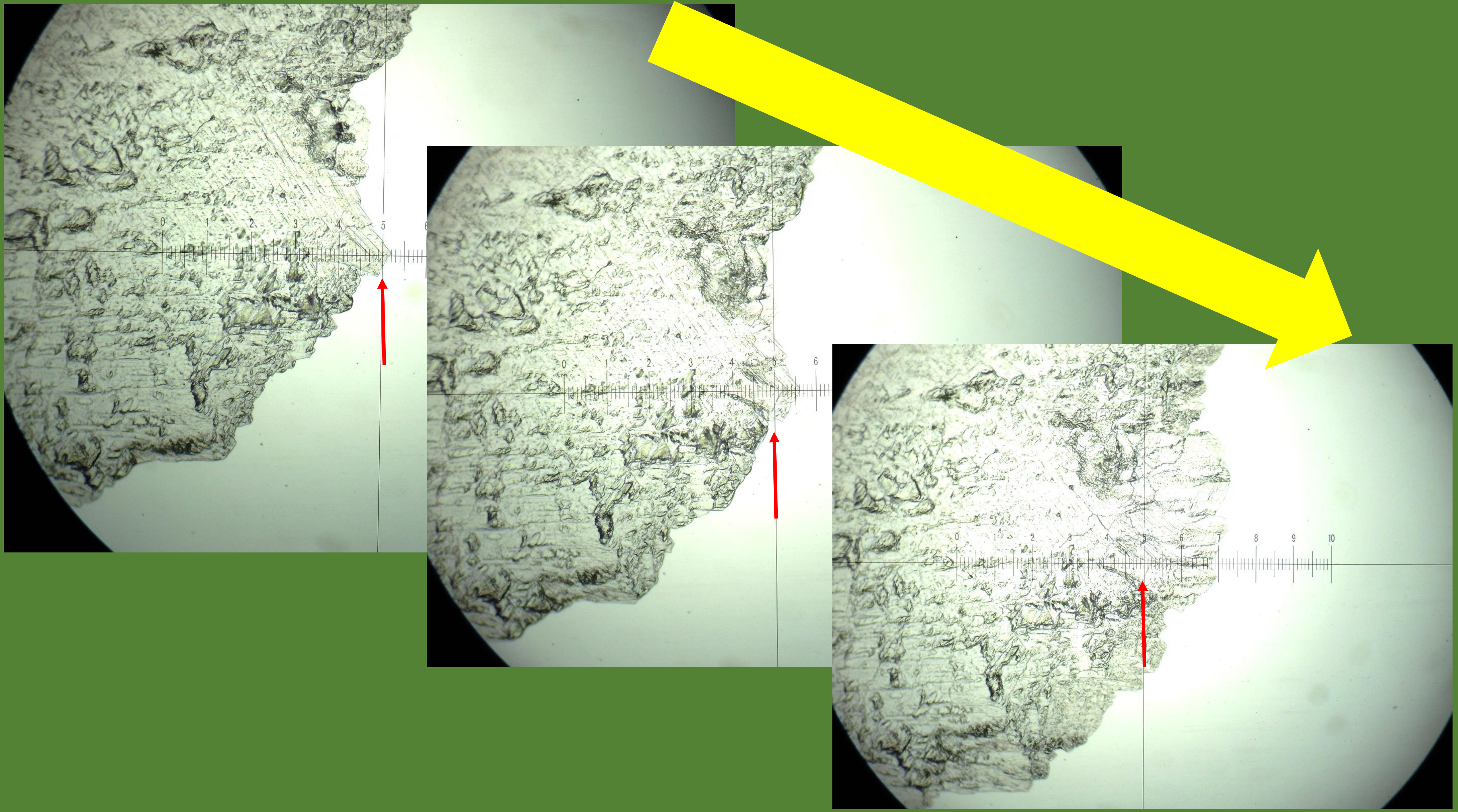
Na^+Cl^-, Halite, Salt



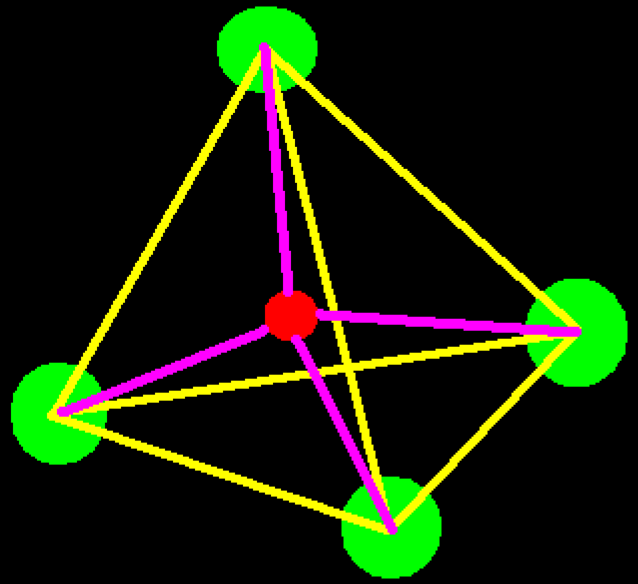
Note how the atoms and molecules line up perfectly in a geometric 3D pattern



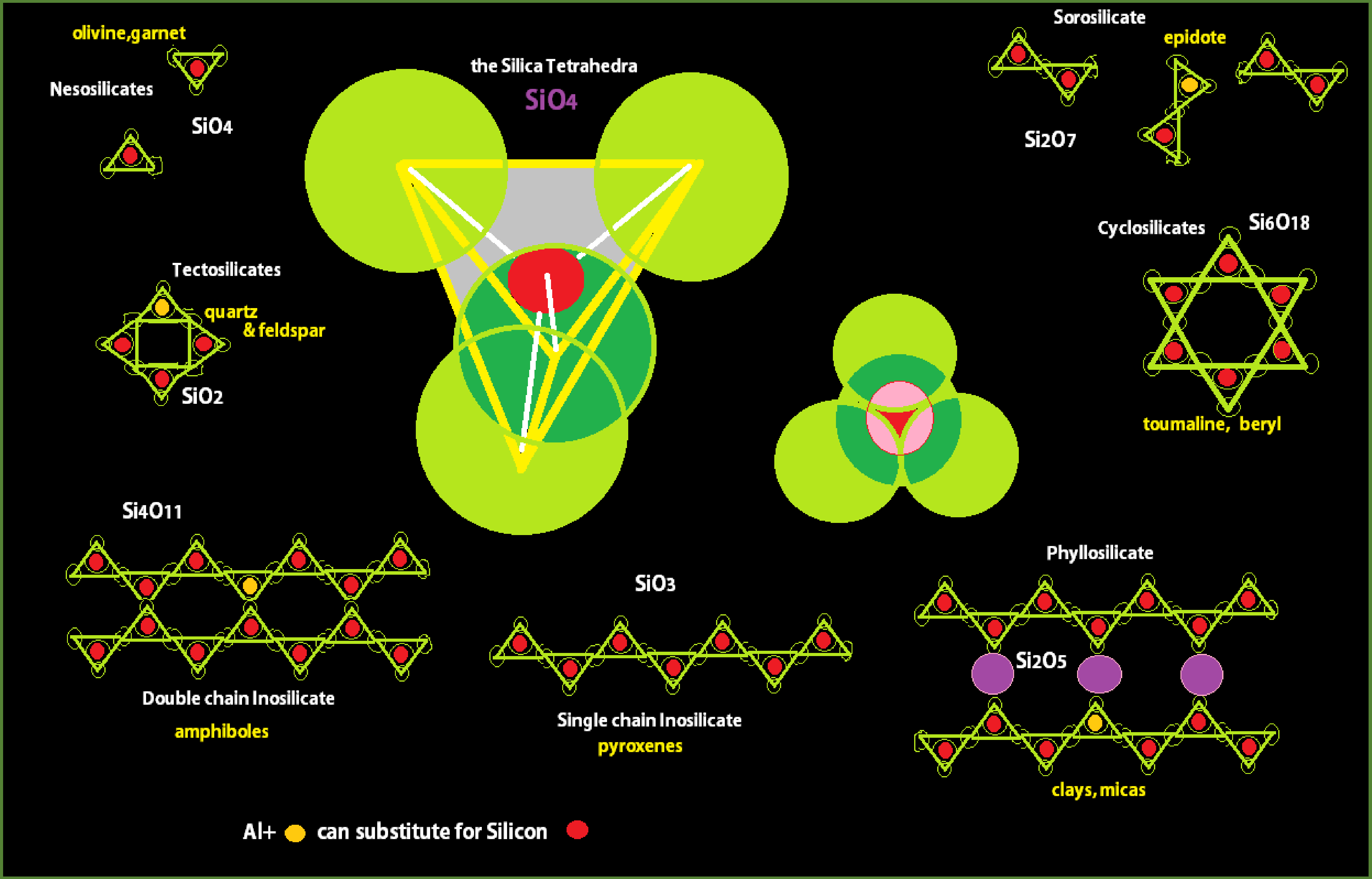

air
Salt + H_2O
1
2
3
4
5
6
7
Salt crystals

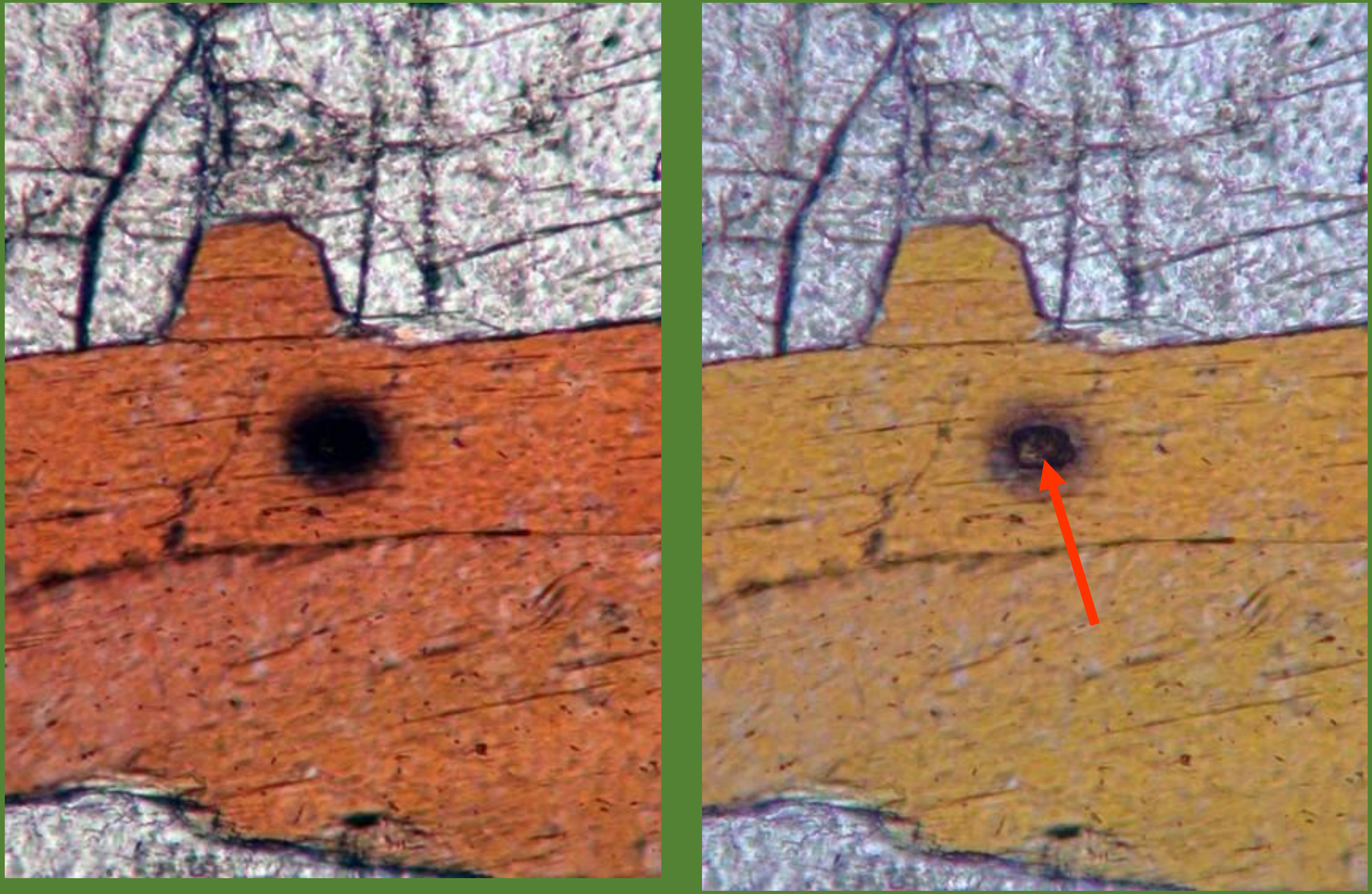

0 1 2 3 4 5 6
0 1 2 3 4 5 6
0 1 2 3 4 5 6 7 8 9 10

SILICA TETRAHEDRON 4:1

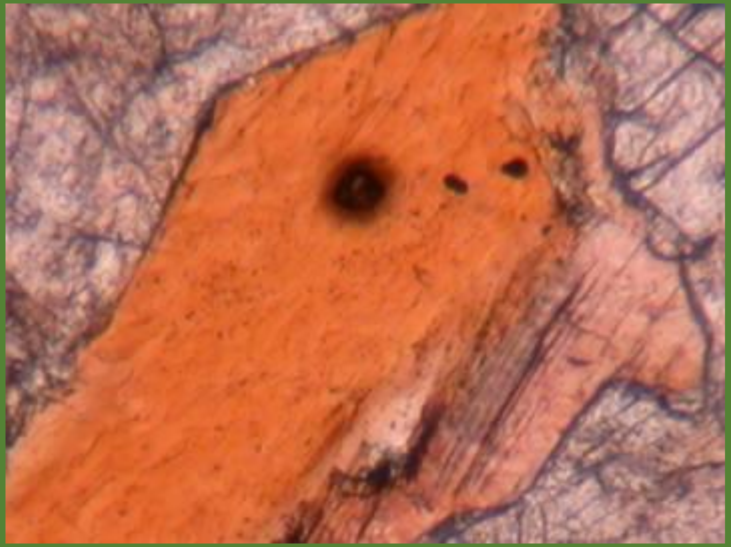
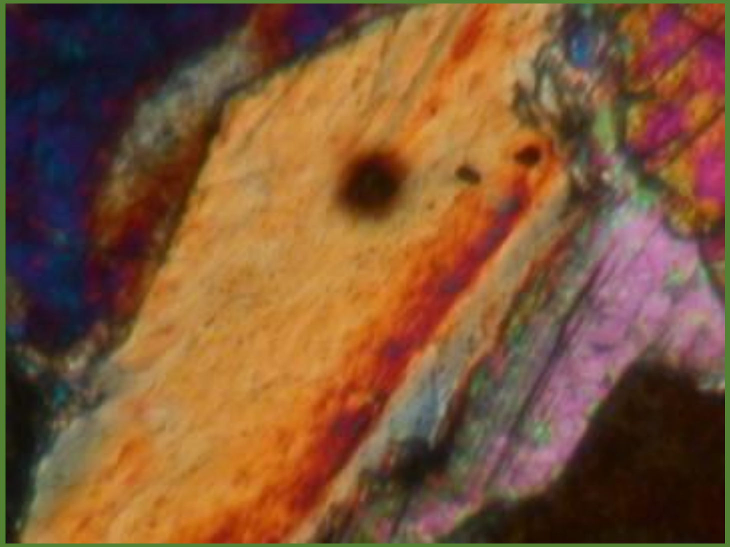


SiO_4


olivine,garnet
Nesosilicates
SiO4
the Silica Tetrahedra
SiO4
Sorosilicate
epidote
Si2O7
Cyclosilicates
Si6O18
toumaline, beryl
Tectosilicates
quartz
& feldspar
SiO2
Si4O11
Double chain Inosilicate
amphiboles
SiO3
Single chain Inosilicate
pyroxenes
Phyllosilicate
Si2O5
clays, micas
Al+ can substitute for Silicon



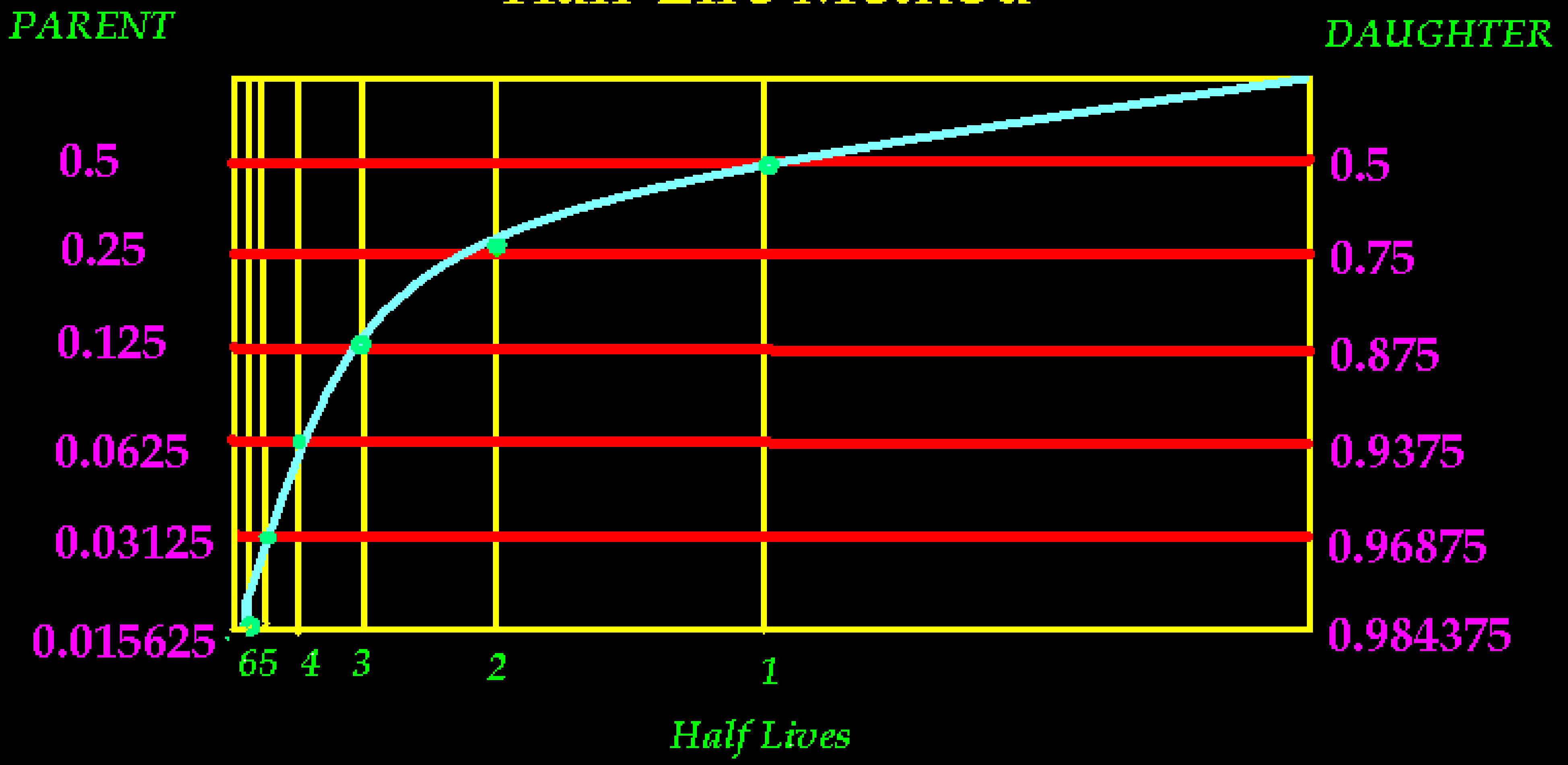
Pleochroic Biotite (note bird's eye texture) with radioactively 'burned' halos around tiny Zircon xl: Granite


Pleochroic Biotite (note bird's eye texture) with radioactively 'burned' halos around tiny Zircon xl: Granite

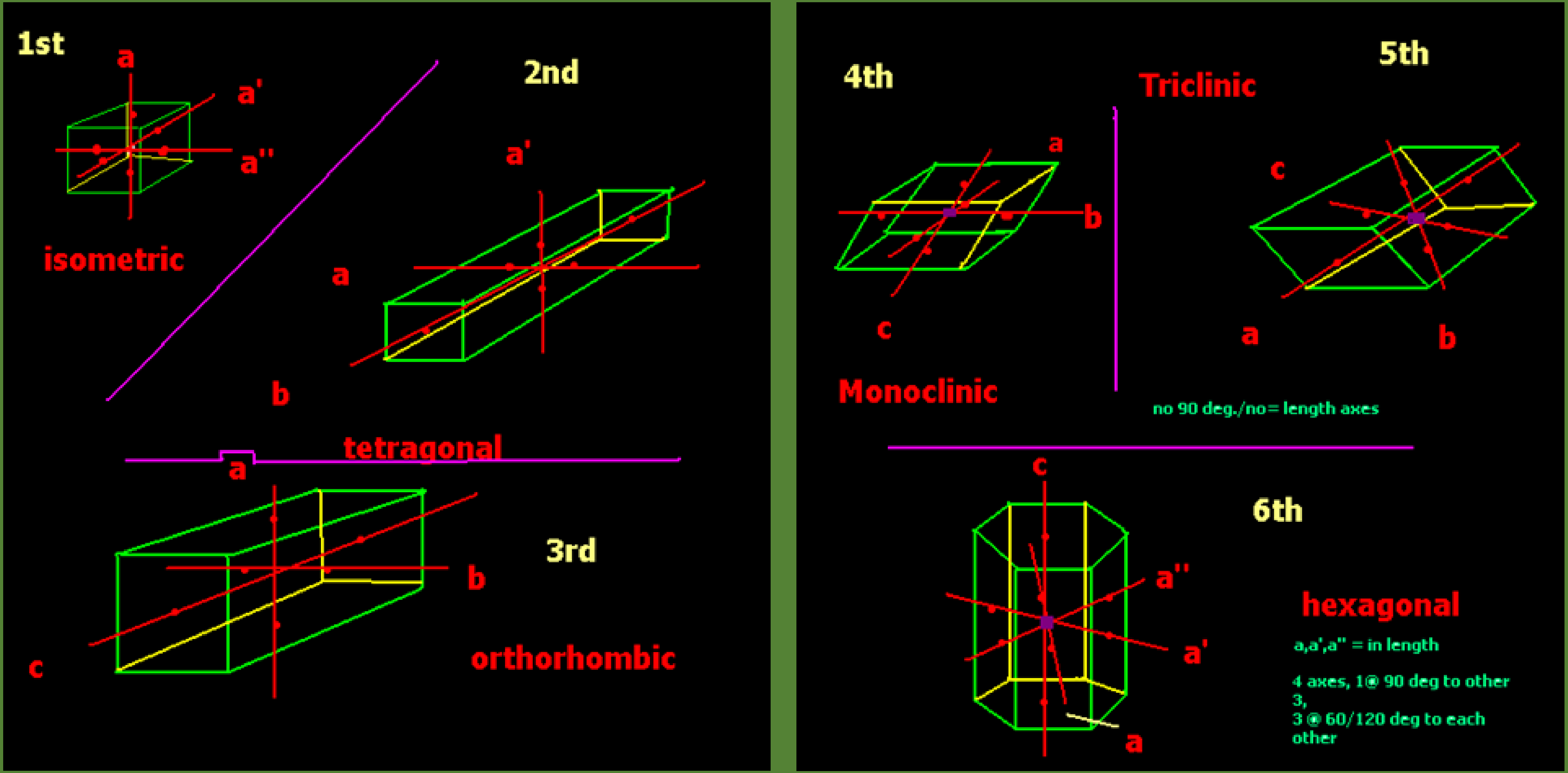
Geologists don't use carbon; they use U/Pb. , K/Ar. etc.

Radiometric Dating: Half Life Method

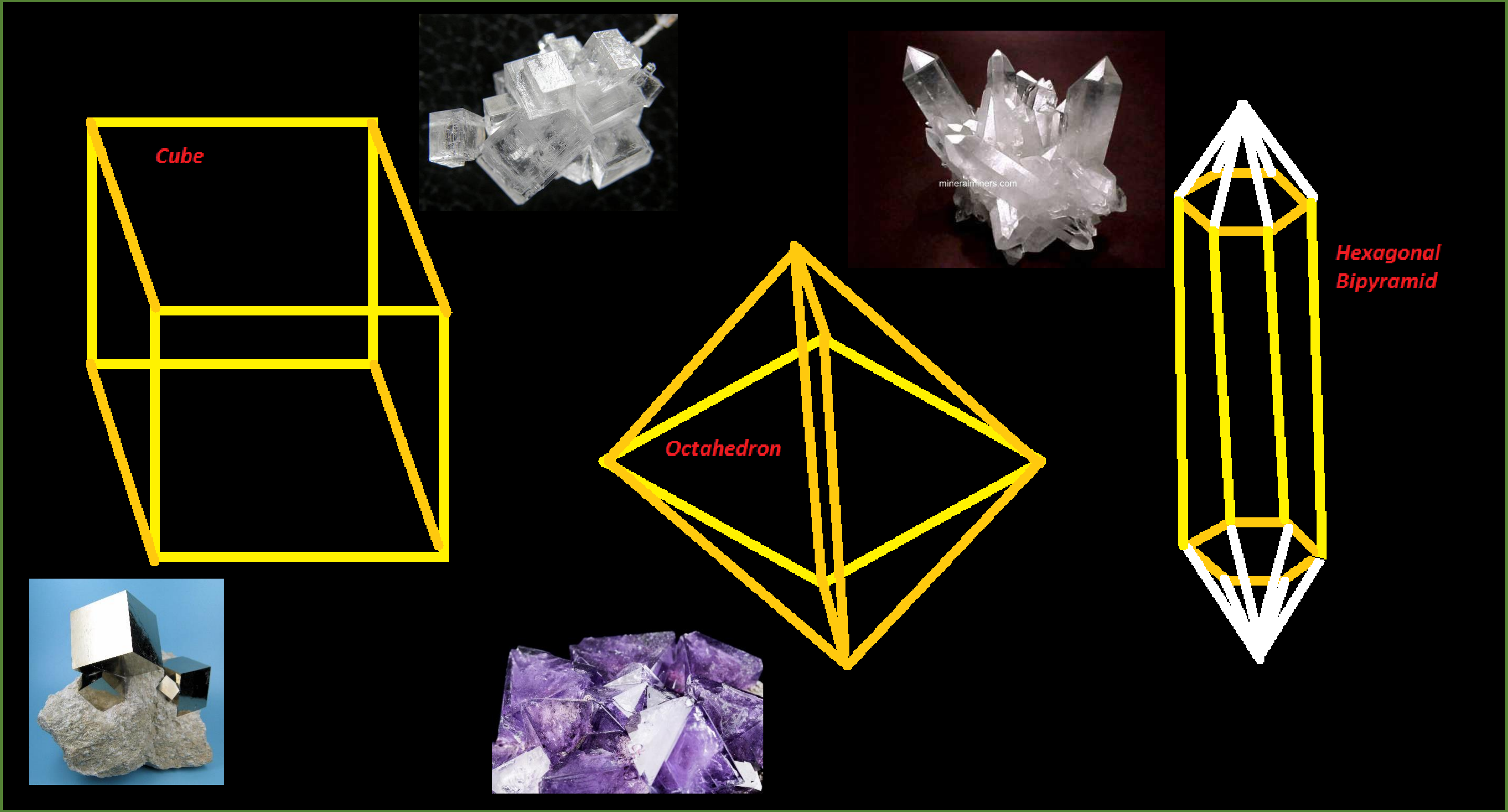



Rhodochrosite – Quartz - Pyrite

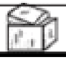

Fluorite



The six crystal systems


Cube
Octahedron
Hexagonal
Bipyramid
mineralminers.com

Properties of Common Minerals

LUSTER	HARD-NESS	CLEAVAGE	FRACTURE	COMMON COLORS	DISTINGUISHING CHARACTERISTICS	USE(S)	MINERAL NAME	COMPOSITION*
Metallic Luster	1–2	✓		silver to gray	black streak, greasy feel	pencil lead, lubricants	**Graphite**	C
	2.5	✓		metallic silver	very dense (7.6 g/cm^3), gray-black streak 	ore of lead	**Galena**	PbS
	5.5–6.5		✓	black to silver	attracted by magnet, black streak	ore of iron	**Magnetite**	Fe_3O_4
	6.5		✓	brassy yellow	green-black streak, cubic crystals 	ore of sulfur	**Pyrite**	FeS_2
Either	1–6.5		✓	metallic silver or earthy red	red-brown streak	ore of iron	**Hematite**	Fe_2O_3
Nonmetallic Luster	1	✓		white to green	greasy feel	talcum powder, soapstone	**Talc**	$Mg_3Si_4O_{10}(OH)_2$
	2		✓	yellow to amber	easily melted, may smell	vulcanize rubber, sulfuric acid	**Sulfur**	S
	2	✓		white to pink or gray	easily scratched by fingernail	plaster of paris and drywall	**Gypsum** (Selenite)	$CaSO_4 \cdot 2H_2O$
	2–2.5	✓		colorless to yellow	flexible in thin sheets 	electrical insulator	**Muscovite Mica**	$KAl_3Si_3O_{10}(OH)_2$
	2.5	✓		colorless to white	cubic cleavage, salty taste 	food additive, melts ice	**Halite**	NaCl
	2.5–3	✓		black to dark brown	flexible in thin sheets 	electrical insulator	**Biotite Mica**	$K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$
	3	✓		colorless or variable	bubbles with acid 	cement, polarizing prisms	**Calcite**	$CaCO_3$
	3.5	✓		colorless or variable	bubbles with acid when powdered	source of magnesium	**Dolomite**	$CaMg(CO_3)_2$
	4	✓		colorless or variable	cleaves in 4 directions	hydrofluoric acid	**Fluorite**	CaF_2
	5–6	✓		black to dark green	cleaves in 2 directions at 90° 	mineral collections	**Pyroxene** (commonly Augite)	$(Ca,Na)(Mg,Fe,Al)(Si,Al)_2O_6$
	5.5	✓		black to dark green	cleaves at 56° and 124° 	mineral collections	**Amphiboles** (commonly Hornblende)	$CaNa(Mg,Fe)_4(Al,Fe,Ti)_3Si_6O_{22}(O,OH)_2$
	6	✓		white to pink	cleaves in 2 directions at 90°	ceramics and glass	**Potassium Feldspar** (Orthoclase)	$KAlSi_3O_8$
	6	✓		white to gray	cleaves in 2 directions, striations visible	ceramics and glass	**Plagioclase Feldspar** (Na-Ca Feldspar)	$(Na,Ca)AlSi_3O_8$
	6.5		✓	green to gray or brown	commonly light green and granular	furnace bricks and jewelry	**Olivine**	$(Fe,Mg)_2SiO_4$
	7		✓	colorless or variable	glassy luster, may form hexagonal crystals 	glass, jewelry, and electronics	**Quartz**	SiO_2
	7		✓	dark red to green	glassy luster, often seen as red grains in NYS metamorphic rocks	jewelry and abrasives	**Garnet** (commonly Almandine)	$Fe_3Al_2Si_3O_{12}$

*Chemical Symbols: Al = aluminum, C = carbon, Ca = calcium, Cl = chlorine, F = fluorine, Fe = iron, H = hydrogen, K = potassium, Mg = magnesium, Na = sodium, O = oxygen, Pb = lead, S = sulfur, Si = silicon, Ti = titanium

✓ = dominant form of breakage

Common Mineral Identification

Rocks

1 or more minerals grown or cemented together form a rock

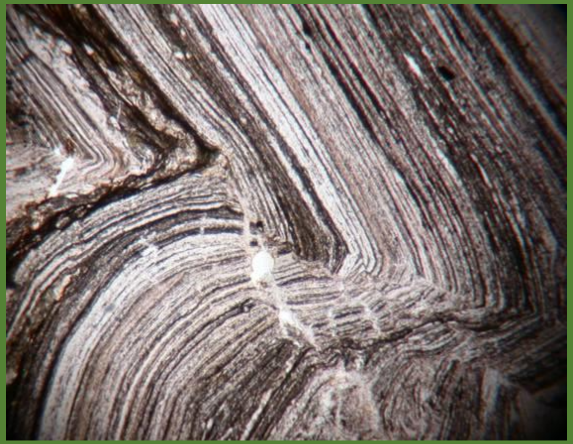
Rocks are made of one or more MINERALS. Rocks tell stories of their origin.

3 Kinds:

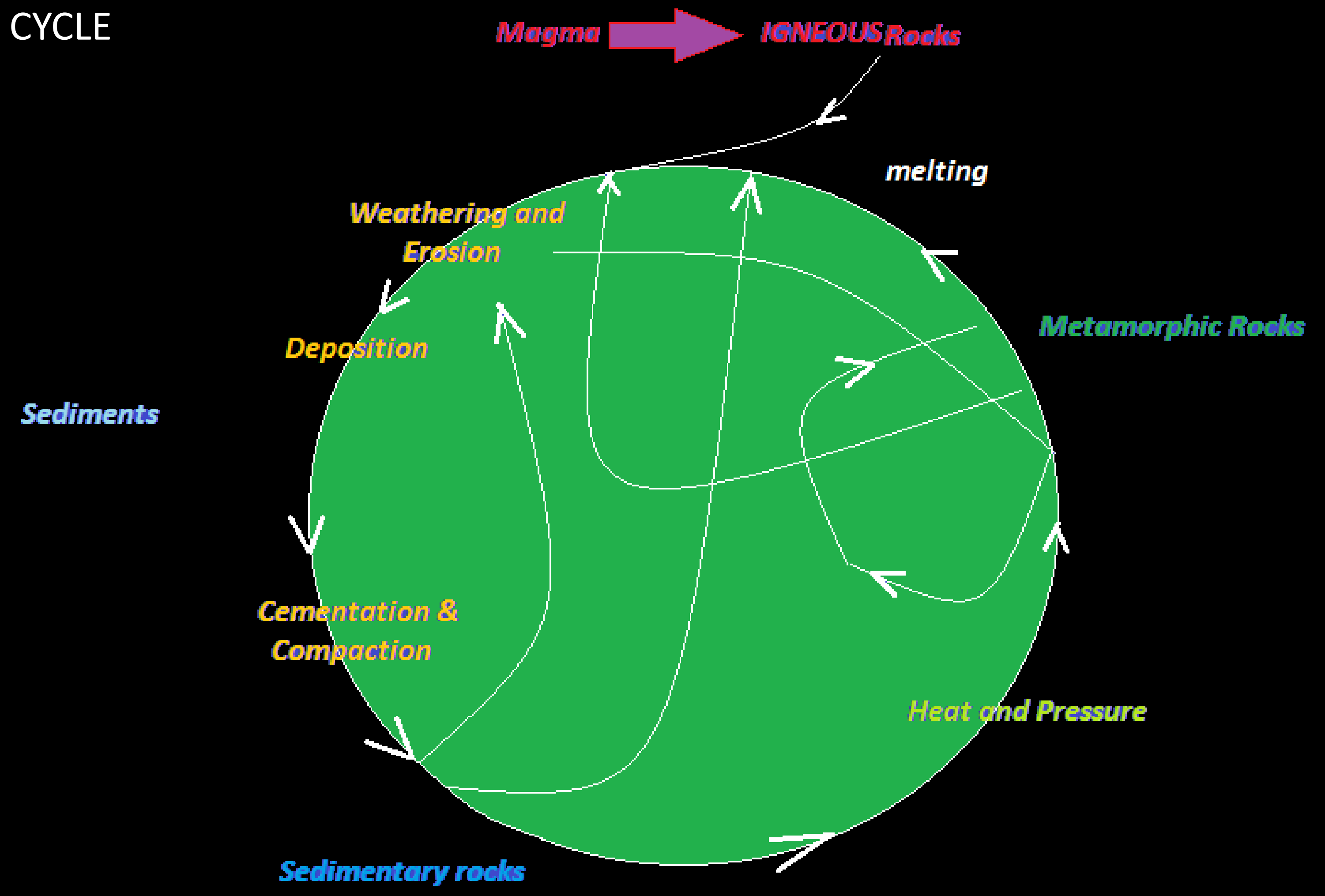
Igneous- formed from MAGMA (below the surface) or LAVA (above the surface),
Both of which are molten material from the earth: Volcanic rocks and Plutonic rocks

Sedimentary – formed from pre-existing rocks grains that have been weathered and eroded and then deposited in layers one upon the other *or* from precipitation from the water (salt and gypsum) *or* the accumulation of organic material (coal). These sediments are compacted, compressed and cemented together to form rocks.

Metamorphic – formed from any other rock buried and exposed to great heat and/or pressure: anthracite coal from plant debris in an ancient swamp; slate from shale; gneiss from any rock for long enough.

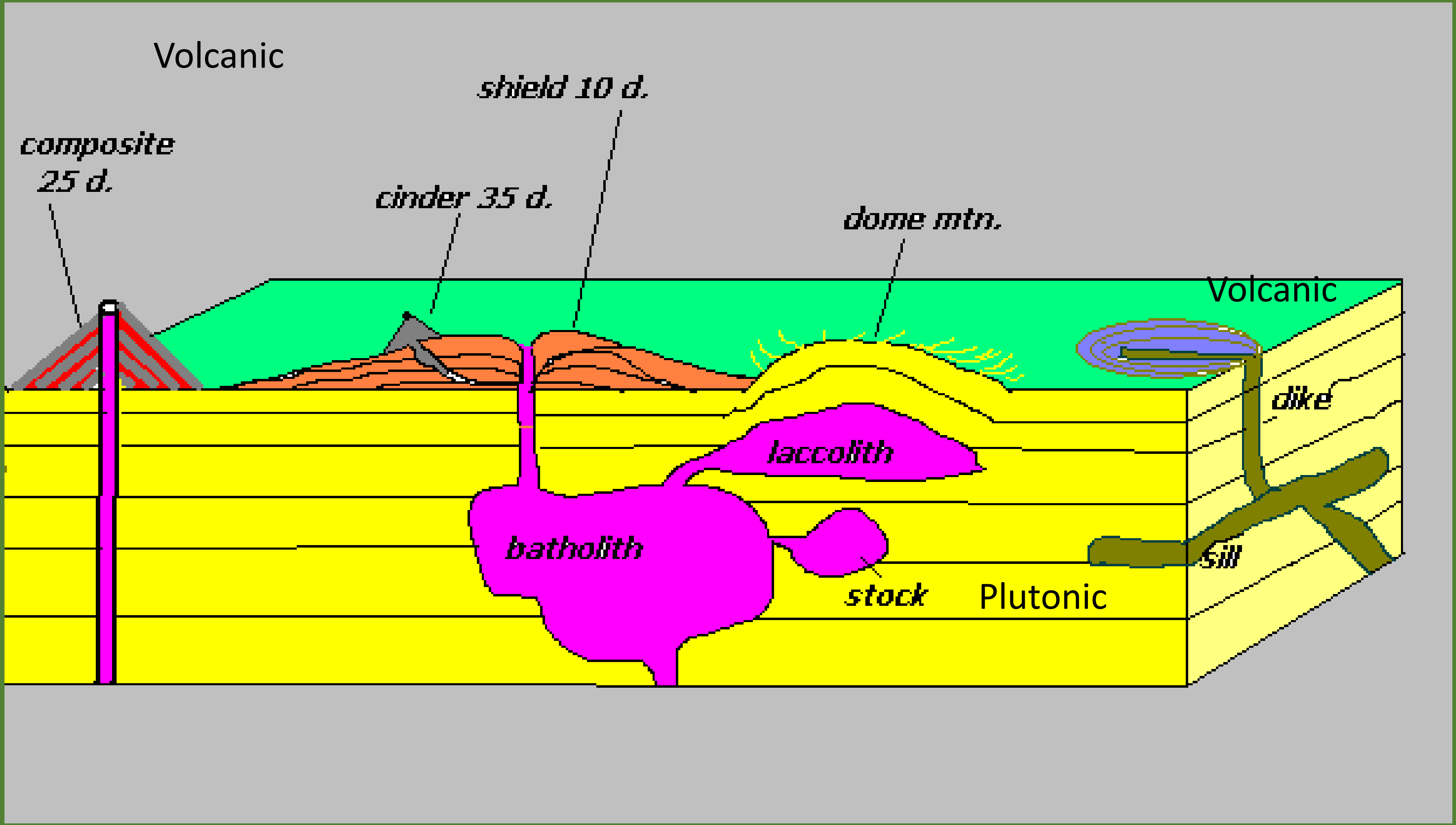


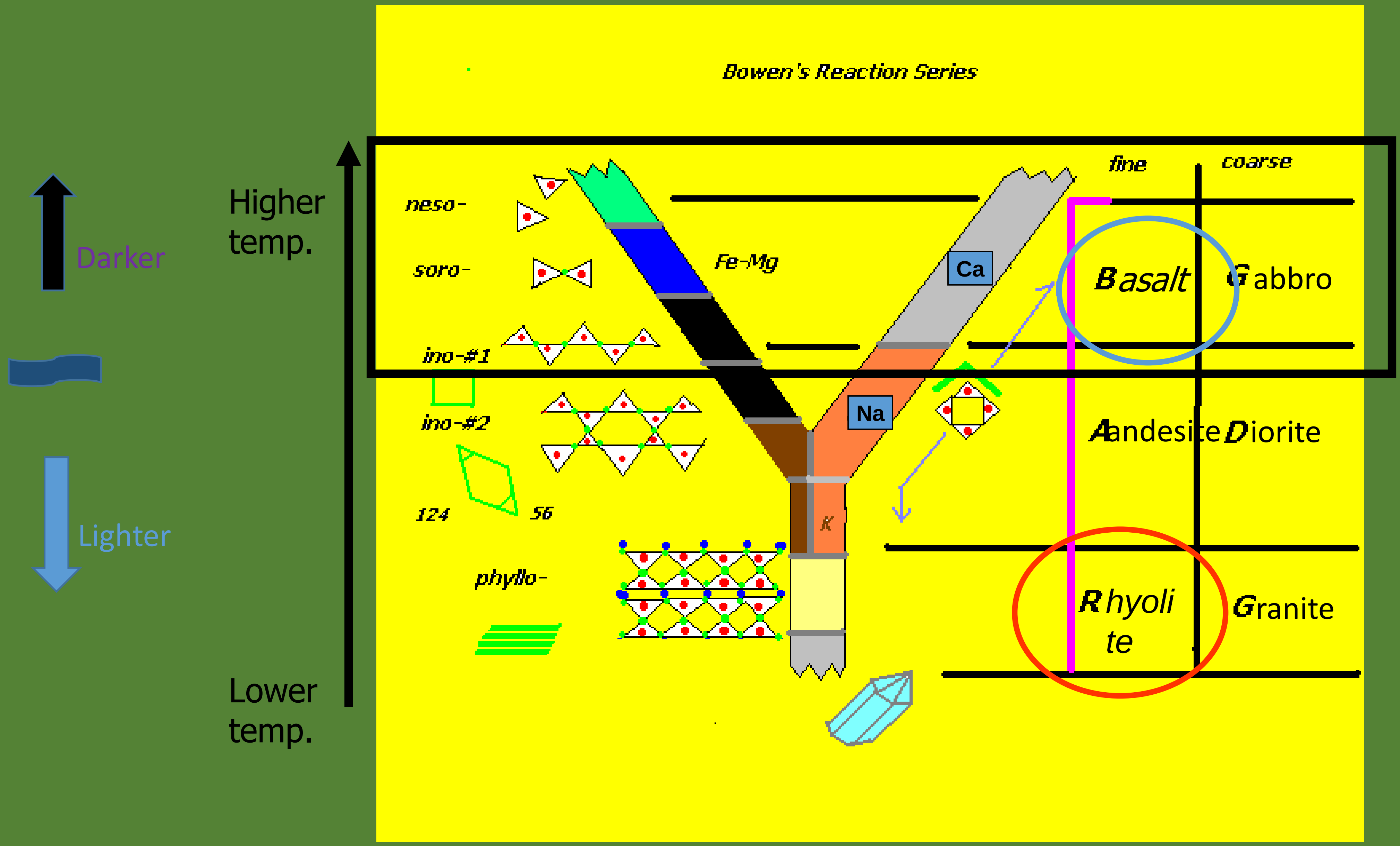
THE ROCK CYCLE

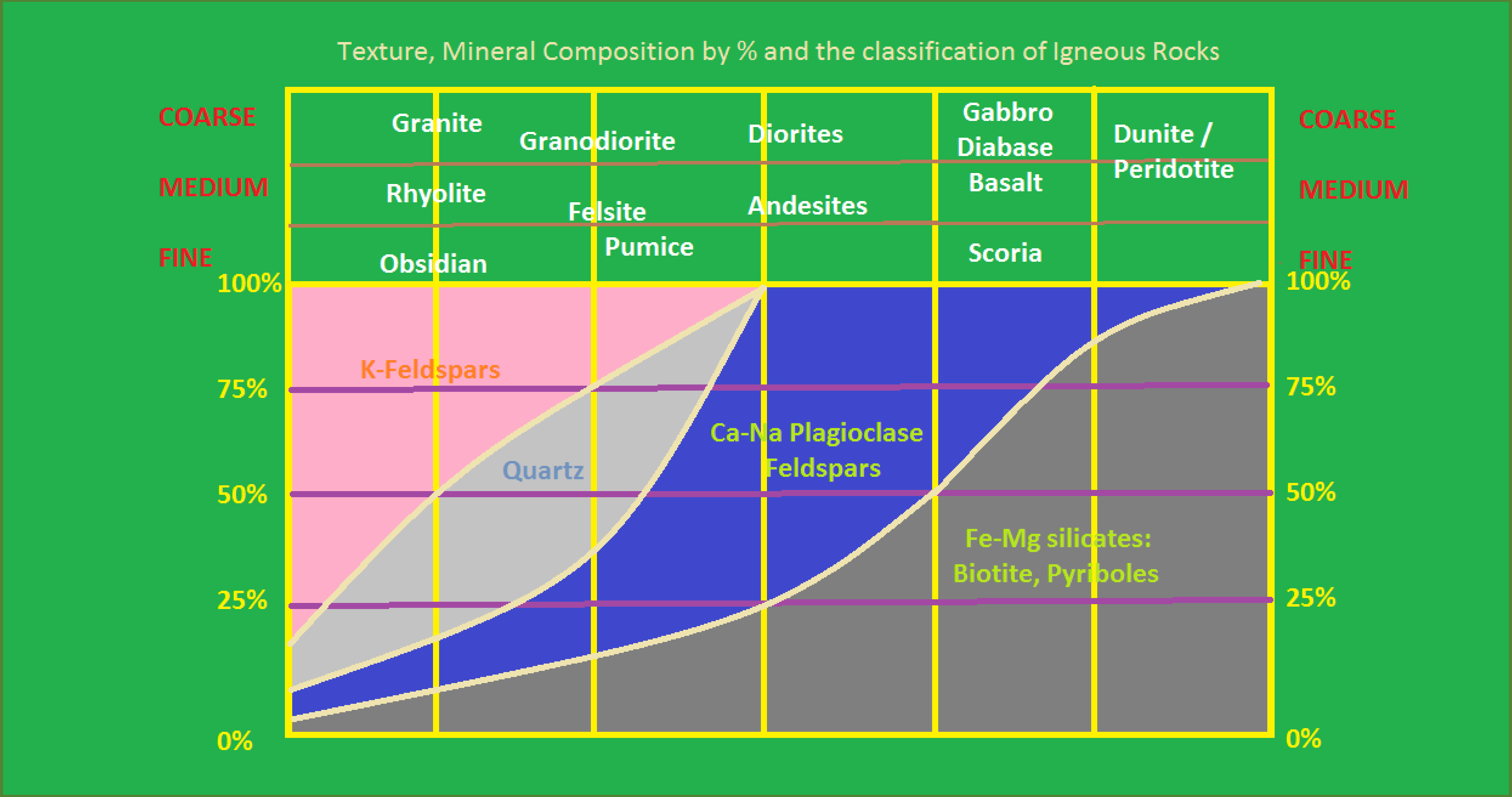


Igneous Rocks

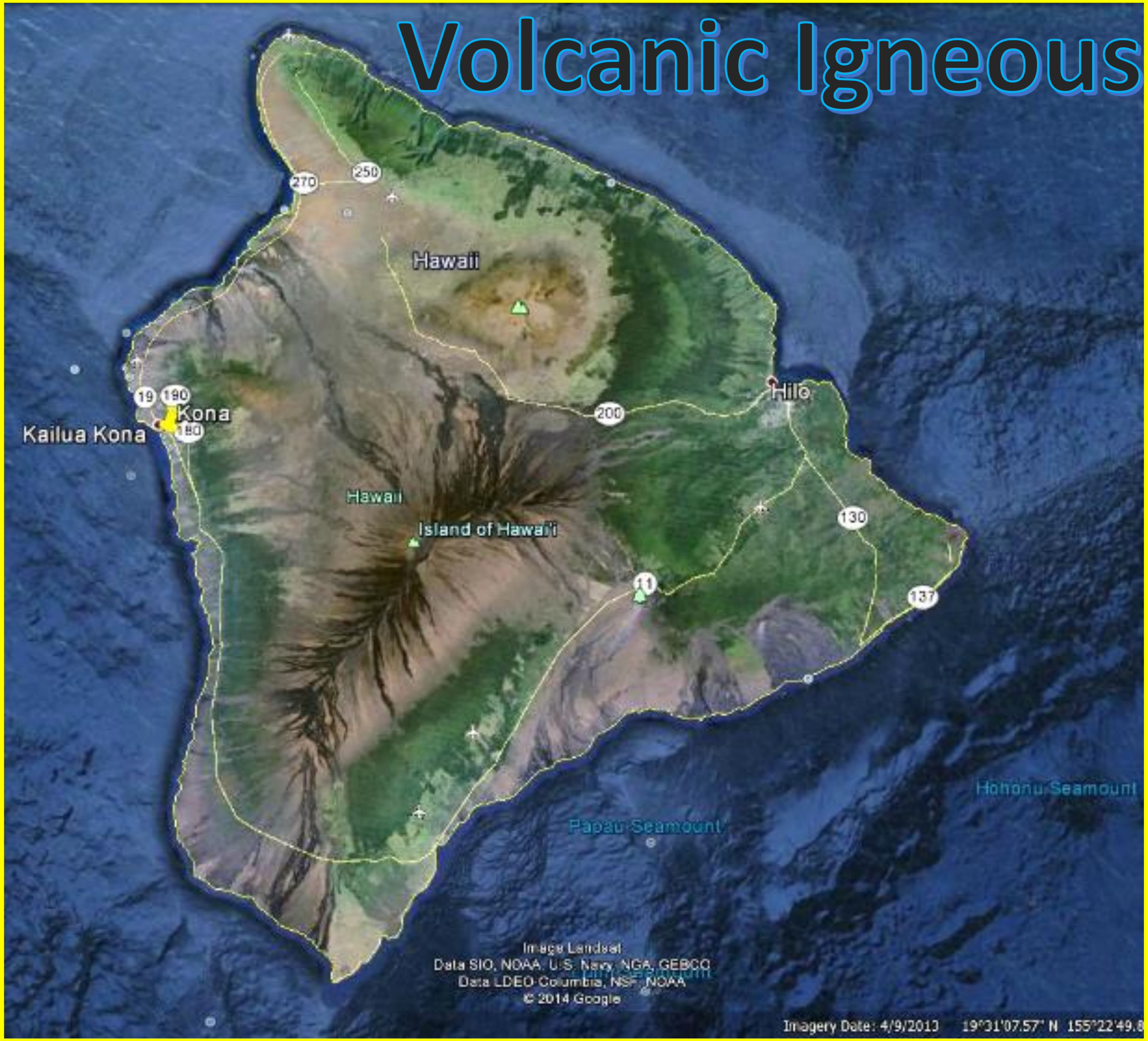
Formed from molten ***Magma*** that may come to the surface as ***Lava***




Darker
Lighter
Higher temp.
Lower temp.
Bowen's Reaction Series
neso-
soro-
ino-#1
ino-#2
124
56
phyllo-
Fe-Mg
Ca
Na
K
fine
coarse
Basalt
Gabbro
Andesite
Diorite
Rhyolite
Granite


Texture, Mineral Composition by % and the classification of Igneous Rocks
COARSE
MEDIUM
FINE
Granite
Granodiorite
Diorites
Gabbro
Diabase
Dunite /
Peridotite
Rhyolite
Felsite
Andesites
Basalt
Obsidian
Pumice
Scoria
COARSE
MEDIUM
FINE
100%
75%
50%
25%
0%
K-Feldspars
Quartz
Ca-Na Plagioclase
Feldspars
Fe-Mg silicates:
Biotite, Pyriboles
100%
75%
50%
25%
0%

Volcanic Igneous Rocks:



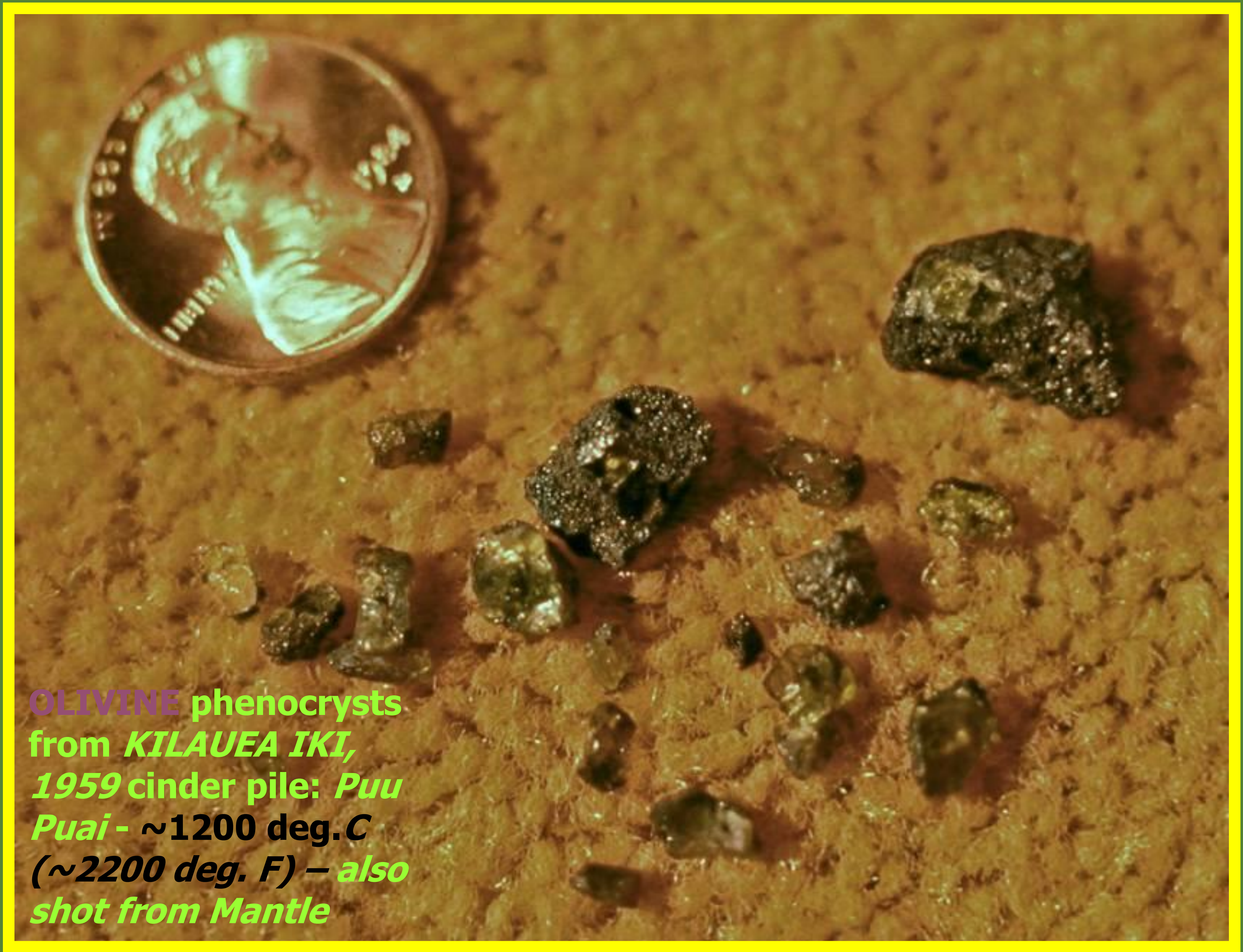
Form at shallow depth or on the surface, cool rapidly, with smaller crystals thus are fine grained

Haleakala, Maui: late stage, post erosional *cinder cones*


PuuPuai 25 yrs later

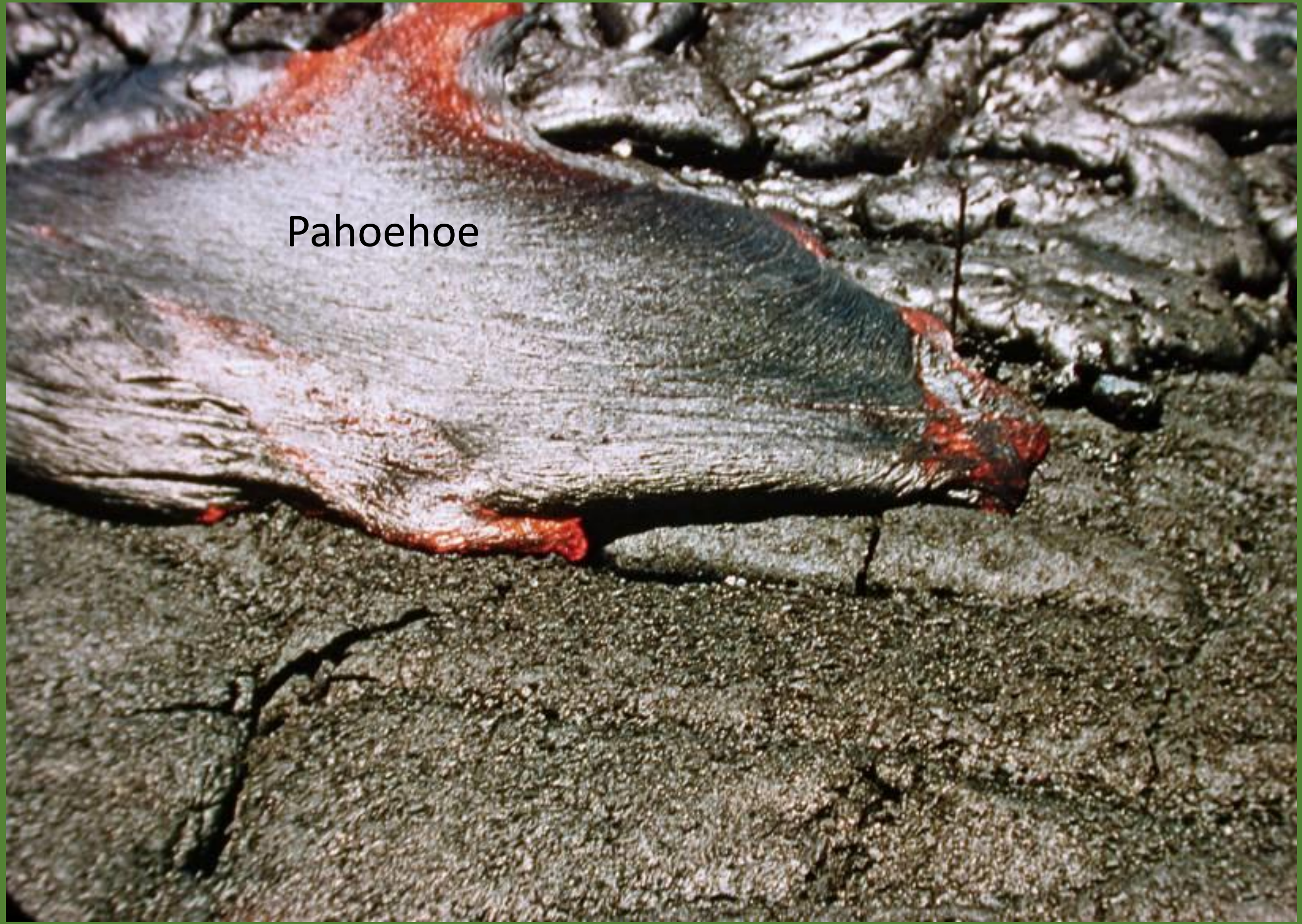

USGS-NPS

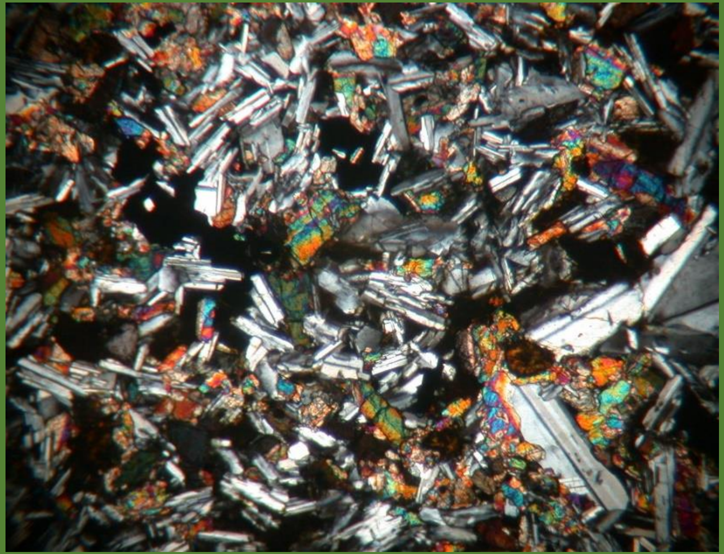

DEVASTATION TRAIL
KILAUEA IKI
IF ONE PERSON DRIVES YOUR CAR AROUND TO PUU-PUAI OVERLOOK, THE REST MAY TAKE THE 15 MINUTE WALK ALONG THE DEVASTATION TRAIL TO MEET IT.


OLIVINE phenocrysts
from *KILAUEA IKI,*
1959 cinder pile: *Puu*
Puai - ~1200 deg.*C*
(~2200 deg. F) – *also*
shot from Mantle

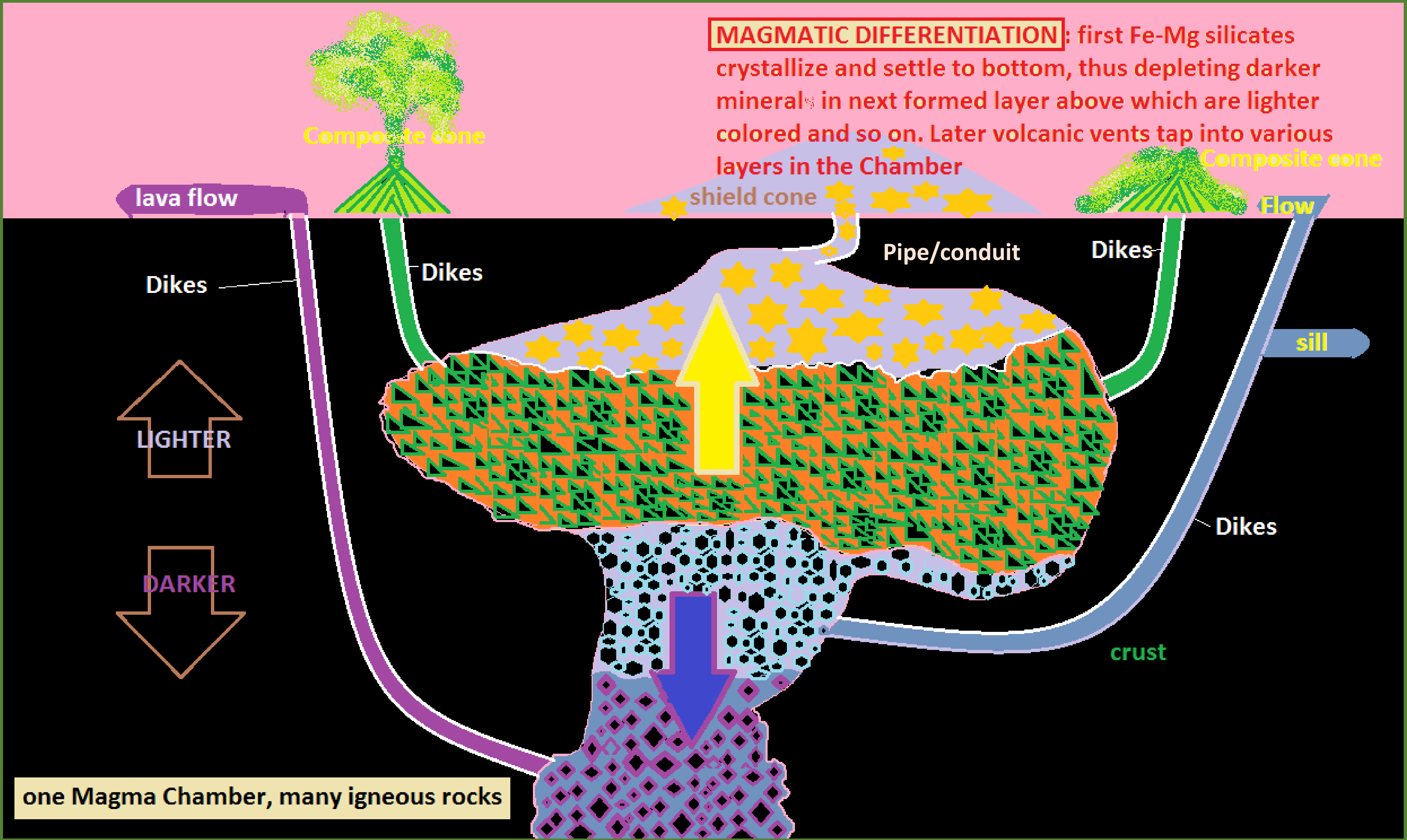
Olivine grains thrown out on Puu Puai '59

Basalt Lava Flows





Hook Mountain **Basalt**, 40X



MAGMATIC DIFFERENTIATION: first Fe-Mg silicates crystallize and settle to bottom, thus depleting darker minerals in next formed layer above which are lighter colored and so on. Later volcanic vents tap into various layers in the Chamber
Composite cone
lava flow
shield cone
Composite cone
Flow
Pipe/conduit
Dikes
Dikes
Dikes
sill
LIGHTER
DARKER
Dikes
crust
one Magma Chamber, many igneous rocks

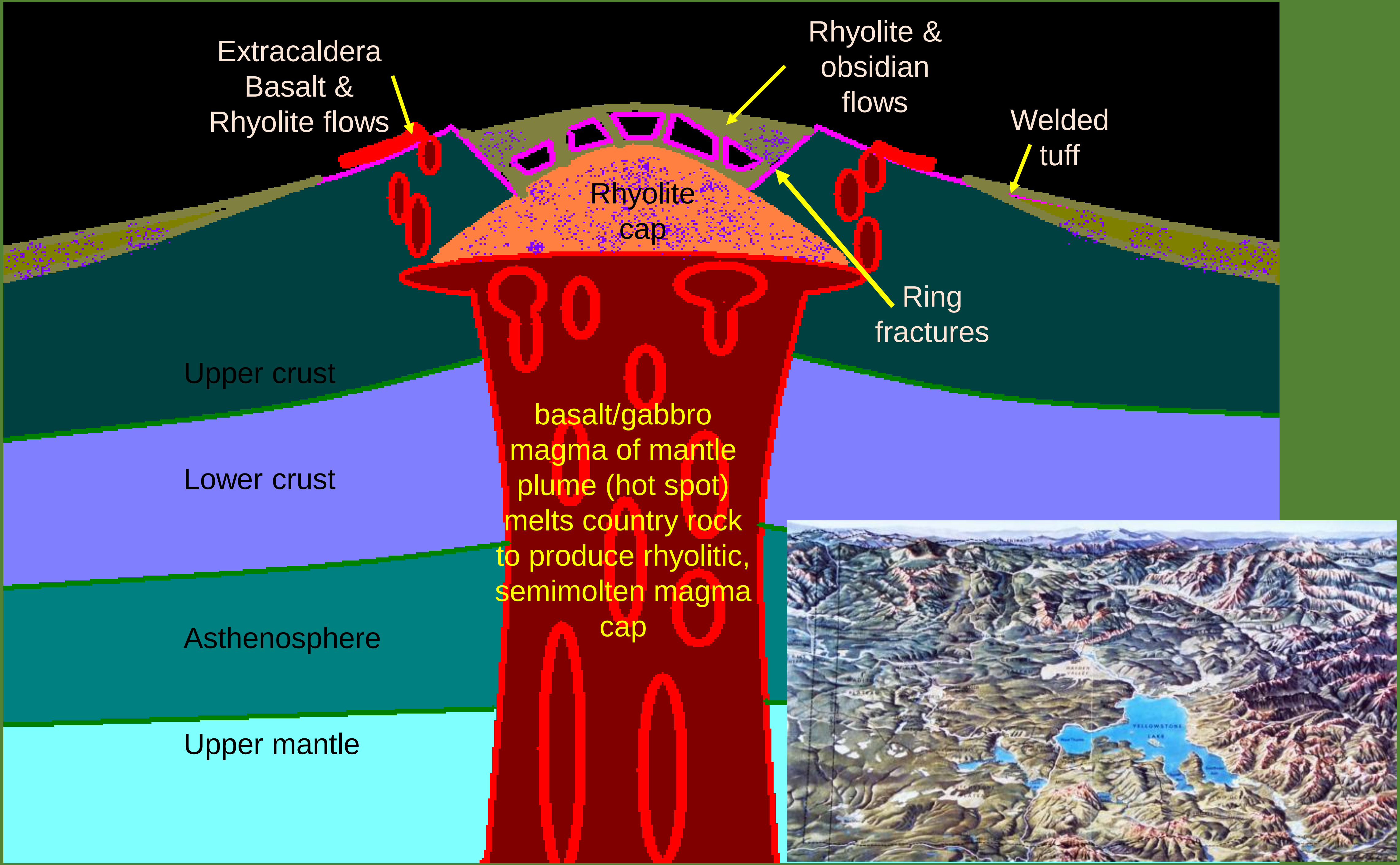
Porphyry – *2* *stages of Cooling : 1 – earlier at greater depth (Coarse) & 2 – one later at shallower depth or surface (Fine)*

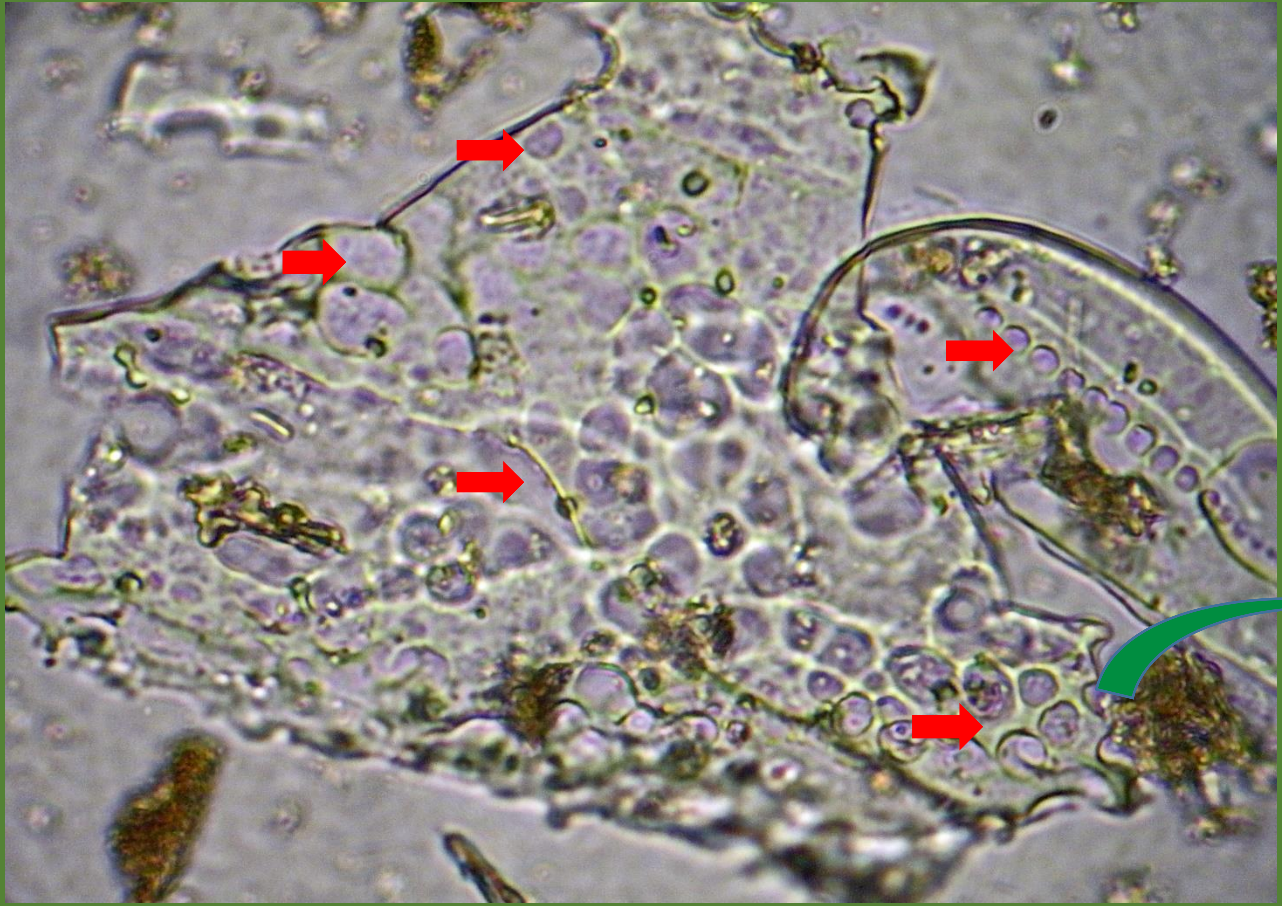
Phenocryst

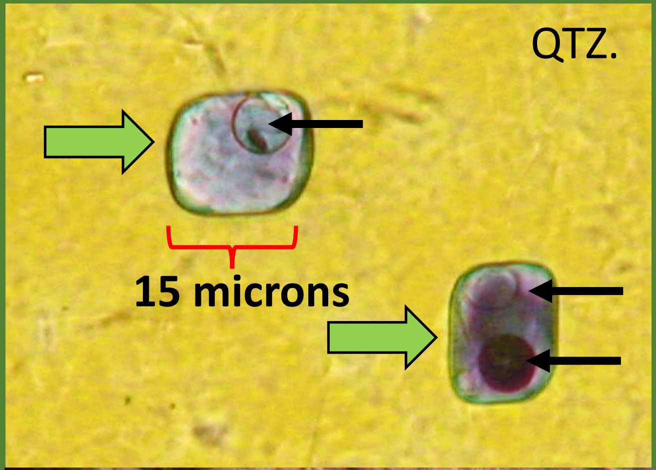
Groundmass or Matrix of typical fine grain Basalt

Late stage Haleakala Ankaramite, Maui, Hawaii

50 mile diameter Yellowstone collapse caldera

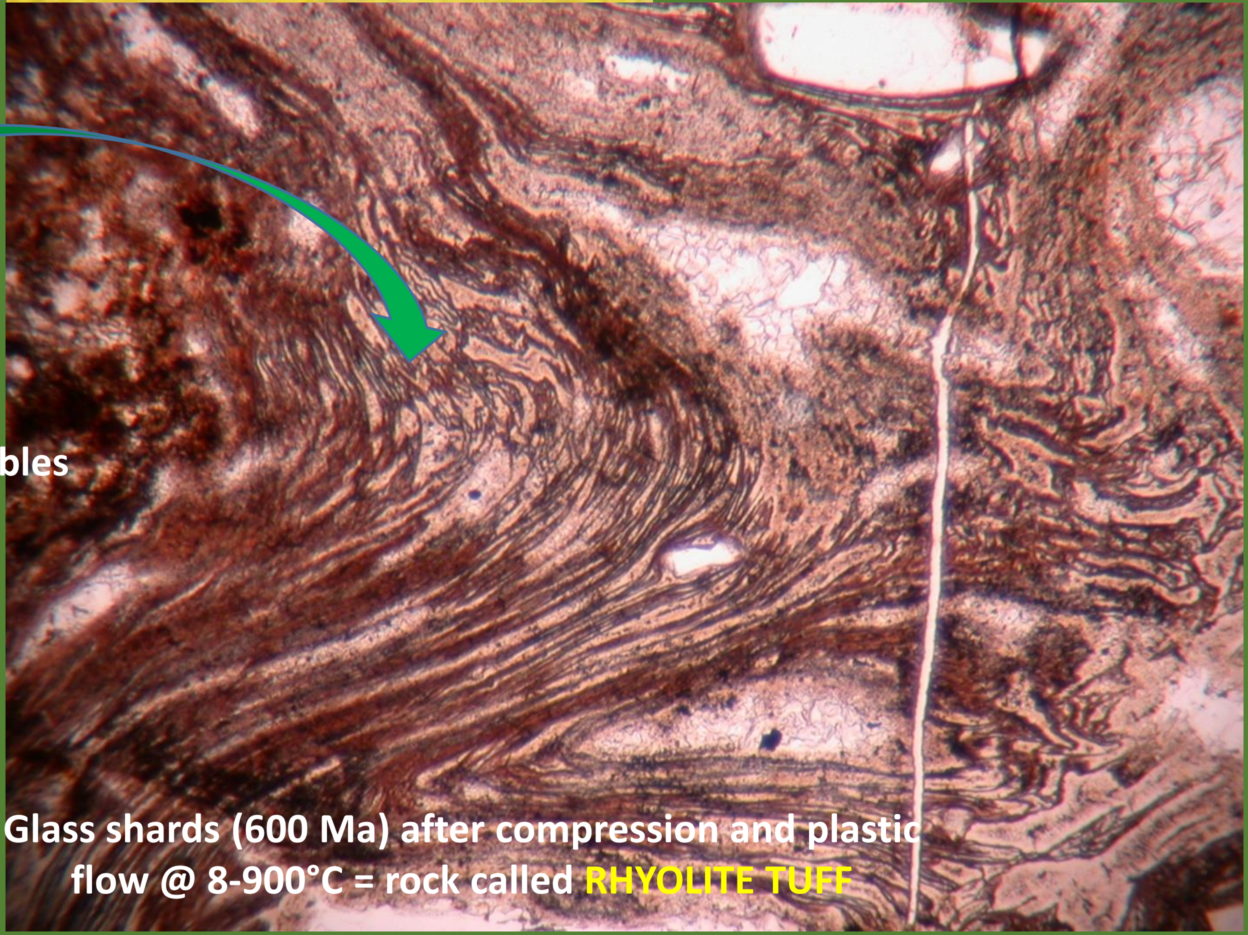


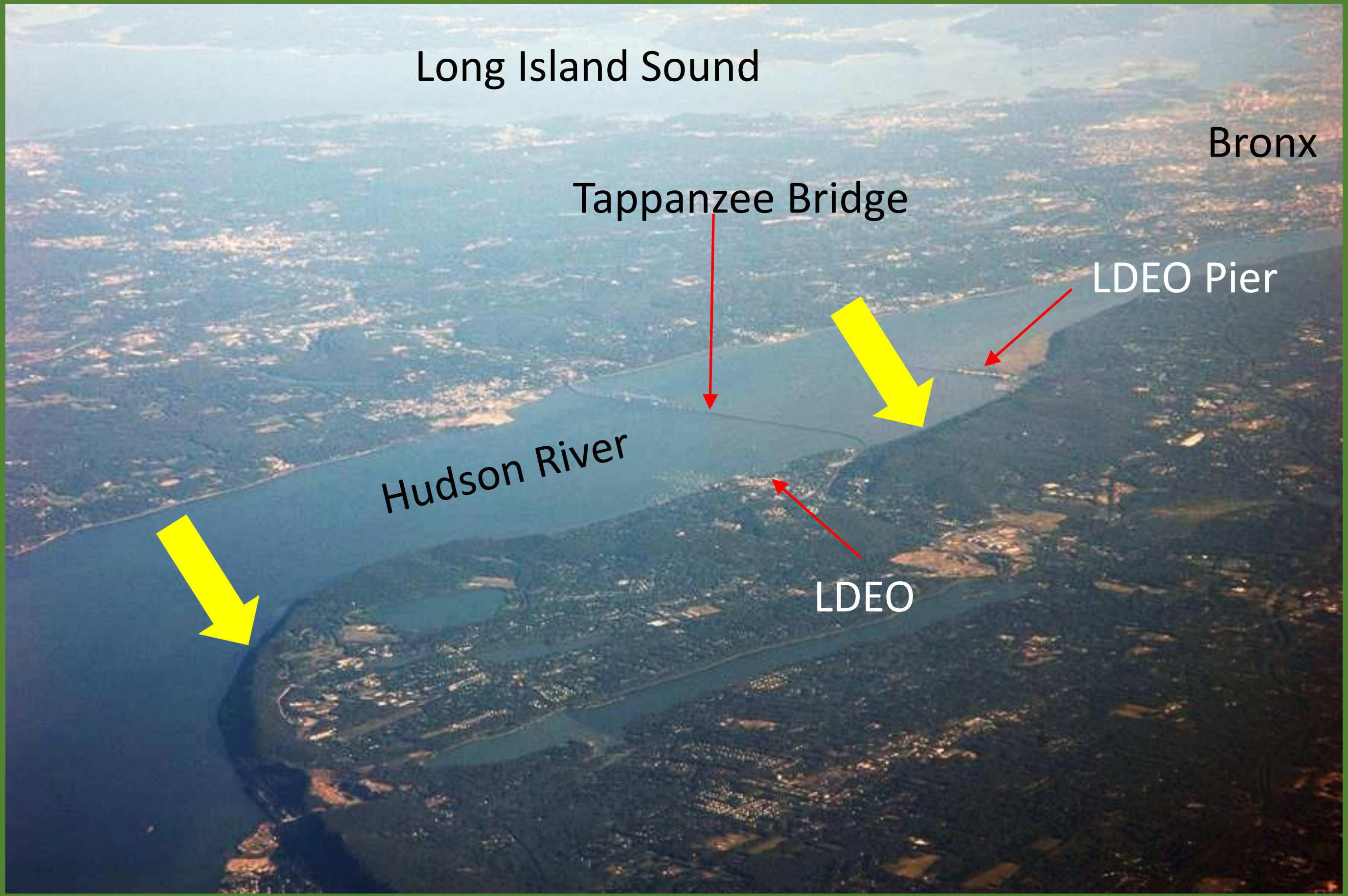


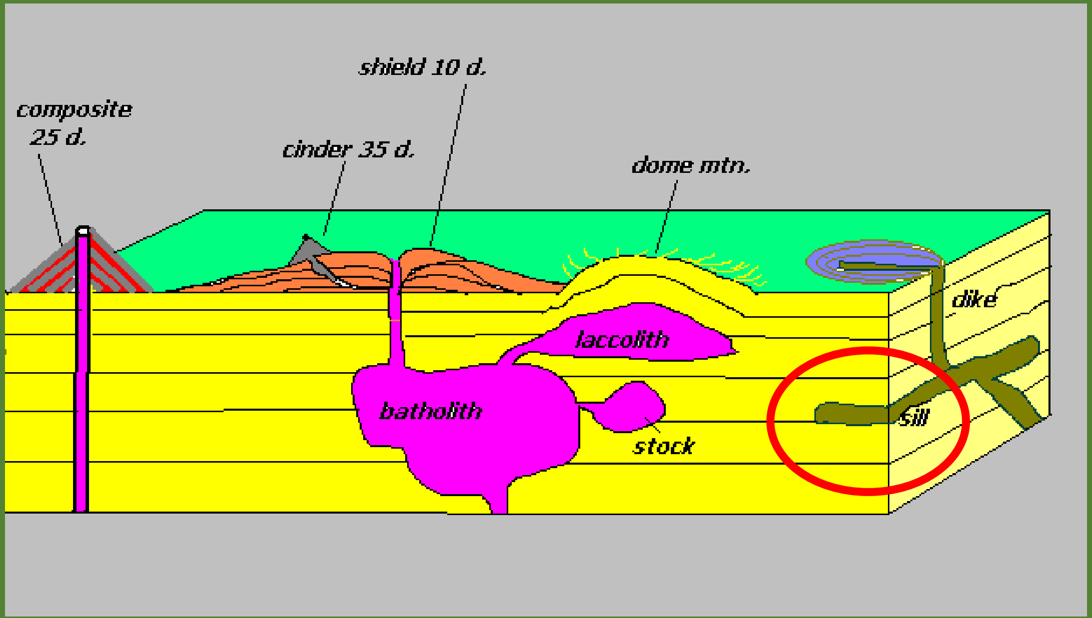


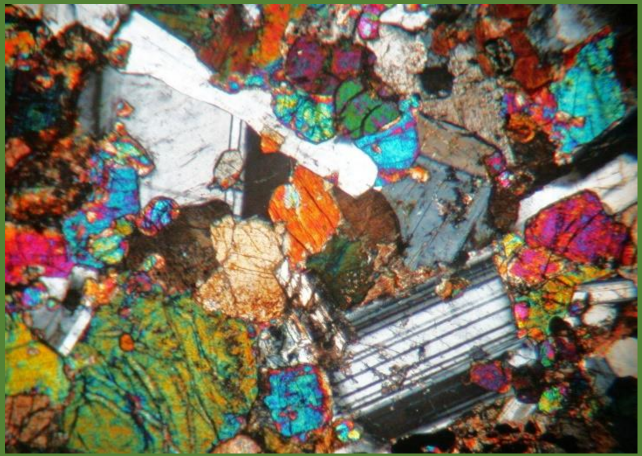
gas & liquid bubbles

Yellowstone eruption (1.2 Ma) volcanic glass shard with gas & liquid bubbles





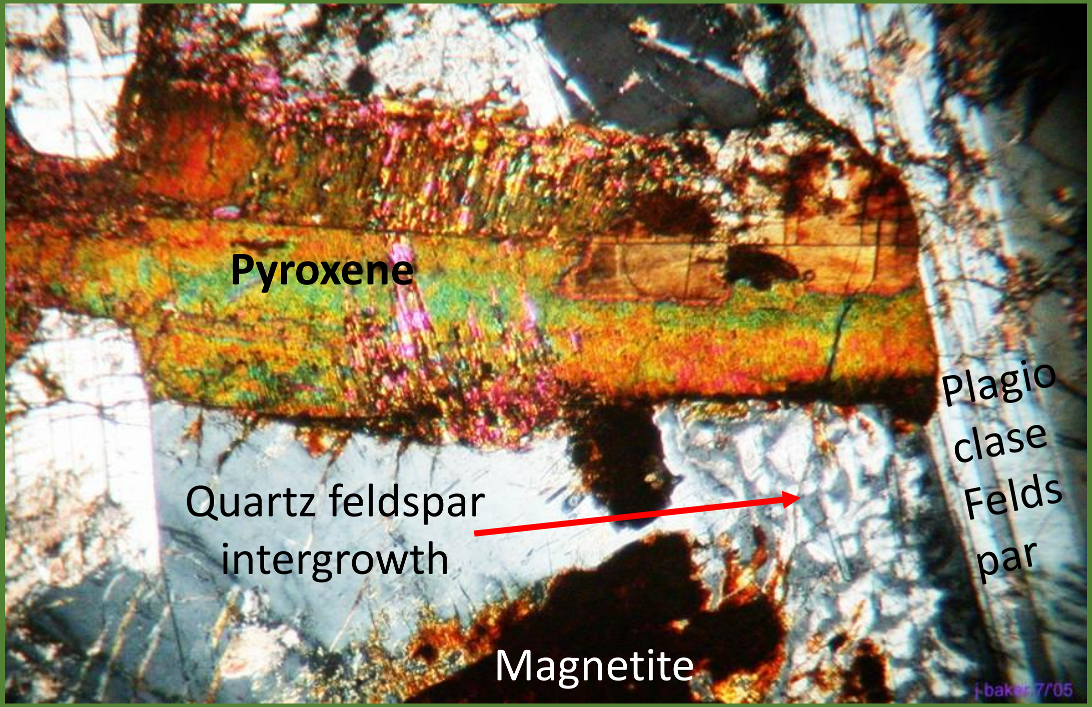


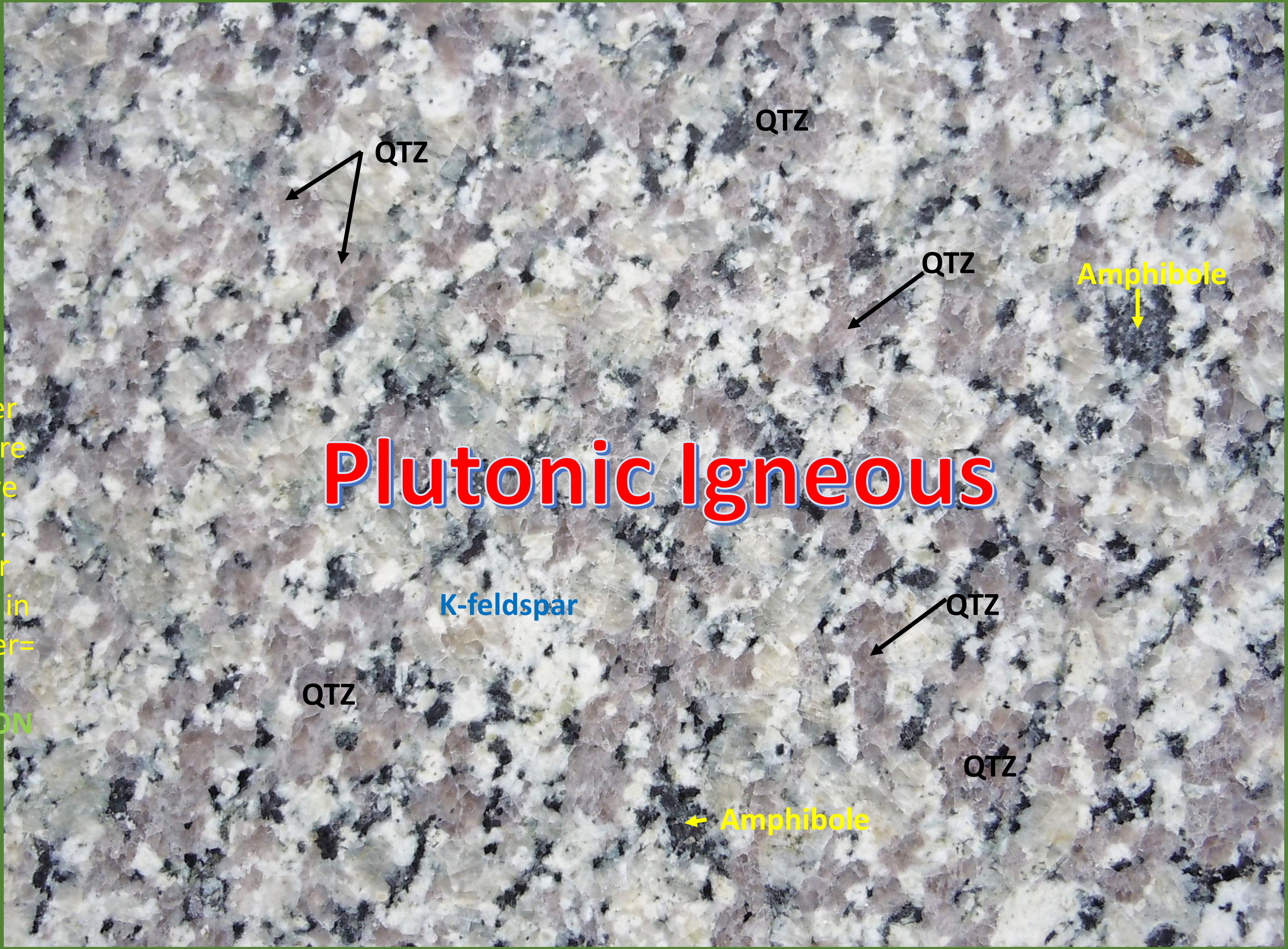


Sill Bottom
OLIVINE

Palisade Sill, NJ

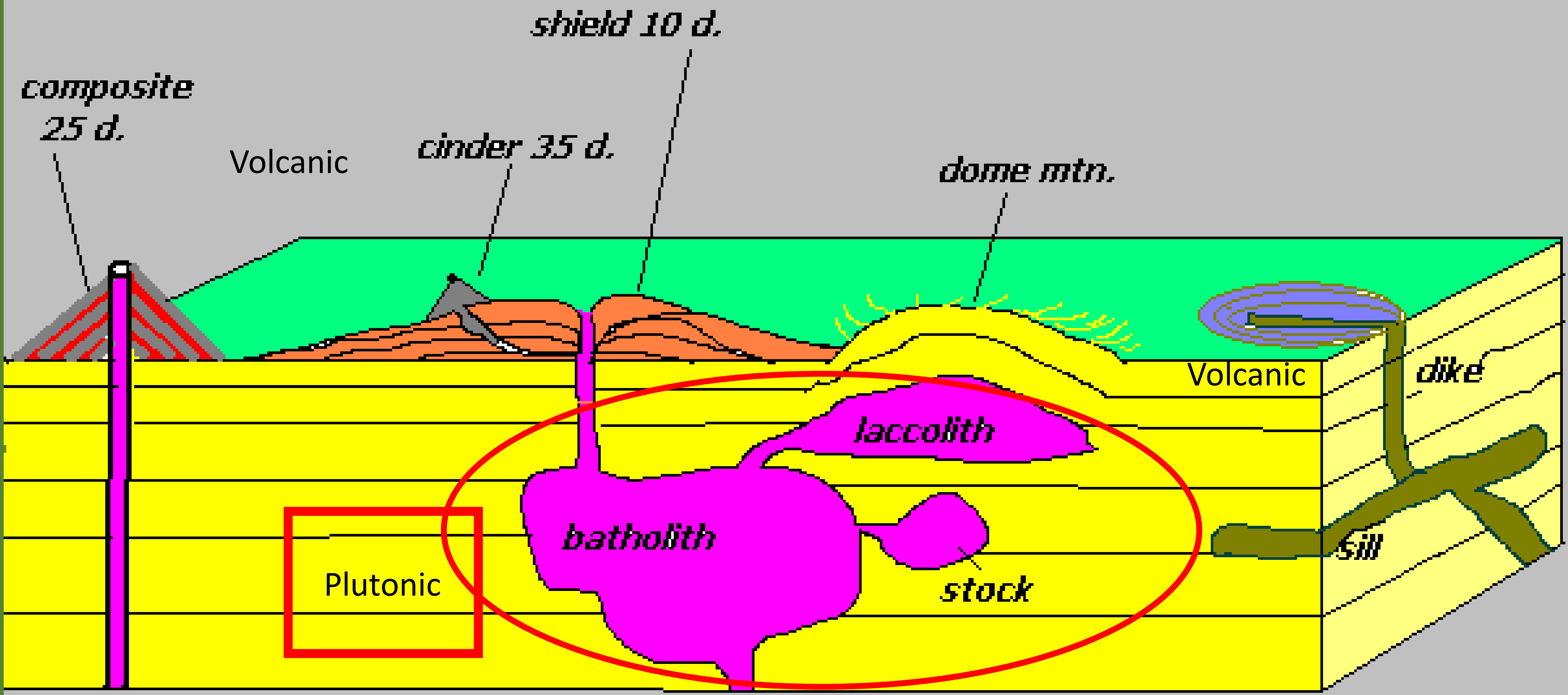
Sill Top





Form @ greater depth, cool more slowly and have larger crystals. Darker, Denser ones settle first in Magma Chamber= **MAGMATIC DIFFERENTIATION**

GRANITE

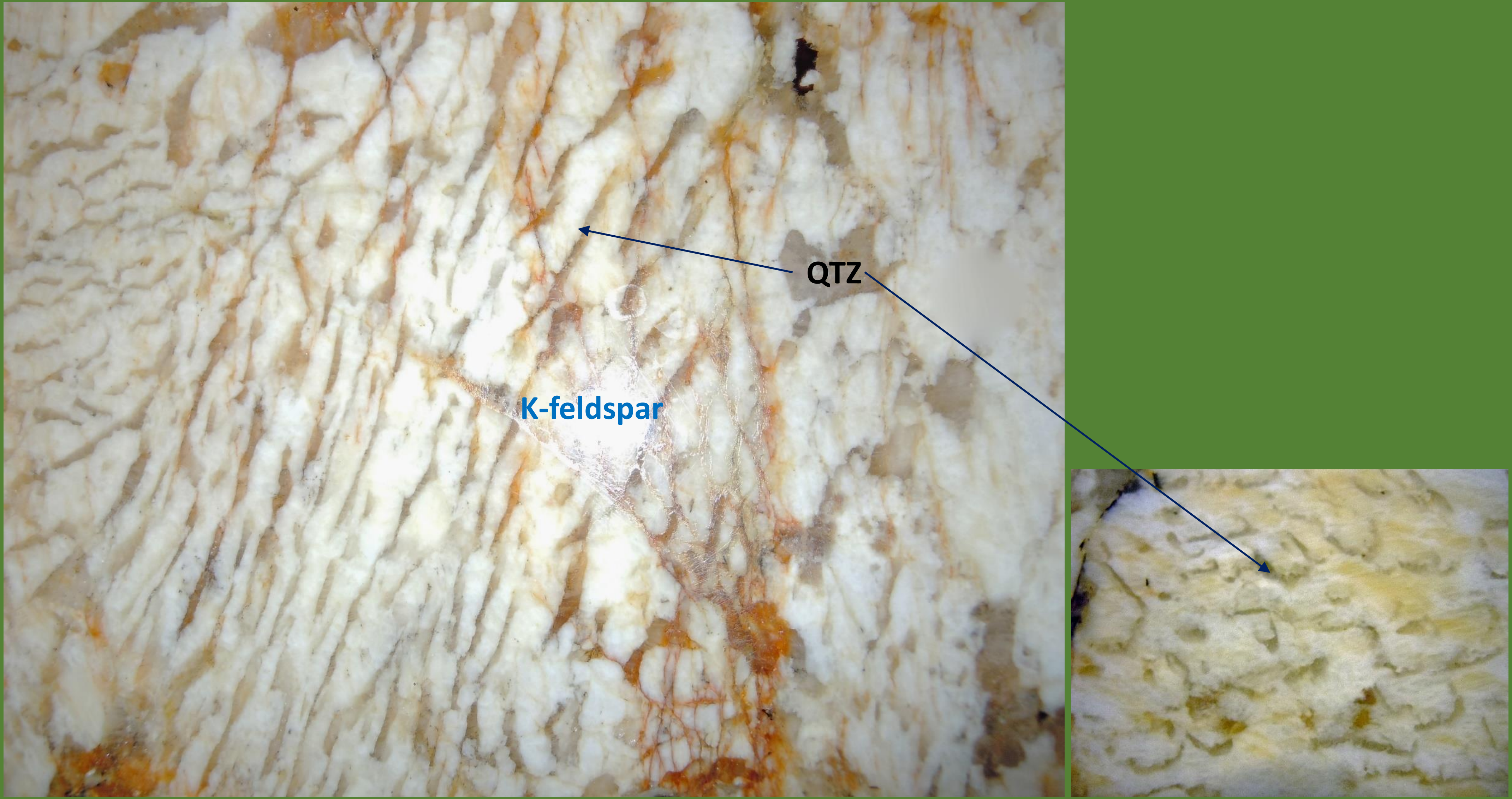


Form @ greater depth, cool more slowly and have larger crystals.
Darker, Denser ones settle first in Magma Chamber= **MAGMATIC DIFFERENTIATION**

Plutonic Igneous Rock

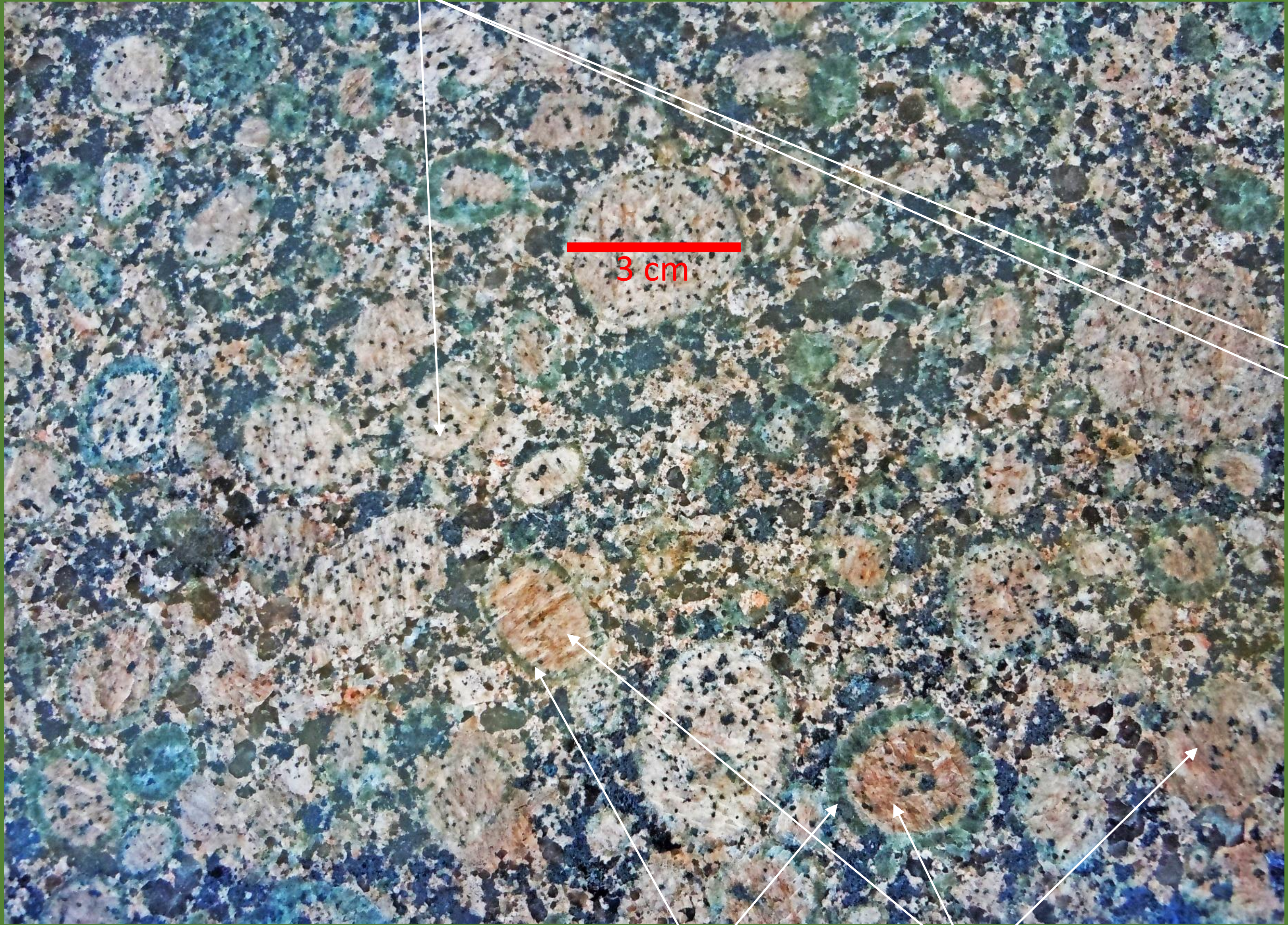
form at depth, cool slower & grow larger crystals (=Coarse grained): *e.g.*. Granite(Light), Diorite(Medium), Gabbro (Dark) depending on how hot the original MAGMA was.

Granite - Graphic Granite



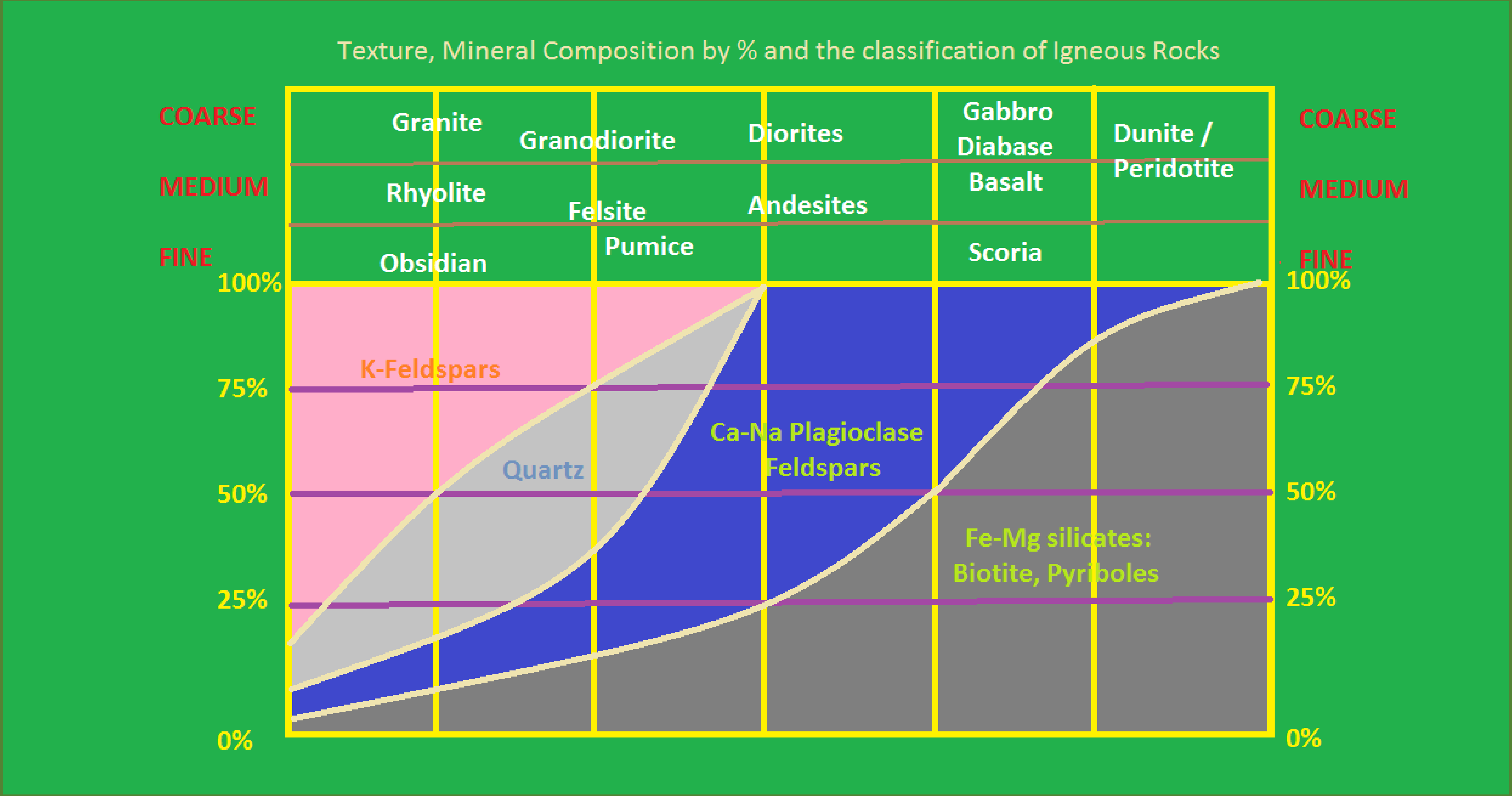
Rapakivi Granite of K-feldspar phenocrysts and dark (magnetite, biotite, pyriboles) groundmass – rising and falling of growing crystals in large, deep magma chamber followed by settling at bottom of chamber

Note concentric inclusions



Plagioclase Feldspar Exsolution rim

Reddish Potassium Feldspar core



Texture, Mineral Composition by % and the classification of Igneous Rocks
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Granodiorite
Diorites
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Peridotite
Rhyolite
Felsite
Andesites
Basalt
Obsidian
Pumice
Scoria
COARSE
MEDIUM
FINE
100%
75%
50%
25%
0%
K-Feldspars
Quartz
Ca-Na Plagioclase
Feldspars
Fe-Mg silicates:
Biotite, Pyriboles
100%
75%
50%
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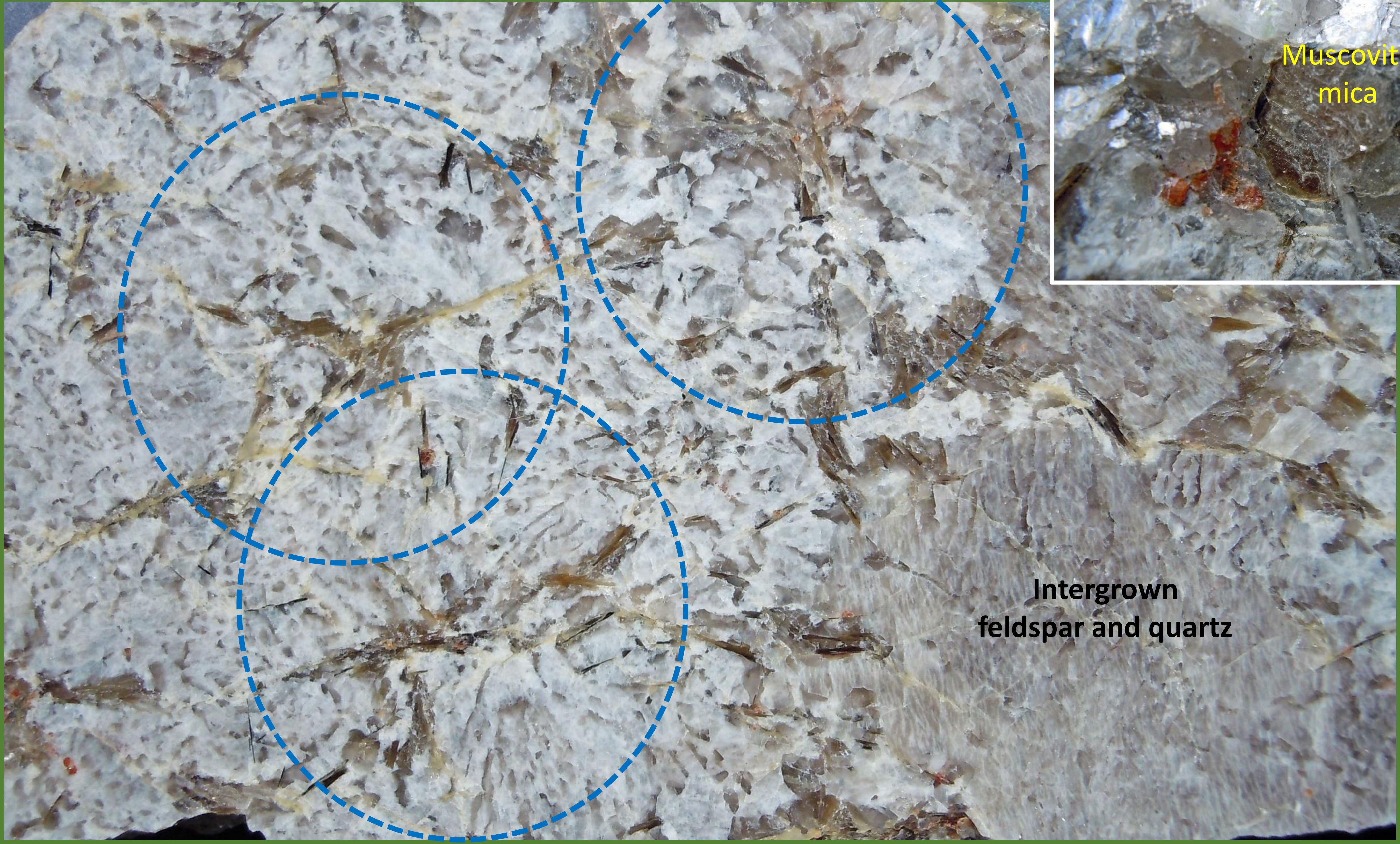
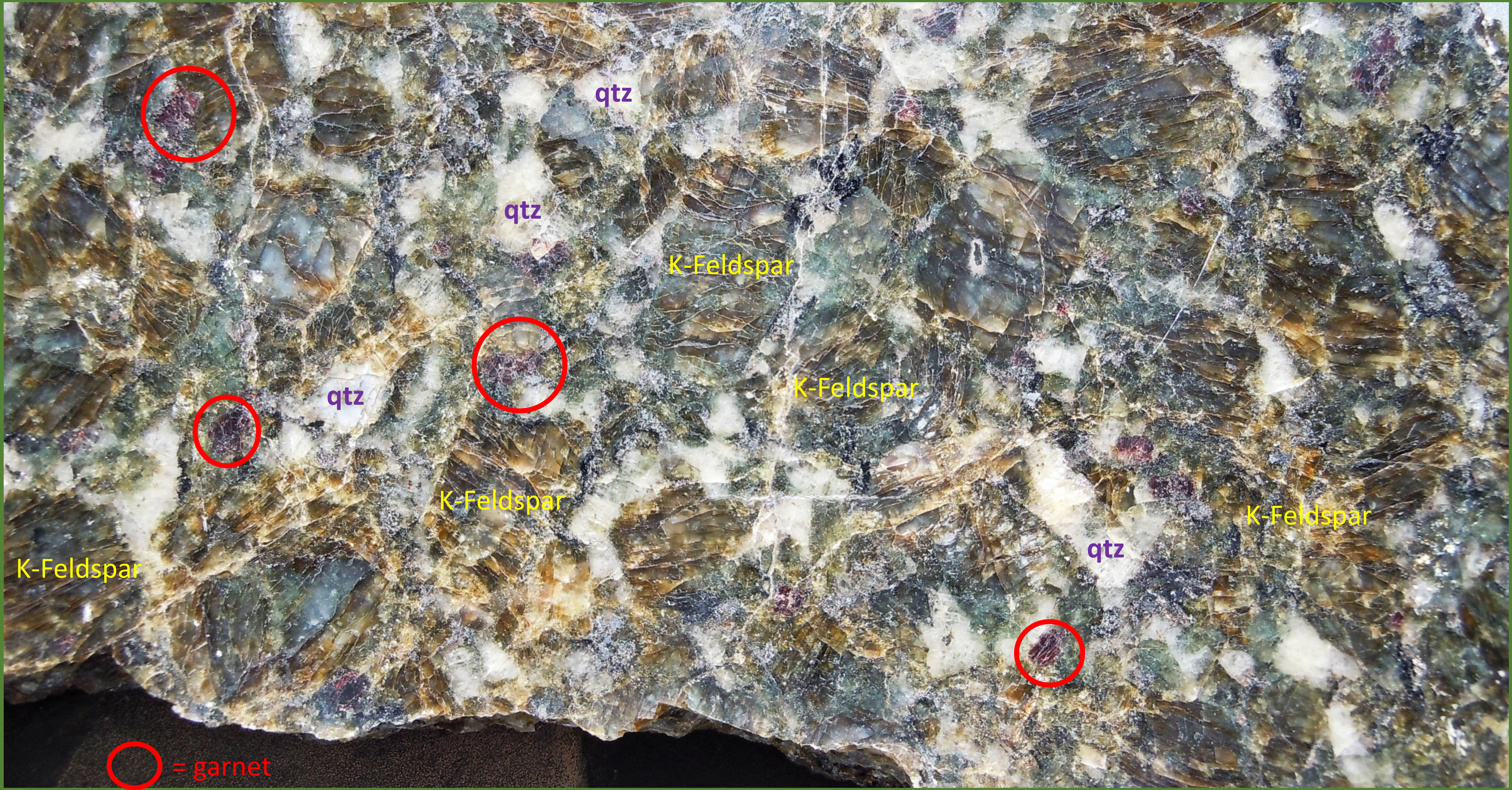
0%


Intergrown
feldspar and quartz

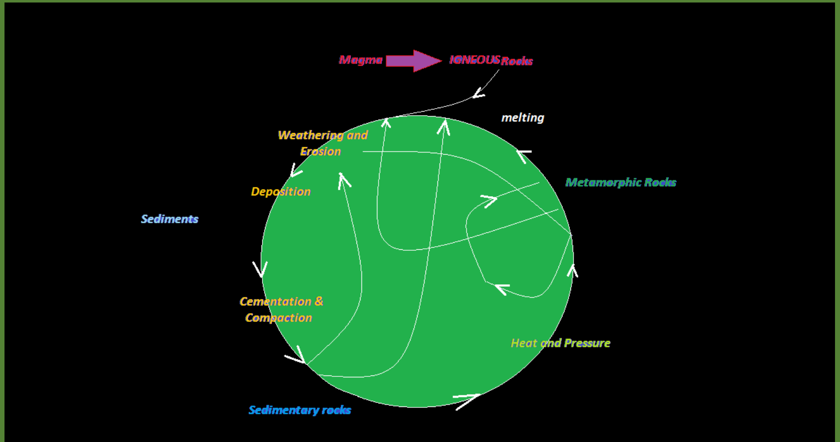

Muscovite
mica

Coarse Grain, slow cooling @depth, mica/ feldspar/quartz/ garnet



SEDIMENTARY ROCKS:

1 - <u>Clastic</u> particles of pre-existing rocks (size: *clay, silt, sand, cobbles and boulders*)weathered and eroded (moved) by gravity, rivers, glaciers, wind, waves, currents and deposited by gravity in *horizontal* layers with older strata on the bottom and progressively younger on top. Grains are then compressed by overlying sediment, or cemented together by Calcium Carbonate, Silica or Quartz , Iron Oxides, etc.



Remember the rock cycle

SEDIMENTARY ROCKS

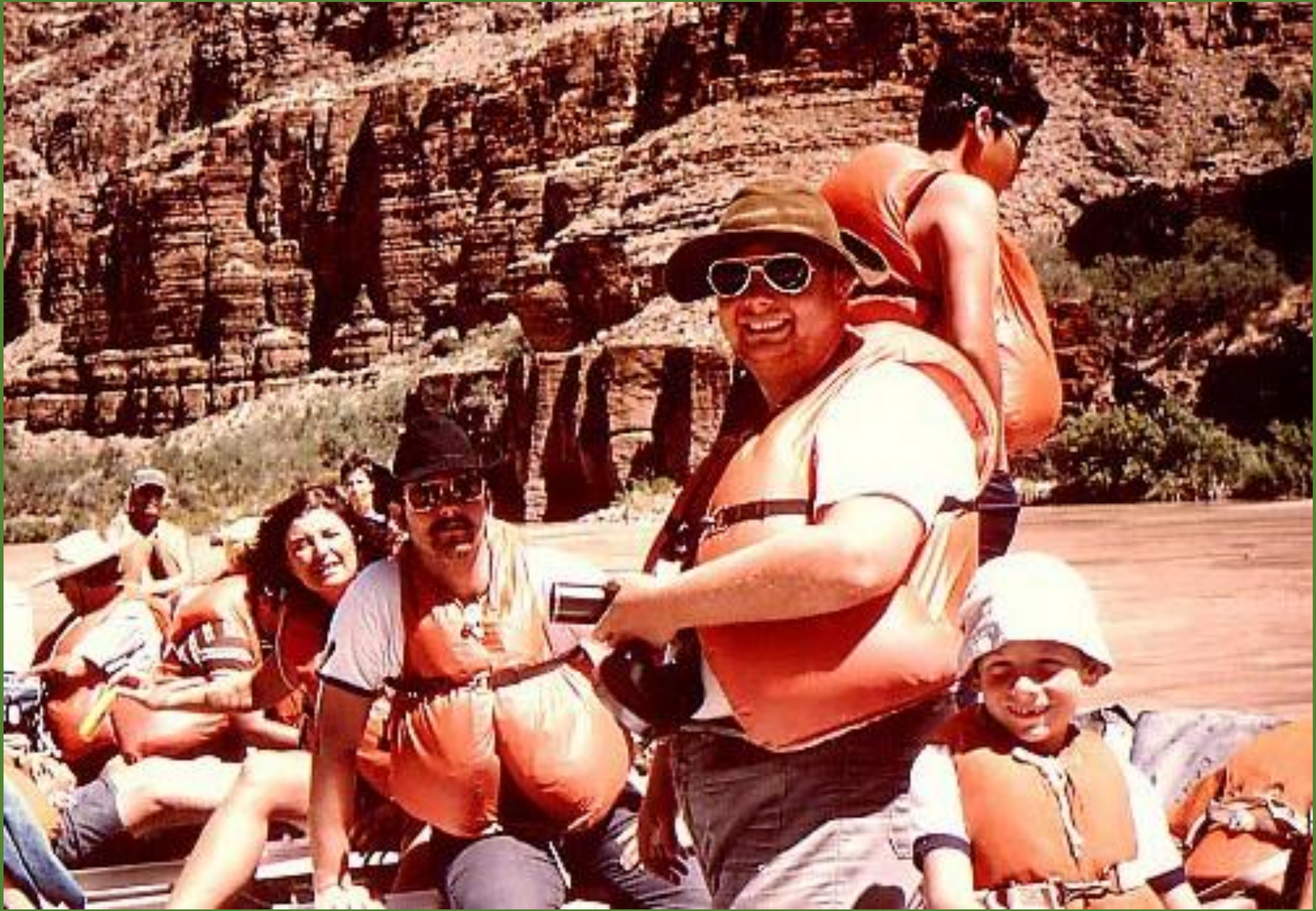
Grain or 'Clast' size:

Clay 1-4 microns
Silt 5-67 microns } Mud, Mudstone or Shale

Sand 68-2000 microns or 2 mm — Sand or Sandstone

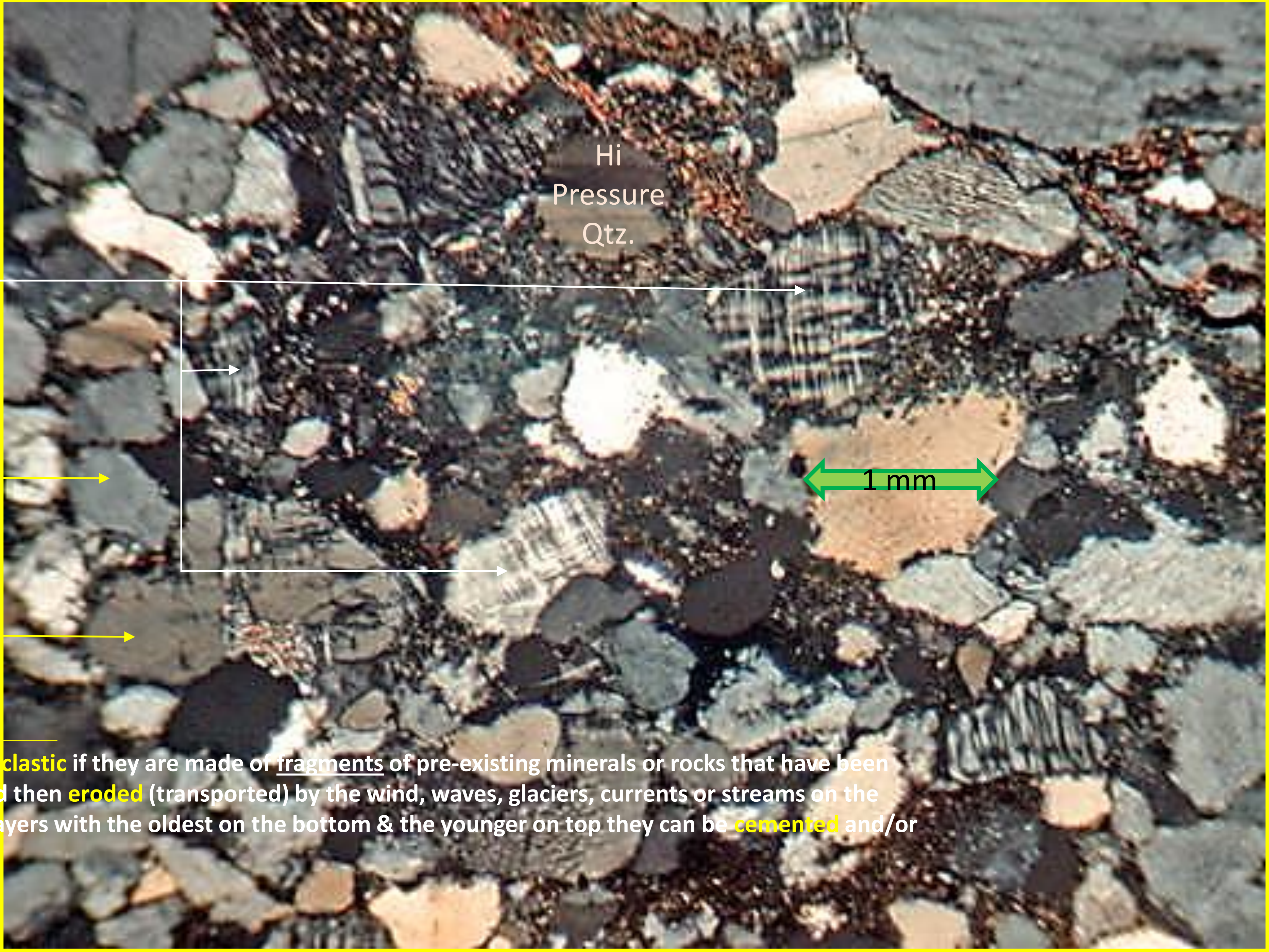
Pebbles
Cobbles
Boulders } Conglomerate(if angular= Breccia)

1973
7 day
GRAND
CANYON
raft trip



Sandstone cemented with fine compacted clay: 1- source was near because grains are angular; 2- source was a granite because the 2 minerals are K-Feldspar and Quartz

Note : coarse grains=near source; angularity = very near; minerals tell us source was a granite or gneiss; poor sorting = rapid deposition



Sediments an sedimentary rocks are clastic if they are made of fragments of pre-existing minerals or rocks that have been weathered (chemical or physical) and then eroded (transported) by the wind, waves, glaciers, currents or streams on the earth's surface. When deposited in layers with the oldest on the bottom & the younger on top they can be cemented and/or compacted into Clastic Sed. Rock.:

Mud → MUDSTONE, SHALE

Sand → SANDSTONE

Pebbles → CONGLOMERATE

ORGANIC or BIOGENIC SEDIMENTS: swamps with plant debris (are filled and later drained and the overlying sediments compact the "Peat" into Lignite, then Bituminous Coal and if metamorphosed into Anthracite coal; Oil and Natural Gas are organic also and easily migrate through pores in sedimentary rocks. Shells can accumulate to form Limestone.

Bituminous coal in West Virginia

Surface mine for *Anthracite* *Coal* (metamorphosed coal) in Folded Appalachians of eastern Pa.: note luster

ORGANIC SEDIMENTS: Coal, Oil and natural gas

EVAPORITES: dissolved minerals in water slowly precipitate out and sink in layers on the sea floor, accumulating as layers of *Salt* , *Gypsum* and in Florida – *Phosphate;* especially in tropical to sub tropical areas

Fertilizer

Sheet Rock

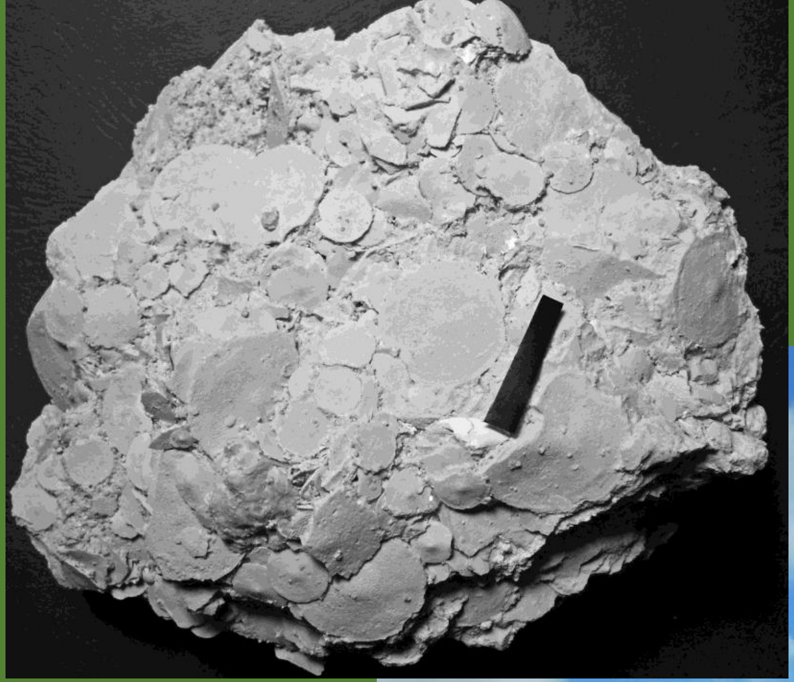
Deep salt (NaCl) mines under Lake Erie

Note layering

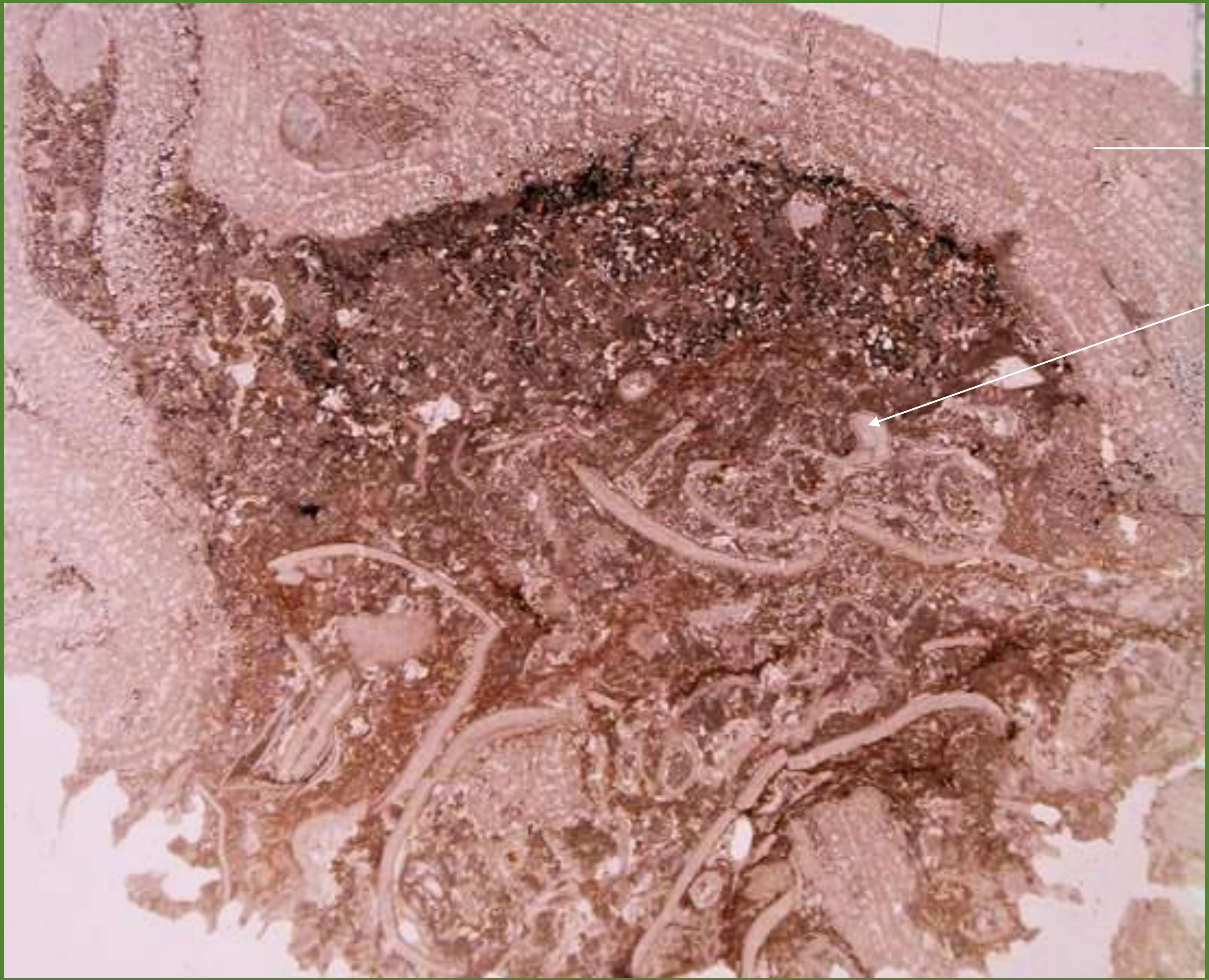

Layers of mollusk shell (clams and snails) in Lakewood Ranch off of University Ave

<u>*Coquina*</u> (shell hash, lightly cemented by $CaCO_3$) as in St. Augustine (Castillo)

Ocala Limestone (34 MYA)




Limestone
(400 MYA) NJ



Shell debris encrusted with a sponge

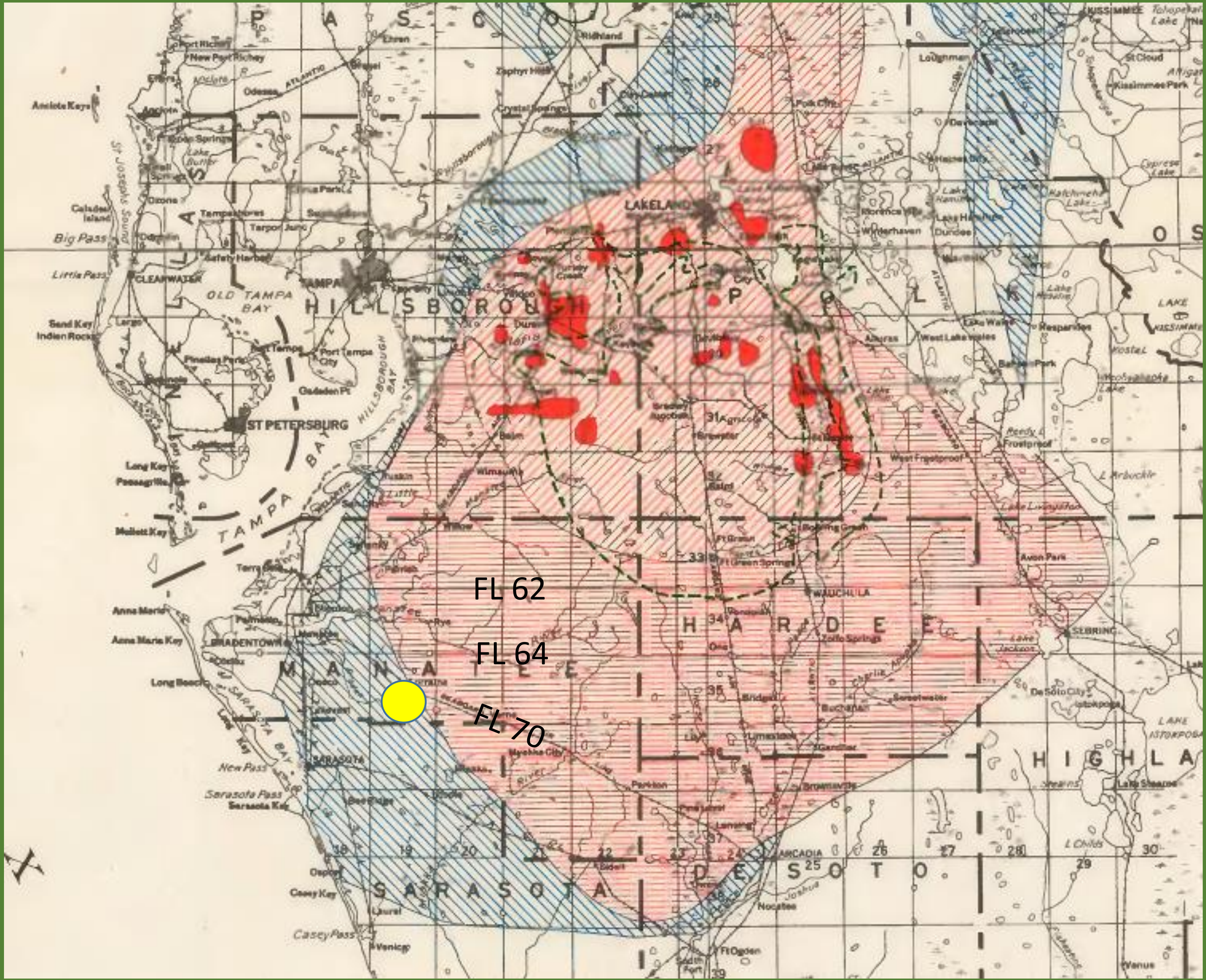
Limestone (400 MYA) NJ

Mosaic Mine

Water jets convert buckets of ore to be pumped as a slurry in pipes to *beneficiation* plant

Mansfield-USGS-1942-B934

Late Miocene
Bone Valley
Mbr.



Phosphate ore in our area

radioactive

Francolite + Sulfuric Acid → Gypsum Stacks + Phosphoric Acid

$$\mathrm{Ca_3(PO_4)_2 + 3H_2(SO_4) \rightarrow 3Ca(SO_4) + \boxed{2(H_3PO_4)}}$$

heat

$+\ NH_3$

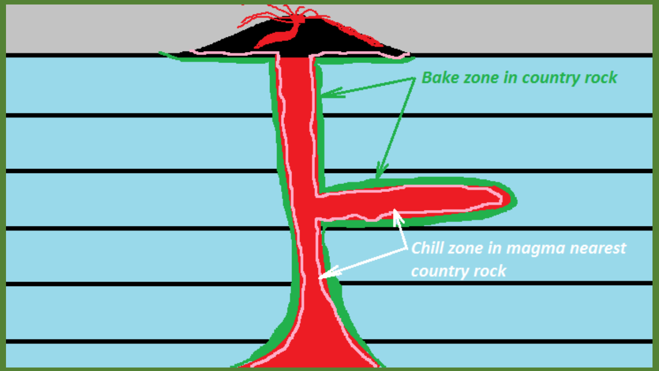
Anhyhydrous Ammonia

DAP	&	MAP
18-40-0		**10-50-0**
N- P –K		**N- P -K**
diammonium phosphate		**monoammonium phosphate**

Ammonium Phosphate

Chemical Formula (a ‘double-replacement reaction’) for Phosphate Production in Florida

Metamorphic Rocks: altered pre-existing rocks of any kind that are altered by heat or pressure or both. Usually at great depth where one plate hits and is thrust under another.



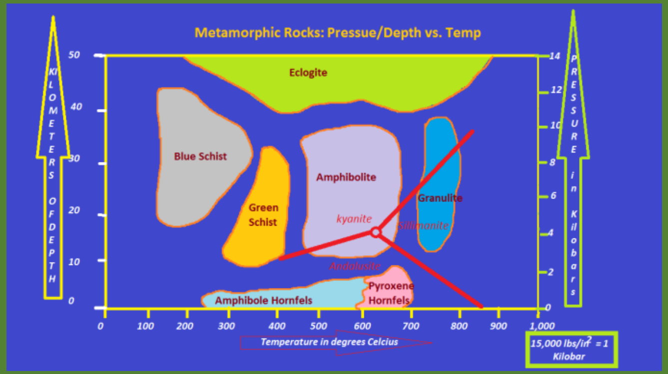
Small area

1) Heat only – *Baking* as when lava or magma bake the rock they pass through or over

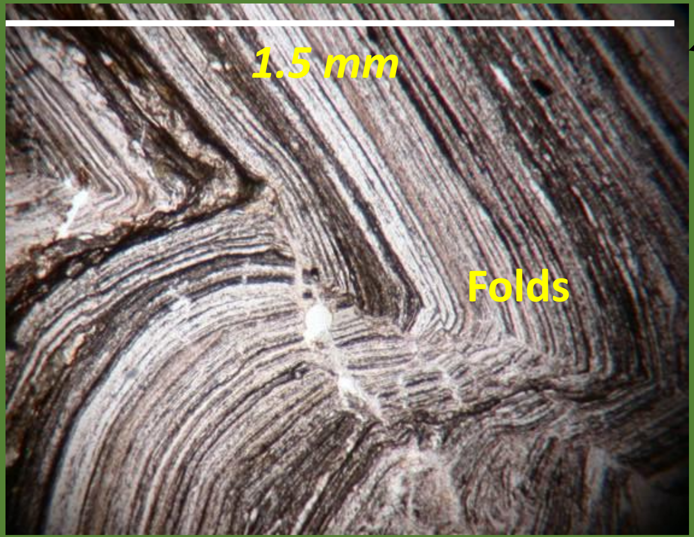
2) Pressure only – when rocks slip passed one another as in a *fault*

Large area

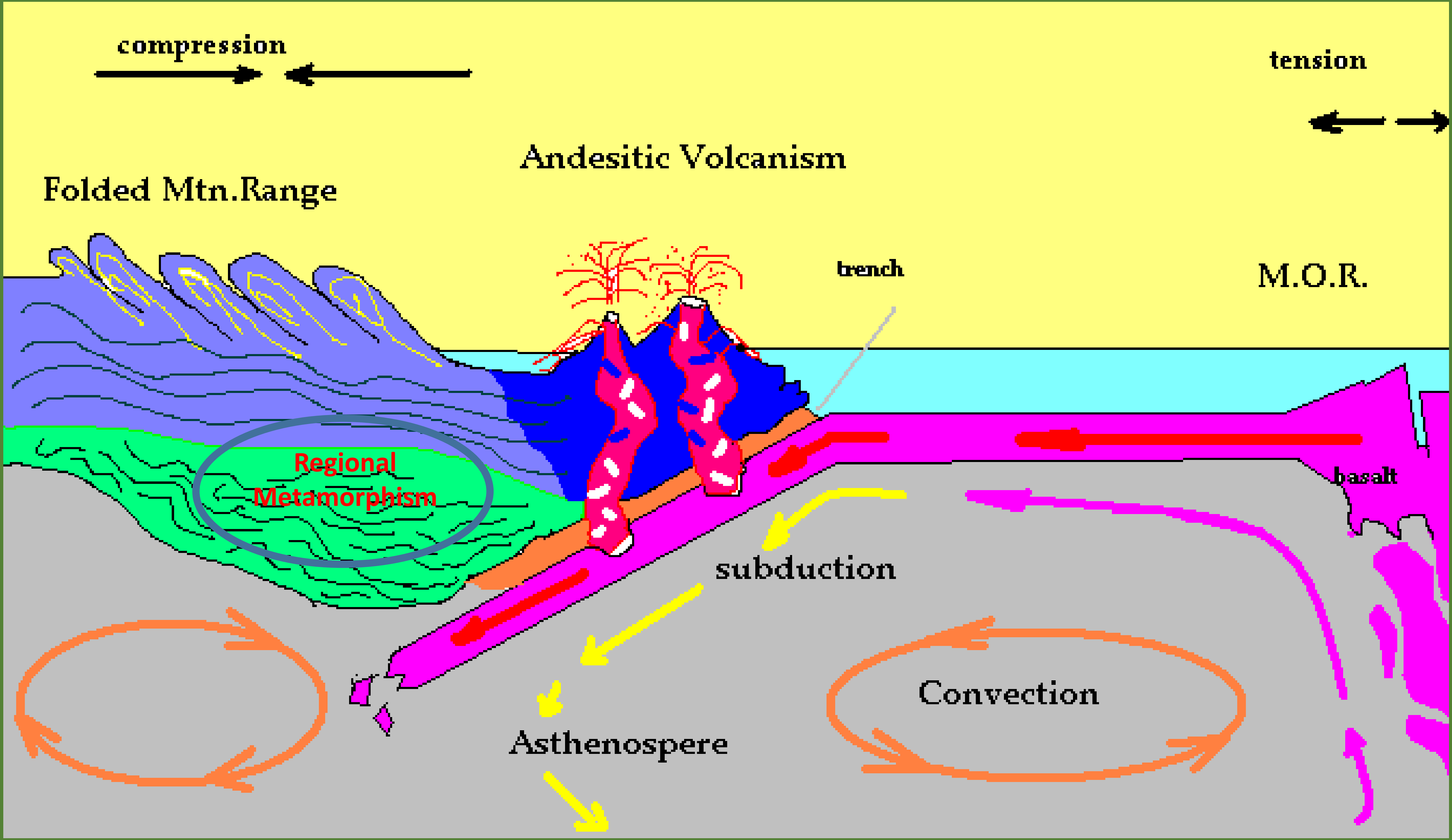
3) Heat and Pressure together: as when large areas of the crust are subducted to great depths – minerals are compacted together and grow larger, dark and light colored minerals <u>separate</u> into bands, rock 'cleavage' develops and rock becomes much denser. Examples: Shale becomes Slate and later Schist; Sandstone becomes Quartzite; Slate becomes Gneiss; limestone becomes Marble; Bituminous Coal becomes Anthracite Coal.



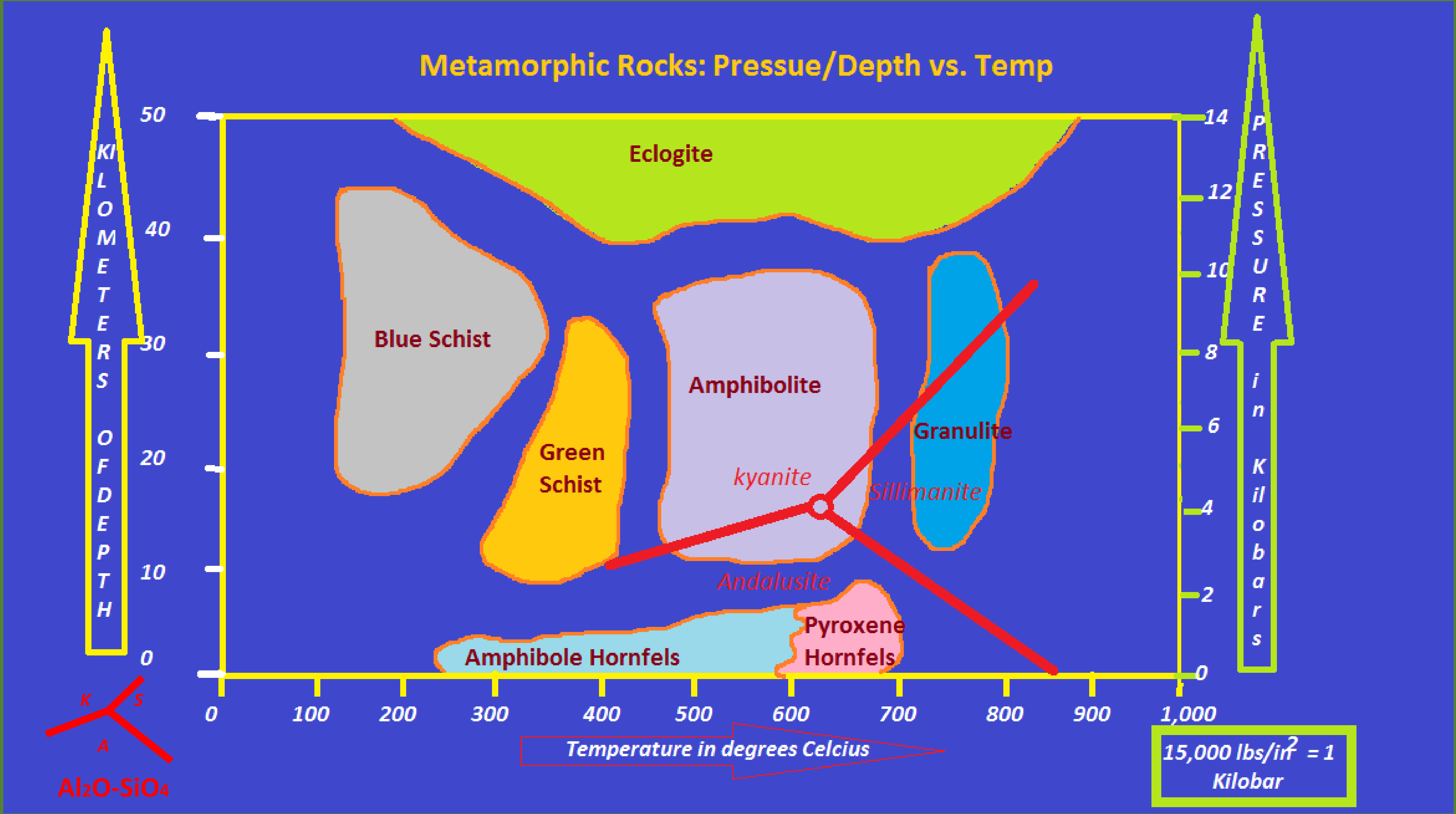
Metamorphic Rocks



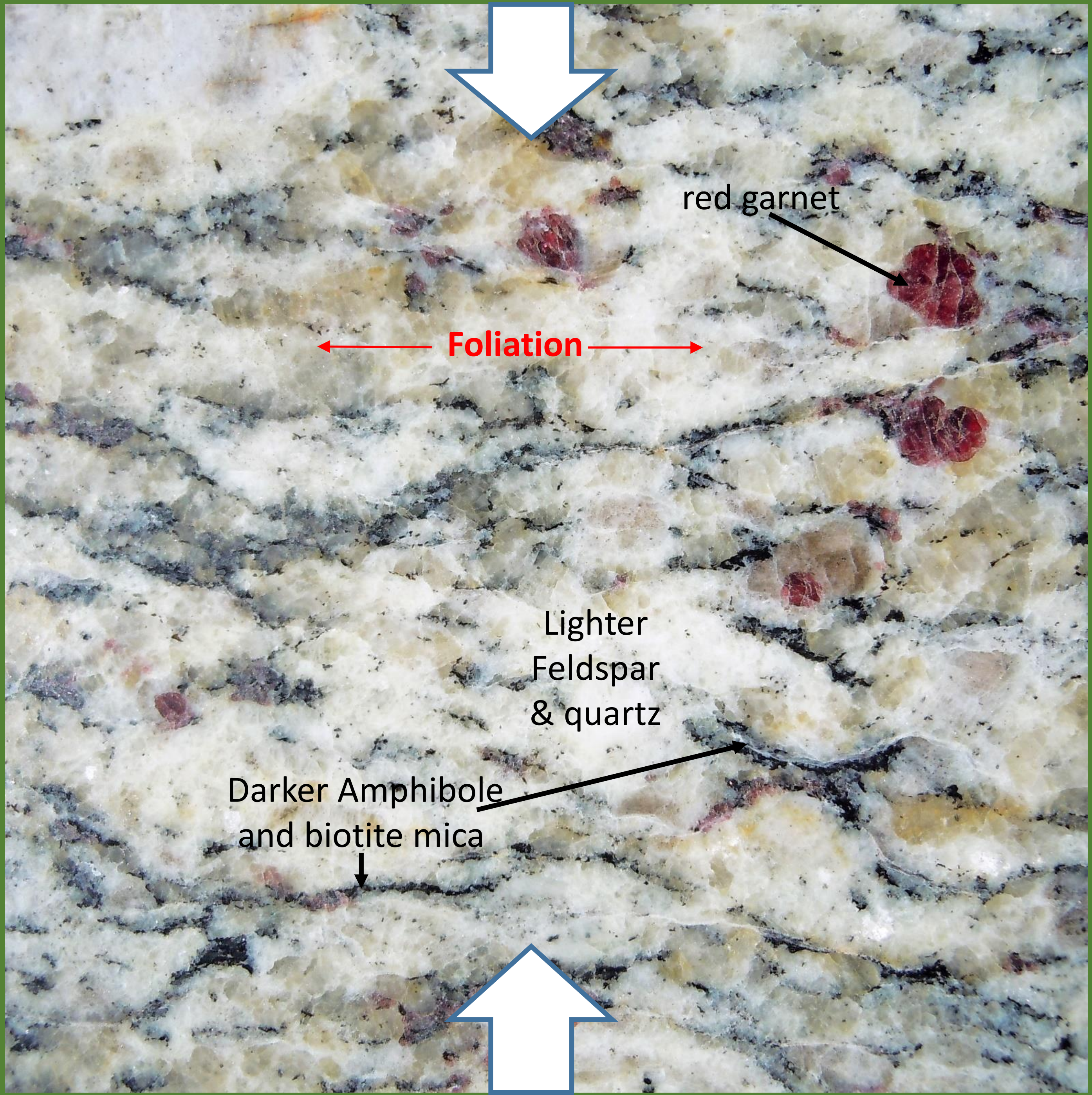
Metamorphic Rocks: cataclastic mets.



compression
tension
Andesitic Volcanism
Folded Mtn.Range
trench
M.O.R.
Regional
Metamorphism
basalt
subduction
Convection
Asthenospere



Metamorphic Rocks: Pressue/Depth vs. Temp
KILOMETERS OF DEPTH
50
40
30
20
10
0
PRESSURE in Kilobars
14
12
10
8
6
4
2
0
Eclogite
Blue Schist
Green Schist
Amphibolite
Granulite
kyanite
Sillimanite
Andalusite
Pyroxene Hornfels
Amphibole Hornfels
0
100
200
300
400
500
600
700
800
900
1,000
Temperature in degrees Celcius
15,000 lbs/in2 = 1 Kilobar
K
S
A
Al2O-SiO4



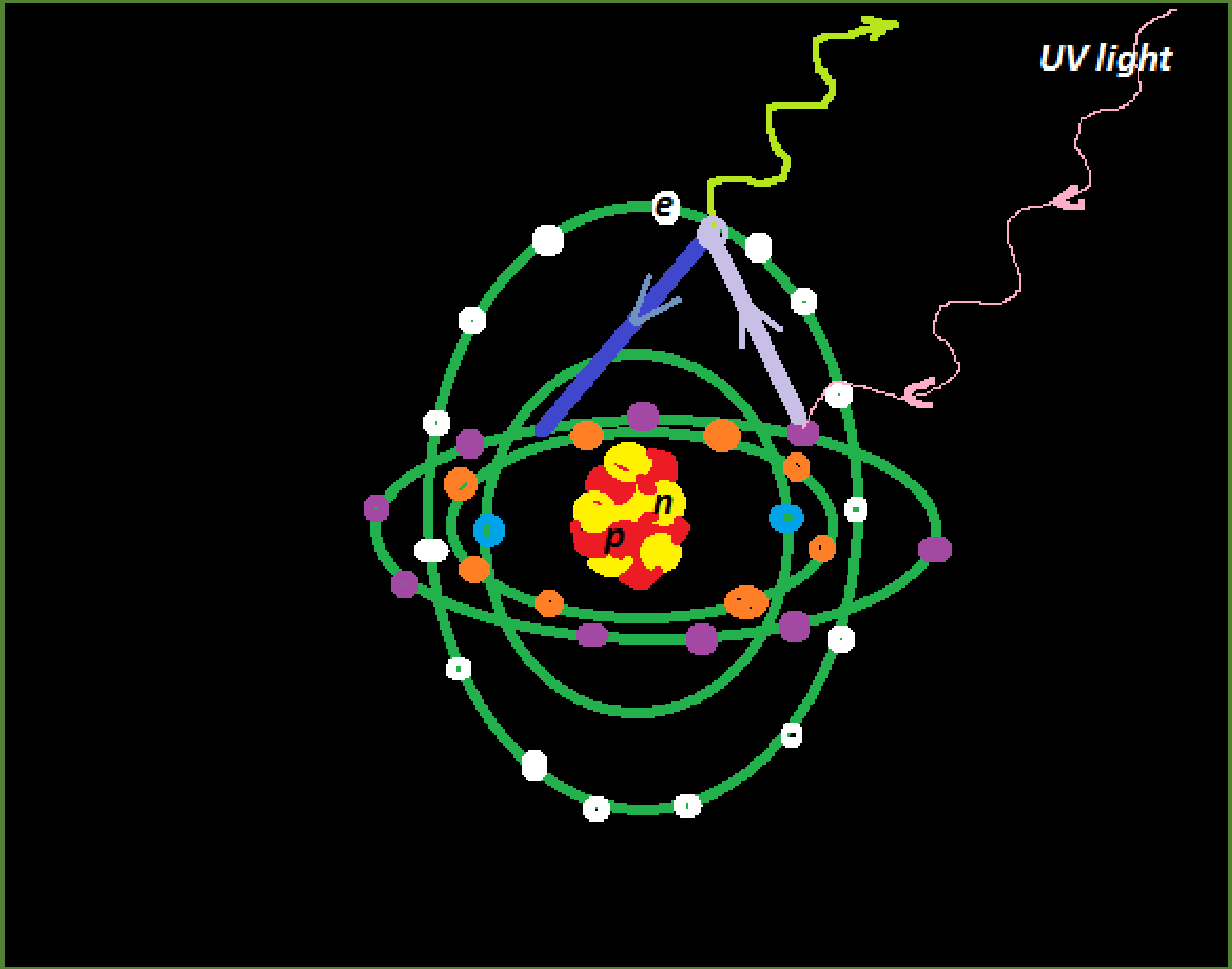
GNEISS

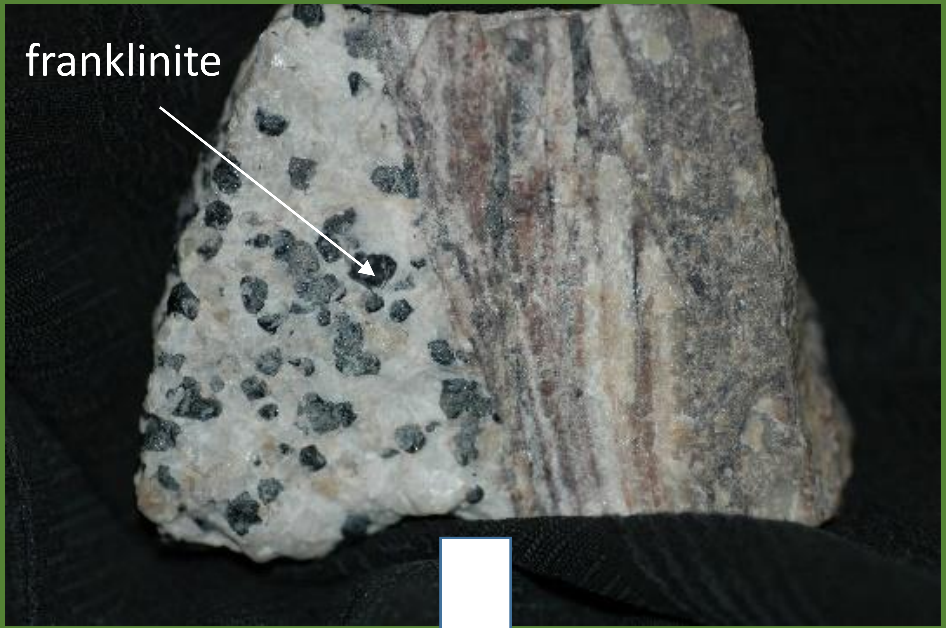
Alternating **dark** & **light** bands due to separation of darker & lighter minerals arranged @ right angles to direction of pressure

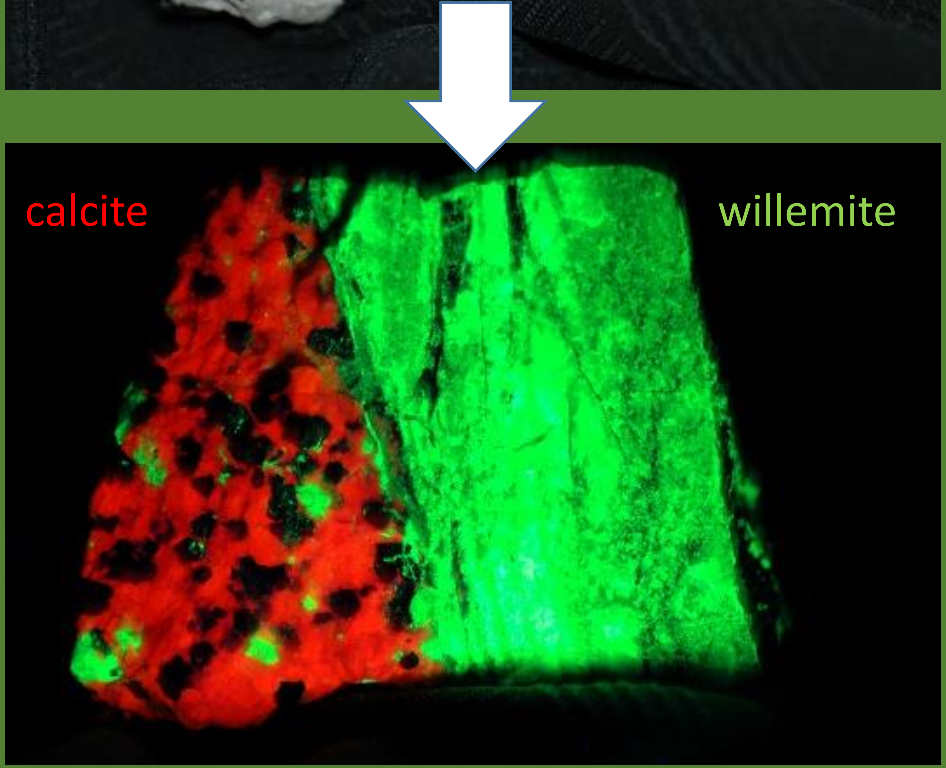
Sterling Hill Zinc
Mine, Franklin, NJ

@ 1,850 feet down

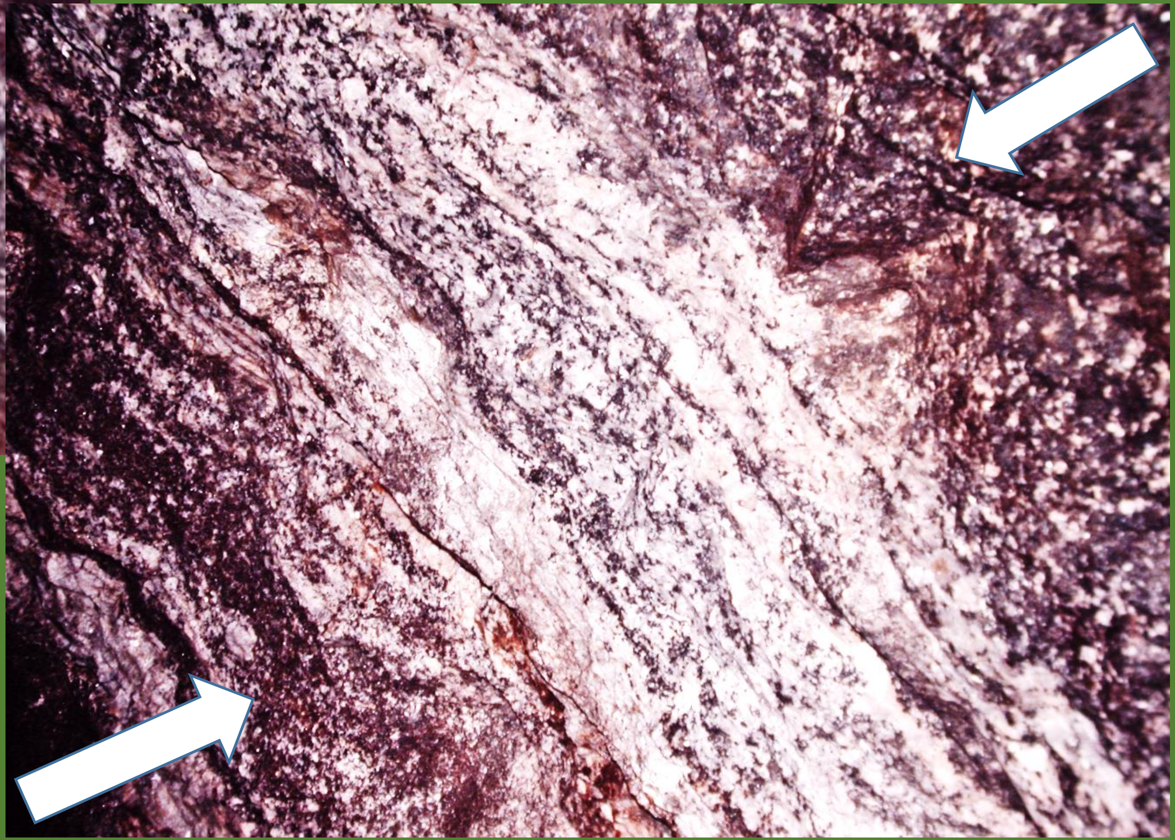
Fluorescence

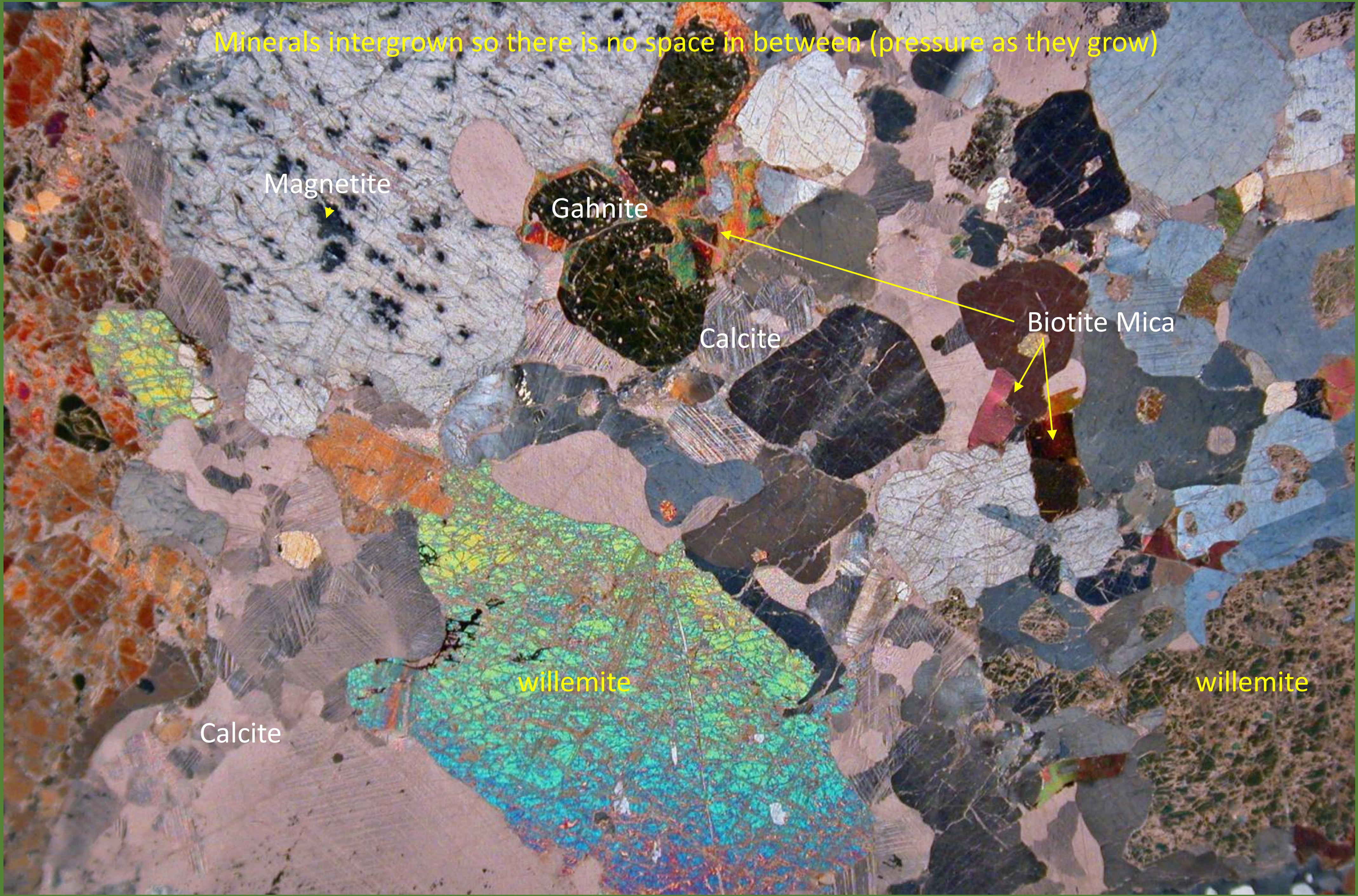






Highly Metamorphosed marine limestone sediments near a Volcanic M.O.R.(S-F-Sp. Zone)





Minerals intergrown so there is no space in between (pressure as they grow)
Magnetite
Gahnite
Calcite
Biotite Mica
willemite
willemite
Calcite


Marble from limestone ‘breccia’

ROCKS and MINERALS and the water, oil or gas they contain are important substances used by man. Think Gold ,Silver, Platinum, Iron, Titanium, Aluminum, Copper, Diamonds, Rubies and Saphires, Emeralds; even the pulverized rock and cement of our buildings and roads.=Economic importance

The ROCKS tell the story of how each area of the earth formed, how and why it has changed, how old it is and its fossils tell the story of the history of life on the earth.

Earth History

John E.B. Baker

Geologic Time
Relative Dating

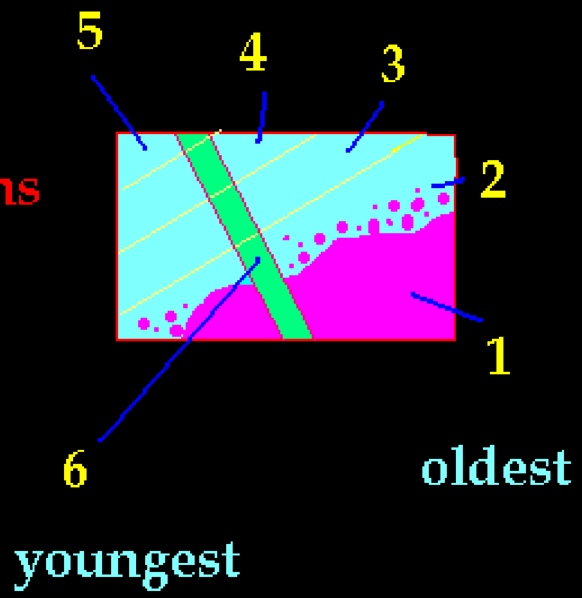
1. Unconformities

2. Principle of Cross Cutting Relations

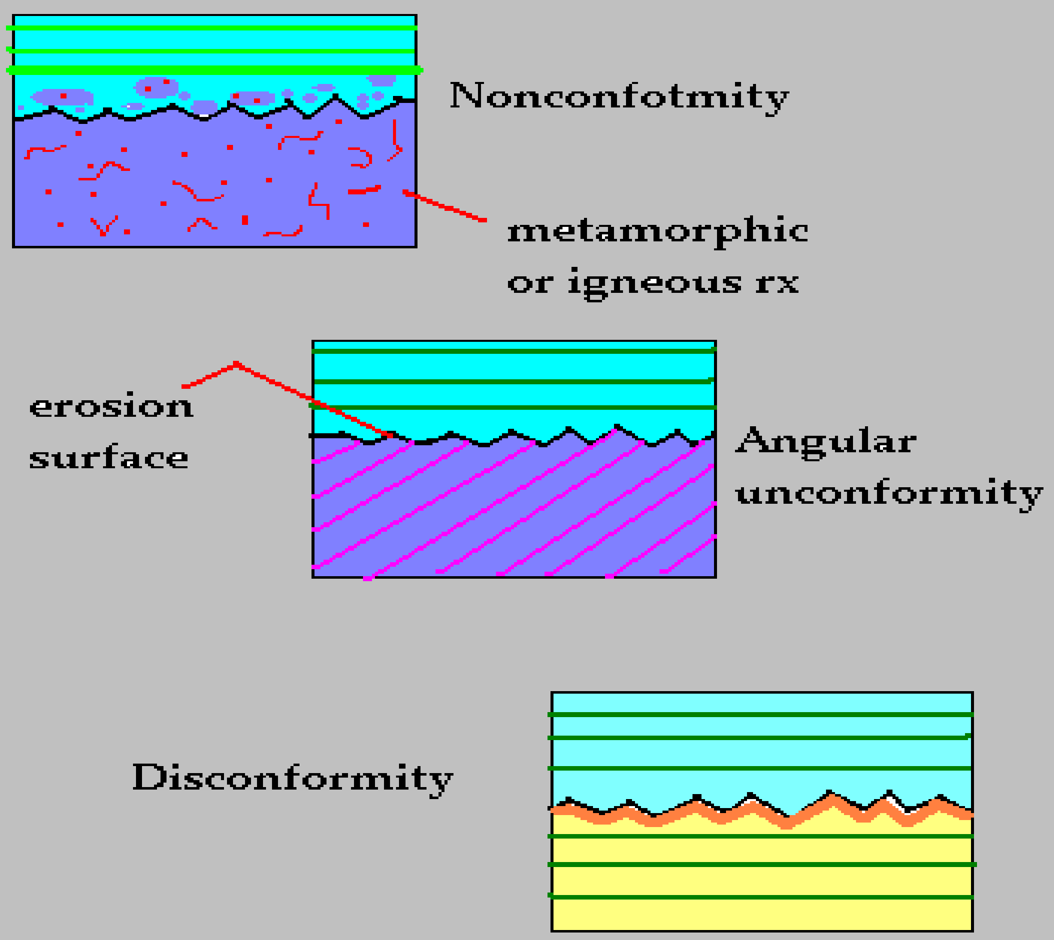
3. Superposition

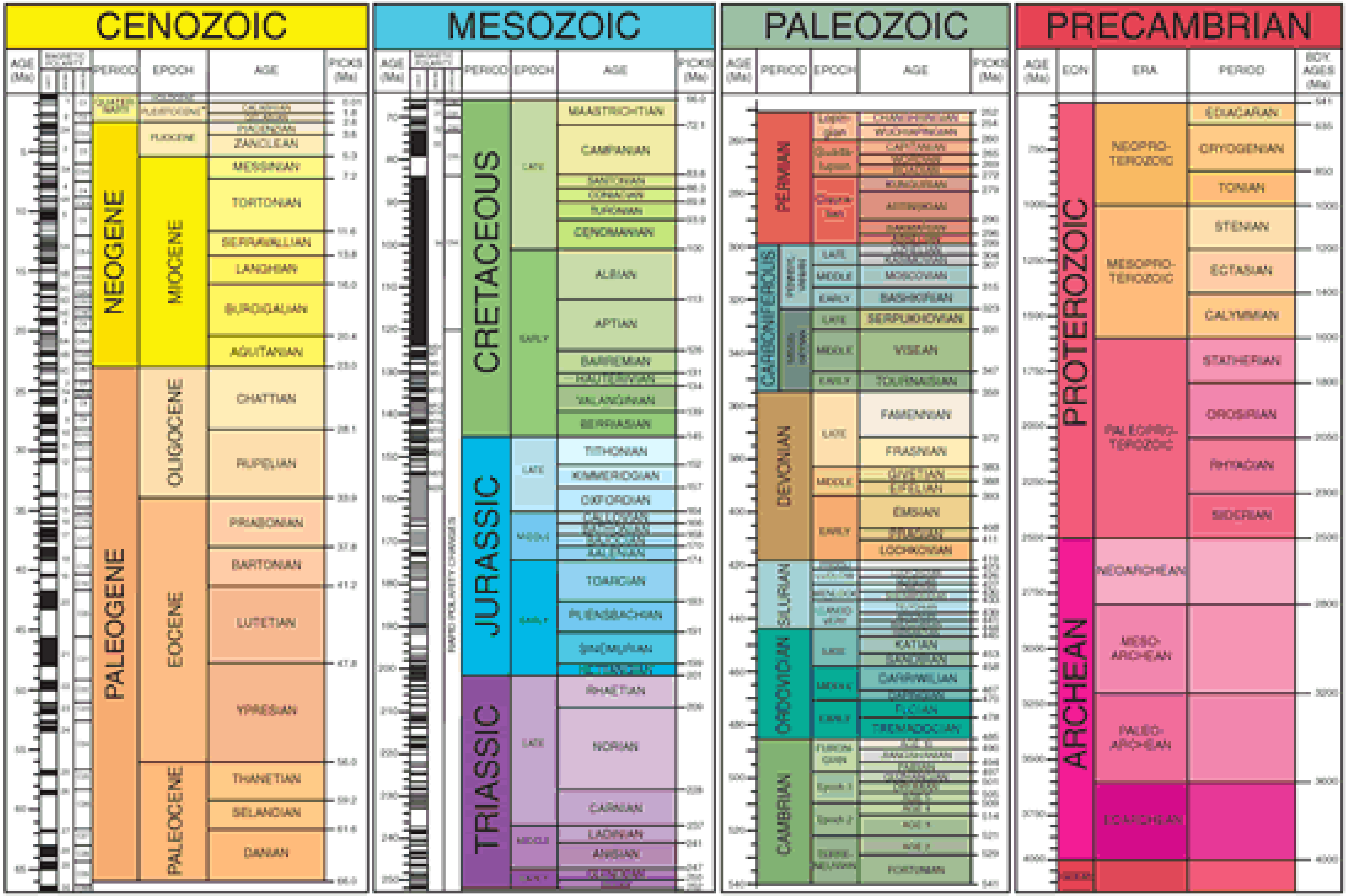
4. Law of Original Horizontality

5. Uniformitarianism: Present is key to past



UNCONFORMITIES




CENOZOIC
MESOZOIC
PALEOZOIC
PRECAMBRIAN
NEOGENE
PALEOGENE
MIOCENE
OLIGOCENE
EOCENE
PALEOCENE
ZANCLEAN
MESSINIAN
TORTONIAN
SERRAVALLIAN
LANGHIAN
BURDIGALIAN
AQUITANIAN
CHATTIAN
RUPELIAN
PRIABONIAN
BARTONIAN
LUTETIAN
YPRESIAN
THANETIAN
SELANDIAN
DANIAN
CRETACEOUS
JURASSIC
TRIASSIC
MAASTRICHTIAN
CAMPANIAN
SANTONIAN
CONIACIAN
TURONIAN
CENOMANIAN
ALBIAN
APTIAN
BARREMIAN
HAUTERIVIAN
VALANGINIAN
BERRIASIAN
TITHONIAN
KIMMERIDGIAN
OXFORDIAN
CALLOVIAN
BATHONIAN
BAJOCIAN
AALENIAN
TOARCIAN
PLIENSBACHIAN
SINEMURIAN
HETTANGIAN
RHAETIAN
NORIAN
CARNIAN
LADINIAN
ANISIAN
PERMIAN
CARBONIFEROUS
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN
KUNGURIAN
ARTINSKIAN
MOSCOVIAN
BASHKIRIAN
SERPUKHOVIAN
VISEAN
TOURNAISIAN
FAMENNIAN
FRASNIAN
GIVETIAN
EIFELIAN
EMSIAN
PRAGIAN
LOCHKOVIAN
KATIAN
SANDBIAN
DARRIWILIAN
FLOIAN
TREMADOCIAN
FORTUNIAN
PROTEROZOIC
ARCHEAN
NEOPRO-TEROZOIC
MESOPRO-TEROZOIC
PALEOPRO-TEROZOIC
NEOARCHEAN
MESO-ARCHEAN
PALEO-ARCHEAN
EOARCHEAN
EDIACARAN
CRYOGENIAN
TONIAN
STENIAN
ECTASIAN
CALYMMIAN
STATHERIAN
OROSIRIAN
RHYACIAN
SIDERIAN

Rte.94 in Vernon,Sussex Co

Fossils

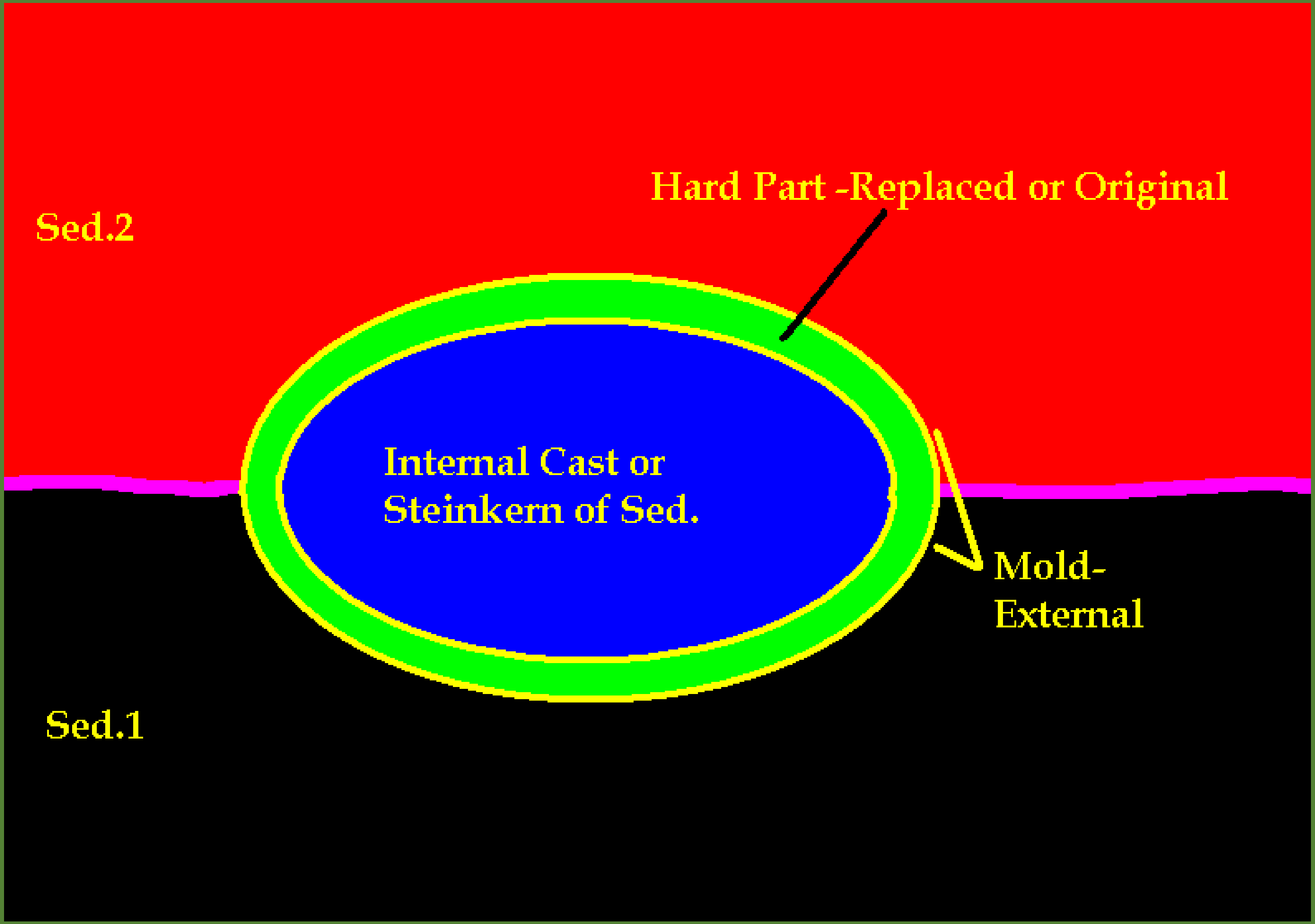
1. Any evidence of pre-existing life

2. General Requirements: a) Rapid Burial
   b) Hard Parts

3. May be: a) Original bone or shell
   b) Dissolved and Replaced by same or different mineral
   c) Molds or Casts- internal (Steinkern)& external
   d) pores in bone can be filled with cement
   e) traces, tracks or coprolites (fecal)

Shell beds at SE corner of University & Loraine Rd, Sarasota, Fl Pinecrest Beds of Tamiami Fm. ~2.5 Ma

Fossils and earth history



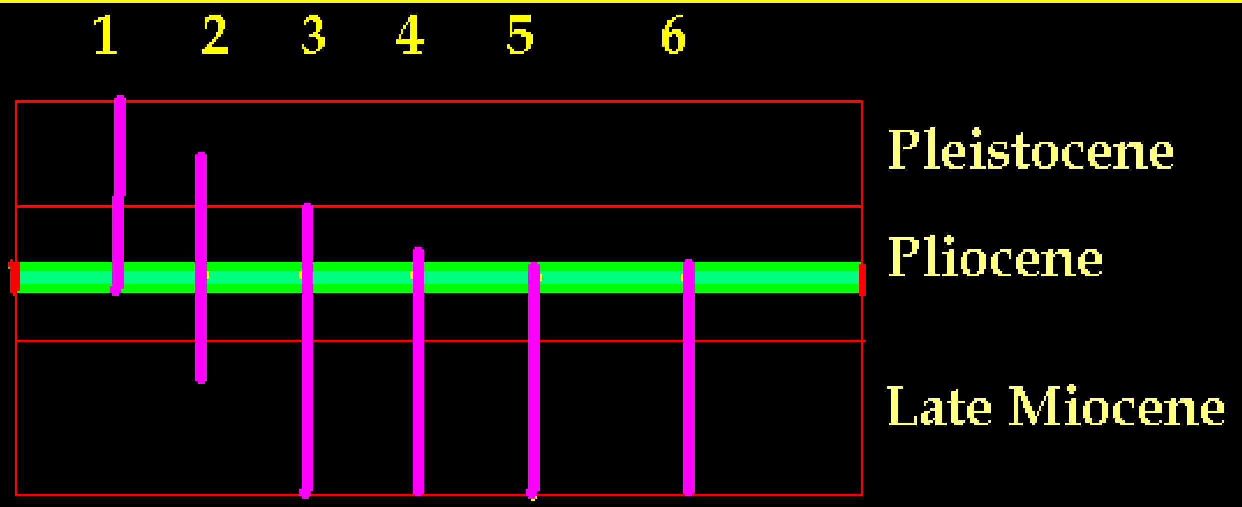
Index ('Key") Fossils

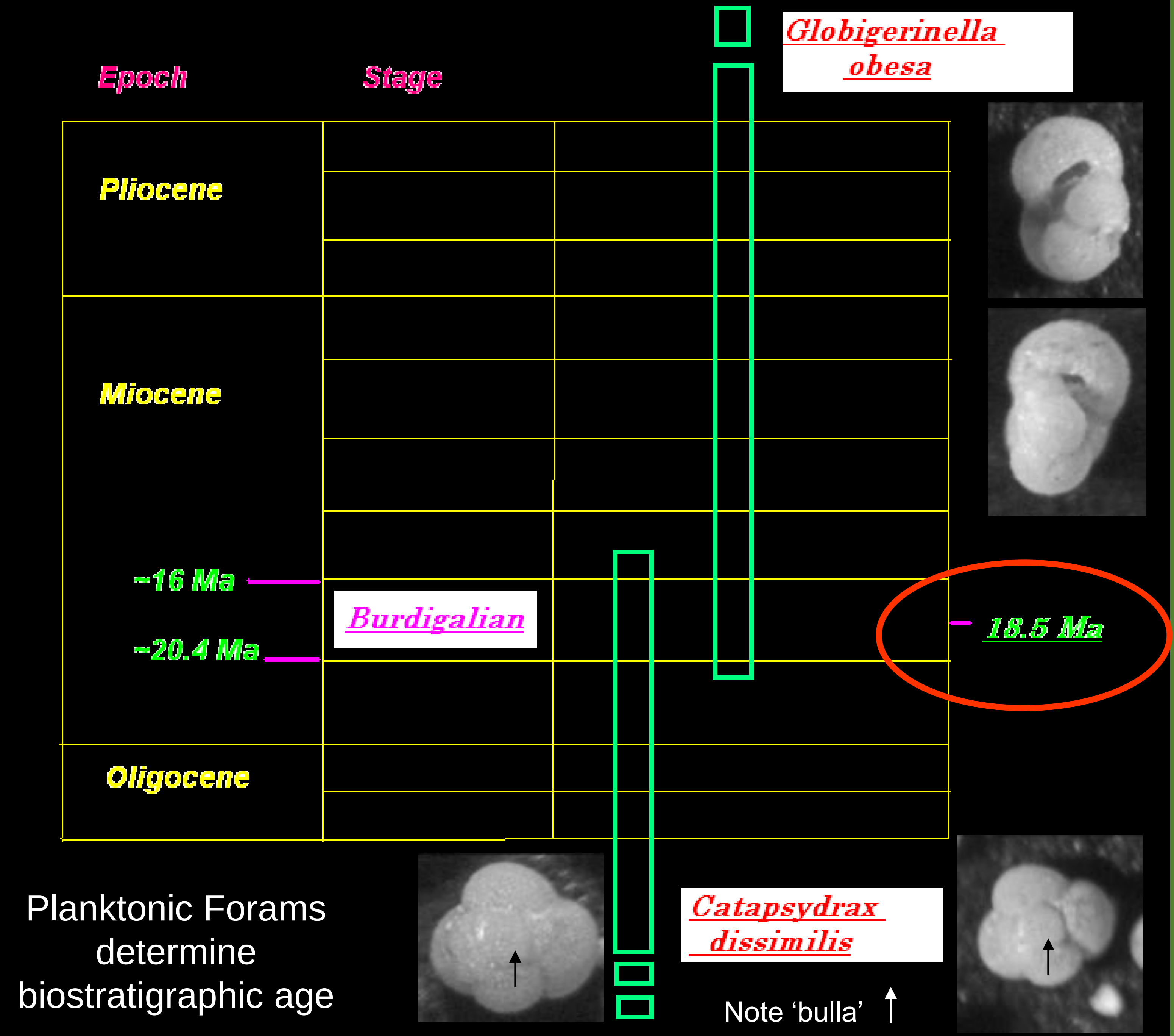
1. Short Geologic Time Range

2. Wide Geographic Range

3. Easily Recognized

4. Common

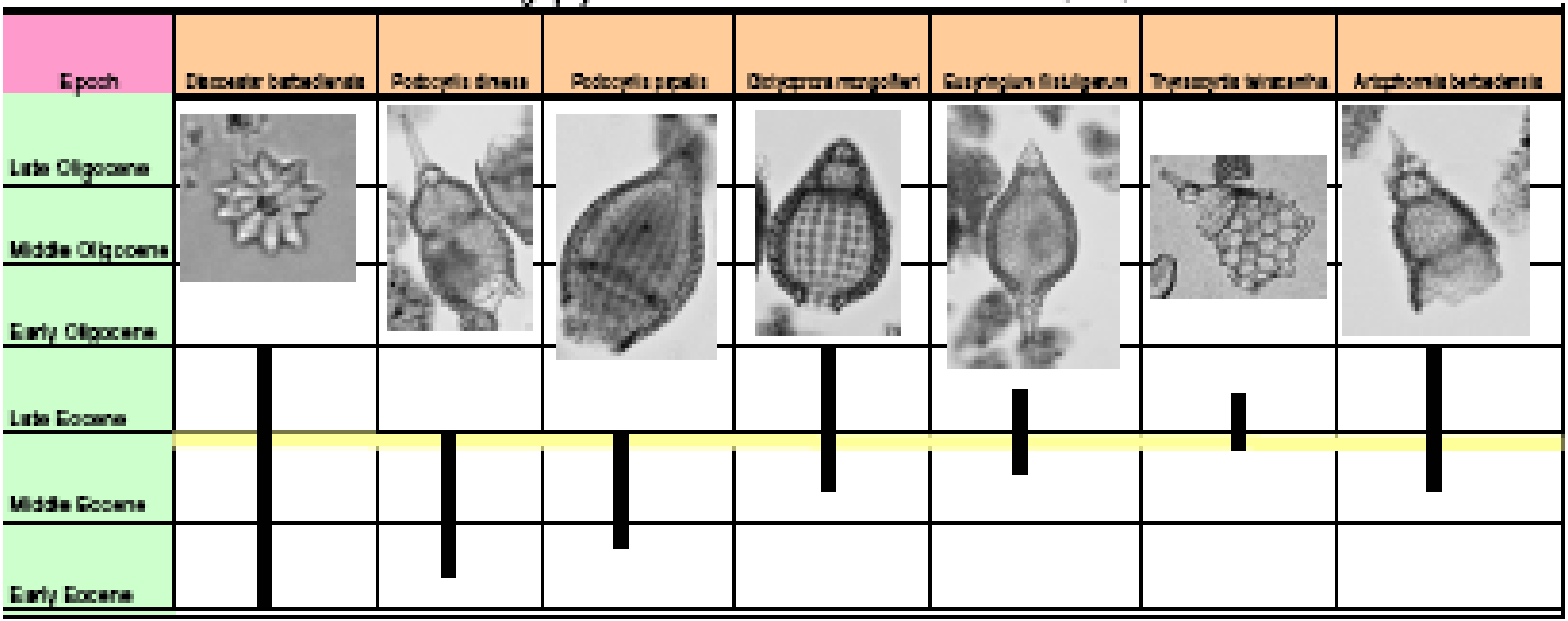




Planktonic Forams determine biostratigraphic age

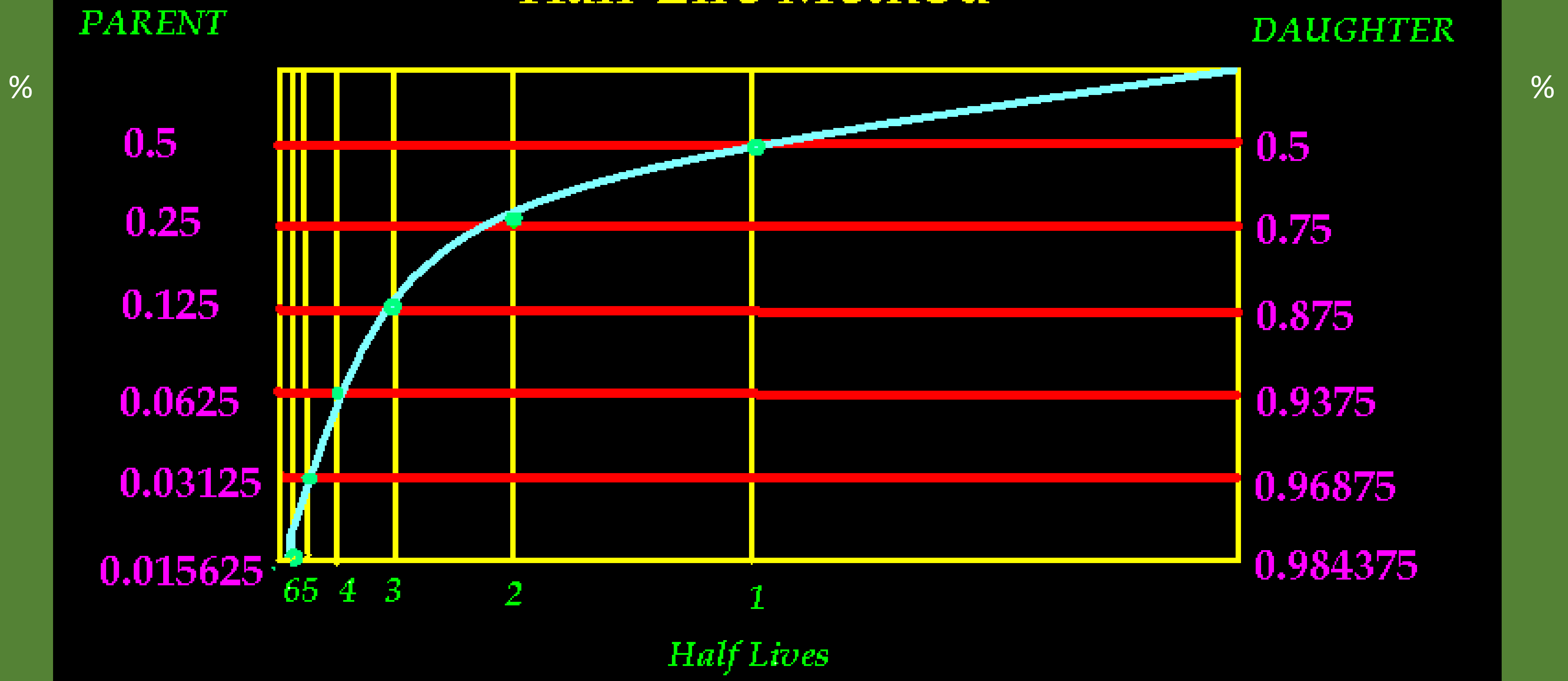
Index Fossil Radiolaria of Barbados

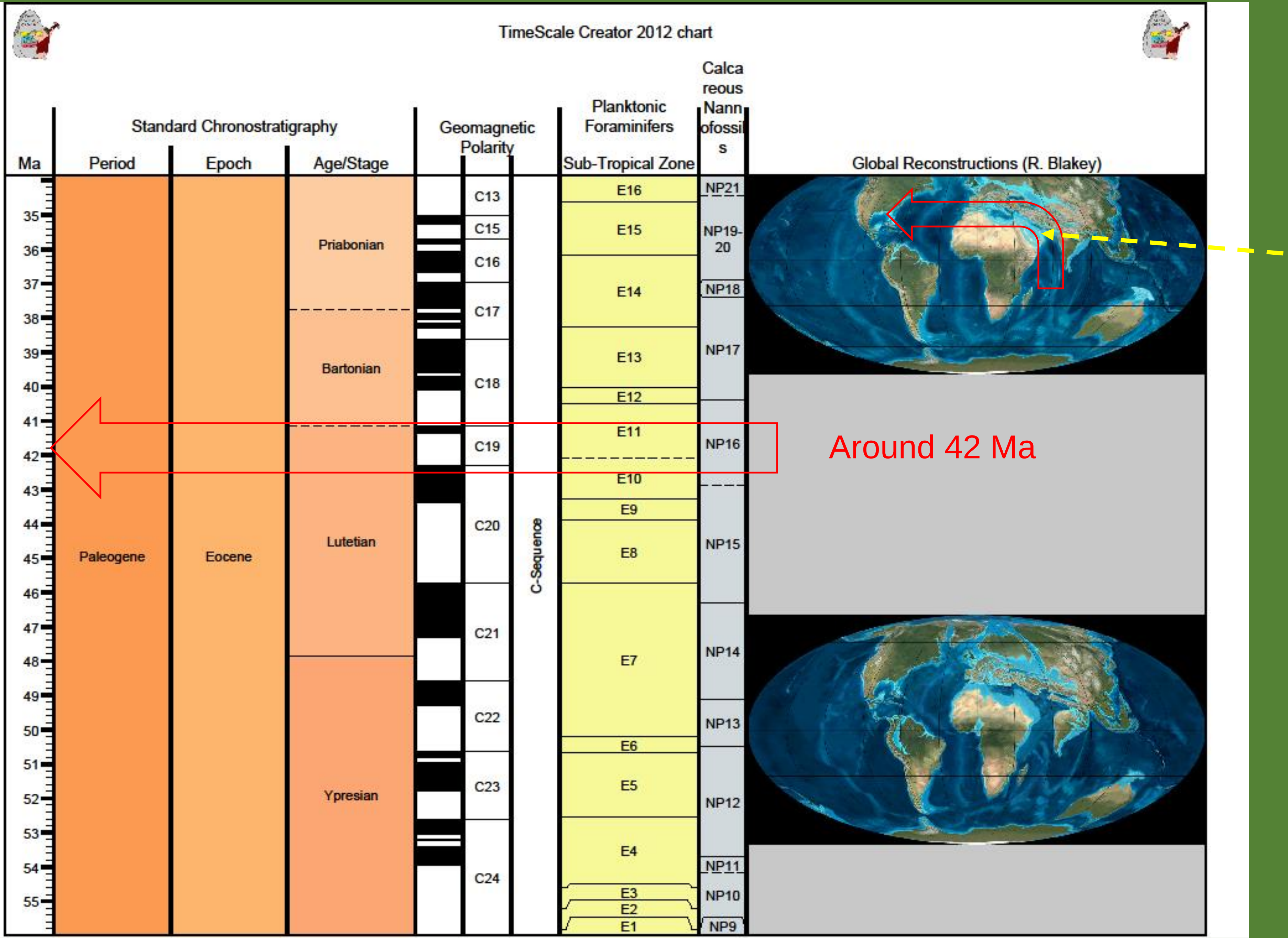
Biostratigraphy of the Latest Middle Eocene Oceanic Formation, Bath, Barbados



Geologists don't use carbon; they use U/Pb. , K/Ar. etc.

Radiometric Dating: Half Life Method




TimeScale Creator 2012 chart
Standard Chronostratigraphy
Ma
Period
Epoch
Age/Stage
Geomagnetic Polarity
Planktonic Foraminifers
Sub-Tropical Zone
Calcareous Nannofossils
Global Reconstructions (R. Blakey)
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
Paleogene
Eocene
Priabonian
Bartonian
Lutetian
Ypresian
C13
C15
C16
C17
C18
C19
C20
C21
C22
C23
C24
C-Sequence
E16
E15
E14
E13
E12
E11
E10
E9
E8
E7
E6
E5
E4
E3
E2
E1
NP21
NP19-20
NP18
NP17
NP16
NP15
NP14
NP13
NP12
NP11
NP10
NP9
Around 42 Ma
Tethys sea

Ogg-TSC-2014