

Reference Tables for Physical Setting/EARTH SCIENCE

Radioactive Decay Data

RADIOACTIVE ISOTOPE	DISINTEGRATION	HALF-LIFE (years)
Carbon-14	$^{14}\text{C} \rightarrow ^{14}\text{N}$	5.7×10^3
Potassium-40	$^{40}\text{K} \rightarrow ^{40}\text{Ar}$ $^{40}\text{K} \rightarrow ^{40}\text{Ca}$	1.3×10^9
Uranium-238	$^{238}\text{U} \rightarrow ^{206}\text{Pb}$	4.5×10^9
Rubidium-87	$^{87}\text{Rb} \rightarrow ^{87}\text{Sr}$	4.9×10^{10}

Specific Heats of Common Materials

MATERIAL	SPECIFIC HEAT (Joules/gram • °C)
Liquid water	4.18
Solid water (ice)	2.11
Water vapor	2.00
Dry air	1.01
Basalt	0.84
Granite	0.79
Iron	0.45
Copper	0.38
Lead	0.13

Equations

$$\text{Eccentricity} = \frac{\text{distance between foci}}{\text{length of major axis}}$$

$$\text{Gradient} = \frac{\text{change in field value}}{\text{distance}}$$

$$\text{Rate of change} = \frac{\text{change in value}}{\text{time}}$$

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

Properties of Water

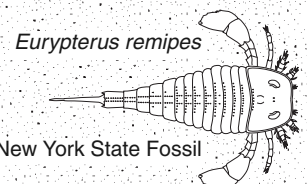
Heat energy gained during melting	334 J/g
Heat energy released during freezing	334 J/g
Heat energy gained during vaporization	2260 J/g
Heat energy released during condensation	2260 J/g
Density at 3.98°C	1.0 g/mL

Average Chemical Composition of Earth's Crust, Hydrosphere, and Troposphere

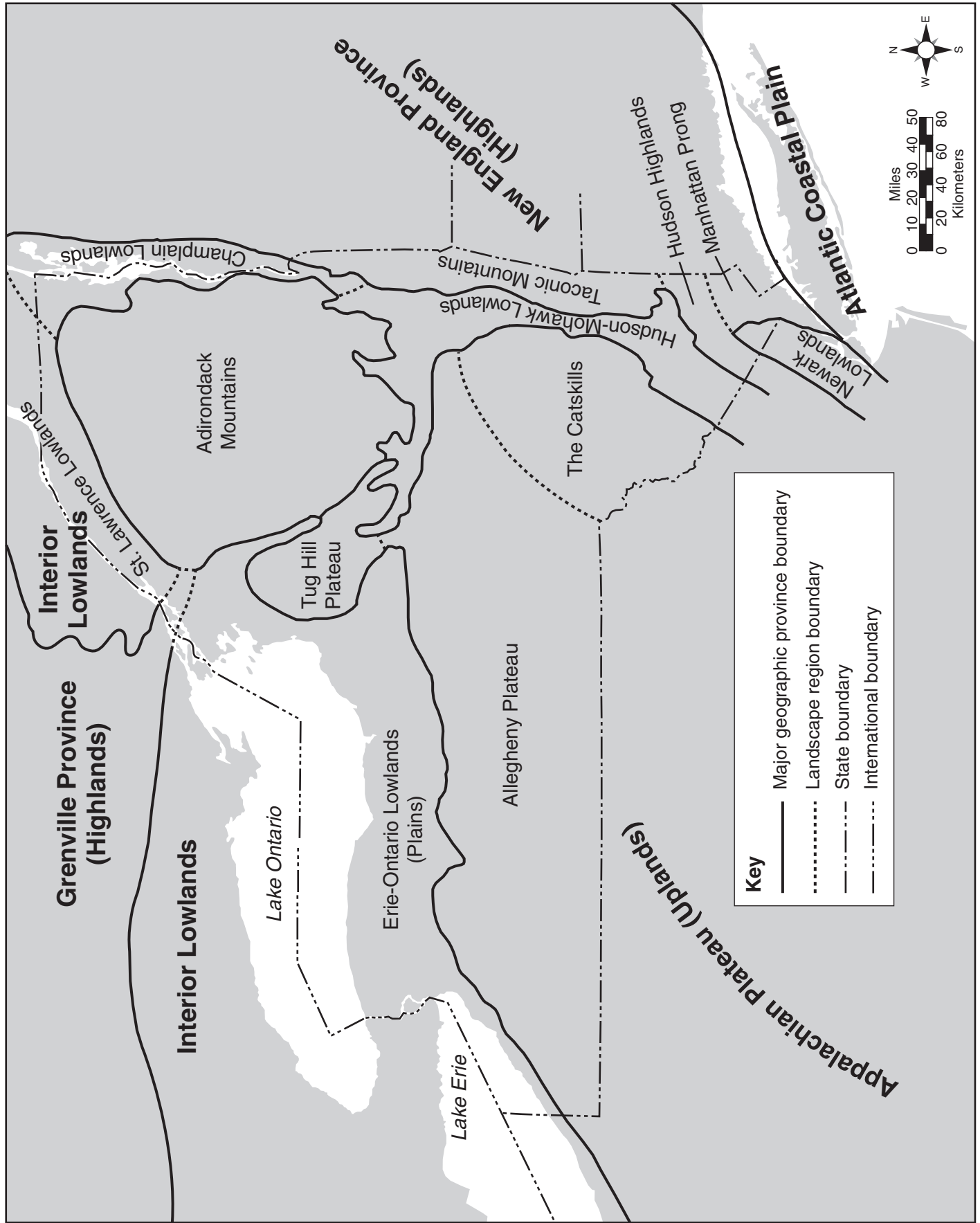
ELEMENT (symbol)	CRUST		HYDROSPHERE	TROPOSPHERE
	Percent by mass	Percent by volume	Percent by volume	Percent by volume
Oxygen (O)	46.10	94.04	33.0	21.0
Silicon (Si)	28.20	0.88		
Aluminum (Al)	8.23	0.48		
Iron (Fe)	5.63	0.49		
Calcium (Ca)	4.15	1.18		
Sodium (Na)	2.36	1.11		
Magnesium (Mg)	2.33	0.33		
Potassium (K)	2.09	1.42		
Nitrogen (N)				78.0
Hydrogen (H)			66.0	
Other	0.91	0.07	1.0	1.0

2011 EDITION

This edition of the Earth Science Reference Tables should be used in the classroom beginning in the 2011–12 school year. The first examination for which these tables will be used is the January 2012 Regents Examination in Physical Setting/Earth Science.

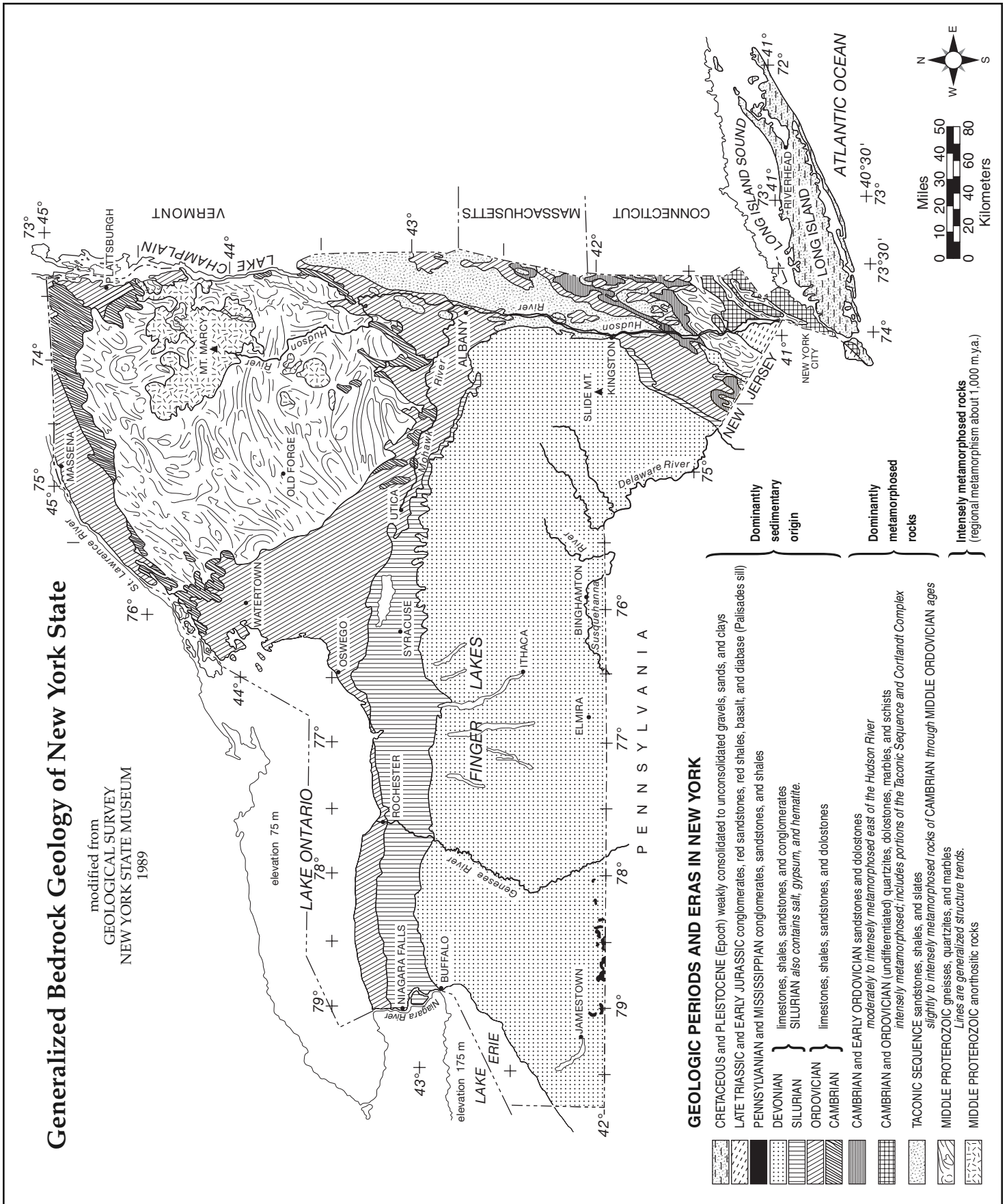


Generalized Landscape Regions of New York State



Generalized Bedrock Geology of New York State

modified from
GEOLOGICAL SURVEY
NEW YORK STATE MUSEUM
1989



GEOLOGIC PERIODS AND ERAS IN NEW YORK

- CRETACEOUS and PLEISTOCENE (Epoch) weakly consolidated gravels, sands, and clays
- LATE TRIASSIC and EARLY JURASSIC conglomerates, red sandstones, red shales, basalt, and diabase (Palisades sill)
- PENNSYLVANIAN and MISSISSIPPIAN conglomerates, sandstones, and shales
- DEVONIAN } limestones, shales, sandstones, and conglomerates
- SILURIAN } SILURIAN also contains salt, gypsum, and hematite.
- ORDOVICIAN } limestones, shales, sandstones, and dolostones
- CAMBRIAN } limestones, shales, sandstones, and dolostones
- CAMBRIAN and EARLY ORDOVICIAN sandstones and dolostones moderately to intensely metamorphosed east of the Hudson River
- CAMBRIAN and ORDOVICIAN (undifferentiated) quartzites, dolostones, marbles, and schists intensely metamorphosed; includes portions of the Taconic Sequence and Corlandt Complex
- TACONIC SEQUENCE sandstones, shales, and slates slightly to intensely metamorphosed rocks of CAMBRIAN through MIDDLE ORDOVICIAN ages
- MIDDLE PROTEROZOIC gneisses, quartzites, and marbles
- MIDDLE PROTEROZOIC anorthositic rocks

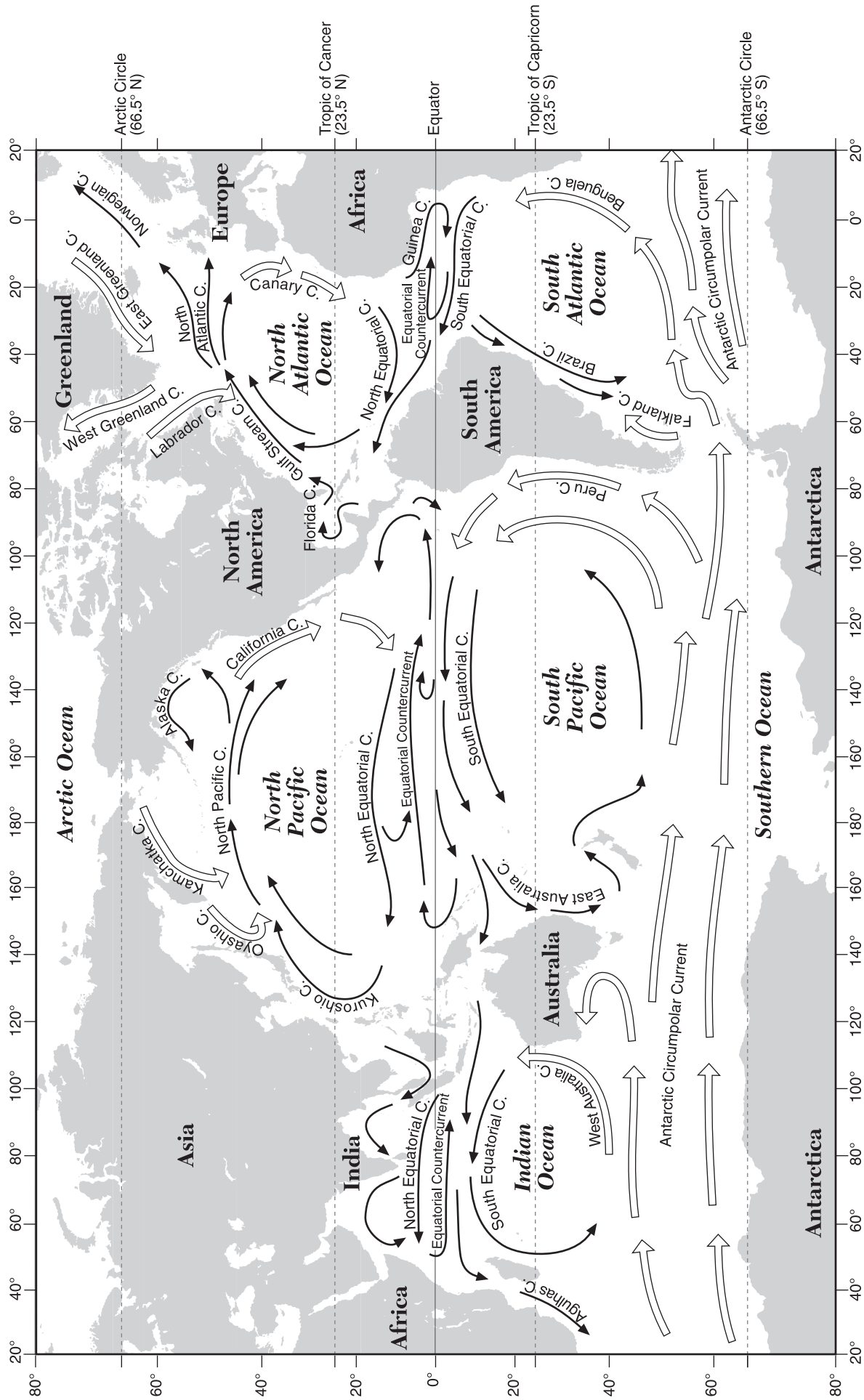
Dominantly sedimentary origin

Dominantly metamorphosed rocks

Intensely metamorphosed rocks
(regional metamorphism about 1,000 m.y.a.)



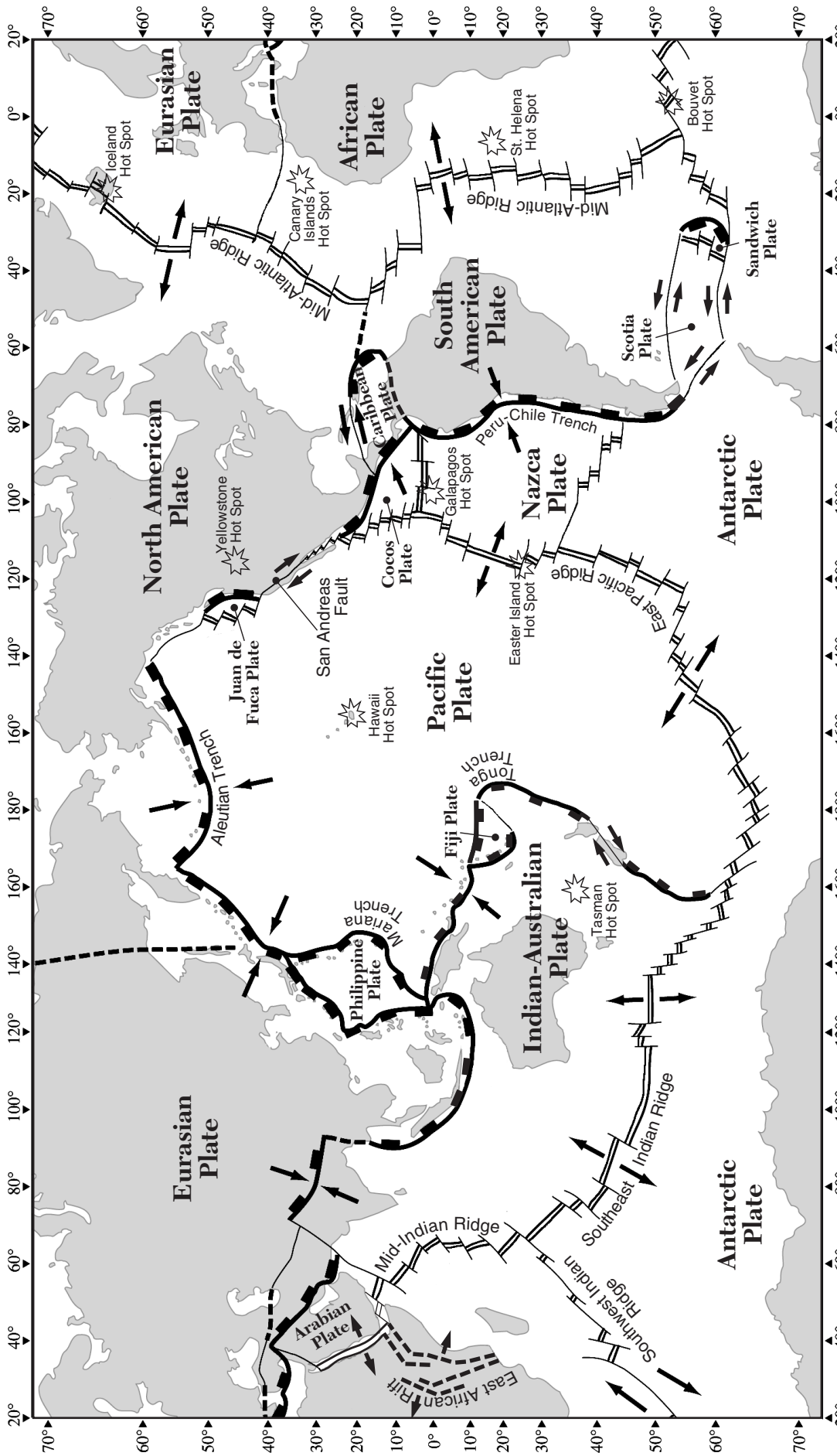
Surface Ocean Currents



NOTE: Not all surface ocean currents are shown.

Key	
	Warm currents
	Cool currents

Tectonic Plates

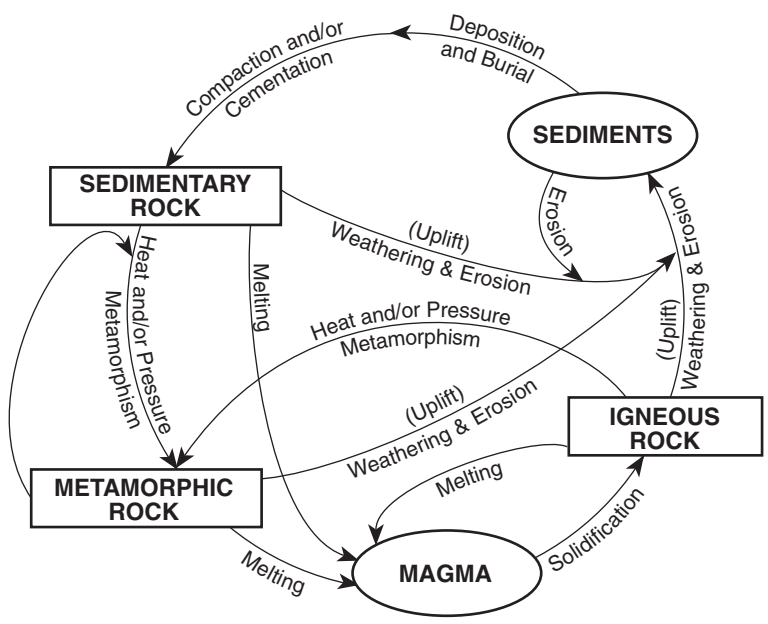


Key

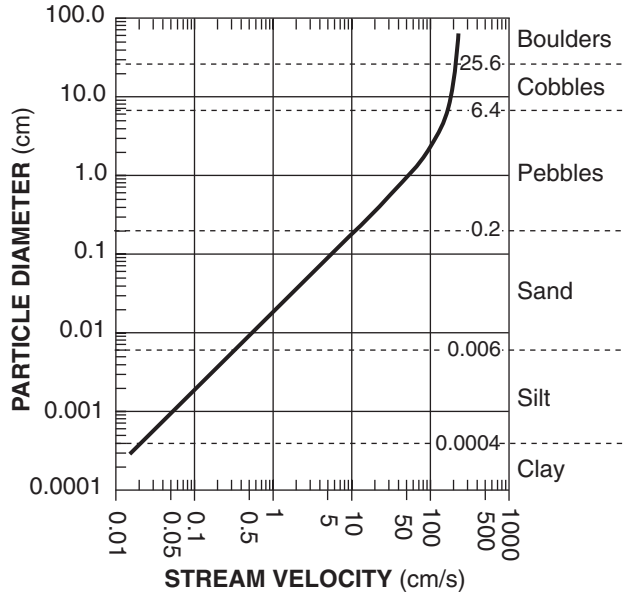
- Relative motion at plate boundary (transform fault)
- Complex or uncertain plate boundary
- Convergent plate boundary (subduction zone)
- Divergent plate boundary (usually broken by transform faults along mid-ocean ridges)
- Mantle hot spot

NOTE: Not all mantle hot spots, plates, and boundaries are shown.

Rock Cycle in Earth's Crust



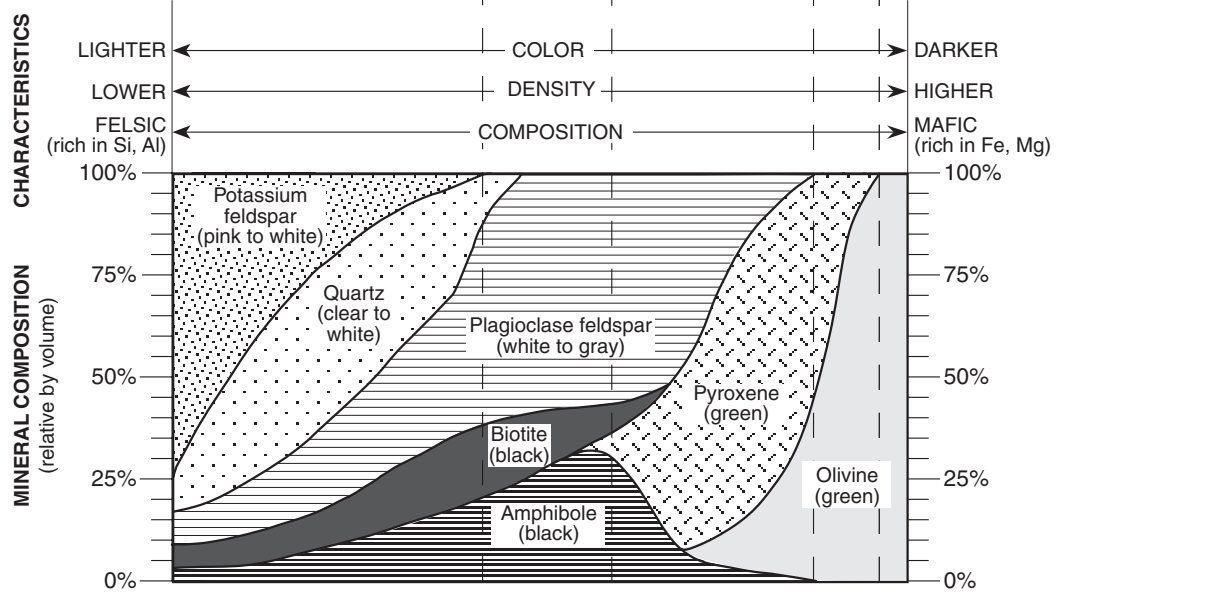
Relationship of Transported Particle Size to Water Velocity





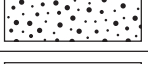
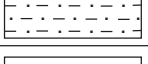

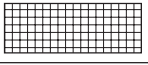

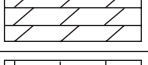
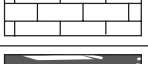
This generalized graph shows the water velocity needed to maintain, but not start, movement. Variations occur due to differences in particle density and shape.

Scheme for Igneous Rock Identification






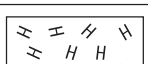
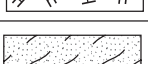


ENVIRONMENT OF FORMATION		CRYSTAL SIZE				TEXTURE	
		Obsidian (usually appears black)		Basaltic glass		Glassy	Non-vesicular
EXTRUSIVE (Volcanic)	Pumice		Scoria		non-crystalline	Vesicular (gas pockets)	
	Vesicular rhyolite	Vesicular andesite	Vesicular basalt				
	Rhyolite	Andesite	Basalt		less than 1 mm	Fine	
INTRUSIVE (Plutonic)	Granite	Diorite	Diabase				1 mm to 10 mm
			Gabbro		Peridotite Dunite		
	Pegmatite			10 mm or larger		Very coarse	



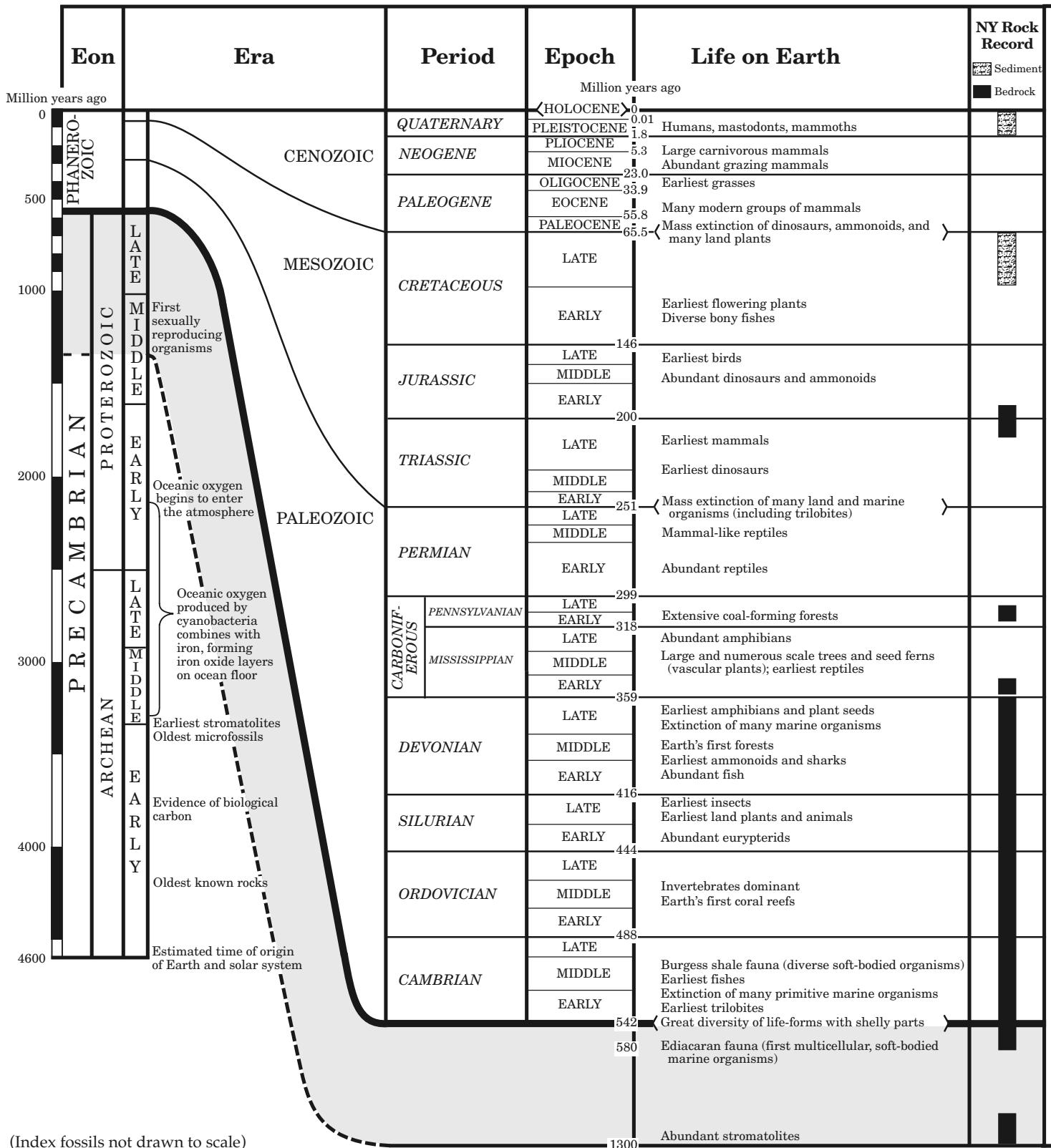
Scheme for Sedimentary Rock Identification

INORGANIC LAND-DERIVED SEDIMENTARY ROCKS					
TEXTURE	GRAIN SIZE	COMPOSITION	COMMENTS	ROCK NAME	MAP SYMBOL
Clastic (fragmental)	Pebbles, cobbles, and/or boulders embedded in sand, silt, and/or clay	Mostly quartz, feldspar, and clay minerals; may contain fragments of other rocks and minerals	Rounded fragments	Conglomerate	
			Angular fragments	Breccia	
	Sand (0.006 to 0.2 cm)		Fine to coarse	Sandstone	
	Silt (0.0004 to 0.006 cm)		Very fine grain	Siltstone	
Clay (less than 0.0004 cm)	Compact; may split easily	Shale			
CHEMICALLY AND/OR ORGANICALLY FORMED SEDIMENTARY ROCKS					
TEXTURE	GRAIN SIZE	COMPOSITION	COMMENTS	ROCK NAME	MAP SYMBOL
Crystalline	Fine to coarse crystals	Halite	Crystals from chemical precipitates and evaporites	Rock salt	
		Gypsum		Rock gypsum	
		Dolomite		Dolostone	
Crystalline or bioclastic	Microscopic to very coarse	Calcite	Precipitates of biologic origin or cemented shell fragments	Limestone	
Bioclastic		Carbon		Compacted plant remains	Bituminous coal

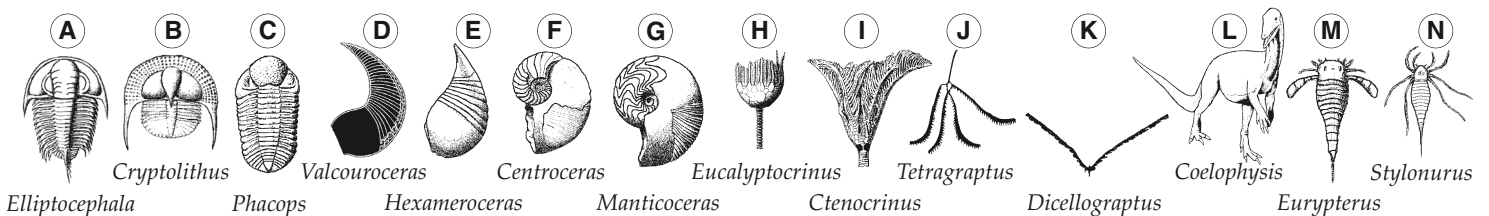
Scheme for Metamorphic Rock Identification

TEXTURE	GRAIN SIZE	COMPOSITION	TYPE OF METAMORPHISM	COMMENTS	ROCK NAME	MAP SYMBOL
FOLIATED MINERAL ALIGNMENT BAND- ING	Fine	MICA QUARTZ FELDSPAR AMPHIBOLE GARNET PYROXENE	Regional (Heat and pressure increases) ↓	Low-grade metamorphism of shale	Slate	
	Fine to medium			Foliation surfaces shiny from microscopic mica crystals	Phyllite	
	Medium to coarse			Platy mica crystals visible from metamorphism of clay or feldspars	Schist	
				High-grade metamorphism; mineral types segregated into bands	Gneiss	
NONFOLIATED	Fine	Carbon	Regional	Metamorphism of bituminous coal	Anthracite coal	
	Fine	Various minerals	Contact (heat)	Various rocks changed by heat from nearby magma/lava	Hornfels	
	Fine to coarse	Quartz	Regional or contact	Metamorphism of quartz sandstone	Quartzite	
		Calcite and/or dolomite		Metamorphism of limestone or dolostone	Marble	
Coarse	Various minerals		Pebbles may be distorted or stretched	Metaconglomerate		

GEOLOGIC HISTORY

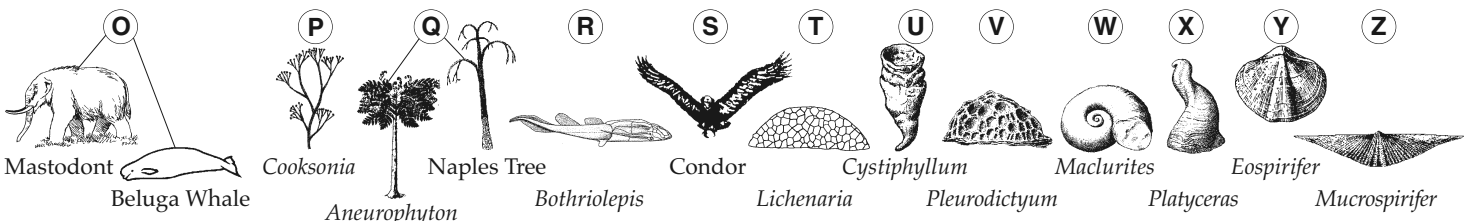


(Index fossils not drawn to scale)

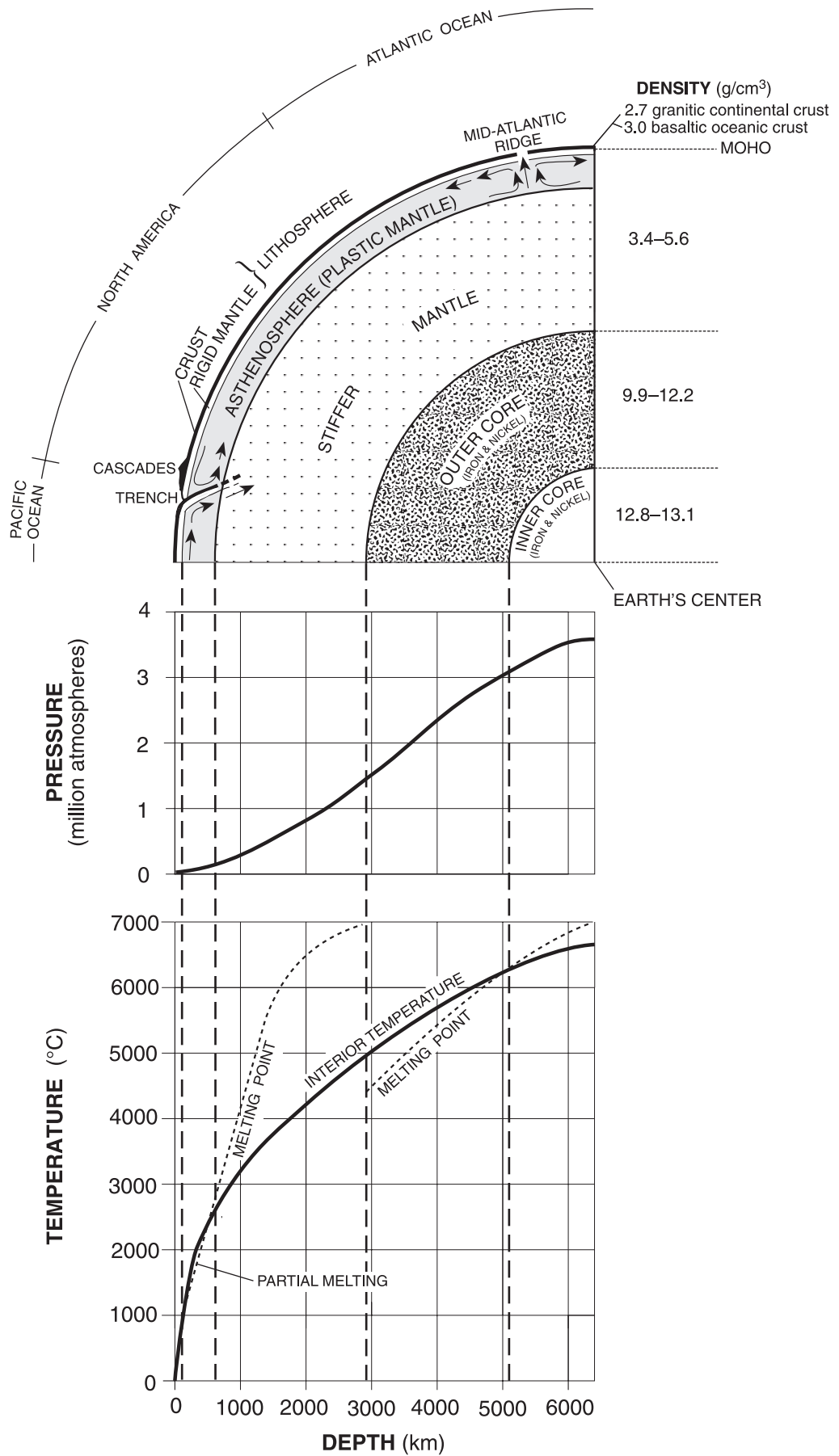


OF NEW YORK STATE

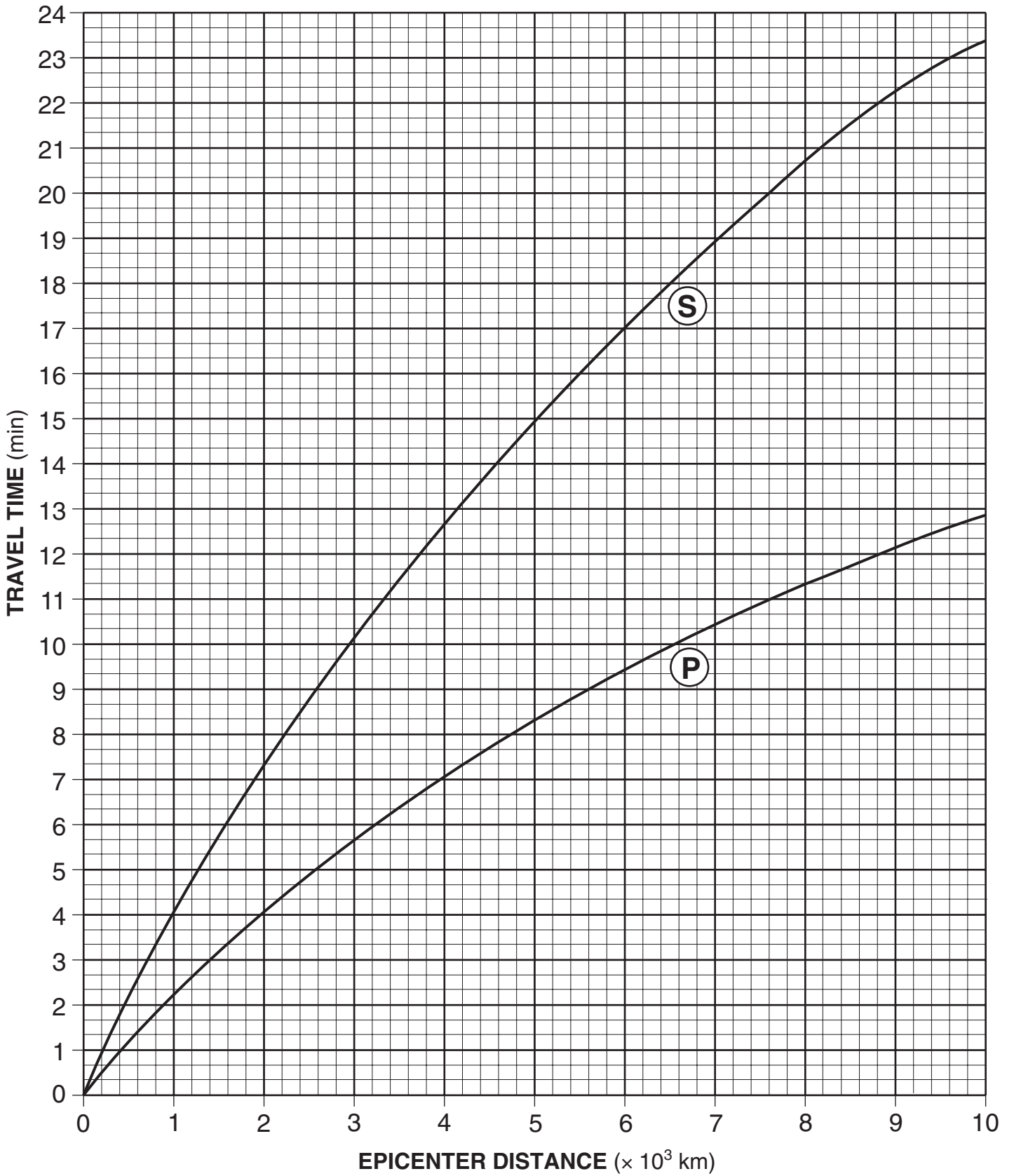
Time Distribution of Fossils (including important fossils of New York) The center of each lettered circle indicates the approximate time of existence of a specific index fossil (e.g. Fossil A) lived at the end of the Early Cambrian).	Important Geologic Events in New York	Inferred Positions of Earth's Landmasses
	Advance and retreat of last continental ice	
NAUTILOIDS DINOSAURS MAMMALS BIRDS	Sands and clays underlying Long Island and Staten Island deposited on margin of Atlantic Ocean Dome-like uplift of Adirondack region begins	59 million years ago
CRINOIDS L VASCULAR PLANTS CORALS GASTROPODS BRACHIOPODS	Initial opening of Atlantic Ocean North America and Africa separate { Intrusion of Palisades sill } Pangaea begins to break up	119 million years ago
TRILOBITES AMMONOIDS CRINOIDS L VASCULAR PLANTS CORALS GASTROPODS BRACHIOPODS	Alleghenian orogeny caused by collision of North America and Africa along transform margin, forming Pangaea	232 million years ago
C F G I H M P R N Q X Z GRAPTOLITES EURYPTERIDS PLACODERM FISH	Catskill delta forms Erosion of Acadian Mountains Acadian orogeny caused by collision of North America and Avalon and closing of remaining part of Iapetus Ocean	359 million years ago
B D K J U Y V X Z T W	Salt and gypsum deposited in evaporite basins Erosion of Taconic Mountains; Queenston delta forms Taconian orogeny caused by closing of western part of Iapetus Ocean and collision between North America and volcanic island arc	458 million years ago
A	Widespread deposition over most of New York along edge of Iapetus Ocean	458 million years ago
	Rifting and initial opening of Iapetus Ocean Erosion of Grenville Mountains Grenville orogeny: metamorphism of bedrock now exposed in the Adirondacks and Hudson Highlands	



Inferred Properties of Earth's Interior



Earthquake P-Wave and S-Wave Travel Time



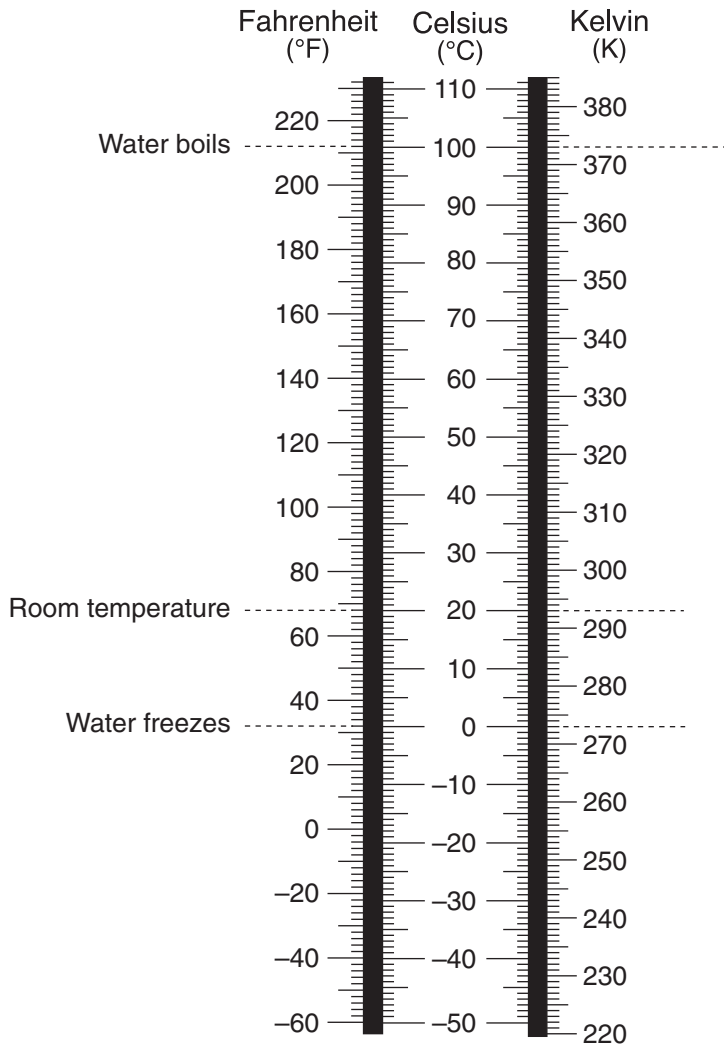
Dewpoint (°C)

Dry-Bulb Temperature (°C)	Difference Between Wet-Bulb and Dry-Bulb Temperatures (C°)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
-20	-20	-33														
-18	-18	-28														
-16	-16	-24														
-14	-14	-21	-36													
-12	-12	-18	-28													
-10	-10	-14	-22													
-8	-8	-12	-18	-29												
-6	-6	-10	-14	-22												
-4	-4	-7	-12	-17	-29											
-2	-2	-5	-8	-13	-20											
0	0	-3	-6	-9	-15	-24										
2	2	-1	-3	-6	-11	-17										
4	4	1	-1	-4	-7	-11	-19									
6	6	4	1	-1	-4	-7	-13	-21								
8	8	6	3	1	-2	-5	-9	-14								
10	10	8	6	4	1	-2	-5	-9	-14	-28						
12	12	10	8	6	4	1	-2	-5	-9	-16						
14	14	12	11	9	6	4	1	-2	-5	-10	-17					
16	16	14	13	11	9	7	4	1	-1	-6	-10	-17				
18	18	16	15	13	11	9	7	4	2	-2	-5	-10	-19			
20	20	19	17	15	14	12	10	7	4	2	-2	-5	-10	-19		
22	22	21	19	17	16	14	12	10	8	5	3	-1	-5	-10	-19	
24	24	23	21	20	18	16	14	12	10	8	6	2	-1	-5	-10	-18
26	26	25	23	22	20	18	17	15	13	11	9	6	3	0	-4	-9
28	28	27	25	24	22	21	19	17	16	14	11	9	7	4	1	-3
30	30	29	27	26	24	23	21	19	18	16	14	12	10	8	5	1

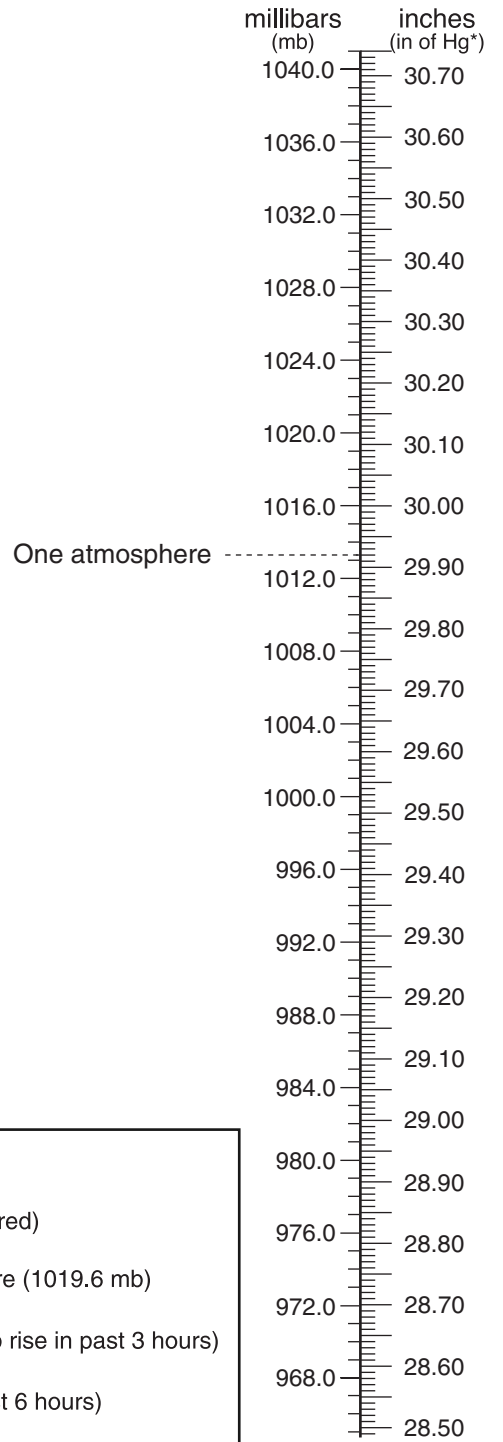
Relative Humidity (%)

Dry-Bulb Temperature (°C)	Difference Between Wet-Bulb and Dry-Bulb Temperatures (C°)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
-20	100	28														
-18	100	40														
-16	100	48														
-14	100	55	11													
-12	100	61	23													
-10	100	66	33													
-8	100	71	41	13												
-6	100	73	48	20												
-4	100	77	54	32	11											
-2	100	79	58	37	20	1										
0	100	81	63	45	28	11										
2	100	83	67	51	36	20	6									
4	100	85	70	56	42	27	14									
6	100	86	72	59	46	35	22	10								
8	100	87	74	62	51	39	28	17	6							
10	100	88	76	65	54	43	33	24	13	4						
12	100	88	78	67	57	48	38	28	19	10	2					
14	100	89	79	69	60	50	41	33	25	16	8	1				
16	100	90	80	71	62	54	45	37	29	21	14	7	1			
18	100	91	81	72	64	56	48	40	33	26	19	12	6			
20	100	91	82	74	66	58	51	44	36	30	23	17	11	5		
22	100	92	83	75	68	60	53	46	40	33	27	21	15	10	4	
24	100	92	84	76	69	62	55	49	42	36	30	25	20	14	9	4
26	100	92	85	77	70	64	57	51	45	39	34	28	23	18	13	9
28	100	93	86	78	71	65	59	53	47	42	36	31	26	21	17	12
30	100	93	86	79	72	66	61	55	49	44	39	34	29	25	20	16

Temperature



Pressure



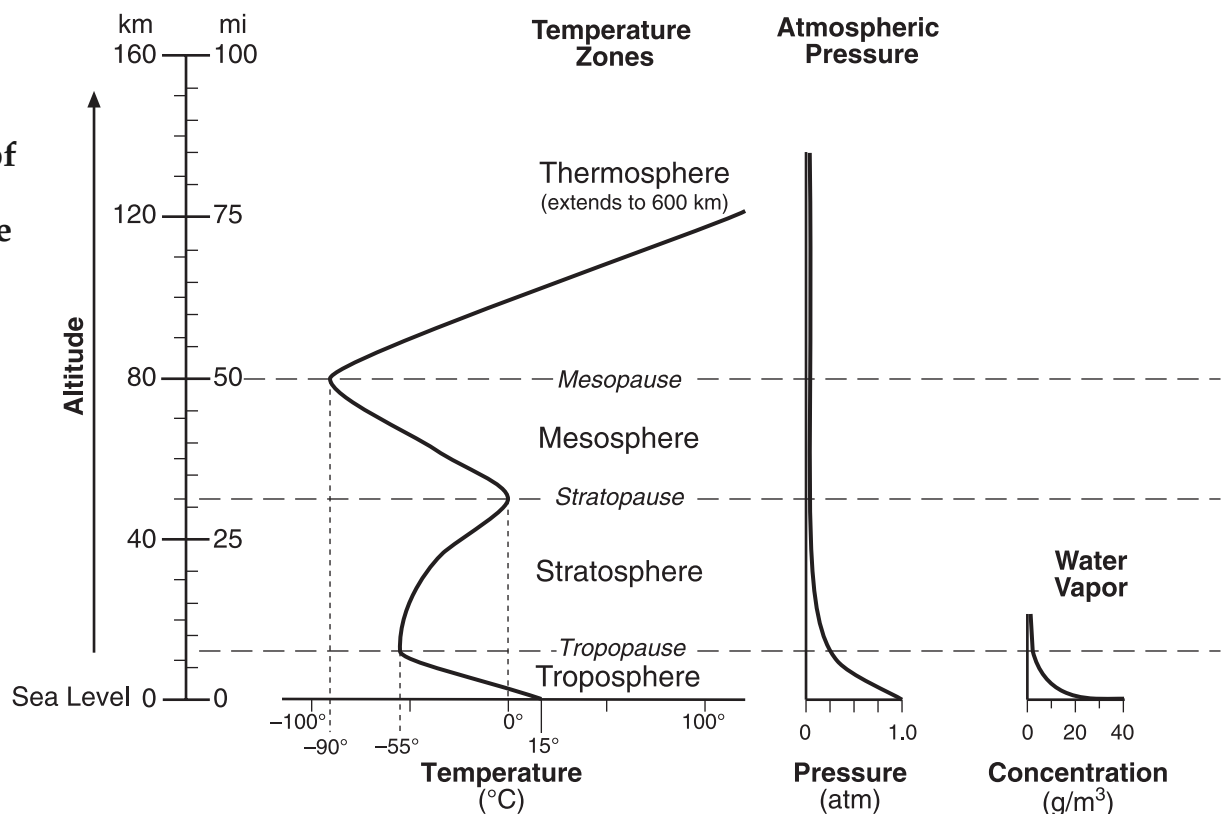
Key to Weather Map Symbols

Station Model	Station Model Explanation
	<p style="text-align: center;">Present weather</p> <p style="text-align: center;">Amount of cloud cover (approximately 75% covered)</p> <p>Temperature (°F) 28</p> <p>Visibility (mi) $\frac{1}{2}*$</p> <p>Dewpoint (°F) 27</p> <p>Wind speed 196</p> <p style="text-align: center;">Wind direction (from the southwest)</p> <p style="text-align: center;">(1 knot = 1.15 mi/h)</p> <p style="text-align: center;">Barometric pressure (1019.6 mb)</p> <p style="text-align: center;">Barometric trend (a steady 1.9-mb rise in past 3 hours)</p> <p style="text-align: center;">Precipitation (.25) (0.25 inches in past 6 hours)</p> <p style="font-size: small;">[whole feather = 10 knots half feather = 5 knots total = 15 knots]</p>

*Hg = mercury

Present Weather	Air Masses	Fronts	Hurricane
	<p>cA continental arctic</p> <p>cP continental polar</p> <p>cT continental tropical</p> <p>mT maritime tropical</p> <p>mP maritime polar</p>	<p>Cold </p> <p>Warm </p> <p>Stationary </p> <p>Occluded </p>	<p></p> <p>Tornado</p> <p></p>

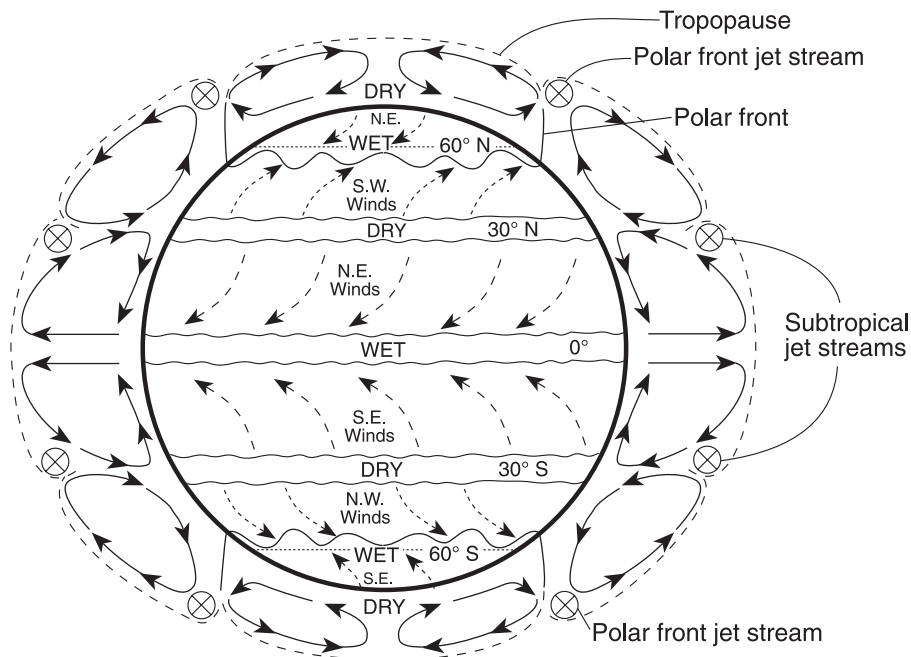
Selected Properties of Earth's Atmosphere



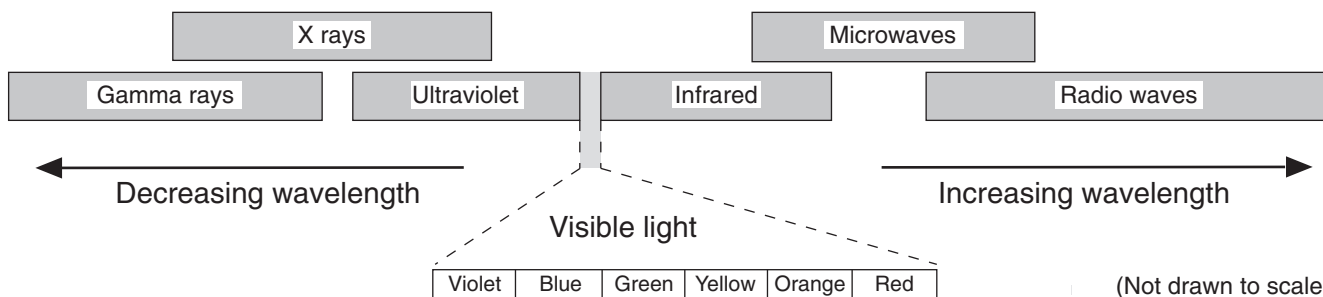
Planetary Wind and Moisture Belts in the Troposphere

The drawing on the right shows the locations of the belts near the time of an equinox. The locations shift somewhat with the changing latitude of the Sun's vertical ray. In the Northern Hemisphere, the belts shift northward in the summer and southward in the winter.

(Not drawn to scale)



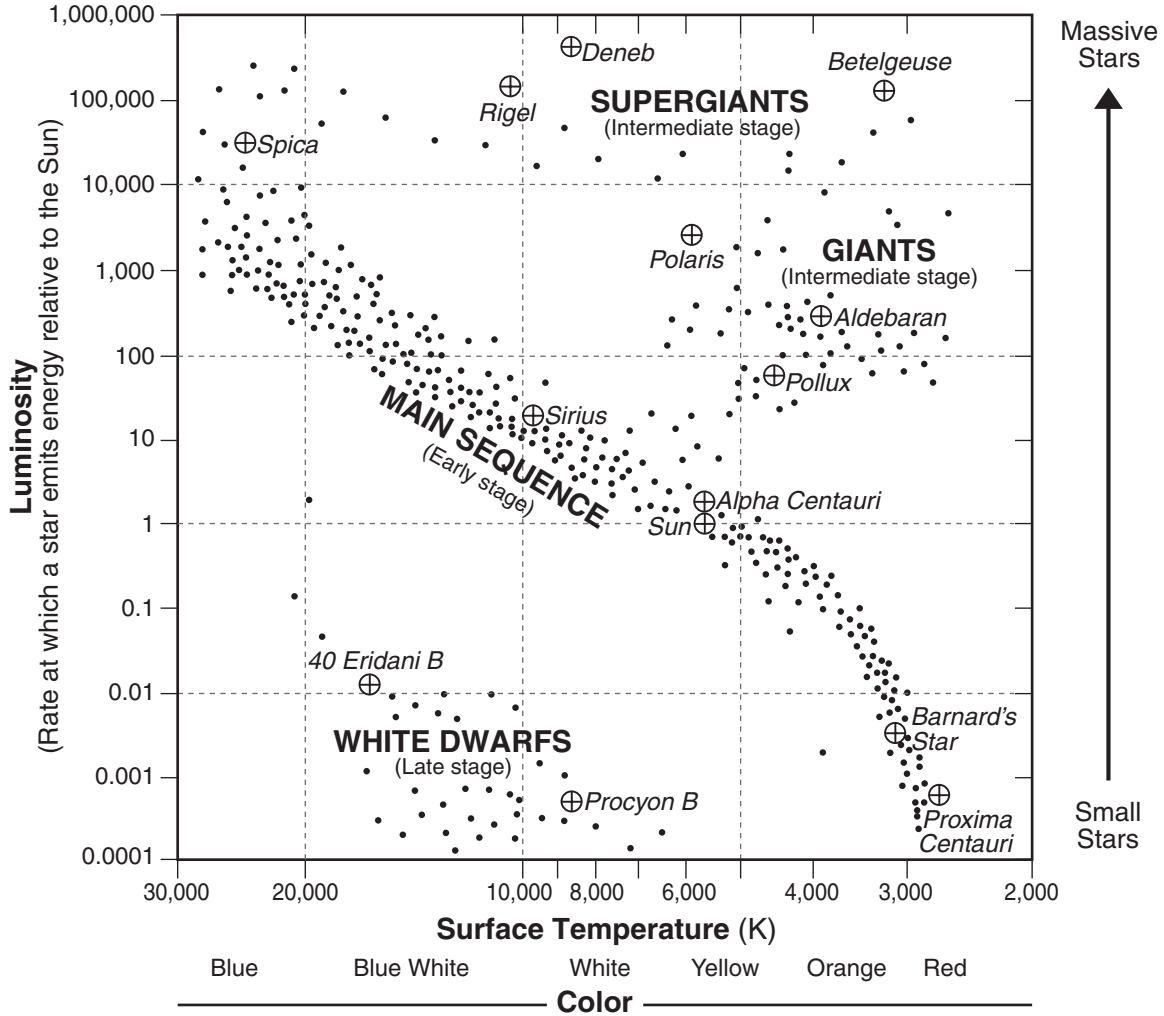
Electromagnetic Spectrum



(Not drawn to scale)

Characteristics of Stars

(Name in *italics* refers to star represented by a ⊕.)
 (Stages indicate the general sequence of star development.)



Solar System Data

Celestial Object	Mean Distance from Sun (million km)	Period of Revolution (d=days) (y=years)	Period of Rotation at Equator	Eccentricity of Orbit	Equatorial Diameter (km)	Mass (Earth = 1)	Density (g/cm ³)
SUN	—	—	27 d	—	1,392,000	333,000.00	1.4
MERCURY	57.9	88 d	59 d	0.206	4,879	0.06	5.4
VENUS	108.2	224.7 d	243 d	0.007	12,104	0.82	5.2
EARTH	149.6	365.26 d	23 h 56 min 4 s	0.017	12,756	1.00	5.5
MARS	227.9	687 d	24 h 37 min 23 s	0.093	6,794	0.11	3.9
JUPITER	778.4	11.9 y	9 h 50 min 30 s	0.048	142,984	317.83	1.3
SATURN	1,426.7	29.5 y	10 h 14 min	0.054	120,536	95.16	0.7
URANUS	2,871.0	84.0 y	17 h 14 min	0.047	51,118	14.54	1.3
NEPTUNE	4,498.3	164.8 y	16 h	0.009	49,528	17.15	1.8
EARTH'S MOON	149.6 (0.386 from Earth)	27.3 d	27.3 d	0.055	3,476	0.01	3.3

Properties of Common Minerals

LUSTER	HARD- NESS	CLEAVAGE FRACTURE	COMMON COLORS	DISTINGUISHING CHARACTERISTICS	USE(S)	COMPOSITION*	MINERAL NAME
Metallic luster	1–2	✓	silver to gray	black streak, greasy feel	pencil lead, lubricants	C	Graphite
	2.5	✓	metallic silver	gray-black streak, cubic cleavage, density = 7.6 g/cm ³	ore of lead, batteries	PbS	Galena
	5.5–6.5	✓	black to silver	black streak, magnetic	ore of iron, steel	Fe ₃ O ₄	Magnetite
	6.5	✓	brassy yellow	green-black streak, (fool's gold)	ore of sulfur	FeS ₂	Pyrite
Either	5.5 – 6.5 or 1	✓	metallic silver or earthy red	red-brown streak	ore of iron, jewelry	Fe ₂ O ₃	Hematite
Nonmetallic luster	1	✓	white to green	greasy feel	ceramics, paper	Mg ₃ Si ₄ O ₁₀ (OH) ₂	Talc
	2	✓	yellow to amber	white-yellow streak	sulfuric acid	S	Sulfur
	2	✓	white to pink or gray	easily scratched by fingernail	plaster of paris, drywall	CaSO ₄ •2H ₂ O	Selenite gypsum
	2–2.5	✓	colorless to yellow	flexible in thin sheets	paint, roofing	KAl ₃ Si ₃ O ₁₀ (OH) ₂	Muscovite mica
	2.5	✓	colorless to white	cubic cleavage, salty taste	food additive, melts ice	NaCl	Halite
	2.5–3	✓	black to dark brown	flexible in thin sheets	construction materials	K(Mg,Fe) ₃ AlSi ₃ O ₁₀ (OH) ₂	Biotite mica
	3	✓	colorless or variable	bubbles with acid, rhombohedral cleavage	cement, lime	CaCO ₃	Calcite
	3.5	✓	colorless or variable	bubbles with acid when powdered	building stones	CaMg(CO ₃) ₂	Dolomite
	4	✓	colorless or variable	cleaves in 4 directions	hydrofluoric acid	CaF ₂	Fluorite
	5–6	✓	black to dark green	cleaves in 2 directions at 90°	mineral collections, jewelry	(Ca,Na)(Mg,Fe,Al)(Si,Al) ₂ O ₆	Pyroxene (commonly augite)
	5.5	✓	black to dark green	cleaves at 56° and 124°	mineral collections, jewelry	CaNa(Mg,Fe) ₄ (Al,Fe,Ti) ₃ Si ₆ O ₂₂ (O,OH) ₂	Amphibole (commonly hornblende)
	6	✓	white to pink	cleaves in 2 directions at 90°	ceramics, glass	KAlSi ₃ O ₈	Potassium feldspar (commonly orthoclase)
	6	✓	white to gray	cleaves in 2 directions, striations visible	ceramics, glass	(Na,Ca)AlSi ₃ O ₈	Plagioclase feldspar
	6.5	✓	green to gray or brown	commonly light green and granular	furnace bricks, jewelry	(Fe,Mg) ₂ SiO ₄	Olivine
7	✓	colorless or variable	glassy luster, may form hexagonal crystals	glass, jewelry, electronics	SiO ₂	Quartz	
6.5–7.5	✓	dark red to green	often seen as red glassy grains in NYS metamorphic rocks	jewelry (NYS gem), abrasives	Fe ₃ Al ₂ Si ₃ O ₁₂	Garnet	

*Chemical symbols: Al = aluminum Cl = chlorine H = hydrogen Na = sodium S = sulfur
 C = carbon F = fluorine K = potassium O = oxygen Si = silicon
 Ca = calcium Fe = iron Mg = magnesium Pb = lead Ti = titanium

✓ = dominant form of breakage