



Amphibole



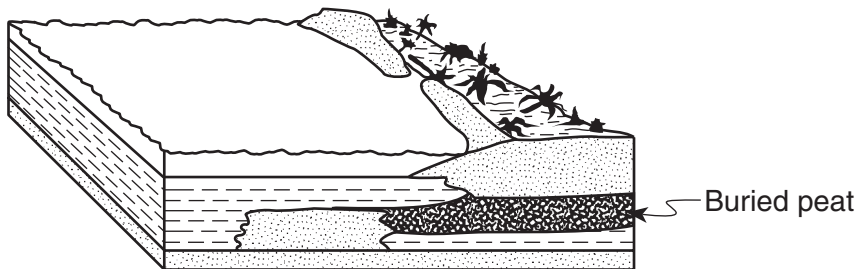




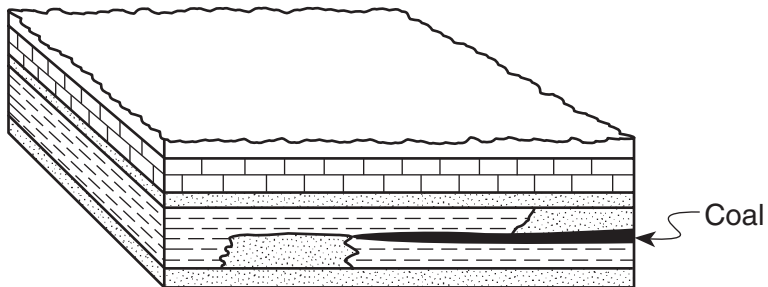




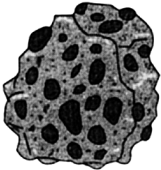
Stage 1

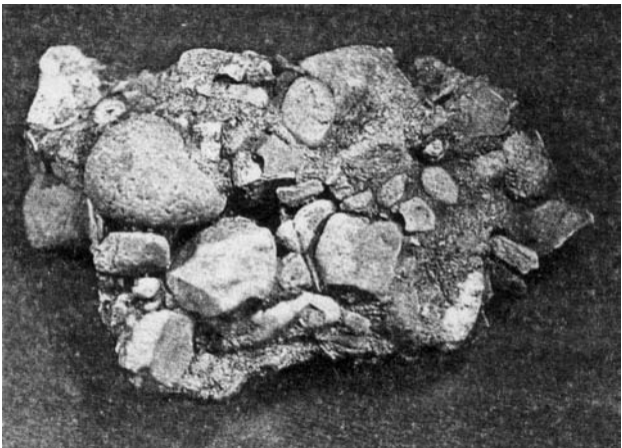


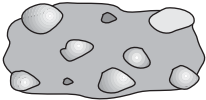
Stage 2

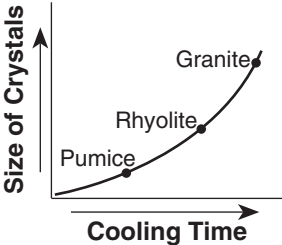


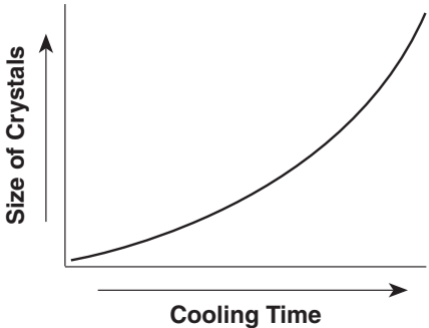
Stage 3



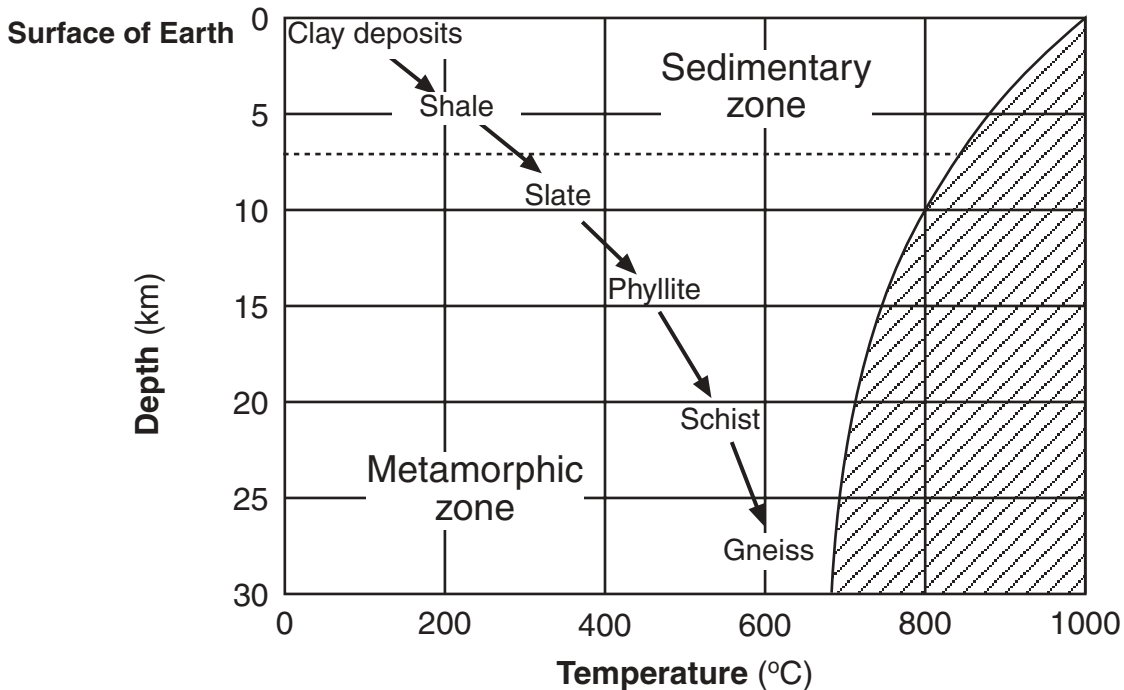


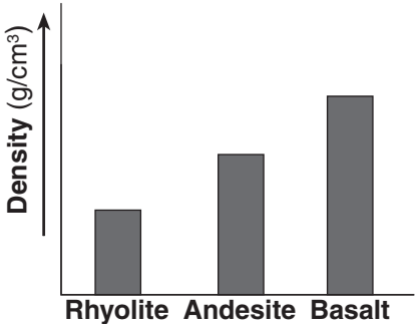






Inferred Metamorphism of Shale





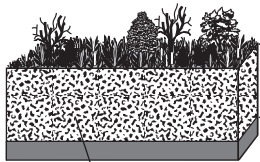
Stage 1

Stage 2

Stage 3

Stage 4

Swamp environment

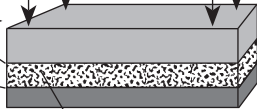


Peat

partially altered
plant material;
very smoky when
burned; low energy

Burial

Compaction

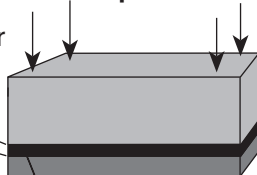


Lignite

soft, brown coal;
moderate energy

Greater
burial

Compaction



Bituminous

soft, black coal;
major coal used in
power generation and
industry; high energy

Greater
pressure

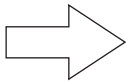
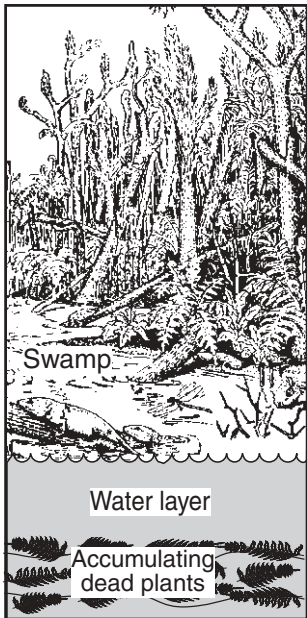
Stress



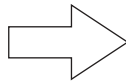
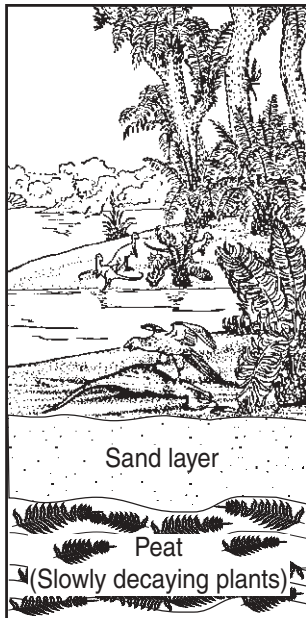
Anthracite

hard, black coal;
used in industry;
high energy

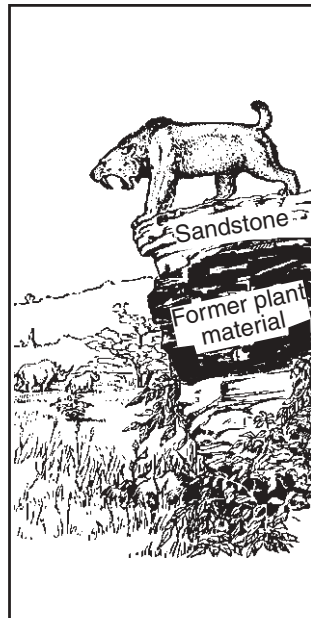
300 Million Years Ago



175 Million Years Ago



40 Million Years Ago

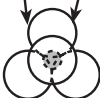


Oxygen atoms

Silicon atoms



Chemically unite to form



Silica tetrahedron

May be arranged to become



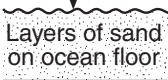
Mineral quartz

Combines with other minerals to form



Andesite rock

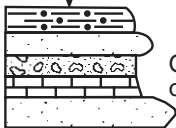
Box A



Layers of sand on ocean floor

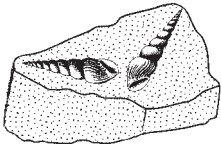
Sand particles of 0.01 cm

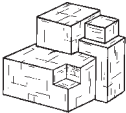
Compaction/cementation followed by uplift



Outcrop of bedrock

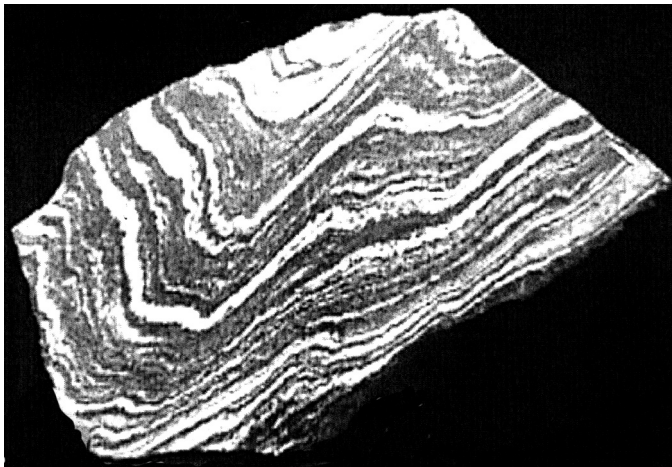






Galena



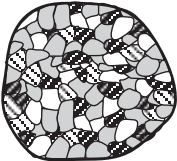


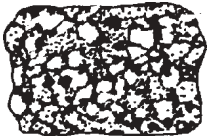






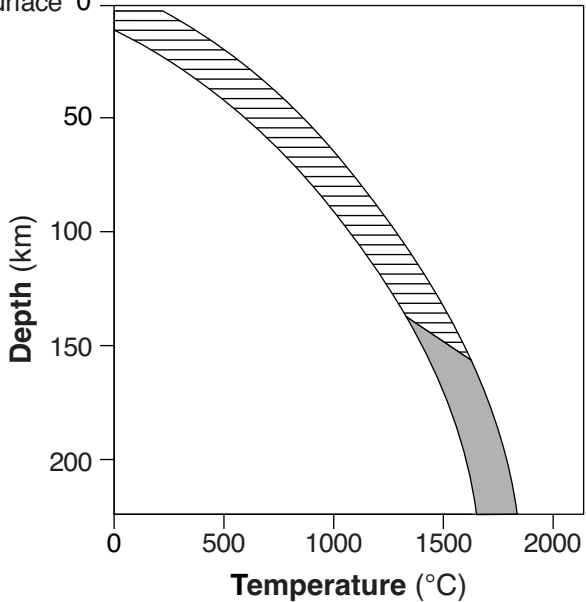
Bands of alternating
light and dark
minerals





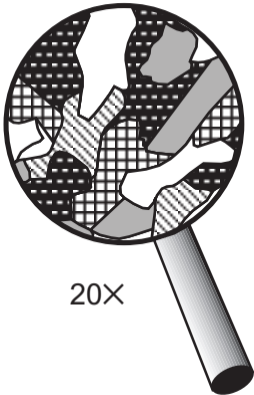
Interlocking
0.5-cm-diameter
crystals of various colors

Earth's surface 0

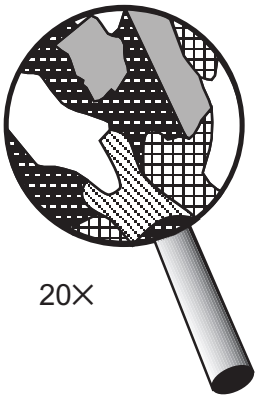




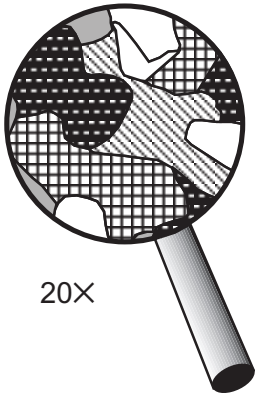
Mineral	Color	Chemical Composition	Luster	Hardness	Dominant Form of Breakage
“Herkimer Diamond” (quartz)	Colorless or variable	SiO ₂	Glassy	7	Fracture
True diamond	Colorless or variable	C	Glassy	10	Cleavage



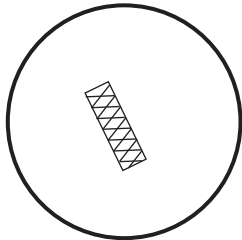
20X



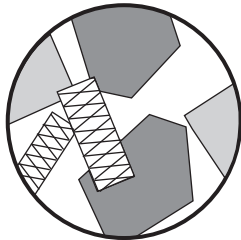
20X



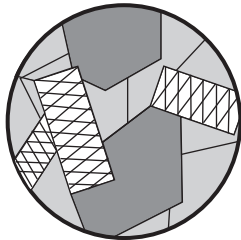
20X



Stage 1

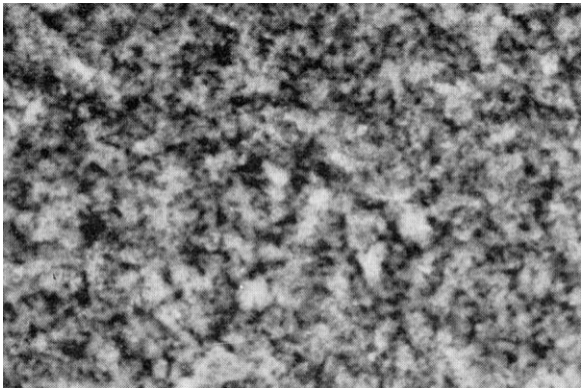


Stage 2



Stage 3

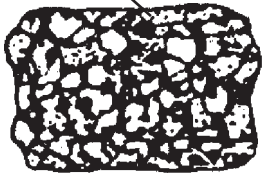




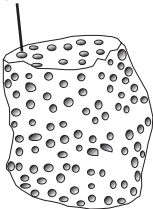
(Shown to actual size)

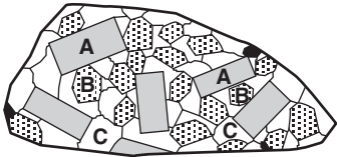


Large intergrown
crystals



Gas pockets in glass





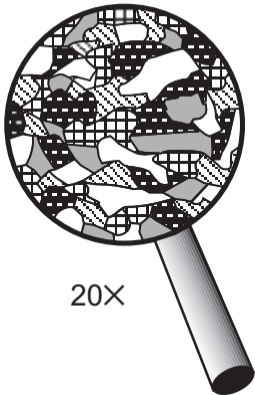
Melted
rock

```
graph LR; A([Melted rock]) -- Solidification --> B[Basalt]
```

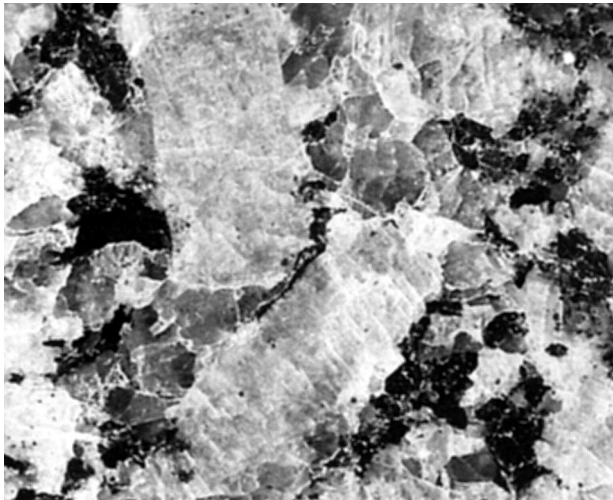
The diagram illustrates a geological process. On the left, an oval contains the text "Melted rock". A horizontal arrow points from this oval to the right. Above the arrow is the word "Solidification". On the right, a rectangular box contains the word "Basalt".

Solidification

Basalt

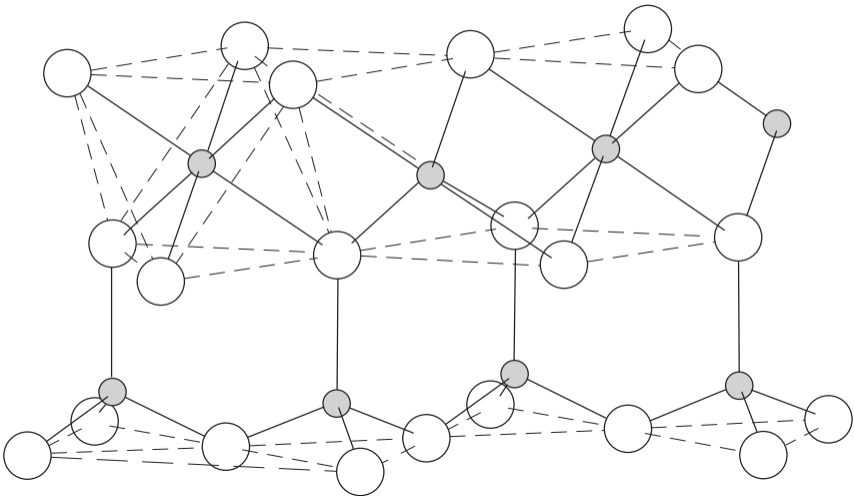


20X

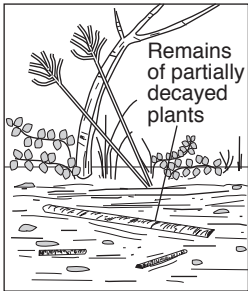


(Actual size)

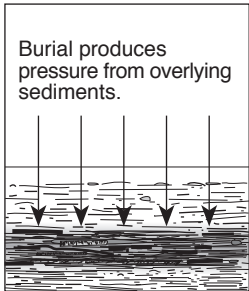
Structure of Kaolinite



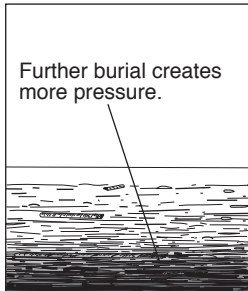
Stage 1

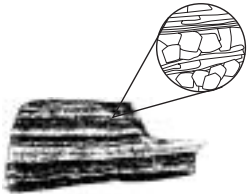


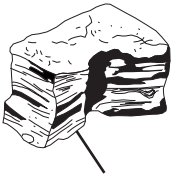
Stage 2



Stage 3







Mica crystals
in foliated
layers

Mineral Property	Mineral			
	Smithsonite	Sphalerite	Willemite	Zincite
Composition	ZnCO_3	ZnS	Zn_2SiO_4	ZnO
Hardness	4–4.5	3.5–4	5.5	4
Density (g/cm ³)	4.4	4.0	4.0	5.6
Color	white, gray, green, blue, yellow	brown, yellow, red, green, black	white, yellow, green, reddish brown, black	deep red to orange yellow
Streak	white	white to yellow to brown	white	orange yellow

Physical Property	Observation
color	white
hardness	scratched by the mineral calcite
distinguishing characteristic	feels greasy
cleavage/fracture	shows some definite flat surfaces

Table 1

Gemstone Mineral	Composition	Hardness	Average Density (g/cm³)
emerald	$\text{Be}_3\text{Al}_2(\text{Si}_6\text{O}_{18})$	7.5–8	2.7
sapphire	Al_2O_3	9	4.0
spinel	MgAl_2O_4	8	3.8
zircon	ZrSiO_4	7.5	4.7

Data Table

Mineral	Density (g/cm³)
corundum	4.0
galena	7.6
hematite	5.3
quartz	2.7

Harder than glass

Metallic luster

A

B

C

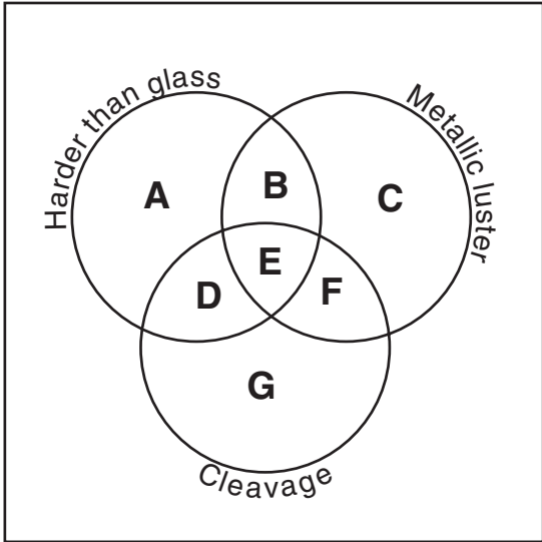
D

E

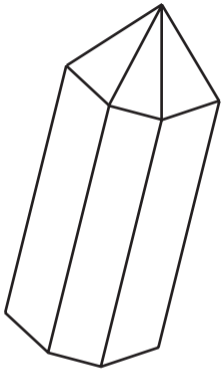
F

G

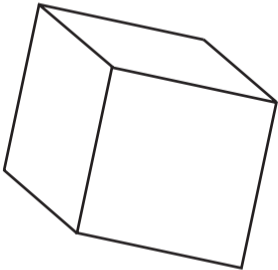
Cleavage



Mineral Variety	Color	Hardness	Luster	Composition
flint	black	7	nonmetallic	SiO ₂
chert	gray, brown, or yellow	7	nonmetallic	SiO ₂
jasper	red	7	nonmetallic	SiO ₂
chalcedony	white or light color	7	nonmetallic	SiO ₂



Quartz



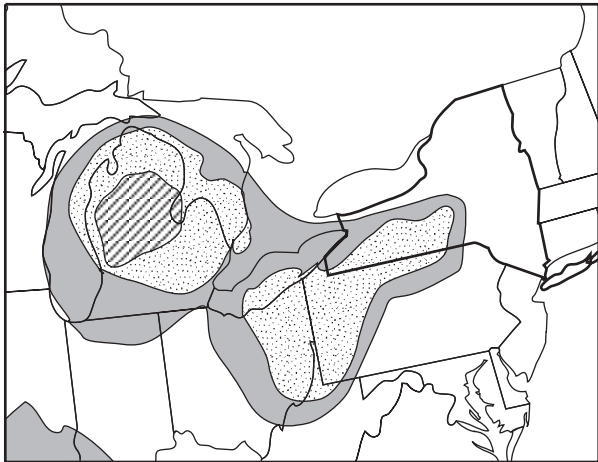
Halite

Pyrite

Sample	Volume (cm³)	Mass (g)
<i>A</i>	2.5	12.5
<i>B</i>	6.0	30.0
<i>C</i>	20.0	100.0

Mineral	Density (g/cm³)
Cinnabar	8.2
Magnetite	5.2
Quartz	2.7
Siderite	3.9

Mineral Deposits



Key



Gypsum



Gypsum and halite



Gypsum, halite,
and potassium salts

Minerals

Some physical properties

Hardness

which means

How easily a mineral is scratched

Example

C

which scratches olivine

A

which means

The way a mineral reflects light

Example

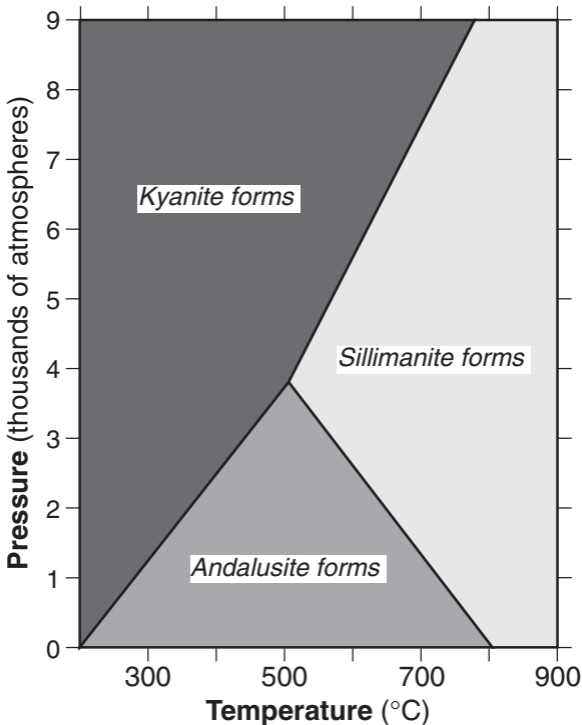
Metallic

Streak

which means

B

Conditions Under Which Three Different Minerals Composed of Al_2SiO_5 Form



Hardness of Four Materials

Material	Hardness
human fingernail	2.5
copper penny	3.0
window glass	4.5
steel nail	6.5

Group A

olivine

garnet

calcite

Group B

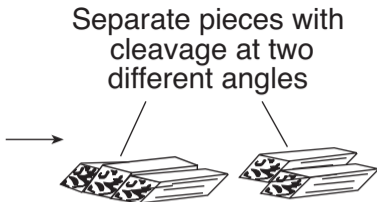
pyrite

galena

graphite

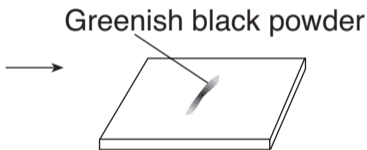
Test A

Struck with a hammer



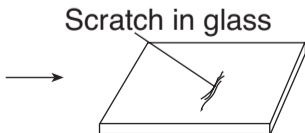
Test B

Rubbed on an unglazed porcelain plate



Test C

Rubbed on a glass square



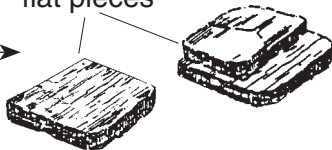
Test A



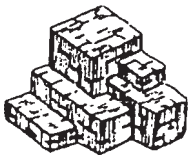
Mineral #1

→ Hit on the side
with a wedge →

Two separate
flat pieces



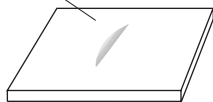
Test B



Mineral #2

→ Rubbed on
an unglazed
porcelain plate →

Gray/black powder



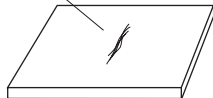
Test C

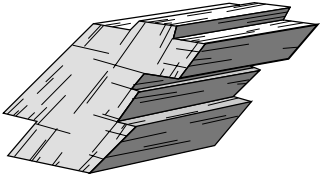


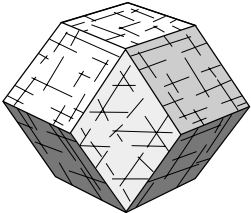
Mineral #3

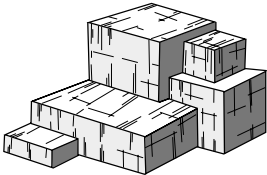
→ Rubbed on a
glass square →

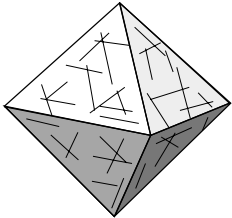
Scratch in glass



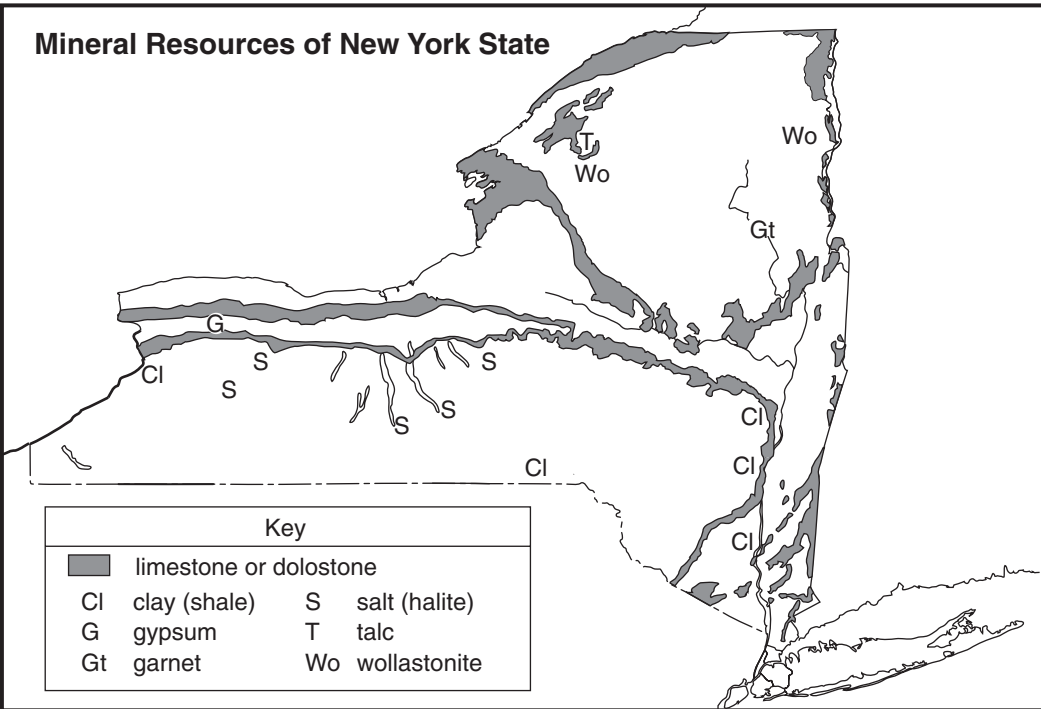








Mineral Resources of New York State



Index Minerals

Common Objects

Diamond

10

Corundum

9

Topaz

8

Quartz

7

Steel file

Orthoclase

6

Glass

Apatite

5

Fluorite

4

Calcite

3

Copper penny

Fingernail

Gypsum

2

Talc

1

Moh's Mineral Hardness Scale

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

Approximate Hardness of Common Objects

Fingernail (2.5)

Copper penny
(3.5)

Iron nail (4.5)

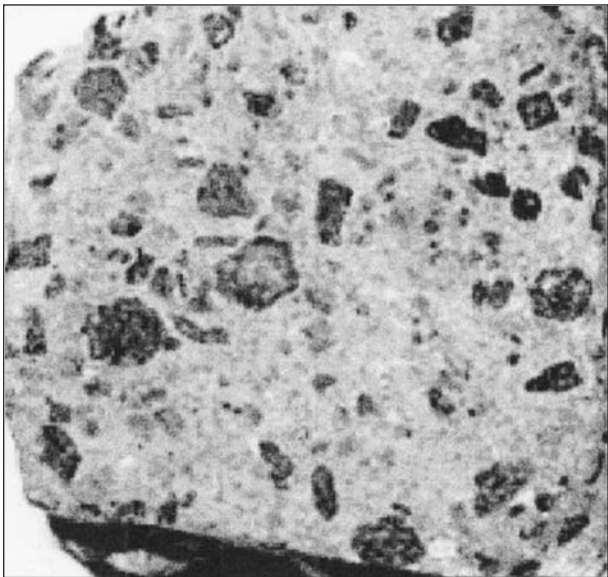
Glass (5.5)

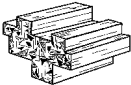
Steel file (6.5)

Streak plate (7.0)



Glassy black rock
that breaks with a
shell-shape fracture

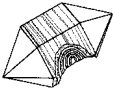




Pyroxene

Photographs of "Herkimer Diamonds" (Quartz)





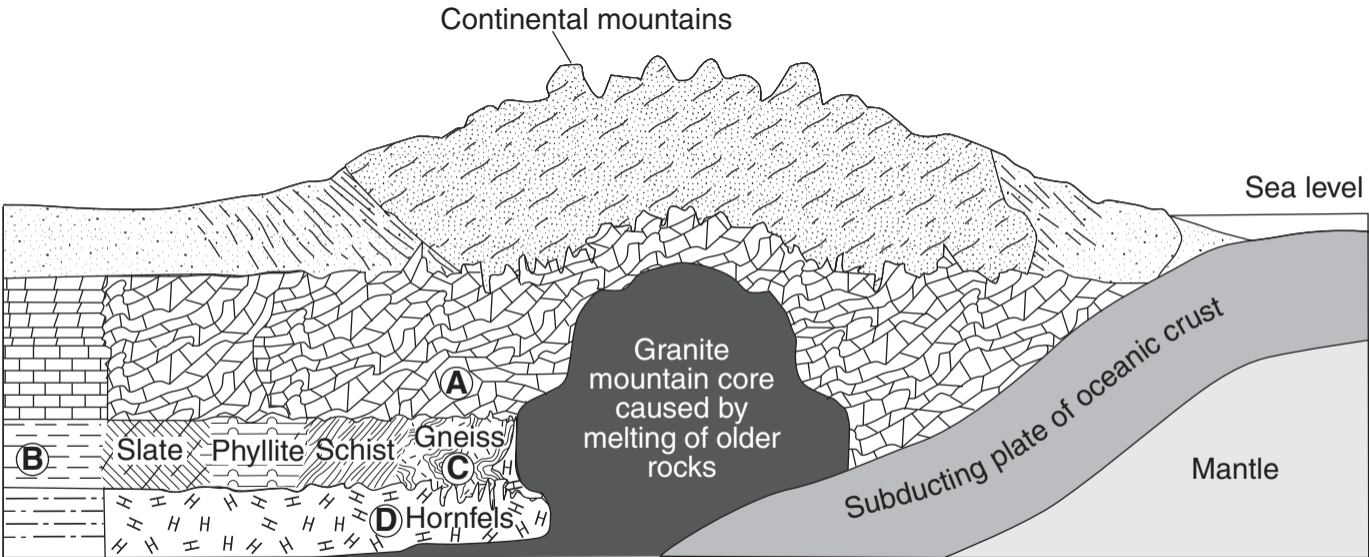
Quartz



Mineral Arrangement
Before Metamorphism



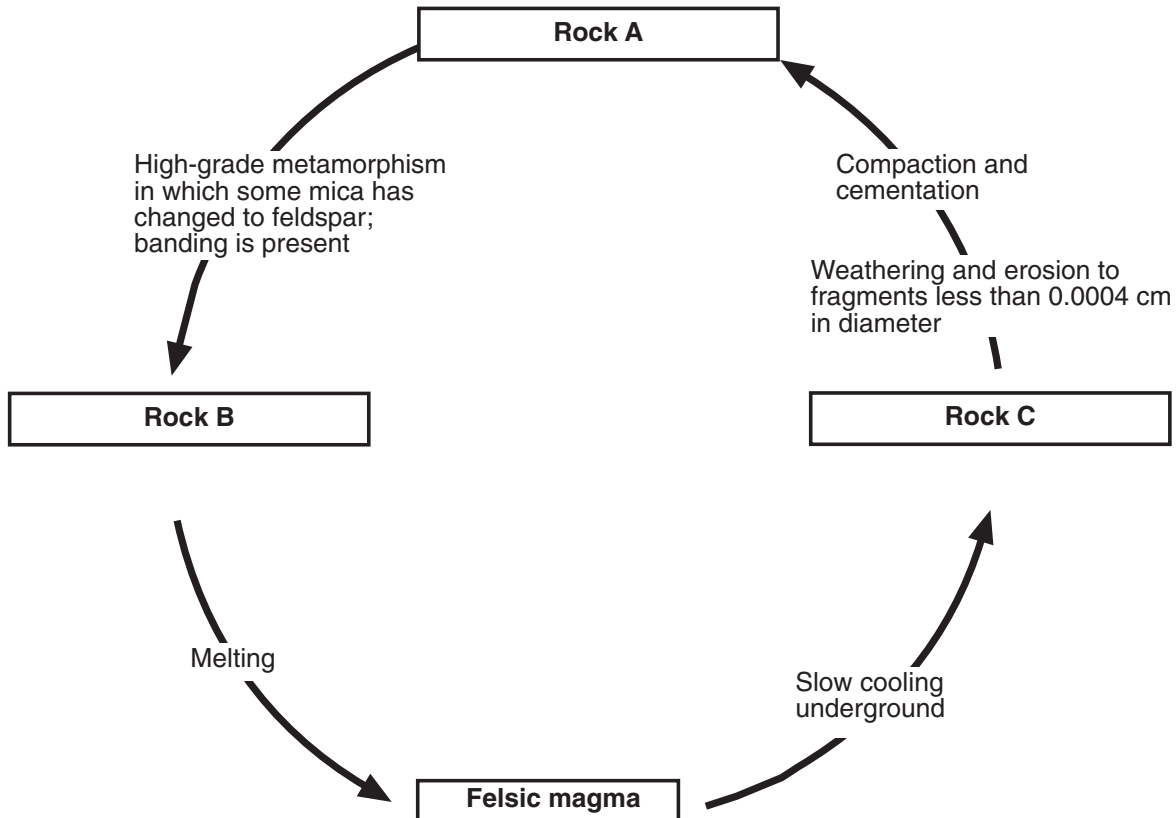
Rock C Showing Banding
After Metamorphism

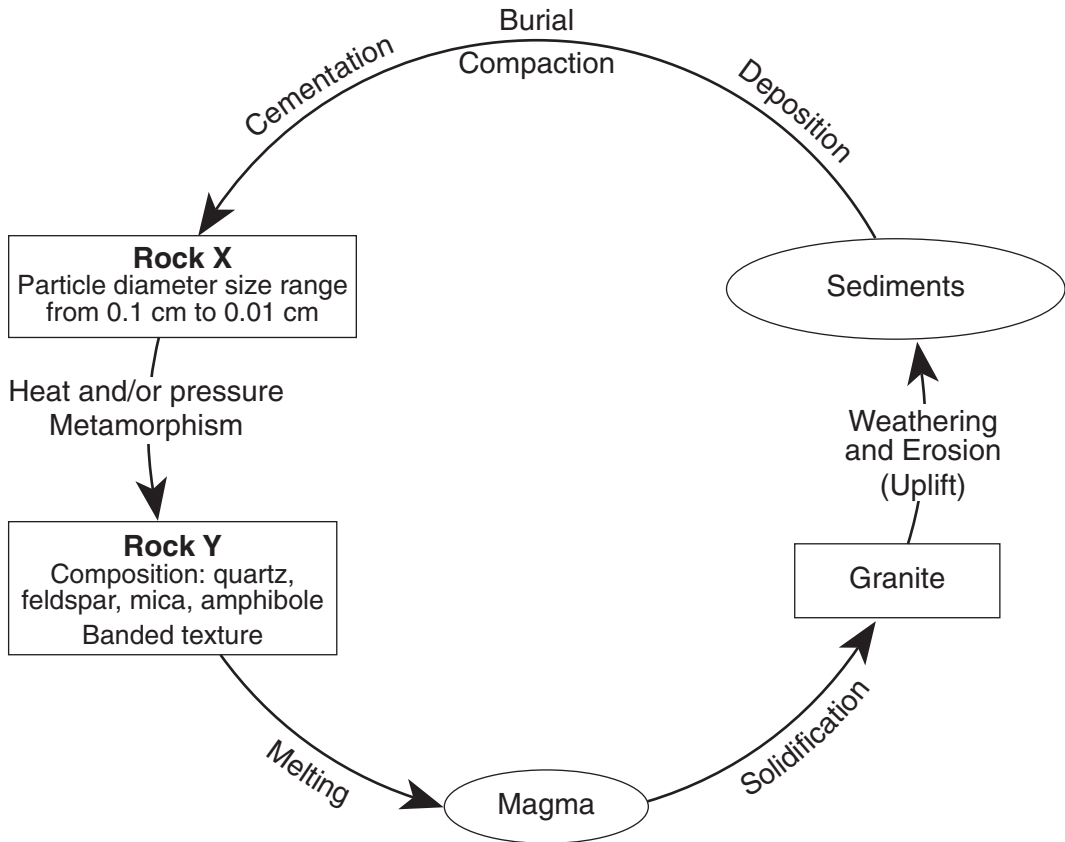


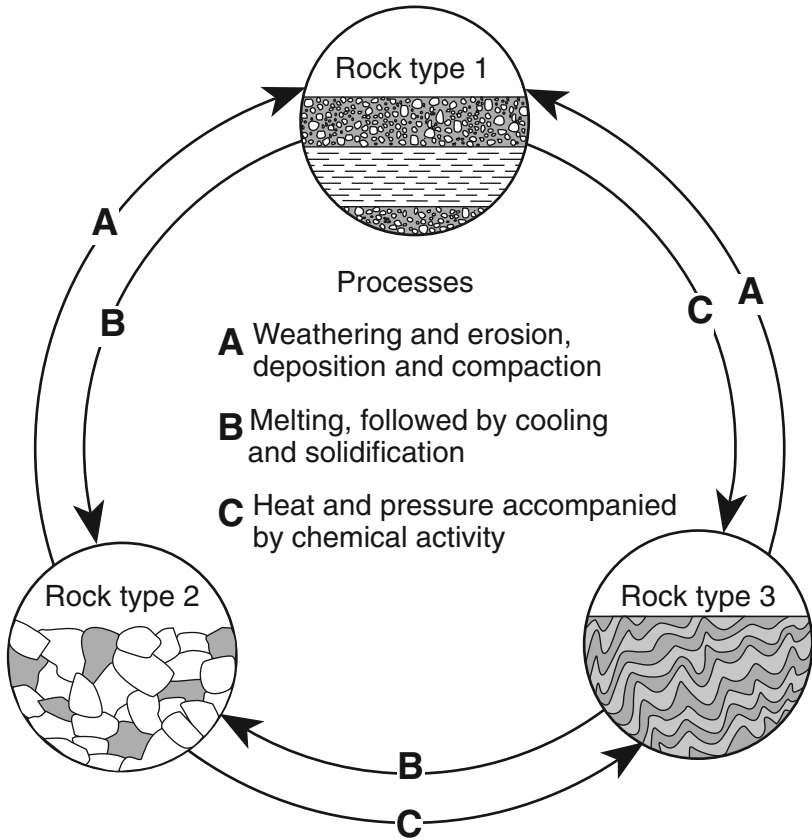
(Not drawn to scale)

Data Table

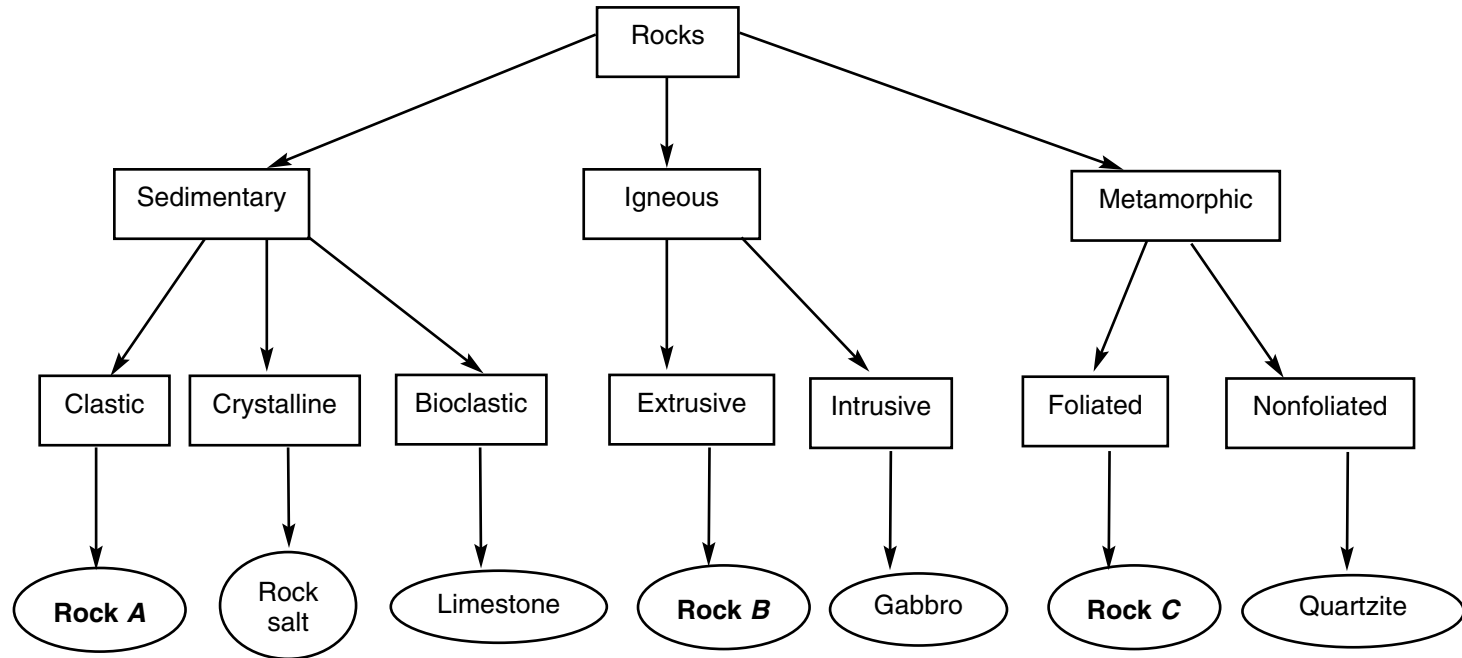
Rock Sample Number	Composition	Grain Size	Texture	Rock Name
1	mostly clay minerals		clastic	shale
2	all mica	microscopic, fine	foliated with mineral alignment	
3	mica, quartz, feldspar, amphibole, garnet, pyroxene	medium to coarse	foliated with banding	gneiss
4	potassium feldspar, quartz, biotite, plagioclase feldspar, amphibole	5 mm		granite



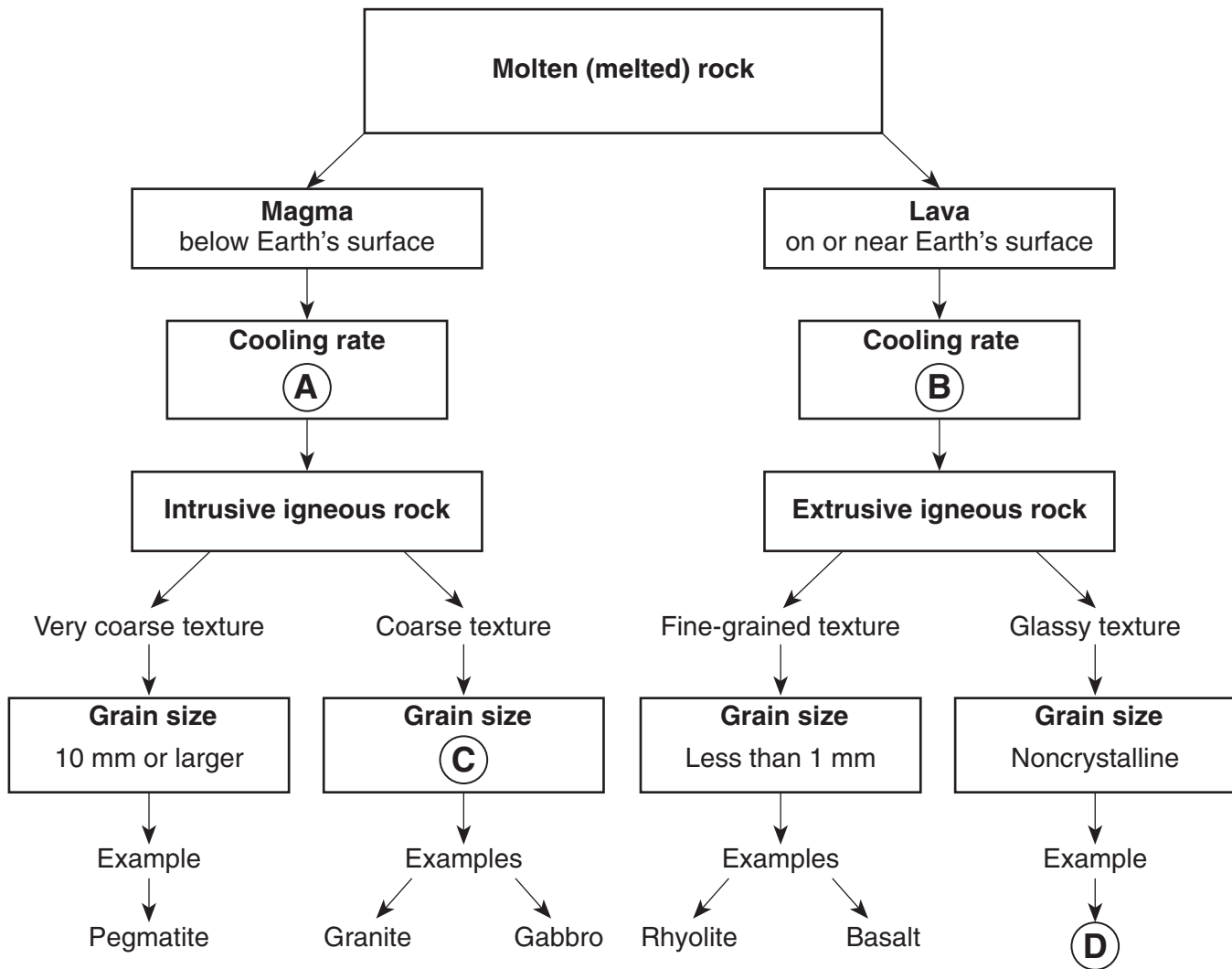




Rock Classification Flowchart



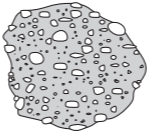
Some Igneous Rocks







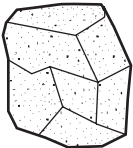
Igneous



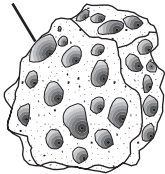
Sedimentary



Metamorphic

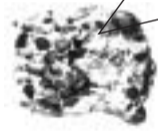


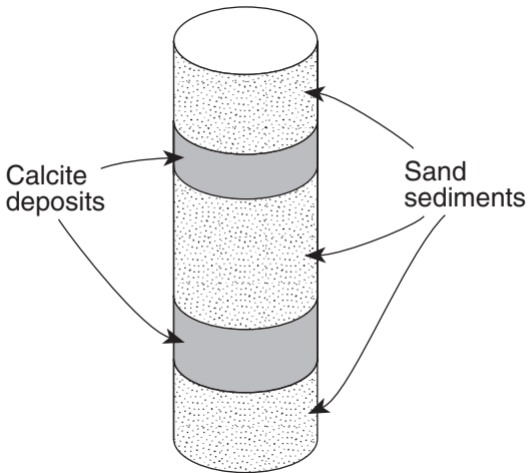
Pebbles
cemented in
sand matrix

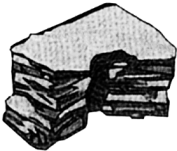




(Shown actual size)









Easily split layers of
0.0001-cm-diameter
particles cemented together

