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Reference Tables for Physical Setting/EARTH SCIENCE

Radioactive Decay Data

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

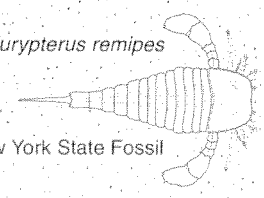
Heat energy gained during melting	334 J/g
Heat energy released during freezing	334 J/g
Heat energy gained during vaporization	2260 J/g
Heat energy released during condensation	2260 J/g
Density at 3.98°C	1.0 g/mL

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

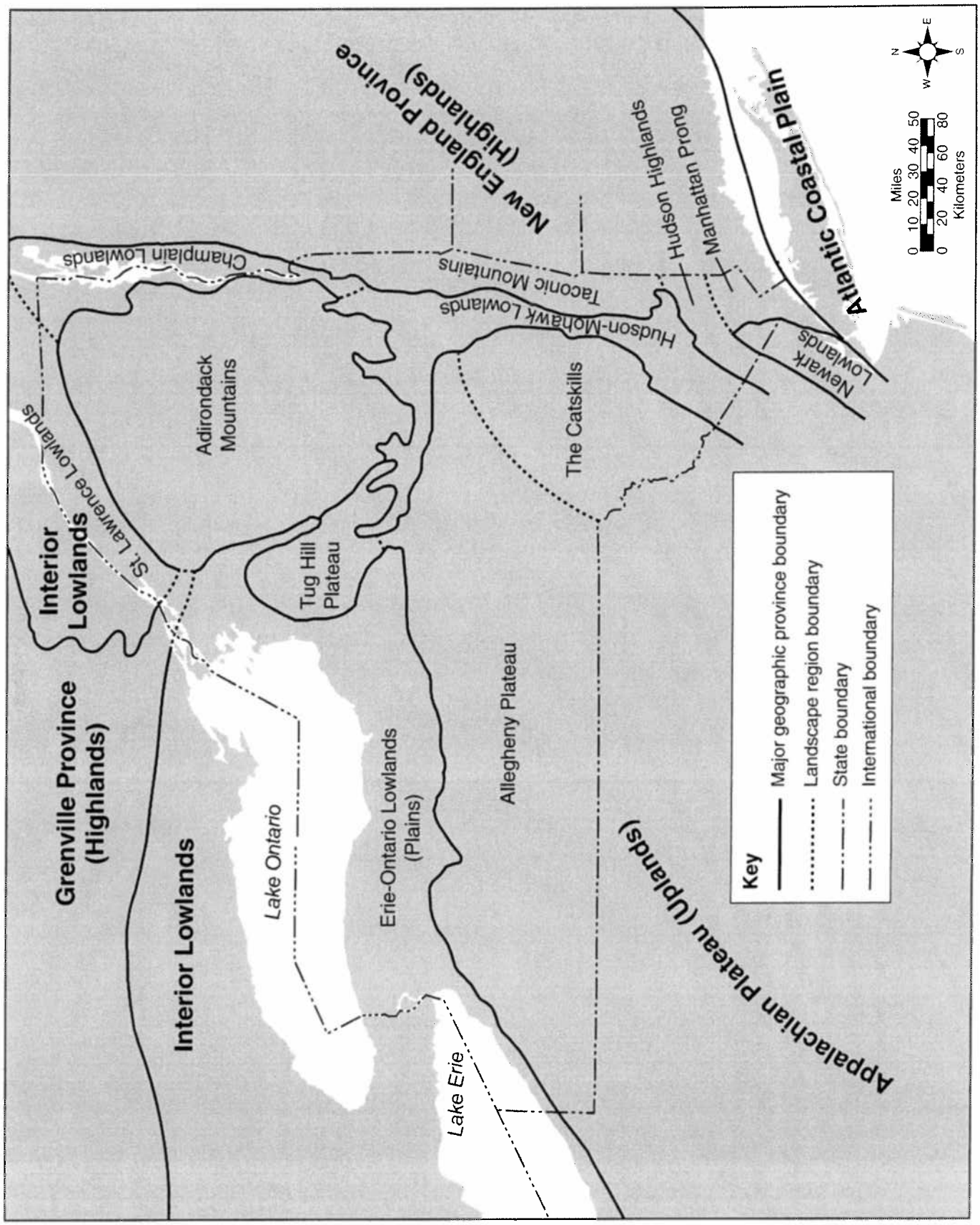
This edition of the Earth Science Reference Tables should be used in the classroom beginning in the 2011–12 school year. The first examination for which these tables will be used is the January 2012 Regents Examination in Physical Setting/Earth Science.



Eurypterus remipes

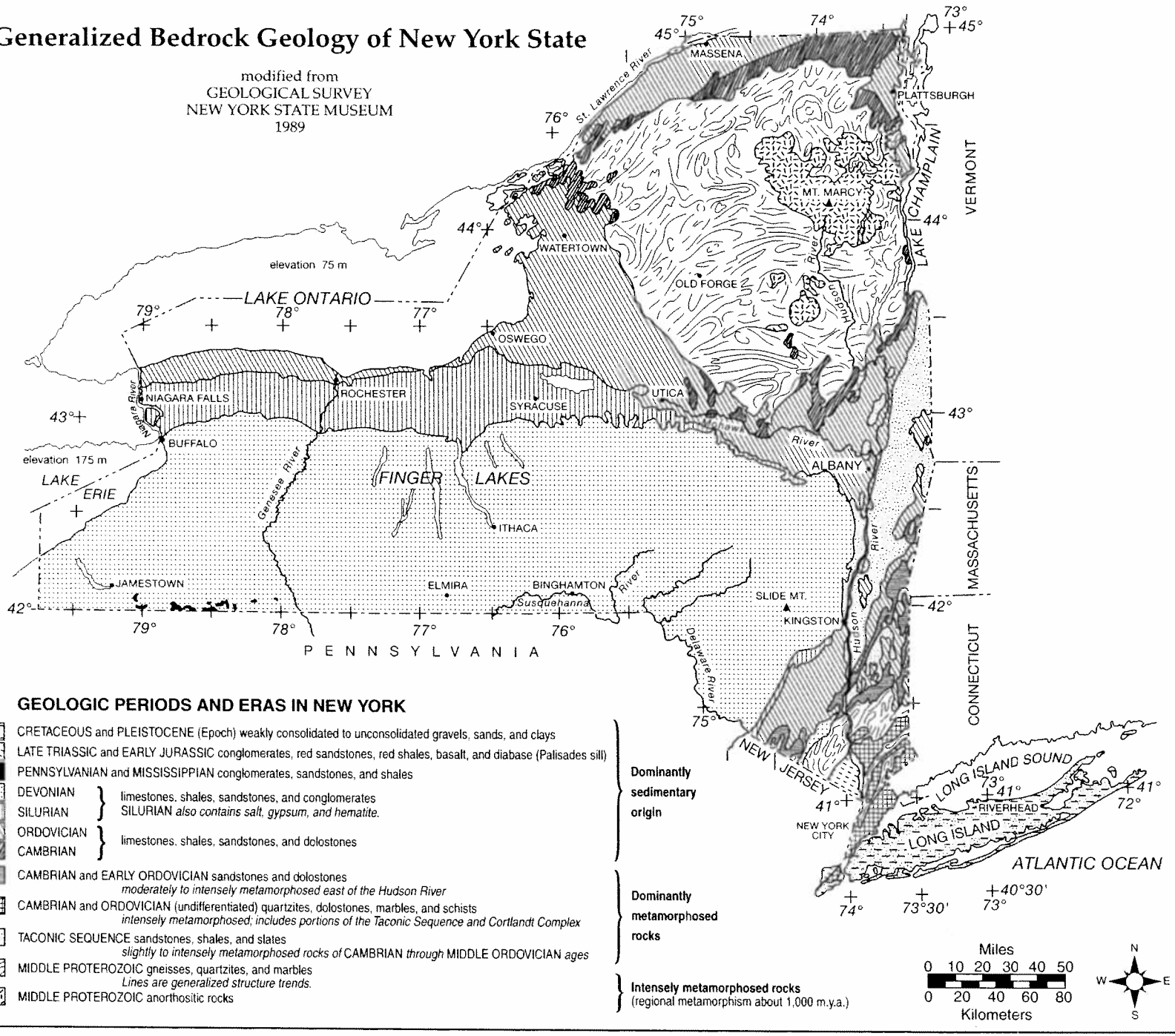
New York State Fossil

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

Dominantly sedimentary origin

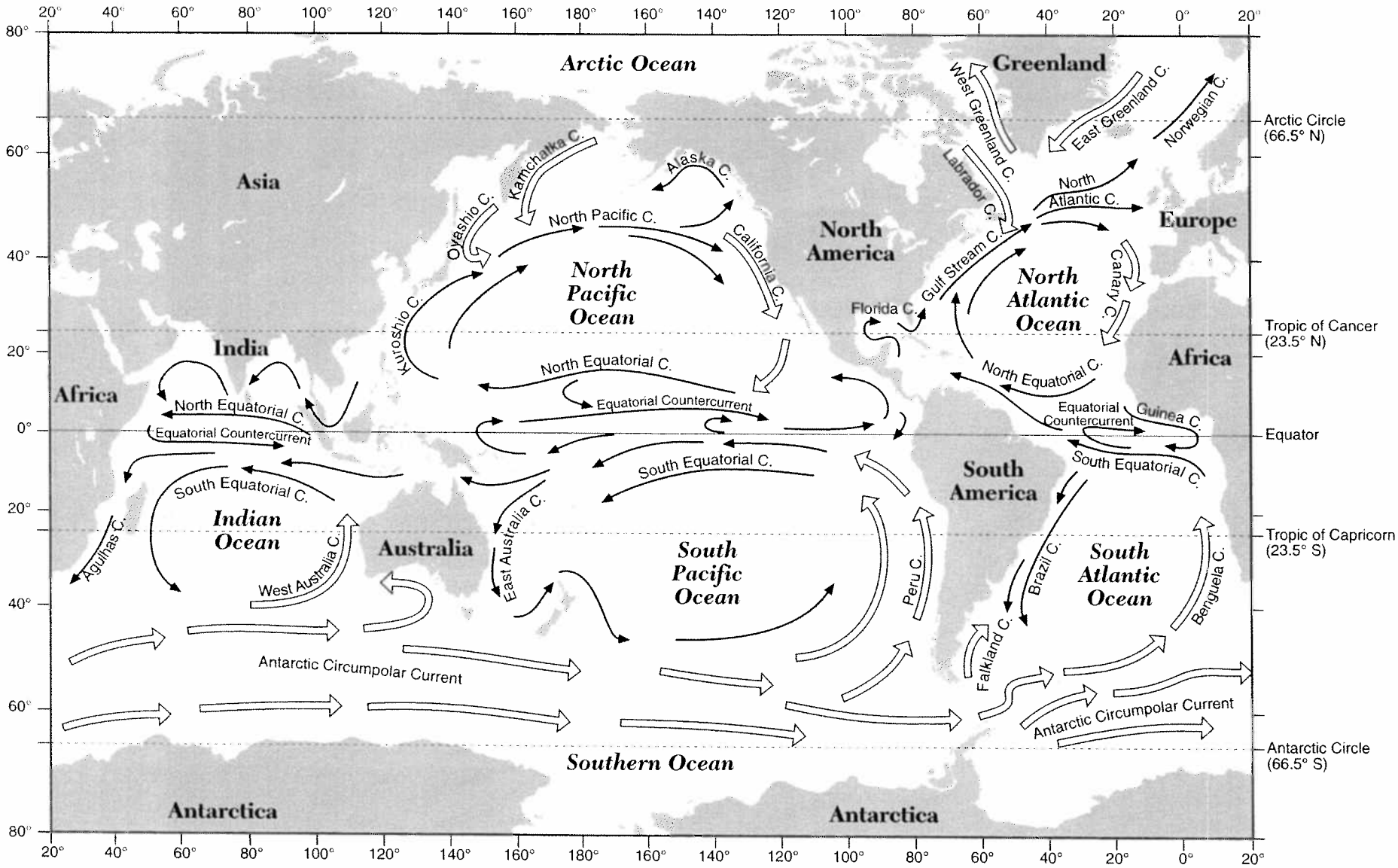
- CRETACEOUS and PLEISTOCENE (Epoch) weakly consolidated to unconsolidated gravels, sands, and clays
- LATE TRIASSIC and EARLY JURASSIC conglomerates, red sandstones, red shales, basalt, and diabase (Palisades sill)
- PENNSYLVANIAN and MISSISSIPPIAN conglomerates, sandstones, and shales
- DEVONIAN, SILURIAN — limestones, shales, sandstones, and conglomerates; SILURIAN *also contains salt, gypsum, and hematite.*
- ORDOVICIAN, CAMBRIAN — limestones, shales, sandstones, and dolostones

Dominantly metamorphosed rocks

- 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 Cortlandt Complex*
- TACONIC SEQUENCE sandstones, shales, and slates *slightly to intensely metamorphosed rocks of* CAMBRIAN *through* MIDDLE ORDOVICIAN *ages*
- MIDDLE PROTEROZOIC gneisses, quartzites, and marbles *Lines are generalized structure trends.*
- MIDDLE PROTEROZOIC anorthositic rocks

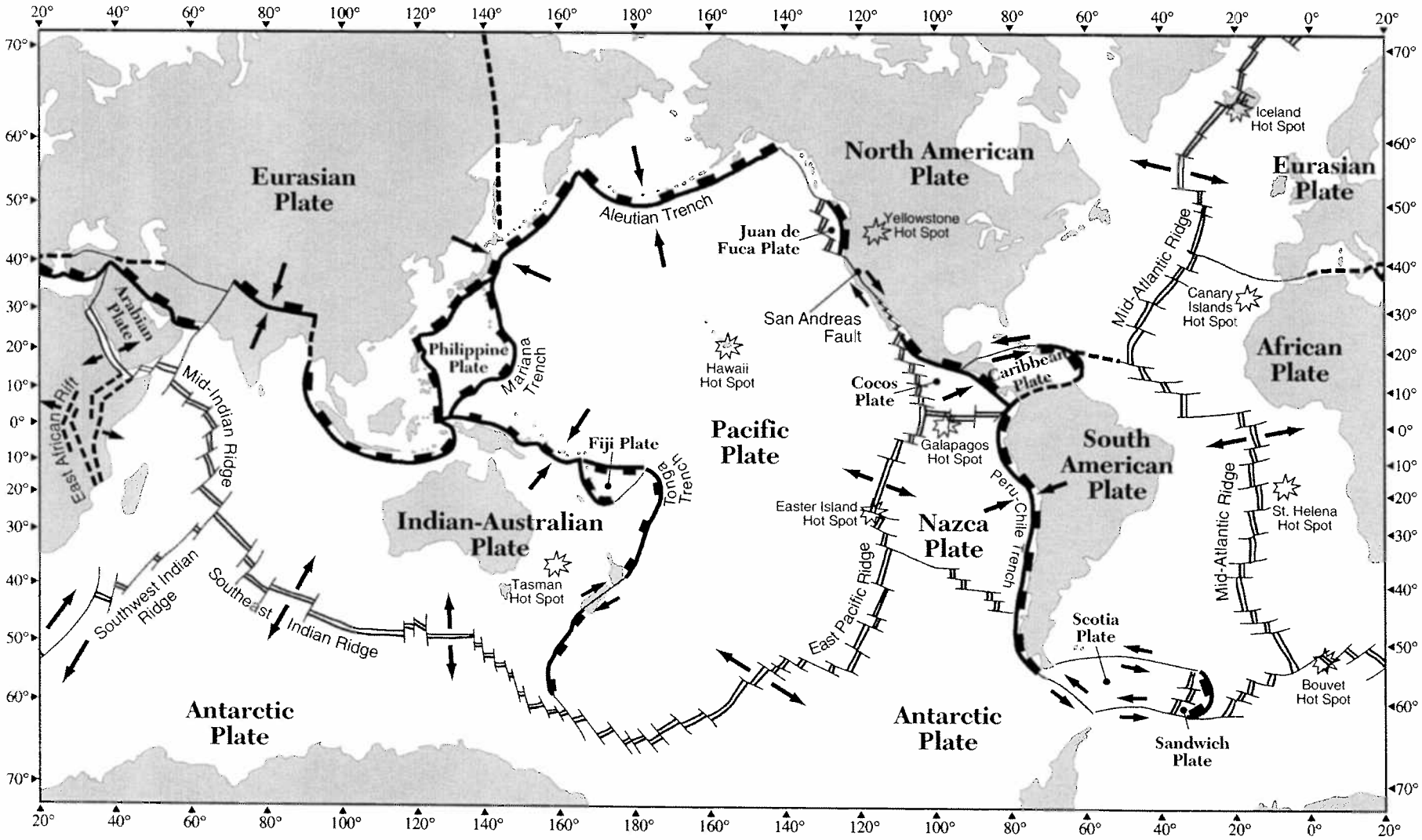
Intensely metamorphosed rocks (regional metamorphism about 1,000 m.y.a.)

Surface Ocean Currents



NOTE: Not all surface ocean currents are shown.

Tectonic Plates

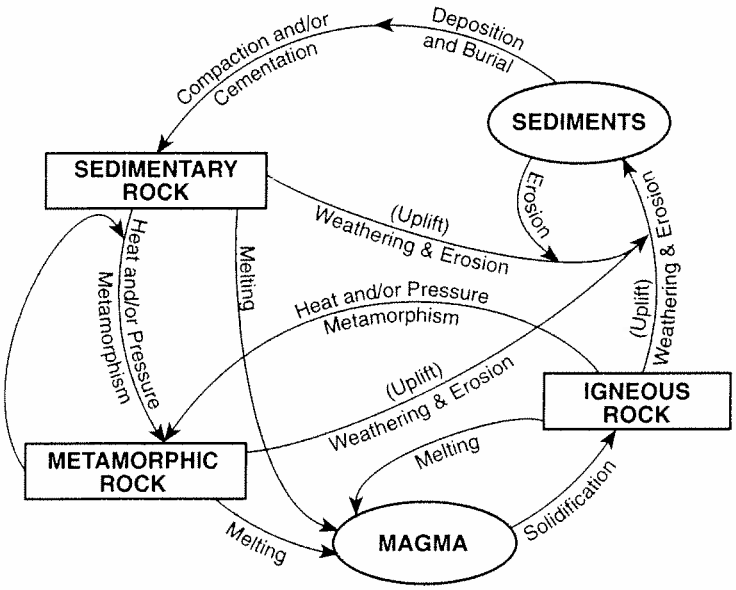


Key

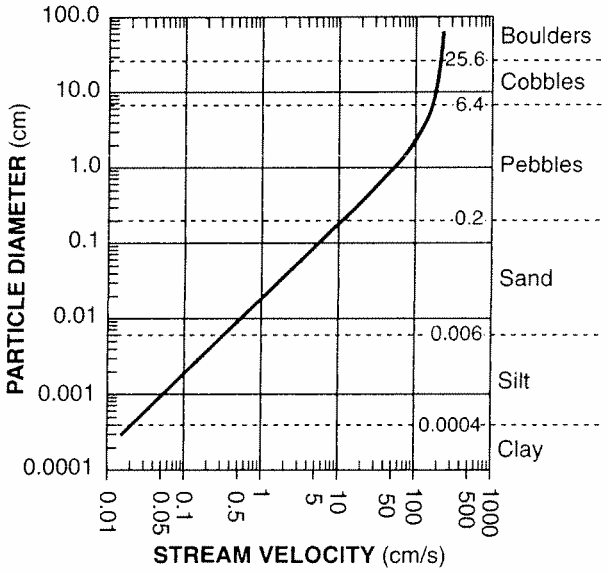
- Relative motion at plate boundary
- Transform plate boundary (transform fault)
- Divergent plate boundary (usually broken by transform faults along mid-ocean ridges)
- overriding plate / subducting plate — Convergent plate boundary (subduction zone)
- Complex or uncertain plate boundary
- Mantle hot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

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

Rock Cycle in Earth's Crust



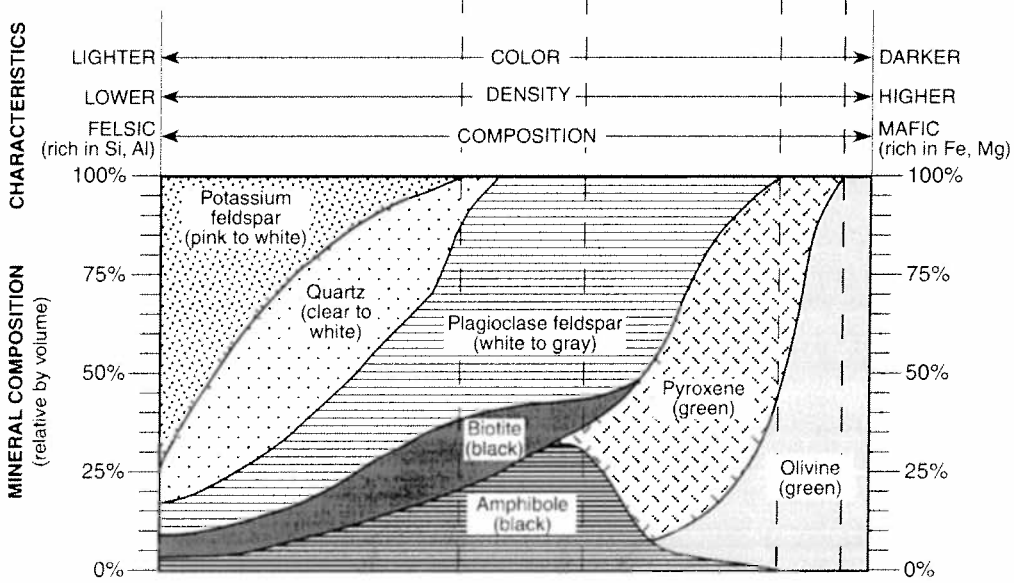
Relationship of Transported Particle Size to Water Velocity



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

IGNEOUS ROCKS	ENVIRONMENT OF FORMATION					CRYSTAL SIZE	TEXTURE	
	EXTRUSIVE (Volcanic)	Obsidian (usually appears black)		Basaltic glass		non-crystalline	Glassy	Non-vesicular
		Pumice		Scoria				Vesicular (gas pockets)
		Vesicular rhyolite	Vesicular andesite	Vesicular basalt		less than 1 mm	Fine	
		Rhyolite	Andesite	Basalt				Non-vesicular
	INTRUSIVE (Plutonic)	Granite	Diorite	Diabase / Gabbro	Peri-dotite / Dunite	1 mm to 10 mm	Coarse	
		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	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**	
					Platy mica crystals visible from metamorphism of clay or feldspars	**Schist**	
	BAND-ING	Medium to coarse			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

Eon	Era	Period	Epoch	Million years ago	Life on Earth	NY Rock Record
			HOLOCENE	0		Sediment
PHANEROZOIC	CENOZOIC	QUATERNARY	PLEISTOCENE	0.01	Humans, mastodonts, mammoths	
		NEOGENE	PLIOCENE	1.8		
			MIOCENE	5.3	Large carnivorous mammals Abundant grazing mammals	
		PALEOGENE	OLIGOCENE	23.0		
			EOCENE	33.9	Earliest grasses Many modern groups of mammals	
			PALEOCENE	55.8		
				65.5	Mass extinction of dinosaurs, ammonoids, and many land plants	
PROTEROZOIC	MESOZOIC	CRETACEOUS	LATE			Bedrock
			EARLY		Earliest flowering plants Diverse bony fishes	
				146		
		JURASSIC	LATE		Earliest birds	
			MIDDLE		Abundant dinosaurs and ammonoids	
			EARLY			
				200		
		TRIASSIC	LATE		Earliest mammals	
			MIDDLE		Earliest dinosaurs	
			EARLY			
				251	Mass extinction of many land and marine organisms (including trilobites)	
	PALEOZOIC	PERMIAN	LATE			
			MIDDLE		Mammal-like reptiles	
			EARLY		Abundant reptiles	
				299		
		CARBONIFEROUS – PENNSYLVANIAN	LATE			
			EARLY		Extensive coal-forming forests	
				318		
		CARBONIFEROUS – MISSISSIPPIAN	LATE		Abundant amphibians	
			MIDDLE		Large and numerous scale trees and seed ferns (vascular plants); earliest reptiles	
			EARLY			
				359		
		DEVONIAN	LATE		Earliest amphibians and plant seeds Extinction of many marine organisms	
			MIDDLE		Earth's first forests Earliest ammonoids and sharks	
			EARLY		Abundant fish	
				416		
		SILURIAN	LATE		Earliest insects Earliest land plants and animals	
			EARLY		Abundant eurypterids	
				444		
		ORDOVICIAN	LATE			
			MIDDLE		Invertebrates dominant Earth's first coral reefs	
			EARLY			
				488		
		CAMBRIAN	LATE			
			MIDDLE		Burgess shale fauna (diverse soft-bodied organisms) Earliest fishes	
			EARLY		Extinction of many primitive marine organisms Earliest trilobites	
				542	Great diversity of life-forms with shelly parts	
				580	Ediacaran fauna (first multicellular, soft-bodied marine organisms)	
				1300	Abundant stromatolites	

Million years ago: 0, 500, 1000, 2000, 3000, 4000, 4600

PRECAMBRIAN — PROTEROZOIC: LATE, MIDDLE, EARLY; ARCHEAN: LATE, MIDDLE, EARLY

First sexually reproducing organisms

Oceanic oxygen begins to enter the atmosphere

Oceanic oxygen produced by cyanobacteria combines with iron, forming iron oxide layers on ocean floor

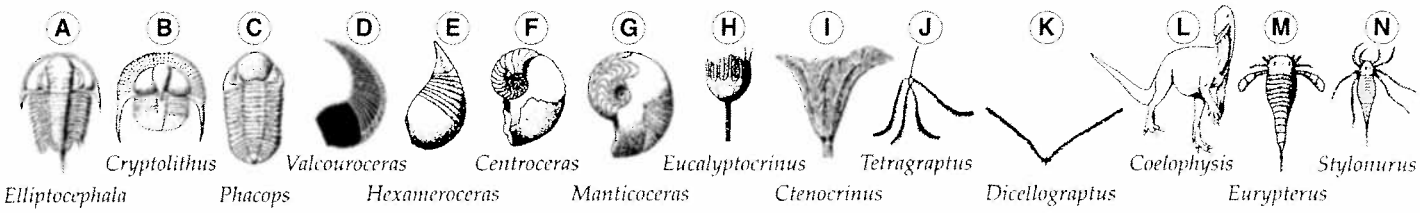
Earliest stromatolites
Oldest microfossils

Evidence of biological carbon

Oldest known rocks

Estimated time of origin of Earth and solar system

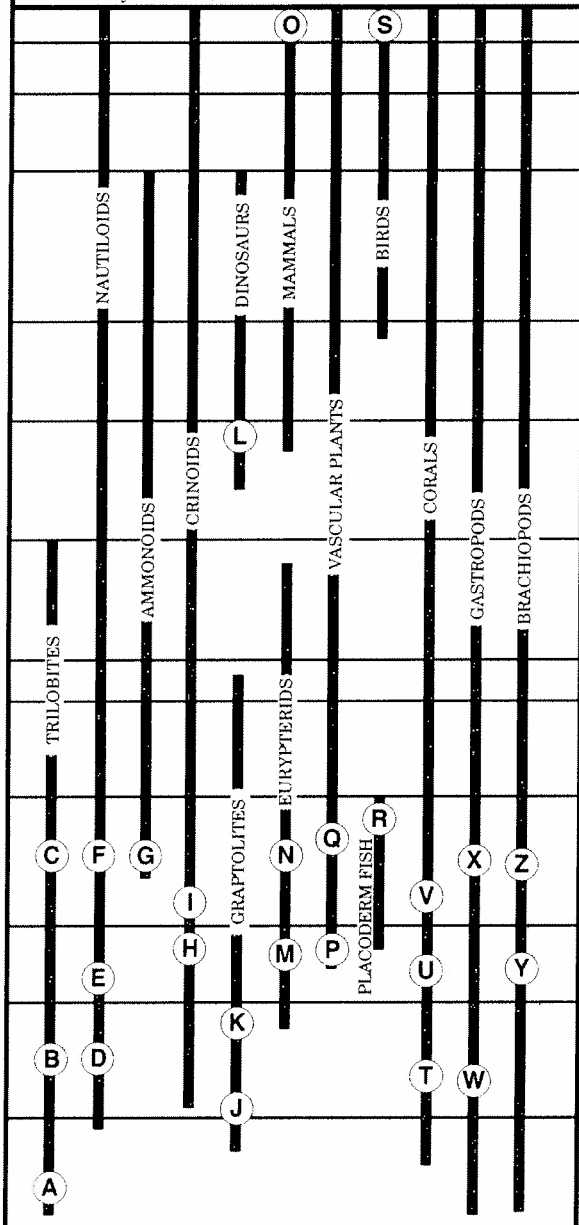
(Index fossils not drawn to scale)



OF NEW YORK STATE

Time Distribution of Fossils (including important fossils of New York)

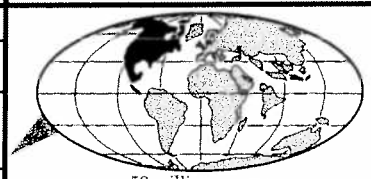
The center of each lettered circle indicates the approximate time of existence of a specific index fossil (e.g. Fossil (A) lived at the end of the Early Cambrian).



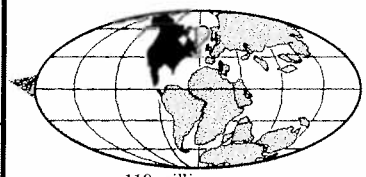
Important Geologic Events in New York

- Advance and retreat of last continental ice
- Sands and clays underlying Long Island and Staten Island deposited on margin of Atlantic Ocean
- Dome-like uplift of Adirondack region begins
- Initial opening of Atlantic Ocean
- North America and Africa separate
- ⟨ Intrusion of Palisades sill ⟩
- Pangaea begins to break up
- **Alleghenian orogeny** caused by collision of North America and Africa along transform margin, forming Pangaea
- 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
- 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
- Widespread deposition over most of New York along edge of Iapetus Ocean
- Rifting and initial opening of Iapetus Ocean
- Erosion of Grenville Mountains
- **Grenville orogeny:** metamorphism of bedrock now exposed in the Adirondacks and Hudson Highlands

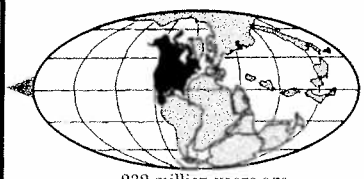
Inferred Positions of Earth's Landmasses



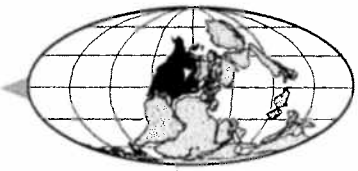
59 million years ago



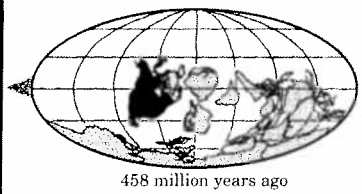
119 million years ago



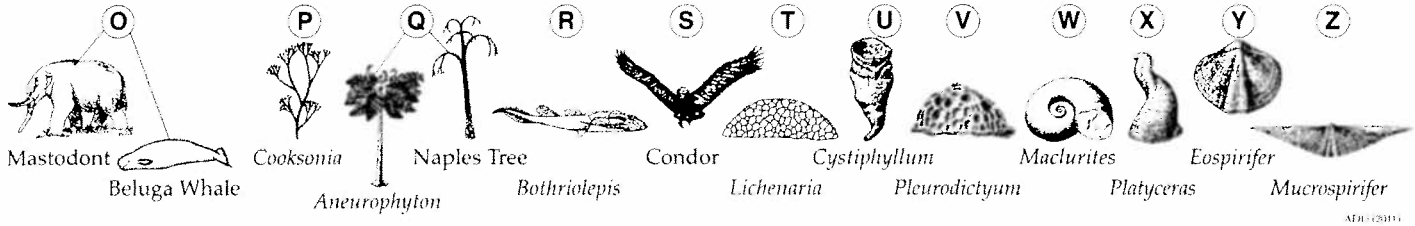
232 million years ago



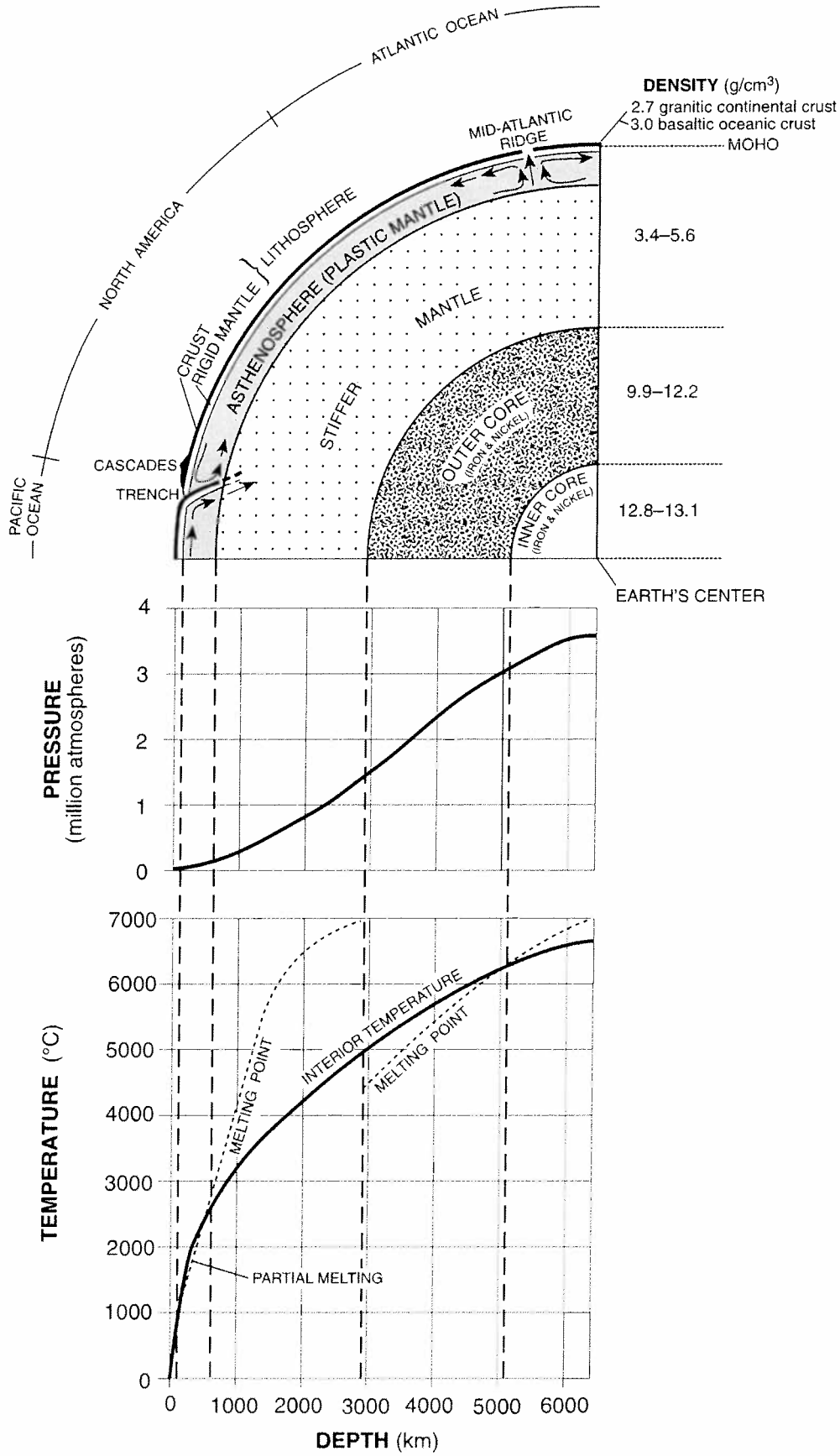
359 million years ago



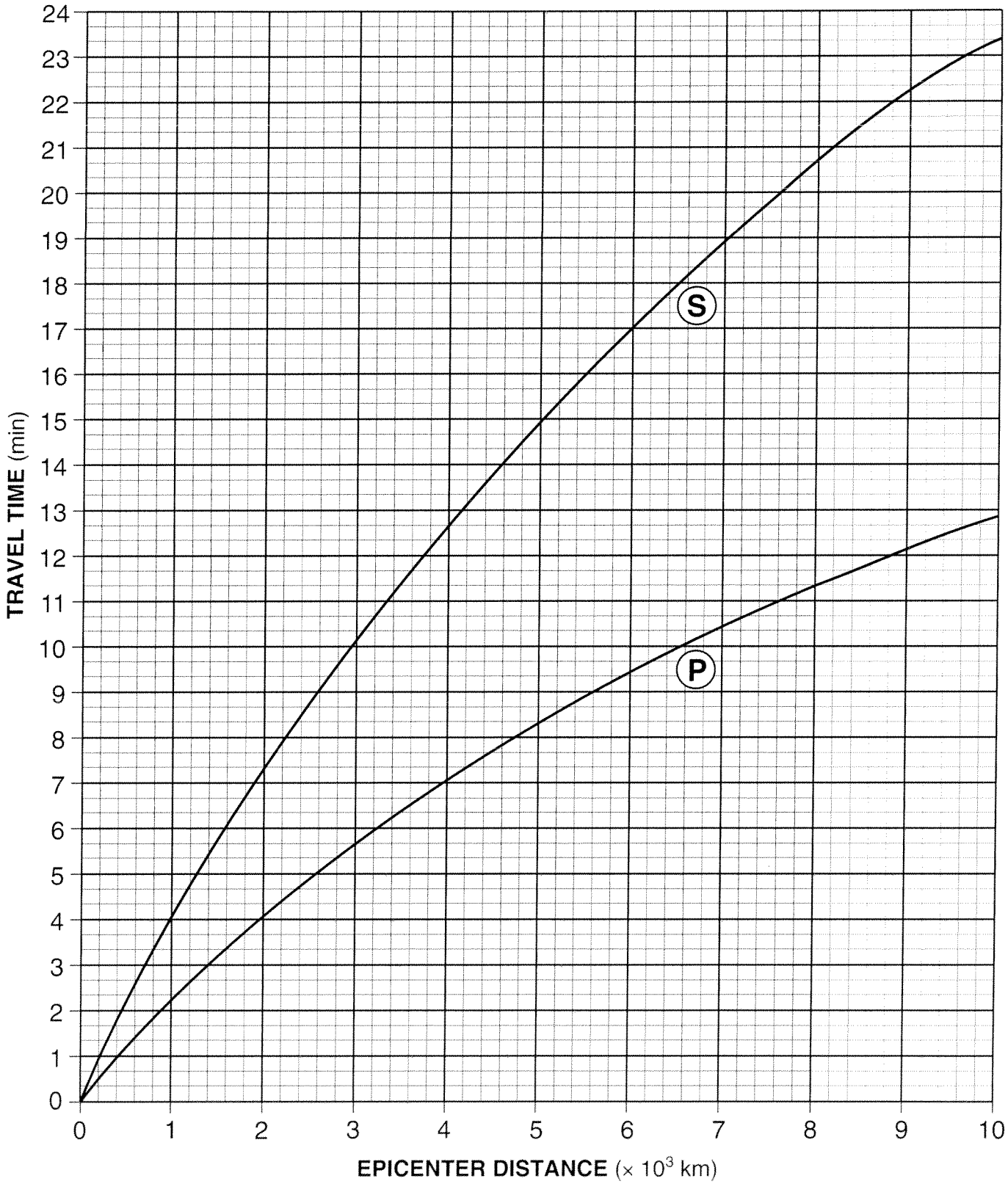
458 million years ago



Inferred Properties of Earth's Interior



Earthquake P-Wave and S-Wave Travel Time



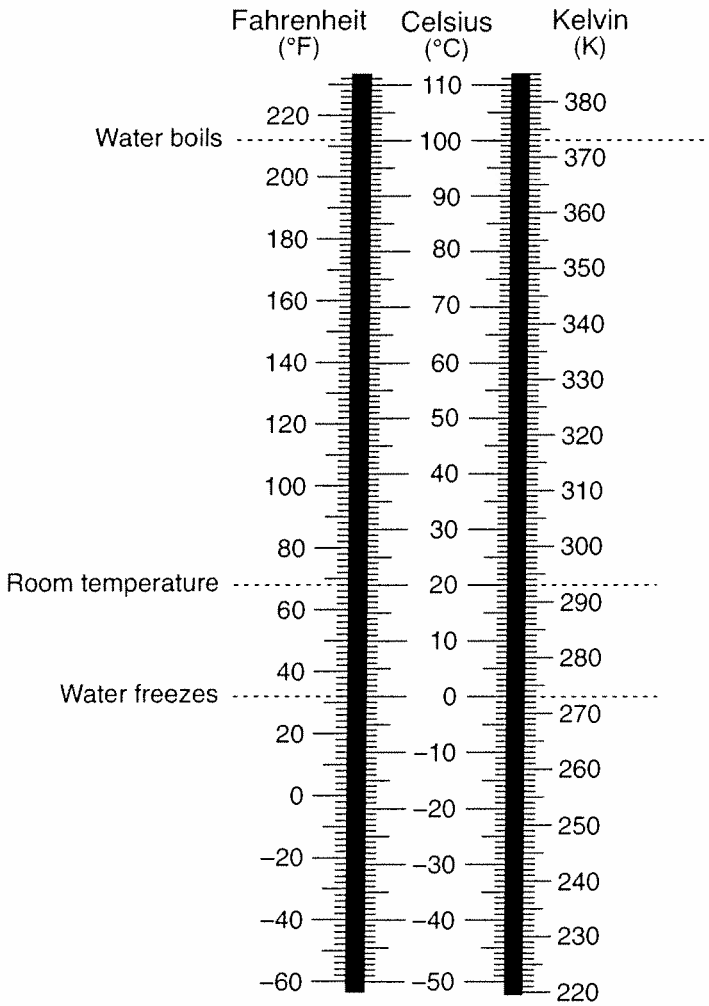
Dewpoint (°C)

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

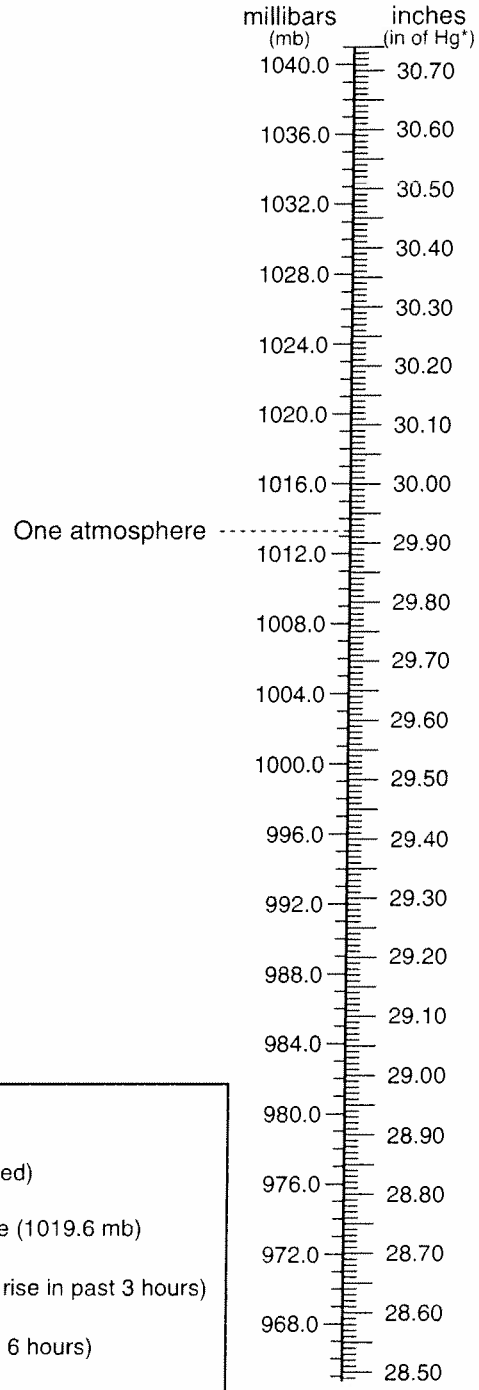
Relative Humidity (%)

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



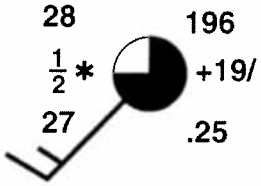
Pressure



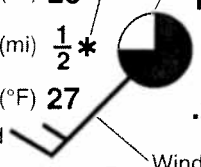
*Hg = mercury

Key to Weather Map Symbols

Station Model



Station Model Explanation



Present weather

Amount of cloud cover (approximately 75% covered)

Temperature (°F) **28**

196 Barometric pressure (1019.6 mb)

Visibility (mi) **½ ***

+19/ Barometric trend (a steady 1.9-mb rise in past 3 hours)

Dewpoint (°F) **27**

.25 Precipitation (0.25 inches in past 6 hours)

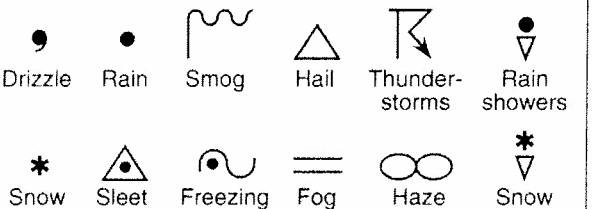
Wind speed

Wind direction (from the southwest)

[whole feather = 10 knots
half feather = 5 knots
total = 15 knots]

(1 knot = 1.15 mi/h)

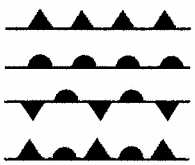
Present Weather



Air Masses

cA	continental arctic
cP	continental polar
cT	continental tropical
mT	maritime tropical
mP	maritime polar

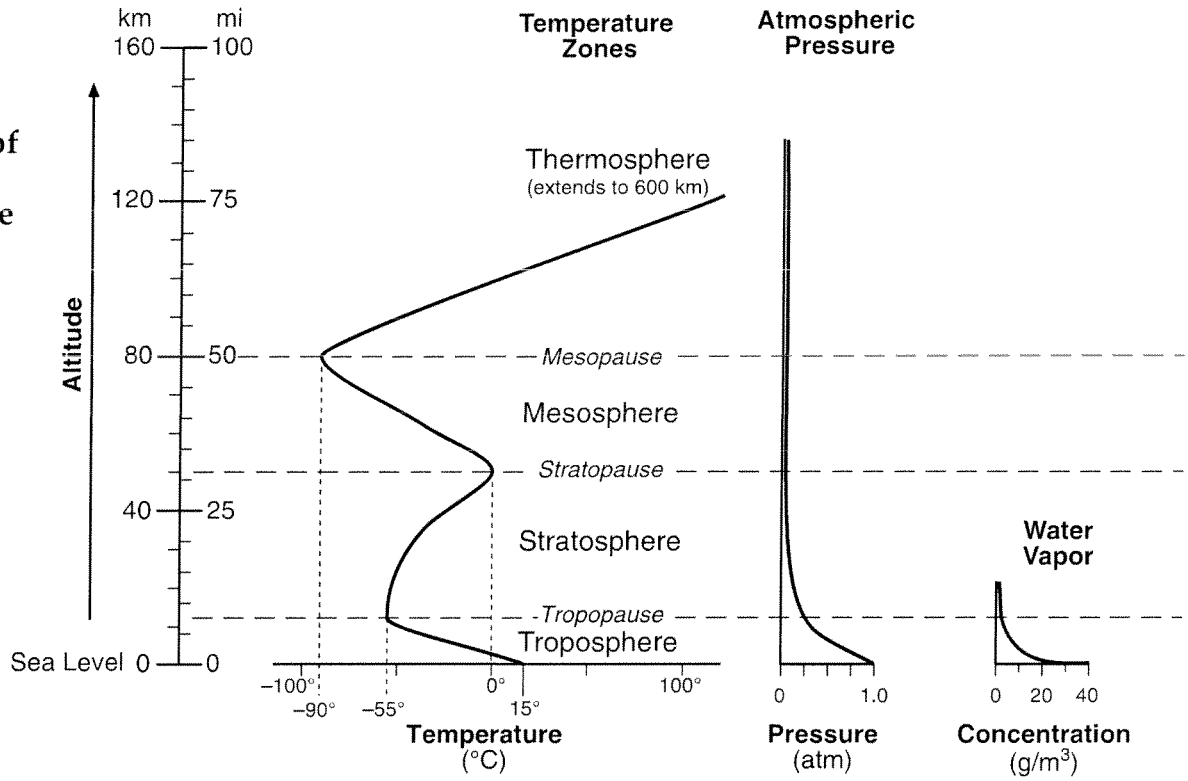
Fronts



Hurricane

Tornado

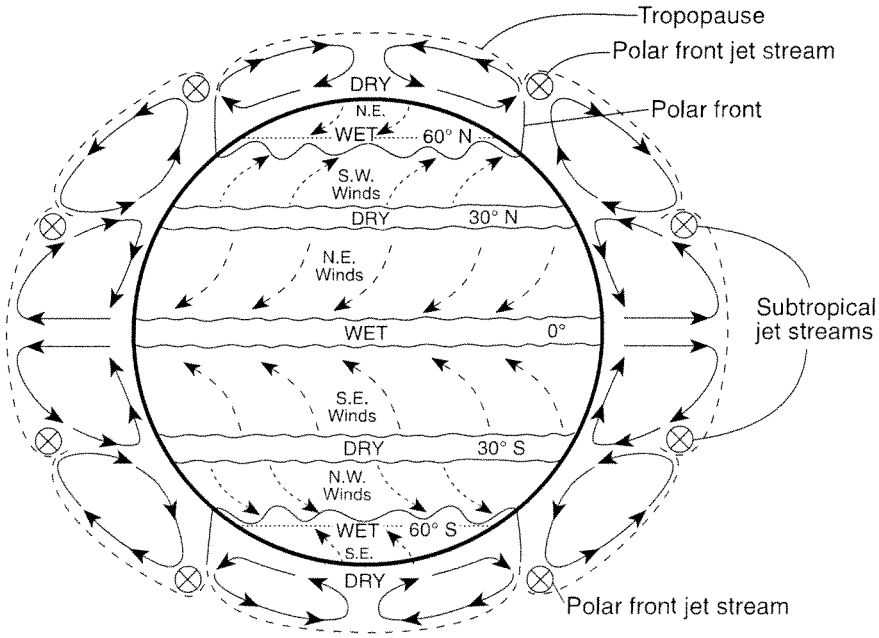
Selected Properties of Earth's Atmosphere



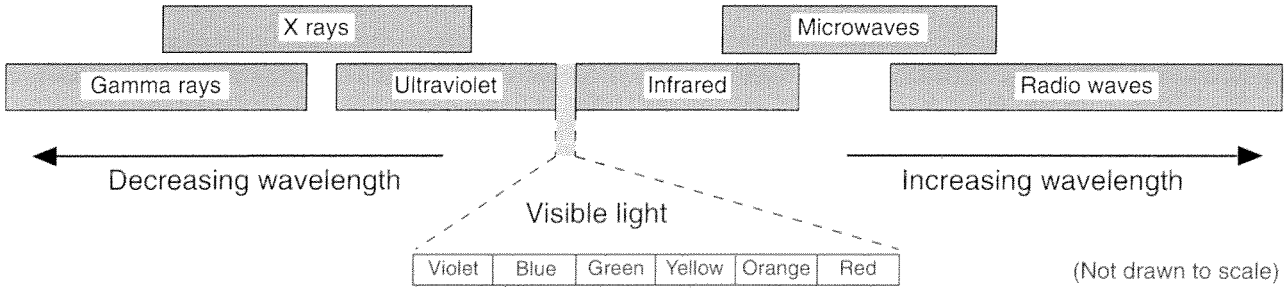
Planetary Wind and Moisture Belts in the Troposphere

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)

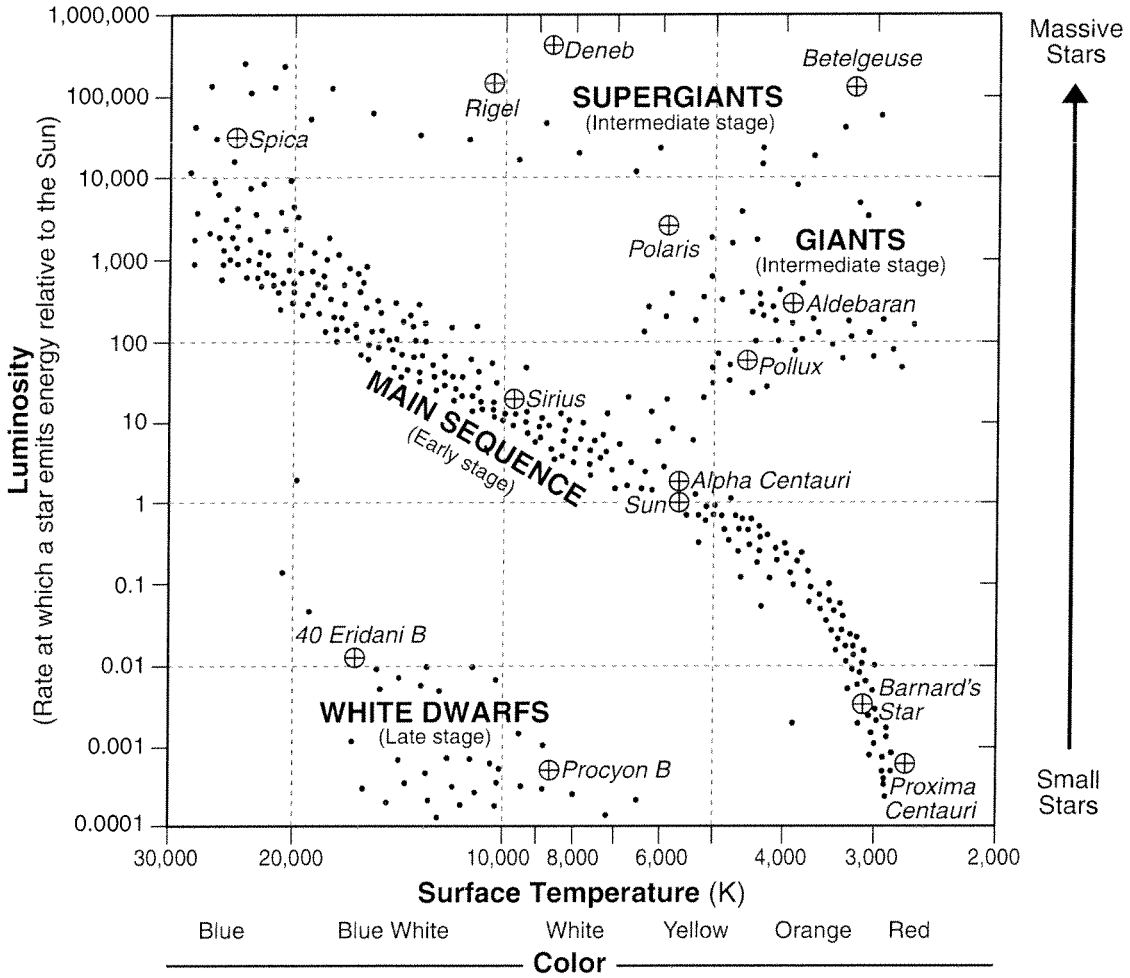


Electromagnetic Spectrum



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_3O_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_2O_3	**Hematite**
Nonmetallic luster	1	✔		white to green	greasy feel	ceramics, paper	$Mg_3Si_4O_{10}(OH)_2$	**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	$CaSO_4 \cdot 2H_2O$	**Selenite gypsum**
	2–2.5	✔		colorless to yellow	flexible in thin sheets	paint, roofing	$KAl_3Si_3O_{10}(OH)_2$	**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	$K(Mg,Fe)_3 AlSi_3O_{10}(OH)_2$	**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	$(Ca,Na)(Mg,Fe,Al)(Si,Al)_2O_6$	**Pyroxene** (commonly augite)
	5.5	✔		black to dark green	cleaves at 56° and 124°	mineral collections, jewelry	$CaNa(Mg,Fe)_4(Al,Fe,Ti)_3Si_6O_{22}(O,OH)_2$	**Amphibole** (commonly hornblende)
	6	✔		white to pink	cleaves in 2 directions at 90°	ceramics, glass	$KAlSi_3O_8$	**Potassium feldspar** (commonly orthoclase)
	6	✔		white to gray	cleaves in 2 directions, striations visible	ceramics, glass	$(Na,Ca)AlSi_3O_8$	**Plagioclase feldspar**
	6.5		✔	green to gray or brown	commonly light green and granular	furnace bricks, jewelry	$(Fe,Mg)_2SiO_4$	**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	$Fe_3Al_2Si_3O_{12}$	**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