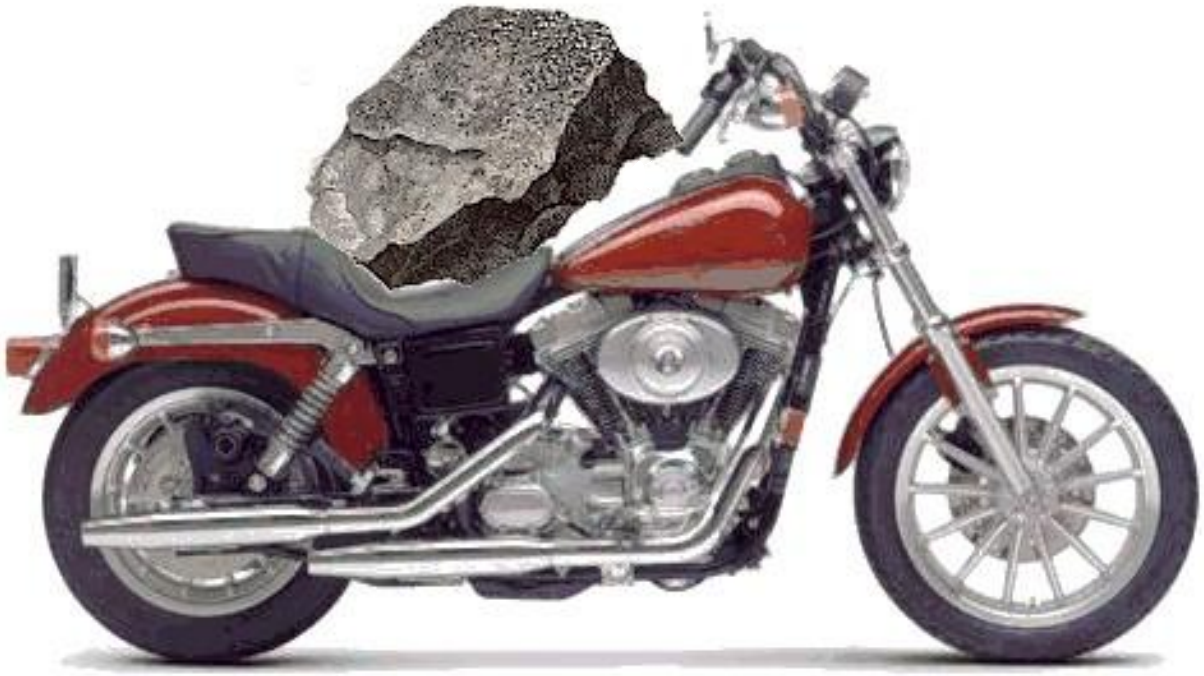
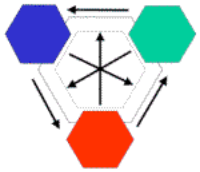
The Rock Cycle

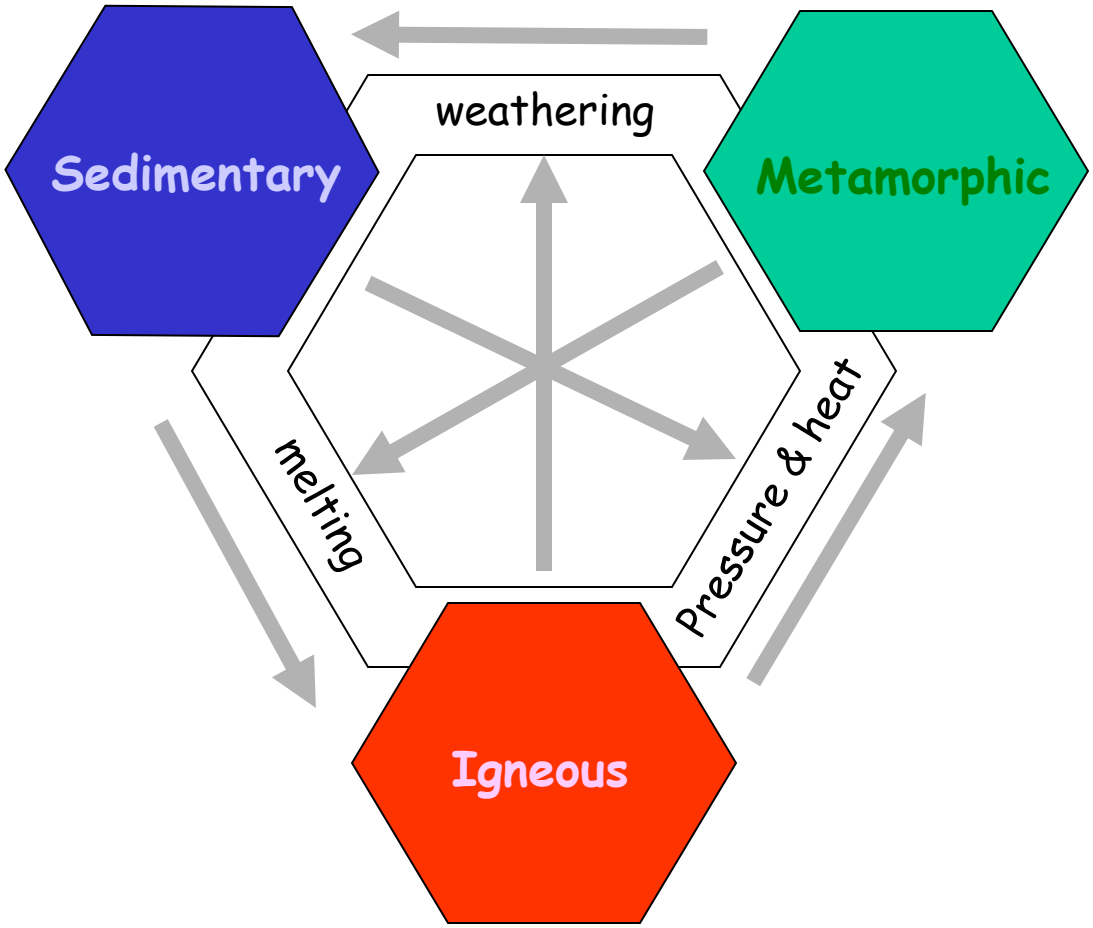


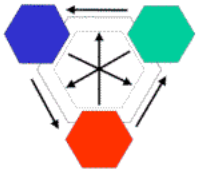


What is the

Rock Cycle ?

The Rock Cycle explains how Rocks and Natural Processes are related



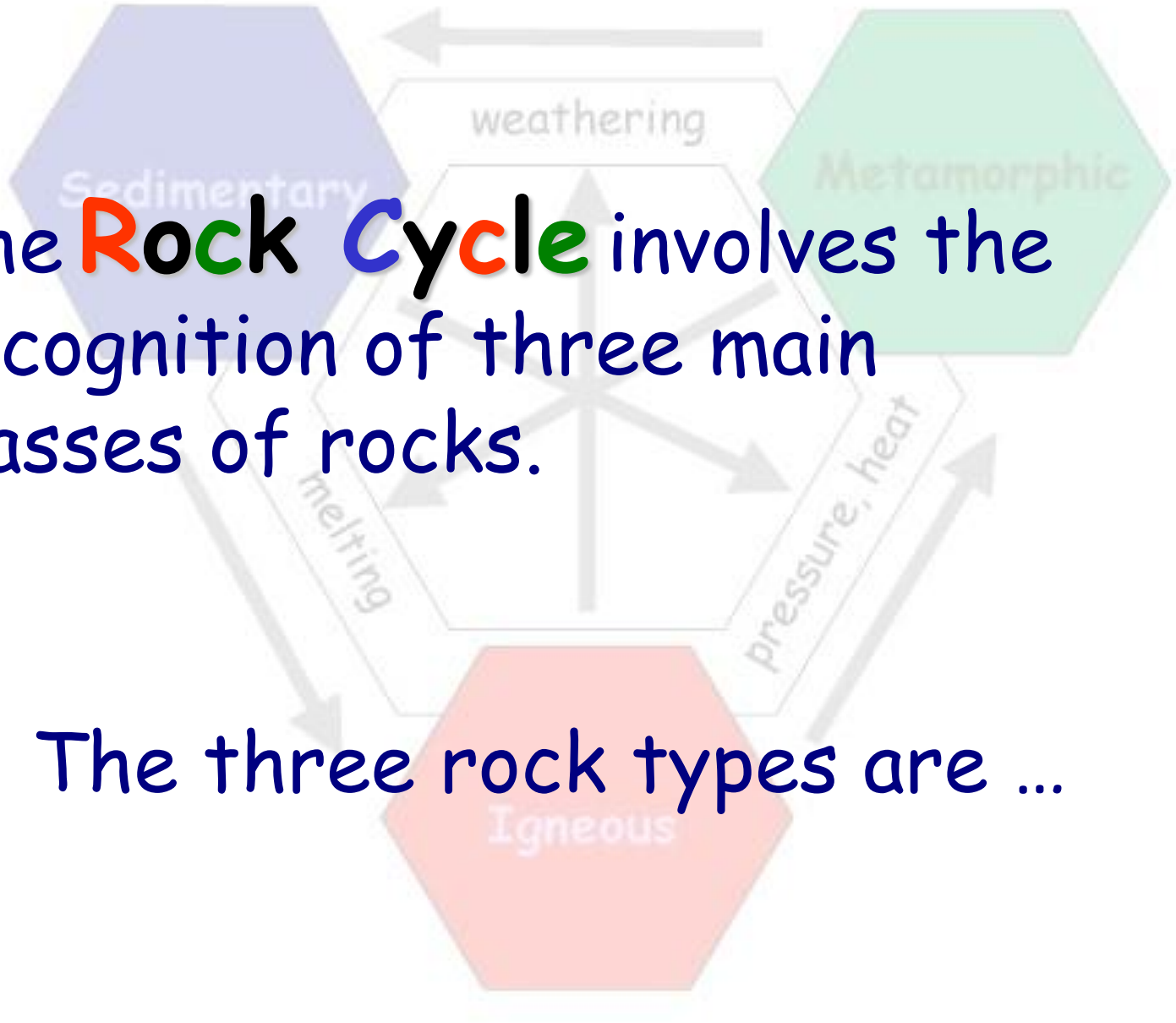


A more traditional definition is:

Rock Cycle

is a sequence of events involving the formation, alteration, destruction, and reformation of rocks as a result of natural processes ...

Glossary of Geology, Bates & Jackson, AGI



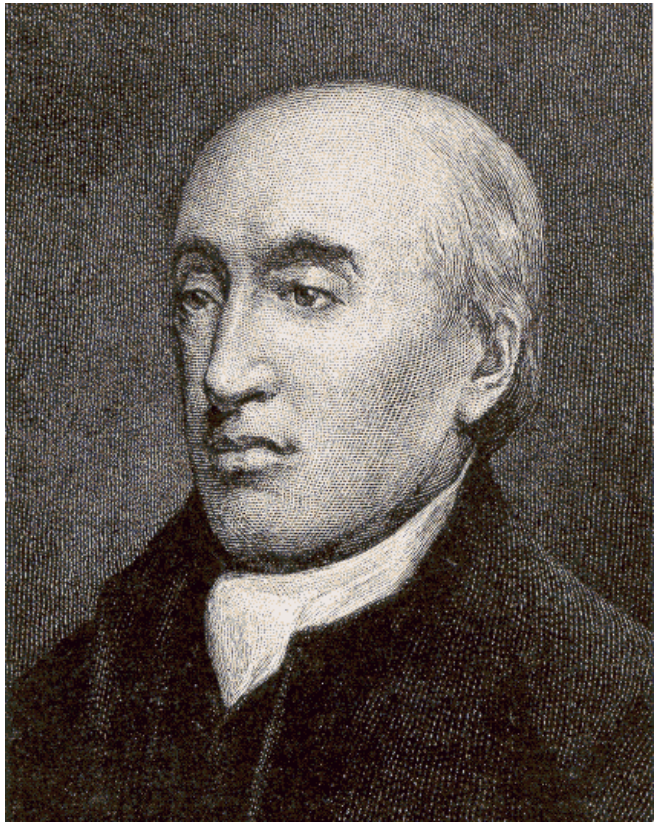
The **Rock Cycle** involves the recognition of three main classes of rocks.

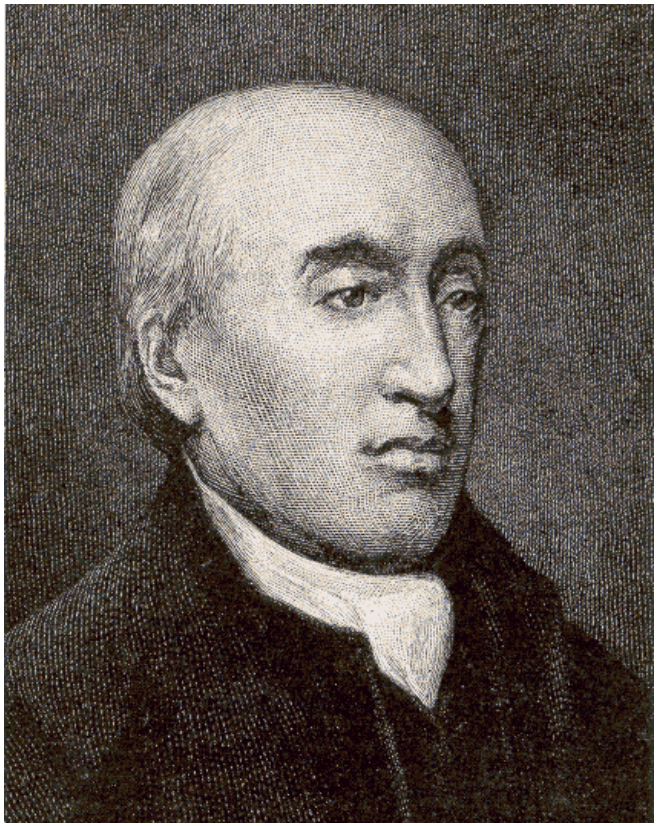
The three rock types are …

The eminent 18th century lawyer, doctor, gentleman farmer and founder of modern geoscience,

James Hutton,

developed the concept of the **Rock Cycle** to show how rocks and natural, physical processes are interrelated.



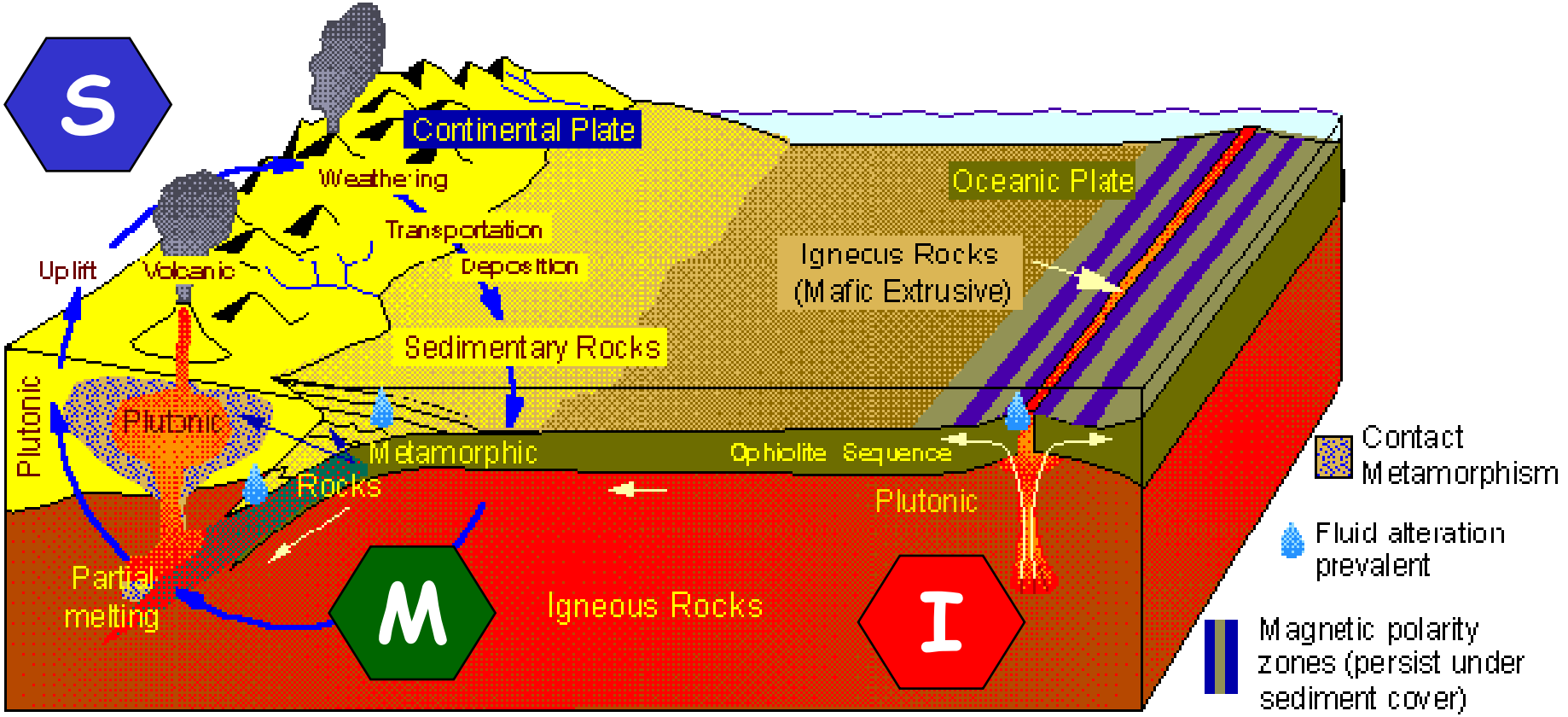


Hutton knew about **solar energy** and **gravity** at the surface. He did not know about **radioactive heating** from inside the earth.

Solar energy, gravity and radioactive heating are the major forces driving the **Rock Cycle**.

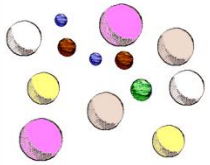
As a result, the **Rock Cycle** will be self-sustaining for a very long time.

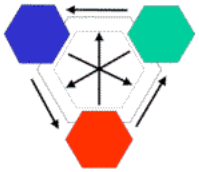
The mantle, crust and surface of the earth can be thought of as a giant recycling machine; rocks are neither created nor destroyed, but redistributed and transformed from one rock type to another.



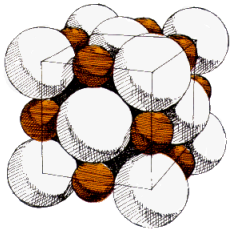
Redrawn by W. Milner, as modfied from Montgomery (1990) and Monroe and Wicander (1994).

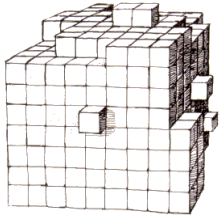
Atoms make up **elements**.



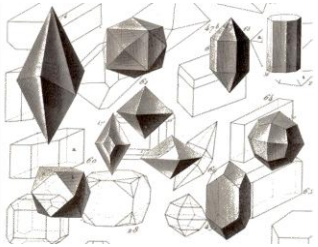


Elements combine to form the natural **compounds**.





Natural **compounds** and **elements** combine to form **minerals**.



Minerals make up **rocks**.

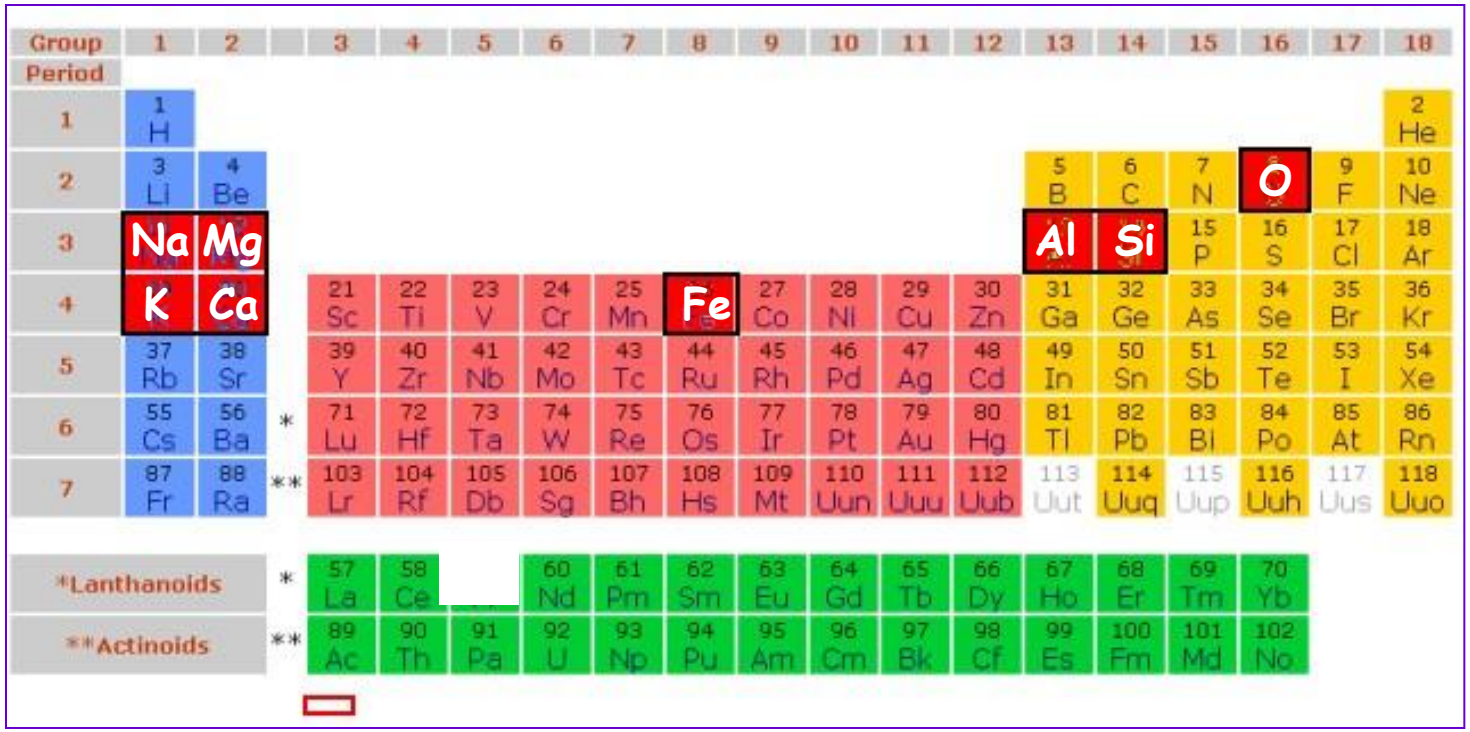
Rocks make up the **Earth**.

Atomic Theory proposes that all matter is composed of the **atoms** of about 100 different chemical **elements**. It further proposes that chemical **compounds** are formed by the combination of the atoms of different chemical elements.

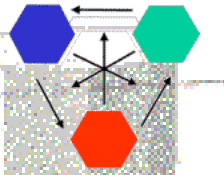
Group	1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Period																			
1	1 H																		2 He
2	3 Li	4 Be												5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg												13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca		21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr		39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	*	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	**	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Uun	111 Uuu	112 Uub	113 Uut	114 Uuq	115 Uup	116 Uuh	117 Uus	118 Uuo

*Lanthanoids	*	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb
**Actinoids	**	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No

Elements can be arranged, based on their identifiable properties, into the **Periodic Table**



Only **eight** elements make up over **98%** of the earth's crust!



The identifiable characteristics of **Minerals** are

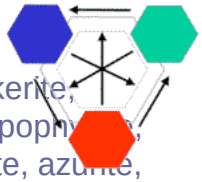
naturally occurring inorganic elements or compounds

having an orderly internal structure

and a characteristic chemical composition,

crystal form and

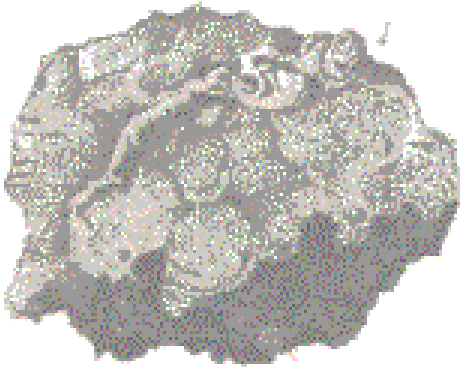
physical properties of a solid

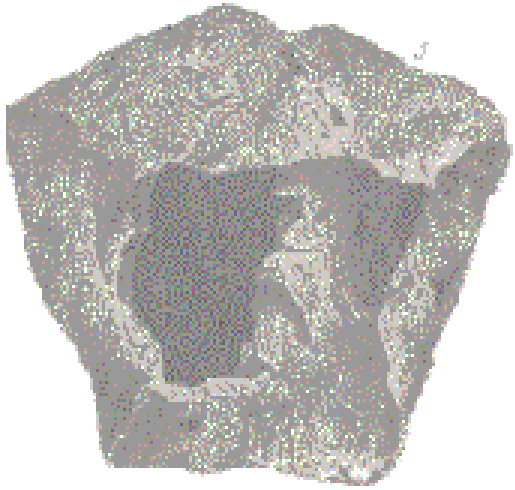


alunite, amethyst, amphibole, analcite, anatase, andalusite, andesine, andradite, anglesite, anhydrite, ankerite, annabergite, anorthite, anthonyite, anthophyllite, anthraconite, anthraxolite, antigorite, apatite, aphrosiderite, apophyllite, aragonite, ardennite, argentoalgodonite, arsenopyrite, asbestos, atacamite, attapulgite, augite,awarurite, axinite, azurite, babingtonite, baddeleyite, barite, bassetite, bastnaesite, beaconite, beryl, biotite, bismuthinite, blomstrandine, bornite, bowlingite, brannerite, braunite, brochantite, bronzite, brookite, brucite, brunsvigite, buttgenbachite, byssolite, bytownite, calciovolborthite, calcite, calderite, calumetite, carnallite, carnelian, celadonite, celestite, cerargyrite, chabazite, chalcedony, chalcocite, chalconatronite, chalcopyrite, chalcotrichite, chamosite, chert, chloanthite, chlorargyrite, chlorastrolite, chlorite, clinochlore, clino-chrysotile, clinozoisite, collophane, columbite, copiapite, copper, coquimbite, cordierite, corrensite, corundum, covellite, crocidolite, cubanite, cummingtonite, cuprite, dahllite, datolite, daubreelite, delessite, diabantite, diallage, diamond, dickite, digenite, dihydrite, diopside, dioptase, diurleite, dolomite, domeykite, forsterite, francolite, freirinite, fuchsite, fulgurite, galena, garnet,garnierite, gersdorffite, gibbsite, glauconite, goethite, gold, halite, halloysite, halotrichite, harmotome, heterosite, heulandite, hisingerite, hollandite, hornblende, hyacinth, hydrocarbon, hydrohausmannite, hydromica, hydromuscovite, hydrotroilite, hypersthene, iddingsite, illite, ilmenite, isle royale greenstone, jacksonite, jacobsite, jasper, jaspilite, julgoldite, kamacite, kamiokite, kaolinite, kearsargeite, keweenawite, kinoite, koutekite, kupfferite, kutnahorite, kyanite, labradorite, langite, laumontite, lavendulan, lead, lechetelierite, ledouxite, leonhardite, lepidocrocite, lepidolite, manganoan siderite, manganocalcite, marcasite, margarite, marmolite, martite, masonite, maucherite, melaconite, melanochalcite, melanterite, melilite, mercury, mesolite, meta-autunite, metatorbernite, metatyuyamunite, microcline, millerite, minnesotaite, mirabilite, mohawk-algodonite, mohawkite, molybdenite, monazite, monticellite, muscovite, nagyagite, nantokite, natrojarosite, natrolite, neltnerite, neotocite, niccolite, nontronite, oligoclase, oligonite, olivenite, olivine, orientite, orthoclase, ottrelite, palygorskite, paragonite, paramelaconite, pararammelsbergite, paratacamite, pargasite, patricianite, paxite, pectolite, pennine, pentlandite, peristerite, perthite, phaenacite, phengite, phillipsite, phlogopite, phosphates, phosphorite, picrolite, picropharmacolite, pigeonite, pistacite, pitchblende, plagioclase, plancheite, plessite, polyhalite, posnjakite, powellite, prehnite, priorite, prochlorite, protolithionite, pyrolusite, pyrope, pyrophyllite, pyrostilpnite, pyroxene, pyrrhotite, quartz, rammelsbergite, rauenthalite, realgar, rhodochrosite, rhodonite, riebeckite, rodolicoite, roscoelite, rubellan, ruthenarsenite, rutile, salite, salt, sanidine, saponite, saussurite, scapolite, scheelite, schefferite, schorl, schreibersite, scolectite, seamanite, semi-whitneyite, sericite, serpentine, siderite, silicon, sillimanite, silver, smaltite, smectite, soapstone, specularite, spessartite, sphalerite, sphene, spinel, spodumene, staurolite, steatite, stellerite, stibiodomeykite, stilbite, stilpnomelane, stinkstone, strontianite, sulfur, sussexite, sylvanite, sylvite, synchisite, szaibelyite, taenite, talc, tantalite, tellurium, tenorite, tetrahedrite, thomsonite, thuringite, tirodite, titanite, titanomagnetite, topaz, tourmaline, tremolite, trichalcite, tridymite, troilite, tyrolite, uralite, uraninite, uranothorite, uvarovite, vaterite,, vesuvianite, violarite, viridite, vivianite, vladimirite, wairakite, whitneyite, williamsite, wollastonite, wurtzite, xanthosiderite, xonotlite, zeolite, zircon, zoisite, zonochlorite

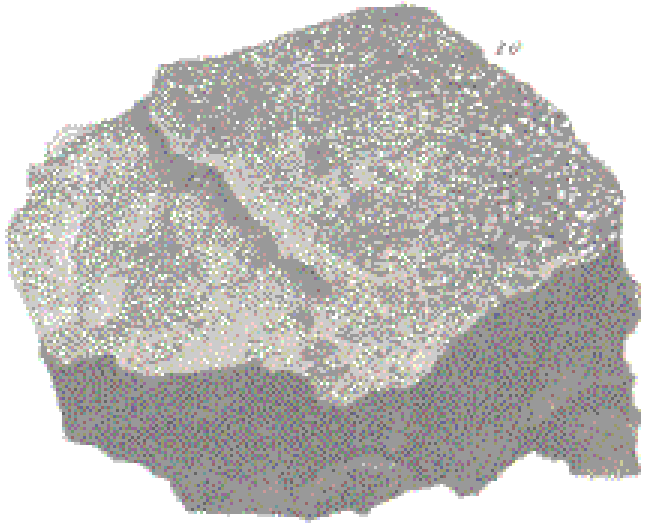
There are over 300 minerals found in Arizona.

Each mineral has its own set of uniquely identifiable properties or characteristics



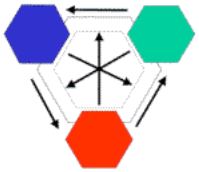


Minerals combine to form **Rocks**



Some **Rocks** are made up of just one mineral - like the sedimentary **rock salt** (made up of the mineral halite).

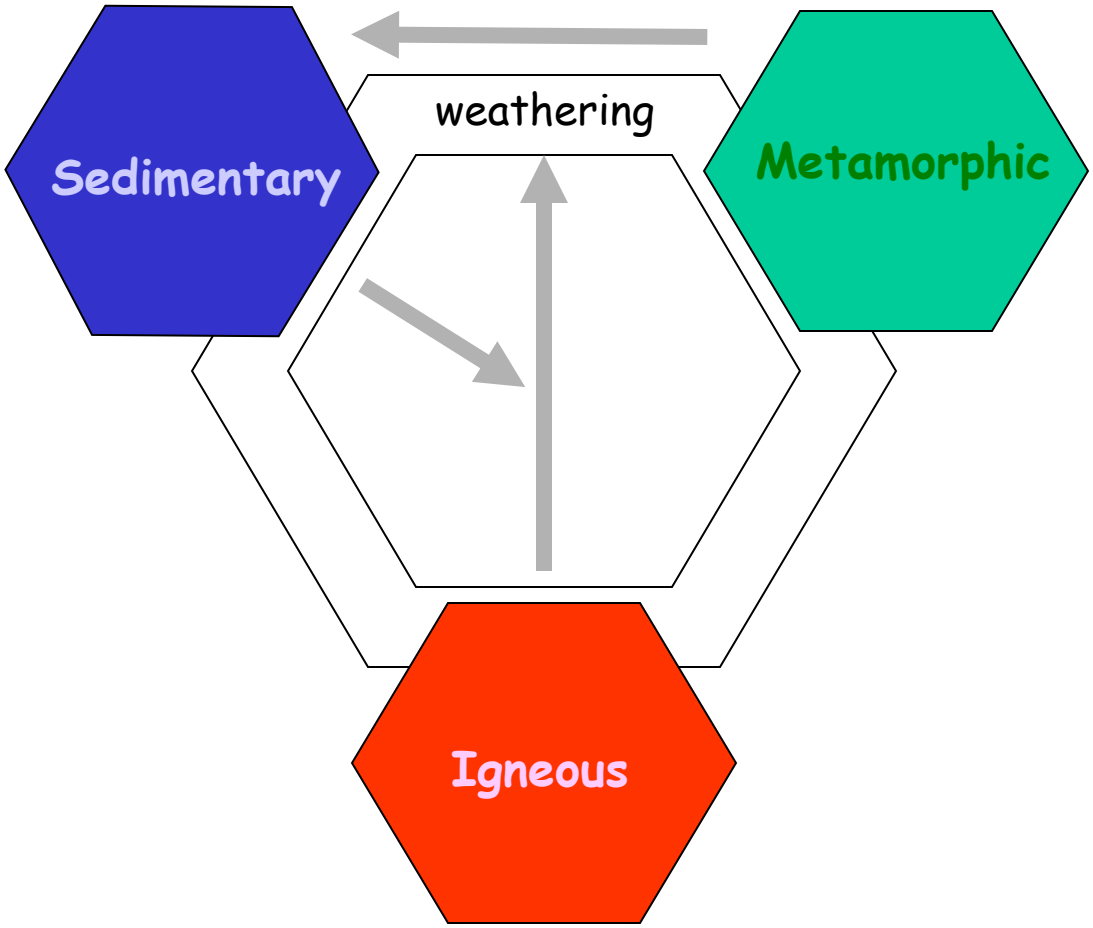
Others **Rocks** are made up of many minerals - like the igneous rock **granite** and the metamorphic rock **gneiss**,.



Now that some of the basics have been covered, lets consider some of the details about the

Rock Cycle

The Rock Cycle



Rocks are **weathered, eroded, transported, and deposited** to form **sedimentary rocks**

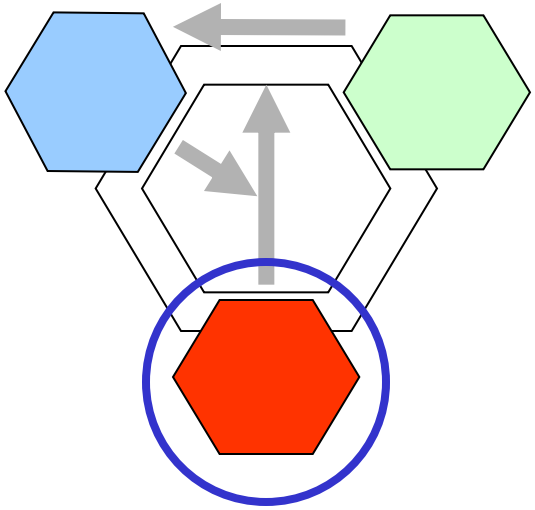
Becoming a SEDIMENTARY ROCK …

The igneous rock granite can be physically weathered to produce clay and sand.

These sediments can be transported deposited and lithified to form sedimentary rocks.

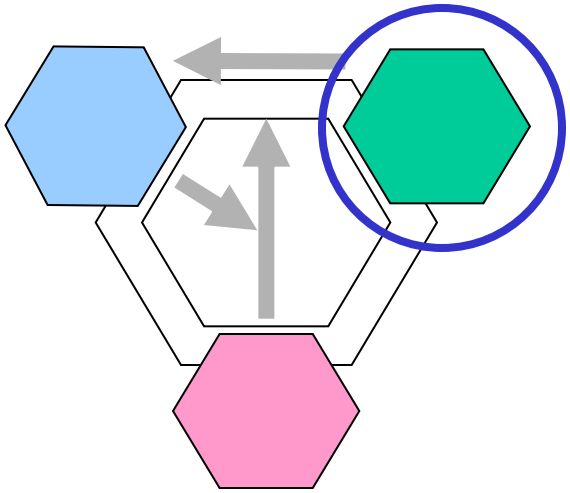
Clay can become shale

Sand can become sandstone.



Becoming a SEDIMENTARY ROCK …

The **metamorphic rock** gneiss can be physically weathered to produce **clay** and **sand**.



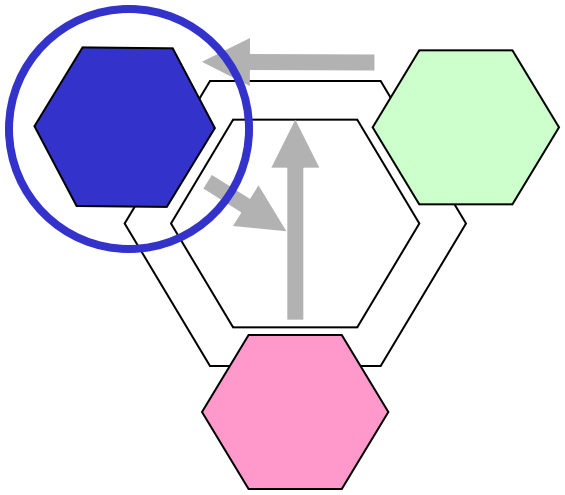
These **sediments** can be transported deposited and lithified to form **sedimentary rocks**.

Clay can become **shale**

Sand can become **sandstone**.

Becoming a SEDIMENTARY ROCK …

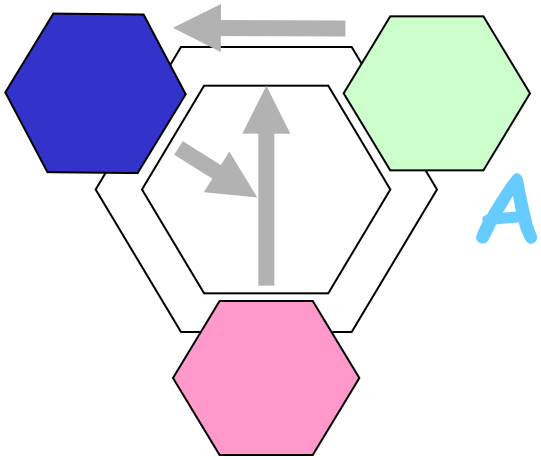
Sedimentary rocks can be physically weathered to produce sediments that can become other **sedimentary rocks**.



Becoming a SEDIMENTARY ROCK …

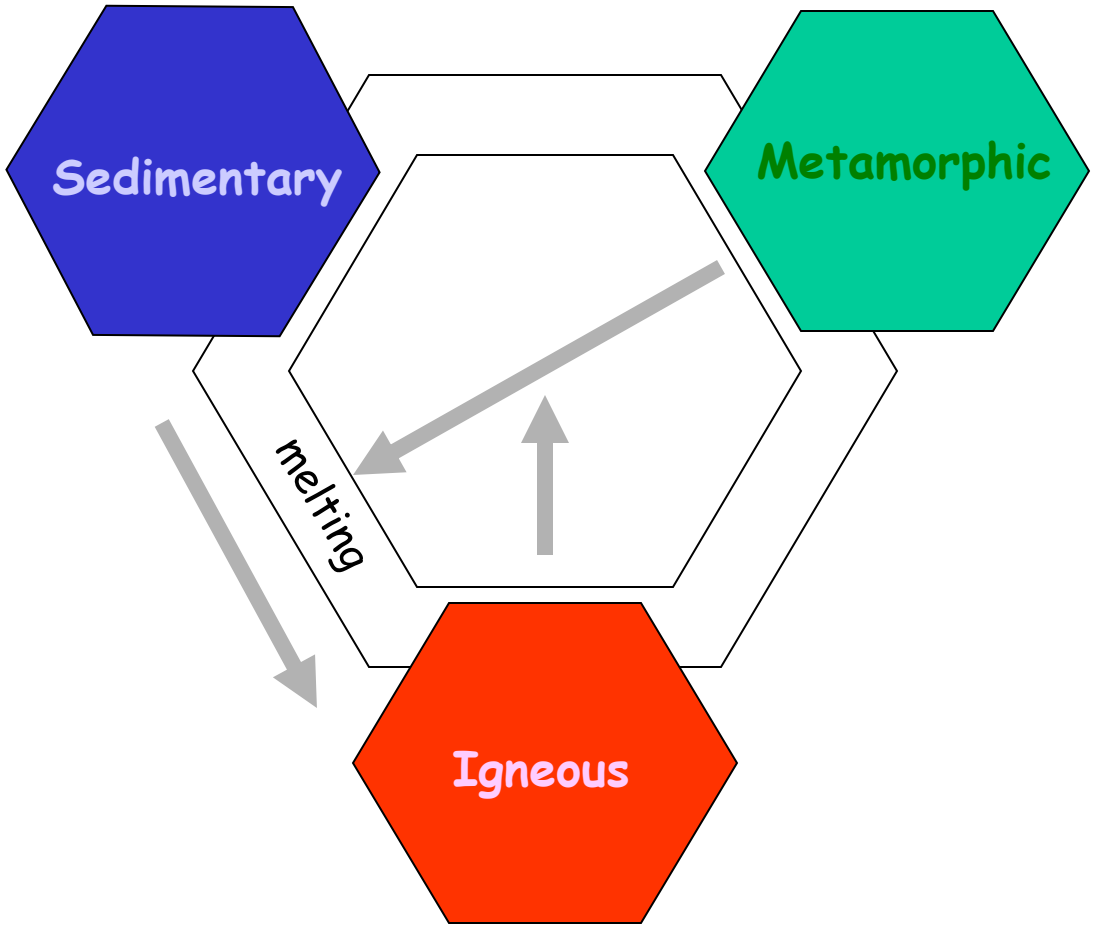
$$H_2O + CO_2 \rightarrow H_2CO_3$$

Chemical weathering dissolves the minerals in rocks. The resulting dissolved compounds could form evaporites like **rock salt** or **rock gypsum** or chemical precipitates like some kinds of **limestones**. What forms depends upon composition and depositional environment factors.



$$2KAlSi_3O_8 + 2H^+ + H_2O \rightarrow Al_2Si_2O_5(OH)_4 + 2K^+ + 4SiO_2$$

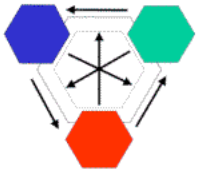
The Rock Cycle



Igneous Rocks

form from molten rock or magma in the subsurface or from lava extruded at the surface

Becoming an IGNEOUS ROCK …



Any existing rock – **igneous**, **metamorphic** or **sedimentary** - can be subjected to enough heat and or pressure causing it to melt.

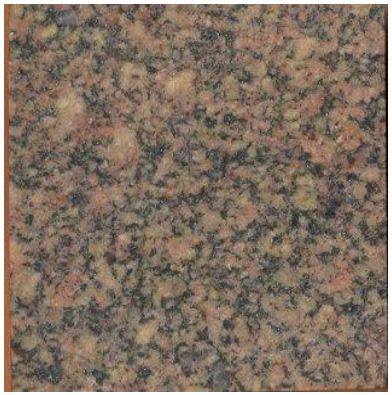
Molten rock is called magma or lava.

When magma cools to a solid it becomes an igneous rock.

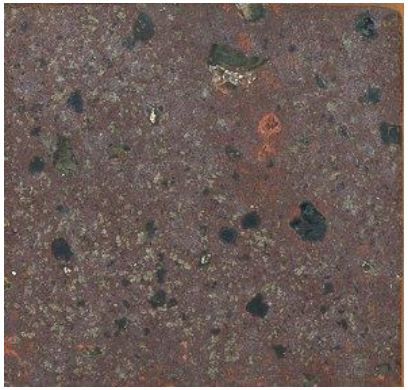
The kind of **igneous rock** formed depends on what was melted and how it cooled.

Igneous rocks are classified based on their mineral composition and texture.

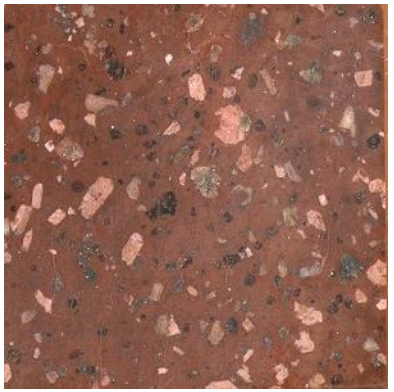
Igneous rocks include:



granite

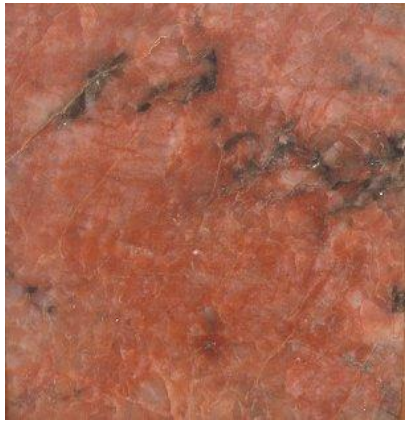


basalt



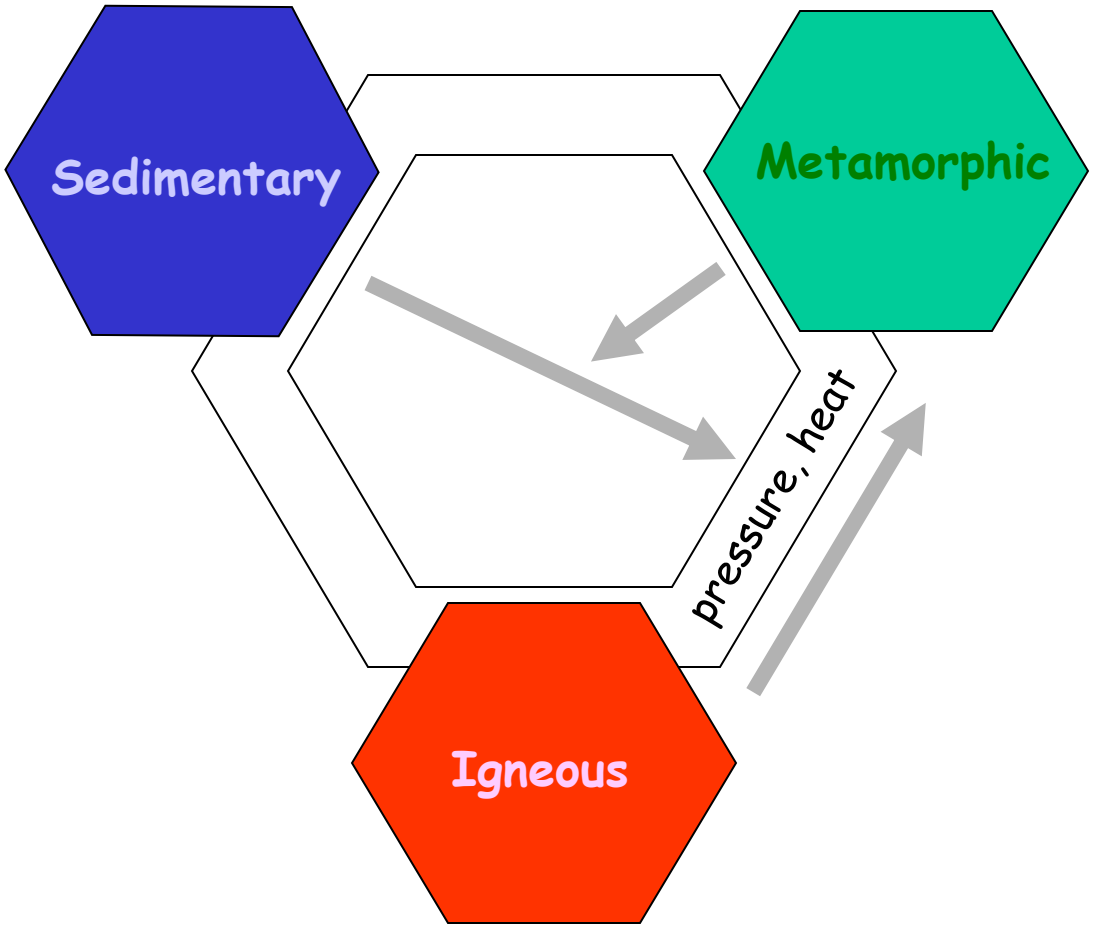
rhyolite

granodiorite



pegmatite

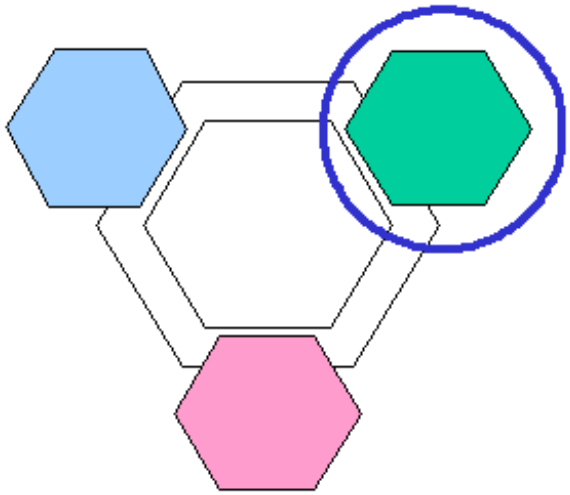
The Rock Cycle



Pressure and heat cause preexisting rocks or sediments to become **metamorphic rocks**

Becoming a METAMORPHIC ROCK …

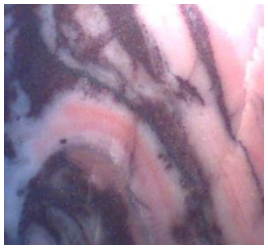
If the igneous rock **basalt** is exposed to sufficient heat and or pressure it can be transformed into the metamorphic rock call **metabasalt**



When the prefix ***meta*** is applied to a rock name that means that the original rock has been metamorphosed.

Becoming a METAMORPHIC ROCK …

If the sedimentary rock **limestone** or **dolomite** is metamorphosed it can become the metamorphic rock **marble**.



If the sedimentary rock **sandstone** is metamorphosed it can become the metamorphic rock **quartzite**.

If the sedimentary rock **shale** is metamorphosed it can become the metamorphic rock **slate**.

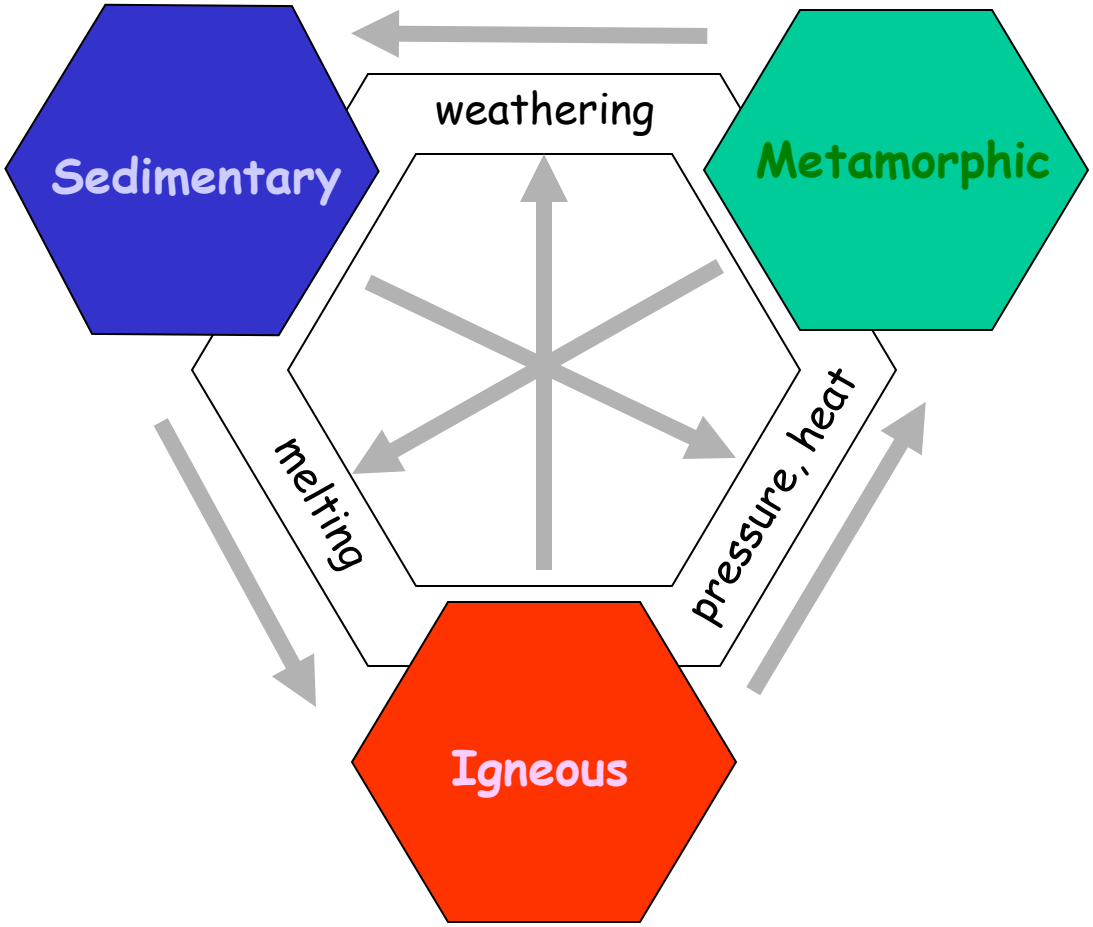
Becoming a METAMORPHIC ROCK …

If the metamorphic rock **slate** is metamorphosed it can become the metamorphic rock **phyllite**

If the metamorphic rock **phyllite** is metamorphosed it can become the metamorphic rock **schist**.

If the metamorphic rock **schist** is metamorphosed it can become the metamorphic rock **gneiss**.

The Rock Cycle



The Rock Cycle does not go in just one direction.
Any given rock can go through any part of the cycle any number of times.