Dr. Helen Lang
Dept. of Geology & Geography
West Virginia University

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GEOLOGY 284: MINERALOGY

Mineral Classification: There are many possibilities

- "biological type" classification (genus & species?)
  - Linneaus tried in 1768, but unsatisfactory for minerals
- "petrologic" classification
  - igneous minerals — textbook organization
  - sedimentary minerals
  - metamorphic minerals
- classification by properties
  - what we use in lab (by luster, hardness, streak, etc.)

In the Mineralogist's classification (J. D. Dana, 1837) – Minerals are grouped by their **dominant anion** or **anionic complex**

- The group can be told directly from the chemical formula
- Minerals with the same anion have similar properties
- Minerals with the same anion occur together

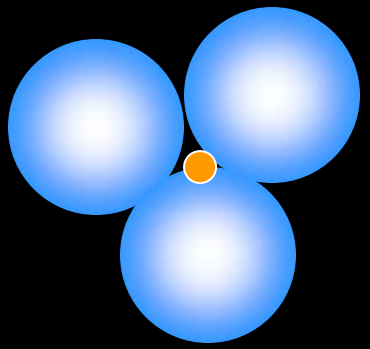
Class	Anion	Example	Formula
Native elements	none	gold	Au
Sulfides	S*	galena	PbS

*bonding is mostly metallic, so there is no true anion, therefore, no charge is given

Class			Anion
Halides			Cl^-, F^-, Br^-, I^-
	Ex: fluorite	CaF_2	
	Ex: halite	NaCl	
Oxides			O^{2-}
	Ex: magnetite	Fe_3O_4	
	Ex: hematite	Fe_2O_3	
Hydroxides			OH^-
	Ex: brucite	$Mg(OH)_2$	

These have “simple” anions - approximately spherical

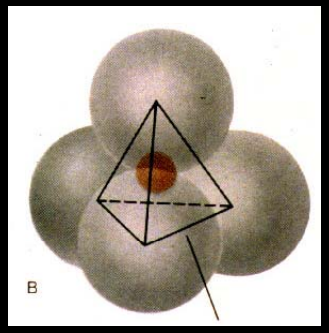
Class Anion



These have triangular-shaped **complex** anions

Carbonates	$(CO_3)^{2-}$
Ex: dolomite	$CaMg(CO_3)_2$
Nitrates	$(NO_3)^{1-}$
Ex: niter	KNO_3
Borates	$(BO_3)^{2-}$ or $(BO_4)^{5-}$
Ex: sinhalite	$MgAlBO_4$

Class Anion



These all have **tetrahedral complex** anions

Sulfates $(SO_4)^{2-}$

Ex: anhydrite $Ca(SO_4)$

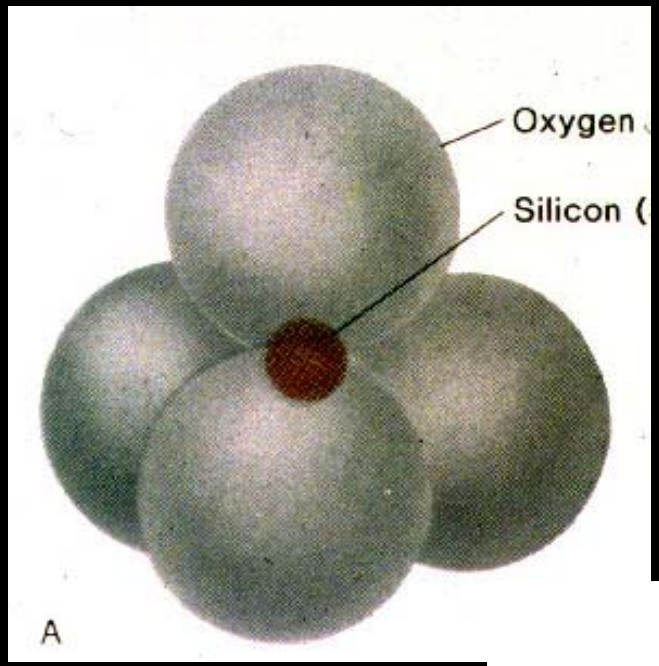
Phosphates $(PO_4)^{3-}$

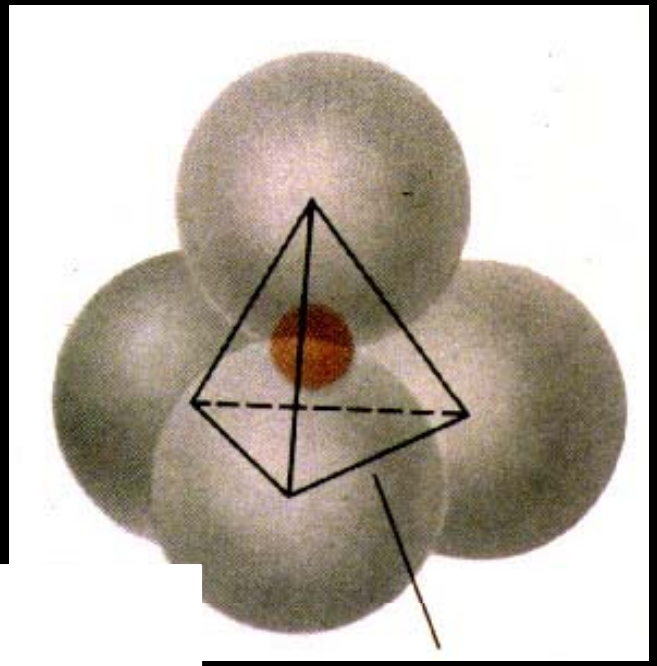
Ex: apatite $Ca_5(PO_4)_3(OH)$

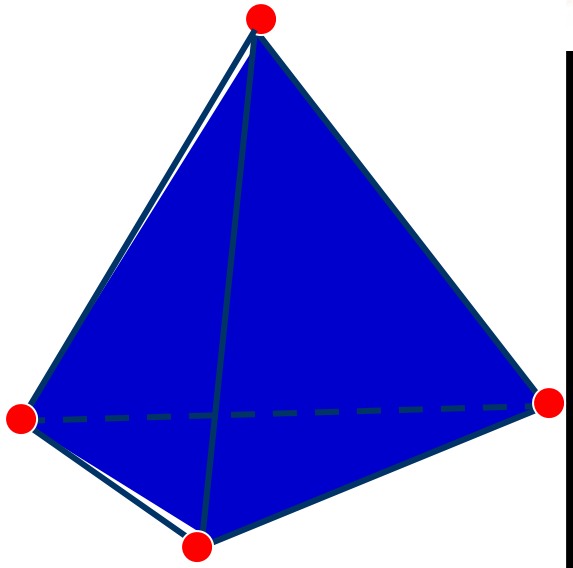
Silicates $(SiO_4)^{4-}$

Ex: quartz SiO_2

The Tetrahedron







Because there are so many (>800) important silicate minerals in rocks

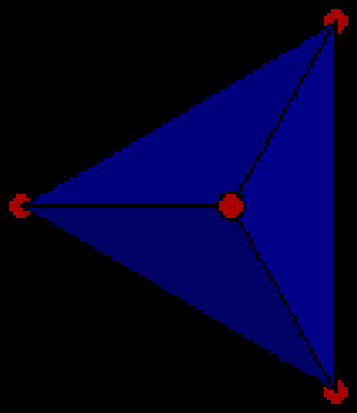
and

Because silicate minerals are polymerized in many different ways

The silicates are considered separately and are subdivided

Silicates are subdivided by how the silica $(SiO_4)^{4-}$ tetrahedra are stuck together or polymerized

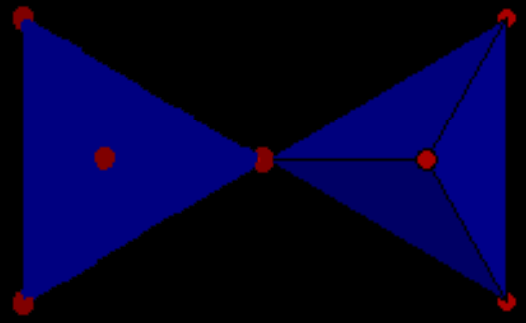
Silicate Mineral Subclasses



Isolated tetrahedral silicates (nesosilicates)

# corners shared by each tetrahedron	0
Si,O part of formula	$(SiO_4)^{4-}$
Si:O ratio	1:4
Example	olivine
Formula	Mg_2SiO_4

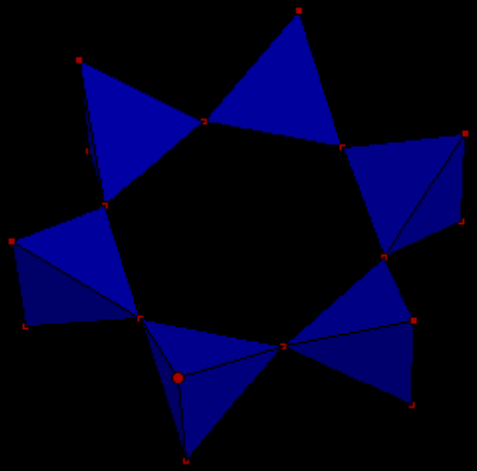
Silicate Mineral Subclasses



Paired tetrahedral silicates (sorosilicates)

# corners shared by each tetrahedron	1
Si,O part of formula	$(Si_2O_7)^{-6}$
Si:O ratio	2:7
Example	ackermanite
Formula	$Ca_2MgSi_2O_7$

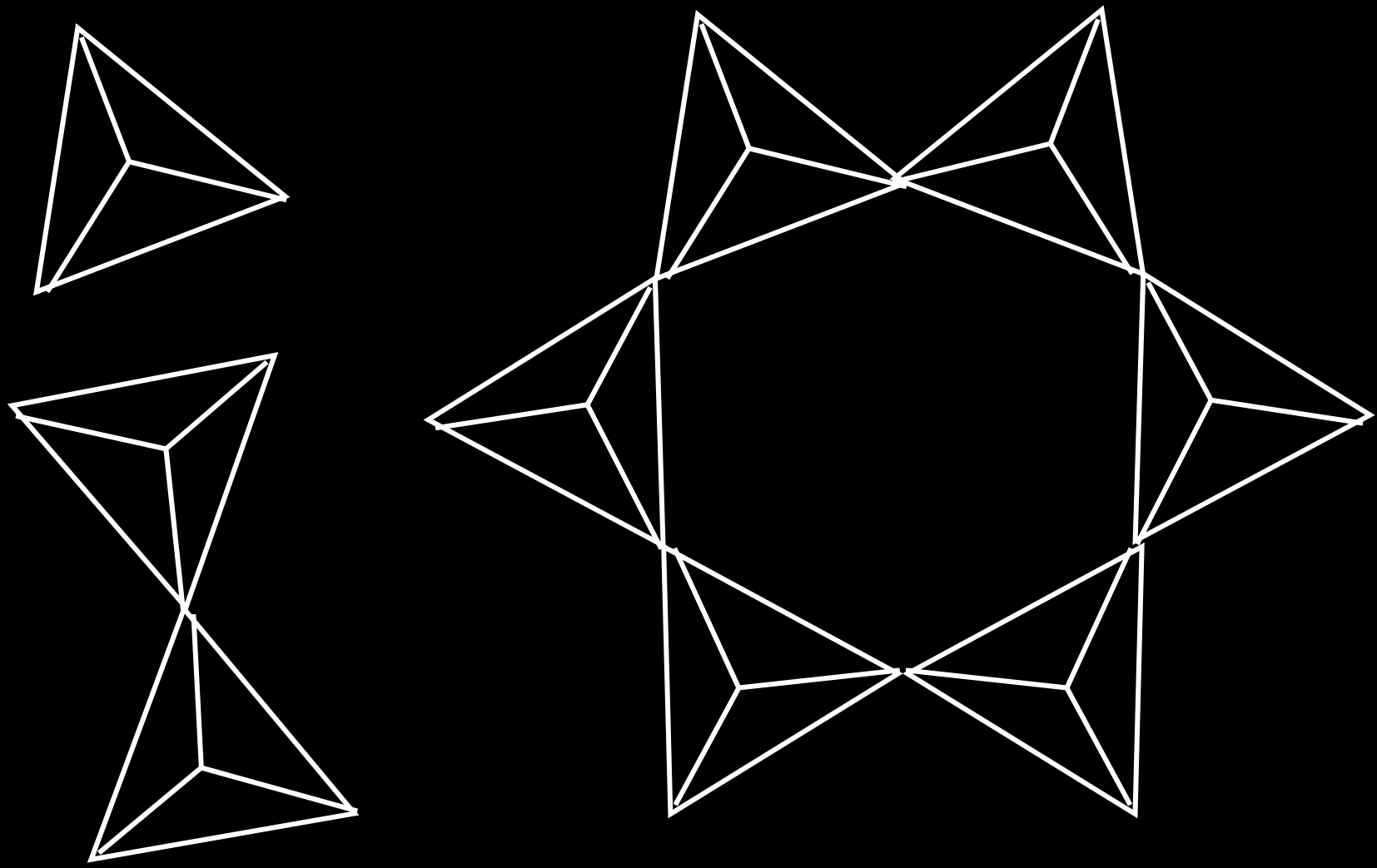
Silicate Mineral Subclasses



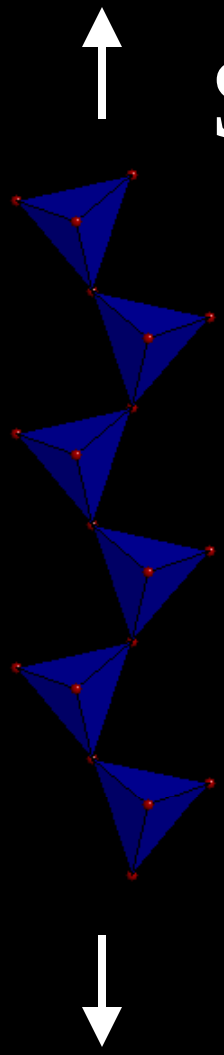
6-membered ring silicates (cyclosilicates)

# corners shared by each tetrahedron	2
Si,O part of formula	$(Si_6O_{18})^{-12}$
Si:O ratio	6:18, 1:3
Example	beryl
Formula	$Be_3Al_2Si_6O_{18}$

You can make simple sketches



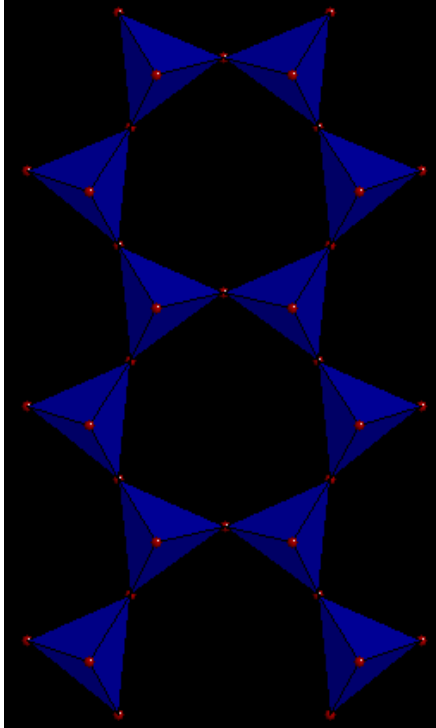
Silicate Mineral Subclasses



Single chain silicates (inosilicates)

# corners shared by each tetrahedron	2
Si,O part of formula	$(Si_2O_6)^{-4}$
Si:O ratio	2:6, 1:3
Example	pyroxenes, diopside
Formula	$CaMgSi_2O_6$

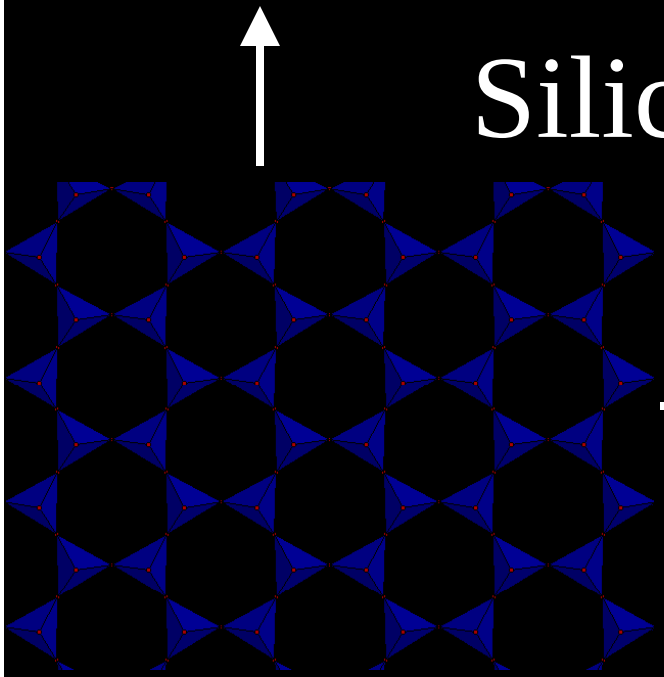
Silicate Mineral Subclasses



Double chain silicates (inosilicates)

# corners shared by each tetrahedron	2 or 3
Si,O part of formula	$(Si_8O_{22})^{-12}$
Si:O ratio	4:11, 8:22
Example	amphiboles, tremolite
Formula	$Ca_2Mg_5Si_8O_{22}(OH)_2$
Hydrous	(contains OH^-)

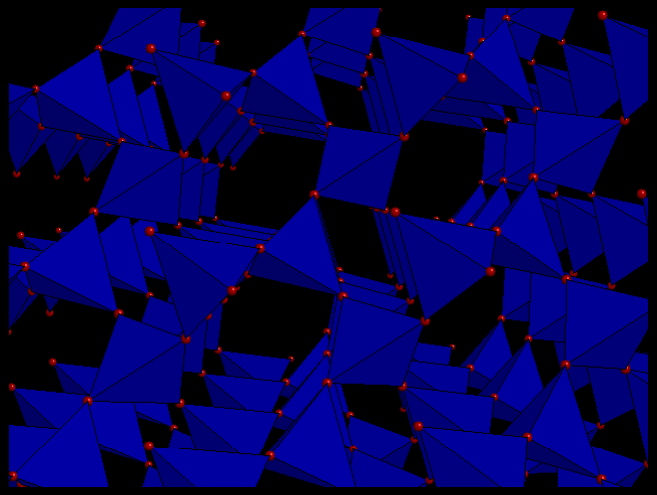
Silicate Mineral Subclasses



Sheet silicates (phyllosilicates)

# corners shared by each tetrahedron	3
Si,O part of formula	$(Si_4O_{10})^{-4}$
Si:O ratio	2:5, 4:10
Example	micas, clays, e.g., kaolinite
Formula	$Al_4Si_4O_{10}(OH)_8$
Hydrous	(contains OH^-)

Silicate Mineral Subclasses



Framework silicates (tectosilicates)

# corners shared by each tetrahedron	4
Si,O part of formula	$(SiO_2)^0$ or $((Al,Si)_4O_8)^{1\text{-to}2-}$
Si (±Al):O ratio	1:2
Example	quartz, K-feldspar
Formula	SiO_2, $KAlSi_3O_8$

Silicate Subgroup	# corners shared	What is Si-O part of formula?
Isolated tetrahedral silicates		
Paired tetrahedral silicates		
6-membered Ring silicates		
Single Chain silicates		
Double Chain silicates		
Sheet silicates		
Framework silicates		

Sketch tetrahedra. Count Si and O. You need to know charge of Si and charge of O.

Silicate Subgroup	# corners shared	Si-O part of formula
Isolated tetrahedral silicates	0	$(SiO_4)^{-4}$
Paired tetrahedral silicates	1	$(Si_2O_7)^{-6}$
6-membered Ring silicates	2	$(Si_6O_{18})^{-12}$
Single Chain silicates	2	$(SiO_3)^{-2}$
Double Chain silicates	2, 3	$(Si_2O_6)^{-4}$ $(Si_4O_{11})^{-6}$ $(Si_8O_{22})^{-12}$
Sheet silicates	3	$(Si_2O_5)^{-2}$ $(Si_4O_{10})^{-4}$
Framework silicates	4	$(SiO_2)^{0}$ $((Al,Si)_4O_8)^{-1 \text{ to } -2}$

Class			Anion
• Native elements			no anion
•	Ex: gold	Au	
• Sulfides			S* (metallic bonding, no anion as such)
•	Ex: galena	PbS	
• Halides			Cl^-, F^-, Br^-, I^-
•	Ex: fluorite	CaF_2	
•	Ex: halite	NaCl	
• Oxides			O^{2-}
•	Ex: magnetite	Fe_3O_4	
• Hydroxides			OH^-
•	Ex: brucite	$Mg(OH)_2$	
• Carbonates			$(CO_3)^{2-}$
•	Ex: dolomite	$CaMg(CO_3)_2$	
• Nitrates			$(NO_3)^{1-}$
•	Ex: niter	KNO_3	
• Borates			$(BO_3)^{2-}$ or $(BO_4)^{5-}$
•	Ex: sinhalite	$MgAlBO_4$	
• Sulfates			$(SO_4)^{2-}$
•	Ex: anhydrite	$Ca(SO_4)$	
• Phosphates			$(PO_4)^{3-}$
•	Ex: apatite	$Ca_5(PO_4)_3(OH)$	
• Silicates			$(SiO_4)^{4-}$
•	Ex: quartz	SiO_2	

Silicate Mineral Subclasses

Silicate Subclasses	**# of Corners Shared/tetra**	**Si-O Formula**	**Si:O ratio**	**Example**	**Formula**
Isolated tetrahedral silicates (nesosilicates, orthosilicates)	none	$(SiO_4)^{4-}$	1:4	Olivine	Mg_2SiO_4
Paired tetrahedral silicates (sorosilicates)	one	$(Si_2O_7)^{6-}$	2:7	Ackermanite	$Ca_2MgSi_2O_7$
Ring silicates (cyclosilicates)	two	$(Si_6O_{18})^{12-}$	6:18	Beryl	$Be_3Al_2Si_6O_{18}$
Single chain silicates (inosilicates)	two	$(SiO_3)^{2-}$ $(Si_2O_6)^{4-}$	1:3 2:6	Diopside (pyroxene)	$CaMgSi_2O_6$
Double chain silicates (inosilicates)	half two, half three	$(Si_4O_{11})^{6-}$ $(Si_8O_{22})^{12-}$	4:11 8:22	Tremolite (amphibole)	$Ca_2Mg_5Si_8O_{22}(OH)_2$
Sheet silicates (phyllosilicates)	three	$(Si_2O_5)^{2-}$ $(Si_4O_{10})^{4-}$	2:5 4:10	Kaolinite	$Al_4Si_4O_{10}(OH)_8$
Framework silicates (tectosilicates)	four	$(SiO_2)^0$ $((Al,Si)_4O_8)^{(1-2)-}$	1:2	Quartz Feldspars	SiO_2 $(Ca,Na,K)(Al,Si)_4O_8$