

# Earth Science Reference Tables

## PHYSICAL CONSTANTS

### Radioactive Decay Data

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

### Specific Heats of Common Materials

MATERIAL	SPECIFIC HEAT (calories/gram • C°)
Water $\left\{ \begin{matrix} \text{solid} \\ \text{liquid} \\ \text{gas} \end{matrix} \right.$	0.5
	1.0
	0.5
Dry air	0.24
Basalt	0.20
Granite	0.19
Iron	0.11
Copper	0.09
Lead	0.03

### Properties of Water

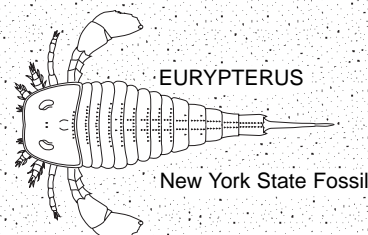
Energy gained during melting	80 calories/gram
Energy released during freezing	80 calories/gram
Energy gained during vaporization	540 calories/gram
Energy released during condensation	540 calories/gram
Density at 3.98°C	1.00 gram/milliliter

## EQUATIONS

Percent deviation from accepted value	$\text{deviation (\%)} = \frac{\text{difference from accepted value}}{\text{accepted value}} \times 100$
Eccentricity of an ellipse	$\text{eccentricity} = \frac{\text{distance between foci}}{\text{length of major axis}}$
Gradient	$\text{gradient} = \frac{\text{change in field value}}{\text{distance}}$
Rate of change	$\text{rate of change} = \frac{\text{change in field value}}{\text{time}}$
Density of a substance	$\text{density} = \frac{\text{mass}}{\text{volume}}$

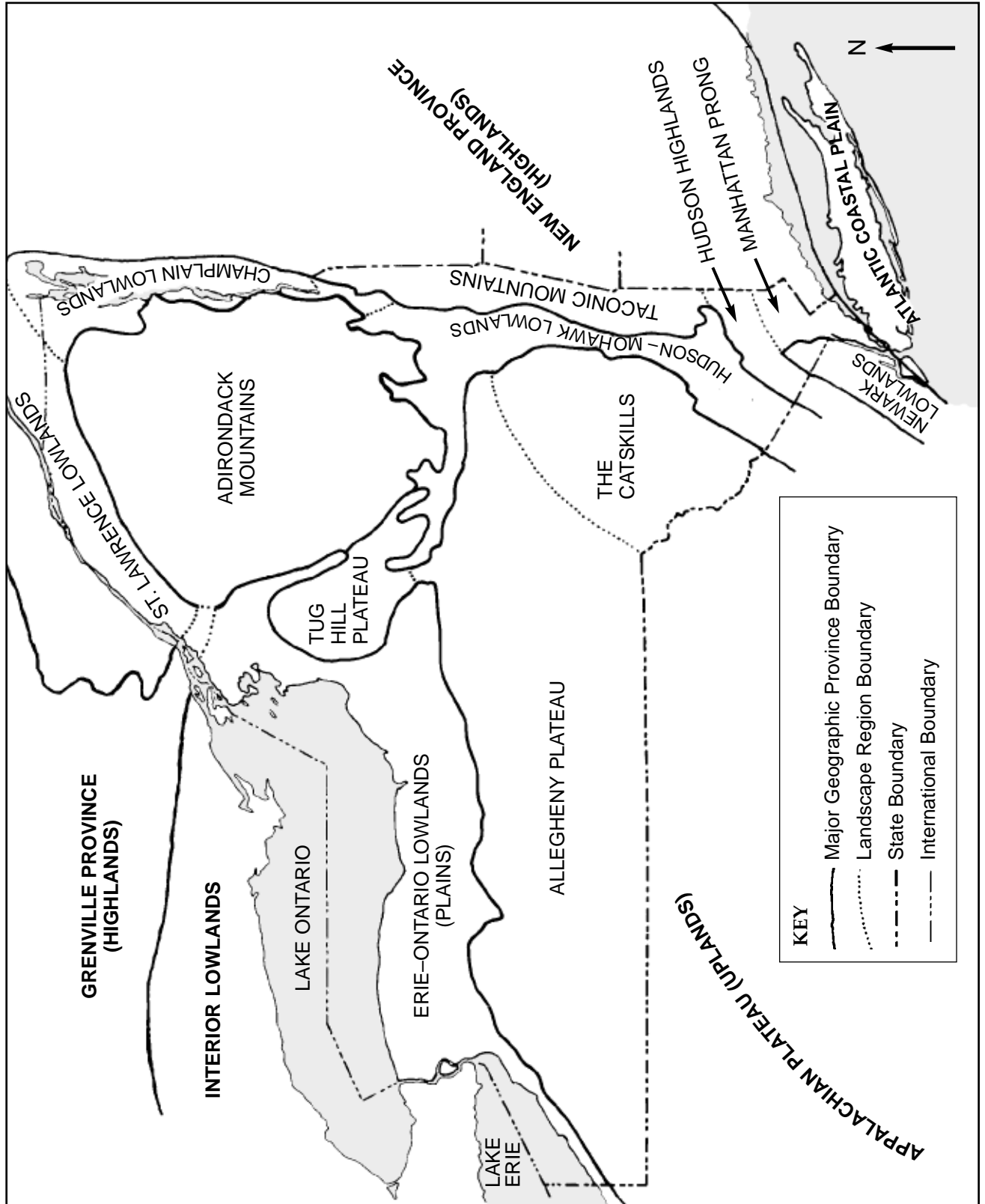
### 2001 EDITION

This edition of the Earth Science Reference Tables should be used in the classroom beginning in the 2000–2001 school year. The first examination for which these tables will be used is the January 2001 Regents Examination in Earth Science.



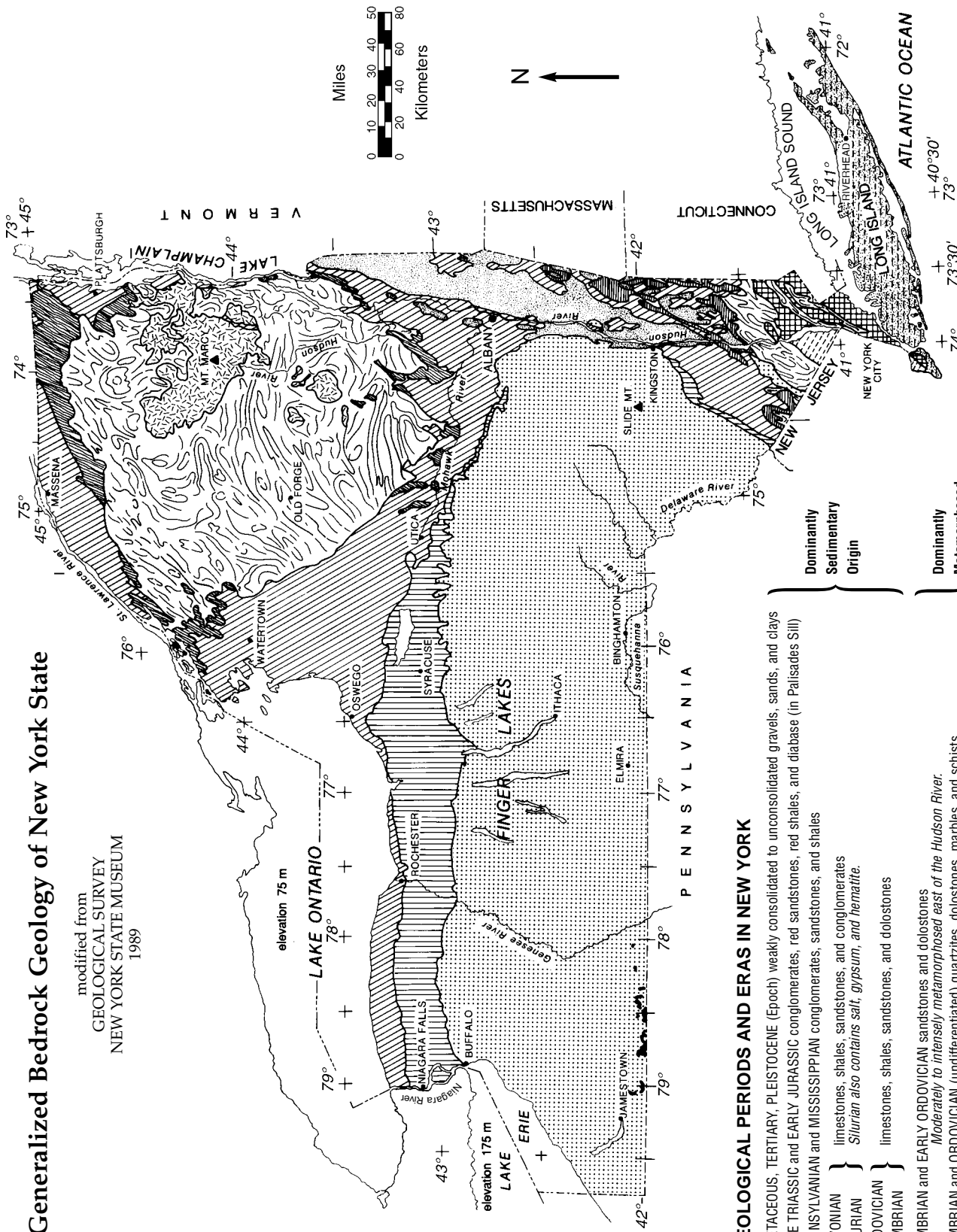
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# Generalized Landscape Regions of New York State



# Generalized Bedrock Geology of New York State

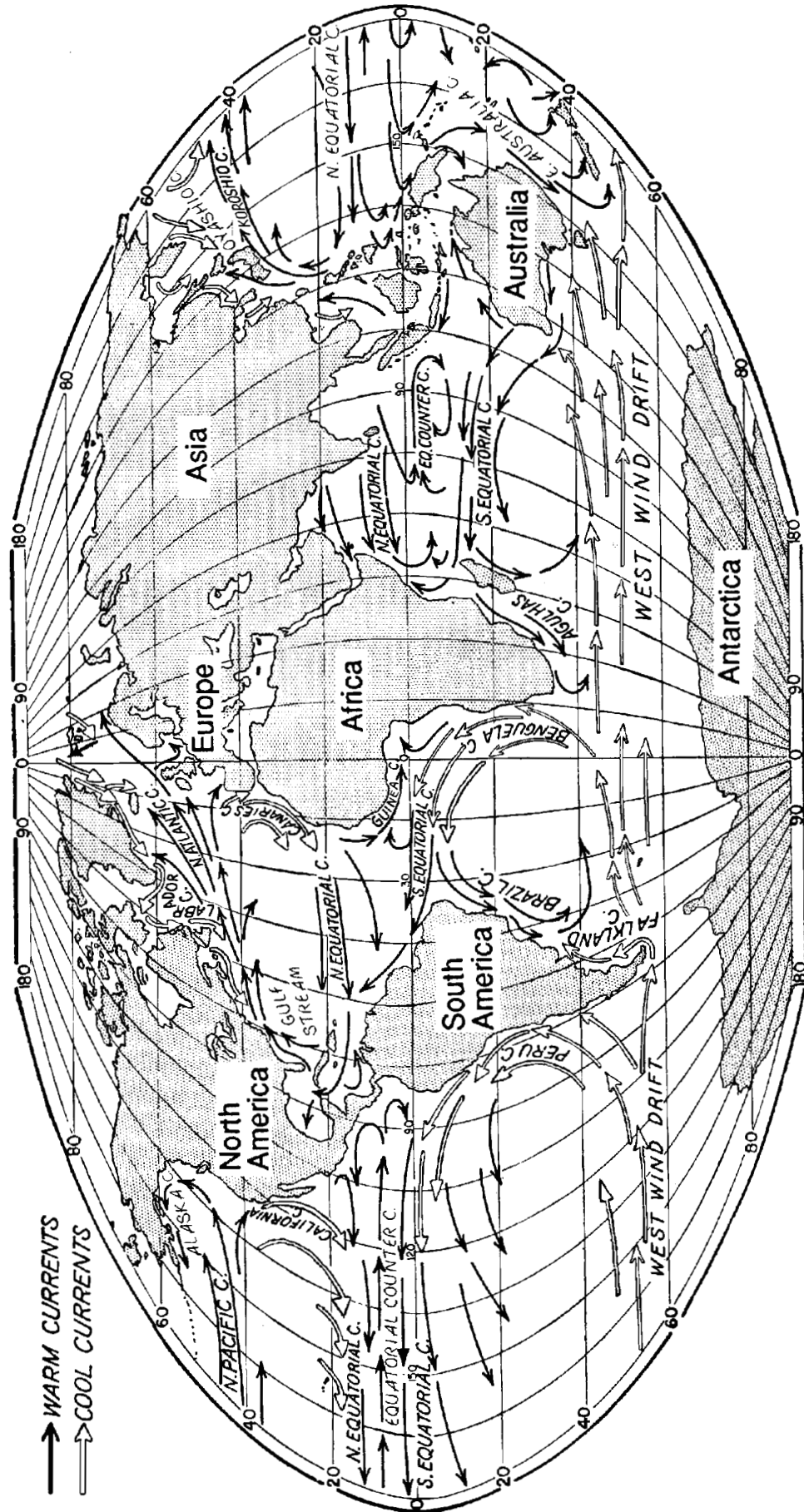
modified from  
GEOLOGICAL SURVEY  
NEW YORK STATE MUSEUM  
1989



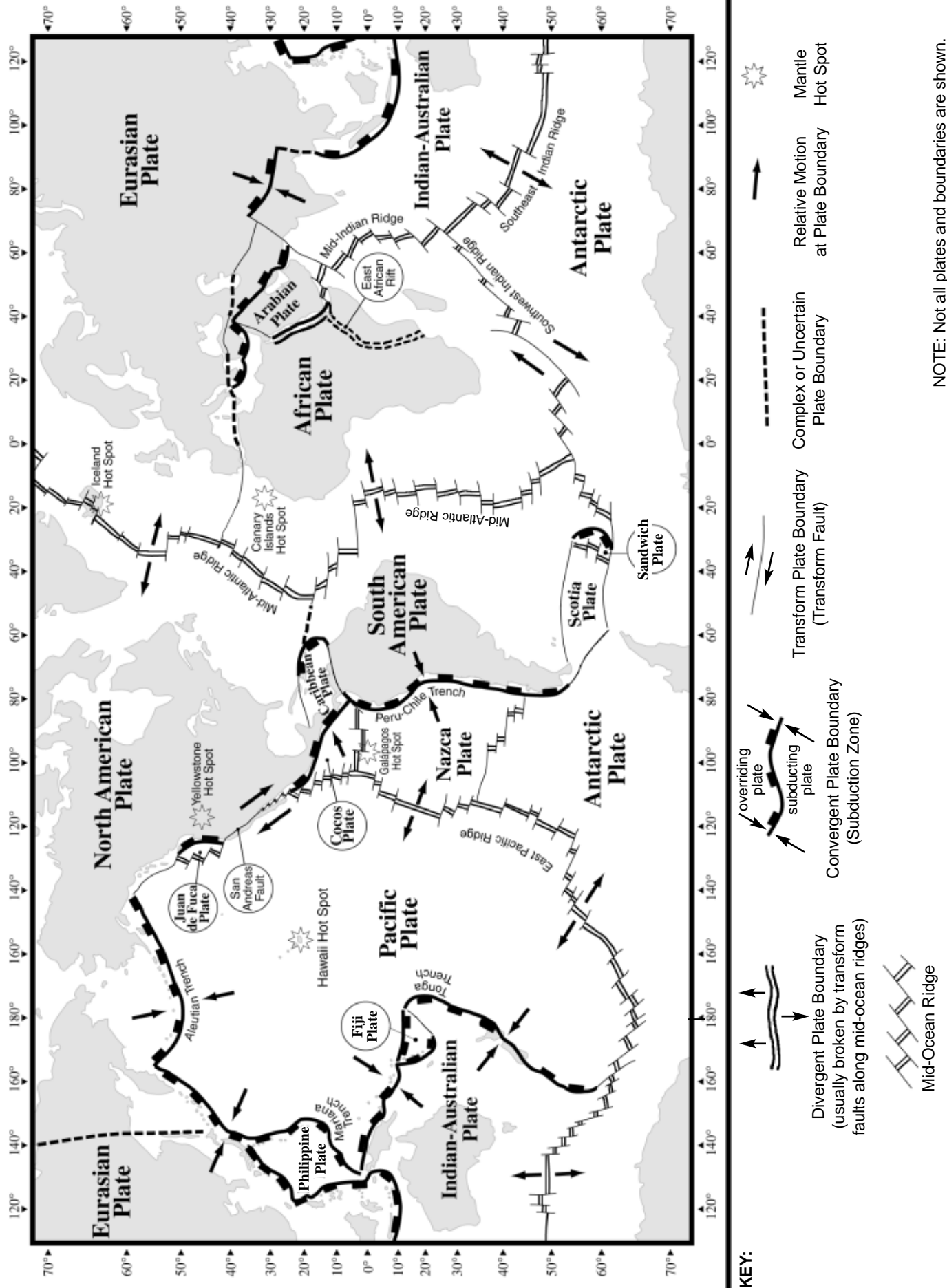
## GEOLOGICAL PERIODS AND ERAS IN NEW YORK

	CRETACEOUS, TERTIARY, PLEISTOCENE (Epoch) weakly consolidated gravels, sands, and clays	} <b>Dominantly Sedimentary Origin</b>
	LATE TRIASSIC and EARLY JURASSIC conglomerates, red sandstones, red shales, and diabase (in Palisades Sill)	
	PENNSYLVANIAN and MISSISSIPPIAN conglomerates, sandstones, and shales	} <b>Dominantly Metamorphosed Rocks</b>
	DEVONIAN limestones, shales, sandstones, and conglomerates <i>Silurian also contains salt, gypsum, and hematite.</i>	
	SILURIAN	
	ORDOVICIAN limestones, shales, sandstones, and dolostones	
	CAMBRIAN	
	CAMBRIAN and EARLY ORDOVICIAN sandstones and dolostones <i>Moderately to intensely metamorphosed east of the Hudson River.</i>	
	CAMBRIAN and ORDOVICIAN (undifferentiated) quartzites, dolostones, marbles, and schists <i>intensely metamorphosed; includes portions of the Taconic Sequence and Cortland Complex.</i>	
	TACONIC SEQUENCE sandstones, shales, and slates <i>Slightly to intensely metamorphosed rocks of CAMBRIAN through MIDDLE ORDOVICIAN ages.</i>	
	MIDDLE PROTEROZOIC gneisses, quartzites, and marbles <i>Lines are generalized structure trends.</i>	
	MIDDLE PROTEROZOIC anorthositic rocks <b>Intensely Metamorphosed Rocks</b> (regional metamorphism about 1,000 m.y.a.)	

# Surface Ocean Currents

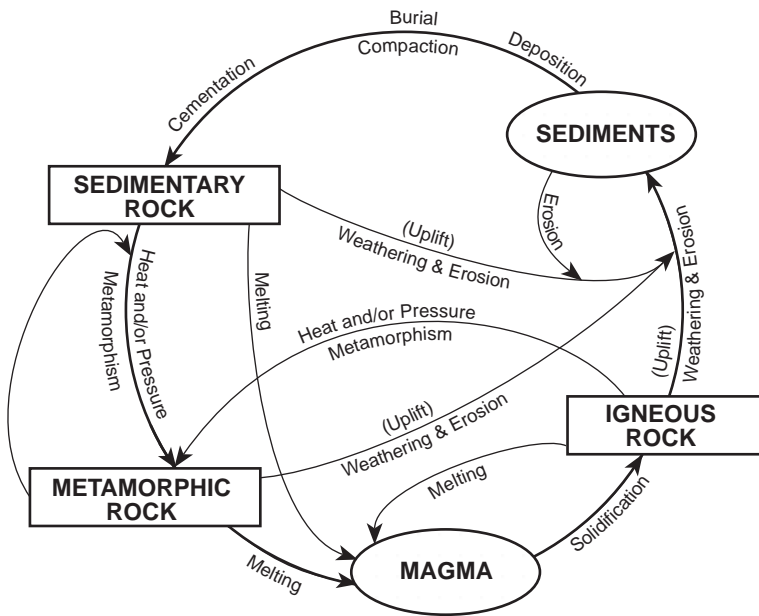


# Tectonic Plates

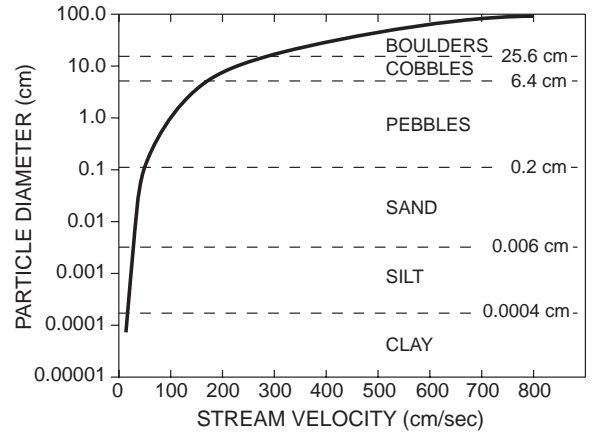


NOTE: Not all plates and boundaries are shown.

## Rock Cycle in Earth's Crust



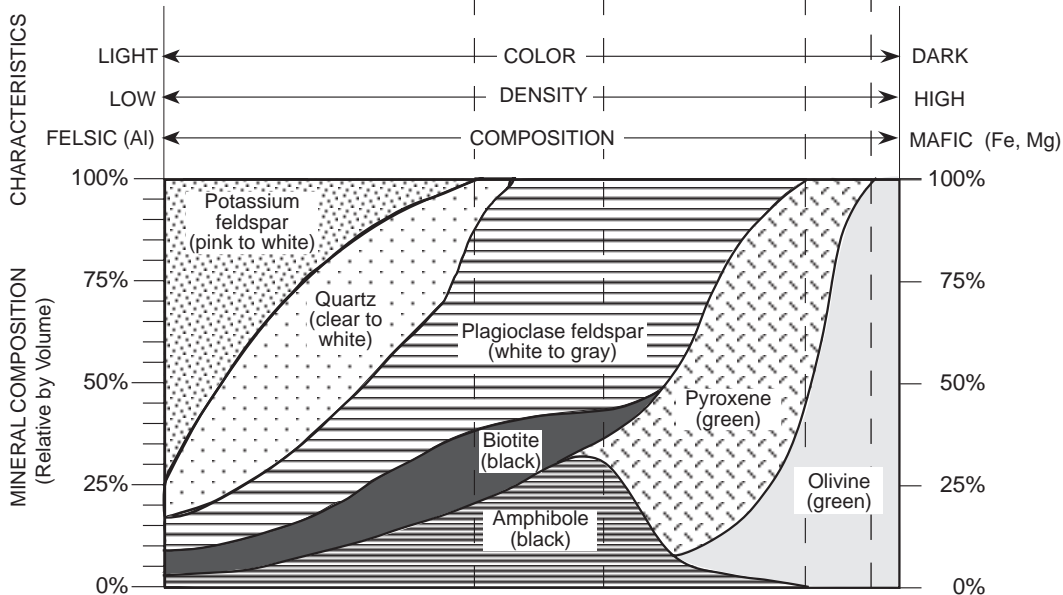
## Relationship of Transported Particle Size to Water Velocity




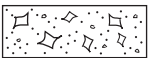

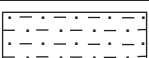

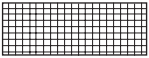
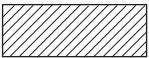

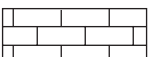

\*This generalized graph shows the water velocity needed to maintain, but not start, movement. Variations occur due to differences in particle density and shape.

## Scheme for Igneous Rock Identification


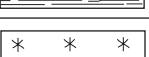
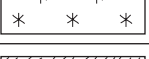

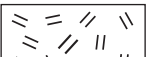
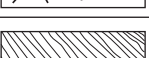


					GRAIN SIZE	TEXTURE		
IGNEOUS ROCKS	ENVIRONMENT OF FORMATION	EXTRUSIVE (Volcanic)	Obsidian (usually appears black)		Basaltic Glass	Non-crystalline	Glassy	Non-vesicular
			Pumice		Vesicular Basaltic Glass		less than 1 mm	Fine
			Vesicular Rhyolite	Vesicular Andesite	Scoria / Vesicular Basalt	1 mm to 10 mm		
			Rhyolite	Andesite	Basalt			
	INTRUSIVE (Plutonic)	Granite	Diorite	Gabbro	Peridotite	10 mm or larger	Very Coarse	
		Pegmatite						



## Scheme for Sedimentary Rock Identification

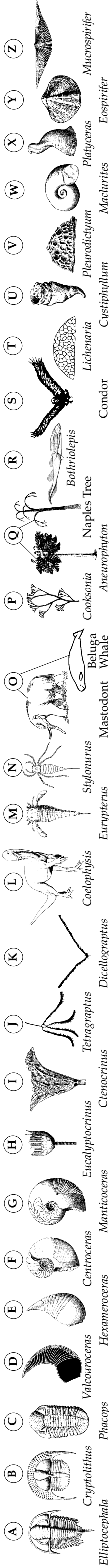
INORGANIC LAND-DERIVED SEDIMENTARY ROCKS					
TEXTURE	GRAIN SIZE	COMPOSITION	COMMENTS	ROCK NAME	MAP SYMBOL
Clastic (fragmental)	Pebbles, cobbles, and/or boulders embedded in sand, silt, and/or clay	Mostly quartz, feldspar, and clay minerals; may contain fragments of other rocks and minerals	Rounded fragments	Conglomerate	
			Angular fragments	Breccia	
	Sand (0.2 to 0.006 cm)		Fine to coarse	Sandstone	
	Silt (0.006 to 0.0004 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	Varied	Halite	Crystals from chemical precipitates and evaporites	Rock Salt	
	Varied	Gypsum		Rock Gypsum	
	Varied	Dolomite		Dolostone	
Bioclastic	Microscopic to coarse	Calcite	Cemented shell fragments or precipitates of biologic origin	Limestone	
	Varied	Carbon	From plant remains	Coal	

## Scheme for Metamorphic Rock Identification

TEXTURE	GRAIN SIZE	COMPOSITION	TYPE OF METAMORPHISM	COMMENTS	ROCK NAME	MAP SYMBOL
FOLIATED  MINERAL ALIGNMENT	Fine	MICA QUARTZ FELDSPAR AMPHIBOLE GARNET PYROXENE	Regional  (Heat and pressure increase with depth) ↓	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	
BAND- ING	Medium to coarse			High-grade metamorphism; some mica changed to feldspar; segregated by mineral type into bands	Gneiss	
NONFOLIATED	Fine	Variable	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 in particles and matrix			Pebbles may be distorted or stretched	Metaconglomerate	

# GEOLOGIC HISTORY OF NEW YORK STATE

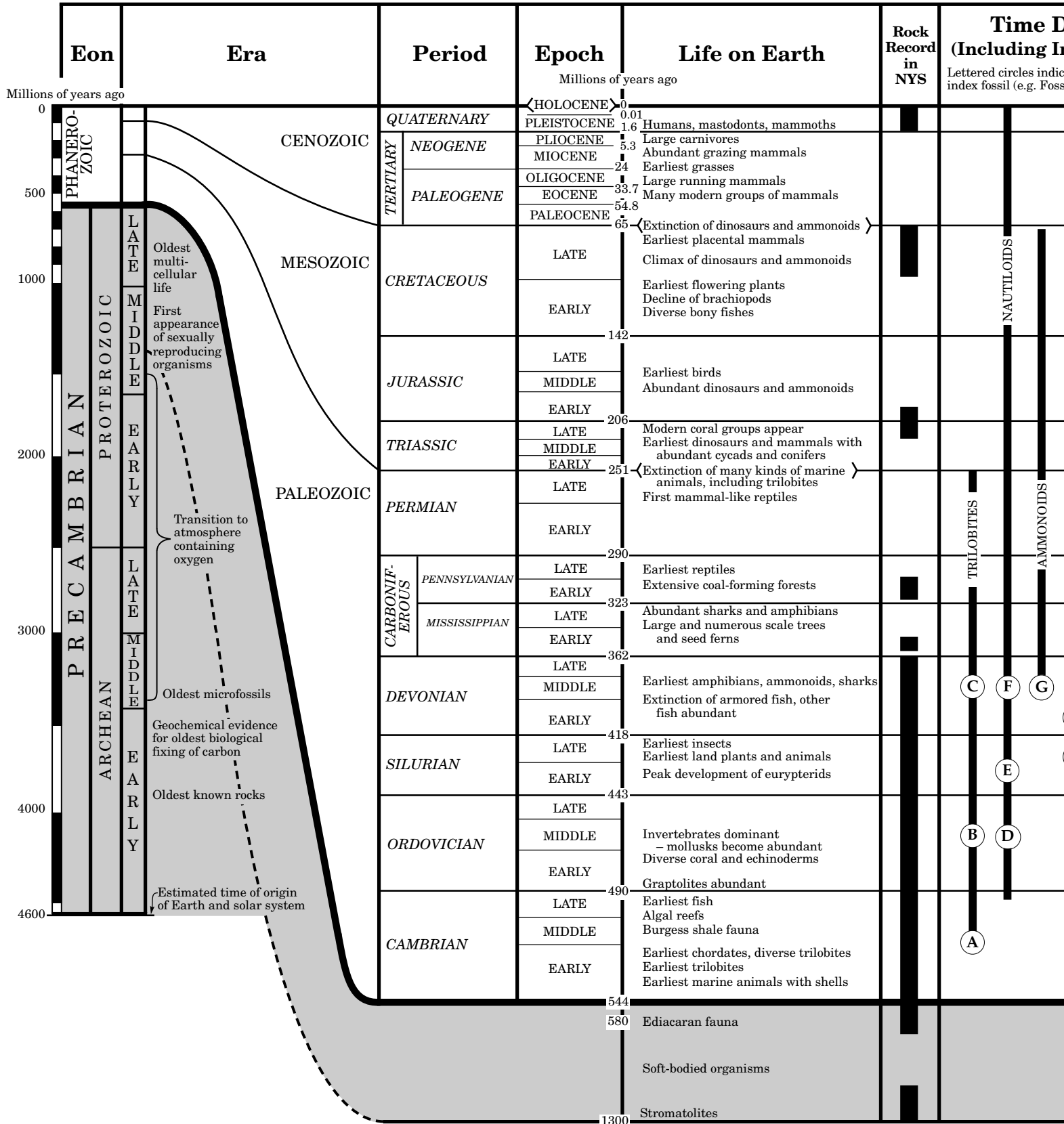
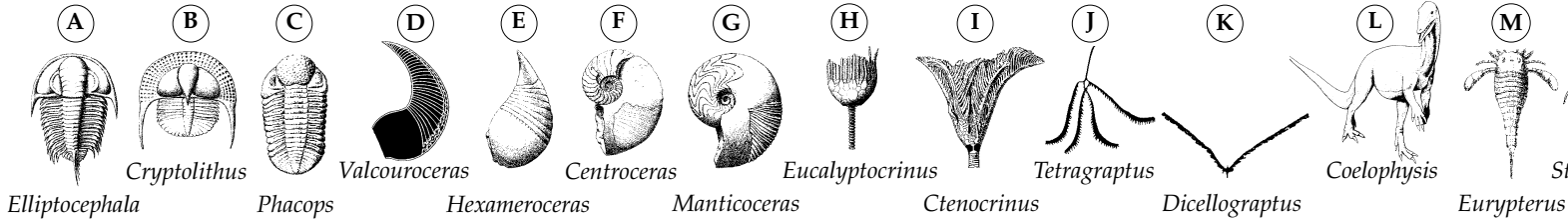
(Fossils not drawn to scale)



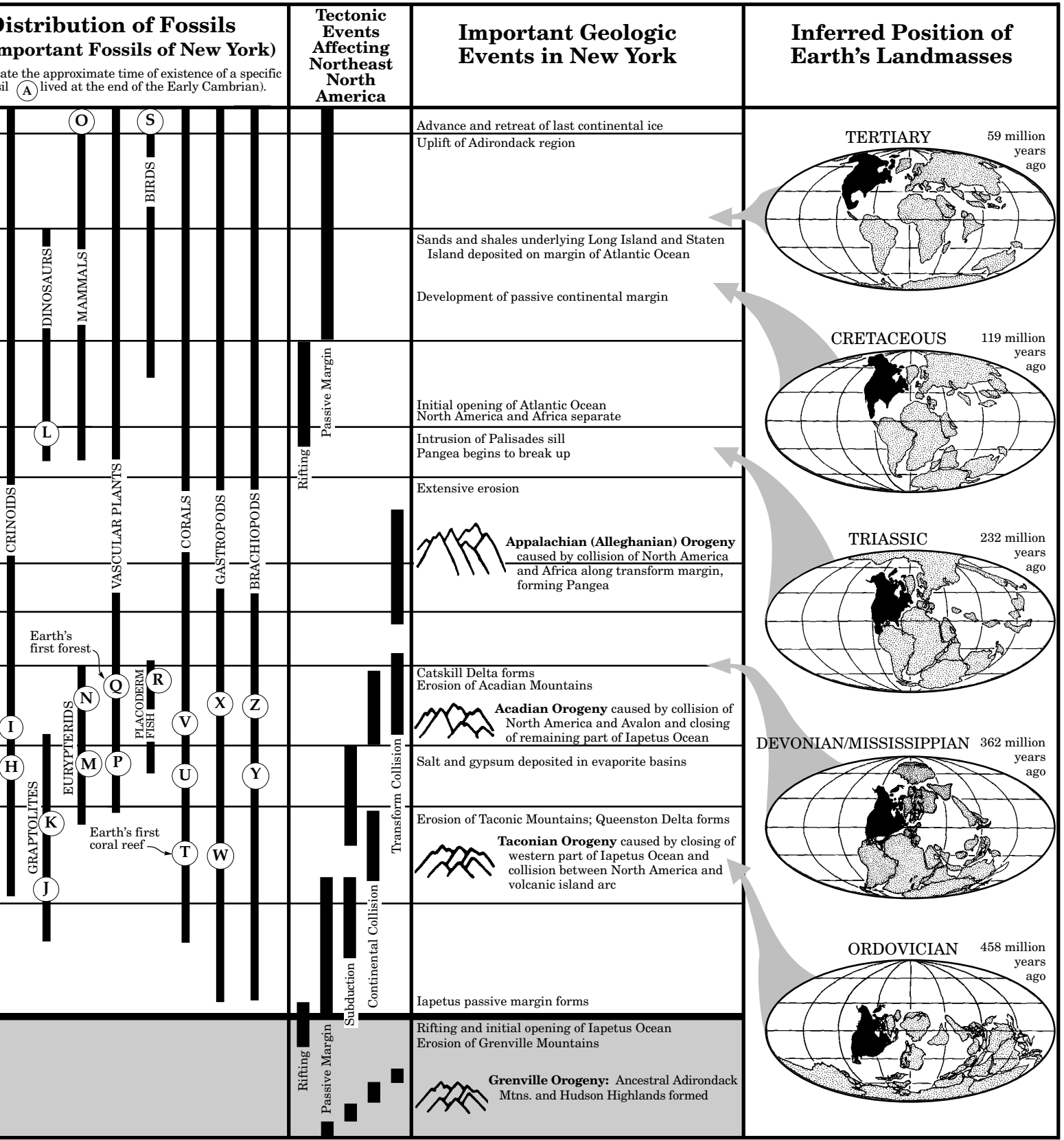
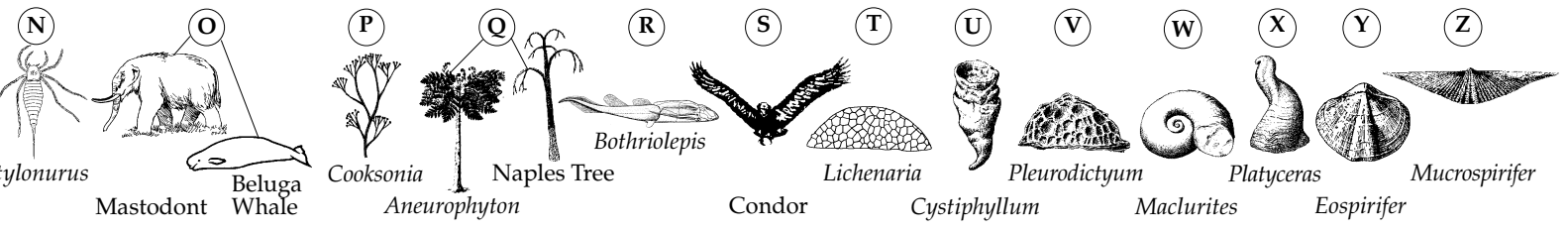
Eon	Era	Period	Epoch	Life on Earth	Rock Record in NYS	Time Distribution of Fossils (Including Important Fossils of New York)	Tectonic Events Affecting Northeast North America	Important Geologic Events in New York	Inferred Position of Earth's Landmasses	
PHANEROZOIC	CENOZOIC	QUATERNARY	HOLOCENE	Millions of years ago: 0-0.01 Humans, mastodonts, mammoths	■	■	■	Advance and retreat of last continental ice Uplift of Adirondack region	TERTIARY 59 million years ago	
		NEOGENE	PLIOCENE	0.01-1.6 Large carnivores	■	■	■	Sands and shales underlying Long Island and Staten Island deposited on margin of Atlantic Ocean Development of passive continental margin	CRETACEOUS 119 million years ago	
PROTEROZOIC	MESOZOIC	TERTIARY	MIOCENE	1.6-5.3 Abundant grazing mammals	■	■	■	Initial opening of Atlantic Ocean North America and Africa separate	TRIASSIC 232 million years ago	
			OLIGOCENE	5.3-24 Earliest grasses	■	■	■	Intrusion of Palisades sill Pangea begins to break up		
		PALEOGENE	Eocene	24-33.7 Large running mammals	■	■	■	■	DEVONIAN/MISSISSIPPIAN 362 million years ago	
			Eocene	33.7-54.8 Many modern groups of mammals	■	■	■	■		
		PALEOZOIC	CRETACEOUS	LATE	54.8-65 (Extinction of dinosaurs and ammonoids) Earliest placental mammals	■	■	■	Appalachian (Alleghenian) Orogeny caused by collision of North America and Africa along transform margin, forming Pangea	ORDOVICIAN 458 million years ago
				EARLY	65-142 Climax of dinosaurs and ammonoids Earliest flowering plants Decline of brachiopods Diverse bony fishes	■	■	■		
		PALEOZOIC	JURASSIC	LATE	142-206 Earliest birds Abundant dinosaurs and ammonoids	■	■	■	Acadian Orogeny caused by collision of North America and Avalon and closing of remaining part of Iapetus Ocean	Catskill Delta forms Erosion of Acadian Mountains
				MIDDLE	206-251 Modern coral groups appear Earliest dinosaurs and mammals with abundant cycads and conifers	■	■	■		
		PALEOZOIC	TRIASSIC	EARLY	251-290 (Extinction of many kinds of marine animals, including trilobites) First mammal-like reptiles	■	■	■	Salt and gypsum deposited in evaporite basins	Erosion of Taconic Mountains; Queenston Delta forms
				LATE	290-323 Earliest reptiles Extensive coal-forming forests	■	■	■		
PALEOZOIC	PERMIAN	CARBONIFEROUS	LATE	323-362 Abundant sharks and amphibians Large and numerous scale trees and seed ferns	■	■	■	Taconian Orogeny caused by closing of western part of Iapetus Ocean and collision between North America and volcanic island arc	Lapetus passive margin forms	
			EARLY	362-418 Earliest amphibians, ammonoids, sharks Extinction of armored fish, other fish abundant	■	■	■			
PALEOZOIC	DEVONIAN	SILURIAN	LATE	418-443 Earliest insects Earliest land plants and animals Peak development of eurypterids	■	■	■	Rifting and initial opening of Iapetus Ocean Erosion of Grenville Mountains	Grenville Orogeny: Ancestral Adirondack Mtns. and Hudson Highlands formed	
			MIDDLE	443-490 Invertebrates dominant - mollusks become abundant Diverse coral and echinoderms	■	■	■			
PALEOZOIC	ORDOVICIAN	CAMBRIAN	EARLY	490-544 Graptolites abundant	■	■	■	Lapetus passive margin forms	Grenville Orogeny: Ancestral Adirondack Mtns. and Hudson Highlands formed	
			LATE	544-580 Earliest fish Algal reefs Burgess shale fauna	■	■	■			
ARCHEAN	PALEOZOIC	CAMBRIAN	MIDDLE	580-1300 Earliest chordates, diverse trilobites Earliest trilobites Earliest marine animals with shells	■	■	■	Lapetus passive margin forms	Grenville Orogeny: Ancestral Adirondack Mtns. and Hudson Highlands formed	
			EARLY	1300-4600 Soft-bodied organisms Stromatolites	■	■	■			

# GEOLOGIC HISTORY

(Fossils not drawn to scale)

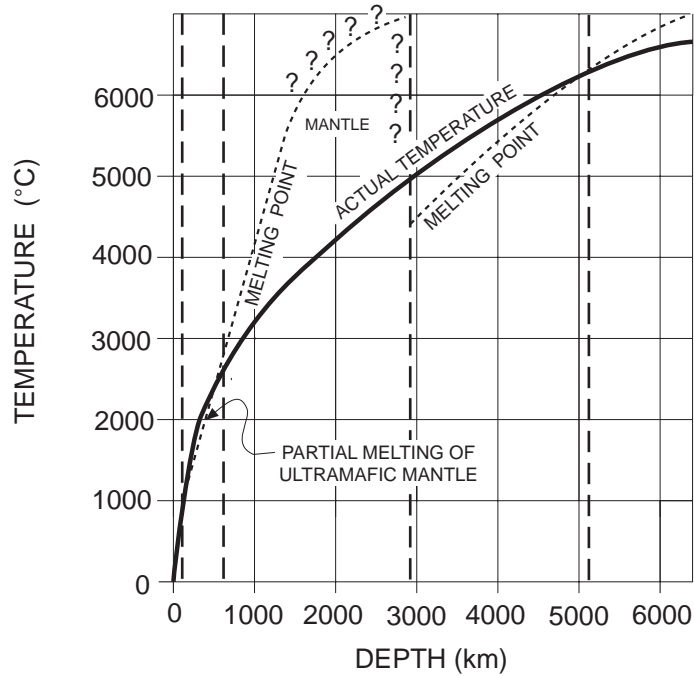
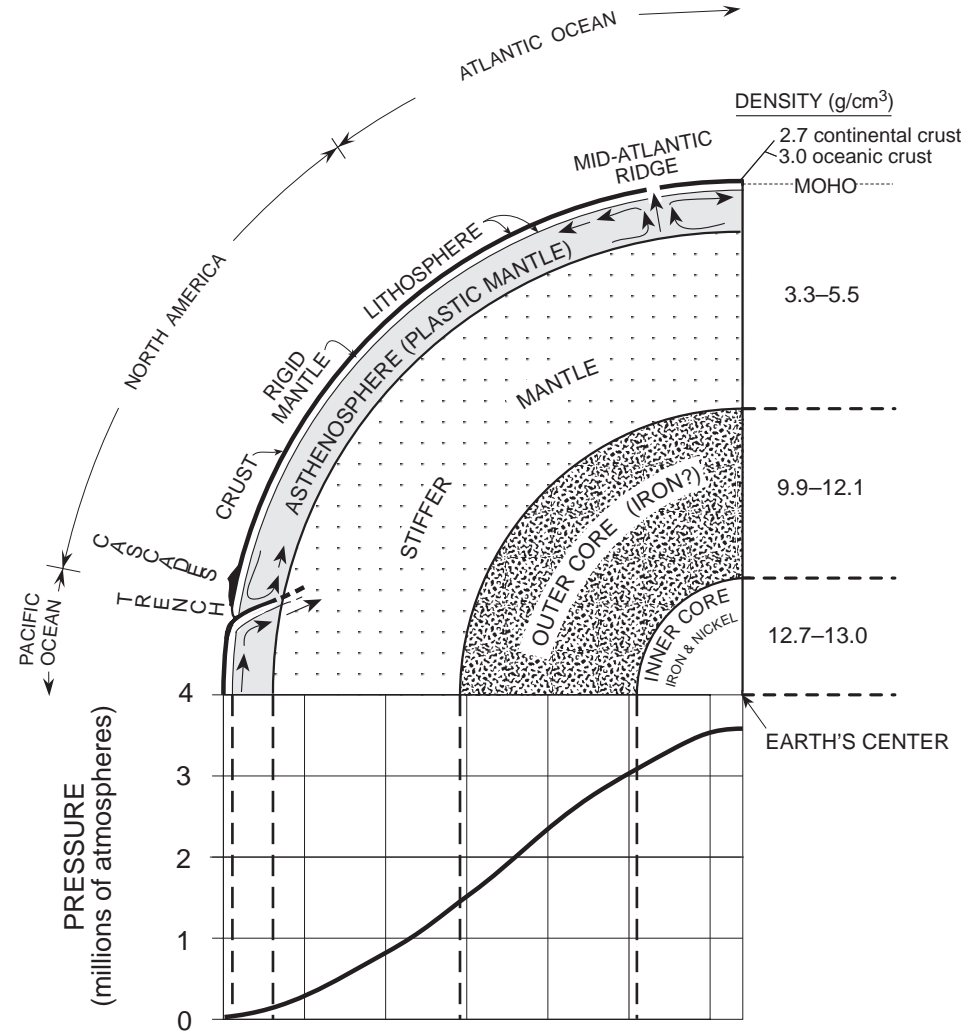


# DISTRIBUTION OF FOSSILS OF NEW YORK STATE



99-098 CDK(rev) 8/2000

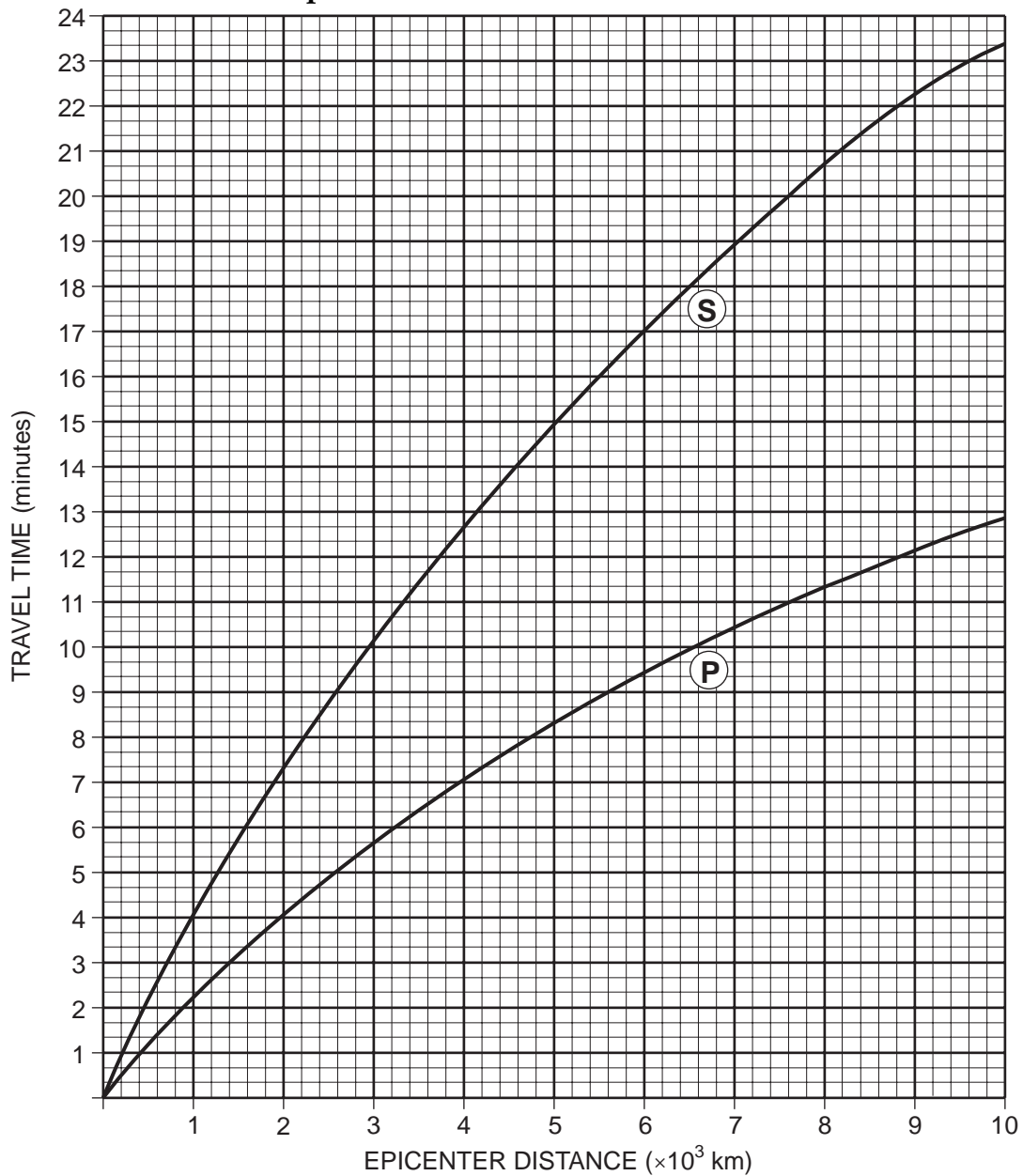
# Inferred Properties of Earth's Interior



## 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)	46.40	94.04	33.0	21.0
Silicon (Si)	28.15	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	0.66	0.07	1.0	1.0

### Earthquake P-wave and S-wave Travel Time



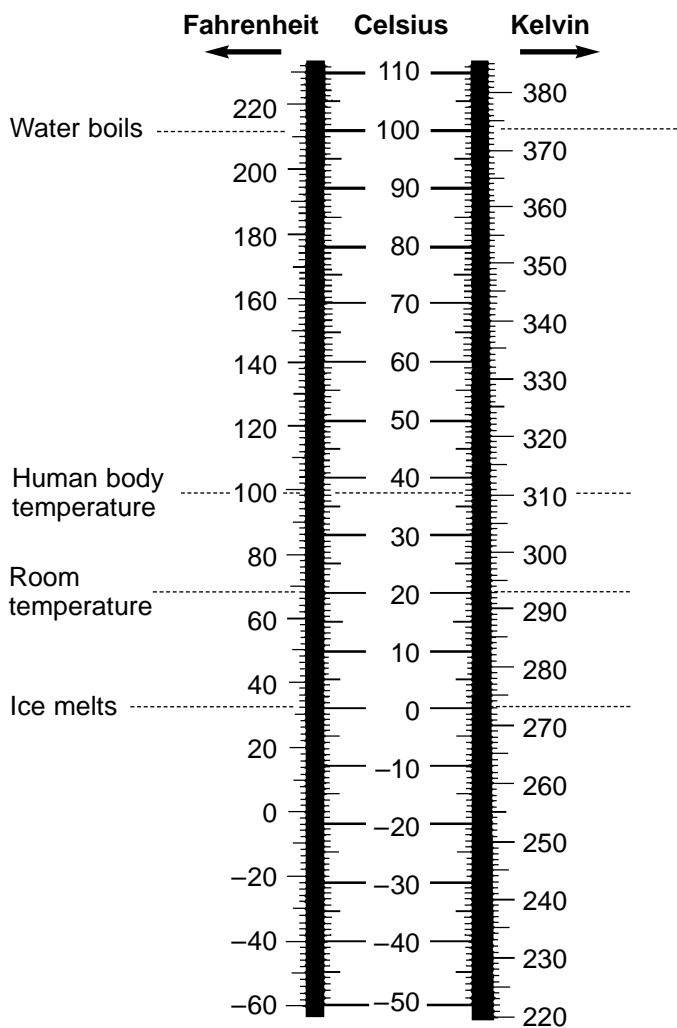
## Dewpoint Temperatures (°C)

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

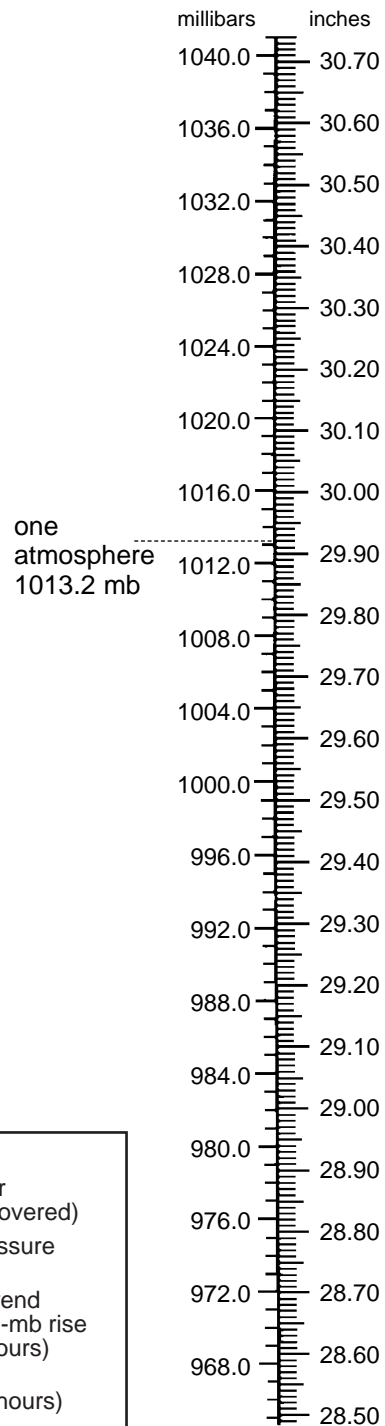
## Relative Humidity (%)

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

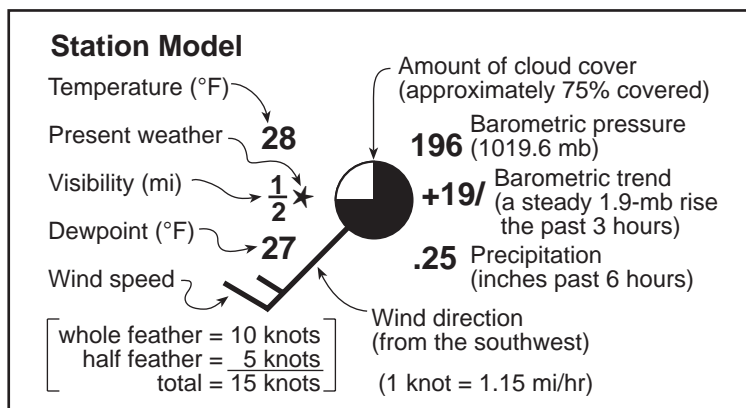
## Temperature



## Pressure

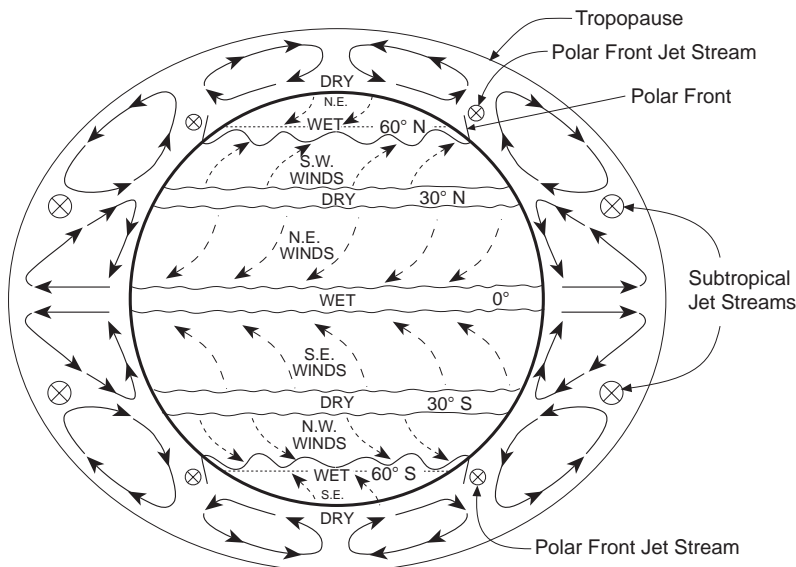
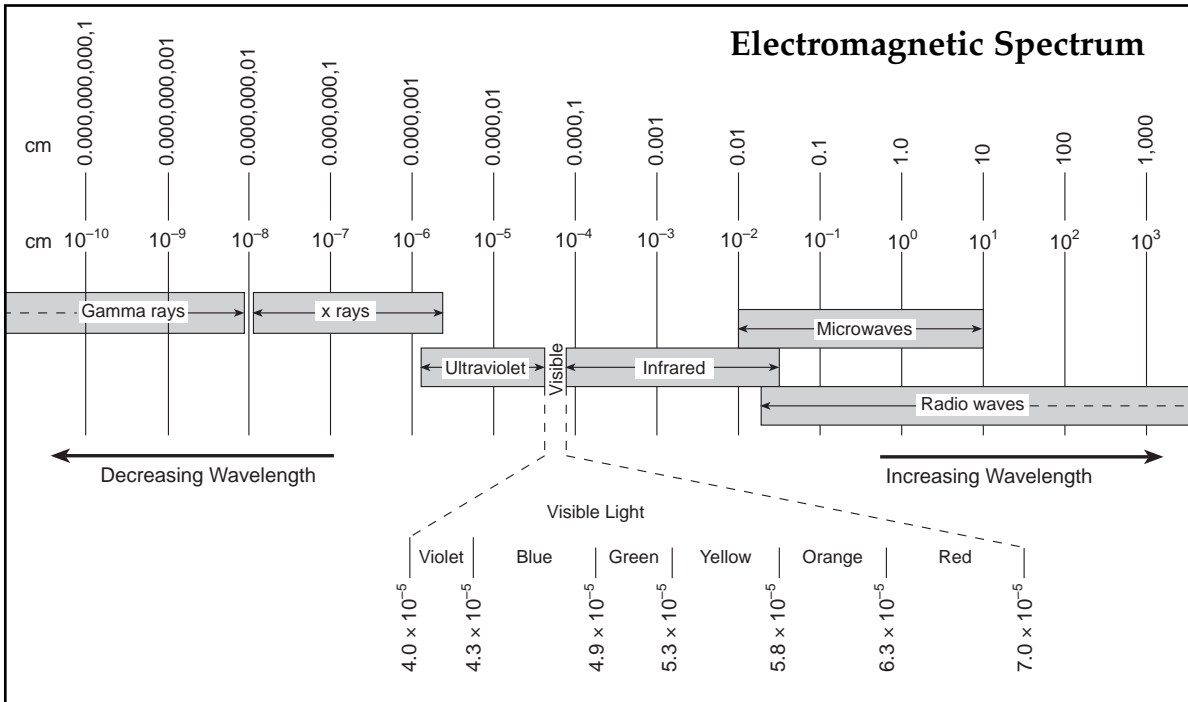
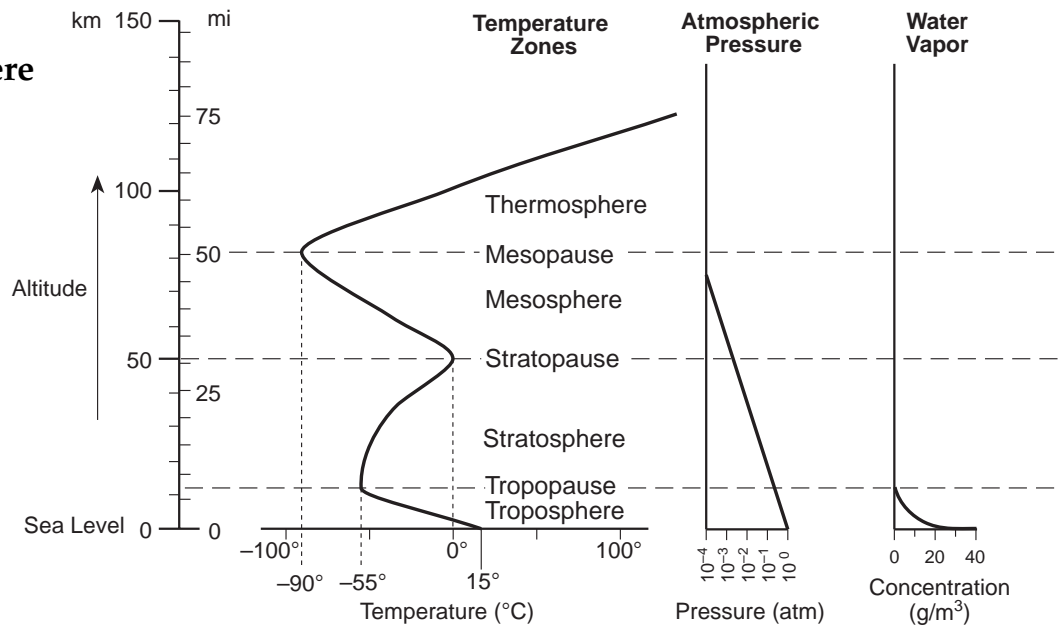


## Weather Map Symbols



Present Weather						Air Masses				Front Symbols			Hurricane
						cA	continental arctic	Cold					
						cP	continental polar	Warm					
						cT	continental tropical	Stationary					
						mT	maritime tropical	Occluded					
						mP	maritime polar						

# Selected Properties of Earth's Atmosphere

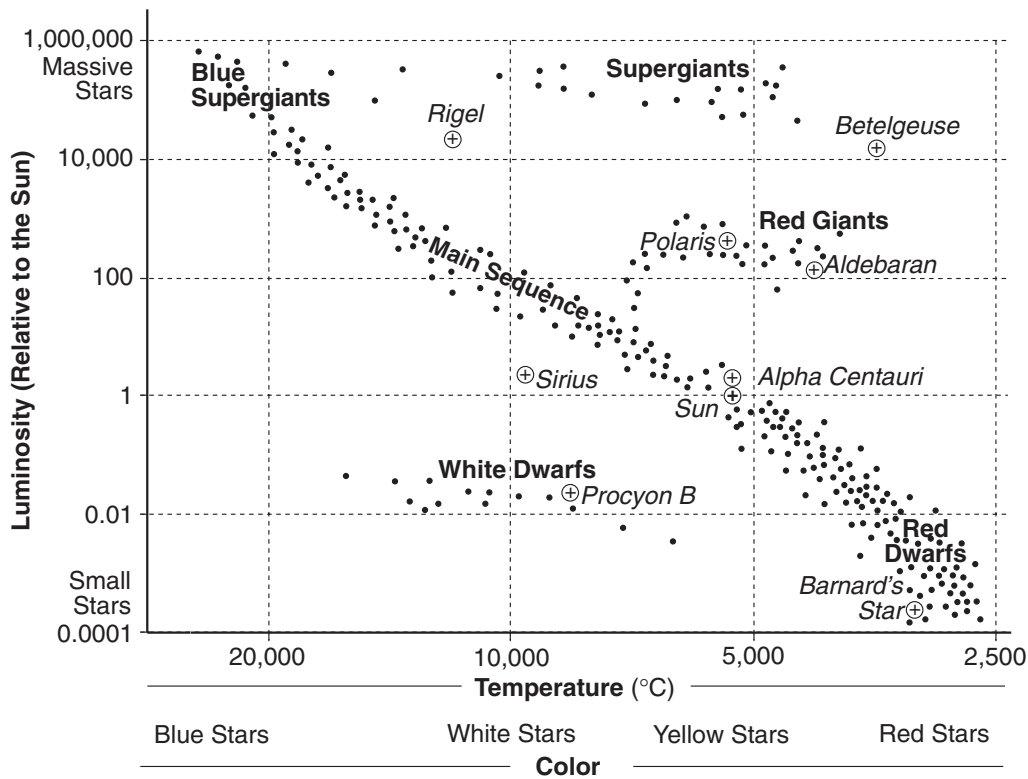


## Planetary Wind and Moisture Belts in the Troposphere

The drawing to the left 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 summer and southward in winter.

## Luminosity and Temperature of Stars

(Name in italics refers to star shown by a ⊕)







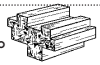




Luminosity is the brightness of stars compared to the brightness of our Sun as seen from the same distance from the observer.

## Solar System Data

Object	Mean Distance from Sun (millions of km)	Period of Revolution	Period of Rotation	Eccentricity of Orbit	Equatorial Diameter (km)	Mass (Earth = 1)	Density (g/cm <sup>3</sup> )	Number of Moons
SUN	—	—	27 days	—	1,392,000	333,000.00	1.4	—
MERCURY	57.9	88 days	59 days	0.206	4,880	0.553	5.4	0
VENUS	108.2	224.7 days	243 days	0.007	12,104	0.815	5.2	0
EARTH	149.6	365.26 days	23 hr 56 min 4 sec	0.017	12,756	1.00	5.5	1
MARS	227.9	687 days	24 hr 37 min 23 sec	0.093	6,787	0.1074	3.9	2
JUPITER	778.3	11.86 years	9 hr 50 min 30 sec	0.048	142,800	317.896	1.3	16
SATURN	1,427	29.46 years	10 hr 14 min	0.056	120,000	95.185	0.7	18
URANUS	2,869	84.0 years	17 hr 14 min	0.047	51,800	14.537	1.2	21
NEPTUNE	4,496	164.8 years	16 hr	0.009	49,500	17.151	1.7	8
EARTH'S MOON	149.6 (0.386 from Earth)	27.3 days	27 days 8 hr	0.055	3,476	0.0123	3.3	—

## Properties of Common Minerals

LUSTER	HARD-NESS	CLEAVAGE FRACTURE	COMMON COLORS	DISTINGUISHING CHARACTERISTICS	USE(S)	MINERAL NAME	COMPOSITION*
<b>Metallic Luster</b>	1–2	✓	silver to gray	black streak, greasy feel	pencil lead, lubricants	<b>Graphite</b>	C
	2.5	✓	metallic silver	very dense (7.6 g/cm <sup>3</sup> ), gray-black streak 	ore of lead	<b>Galena</b>	PbS
	5.5–6.5	✓	black to silver	attracted by magnet, black streak	ore of iron	<b>Magnetite</b>	Fe <sub>3</sub> O <sub>4</sub>
	6.5	✓	brassy yellow	green-black streak, cubic crystals 	ore of sulfur	<b>Pyrite</b>	FeS <sub>2</sub>
<b>Either</b>	1–6.5	✓	metallic silver or earthy red	red-brown streak	ore of iron	<b>Hematite</b>	Fe <sub>2</sub> O <sub>3</sub>
<b>Nonmetallic Luster</b>	1	✓	white to green	greasy feel	talcum powder, soapstone	<b>Talc</b>	Mg <sub>3</sub> Si <sub>4</sub> O <sub>10</sub> (OH) <sub>2</sub>
	2	✓	yellow to amber	easily melted, may smell	vulcanize rubber, sulfuric acid	<b>Sulfur</b>	S
	2	✓	white to pink or gray	easily scratched by fingernail	plaster of paris and drywall	<b>Gypsum (Selenite)</b>	CaSO <sub>4</sub> •2H <sub>2</sub> O
	2–2.5	✓	colorless to yellow	flexible in thin sheets 	electrical insulator	<b>Muscovite Mica</b>	KAl <sub>3</sub> Si <sub>3</sub> O <sub>10</sub> (OH) <sub>2</sub>
	2.5	✓	colorless to white	cubic cleavage, salty taste 	food additive, melts ice	<b>Halite</b>	NaCl
	2.5–3	✓	black to dark brown	flexible in thin sheets 	electrical insulator	<b>Biotite Mica</b>	K(Mg,Fe) <sub>3</sub> AlSi <sub>3</sub> O <sub>10</sub> (OH) <sub>2</sub>
	3	✓	colorless or variable	bubbles with acid 	cement, polarizing prisms	<b>Calcite</b>	CaCO <sub>3</sub>
	3.5	✓	colorless or variable	bubbles with acid when powdered	source of magnesium	<b>Dolomite</b>	CaMg(CO <sub>3</sub> ) <sub>2</sub>
	4	✓	colorless or variable	cleaves in 4 directions	hydrofluoric acid	<b>Fluorite</b>	CaF <sub>2</sub>
	5–6	✓	black to dark green	cleaves in 2 directions at 90° 	mineral collections	<b>Pyroxene (commonly Augite)</b>	(Ca,Na)(Mg,Fe,Al)(Si,Al) <sub>2</sub> O <sub>6</sub>
	5.5	✓	black to dark green	cleaves at 56° and 124° 	mineral collections	<b>Amphiboles (commonly Hornblende)</b>	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>
	6	✓	white to pink	cleaves in 2 directions at 90°	ceramics and glass	<b>Potassium Feldspar (Orthoclase)</b>	KAlSi <sub>3</sub> O <sub>8</sub>
	6	✓	white to gray	cleaves in 2 directions, striations visible	ceramics and glass	<b>Plagioclase Feldspar (Na-Ca Feldspar)</b>	(Na,Ca)AlSi <sub>3</sub> O <sub>8</sub>
	6.5	✓	green to gray or brown	commonly light green and granular	furnace bricks and jewelry	<b>Olivine</b>	(Fe,Mg) <sub>2</sub> SiO <sub>4</sub>
	7	✓	colorless or variable	glassy luster, may form hexagonal crystals 	glass, jewelry, and electronics	<b>Quartz</b>	SiO <sub>2</sub>
7	✓	dark red to green	glassy luster, often seen as red grains in NYS metamorphic rocks	jewelry and abrasives	<b>Garnet (commonly Almandine)</b>	Fe <sub>3</sub> Al <sub>2</sub> Si <sub>3</sub> O <sub>12</sub>	

\*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