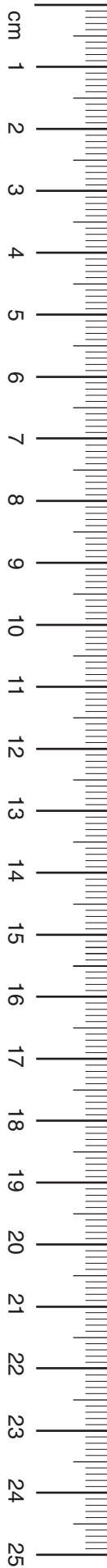


# Reference Tables for Physical Setting/EARTH SCIENCE



### Radioactive Decay Data

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

### 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

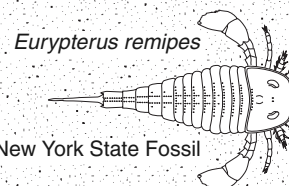
Heat energy gained during melting . . . . .	334 J/g
Heat energy released during freezing . . . . .	334 J/g
Heat energy gained during vaporization . . . . .	2260 J/g
Heat energy released during condensation . . . . .	2260 J/g
Density at 3.98°C . . . . .	1.0 g/mL

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

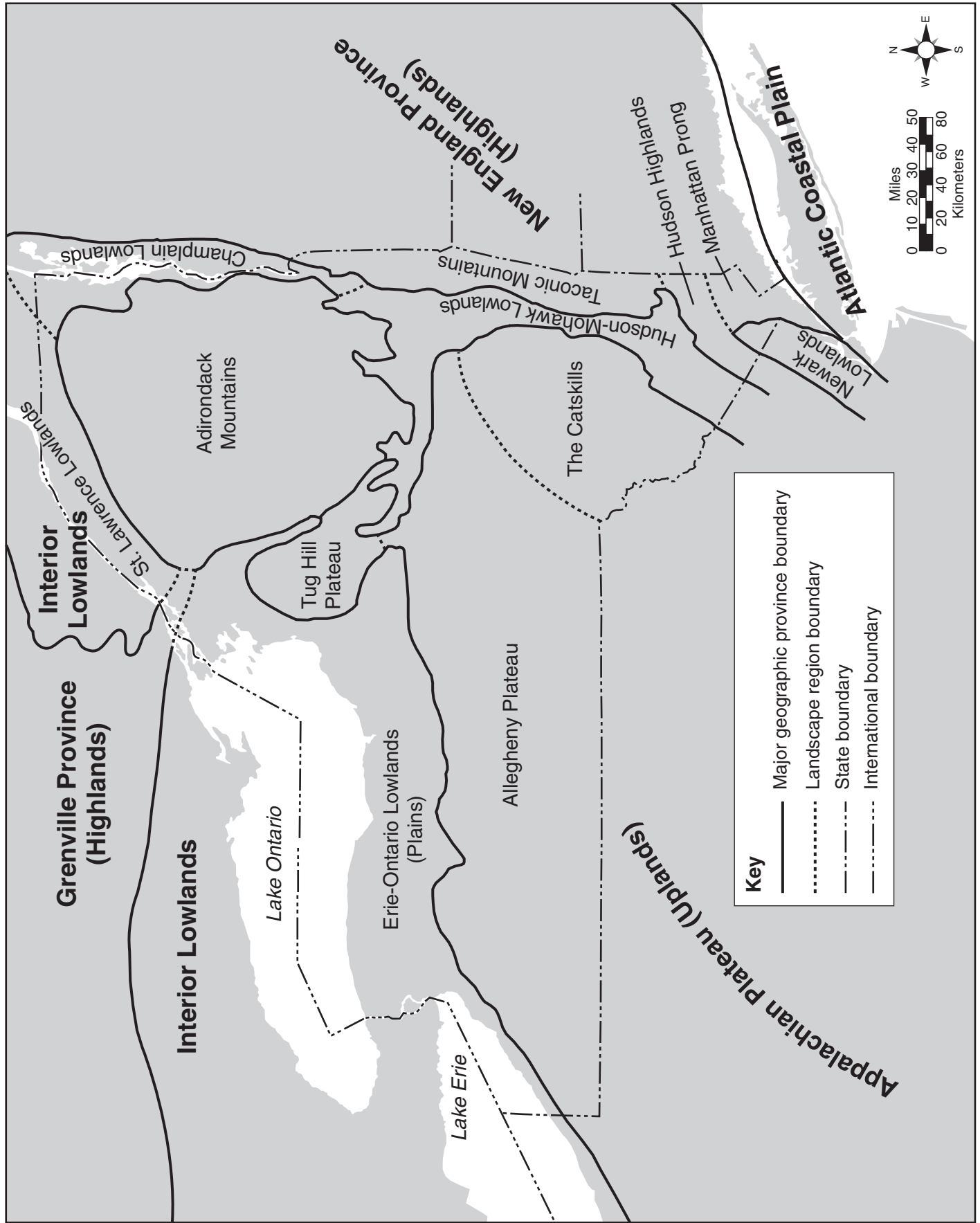
ELEMENT (symbol)	CRUST		HYDROSPHERE	TROPOSPHERE
	Percent by mass	Percent by volume	Percent by volume	Percent by volume
Oxygen (O)	46.10	94.04	33.0	21.0
Silicon (Si)	28.20	0.88		
Aluminum (Al)	8.23	0.48		
Iron (Fe)	5.63	0.49		
Calcium (Ca)	4.15	1.18		
Sodium (Na)	2.36	1.11		
Magnesium (Mg)	2.33	0.33	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

### 2010 EDITION

This edition of the Earth Science Reference Tables should be used in the classroom beginning in the 2009–2010 school year. The first examination for which these tables will be used is the January 2010 Regents Examination in Physical Setting/Earth Science.

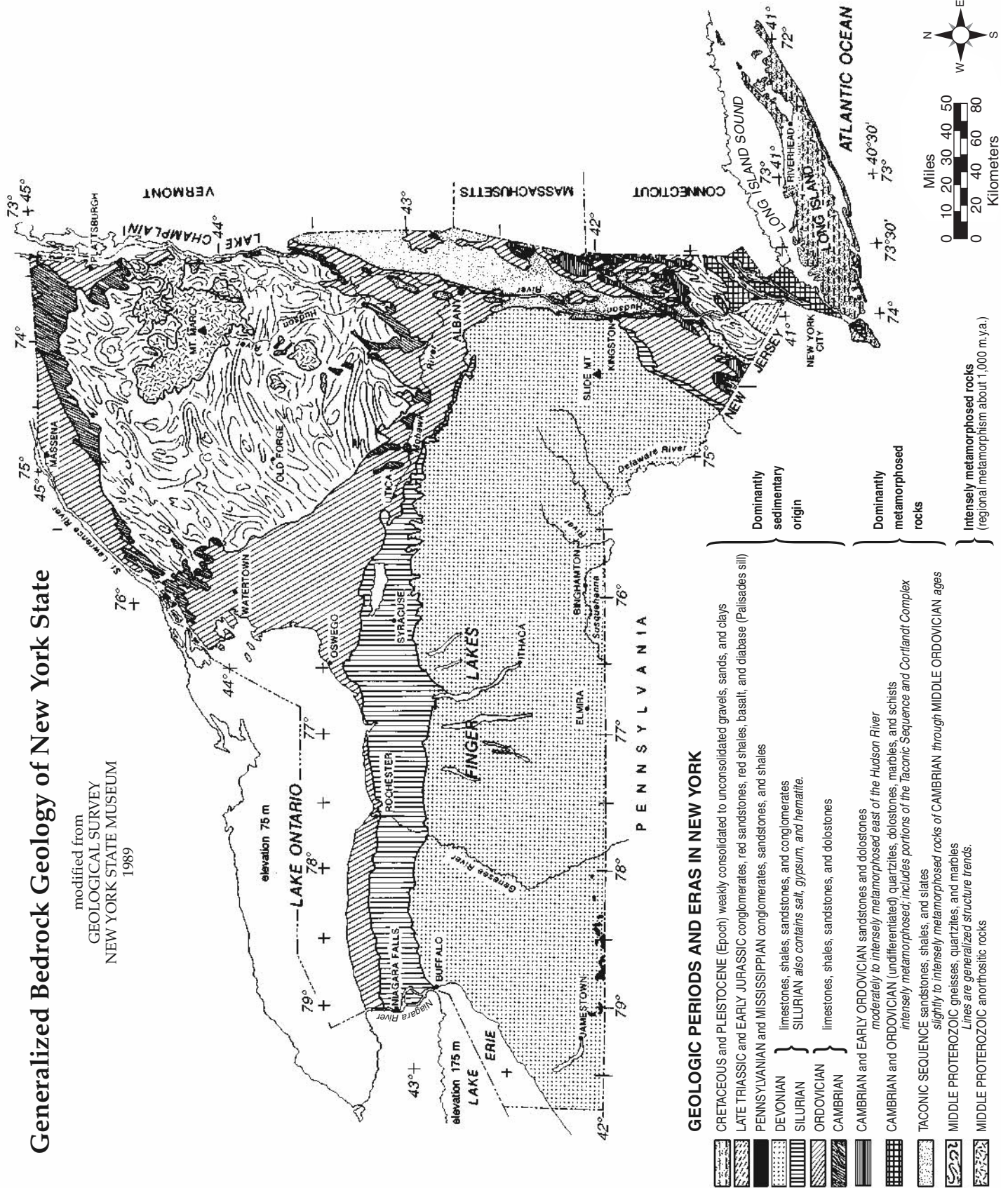


# Generalized Landscape Regions of New York State



# 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 }
- 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

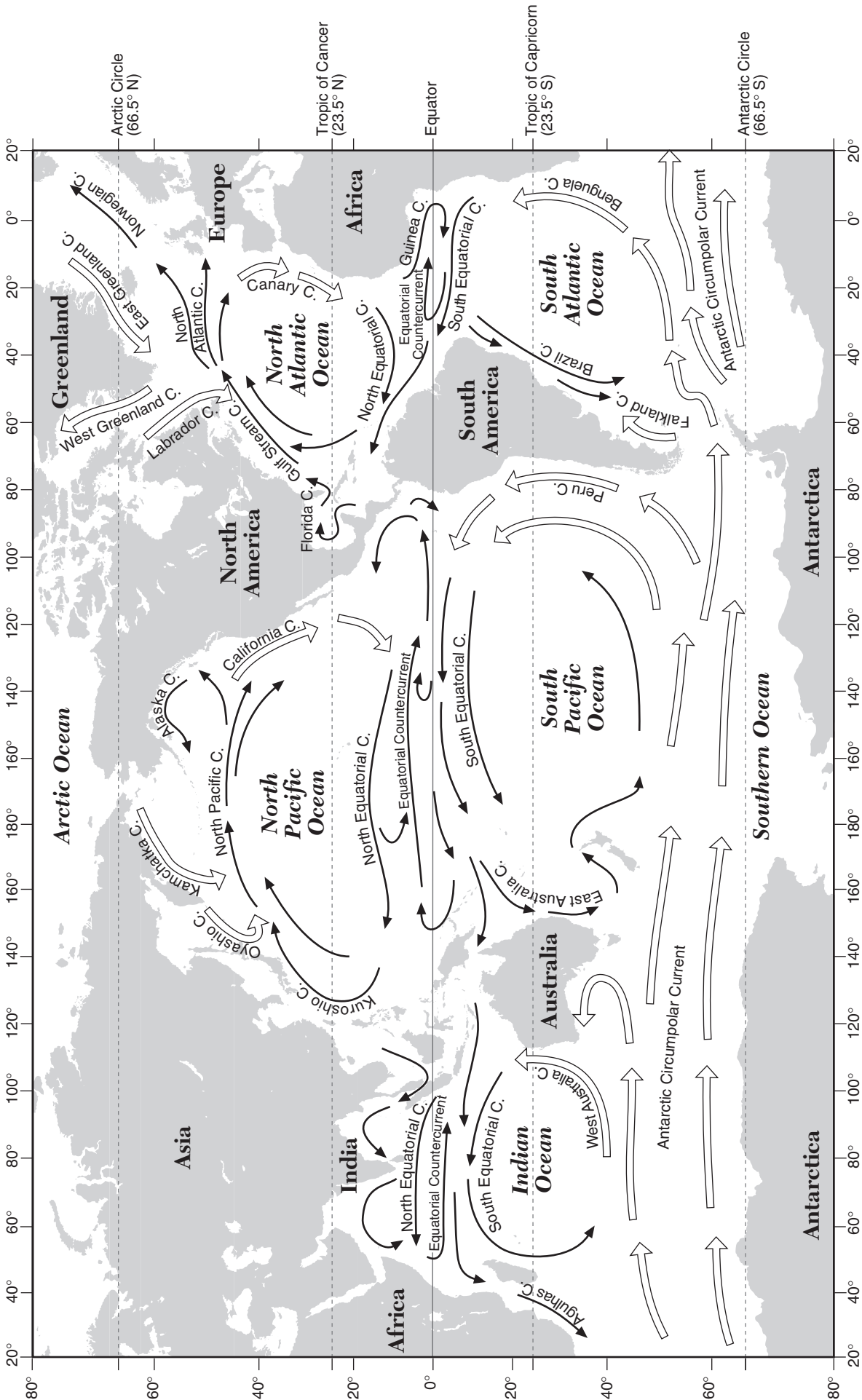
Dominantly sedimentary origin

Dominantly metamorphosed rocks

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



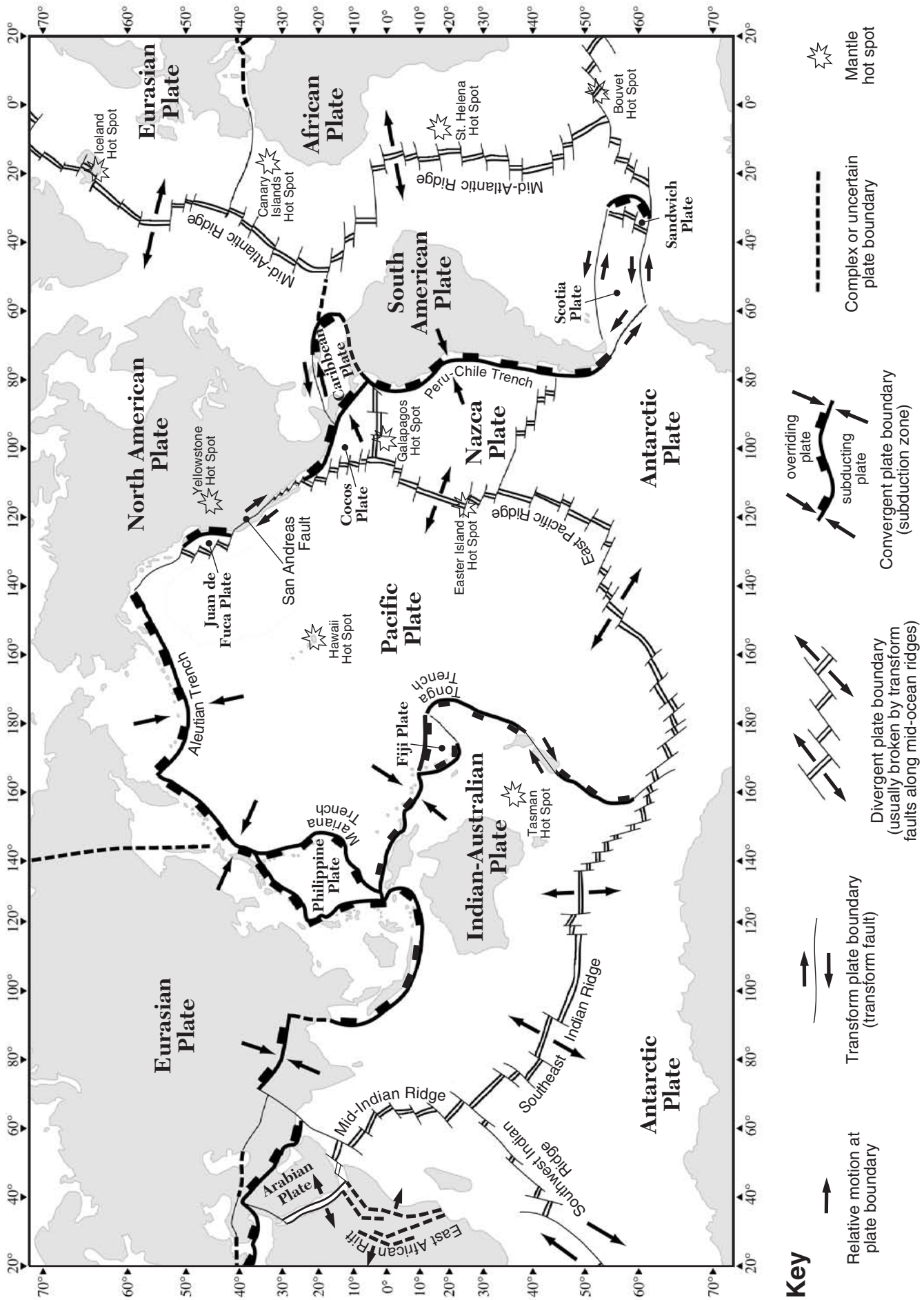
# Surface Ocean Currents



Key	
→	Warm currents
⇨	Cool currents

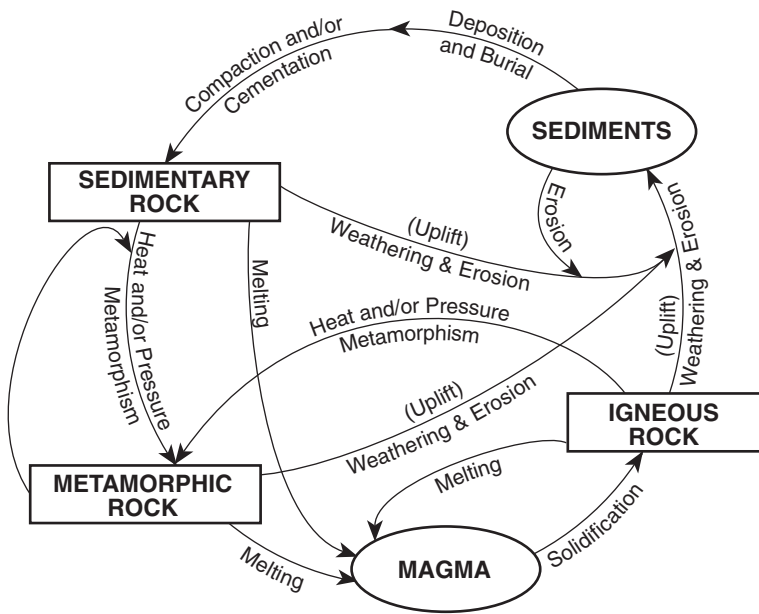
NOTE: Not all surface ocean currents are shown.

# Tectonic Plates

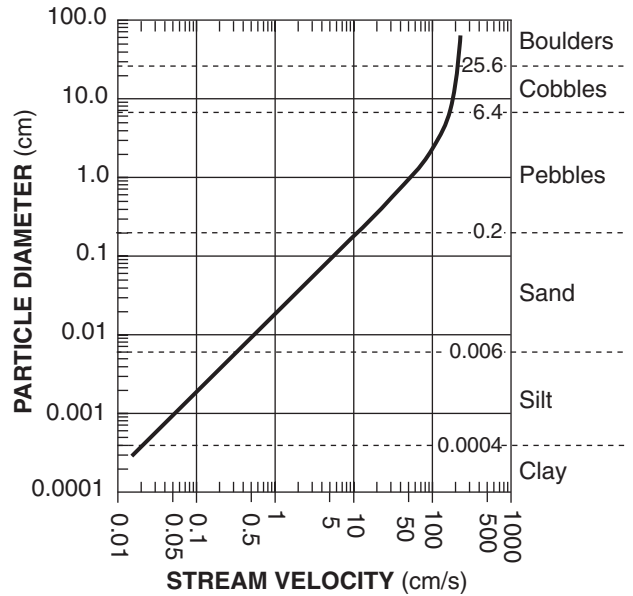


NOTE: Not all mantle hot spots, plates, and boundaries are shown.

## Rock Cycle in Earth's Crust



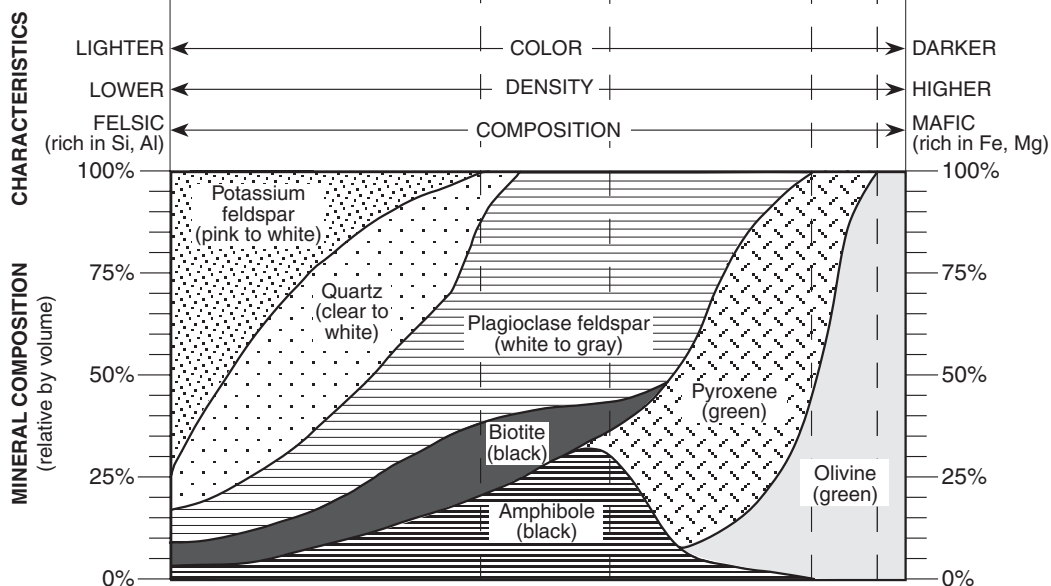
## Relationship of Transported Particle Size to Water Velocity




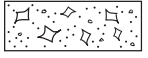
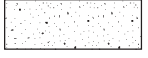
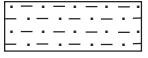

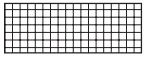

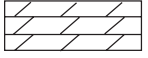

This generalized graph shows the water velocity needed to maintain, but not start, movement. Variations occur due to differences in particle density and shape.

## Scheme for Igneous Rock Identification

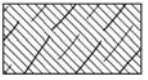
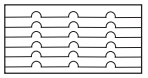
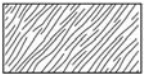
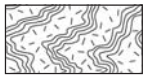

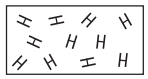



ENVIRONMENT OF FORMATION		CRYSTAL SIZE				TEXTURE	
		Obsidian (usually appears black)		Basaltic glass		Glassy	Non-vesicular
EXTRUSIVE (Volcanic)	Pumice		Scoria		non-crystalline	Glassy	Non-vesicular
	Vesicular rhyolite	Vesicular andesite	Vesicular basalt				Vesicular (gas pockets)
	Rhyolite	Andesite	Basalt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



## 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	<b>Conglomerate</b>	
			Angular fragments	<b>Breccia</b>	
	Sand (0.006 to 0.2 cm)		Fine to coarse	<b>Sandstone</b>	
	Silt (0.0004 to 0.006 cm)		Very fine grain	<b>Siltstone</b>	
Clay (less than 0.0004 cm)	Compact; may split easily	<b>Shale</b>			
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	<b>Rock salt</b>	
		Gypsum		<b>Rock gypsum</b>	
		Dolomite		<b>Dolostone</b>	
Crystalline or bioclastic	Microscopic to very coarse	Calcite	Precipitates of biologic origin or cemented shell fragments	<b>Limestone</b>	
Bioclastic		Carbon		Compacted plant remains	<b>Bituminous coal</b>

## Scheme for Metamorphic Rock Identification

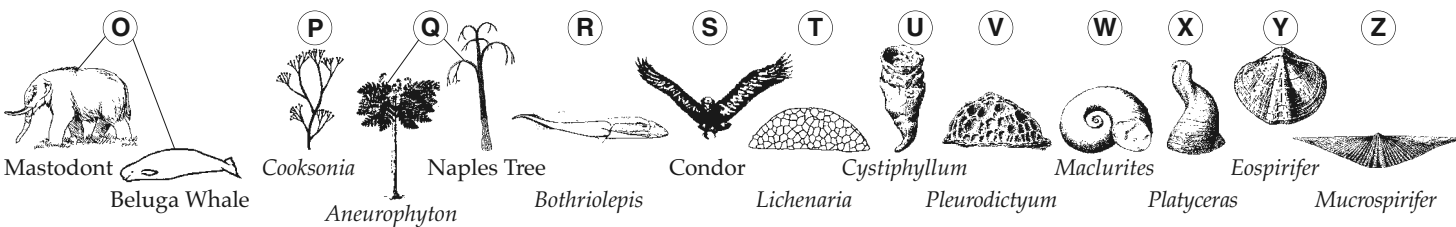
TEXTURE	GRAIN SIZE	COMPOSITION	TYPE OF METAMORPHISM	COMMENTS	ROCK NAME	MAP SYMBOL
FOLIATED  MINERAL ALIGNMENT  BAND- ING	Fine	MICA QUARTZ FELDSPAR AMPHIBOLE GARNET PYROXENE	Regional (Heat and pressure increases)  ↓	Low-grade metamorphism of shale	<b>Slate</b>	
	Fine to medium			Foliation surfaces shiny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





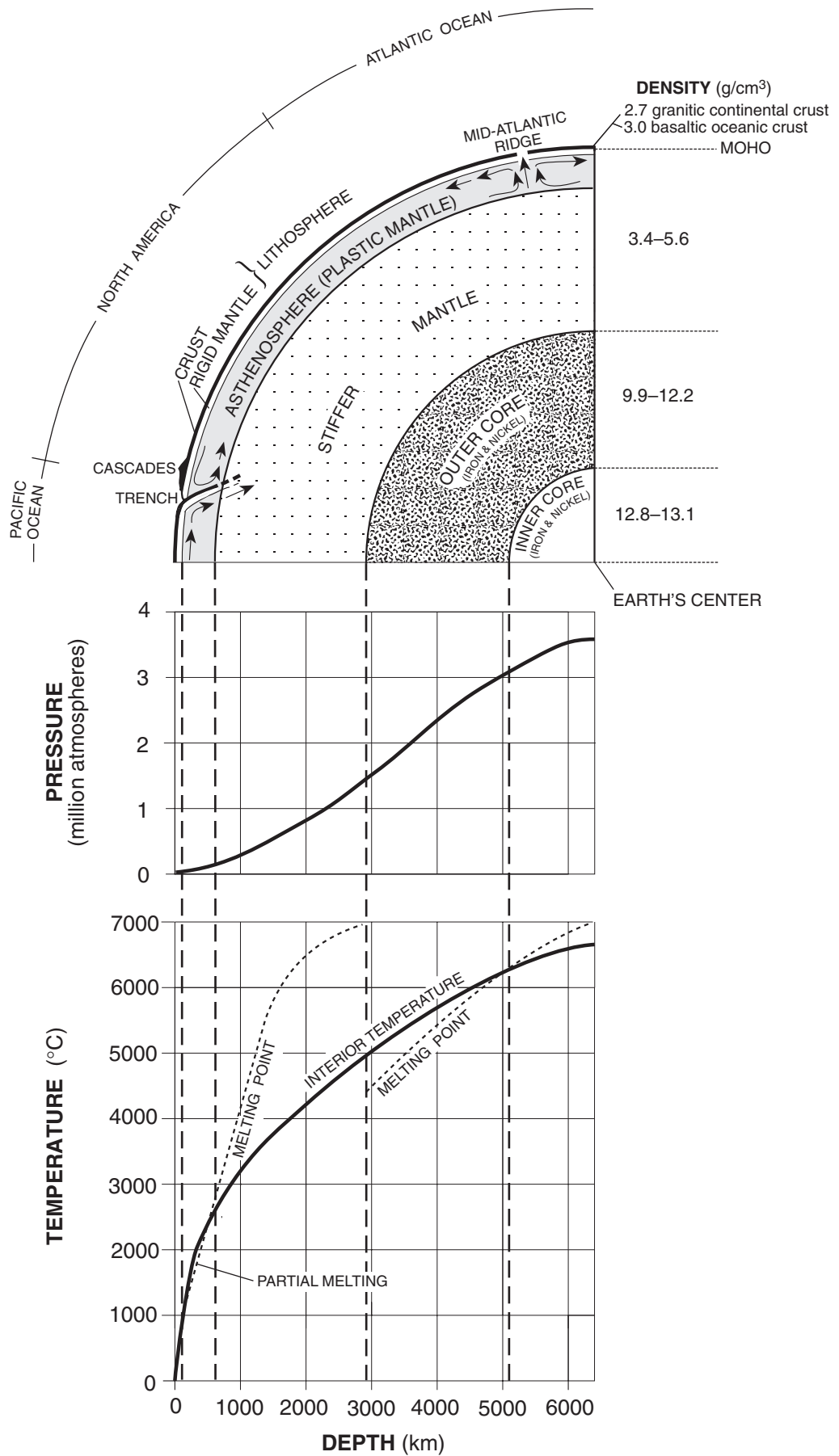
# OF NEW YORK STATE

<b>Time Distribution of Fossils</b> (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 <b>A</b> ) lived at the end of the Early Cambrian).	<b>Important Geologic Events in New York</b>	<b>Inferred Positions of Earth's Landmasses</b>
	Advance and retreat of last continental ice	
	Sands and clays underlying Long Island and Staten Island deposited on margin of Atlantic Ocean	59 million years ago 
	Dome-like uplift of Adirondack region begins	119 million years ago 
	Initial opening of Atlantic Ocean North America and Africa separate { Intrusion of Palisades sill } Pangaea begins to break up	232 million years ago 
	<b>Alleghenian orogeny</b> caused by collision of North America and Africa along transform margin, forming Pangaea	
	Catskill delta forms Erosion of Acadian Mountains <b>Acadian orogeny</b> caused by collision of North America and Avalon and closing of remaining part of Iapetus Ocean	359 million years ago 
	Salt and gypsum deposited in evaporite basins	
	Erosion of Taconic Mountains; Queenston delta forms <b>Taconian orogeny</b> caused by closing of western part of Iapetus Ocean and collision between North America and volcanic island arc	458 million years ago 
	Widespread deposition over most of New York along edge of Iapetus Ocean	
	Rifting and initial opening of Iapetus Ocean Erosion of Grenville Mountains <b>Grenville orogeny:</b> metamorphism of bedrock now exposed in the Adirondacks and Hudson Highlands	

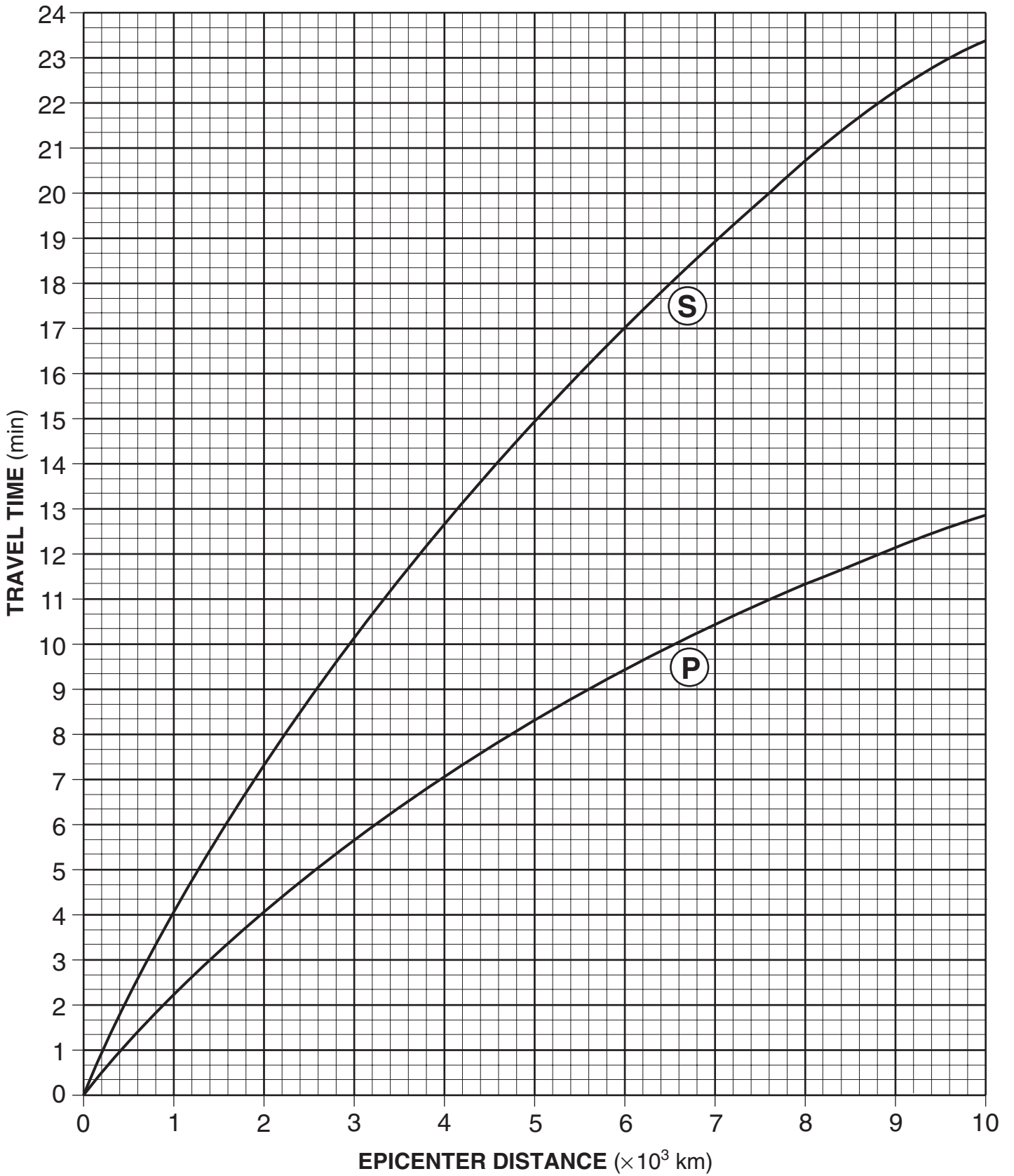


ESC / BW / TN (2009)

# Inferred Properties of Earth's Interior



# Earthquake P-Wave and S-Wave Travel Time



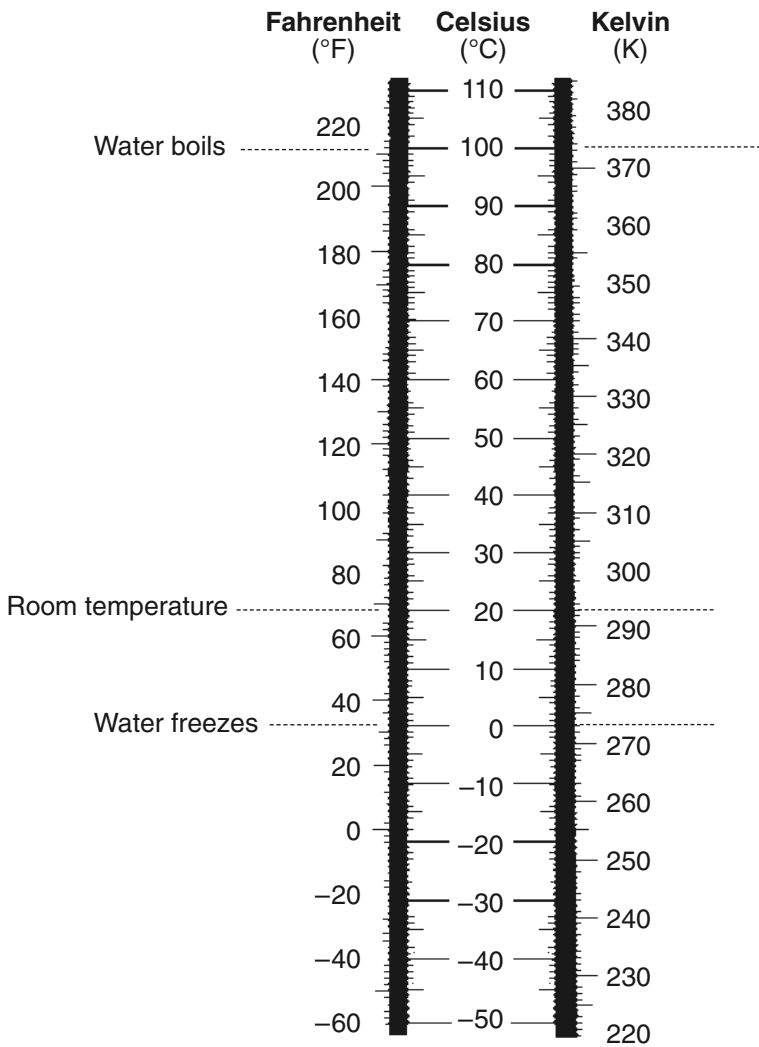
## Dewpoint (°C)

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

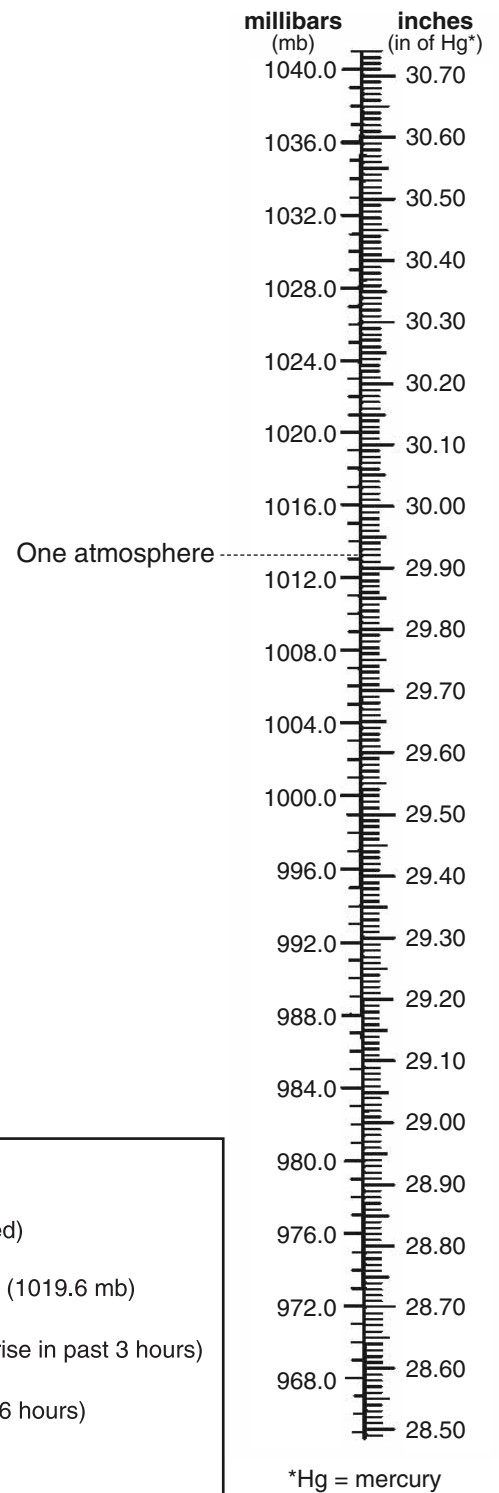
## Relative Humidity (%)

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

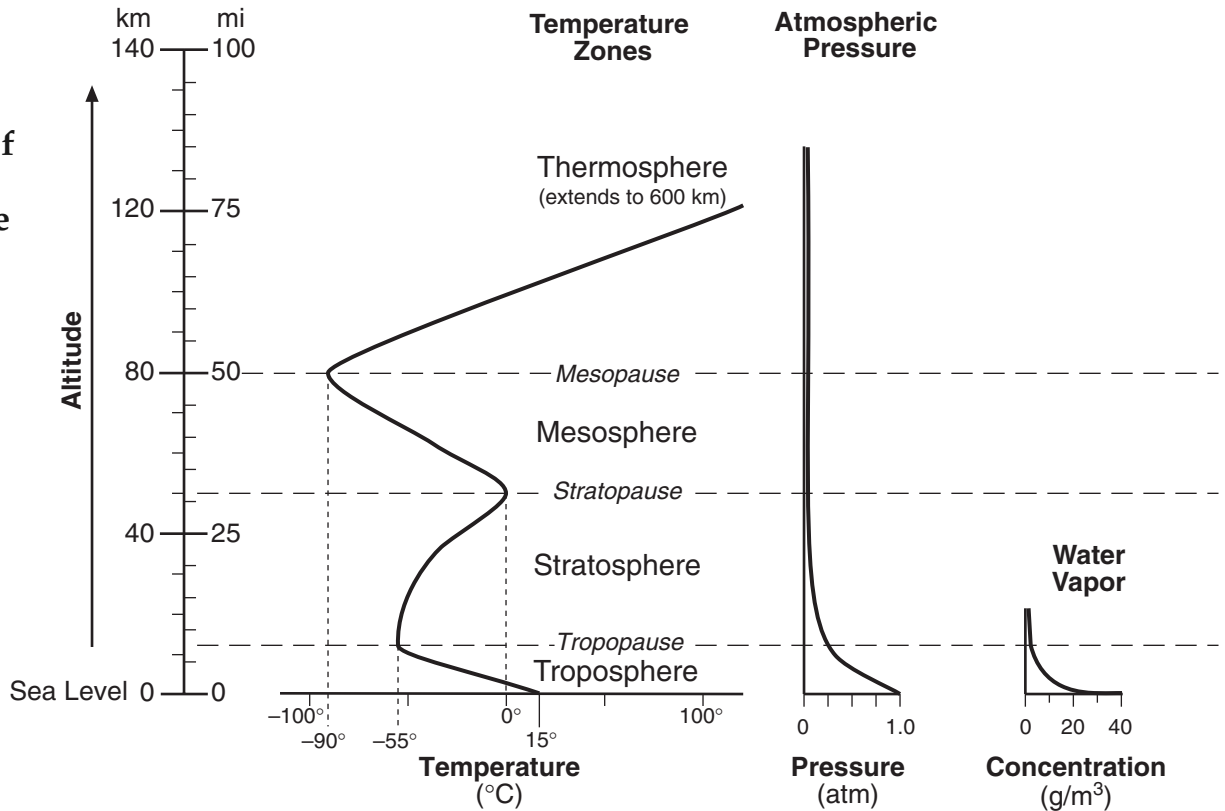


## Key to Weather Map Symbols

Station Model	Station Model Explanation
	<p style="text-align: center;">Present weather</p> <p>Amount of cloud cover (approximately 75% covered)</p> <p>Temperature (°F) <b>28</b></p> <p>Barometric pressure (1019.6 mb) <b>196</b></p> <p>Visibility (mi) <math>\frac{1}{2}*</math></p> <p>Barometric trend (a steady 1.9-mb rise in past 3 hours) <b>+19/</b></p> <p>Dewpoint (°F) <b>27</b></p> <p>Precipitation (0.25 inches in past 6 hours) <b>.25</b></p> <p>Wind speed</p> <p>Wind direction (from the southwest)</p> <p>(1 knot = 1.15 mi/h)</p> <p>[ whole feather = 10 knots half feather = 5 knots total = 15 knots ]</p>

Present Weather	Air Masses	Fronts	Hurricane
Drizzle Rain Smog Hail Thunderstorms Rain showers Snow Sleet Freezing rain Fog Haze Snow showers	cA continental arctic cP continental polar cT continental tropical mT maritime tropical mP maritime polar	Cold Warm Stationary Occluded	 <b>Tornado</b> 

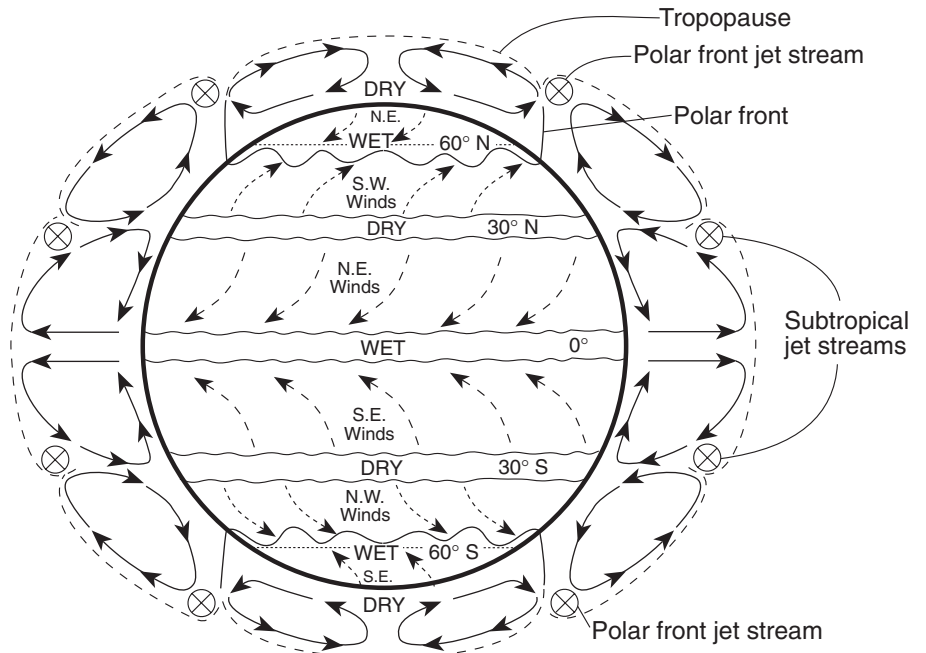
## Selected Properties of Earth's Atmosphere



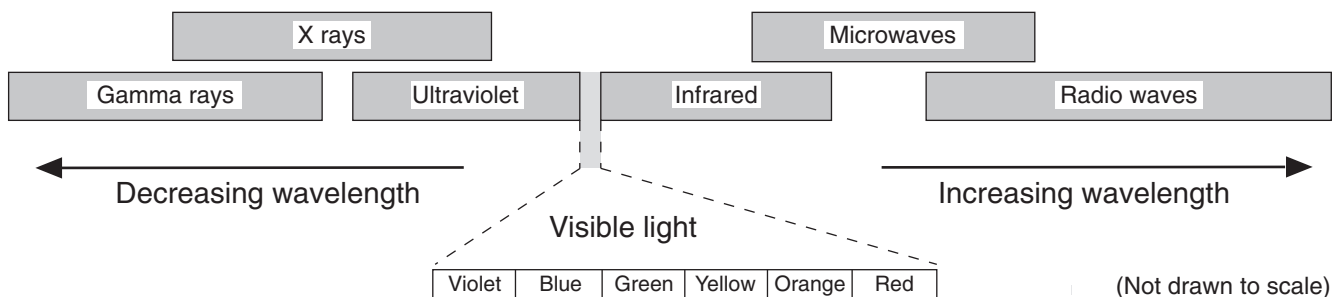
## Planetary Wind and Moisture Belts in the Troposphere

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)



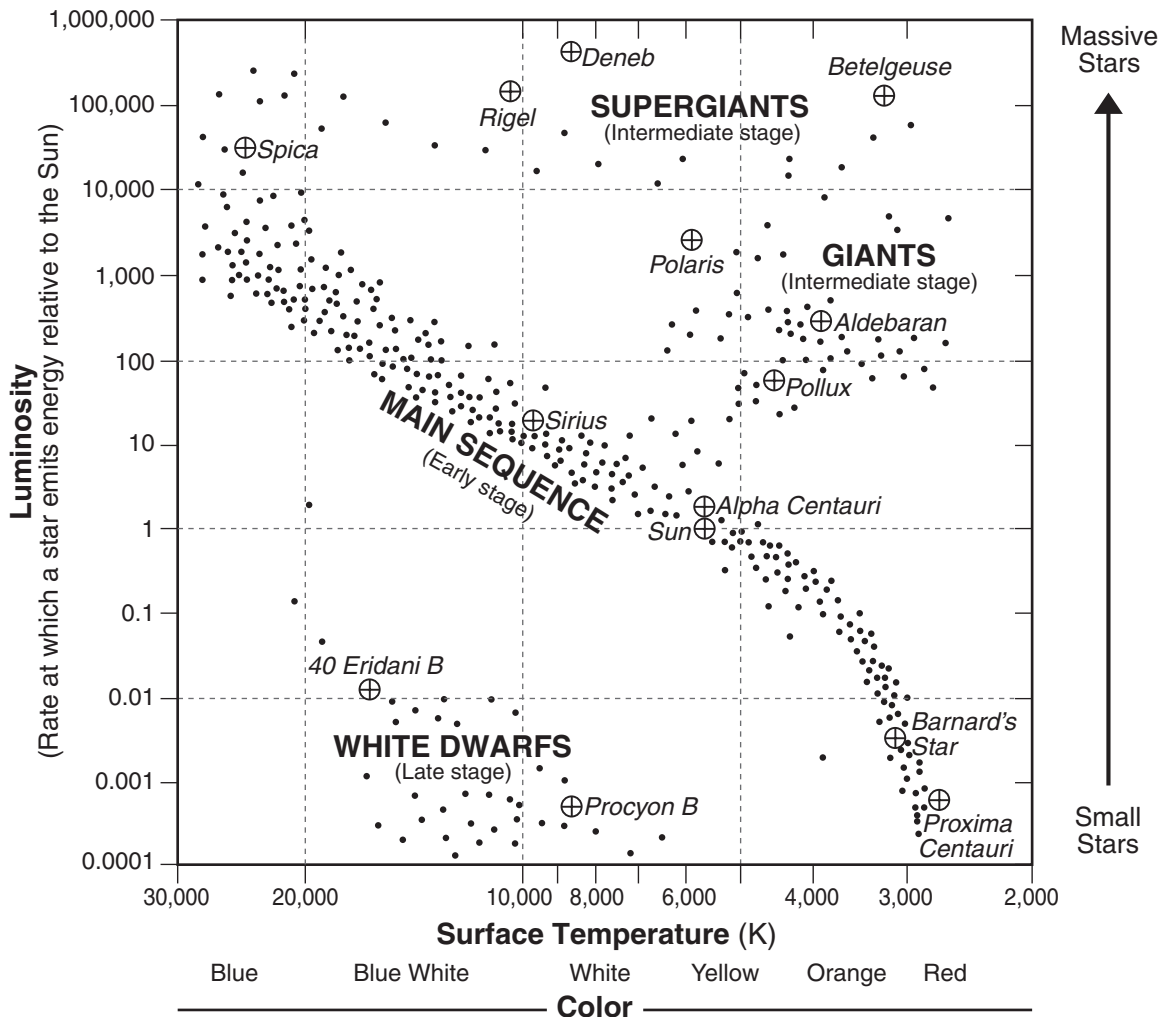
## Electromagnetic Spectrum



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

\*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