Metamorphic Rocks

All of the rocks listed below occur in Michigan.

Texture	Rock Name	Diagnostic Features
FOLIATED	SLATE	Fine grained; most or all mineral grains invisible to the naked eye; similar position in adjacent folia (bands); smooth, even slaty cleavage.
	PHYLLITE	Fine grained; mineral grains barely or not visible; similar composition in adjacent folia; folia minutely wavy.
	SCHIST	Medium grained; many of mineral grains visible to the naked eye; relatively uniform and similar mineral composition in adjacent folia; folia irregular and discontinuous; often rich in mica.
	GNEISS	Coarse to medium grained; mineral grains visible to naked eye; adjacent folia of different mineral composition; contains abundant feldspar; folia irregular and discontinuous.
NONFOLIATED *(may be faintly banded due to presence of original stratification)*	QUARTZITE	Chiefly composed of quartz; if original sedimentary quartz grains are distinguishable, note that rock breaks through the grains rather than along grain boundaries. May be banded.
	MARBLE	Chiefly calcite ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$).

Varieties of schists and gneisses are subdivided on the basis of their mineral composition, which is determined largely by the composition of the original rock, the “grade” or intensity of metamorphism, and the kinds of chemical substances either removed or introduced during metamorphism. Two examples from Michigan are staroulite schist and cummintonite schist. Both of these are from the western northern peninsula.

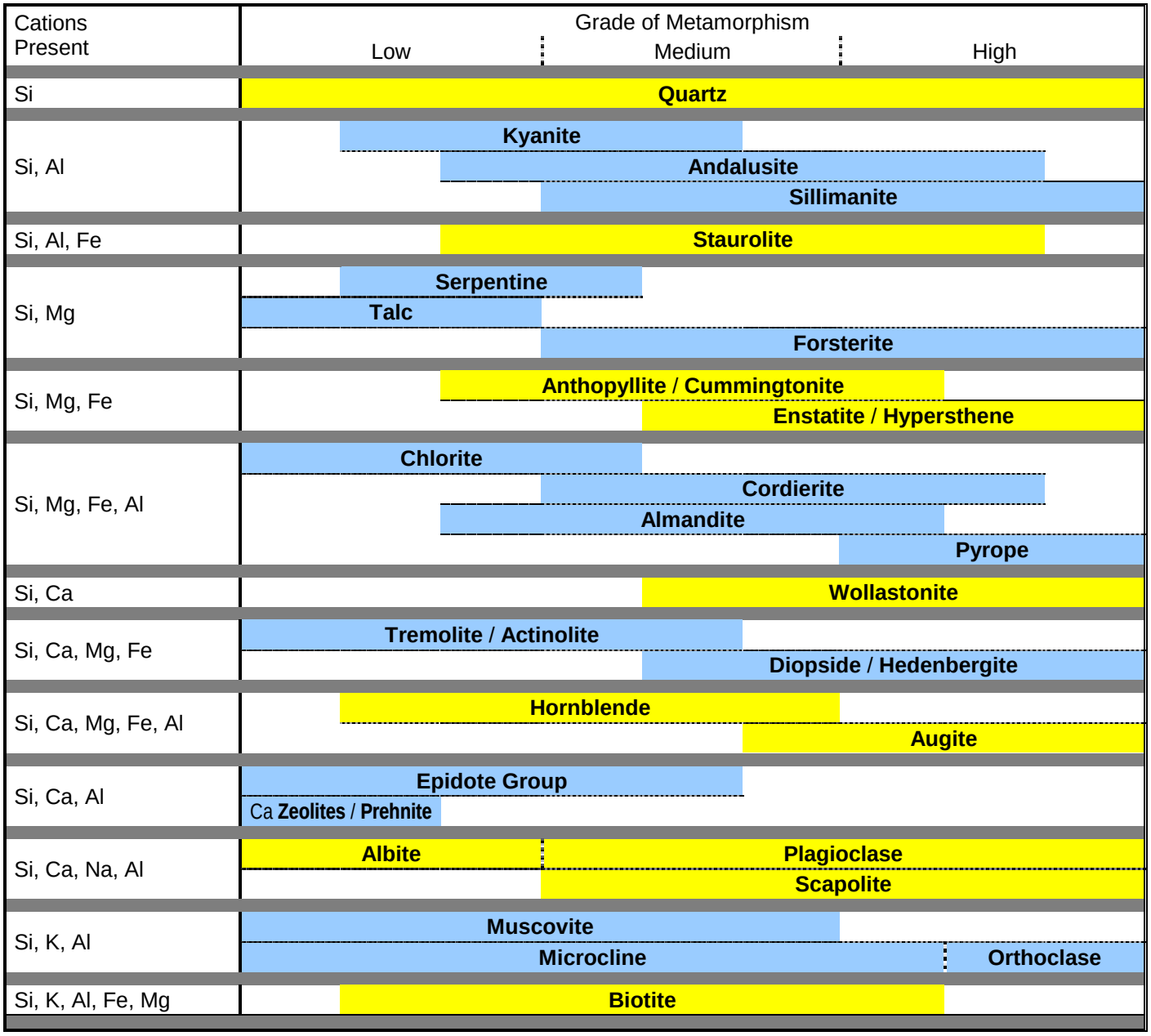
Metamorphic Rock Sources

Source		Result	
Limestone Dolomite	▷▷▶	**Marble**	alteration occurs at low in-and intensity. Little or no change thereafter
Quartz Sandstone	▷▷▶	**Quartzite**	alteration occurs at moderate to high intensities. No mineral change because original composition is simple - SiO_2
Shale	▷▷▶	**Slate**, **Phyllite**, **Schist**, **Gneiss**, **Granite**	
Peat	▷▷▶	**Lignite**, **Bituminous**, **Anthracite**, **Graphite**	
Igneous rocks (many types)	▷▷▶	**Schists and Gneisses**	In general, the iron and magnesium rich rocks are altered to schists and amphibolites, whereas the silica and aluminum rich rocks form gneisses, but almost any variation is possible because of variations in intensity of metamorphism and also because of the opportunity for the addition or removal of elements.

For more information see the **Geology of Michigan,** 1991; Dorr & Eschman, University of Michigan Press, Ann Arbor, Michigan.

Metamorphic Relationships

between Chemical Composition, Grade of Metamorphism, and Minerals Formed



For more information see the **Geology of Michigan,** 1991; Dorr & Eschman, University of Michigan Press, Ann Arbor, Michigan.

Igneous Rocks

Predominant Minerals, Reflecting Chemical Composition

Minerals → **Textures** ↓	**Feldspar** and **Quartz**	**Feldspar** Predominant *(No **Quartz**)*	**Ferromagnesian** Minerals *(Biotite, Hornblende, Augite)* Predominately **Plagioclase** Feldspar *(No **Quartz**)*	**Ferromagnesian** Minerals Only *(No **Quartz**, No **Feldspar**)*
Pyroclastic *or fragmental often classed as Extrusive igneous rocks*	VOLCANIC BRECCIA or CONGLOMERATE - fragments over 4 millimeters in diameter VOLCANIC TUFF or ASH fragments less than ~ millimeters in diameter			
Glassy *Extrusive igneous rocks*	OBSIDIAN—if dense or massive PUMICE—if frothy		SCORIA	
Aphanitic *Fine-grained crystals too small to see Extrusive igneous rocks*	**Felsite**, **Rhyolite** and DACITE	**Andesite**	**Basalt**	
Phaneritic *Granular Mineral crystals clearly visible. May be porphyritic Intrusive igneous rocks*	**Granite** (potassium feldspars such as orthoclase and microcline predominate) **Granodiorite** (plagioclase feldspars predominate)	**Diorite**	**Gabbro**	PERIDOTITE (with olivine and a pyroxene mineral PYROXENITE (pyroxene alone) **Serpentine** (altered olivine and pyroxene minerals)

Highlighted Rocks are **found in Michigan**.

Amygdaloidal Structure is that produced in a vesicular rock by filling of vesicles with mineral matter. If a rock has amygdules, use a compound name, for example, **amygdaloidal basalt**. In Michigan the State Gem pumpellyite variety chlorastrolite and many other interesting minerals are found having filled in these voids.

SCORIA is a vesicular igneous rock of fine or glassy texture, usually of basaltic composition. Some gas grill manufacturers use scoria above the burners.

If a rock falls in one of the above categories on the chart but is porphyritic (visible crystals in a fine grained groundmass or matrix) it is given a compound name, for example, granite porphyry (or porphyritic granite), and **basalt porphyry** (or porphyritic basalt).

For more information see the **Geology of Michigan,** 1991; Dorr & Eschman, University of Michigan Press, Ann Arbor, Michigan.

Sedimentary Rocks I

Detrital or Clastic (Exogenic)

Main Mineral Constituents and Texture

Minerals → ***Texture*** or Grain Size ↓	***Quartz*** (± cement)	***Quartz*** + ***Feldspar*** (± cement)	***Quartz*** +***Clay*** Matrix (± cement)	***Calcite Grains*** (not inter grown crystals) and ***calcite cement***		***Calcareous Fossil*** fragments + ***calcite cement*** (± calcite grains)
Gravel *Coarse grained Majority of grains over 2 mm. in di ameter*	Quartzose Conglomerate *if fragments are rounded* Quartzose Breccia *if fragments are angular*	Arkosic Conglomerate *if fragments are rounded* Arkosic Breccia *if fragments are angular*	Graywacke Conglomerate *if fragments are rounded* Graywacke Breccia *if fragments are angular*	Limestone Conglomerate *if fragments are rounded* **Limestone Breccia** *if fragments are angular*	Coquina *(if fossil fragments dominant or abundant)*	Bioclastic Conglomerate *(if fossil fragments common to few)*
Sand *Medium grained Majority of grains 2 mm. to 1/16 mm. in diameter - Visible to naked eye*	**Quartzose Sandstone**	Arkose *(or Arkosic sandstone)*	Graywacke *(or graywacke sandstone)*	Calcarenite (or detrital limestone)	Coquina	Bioclastic Calcarenite
Silt Fine grained Majority of grains from 1/16 mm. to 1/256 mm. Invisible to naked eye (Very difficult to distinguish different eye but feels gritty when scratched with fingernail	**Siltstone** *(the mineralogy is difficult to distinguish without magnification or laboratory work)*			**Limestone** *(difficult to distinguish from endogenous types of limestone)*		
Clay *Very fine grained Majority of grains less than 1/256 mm. Feels smooth when* scratched with fingernail Earthy odor when damp	**Shale**			**Lithographic Limestone**		

Highlighted Rocks are **found in Michigan**.

Angular grains or particles are referred to as immature, whereas more rounded grains or particles are referred to as mature.

For more information see the **Geology of Michigan,** 1991; Dorr & Eschman, University of Michigan Press, Ann Arbor, Michigan.

Sedimentary Rocks II

Chemical or Biochemical (Endogenic)

Main Mineral Constituents and Fossils

Minerals → ***Fossils*** ↓	***Quartz*** *(or opal)*	***Calcite*** *(or Dolomite)*	*Carbonaceous* *(**Plant** Remains)*	***Hematite*** *(Possibly Some Silica and/or Calcite)*	***Halite*** *(Possibly Some Anhydrite)*	***Gypsum***
Fossils **predominant** or **major**	DIATOMITE (if diatoms) RADIOLARITE (if radiolarians)	**Fossiliferous Limestone** or **Fossiliferous Dolomite** May be named for the predominant fossil type. like Coralline limestone Crinoidal dolomite	**Peat /. Lignite** **Bituminous Coal**			
Fossils **subordinate** or **minor**	DIATOMACEOUS or RADIOLARIAN CHERT	**Fossiliferous Limestone** or **Fossiliferous Dolomite**		some **Iron Ores**	*rare*	*rare*
Fossils **rare** or **absent** Minerals in a chemically precipitated crystalline intergrowth	**Chert , Flint**	**Limestone** **Dolomite** (TRAVERTINE)	ANTHRACITE COAL	OOLITIC IRON ORE *(fossils rare)* **Cherty Iron Ore** *(fossils absent)*	**Rock Salt** *(Halite)* **Evaporites**	**Rock Gypsum**

Highlighted Rocks are **found in Michigan**.

For more information see the **Geology of Michigan,** 1991; Dorr & Eschman, University of Michigan Press, Ann Arbor, Michigan.