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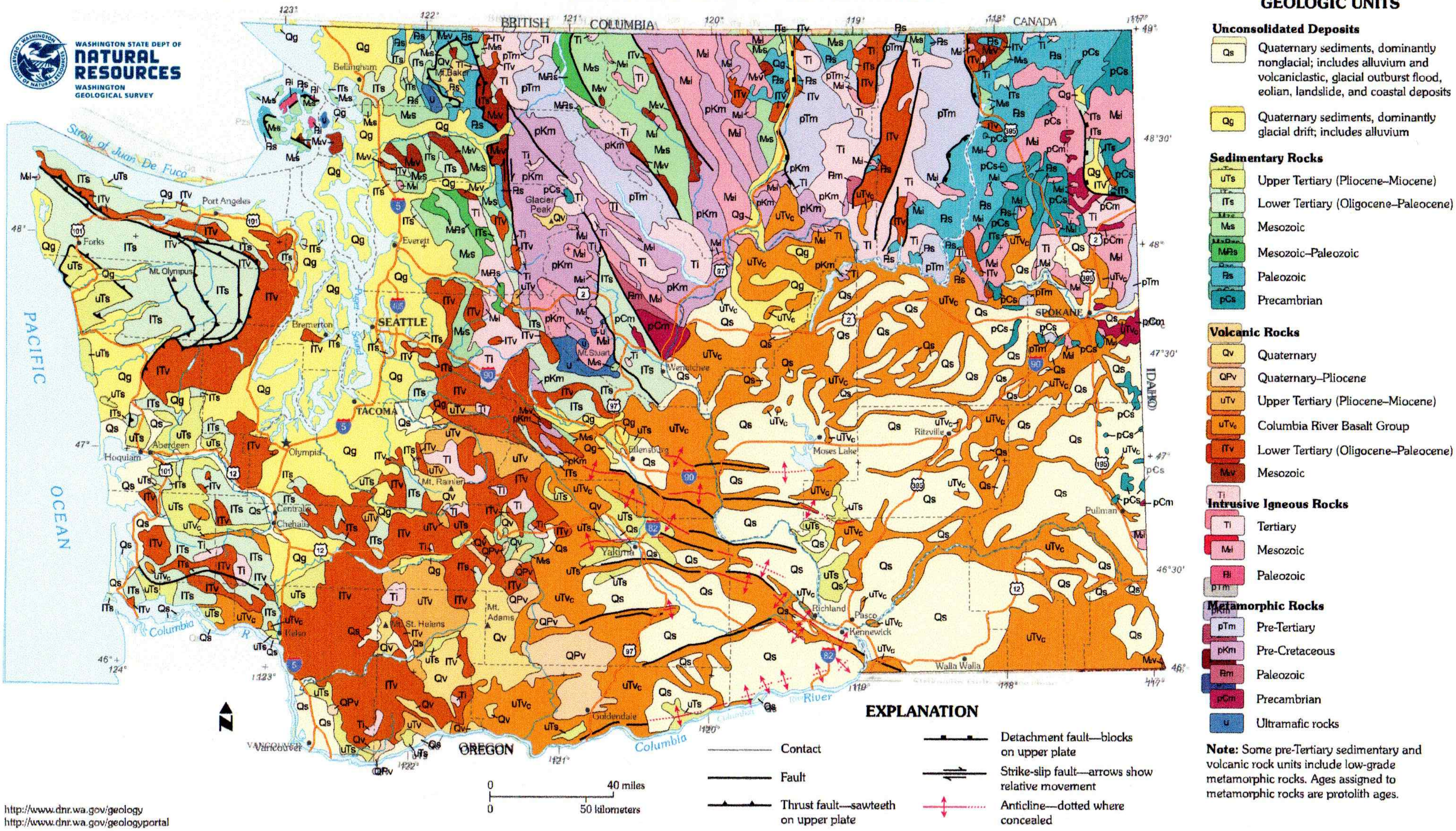
WASHINGTON STATE DEPARTMENT OF NATURAL RESOURCES
WASHINGTON GEOLOGICAL SURVEY
Casey R. Hanell—State Geologist

GEOLOGIC MAP OF WASHINGTON



http://www.dnr.wa.gov/geology
http://www.dnr.wa.gov/geologyportal

THE GEOLOGY OF WASHINGTON STATE

Washington consists of a diverse collection of rocks that tells an amazing geologic history. The deepest rock in Washington, called "basement", consists mostly of terranes accreted to North America over the last 200 million years. These basement terranes are overlain by a variety of sedimentary and volcanic rocks that add detail to the history.

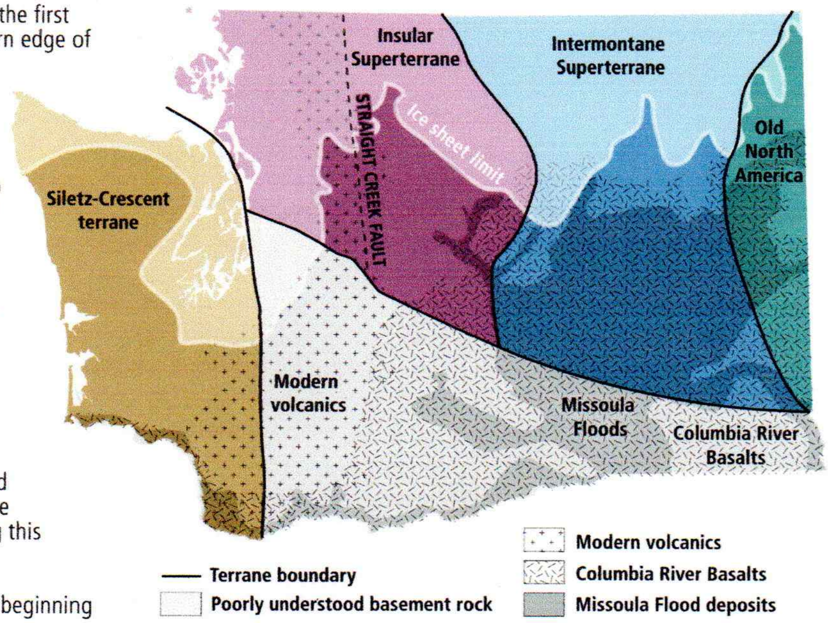
At the eastern edge of Washington State are exposures of **Paleozoic North America**. These rocks are overlain by metamorphosed sedimentary rocks dated around 1.46 billion years ago (unit **pCm**). These are the oldest rocks that have surface exposures in the state. Overlying the oldest rocks are metamorphosed sedimentary and volcanic rocks, dated around 700 million years (unit **pCs**).

For much of the Paleozoic (540 to 250 million years ago), the western coast of North America was tectonically inactive and bordered an ancient ocean. Some Paleozoic rocks in northeast Washington, including quartzite and conglomerate (unit **Pzs**), indicate river, coastal, and ocean environments.

By 250 million years ago, the first of several subduction zones formed along the western edge of Washington.

The onset of subduction brought the first of what would be many arrivals of exotic terranes. The first accreted terrane included a collection of already accreted volcanic islands, collectively known as the **Intermontane Superterrane**. The collision of this terrane around 170 million years ago caused metamorphism and magmatism throughout the region.

Following the arrival of the first superterrane, the western edge of Washington hosted the prehistoric ocean, the Methow ocean. Marine sand and mud built upon the ocean floor (unit **Mzs**), later to be thrust eastward with the arrival of another accreted terrane.



The complex patchwork that is the **Insular Superterrane** arrived throughout the Mesozoic, between 250 and 60 million years ago. Intermittent volcanic arcs contributed plutons that intruded the accreted terranes during this time.

Tectonic rearrangement beginning around 60 million years ago exerted a northward push that created extensive north–south strike-slip faulting through the middle of the North Cascades. Right-lateral motion along these faults, notably the Straight Creek fault, resulted in approximately 90 km of displacement. At the same time, extension created and exposed metamorphic core complexes in the Okanogan Highlands (unit **pTm**) and the metamorphic and intrusive igneous rocks of the North Cascades terranes (unit **pKm**). About 50 million years ago, the final major addition to Washington had arrived. The **Siletz-Crescent terrane** (unit **lTv**) was an exceptionally large chunk of basaltic islands and ocean floor. When it collided with North America, subduction temporarily ceased.

By 40 million years ago, subduction resumed west of Siletzia, resulting in another volcanic arc and uplifting rocks of the Cascade Range. By 17 million years ago, the Yellowstone Hot Spot caused the eruption of the Columbia River Basalt Group, the youngest continental flood basalt eruption on Earth. These eruptions ended by 6 million years ago, and they covered vast areas of southeastern Washington, Oregon, and Idaho (unit **uTvc**). During these eruptions, continental rifting in the Basin and Range and northward drift of much of California caused clockwise rotation and deformation of the Pacific Northwest, creating the Yakima fold and thrust belt. Rotation about a pole near the northeast corner of Oregon is still ongoing.

This rotation likely contributed to the onset of the modern Cascade arc ~10 million years ago. Volcanism and uplift of the mountain range introduced stratovolcanoes that are still active today (unit **Qv**). The mostly basaltic Boring Volcanic Field was also active beginning about 2.7 million years ago.

Pleistocene cooling brought broad continental ice sheets across the northern half of the state (unit **Qg**). Repeated glacial advances and retreats carved the modern landscape, including the Puget Sound and surrounding lowlands. Massive glacial lakes were dammed by ice and episodically breached during this time, releasing the enormous Missoula Floods that spread across eastern Washington to the western coast, traversing the Columbia River.

Washington Department of Natural Resources—WA Geological Survey

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INTERNATIONAL CHRONOSTRATIGRAPHIC CHART

IUGS

www.stratigraphy.org International Commission on Stratigraphy **v 2024/12**

Eonothem / Eon	Erathem / Era	System / Period	Series / Epoch		Stage / Age	GSSP	numerical age (Ma)
							present
Phanerozoic	Cenozoic	Quaternary	Holocene	U/L	Meghalayan	GSSP	0.0042
				M	Northgrippian	GSSP	0.0082
				L/E	Greenlandian	GSSP	0.0117
			Pleistocene	U/L	*Upper*		0.129
				M	Chibanian	GSSP	0.774
					Calabrian	GSSP	1.80
				L/E	Gelasian	GSSP	2.58
		Neogene	Pliocene	U/L	Piacenzian	GSSP	3.600
				L/E	Zanclean	GSSP	5.333
			Miocene	U/L	Messinian	GSSP	7.246
					Tortonian	GSSP	11.63
				M	Serravallian	GSSP	13.82
					Langhian	GSSP	15.98
				L/E	Burdigalian		20.45
					Aquitanian	GSSP	23.04
		Paleogene	Oligocene		Chattian	GSSP	27.30
					Rupelian	GSSP	33.9
			Eocene		Priabonian	GSSP	37.71
					Bartonian		41.03
					Lutetian		48.07
					Ypresian	GSSP	56.00
			Paleocene		Thanetian	GSSP	59.24
					Selandian	GSSP	61.66
					Danian	GSSP	66.00
	Mesozoic	Cretaceous	Upper		Maastrichtian	GSSP	72.2 ±0.2
					Campanian		83.6 ±0.2
					Santonian	GSSP	85.7 ±0.2
					Coniacian	GSSP	89.8 ±0.3
					Turonian	GSSP	93.9 ±0.2
					Cenomanian	GSSP	100.5 ±0.1
			Lower		Albian	GSSP	113.2 ±0.3
					Aptian		121.4 ±0.6
					Barremian	GSSP	125.77
					Hauterivian	GSSP	132.6 ±0.6
					Valanginian	GSSP	137.05 ±0.2
					Berriasian		143.1 ±0.6

Eonothem / Eon	Erathem / Era	System / Period	Series / Epoch	Stage / Age	GSSP	numerical age (Ma)
						143.1 ±0.6
Phanerozoic	Mesozoic	Jurassic	Upper	Tithonian		149.2 ±0.7
				Kimmeridgian	GSSP	154.8 ±0.8
				Oxfordian		161.5 ±1.0
			Middle	Callovian		165.3 ±1.1
				Bathonian	GSSP	168.2 ±1.2
				Bajocian	GSSP	170.9 ±0.8
				Aalenian	GSSP	174.7 ±0.8
			Lower	Toarcian	GSSP	184.2 ±0.3
				Pliensbachian	GSSP	192.9 ±0.3
				Sinemurian	GSSP	199.5 ±0.3
				Hettangian	GSSP	201.4 ±0.2
		Triassic	Upper	Rhaetian		~ 205.7
				Norian		~ 227.3
				Carnian	GSSP	~ 237
			Middle	Ladinian	GSSP	241.464 ±0.28
				Anisian		246.7
			Lower	Olenekian		249.9
				Induan	GSSP	251.902 ±0.024
	Paleozoic	Permian	Lopingian	Changhsingian	GSSP	254.14 ±0.07
				Wuchiapingian	GSSP	259.51 ±0.21
			Guadalupian	Capitanian	GSSP	264.28 ±0.16
				Wordian	GSSP	266.9 ±0.4
				Roadian	GSSP	274.4 ±0.4
			Cisuralian	Kungurian		283.3 ±0.4
				Artinskian	GSSP	290.1 ±0.26
				Sakmarian	GSSP	293.52 ±0.17
				Asselian	GSSP	298.9 ±0.15
		Carboniferous – Pennsylvanian	Upper	Gzhelian		303.7 ±0.1
				Kasimovian		307.0 ±0.1
			Middle	Moscovian		315.2 ±0.2
			Lower	Bashkirian	GSSP	323.4 ±0.4
		Carboniferous – Mississippian	Upper	Serpukhovian		330.3 ±0.4
			Middle	Visean	GSSP	346.7 ±0.4
			Lower	Tournaisian	GSSP	358.86 ±0.19

Eonothem / Eon	Erathem / Era	System / Period	Series / Epoch	Stage / Age	GSSP	numerical age (Ma)
						358.86 ±0.19
Phanerozoic	Paleozoic	Devonian	Upper	Famennian	GSSP	372.15 ±0.46
				Frasnian	GSSP	382.31 ±1.36
			Middle	Givetian	GSSP	387.95 ±1.04
				Eifelian	GSSP	393.47 ±0.99
			Lower	Emsian	GSSP	410.62 ±1.95
				Pragian	GSSP	413.02 ±1.91
				Lochkovian	GSSP	419.62 ±1.36
		Silurian	Pridoli		GSSP	422.7 ±1.6
			Ludlow	Ludfordian	GSSP	425.0 ±1.5
				Gorstian	GSSP	426.7 ±1.5
			Wenlock	Homerian	GSSP	430.6 ±1.3
				Sheinwoodian	GSSP	432.9 ±1.2
			Llandovery	Telychian	GSSP	438.6 ±1.0
				Aeronian	GSSP	440.5 ±1.0
				Rhuddanian	GSSP	443.1 ±0.9
		Ordovician	Upper	Hirnantian	GSSP	445.2 ±0.9
				Katian	GSSP	452.8 ±0.7
				Sandbian	GSSP	458.2 ±0.7
			Middle	Darriwilian	GSSP	469.4 ±0.9
				Dapingian	GSSP	471.3 ±1.4
			Lower	Floian	GSSP	477.1 ±1.2
				Tremadocian	GSSP	486.85 ±1.5
		Cambrian	Furongian	*Stage 10*		~ 491.0
				Jiangshanian	GSSP	~ 494.2
				Paibian	GSSP	~ 497.0
			Miaolingian	Guzhangian	GSSP	~ 500.5
				Drumian	GSSP	~ 504.5
				Wuliuan	GSSP	~ 506.5
			Series 2	*Stage 4*		~ 514.5
				Stage 3		~ 521.0
			Terreneuvian	*Stage 2*		~ 529.0
				Fortunian	GSSP	538.8 ±0.6

Eonothem / Eon	Erathem / Era	System / Period	GSSP / GSSA	numerical age (Ma)
				538.8 ±0.6
Precambrian – Proterozoic	Neo-proterozoic	Ediacaran	GSSP	~ 635
		Cryogenian		~ 720
		Tonian	GSSA	1000
	Meso-proterozoic	Stenian	GSSA	1200
		Ectasian	GSSA	1400
		Calymmian	GSSA	1600
	Paleo-proterozoic	Statherian	GSSA	1800
		Orosirian	GSSA	2050
		Rhyacian	GSSA	2300
		Siderian	GSSA	2500
Precambrian – Archean	Neo-archean		GSSA	2800
	Meso-archean		GSSA	3200
	Paleo-archean		GSSA	3600
	Eo-archean		GSSA	4031 ± 3
Precambrian – Hadean			GSSA	4567

Units of all ranks are in the process of being defined by Global Boundary Stratotype Section and Points (GSSP) for their lower boundaries, including those of the Archean and Proterozoic, long defined by Global Standard Stratigraphic Ages (GSSA). Ratified Subseries/Subepochs are abbreviated as U/L (Upper/Late), M (Middle) and L/E (Lower/Early). Italic fonts indicate informal units and placeholders for unnamed units. Previous versions and detailed information on ratified GSSPs are available at the website http://www.stratigraphy.org. The URL to this chart is provided below.

Numerical ages are subject to ongoing revision and do not define units in the Phanerozoic and the Ediacaran; only GSSPs do. For boundaries in the Phanerozoic without ratified GSSPs or without constrained numerical ages, an approximate numerical age (~) is provided.

Most numerical ages are taken from 'A Geologic Time Scale 2020' by Gradstein et al. (2020), but some ages differ as provided by the relevant ICS subcommissions, with advice from the Timescale Calibration subcommission. These are approved by the ICS executive as the current consensus.

Colouring follows the Commission for the Geological Map of the World (www.ccgm.org)

Chart drafted and maintained online by officers K.M. Cohen and N. Car.

The chart is a product of collective work by all ICS members past and present.

URL: http://www.stratigraphy.org/ICSchart/ChronostratChart2024-12.pdf

To cite: Cohen, K.M., Finney, S.C., Gibbard, P.L. & Fan, J.-X. (2013; updated) The ICS International Chronostratigraphic Chart. Episodes 36: 199-204

Table 8.1 The characteristics of the four types of unconformities

Unconformity Type	Description
Nonconformity	A boundary between non-sedimentary rocks (below) and sedimentary rocks (above)
Angular unconformity	A boundary between two sequences of sedimentary rocks where the underlying ones have been tilted (or folded) and eroded prior to the deposition of the younger ones (as in Figure 8.2.4)
Disconformity	A boundary between two sequences of sedimentary rocks where the underlying ones have been eroded (but not tilted) prior to the deposition of the younger ones (as in Figure 8.2.2)
Paraconformity	A time gap in a sequence of sedimentary rocks that does not show up as an angular unconformity or a disconformity

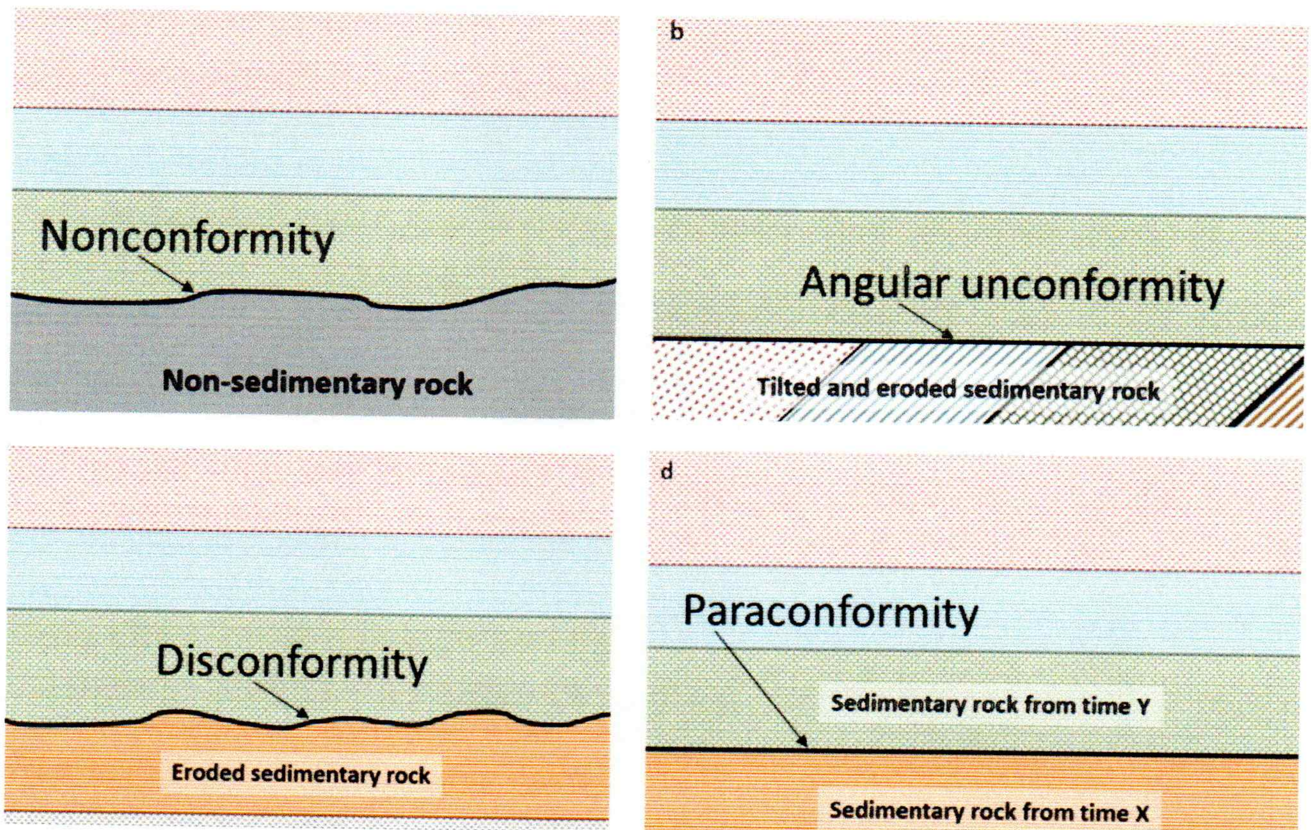
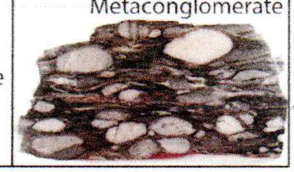
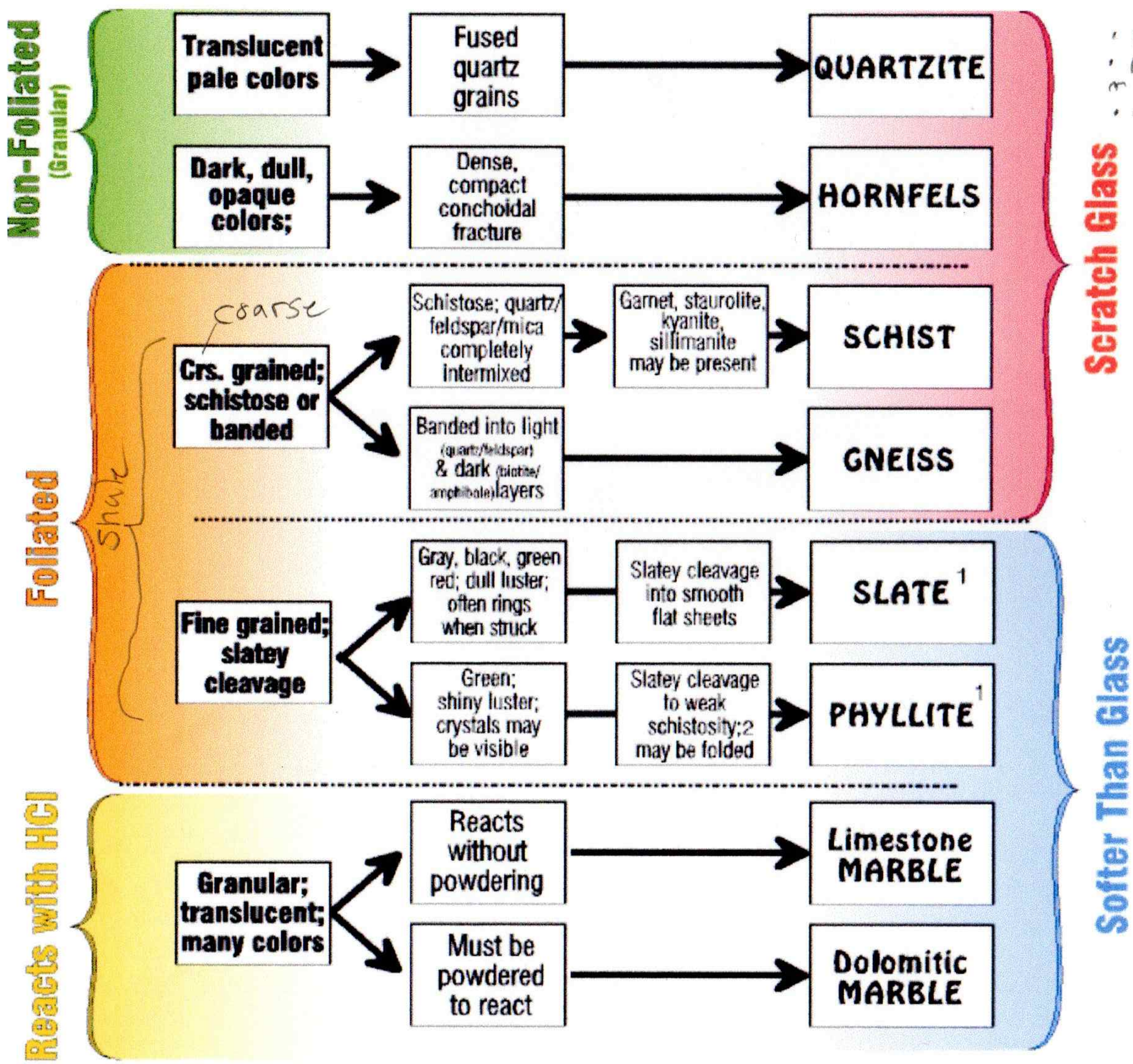


Figure 8.2.5 The four types of unconformities: (a) a nonconformity between older non-sedimentary rock and sedimentary rock, (b) an angular unconformity, (c) a disconformity between layers of sedimentary rock, where the older rock has been eroded but not tilted, and (d) a paraconformity where there is a long period (typically millions of years) of non-deposition between two parallel layers.

Media Attributions

- Figures 8.2.1ab, 8.2.2, 8.2.3, 8.2.4, 8.2.5:

Texture	Composition	Characteristics	Protolith	Metamorphic Rock Name
Foliated — Mineral Alignment (Increasing Temperature & Pressure)	Clay Minerals; Mica	Very fine-grained rock, tends to split in parallel fragments (known as slaty cleavage).	Shale	Slate 
Foliated — Mineral Alignment	Mica, Quartz, Feldspar, Amphibole, Garnet	Fine-grained rock with a shiny surface from microscopic mica crystals. Similar to shale, but with a satin luster and may have wrinkled cleavage.	Shale	Phyllite 
Foliated — Mineral Alignment	Mica, Quartz, Feldspar, Amphibole, Garnet, Pyroxene	Contains visible, shiny, platy mica crystals; may have other minerals, such as quartz, garnet and amphibole. Has schistose pattern of foliation.	Shale	Schist 
Foliated — Banding	Mica, Quartz, Feldspar, Amphibole, Garnet, Pyroxene	Contains alternating bands of light- and dark-colored minerals, called gneissic banding	Shale or Igneous Rock	Gneiss 
Non-foliated	Quartz	Equigranular grains of quartz, which has a hardness of 7.	Sandstone or Siltsone	Quartzite 
Non-foliated	Calcite and/or Dolomite	Equigranular grains of calcite, which has a hardness of 3. Reacts with HCl.	Limestone	Marble 
Non-foliated	Various minerals in clasts and matrix	Coarse-grained rock wherein pebbles may be distorted or streched.	Conglomerate	Metaconglomerate 



· hard
· non-foliated
· white-grey-pink
· glassy

· grainy, glassy, sandpaper-like

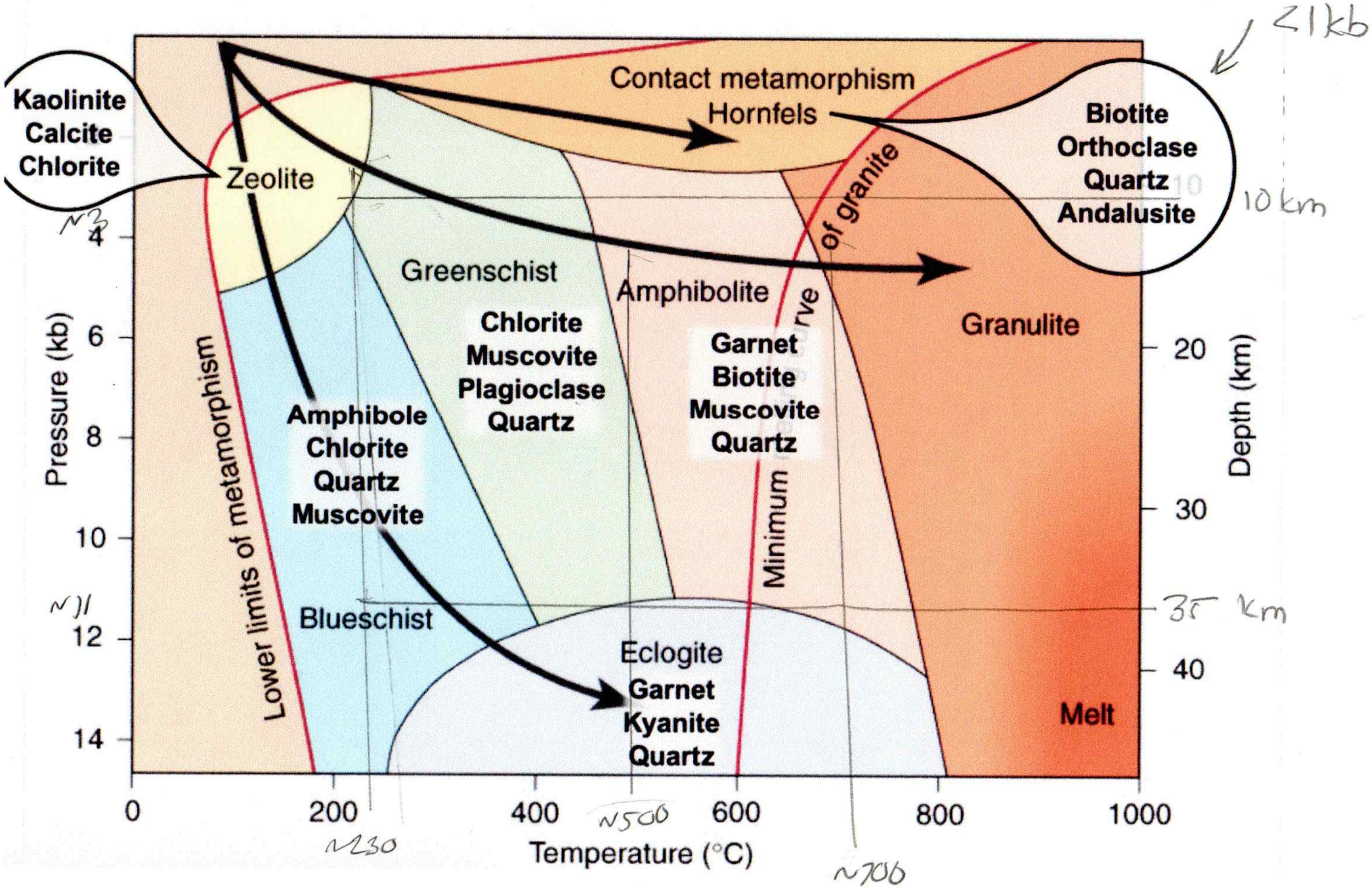
· contact metamorphic
· banded
· fine grained

· contact metamorphism

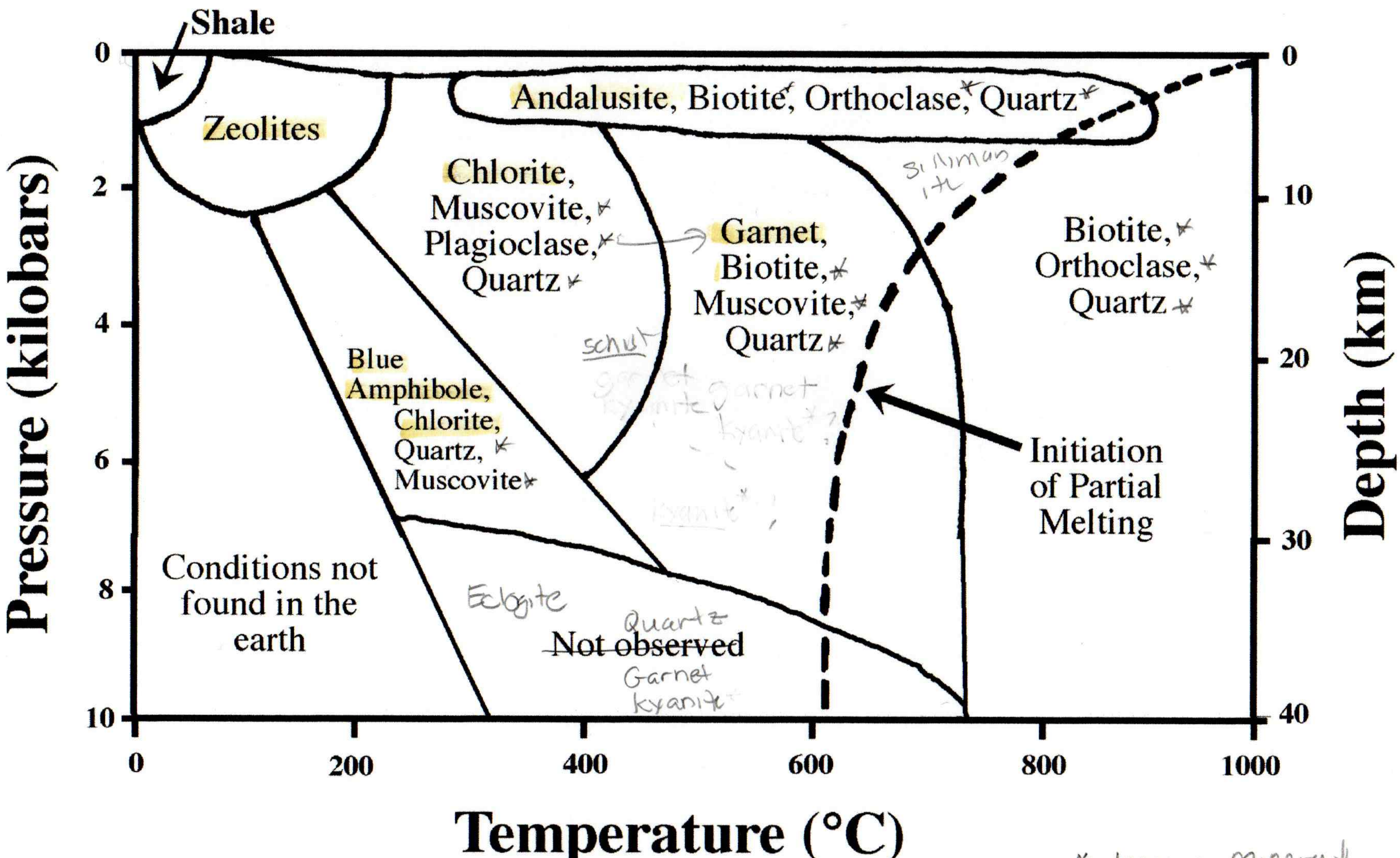
· mica, etc

· banded

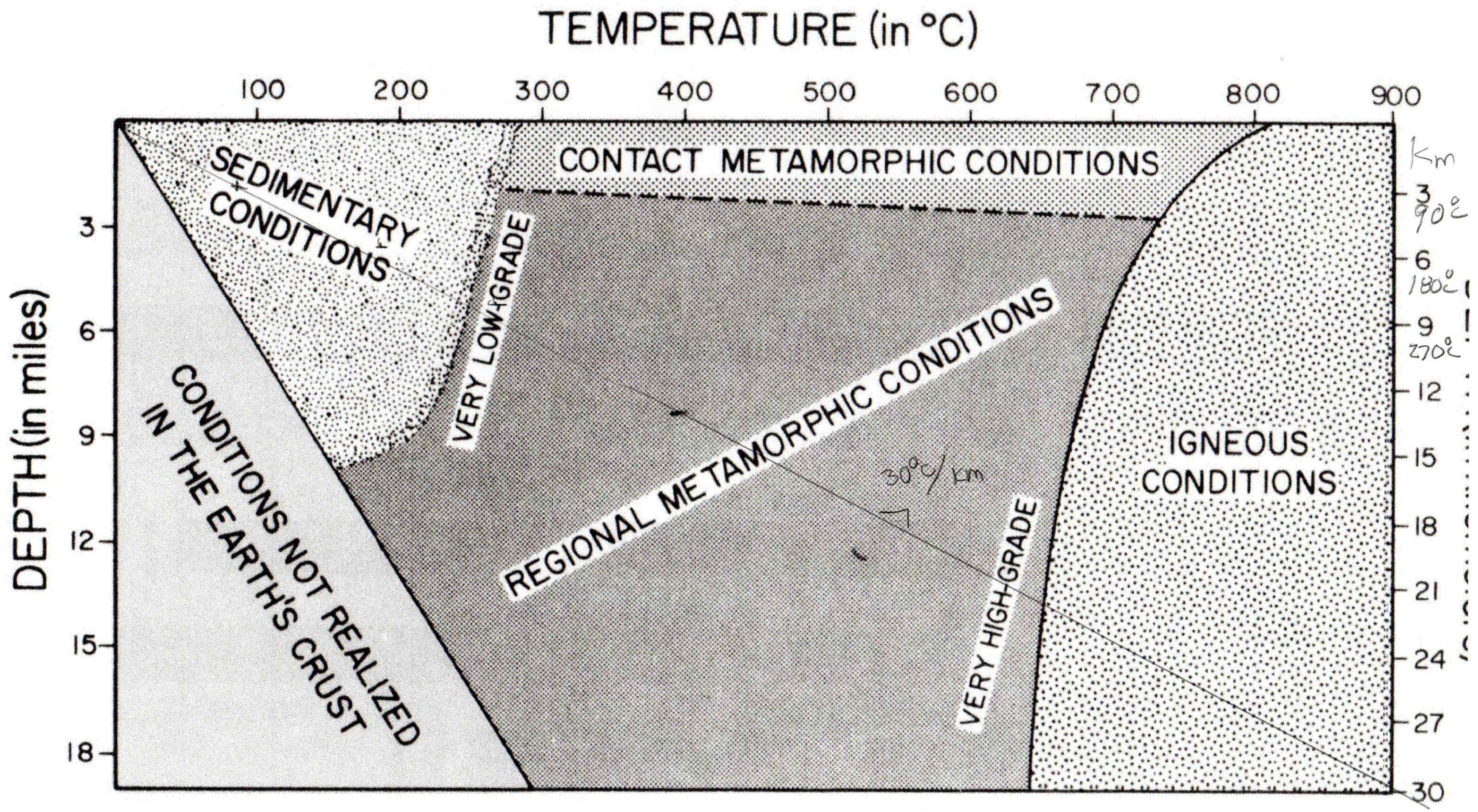
1 (Shale), slate, and phyllite complete intergrade with each other. Distinctions may be difficult.



Lab 6-3 Metamorphism of Shale



* Igneous Minerals
(Orthoclase is K- or Potassium Feldspar)
Plageoclase = Ca-Na Feldspar


TEMPERATURE (in °C)
100
200
300
400
500
600
700
800
900
DEPTH (in miles)
3
6
9
12
15
18
Km
3
90°C
6
180°C
9
270°C
12
15
18
21
24
27
30
SEDIMENTARY CONDITIONS
CONTACT METAMORPHIC CONDITIONS
VERY LOW-GRADE
REGIONAL METAMORPHIC CONDITIONS
30°C/km
VERY HIGH-GRADE
IGNEOUS CONDITIONS
CONDITIONS NOT REALIZED IN THE EARTH'S CRUST

Inorganic Clastic Sedimentary Rocks

Texture	Grain size	Composition	Comments	Rock name	Map symbol	Picture
Clastic (fragmental)	Pebbles, cobbles, and/or boulders in a matrix of sand, silt and/or clay	Mostly quartz, feldspar, and clay minerals; may contain fragments of other rocks and minerals	Rounded fragments concoidal fractures	Conglomerate		
			Angular fragments	Breccia		
	Sand (0.063 to 2 mm)		Fine to coarse in a variety of colors	Sandstone		
	Silt (0.039 to 0.063 mm)		Very fine grained, massive, usually dark	Siltstone		
	Clay (<0.0039 mm)		Compact, brittle, usually dark	Shale		

Chemically and/or Organically Formed Sedimentary Rocks

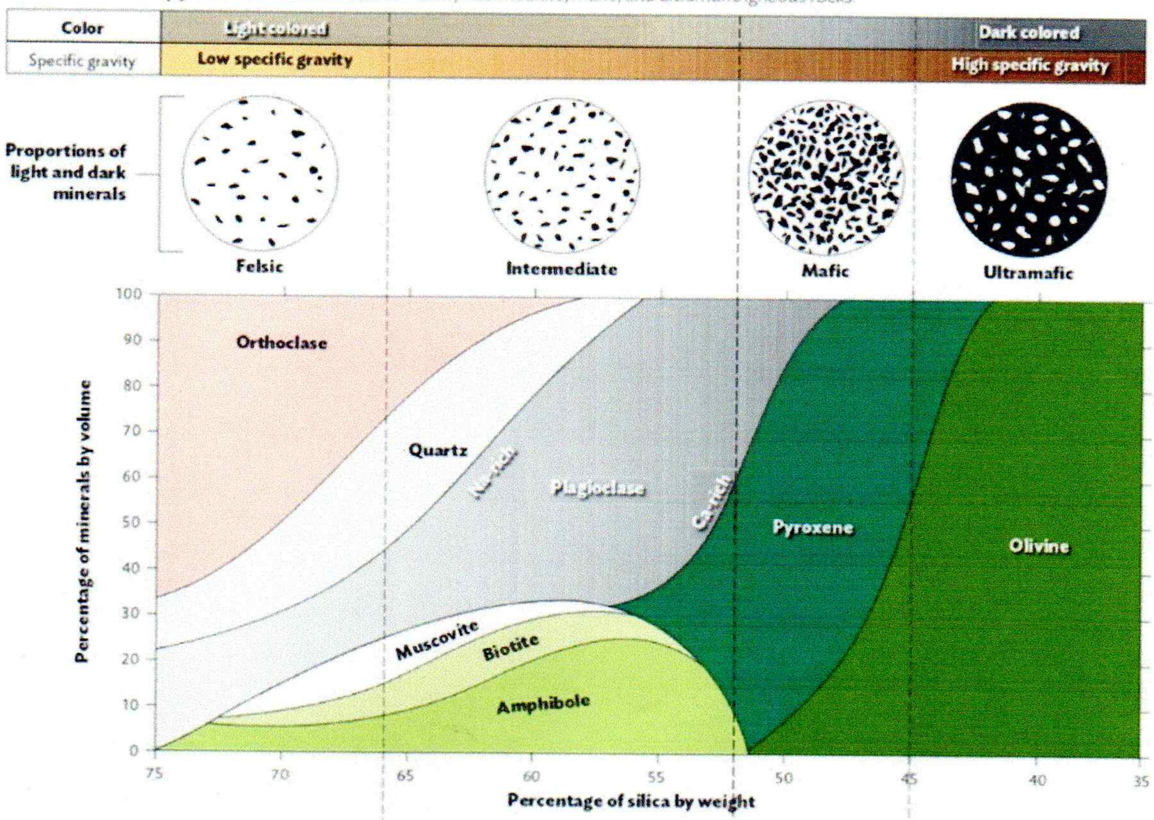
Texture	Grain size	Composition	Comments	Rock name	Map symbol	Picture
Crystalline	Fine to coarse grains	Quartz	Chemical precipitates and evaporites conch-oidal	Chert		
		Halite		Rock salt		
		Gypsum		Rock gypsum		
		$CaMg(CO_3)_2$ Dolomite		Dolostone*		
Crystalline or bioclastic	Microscopic to very coarse	Calcite $CaCO_3$	Biologic precipitates or cemented shell fragments	Chalk Limestone* (oceans)		
Bioclastic	Clay (< 0.0039 mm)	Carbon	Black, compacted plant remains (land)	Coal		
Bioclastic	Clay (< 0.0039 mm)	Clay and kerogen	Dark, may have oily smell or burn (sea)	Oil shale		

Other types of sandtone are arkose and graywacke. Varieties of limestone include chalk, coquina, micrite, travertine, oolite, tufa,and fossiliferous limestone.

* These react with dilute acid.

Classification of igneous rocks.

(a) Abundances of minerals in felsic, intermediate, mafic, and ultramafic igneous rocks.

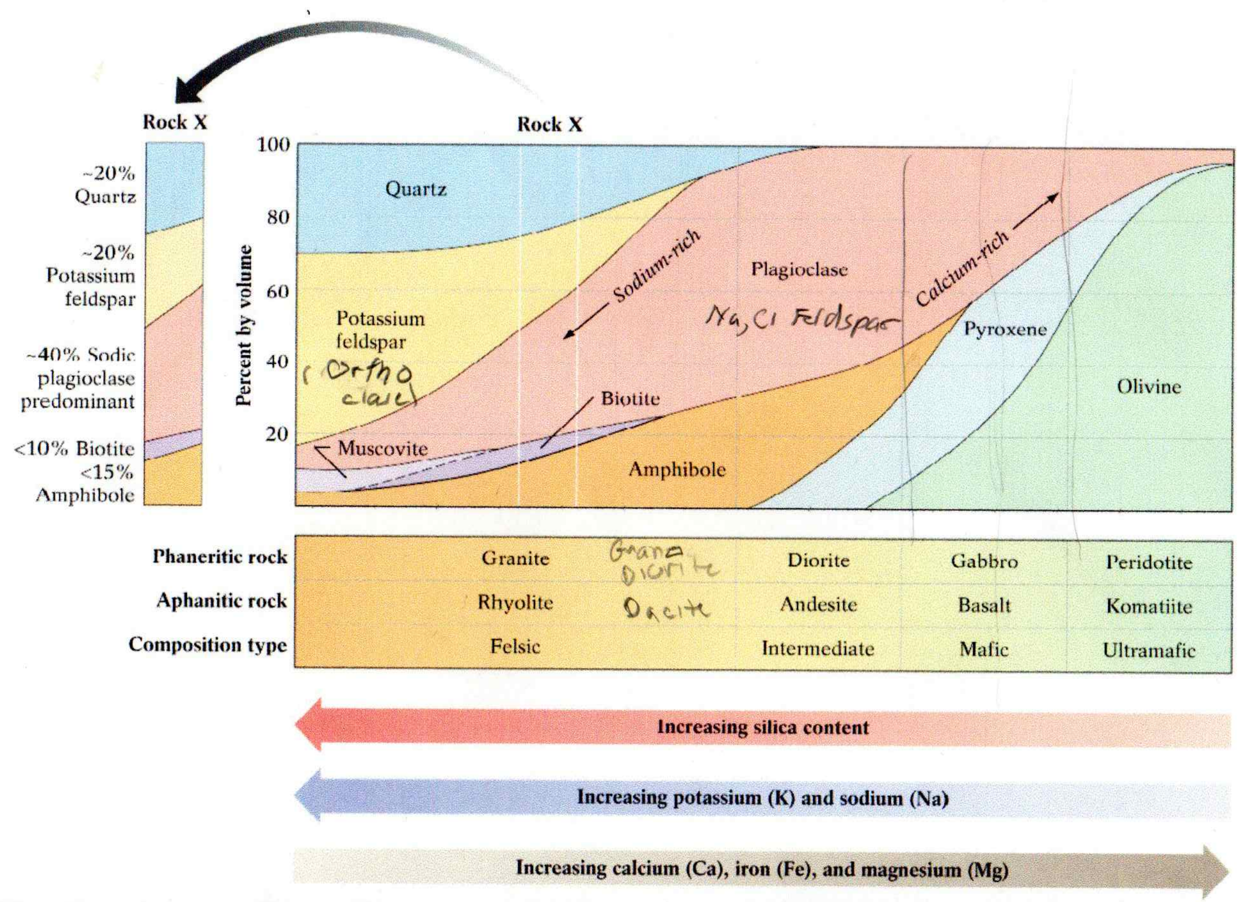


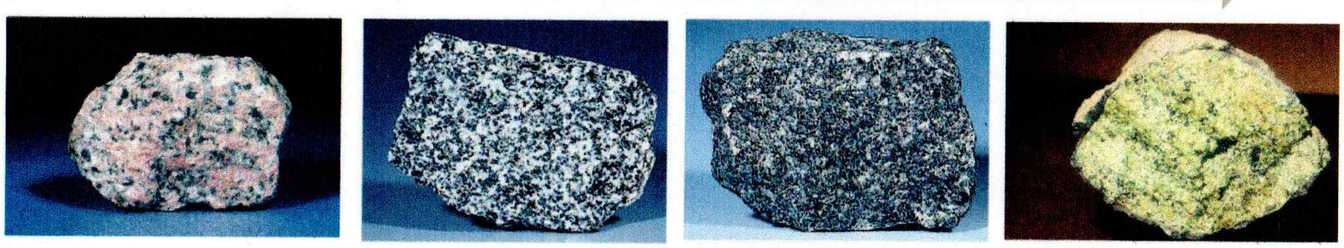
(b) Choose a column based on the abundance of minerals, and select the rock name based on the appropriate texture.

Texture					
Silica (SiO_2) content		**High silica content**			**Low silica content**
Pegmatitic		**Granitic pegmatite**	**Mafic pegmatite**		
Coarse-grained (phaneritic)		Granite	Diorite	Gabbro	Dunite (olivine only) Pyroxenite (pyroxene) Peridotite (olivine + pyroxene)
Fine-grained (aphanitic)		Rhyolite	Andesite	Basalt	*Rocks with these textures and compositions are very rare.*
Porphyritic		Porphyritic granite or* Porphyritic rhyolite	Porphyritic diorite or* Porphyritic andesite	Porphyritic gabbro or* Porphyritic basalt	
Glassy		Obsidian	Tachylite		
Porous		Pumice	Scoria/Vesicular basalt		
Fragmental	Fine	Rhyolite tuff	Andesite tuff	Basalt tuff	
Fragmental	Coarse	Volcanic breccia			

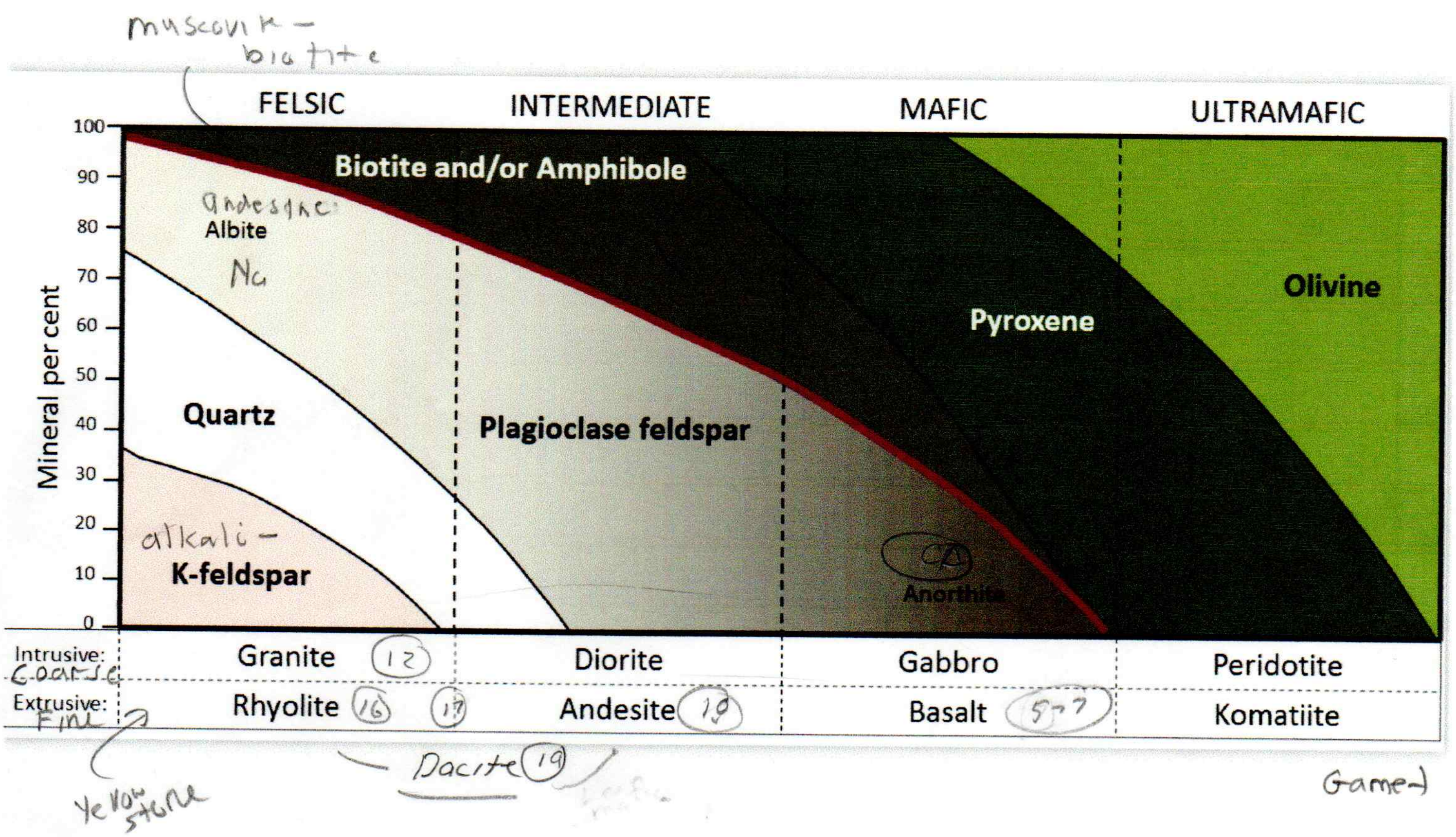
*Porphyritic rocks are named for the size of the groundmass grains. For example, a felsic porphyry in which the groundmass grains are coarse is called *granite porphyry*. If the groundmass grains are small, it is called a *rhyolite porphyry*.

Appendix B-1 Igneous Rock Identification Chart



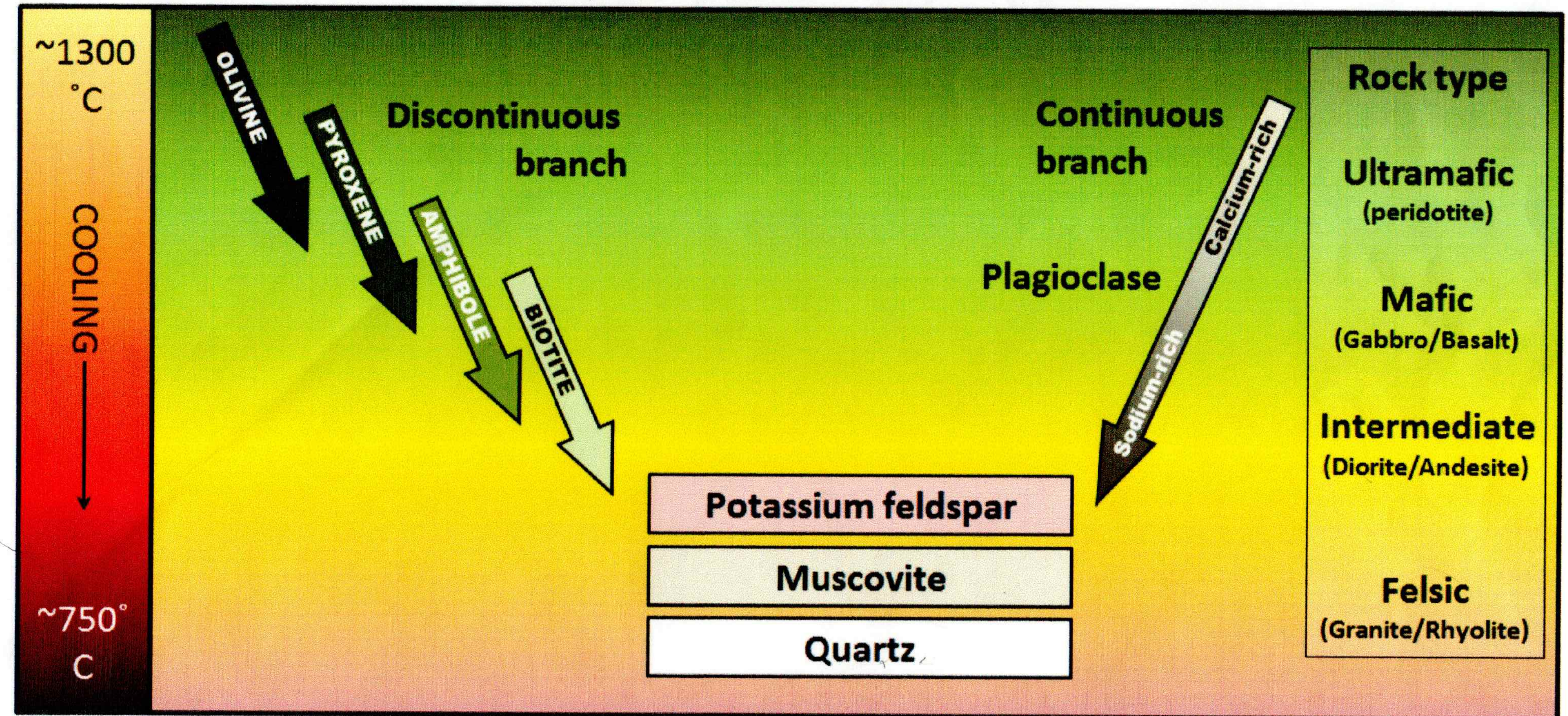


Granite Diorite Gabbro Peridotite


muscovite – biotite
FELSIC
INTERMEDIATE
MAFIC
ULTRAMAFIC
100
90
80
70
60
50
40
30
20
10
0
Mineral per cent
Biotite and/or Amphibole
andesine
Albite
Na
Quartz
Plagioclase feldspar
Pyroxene
Olivine
alkali –
K-feldspar
CA
Anorthite
Intrusive:
coarse
Granite 12
Diorite
Gabbro
Peridotite
Extrusive:
Fine
Rhyolite 16
17
Andesite 18
Basalt 5-7
Komatiite
Yellowstone
Dacite 19
Garnet

(Andesitic)

Bowen's Reaction Series



	Si concent.	T melt	Fe Mg
melt phase	more	lower	less
solid phase	less	high	more

Relative stabilities

Table 7.2 Relative Stabilities of Common Minerals Under Weathering

Stability of Minerals	Rate of Weathering
MOST STABLE	Slowest
Iron oxides (hematite)	
Aluminum hydroxides (gibbsite)	
Quartz	
Clay minerals	
Muscovite mica	
Potassium feldspar (orthoclase)	
Biotite mica	
Sodium-rich feldspar (albite)	
Amphiboles	
Pyroxene	
Calcium-rich feldspar (anorthite)	
Olivine	
Calcite	
Halite	↓
LEAST STABLE	Fastest

Important factors
-Chemical stability
-Solubility
-Rate of dissolution

Note that the rate of weathering of silicate minerals (stability of a mineral at the earth surface conditions) is inversely related to the temperature at which it forms (i.e., olivine is the least stable and quartz is the most stable)

Where do iron oxides and aluminum hydroxides form?

Appendix A-3. Dark Colored Non-metallic Mineral Identification Chart

Luster & Color	Relative Hardness	Hardness	Cleavage	Color (streak)	Specific Gravity	Other Properties	Name	
Non-Metallic Dark Colored	Harder than Glass	9.0	No	brown (variable)	4.0	six-sided prismatic crystals	CORUNDUM	
Non-Metallic Dark Colored	Harder than Glass	7.0	Yes-d	brown	3.8	vitreous to dull luster; prismatic to cross-shaped crystals	STAUROLITE	m
Non-Metallic Dark Colored	Harder than Glass	7.0	No	red or brown	3.5-4.3	twelve-sided crystals common; vitreous luster	GARNET	m
Non-Metallic Dark Colored	Harder than Glass	7.0	No	variable	2.7	vitreous luster; conchoidal fracture; massive but also occurs as 6-sided crystals	QUARTZ	* I S m ✓
Non-Metallic Dark Colored	Harder than Glass	6.5-7.0	No	olive green	3.3-4.4	vitreous luster; granular	OLIVINE	I
Non-Metallic Dark Colored	Similar to Glass	6.0	Yes	gray to white	2.6-2.8	vitreous luster; 2 cleavages at 90°; striations common on cleavage faces	PLAGIOCLASE	* I m ✓
Non-Metallic Dark Colored	Similar to Glass	5.0-6.0	Yes-d	dark green to black	3.3	vitreous to dull luster; 2 poor cleavages at 90°	PYROXENE	I
Non-Metallic Dark Colored	Similar to Glass	5.0-6.0	Yes	dark green to black	3.3	vitreous luster; splintery appearance; 2 perfect cleavages at 120° and 60°	AMPHIBOLE	I m ✓
Non-Metallic Dark Colored	Similar to Glass	5.0-6.0	No	reddish-brown to black	5.0	red-brown streak; dull luster; massive	HEMATITE (iron ore)	
Non-Metallic Dark Colored	Similar to Glass	5.0	Yes-d	green, brown, blue, black	3.2	vitreous luster; six-sided crystals common	APATITE	I m
Non-Metallic Dark Colored	Softer than Glass	3.5-4.0	Yes-d	grass green	4.0	occurs as surface coatings, masses, or tiny crystals; green streak	MALACHITE	
Non-Metallic Dark Colored	Softer than Glass	2.5-3.0	Yes	brown to black	2.8-3.0	vitreous luster; perfect cleavage in 1 direction; forms flexible thin sheets	BIOTITE	I S m
Non-Metallic Dark Colored	Softer than Glass	2.0-2.5	Yes-d	dark or light green	2.6-2.9	flexible crystal flakes; crystal aggregates common	CHLORITE	m

Note: Yes-d means cleavage is present but may be difficult to see.

(obsidian)

Appendix A-2. Light Colored Non-metallic Mineral Identification Chart

Luster & Color	Relative Hardness	Hardness	Cleavage	Color	Specific Gravity	Other Properties	Name	
1,2	3	3	4	2				
Non-Metallic Light Colored	Harder than Glass	7.0	Yes-d	pistachio green	3.3-3.6	surface coatings, or massive	**EPIDOTE**	
		7.0	No	variable	2.7	vitreous luster; conchoidal fracture; massive but also occurs as 6-sided crystals	**QUARTZ**	I S M
	Similar to Glass	6.0	Yes	pinkish-orange (variable)	2.5	vitreous luster; banding; 2 cleavages at 90°	**ORTHOCLASE** (Potassium Feldspar)	I S M
		6.0	Yes	white to gray	2.6-2.8	vitreous luster; 2 cleavages at 90°; striations common on cleavage faces	**PLAGIOCLASE** (Na & Ca Feldspar)	I M
		5.0-7.0	Yes-d	bluish-gray	3.5	vitreous luster; blade shaped crystals	**KYANITE**	S M
		3.5-4	Yes	white-grey	2.8	reacts w. HCl	DOLOMITE	CaMgCO3
	Softer than Glass	4.0	Yes	clear, purple, yellow (variable)	3.2	vitreous luster; 4 perfect cleavages forming octahedrons	**FLUORITE**	
		3.0	Yes	white to clear (variable)	2.7	reacts with HCl; rhombic cleavage; 3 perfect cleavages not at 90°	**CALCITE**	S CaCO3
		2.5	Yes	clear to milky white	2.2	3 perfect cleavages at 90° (cubes); salty taste	**HALITE** (salt)	S
		2.0-2.5	Yes-d	white to tan	2.6	dull luster, powdery; earthy odor; white streak	**KAOLINITE**	S
		2.0-2.5	Yes	clear to light yellow	2.5-3.0	vitreous luster; perfect cleavage in 1 dir.;forms flexible, transparent, thin sheets	**MUSCOVITE**	I S M
		2.0	Yes	clear, white, yellow (variable)	2.3	vitreous to pearly luster; brittle flakes; perfect cleavage in 1 direction	**GYPSUM**	S
		1.5-2.5	No	yellow	2.0	yellow streak; distinctive sulfurous odor	**SULFUR**	
		1.0	Yes-d	apple green to silvery white	2.7	pearly luster; greasy feel	**TALC**	M

Note: Yes-d means cleavage is present but may be difficult to see.

DOLOMITE
A on both light & dark sheet

Appendix A-1
Metallic Mineral Identification Chart

Luster	Streak	Hardness	Cleavage	Color	Specific Gravity	Other Properties	Name
Metallic	Dark Gray to Black	6.0-6.5	No	brass yellow	5.0	cubic crystals (with striations) common	**PYRITE**
Metallic	Dark Gray to Black	6.0	No	dark gray to black	5.2	strongly magnetic	**MAGNETITE**
Metallic	Dark Gray to Black	3.5-4.0	No	golden yellow	4.2	may tarnish to bronze or purple; massive	**CHALCOPYRITE**
Metallic	Dark Gray to Black	2.5	Yes	silvery gray	7.5	perfect cubic cleavage (3 planes at 90°)	**GALENA**
Metallic	Dark Gray to Black	1.0	Yes-d	gray to black	2.5	marks paper and fingers; greasy feel	**GRAPHITE**
Metallic	Red to Red-Brown	5.0-6.5	No	silver to gray to red	5.0	may be tiny glittering flakes	**HEMATITE**
Metallic	Yellow-Brown	3.5-4.0	Yes-d	yellow-brown to dark brown	4.0	submetallic to resinous luster; 6 cleavage planes	**SPHALERITE**
Metallic	Copper	2.5-3.0	No	copper to dark brown	8.9	malleable	**NATIVE COPPER**

Note: Yes-d means cleavage is present but may be difficult to see