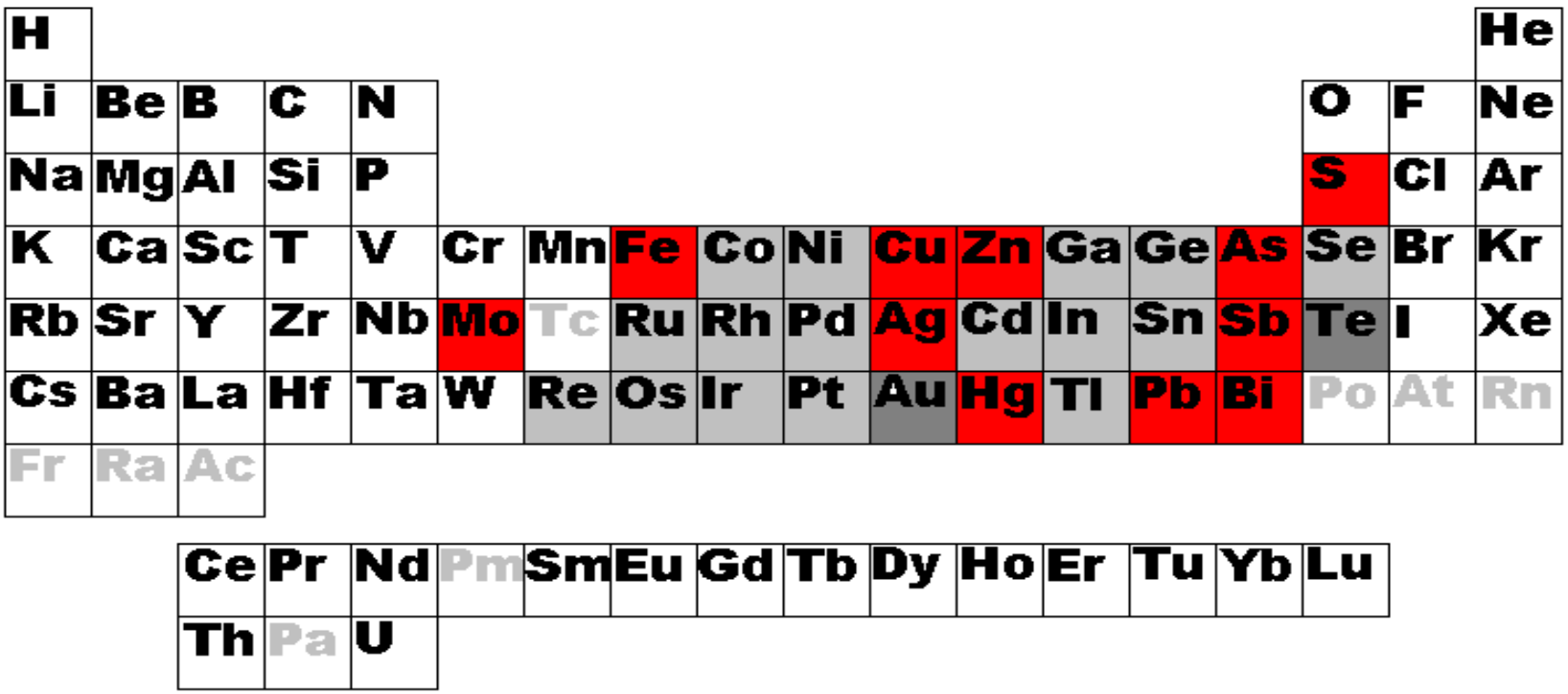
Descriptive Mineralogy

Sulfides

Classification of the Minerals

- *Non-Silicates*
  - *Native Elements*
  - *Halides*
  - *Sulfides*
  - *Oxides*
  - *Hydroxides*
  - *Carbonates*
  - *Sulfates*
  - *Phosphates*
- *Silicates*
  - *Orthosilicates*
  - *Sorosilicates*
  - *Cyclosilicates*
  - *Chain Silicates*
  - *Layer Silicates*
  - *Tektosilicates*

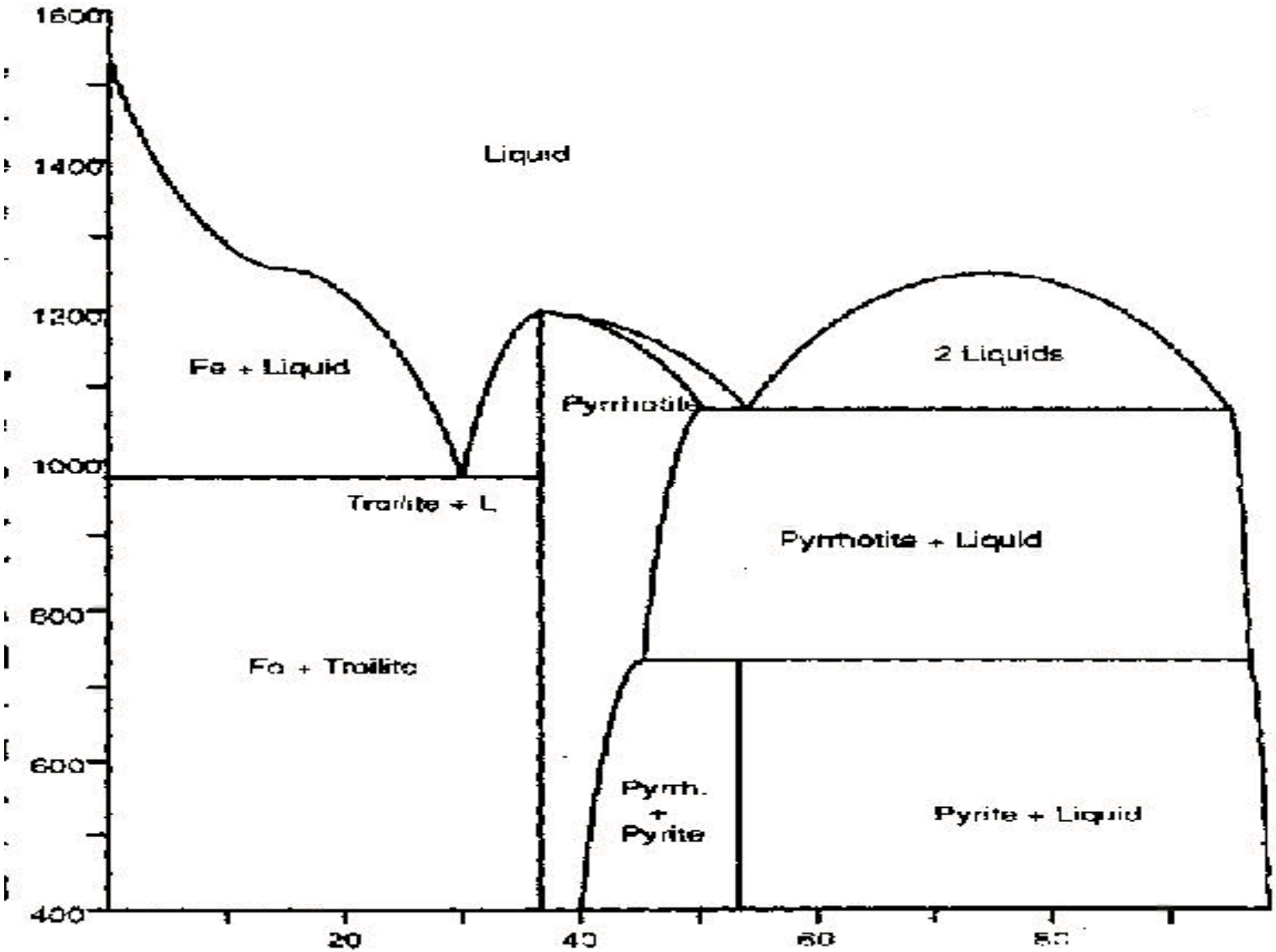
Sulfides


H
He
Li Be B C N
O F Ne
Na Mg Al Si P
S Cl Ar
K Ca Sc T V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr
Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I Xe
Cs Ba La Hf Ta W Re Os Ir Pt Au Hg Tl Pb Bi Po At Rn
Fr Ra Ac
Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tu Yb Lu
Th Pa U

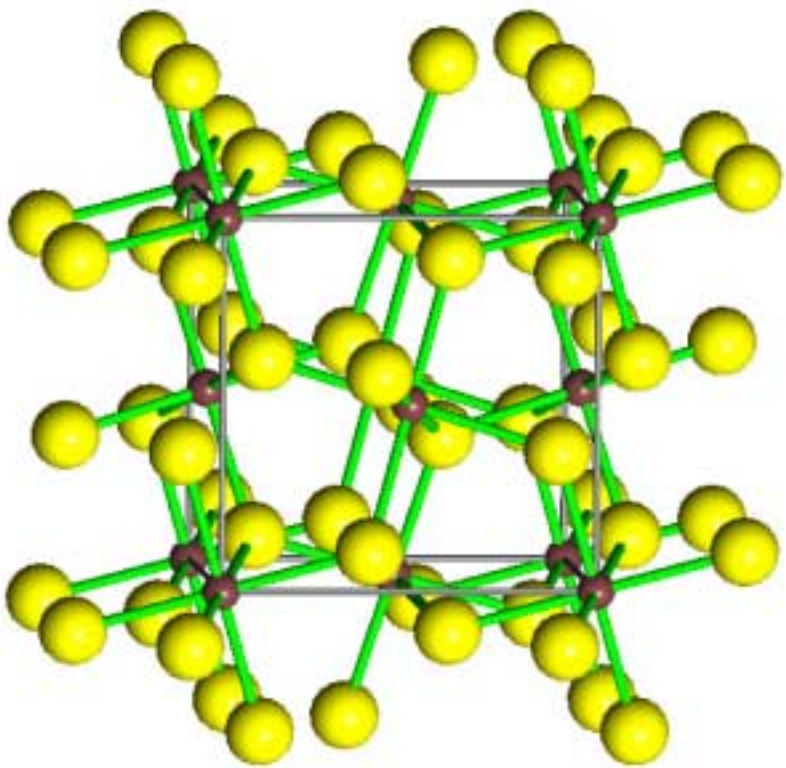
Fe Sulfides

- *Fe:*
  - *Pyrite FeS_2*
  - *Marcasite FeS_2*
  - *Pyrrhotite $Fe_{1-x}S$*
  - *Troilite FeS*
  - *Arsenopyrite FeAsS*

Fe-S Diagram

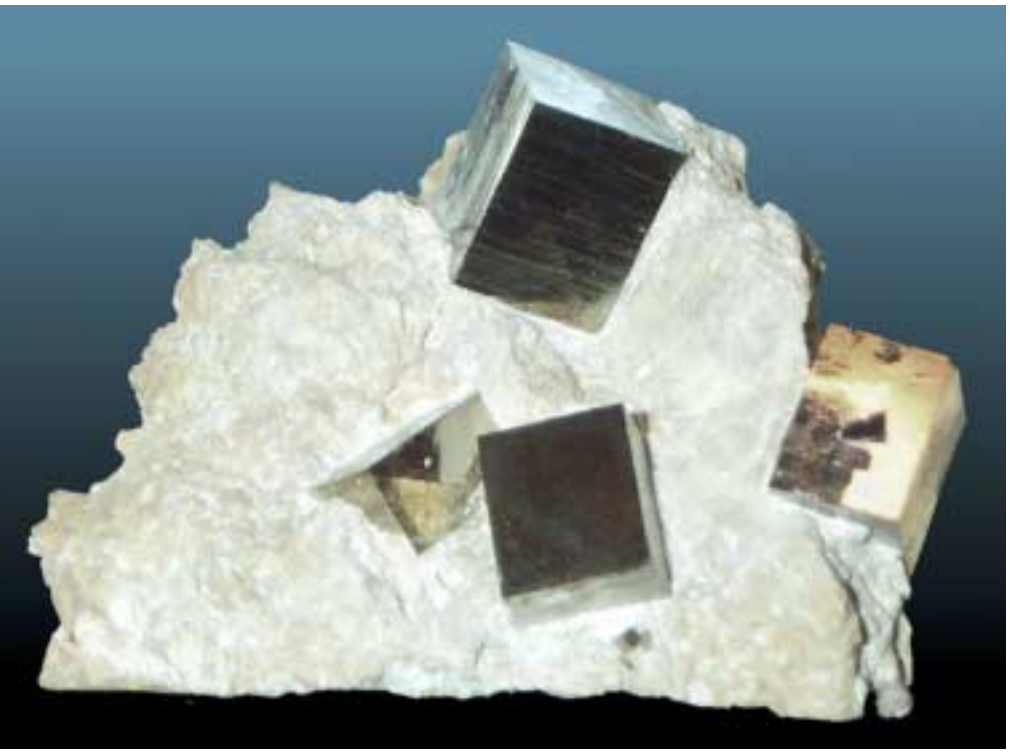

1600
1400
1200
1000
800
600
400
20
40
60
80
Liquid
Fe + Liquid
Pyrrhotite
2 Liquids
Troilite + L
Pyrrhotite + Liquid
Fe + Troilite
Pyrrh.
+
Pyrite
Pyrite + Liquid

Pyrite FeS_2



Crystal System	Cubic
Point Group	2/*m*-3
Space Group	*Pa*3
Optical	opaque
Color	BrassYellow
Luster	Metallic
Hardness	6-6.5
Density	5.02g/cm^3

Pyrite FeS_2



Occurrence: High temperature hydrothermal

Most common sulfide mineral

Source of S in coal

Marcasite (FeS_2)

Crystal System	Orth.
Point Group	*2/m2/m2/m*
Space Group	*Pmnn*
Optical	opaque
Color	PaleYellow
Luster	Metallic
Hardness	6-6.5
Density	4.9 g/cm^3

Marcasite (FeS_2)

Occurrence: Low temperature hydrothermal reduction of iron sulfate.

Secondary sulfide mineral in sedimentary rocks

Pyrrhotite ($Fe_{1-x}S$)

Occurrence: Accessory in mafic igneous rocks

High T Hydrothermal

May contain minor Cu, Ni, Pt

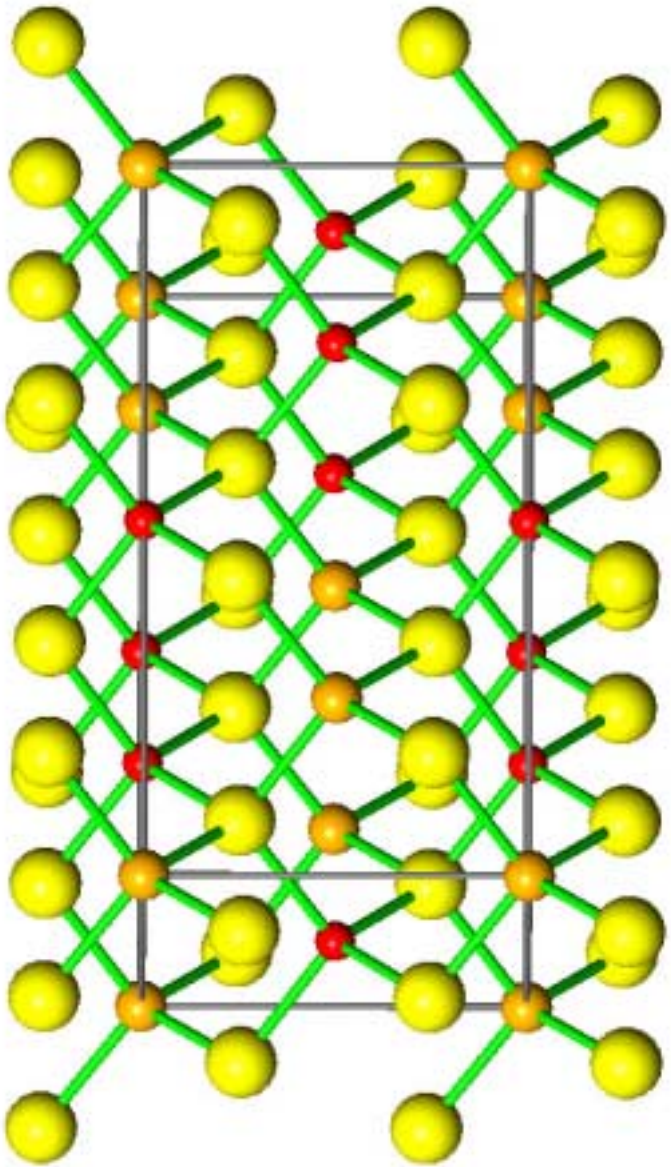
Arsenopyrite FeAsS

Crystal System	Monoclinic
Point Group	2/*m*
Space Group	$P2_1$
Optical	opaque
Color	gray
Luster	Metallic
Hardness	5.5-6
Density	6.1 g/cm^3

Cu Sulfides

- *Cu Sulfides*
  - *Chalcocite Cu_2S*
  - *Covellite CuS*
- *Cu-Fe Sulfides*
  - *Chalcopyrite $CuFeS_2$*
  - *Bornite Cu_5FeS_4*

Chalcopyrite $CuFeS_2$



Crystal System	Tetragonal
Point Group	-42*m*
Space Group	*I-42d*
Optical	opaque
Color	BrassYellow
Luster	Metallic
Hardness	3.5-4
Density	4.2 g/cm^3

Structure: ordered derivative of sphalerite.

Chalcopyrite $CuFeS_2$

Occurrence: Low temperature hydrothermal.

Uses: Major ore of Cu

Bornite Cu_5FeS_4

Crystal System	Tetragonal
Point Group	-42*m*
Space Group	*I-42d*
Optical	opaque
Color	Blue Irridesc.
Luster	Metallic
Hardness	3
Density	5.1 g/cm^3

Chalcocite Cu_2S

Crystal System	Monocl LoT Hexagonal HiT
Point Group	2/m- 6/mmm
Space Group	$P2_1/c$-$P6_3/mmc$
Optical	opaque
Color	Lead Gray
Luster	Metallic
Hardness	2.5-3
Density	5.6 g/cm^3

Covellite CuS

Crystal System	Hexagonal
Point Group	6/*m*2/*m*2/*m*
Space Group	$P6_3/mmc$
Optical	opaque
Color	Indigo Blue
Luster	Metallic
Hardness	1.5-2
Density	4.7 g/cm^3

Other Sulfides

- *Argentite (Acanthite) Ag_2S*
- *Sphalerite ZnS*
- *Molybdenite MoS_2*
- *Galena PbS*
- *Realgar AsS and Orpiment As_2S_3*
- *Stibnite Sb_2S_3*
- *Cinnabar HgS*

Acanthite (Argentite) Ag_2S

Occurrence: Low Temp Hydrothermal

Uses: Major ore of Ag

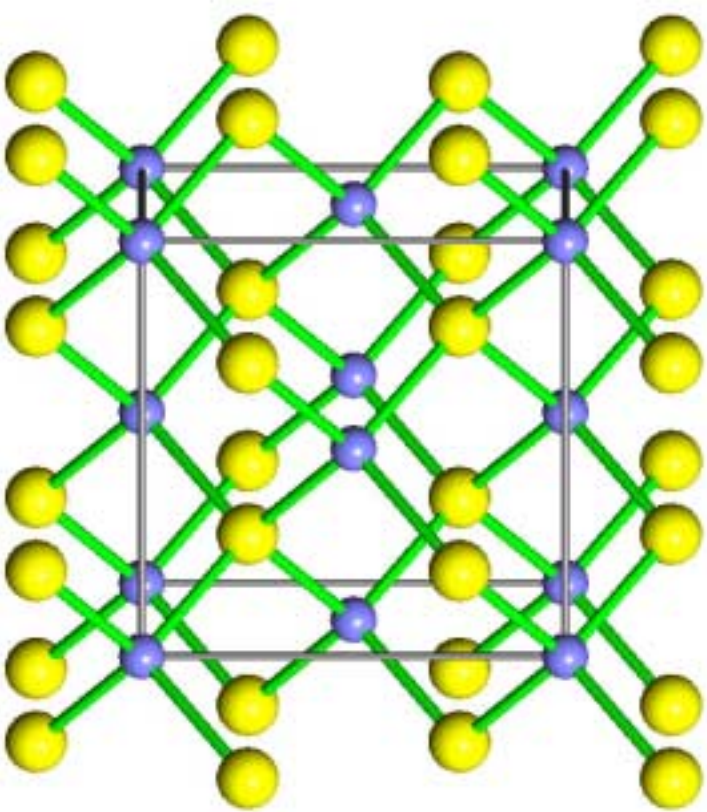
Crystal System	Monocl LoT Hexagonal HiT
Point Group	2/m- 6/mmm
Space Group	$P2_1/c$-$P6_3/mmc$
Optical	opaque
Color	Lead Gray
Luster	Metallic
Hardness	2.5-3
Density	5.6 g/cm^3

Sphalerite ZnS

Occurrence: Low Temperature hydrothermal.

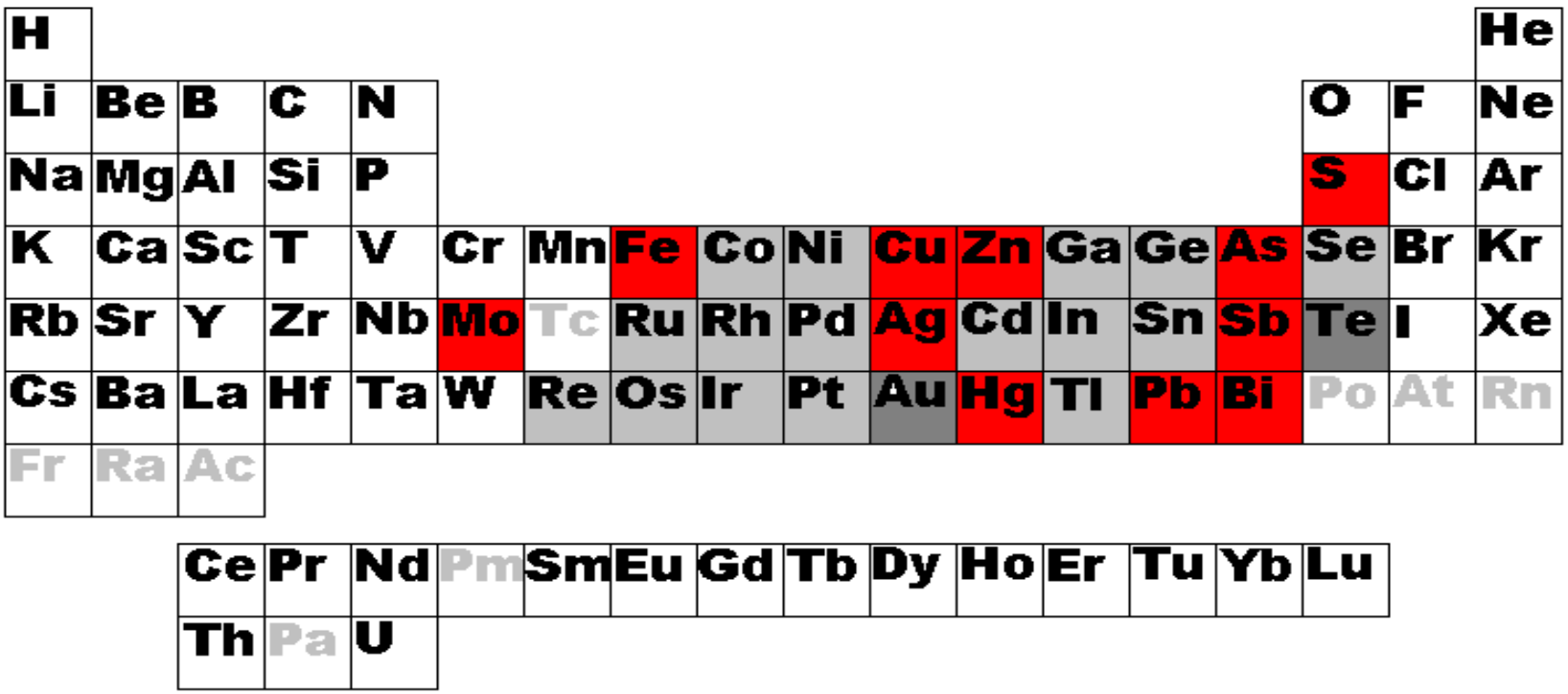
Uses: Principal ore of Zn; major ore of Cd

Sphalerite ZnS



Crystal System	Cubic (diamond
Point Group	-43*m*
Space Group	*F*-43*m*
Optical	Iso n=2.37
Color	Yellow, Red, Brown, Black
Luster	Adamantine
Hardness	3.5
Density	4.0

Sulfides

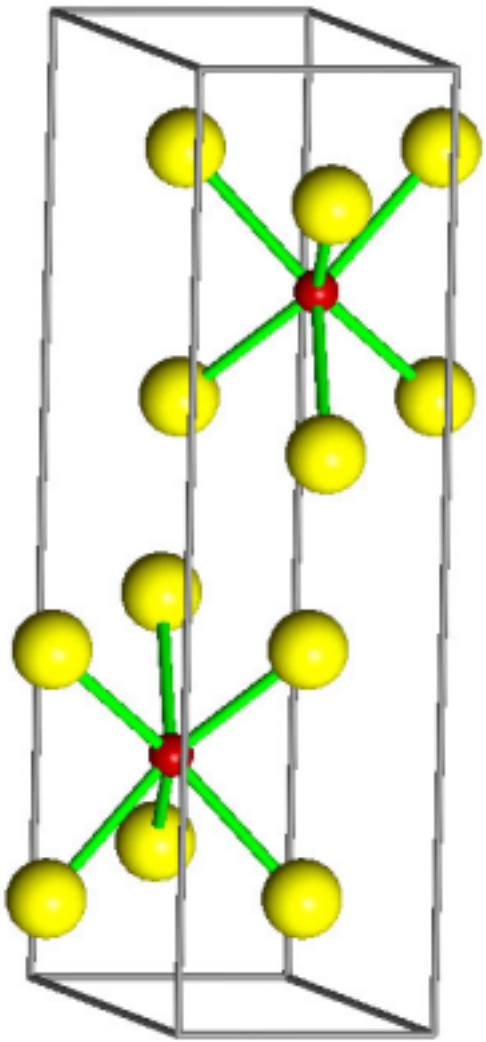

H
He
Li Be B C N
O F Ne
Na Mg Al Si P
S Cl Ar
K Ca Sc T V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr
Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I Xe
Cs Ba La Hf Ta W Re Os Ir Pt Au Hg Tl Pb Bi Po At Rn
Fr Ra Ac
Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tu Yb Lu
Th Pa U

Molybdenite MoS_2

Occurrence: Accessory in granites and pegmatites.

Uses: Principal ore of Mo; major ore of Re

Molybdenite MoS_2



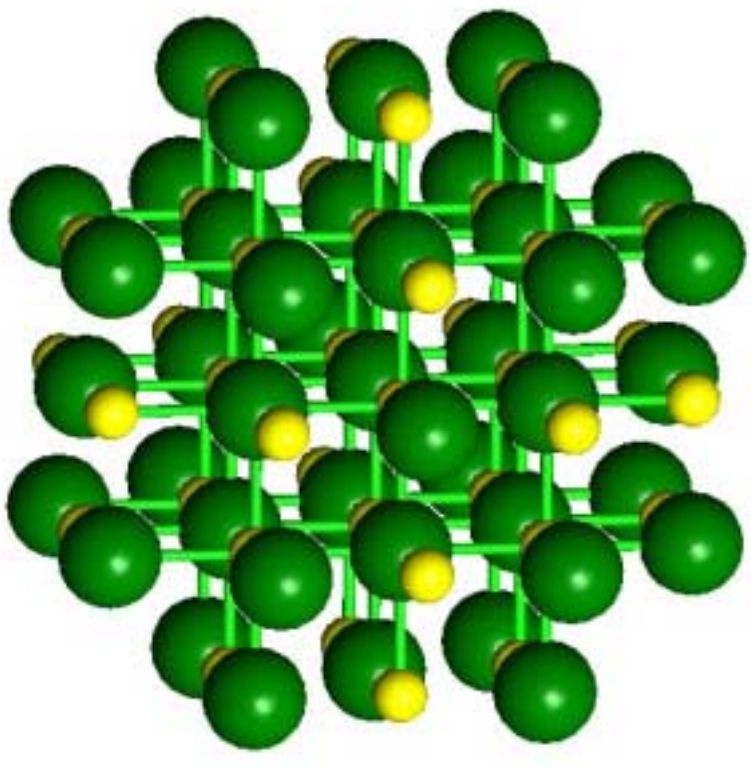
Crystal System	Hexagonal
Point Group	6/*mmm*
Space Group	$P6_3/mmc$
Optical	opaque
Color	Blue-Gray
Luster	Metallic
Hardness	1
Density	4.7

Galena PbS

Occurrence: Low temperature hydrothermal.

Uses: Principal ore of Pb; major ore of Ag

Galena PbS



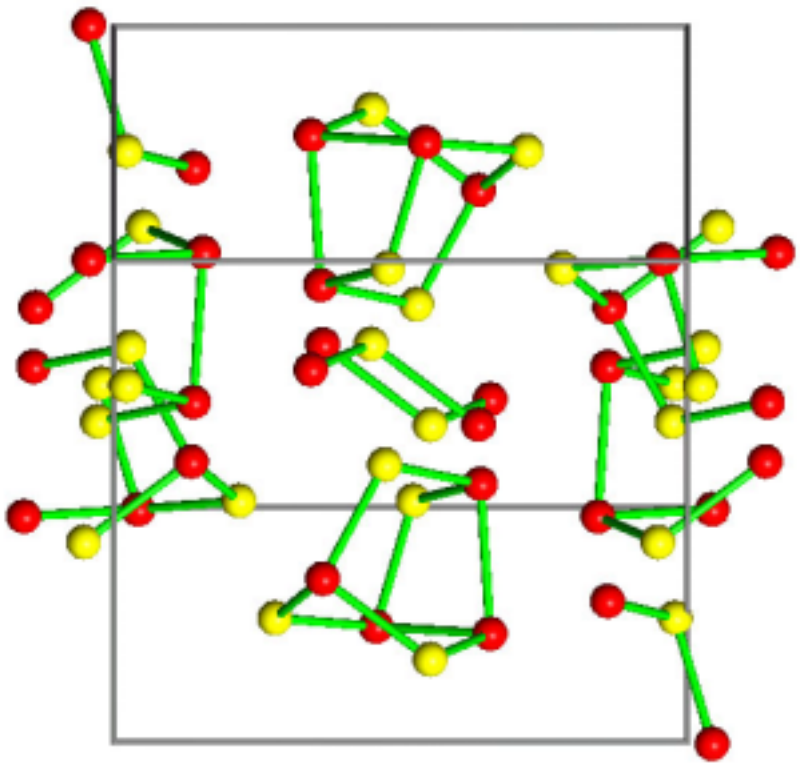
Crystal System	Cubic
Point Group	
Space Group	
Optical	
Color	Yellow, Brown, Black
Luster	Adamantine
Hardness	
Density	

Realgar AsS

Occurrence: Low temperature hydrothermal.

Uses: minor ore of As

Realgar AsS



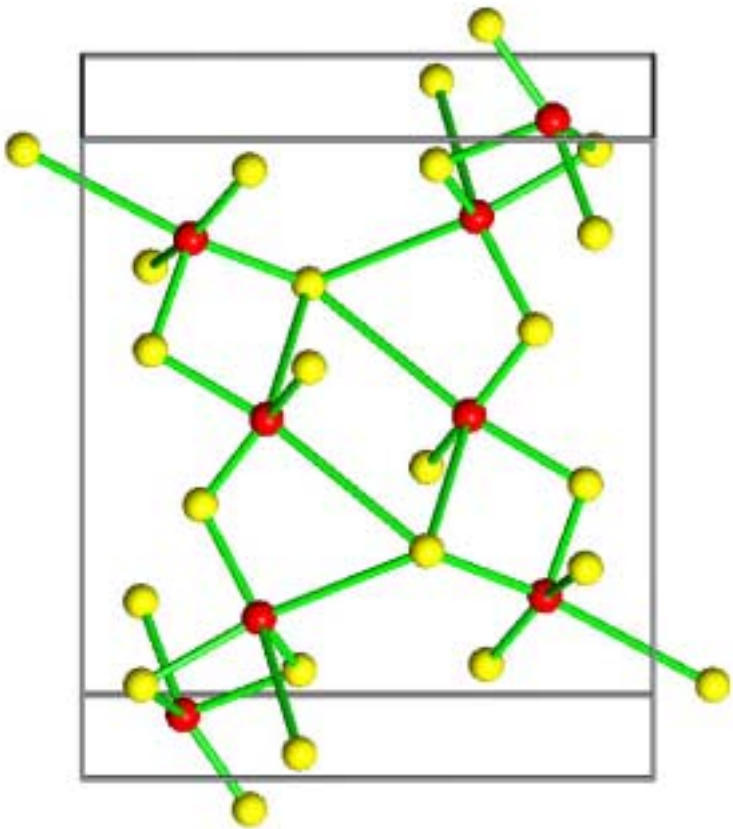
Crystal System	Monoclinic
Point Group	*2/m*
Space Group	$P2_1/n$
Color	Red
Luster	Resinous
Hardness	2
Density	3.5

Orpiment As_2S_3

Occurrence: Low temperature hydrothermal.

Uses: minor ore of As

Orpiment As_2S_3



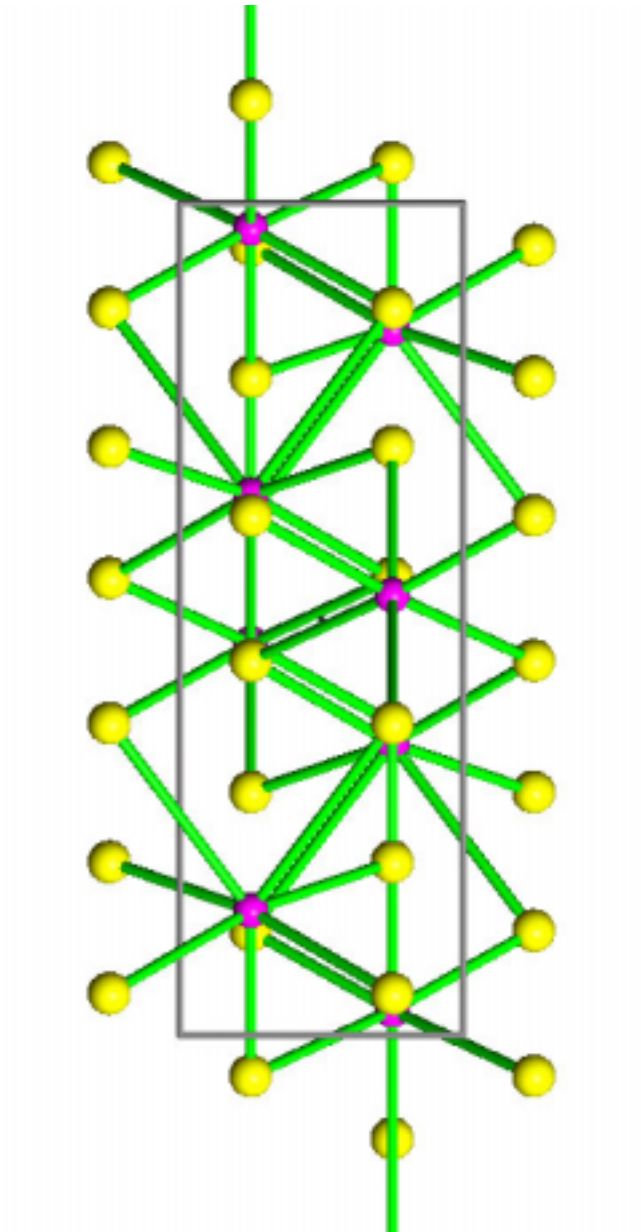
Crystal System	Monoclinic
Point Group	*2/m*
Space Group	$P2_1/n$
Color	Yellow
Luster	Resinous
Hardness	2
Density	3.5

Stibnite Sb_2S_3

Occurrence: Low temperature hydrothermal.

Uses: Principal ore of Sb

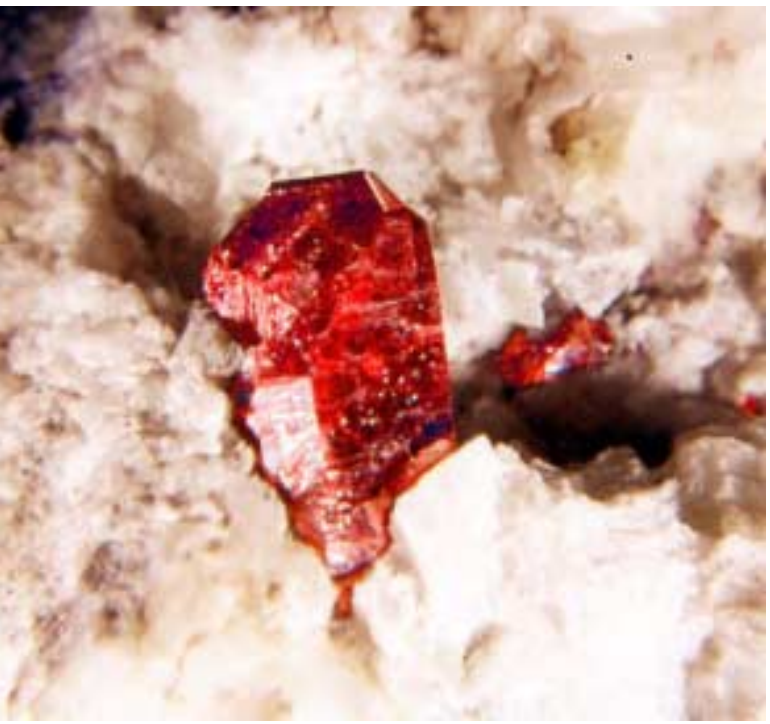
Stibnite Sb_2S_3



Crystal System	Orthorhombic
Point Group	*2/m2/m2/m*
Space Group	*Pbnm*
Optical	Opague
Color	Silver Gray
Luster	Metallic
Hardness	2
Density	4.6

Cinnabar HgS

Cinnabar HgS

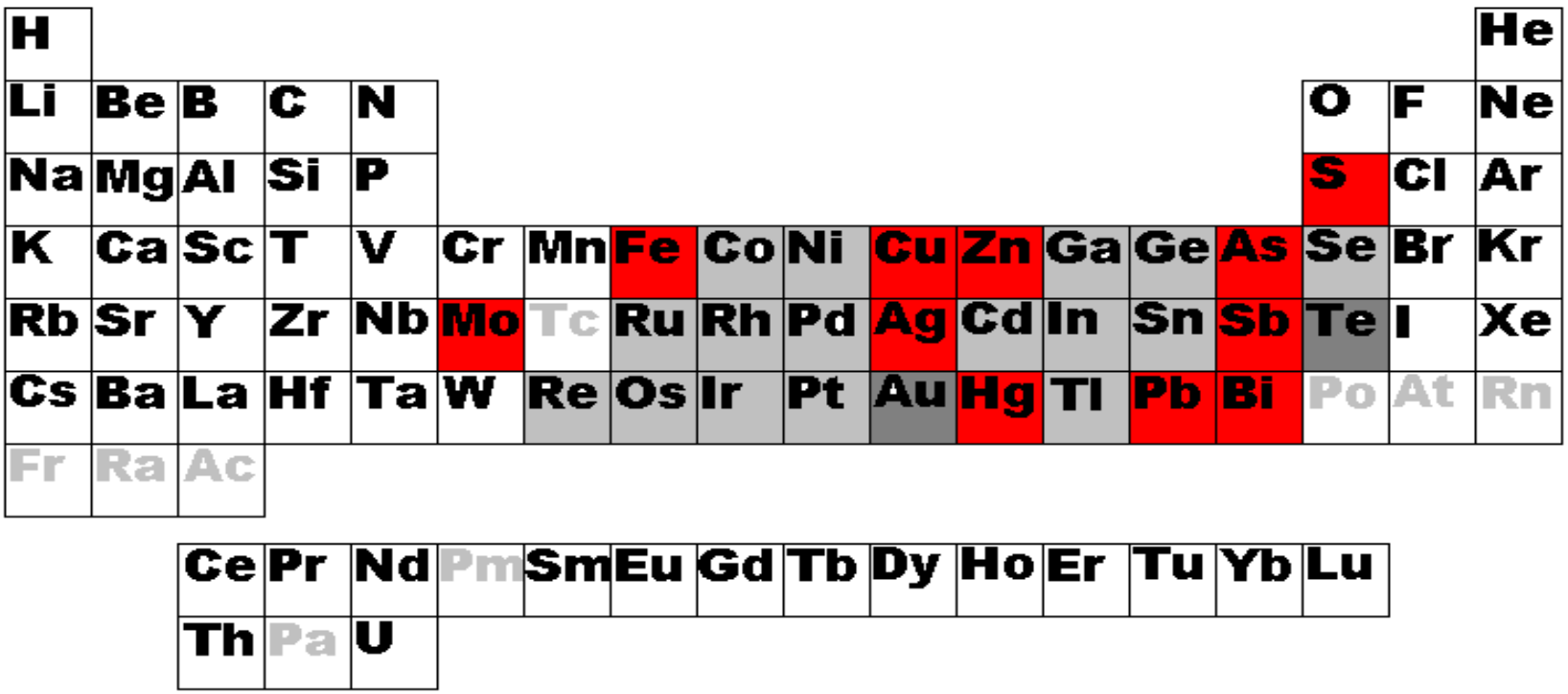


Crystal System	Cubic (HT)
Point Group	-43*m*
Space Group	*F*-43*m*
Optical	
Color	Dark Red
Luster	Adamantine
Hardness	2.5
Density	8.10

Occurrence: Low temperature hydrothermal.

Uses: Principal ore of Hg

Sulfides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