Rocks

Essential Points

1. Sedimentary rocks tell us about earth's past surface environment
2. Igneous and Metamorphic rocks tell us about earth's internal processes

What Rocks *Mean*

Sedimentary Rocks

- Record of the earth's ancient surface environments and of life.
- Record of crustal stability or disturbance.

Igneous Rocks

- Indicate crustal disturbance
- Unusual heat in the crust or mantle.

Metamorphic Rocks

- Indicate crustal disturbance
- Indicate uplift and erosion
- Indicate *orogenic* (mountain-building) events

What Rocks Tell Us

Rock Type	How Classified	What it Tells Us
Igneous	Composition	Tectonic Setting
	Texture	Cooling History
Sedimentary	Chemical Composition	Surface Environment
	Grain Size	Energy of Environment
Metamorphic	Composition	Original Rock Type
	Mineral Makeup	Temperature, Pressure
	Texture	Degree of Change

Igneous Rocks Cool from the Molten State

- Volcanic -- Erupted on Surface
- Plutonic -- Solidify Within Earth

Large Grain Size ---> Slow Cooling

- Volcanic Rocks -- Fine Grained
- Plutonic Rocks -- Coarse Grained

Porphyritic Texture:

- Large crystals in Fine-grained Setting
- Big crystals had a head start

Porphyritic Texture

Igneous Rock Classification

How Much Silica? (account for Si)

Silica means more silica networks

- Viscous lava
- Violent eruptions
- More resistance to weathering

Silica Rich: Rhyolite and Granite

Silica Poor: Andesite and Basalt

Some Igneous Rocks Are Named on Textural Criteria

- Pumice - Porous
- Obsidian - Glass
- Tuff - Cemented Ash
- Breccia - Cemented Fragments

Pumice, Breccia and Obsidian

What Igneous Rocks Mean

Basalt

- What you get if you melt average planetary material

Andesite

- Mantle material mixes with continental crust
- Volcanoes on converging plate boundaries

Rhyolite

- Forms from melting continental crust
- Long period of crustal heating

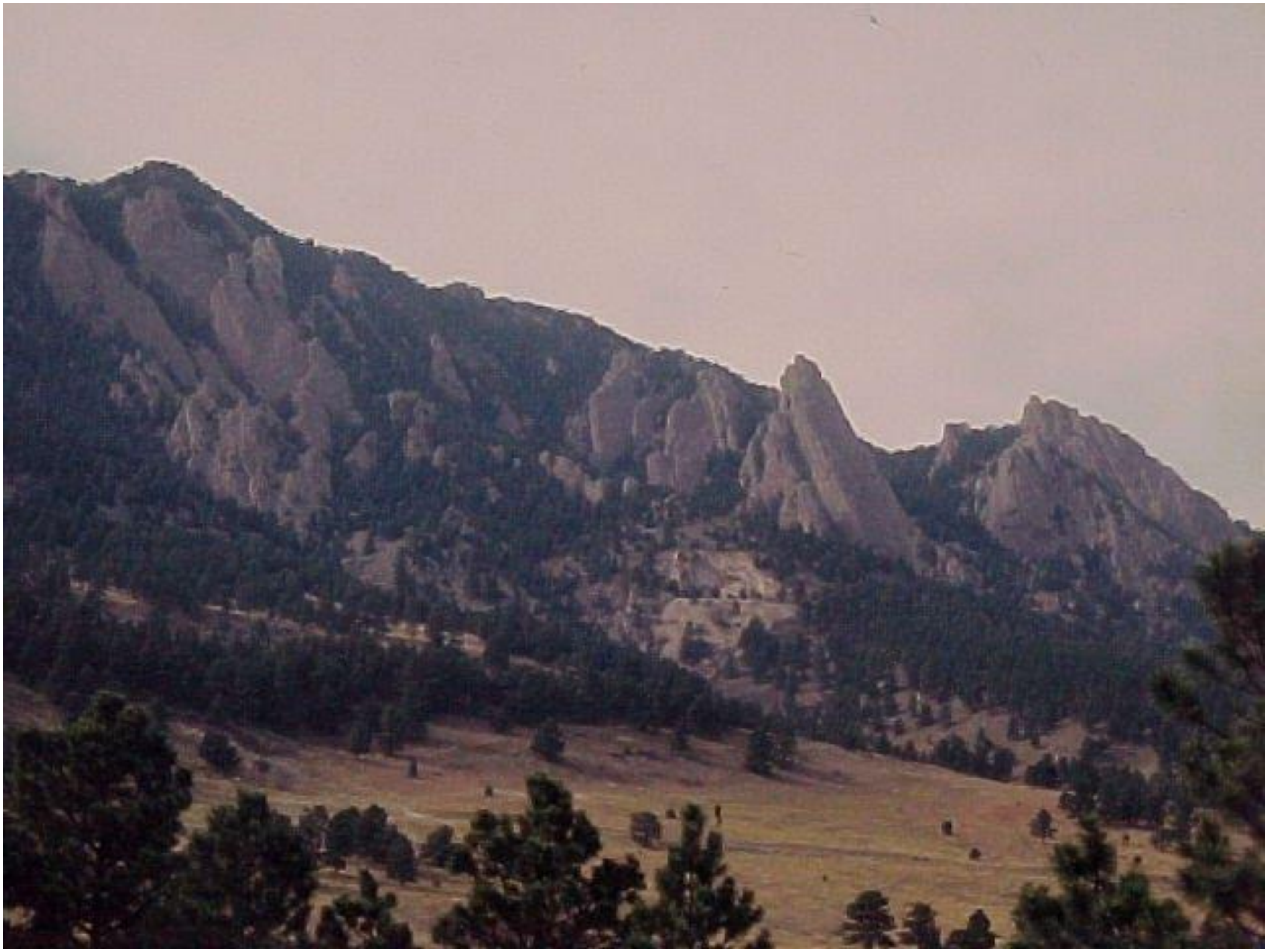
Granite

- Nothing in the earth can melt directly to yield granite
- Long continued crustal activity and re-working of rocks

Sedimentary Rocks are the Principal Repository for Information About the Earth's Past Environment

Bedding (Stratification), Utah

Tilted Beds, Colorado



Environmental Clues in Sedimentary Rocks

- Grain Size - Power of Transport Medium
- Grading - Often Due to Floods
- Rounding
- Sorting

} Transport, Reworking

- Cross-bedding - Wind, Wave or Current Action

Delta Cross-Bedding, Illinois

Fossil Ripple Marks, Baraboo Range

Fossil Mud Cracks, Virginia

Environmental Clues in Sedimentary Rocks

- Fossils
  - Salt Water - Corals, Echinoderms
  - Fresh Water - Insects, Amphibians
  - Terrestrial - Leaves, Land Animals
- Color And Chemistry
  - Red Beds - Often Terrestrial
  - Black Shale - Oxygen Poor, Often Deep Water
  - Evaporites – Arid Climates

Sedimentary Rocks

Clastic Rocks

- Made of Fragmentary Material
- Deposited by
  - Water (Most Common)
  - Wind
  - Glacial Action
  - Gravity

Biochemical Sedimentary Rocks

- Evaporation
- Precipitation
- Biogenic Sediments

Sediment Sizes and Clastic Rock Types

Rock Type	Sediment
Shale	Clay
Siltstone	Silt
Sandstone	Sand
Conglomerate	Gravel

Sedimentary rocks made of silt- and clay-sized particles are collectively called *mudrocks*, and are the most abundant sedimentary rocks.

Biochemical Sediments

Evaporites -Water Soluble

- Halite (Salt), Gypsum

Alteration After Deposition

- Dolomite

Biogenic Sediments

- Limestone - Shells, Reefs, Etc.

Organic Remains

- Coal, Petroleum

What Sedimentary Rocks Mean

Clastic Rocks

- Power of transport mechanism

Mineral Makeup of Clastic Rocks

- Stable vs. Unstable Settings

Carbonate Rocks

- Virtually all are biological in origin
- Important for climate control

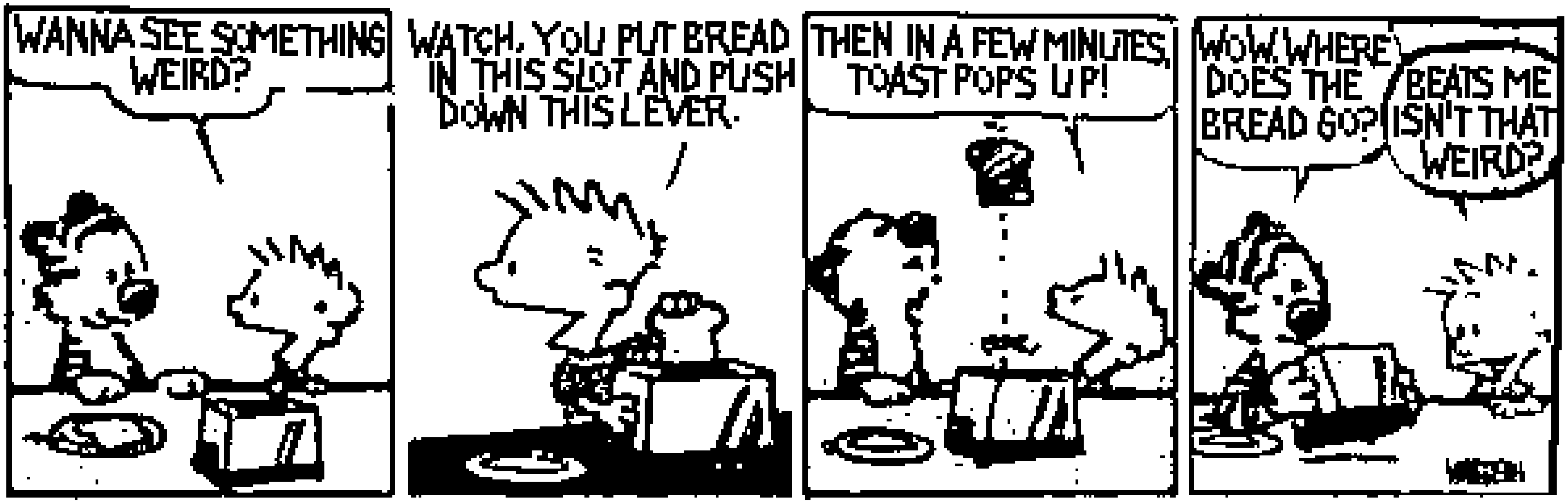
Evaporites

- High evaporation settings: deserts or hot tidal flats

Locale for Petroleum

Markers for Tilting or Fracturing of Crust

Metamorphism



- Changes in Rock Composition or Texture
- Due to Heat, Pressure and Action of Fluids

We Do Not Live at “Normal” Conditions

- By the standards of Earth’s interior, we live in a frozen vacuum
- Things that look “abnormal” to us are normal behavior for materials
  - Solids can flow
  - Solids can react chemically with each other
  - A given material can have several different atomic structures

Chemical Changes in Rocks

Weathering

- At Surface

Diagenesis

- Sedimentary Rocks

Metamorphism

- Starts about 200 C
- Outside range of normal near-surface conditions

Where Do the Heat and Pressure Come from?

Heat:

- Radioactive decay of Uranium, Thorium, Potassium-40
- Some may be original heat

Pressure: Weight of Overlying Rocks

What Happens During Metamorphism

Minerals React to Form New Minerals

Minerals Change Form

New Materials Are Added (Metasomatism)

- Minerals in Solution → Ore Bodies

Recrystallization

Why Don't Rocks "De-metamorphose"?

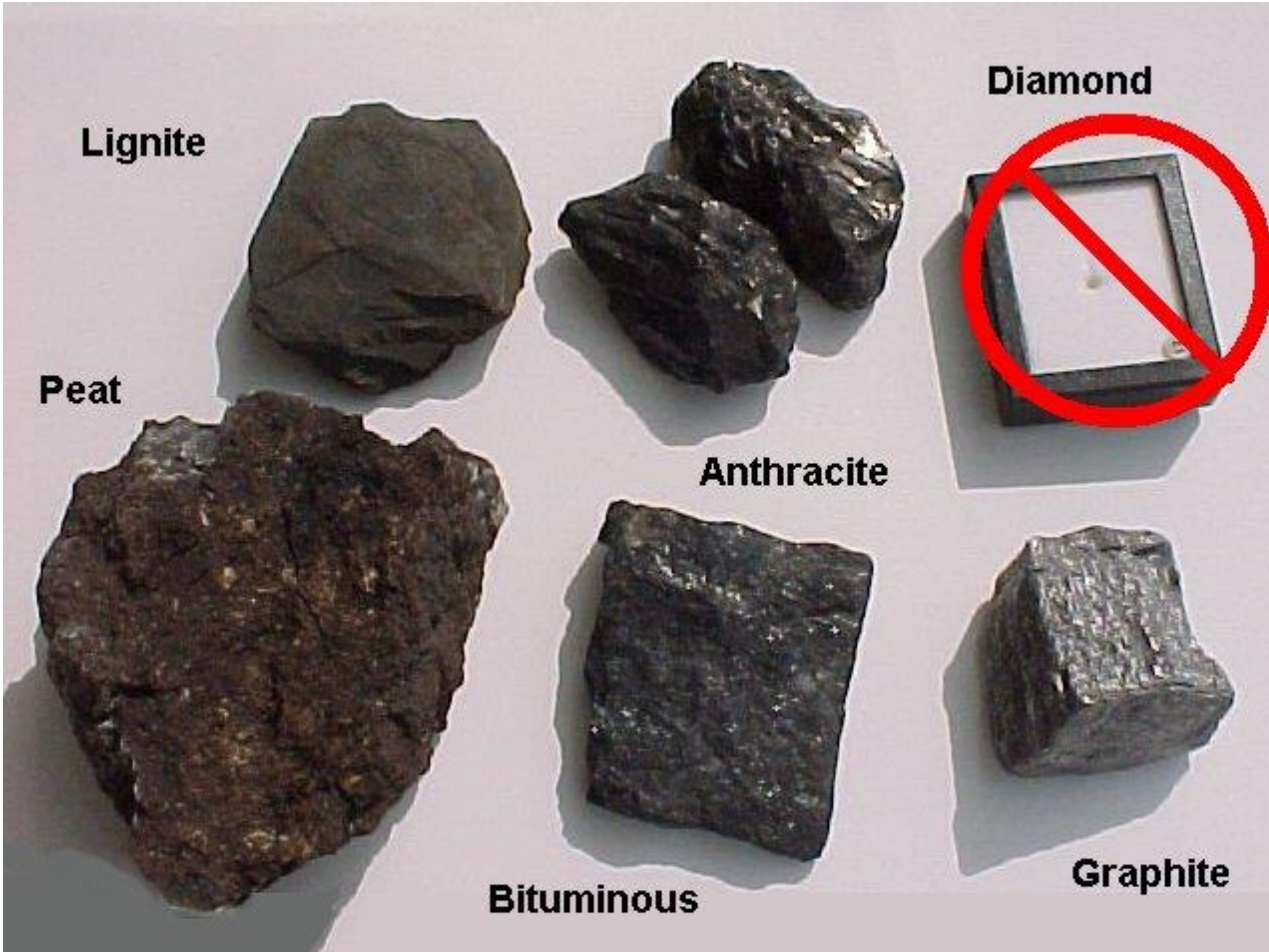
Reactions Can't Reverse Because Ingredients Lost

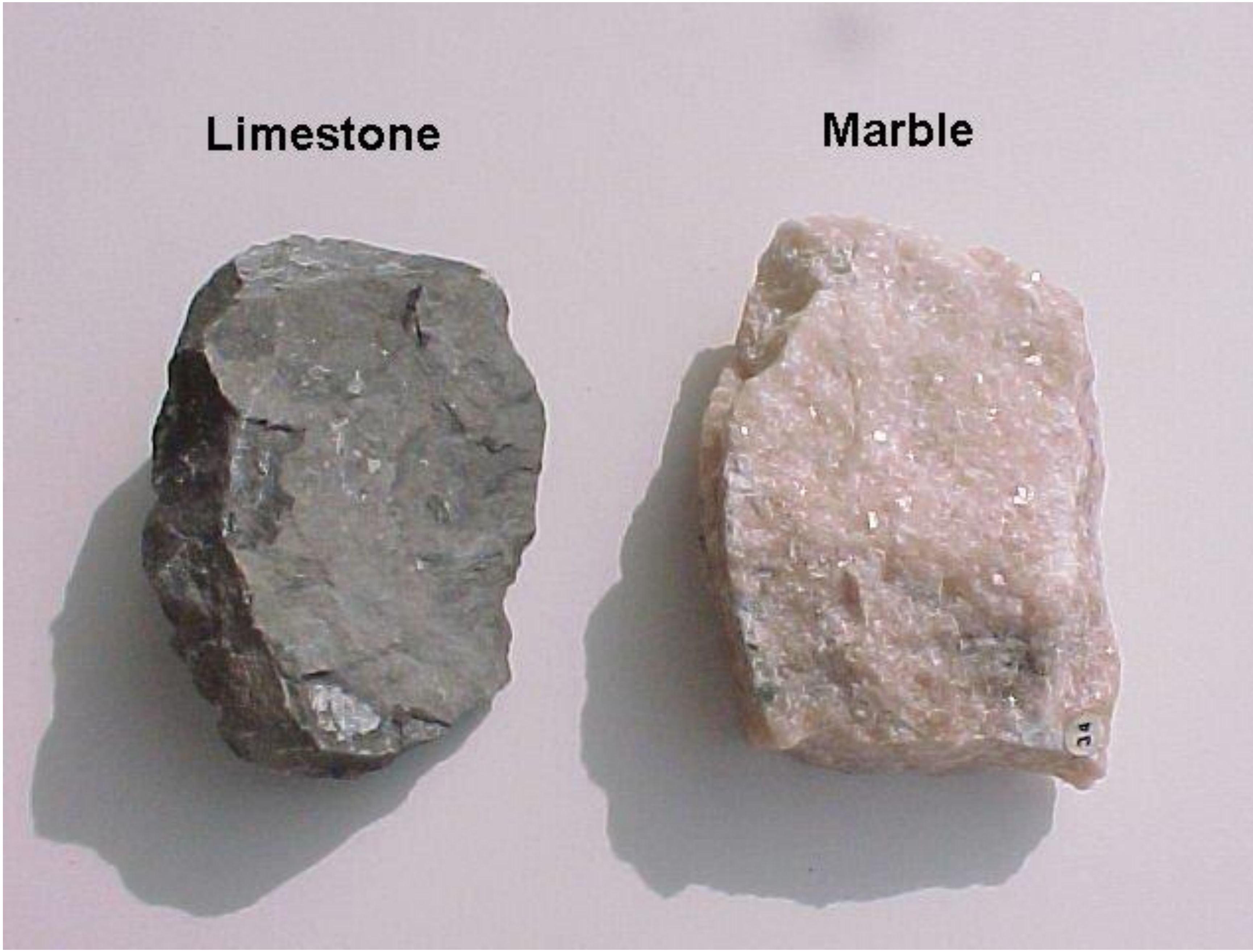
- Almost all reactions involve loss of water or CO_2

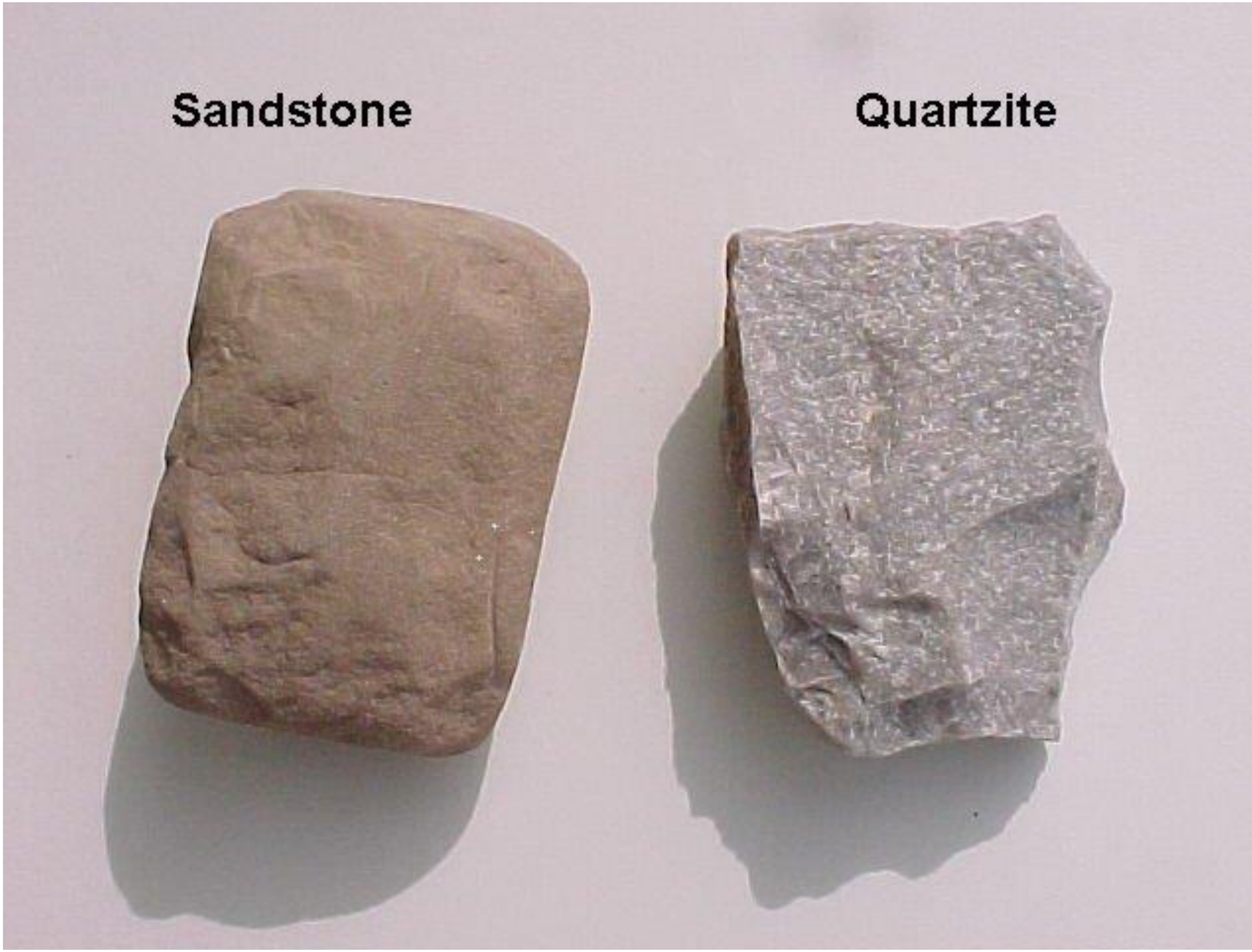
Reactions "Freeze" at Low Temperatures

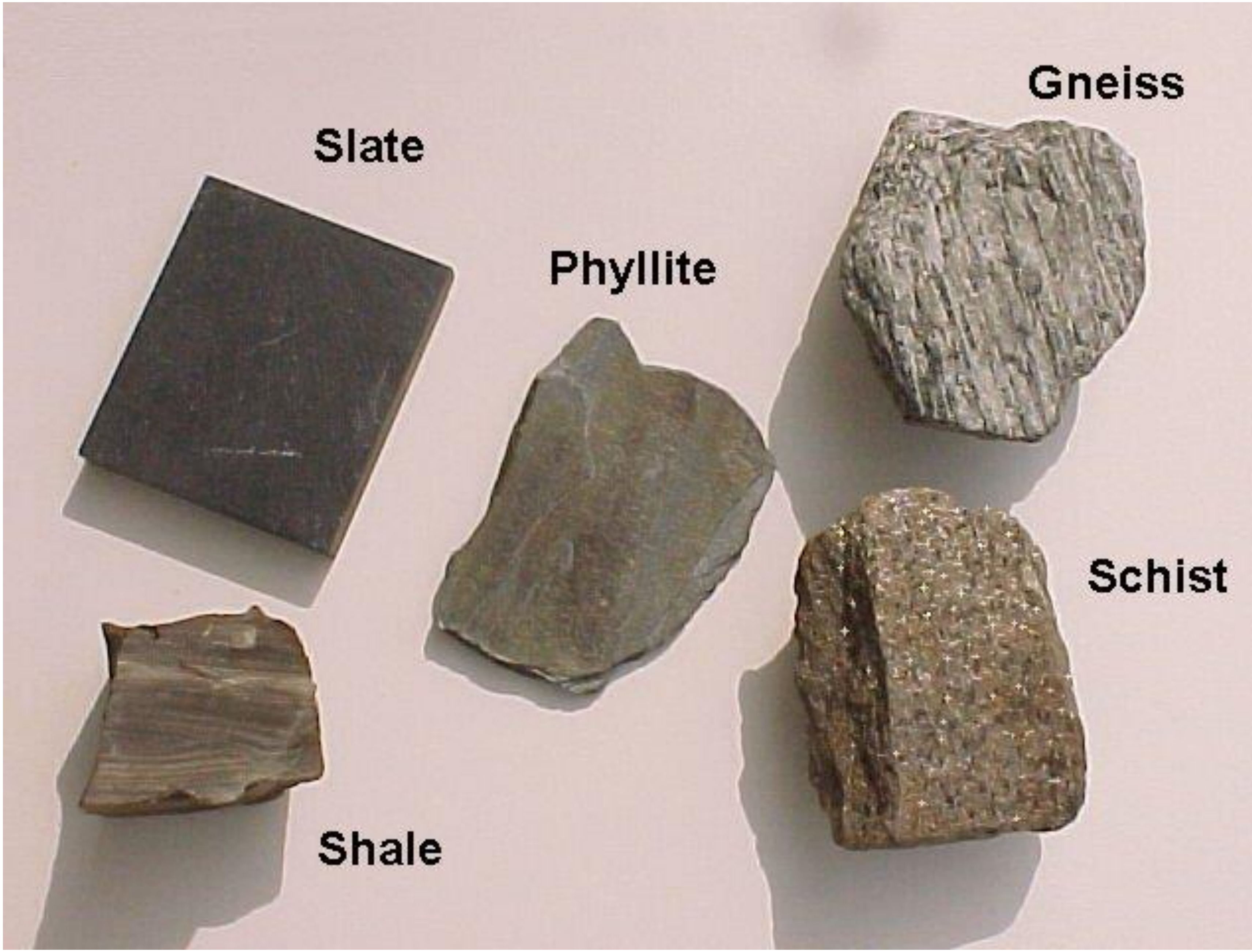
Sometimes it Does Happen if Fluids Present

- Retrograde Metamorphism
- On the surface we call it weathering


Lignite
Diamond
Peat
Anthracite
Bituminous
Graphite


Limestone
Marble


Sandstone
Quartzite

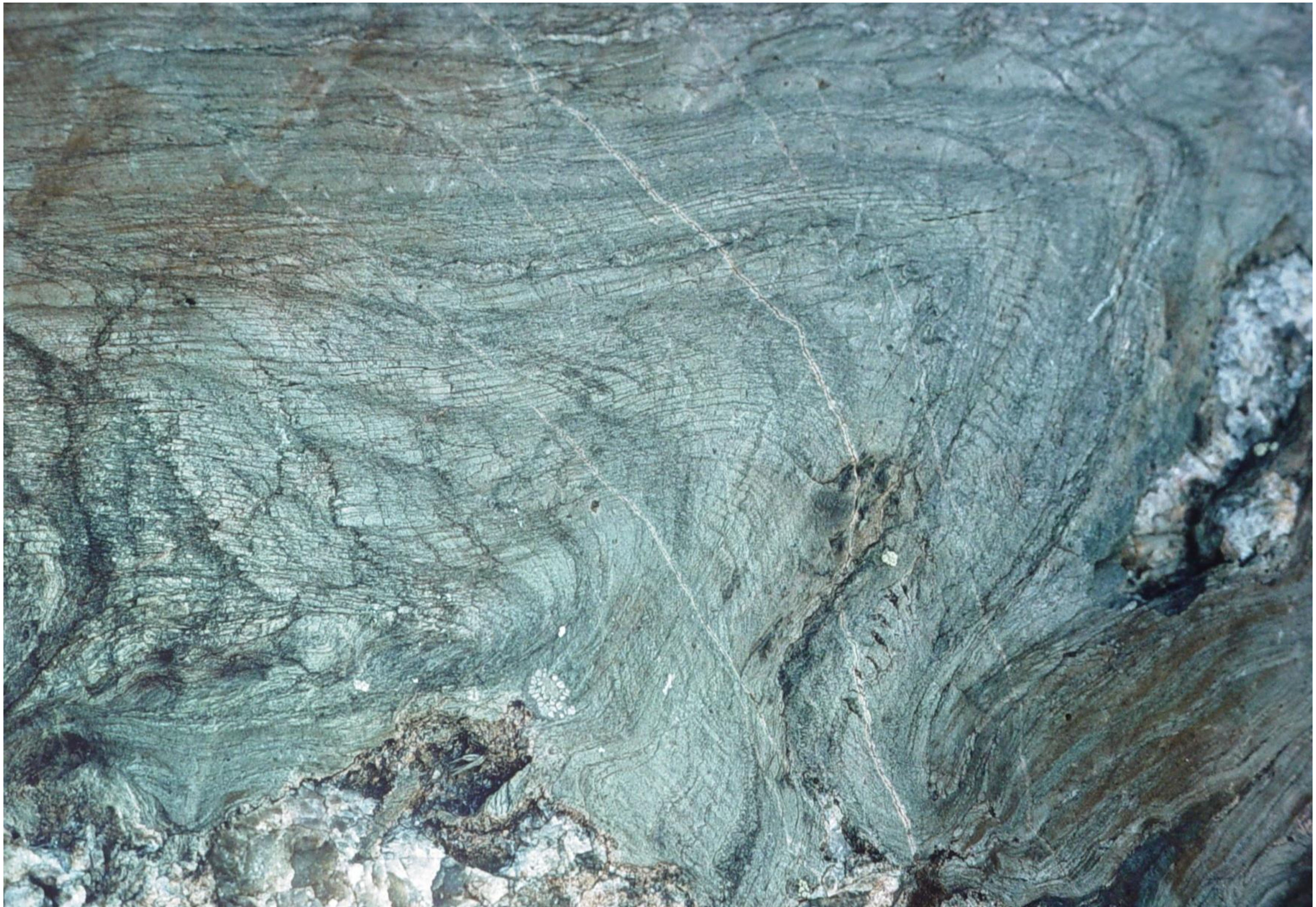

Gneiss
Slate
Phyllite
Schist
Shale

Metamorphic Grade -

Degree to Which the Rock Has Changed

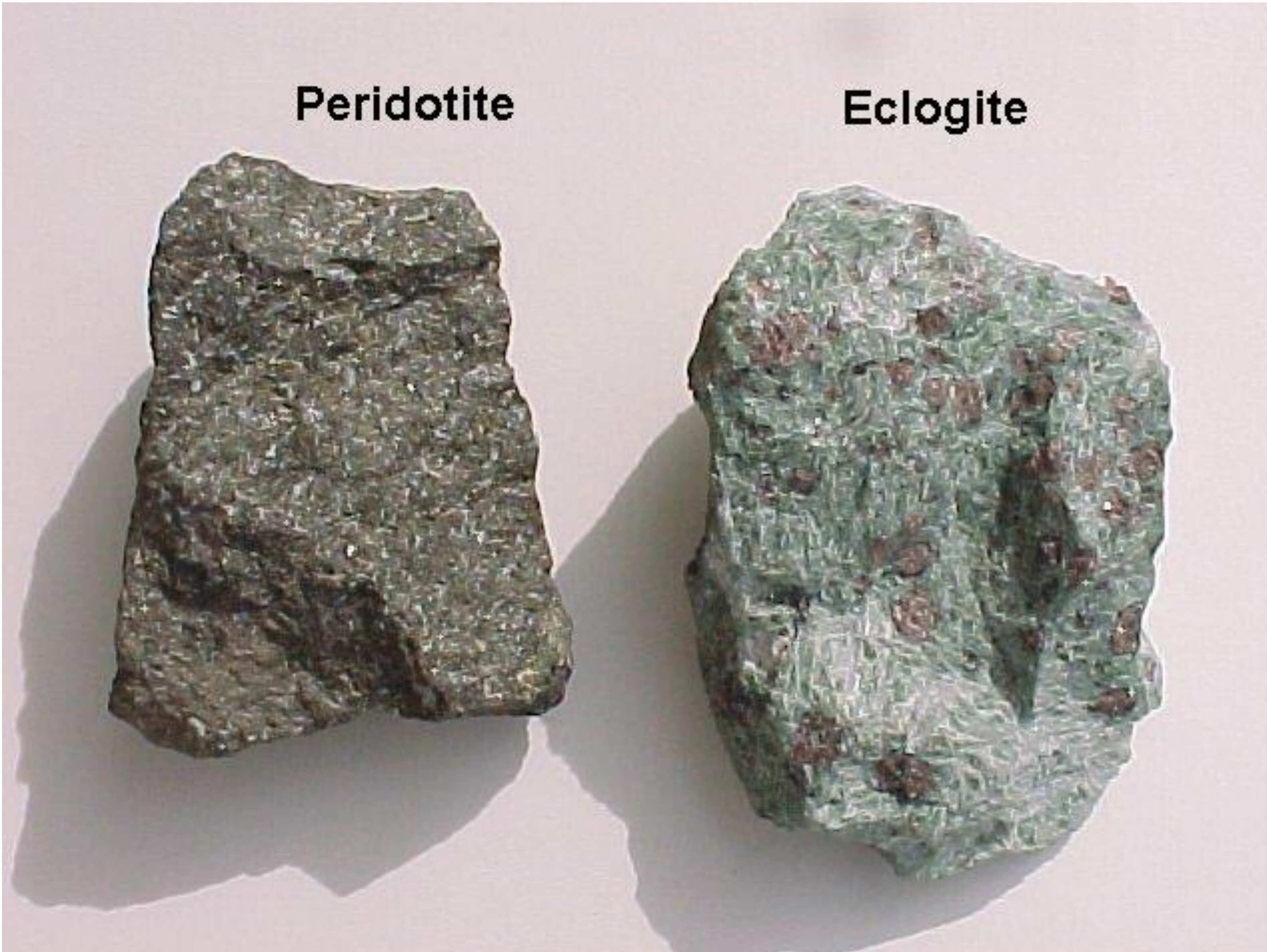
- Can Often See Original Bedding
- Can Sometimes Even See Deformed Fossils
- At High Grades, Rocks Can Often Lose All Trace of Their Original Appearance

Low Grade Metamorphism



High Grade Metamorphism

Mantle Rocks



What Metamorphic Rocks Mean

Originally far below the surface and got to the surface by uplift and erosion.

Low grade Metamorphism

- Margins and upper levels of mountain belts
- Shallow depths

High grade Metamorphism

- Cores of mountain belts
- Great depths (sometimes 50+ km)