1 **Introduction to Environmental Geology, 5e**
Chapter 3
Minerals and Rocks

2 ***Minerals: summary in haiku form***
"Mineral" defined:
natural, inorganic,
solid (and two more).

continued...

Also crystalline,
chemically specific.
There! I fit it in!

3 **Case History: Asbestos**
- A group of silicate minerals
- Some are hazardous to human health: Causing fatal lung diseases
- Useful mineral Material: Fire retardant property for brake lining and insulations
- Fibrous minerals: White asbestos (less harmful), blue asbestos (hazardous)
- Removal of asbestos: Depending upon the properties of the asbestos used and the context in which they are used

4 **Importance of Rocks and Minerals**
- Fundamental building blocks of Earth
- Various uses for modern economic developments
- Important clues for figuring out the history of Earth
- Knowledge of minerals and rocks as the first important step to better manage Earth's resources
- Important to our health and environment

5 **Basic Chemistry Review (1)**
- All matter, including minerals and rocks, made of atoms
- *Atom structure:* Nucleus (proton and neutron) and surrounding electrons
- *Atomic number:* The unique number of protons in an element's nucleus
- *Atomic mass number:* The sum of the member of protons and neutrons

6 **Rock-Forming Mineral Groups**

7 **Basic Chemistry Review (2)**
- *Ion:* Charged atom particles, reactions between different types of atoms
- *Isotopes:* Atoms of the same element with varied number of neutrons
- Chemical bonding
  - Ionic bonds
  - Covalent bonds
  - Metallic bonds
  - van der Waals bond

8 **Mineral Definitive Properties**
- Made of an element or a chemical compound
- Definitive chemical composition

- Orderly, regular repeating internal atomic arrangement (i.e., crystalline structure)
- Inorganic solids
- Formed by natural (geologic) processes

9 **Mineral Diagnostic Properties**

- Color and streak
- Luster
- Crystal form
- Cleavage
- Hardness
- Special properties (taste, smell, feel, tenacity, reaction to acid, magnetism)

10 **Rock-Forming Mineral Groups (1)**

- More than 4,000 minerals, but a few dozen are common on or near Earth's surface
- Common mineral groups are primarily classified by chemical composition
- Silicates: Contain Si-O tetrahedron fundamental building unit, including the two most abundant elements oxygen (O) and silicon (Si) in the Earth crust. The most abundant mineral group
- Carbonates: contain containing the carbonate ion CO_3^{2-}
- Oxides: Contain oxygen atoms bonded to an atom of another element
- Sulfides: Contain sulfur atoms bonded to one or more metallic elements
- Native elements: Made of single element

11 **Rock-Forming Mineral Groups (2)**

12 **Rocks**

- Aggregated solids of minerals
- Three major types of rocks classified by origin, the way the rocks formed
- Fundamental links between rocks and environment (resources, sources for acid rain drainage, land subsidence, structure foundation failures, etc.)
- Rocks deform in response to geologic forces/stress

13 ***Igneous Rocks: summary in haiku form***

Olivine forms first;
quartz forms later, when it's cool.
Thanks Mister Bowen!

14 **Igneous Rocks**

- Cooled, crystallized/solidified from magma
- Records of Earth's thermal cooling history
- *Intrusive rocks:* Crystallized/solidified beneath the Earth surface
- *Extrusive rocks:* Crystallized/solidified at or near the Earth surface
- *Classification:* Based on texture and composition

15 **Igneous Rock Texture (1)**
- Dictated by the rates of magma cooling
- The rates of cooling slower beneath the surface, much faster near or at the surface
- The slower the magma cools, the coarser the mineral particles in igneous rocks
- Igneous rocks formed from two stages of cooling, having distinctive, different sized particles *(porphyritic)*

16 **Igneous Rock Texture (2)**
- Phaneritic (intrusive)
- Porphyritic planeritic (intrusive)
- Aphanitic
- Porphyritic aphanitic
- Vitreous/glassy
- Vesicular
- Pyroclastic

17 **Igneous Rock Composition**
- Depending on the composition of magma
- *Felsic/granitic:* Silica rich, typically related to continental crust
- *Intermediate/andesitic:* Commonly associated with convergent boundaries along the rim of Pacific
- *Mafic/basaltic:* Silica poor, usually related to the oceanic crust

18 **Common Igneous Rocks**

19 **Common Igneous Rocks**

20 ***Sedimentary rocks: summary in haiku form***

Lithification -
glue particles together.
Was sand, now sandstone.

21 **Sedimentary Rocks**
- Formed at the surface environment conditions
- About 75 percent of all rocks exposed at the surface
- Records of present and particularly ancient surface environment (landscape and climate)
- Individual Beds/layers: Law of original horizontality

22 **Clastic Sedimentary Rocks**
- Compacted and cemented from detrital sediments
- *Formation processes:* Transportation, deposition, compaction, and cementation

- Fossil-fuel bearing rocks
-
- Classified based on particle size
-
- *Shale:* The most abundant clastic rocks

23 **Nonclastic Sedimentary Rocks**

- Precipitated from chemical solutions and/or accumulated chemical, biological matter
-
- Classified based on composition and texture
-
- *Limestone:* The most abundant nonclastic sedimentary rocks
-
- Common texture: Crystalline, microcrystalline, skeletal, oolitic, massive

24 **Common Sedimentary Rocks**

25 **Common Sedimentary Rocks**

26 **Sedimentary Structure and Environment**

- *Stratification:* Law of original horizontality, law of supposition
-
- *Cross-bedding:* Movement direction of ancient currents
-
- *Fossil content:* Environment setting (continental, marine, or transitional)
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- Fine-grained clastic rocks and limestone in humid region: Very weak rocks causing environmental problems

27 ***Metamorphism: summary in haiku form***

Shape-shifters in crust.
Just add heat and/or pressure.
Keep it solid please!

28 **Metamorphic Rocks**

- Changed rocks from preexisting rocks under solid state
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- Changes in mineralogy and rock textures
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- Agents of change: Temp, pressure, and chemically active fluid
-
- Records of Earth's dynamic processes: Tectonic movement and igneous intrusion

29 **Metamorphic Rock Texture**

- *Foliation:* Preferred alignment of platy mineral particles
  - Slaty, schistosity, gneissic banding
  - Typically classified by texture: Slate, phyllite, schist, gneiss
  -
- *Nonfoliation:* Random arranged and interlocked mineral particles
  - Fine grained, coarse grained
  - Typically classified by composition: Marble, quartzite

30 **Rock Cycle**

31 **Three Fundamental Rock Laws**

- Three fundamental laws in understanding the relationships of rocks and the earth history
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- The law of crosscutting relationships: Rocks are younger than the ones that it cuts
-
- The law of original horizontality: Sedimentary rock layers nearly horizontal under normal condition

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- The law of superposition: Rocks become progressively younger towards the top in an undisturbed and undeformed rock sequence

32 **Rocks and Environment**

- Inappropriate use for construction materials
  –
- Fossil fuel exploration and extraction from rocks
-
- Reservoir rocks for fuels, groundwater, as well as contaminants
-
- Rock foliation and strength: Site stability for large facilities (nuclear power plant, dams, airports, etc.)

33 **Rock Structure and Strength**

34 **Rock Structure (1)**

- Deformation in response to stress
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- *Brittle deformation:* Fractures, joints, and faults
  – Conduits for fluids, possibly pollutants
  – Weak surfaces for landslide, earthquake, and failures of infrastructure
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- *Ductile deformation:* Folds
  – Mountainous terrain
  – Related to active plate boundaries, linked to environmental problems

35 **Rock Structure (2)**

- *Unconformity:* Contact structure of rocks
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- Representing geologic time gap in geologic records, ancient erosion surface
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- Types: Nonconformity, angular unconformity, and disconformity
-
- Clues for ancient geologic environment
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- Ore-bearing unconformity surface, (e.g., uranium ore)

36 **Critical-Thinking Topics**

- Discuss different ways that rocks and minerals are used to benefit or to harm the environment
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- What rock property and rock structure factors should you consider for a major engineering site selection?
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- Suppose you are the superintendent of schools, what steps would you take to determine if there was an asbestos hazard, and how would you communicate with parents ?
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- What factors contributed to the failure of the St. Francis Dam?

37 **End of Chapter**