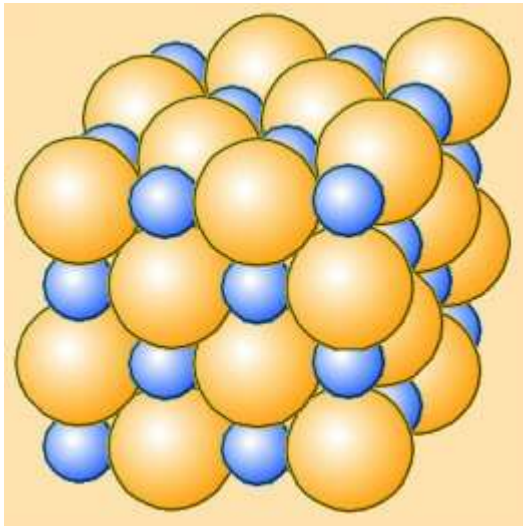
Minerals

- Geological definition of a mineral:
  - naturally occurring
  - crystalline solid
    - crystalline means that minerals
    - have atoms arranged in specific 3-dimensional frameworks
  - minerals have a narrowly defined chemical composition
  - and characteristic physical properties such as
    - density
    - hardness
    - color...



Minerals—The Building Blocks of Rocks

- A mineral's composition is shown by a chemical formula
  - a shorthand way of indicating how many atoms of different kinds it contains
  - Quartz molecules consist of 1 silicon atom and 2 oxygen atoms
  - Orthoclase molecules consists of 1 potassium, 1 aluminum, 3 silicon, and 8 oxygen atoms

Quartz: SiO_2
Ratio: 1: 2

$KAlSi_3O_8$

1: 1: 3: 8

- Minerals Are:
  - Natural crystalline substances with many shapes and compositions.

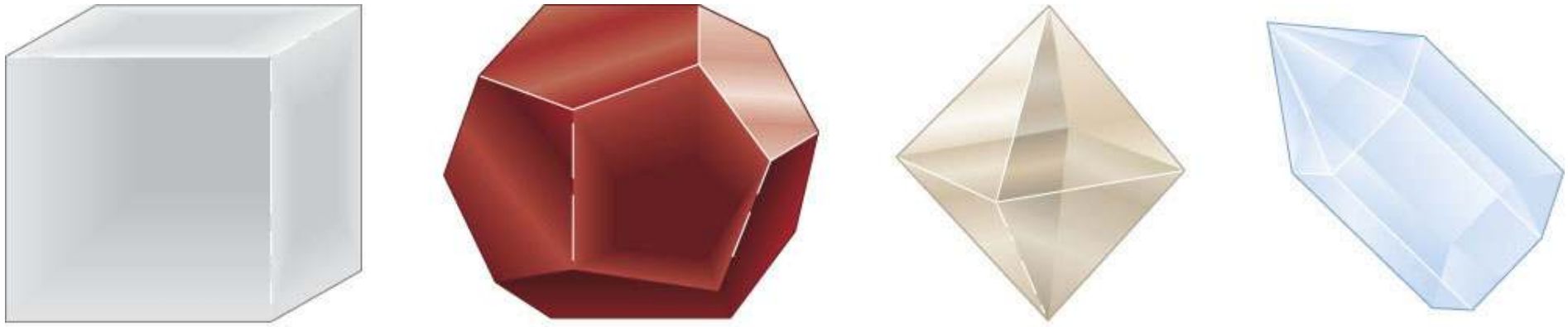
Quartz

Feldspar

Pyrite

Crystalline Solids

- By definition, minerals are crystalline solids
  - with atoms arranged in a specific 3D framework
- If given enough room to grow freely,
  - minerals form perfect crystals with
  - planar surfaces, called crystal faces
  - sharp corners
  - straight edges



(a) (b) (c) (d)

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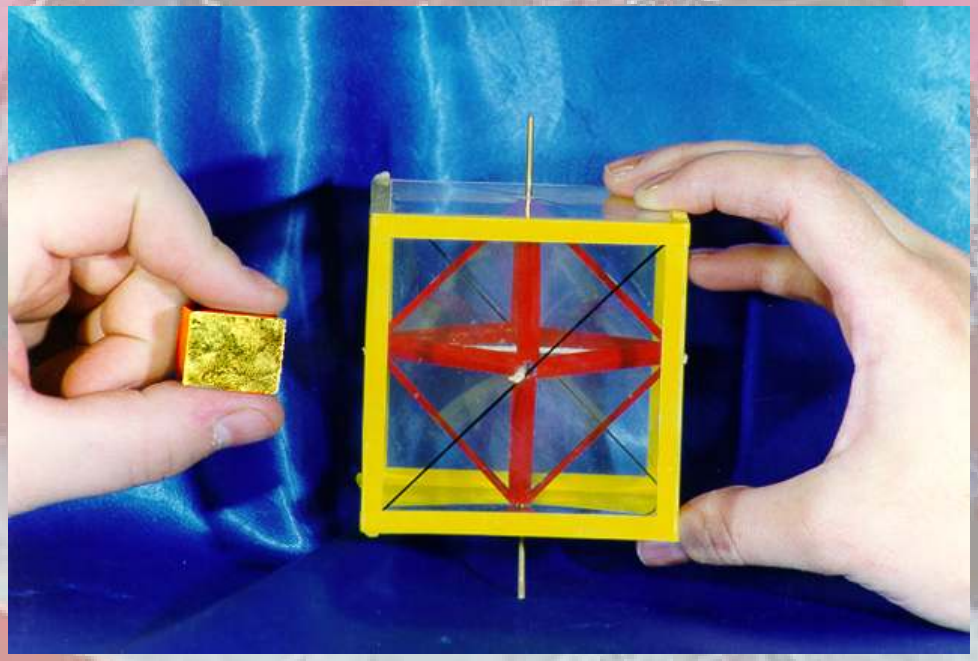
MINERAL CRYSTAL STRUCTURES

* What are some kinds of crystal structures?

1. Cubic - example is pyrite



Note how cube-shaped pyrite crystal reflects cubic crystal structure. (Photo by Parvinder Sethi).

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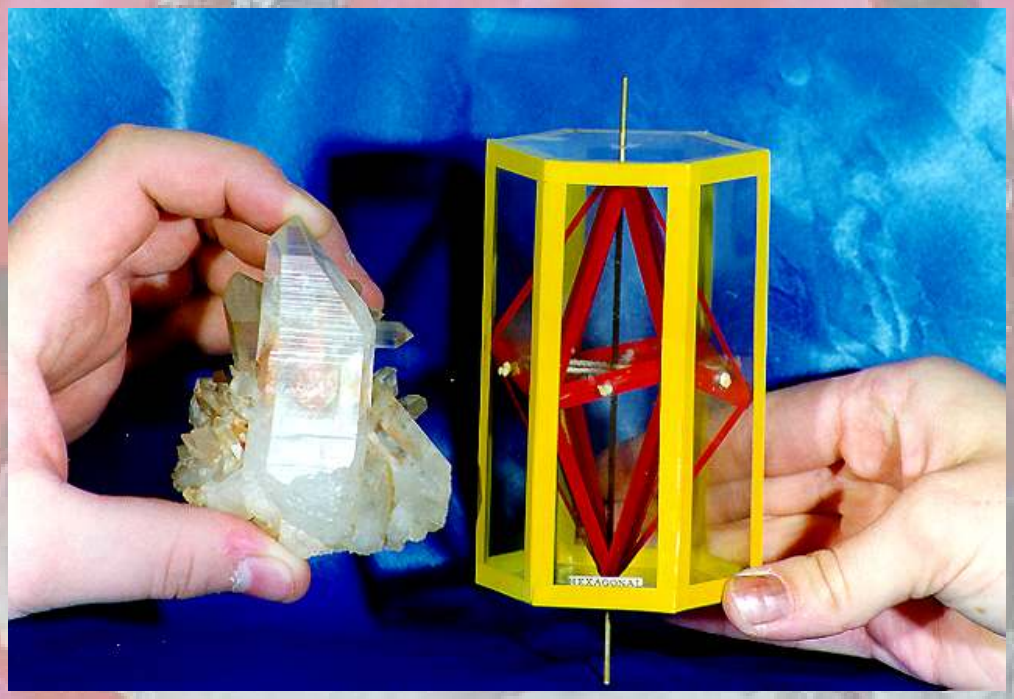
MINERAL CRYSTAL STRUCTURES

2. Hexagonal - example is quartz



Note how six-sided quartz crystals reflect hexagonal crystal structure. (Photo by Parvinder Sethi).

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MAJOR MINERAL GROUPS

* Silicates - contain Si and O

  examples are quartz (SiO_2) and

  orthoclase feldspar ($KAlSi_3O_8$)

* Oxides - contain O; examples are hematite (Fe_2O_3)

  and limonite ($Fe_2O_3 .nH_2O$)

* Sulfates - contain SO_4; example is gypsum ($CaSO_4.2H_2O$)

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MAJOR MINERAL GROUPS (continued) . . .

* Sulfides - contain S; examples are galena (PbS) and pyrite (FeS_2)

* Carbonates - contain CO_3; example is calcite ($CaCO_3$)

* Others - native elements; metals (gold)

  non-metals (diamond)

  halides (halite)

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SILICATE MINERALS

* Composed of Si (silicon) and O (oxygen), two most abundant elements in crust of earth
* Over 90 % of common rock-forming minerals are silicates
* Common silicates:
    1. Olivine - iron, magnesium silicate; typically olive green, granular crystals in dark colored igneous rocks.
    2. Pyroxene - family of complex silicates; augite most common type, occurs as dark green crystals in dark colored igneous rocks
    3. Amphibole - family of complex silicates; hornblende most common type, occurs as shiny black prismatic crystals in igneous and metamorphic rocks

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Ferromagnesian Silicates

- Common ferromagnesian silicates include

(a)

Nonferromagnesian Silicates

(b)

Mineral Properties

- Mineral properties are controlled by
  - Chemical composition
  - Crystalline structure
- Mineral properties are particularly useful
  - for mineral identification and include:
    - color
    - streak
    - luster
    - crystal form
    - cleavage
    - fracture
    - hardness
    - specific gravity

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LUSTER

* Appearance of fresh surface of mineral in reflected light.
* Two basic types - metallic , non-metallic
* Metallic minerals look like shiny metals - gold, silver, copper, brass, etc. *Slides*
* Non-metallic minerals show lusters such as:
  earthy, waxy, vitreous (glassy), adamantine (diamond-like), resinous, pearly, silky, and dull.

Minerals

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Minerals exhibiting metallic luster:
(Photographs by Parvinder Sethi).

Gold

Galena

Native copper

Minerals

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Examples of non-metallic luster (Note that amber is not a mineral because it is organic in origin):

Limonite (Earthy)

Quartz (Vitreous)

Amber (Resinous)

Diamond (Adamantine)

(Photographs by Parvinder Sethi).

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1.3.3

COLOR AND STREAK

* Are related properties in that both have to do with color in minerals

* Color refers to overall color of mineral sample:
    1. Color noticeable, but extremely variable.
    2. Quartz shows many different colors - white (milky), pink (rose), shades of gray (smoky), purple (amethyst), or even colorless

* Streak is the color of a powdered sample of the mineral.
    1. Obtained by rubbing mineral on streak plate (unglazed porcelain)

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Color variation in Quartz:

(Photos by Parvinder Sethi).

Rose

Smoky

Purple

Clear

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HARDNESS

* Measures resistance to scratching
* Mohs scale of hardness widely used - higher numbered minerals scratch lower numbered ones:

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

Minerals

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Gypsum has a hardness of 2.
(Photograph by Parvinder Sethi).

Minerals

Bounty from the Earth...

Calcite has a hardness of 3.
(Photograph by Parvinder Sethi).

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Bounty from the Earth...

Fluorite has a hardness of 4.
(Photograph by Parvinder Sethi).

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Orthoclase has a hardness of 6.

(Photograph by Parvinder Sethi).

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Quartz has a hardness of 7.
(Photograph by Parvinder Sethi).

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Topaz has a hardness of 8.
(Photograph by Parvinder Sethi).

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Diamond has a hardness of 10.
(Photograph by Parvinder Sethi).

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Minerals exhibiting streak:

(Photographs by Parvinder Sethi).

Hematite
(Red)

Galena
(Black)

Minerals

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* Hardnesses of common objects -

fingernail = 2.5
copper penny = 3.5
glass and steel knife blade = 5.5

Quartz (H=7) scratching glass (H=5.5)
(Photograph by Parvinder Sethi).

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FRACTURE AND CLEAVAGE

* Both describe how mineral breaks.
* Fracture refers to rough or irregular surfaces along which mineral breaks randomly.
    1. Examples: conchoidal, splintery, rough, smooth or fibrous.
* Cleavage is breakage of mineral along flat, planar surfaces.
    1. Caused by internal weaknesses between certain planes of atoms.
    2. Examples: one direction
        two directions (may or may not be at 90)
        three directions (may or may not be at 90)
        four or six directions

Home

Minerals

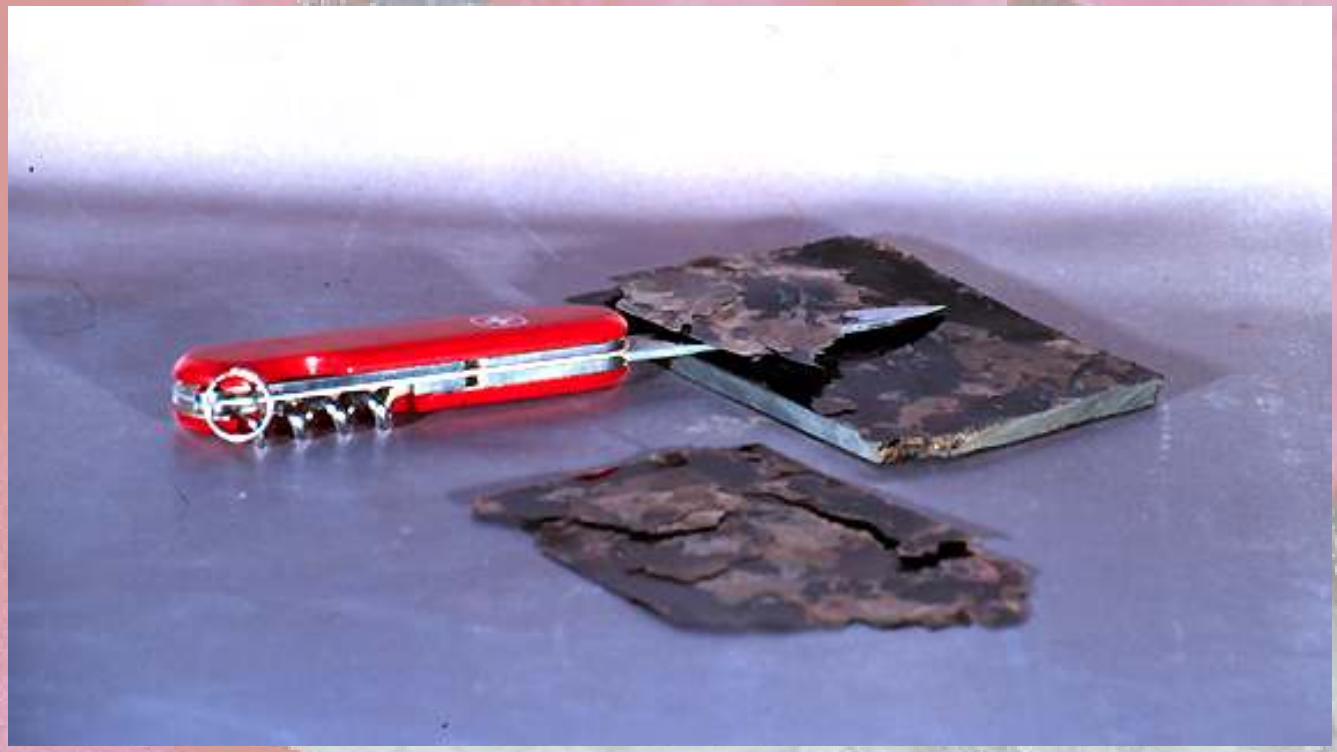
Bounty from the Earth...

Obsidian (volcanic glass) shows excellent conchoidal fracture.
(Photograph by Parvinder Sethi).

Minerals

Bounty from the Earth...

Biotite shows one excellent direction of cleavage.
(Photograph by Parvinder Sethi).



Minerals

Bounty from the Earth...

Orthoclase shows two good directions of cleavage at approximately 90 degrees.
(Photograph by Parvinder Sethi).

Minerals

Bounty from the Earth...

Halite has three good directions of cleavage at 90 degrees.
(Photograph by Parvinder Sethi).

Minerals

Bounty from the Earth...

Magnetite (lodestone) is a naturally magnetic iron oxide mineral.
(Photograph by Parvinder Sethi).

Minerals

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SELECTED VIRGINIA MINERALS

* Quartz
* Feldspar – plagioclase and orthoclase
* Mica - biotite and muscovite
* Iron oxides - hematite and limonite
* Sulfides - galena and pyrite
* Calcite
* Evaporites - halite and gypsum
* Gold
* Diamonds

Minerals

Bounty from the Earth...

(Photograph by Parvinder Sethi)

Quartz

* Composition : SiO_2, silicate
* Key physical properties:
  crystal form = hexagonal;
  luster = vitreous;
  color = extremely variable
  (colorless, white, pink, purple, grey) ; no cleavage,
  fracture = conchoidal;
  hardness = 7;
  specific gravity = 2.65.

* Uses : abrasives, glass-making, gemstones

Minerals

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Quartz (continued) . . .

* Virginia occurrences. Common in all provinces. Abundant transported grains in sand and gravel deposits in Coastal Plain. Crystals common in Piedmont and Blue Ridge (Amelia, Amherst, and Floyd Counties). In Valley and Ridge, common as transported grains in sandstone and conglomerate and as precipitated microcrystalline chert. Plateau occurrences similar to Valley and Ridge.

Minerals

Bounty from the Earth...

(Photograph by Parvinder Sethi)

Plagioclase feldspar

* Composition : $NaAlSi_3O_8$ (albite) to $CaAl_2Si_2O_8$ (anorthite); sodium-calcium silicate
* Key physical properties : non-metallic, vitreous - pearly luster; color = white (albite) to dark gray (anorthite); cleavage = two directions at nearly 90; hardness = 6; specific gravity = 2.6 - 2.8 (albite-anorthite); striations on some cleavage surfaces.

Minerals

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Plagioclase feldspar (continued) . . .

* Uses: ceramics, glass, enamel, soap, false teeth, scouring powders.
* Virginia occurrences : Crystals found in various places in Blue Ridge and Piedmont. Excellent specimens of white albite moonstone (typically with pale blue opalescence) and cleavelandite (platy plagioclase) in Amelia County.

Minerals

Bounty from the Earth...

(Photograph by Parvinder Sethi)

Orthoclase feldspar

* Composition : $KAlSi_3O_8$; potassium silicate
* Key physical properties : non-metallic, vitreous luster; color = white, pink, blue-green (amazonite); cleavage = two directions at 90; hardness = 6; specific gravity = 2.6.
* Uses : ceramics, glass, enamel

Minerals

Bounty from the Earth...

Orthoclase feldspar (continued) . . .

* Virginia occurrences : Crystals common in igneous and metamorphic rocks in Blue Ridge and Piedmont. Excellent specimens of amazonite in Amelia County. Orthoclase moonstone (similar to Ceylon moonstone) reported in Goochland County.

Minerals

Bounty from the Earth...

Amazonite is a blue-green variety of orthoclase.
It is abundant in the Amelia County pegmatite in the eastern Piedmont of Virginia.

(Photograph by Parvinder Sethi)

Minerals

Bounty from the Earth...

(Photograph by Parvinder Sethi)

Biotite mica

* Composition : $K(Mg,Fe)_3(AlSi_3)O_{10}(OH)_2$; complex silicate.
* Key physical properties : non-metallic, shiny luster; dark brown-black color; one perfect cleavage; thin, elastic sheets; hardness = 2.5 - 3; specific gravity = 2.7 - 3.1.
* Uses : fire-resistant tiles, rubber, paint

Minerals

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* Virginia occurrences : Extremely common in igneous and metamorphic rocks in Blue Ridge and Piedmont.

Minerals

Bounty from the Earth...

(Photograph by Parvinder Sethi)

Muscovite mica

* Composition : $KAl_2(AlSi_3)O_{10}(OH_2)$, complex silicate
* Key physical properties : non-metallic vitreous luster; clear to translucent; one perfect cleavage; thin, elastic sheets; hardness = 2 - 2.5; specific gravity = 2.7 - 3.0.

* Uses : computer chip manufacturing, electrical insulation, roof shingles, facial makeup, paint

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Minerals

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Muscovite mica (continued) . . .

* Virginia occurrences : Extremely common in igneous and metamorphic rocks in Blue Ridge and Piedmont. Sheet muscovite previously mined in Henry and Pittsylvania Counties. Excellent specimens in pegmatite bodies in Amelia and Bedford Counties.

Minerals

Bounty from the Earth...

(Photograph by Parvinder Sethi)

Hematite

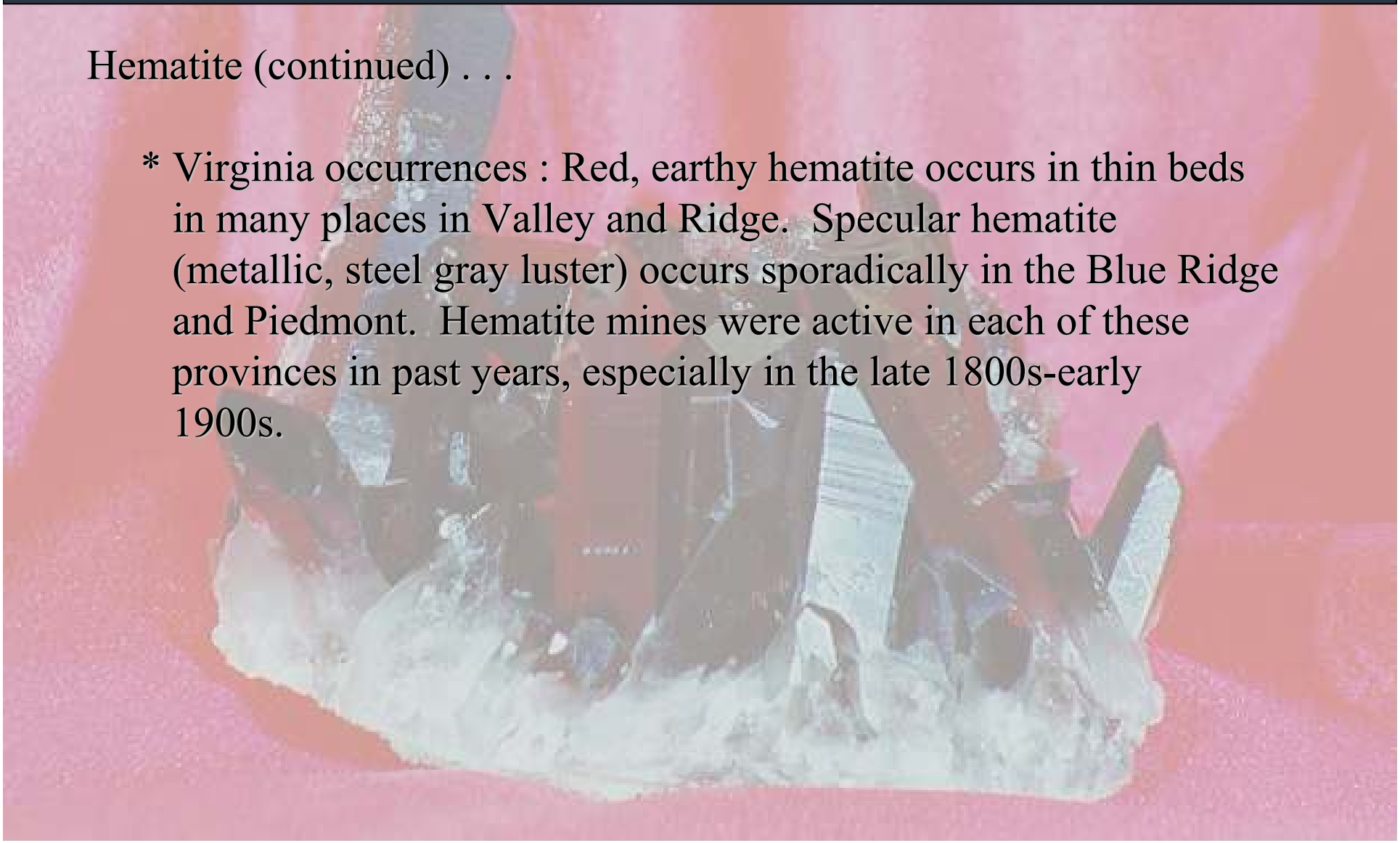
* Composition: Fe_2O_3; iron oxide
* Key physical properties : metallic or non-metallic (dull, earthy) luster; red to red-brown streak; hardness = 1.5 - 5.5; specific gravity = 4.9 - 5.3.
* Uses : ore of iron for numerous iron and steel products, pigment

Minerals

Bounty from the Earth...

Hematite (continued) . . .

* Virginia occurrences : Red, earthy hematite occurs in thin beds in many places in Valley and Ridge. Specular hematite (metallic, steel gray luster) occurs sporadically in the Blue Ridge and Piedmont. Hematite mines were active in each of these provinces in past years, especially in the late 1800s-early 1900s.



Minerals

Bounty from the Earth...

(Photograph by Parvinder Sethi)

Limonite

* Composition : $Fe_2O_3.nH_20$; iron oxide.
* Key physical properties : non-metallic luster; dull earthy yellow - brown to dark brown color; yellow - brown streak; hardness 1.5 - 5.5; specific gravity 3.6 - 4.0.
* Uses : Ore of iron for numerous iron and steel products, pigment.

Minerals

Bounty from the Earth...

Limonite (continued) . . .

* Virginia occurrences : common as weathering product of iron-rich rocks in Appalachian provinces (Piedmont, Blue Ridge, Valley and Ridge, Plateaus). Major portion of Virginia's former iron industry based on limonitic ores in Valley and Ridge. Present mining in southern Pulaski County to produce pigments (only place in United States producing burnt sienna color).

Minerals

Bounty from the Earth...

(Photograph by Parvinder Sethi)

Galena

* Composition : PbS; lead sulfide
* Key physical properties : metallic, silvery gray luster; gray - dark gray streak; cleavage = three directions at 90 (cubic); hardness = 2.5; specific gravity = 7.4 - 7.6 (feels unusually heavy when hefted)
* Uses : ore of lead; used in TV glass, auto batteries, solder, ammunition, paint.

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Minerals

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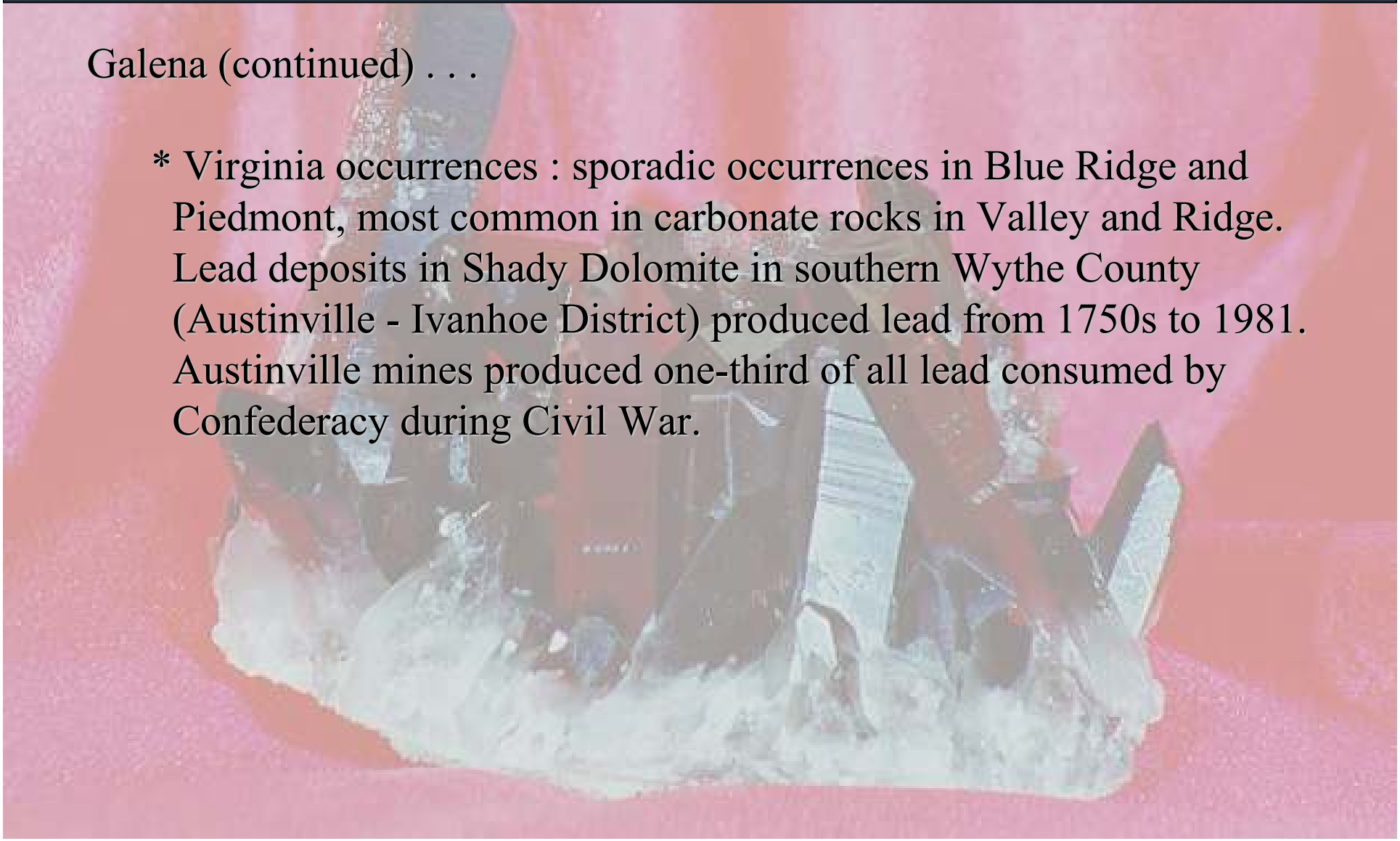
Galena (continued) . . .

* Virginia occurrences : sporadic occurrences in Blue Ridge and Piedmont, most common in carbonate rocks in Valley and Ridge. Lead deposits in Shady Dolomite in southern Wythe County (Austinville - Ivanhoe District) produced lead from 1750s to 1981. Austinville mines produced one-third of all lead consumed by Confederacy during Civil War.



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Bounty from the Earth...

(Photograph by Parvinder Sethi)

Pyrite ("fool's gold")

* Composition : FeS_2, iron sulfide
* Key physical properties : metallic, brassy yellow-gold luster; dark gray streak; brittle, no cleavage, cubic crystals common; hardness = 6 - 6.5; specific gravity = 5.0.
* Uses : Ore of sulfur; used for sulfuric acid, explosives, fertilizers, pulp processing, insecticides

Minerals

Bounty from the Earth...

Pyrite (continued)

* Virginia occurrences : large commercial ore deposits in northern Piedmont mined principally in late 1800s - early 1900s. Common as finely disseminated grains in dark shales and coals in Valley and Ridge, and Plateaus. Coal beds rich in pyrite are high-sulfur, acid drainage-producing seams.

Minerals

Bounty from the Earth...

(Photograph by Parvinder Sethi)

Calcite

* Composition : $CaCO_3$, calcium carbonate
* Key physical properties : non-metallic, vitreous-earthy luster; colorless to white if pure but nearly any color with impurities; perfect cleavage in three directions at about 75 deg. (rhombohedral); fizzes in hydrochloric acid; hardness = 3; specific gravity - 2.7.

Minerals

Bounty from the Earth...

Calcite (continued) . . .

* Uses : Forms limestone (sedimentary rock) and marble (metamorphic rock); as such, used in fertilizer, cement, paper, construction aggregate, and numerous other industries.

* Virginia occurrences : Common in marble belts in Blue Ridge and Piedmont and in limestones in Valley and Ridge and Plateaus. Good crystals found in many limestones quarries in Great Valley (eastern Valley and Ridge).

Minerals

Bounty from the Earth...

(Photograph by Parvinder Sethi)

Halite

* Composition : NaCl, sodium chloride
* Key physical properties : non-metallic luster; colorless (but varies with impurities); perfect cleavage = three directions at 90 (cubic) and cubic crystals; salty taste; hardness = 2.5; specific gravity = 2.1 - 2.6

Minerals

Bounty from the Earth...

Halite (continued) . . .

* Uses : nutrition, snow removal, water softeners, preservative, numerous sodium by-products.

* Virginia occurrences : Found in sedimentary rocks, commonly associated with gypsum (both form from the evaporation of sea water and are called “evaporite” minerals). Salt was taken for many years from underground deposits at Saltville (Smyth County) in the Valley and Ridge. About two-thirds of Confederate salt came from Saltville in the 1860s.

Minerals

Bounty from the Earth...

(Photograph by Parvinder Sethi)

Gypsum

* Composition : $CaSO_4.nH_2O$, calcium sulfate
* Key physical properties : non-metallic; colorless to white; one good cleavage (two poor ones); flexible sheets, satiny fibers, or dull masses; hardness = 2; specific gravity = 2.3.
* Uses : wallboard, drywall, plaster-of-paris

Minerals

Bounty from the Earth...

Gypsum (continued) . . .

* Virginia occurrences : Evaporite mineral formed in sedimentary rocks from evaporation of sea water. Thick gypsum deposits associated with halite located in Saltville area (Smyth and Washington Counties); mined and processed here from early 1800s to 1900s.

Minerals

Bounty from the Earth...

(Photograph by Parvinder Sethi)

Gold

* Composition : Au, native metal
* Key physical properties : metallic gold luster and streak; malleable; hardness = 2.5 - 3; specific gravity = 19.3 (very heavy).
* Uses : Monetary standard, jewelry, scientific and medical instruments

Minerals

Bounty from the Earth...

Gold (continued) . . .

* Virginia occurrences : Most abundant in historic northern Piedmont gold mining district. Also found in Virgilina District in southern Piedmont and Blue Ridge areas of Floyd, Grayson, and Montgomery Counties. Virginia gold mines produced approximately 100,000 oz. (none mined today). Fist-sized nugget from Orange County in the Smithsonian Collection.

Minerals

Bounty from the Earth...

Diamond

* Composition : C, native element.
* Key physical properties : non-metallic, brilliant adamantine luster; colorless to various shades; hardness = 10; specific gravity = 3.5.
* Uses : Jewelry, industrial abrasive

Minerals

Bounty from the Earth...

Diamond (continued) . . .

* Virginia occurrences : Five diamonds known in or near Virginia. Dewey diamond (23.75 carats), found in Richmond area in 1854; Vaucluse gold mine in Orange County, found in mine washings in 1836; Whitehall gold mine in Spotsylvania County found in 1880s; Tazewell County, found in cornfield by laborer in 1913 (0.83 carats wt); and "Punch Jones" diamond, found in Peterstown, WV, in 1928 by small boy along creek (34.48 carats) - second largest diamond found in United States.