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Earth Science Reference Tables

PHYSICAL CONSTANTS

Radioactive Decay Data

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

Specific Heats of Common Materials

MATERIAL	SPECIFIC HEAT (calories/gram • C°)
Water (solid)	0.5
Water (liquid)	1.0
Water (gas)	0.5
Dry air	0.24
Basalt	0.20
Granite	0.19
Iron	0.11
Copper	0.09
Lead	0.03

Properties of Water

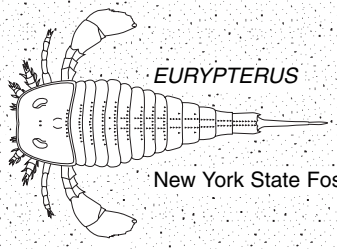
Energy gained during melting	80 calories/gram
Energy released during freezing	80 calories/gram
Energy gained during vaporization	540 calories/gram
Energy released during condensation	540 calories/gram
Density at 3.98°C	1.00 gram/milliliter

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.



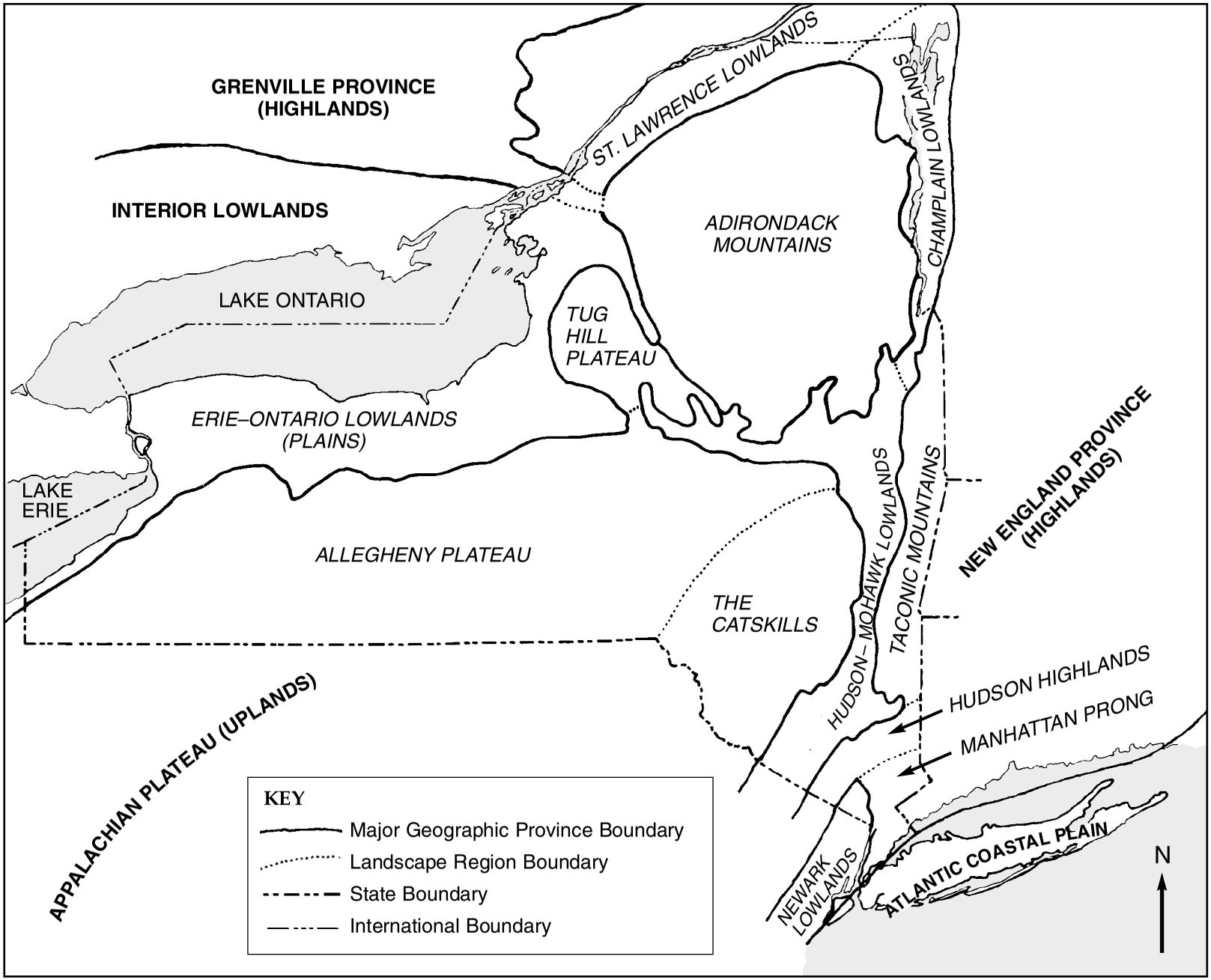
EURYPTERUS

New York State Fossil

CAUTION: Based on your printer settings, ruler may not have printed exactly to scale.

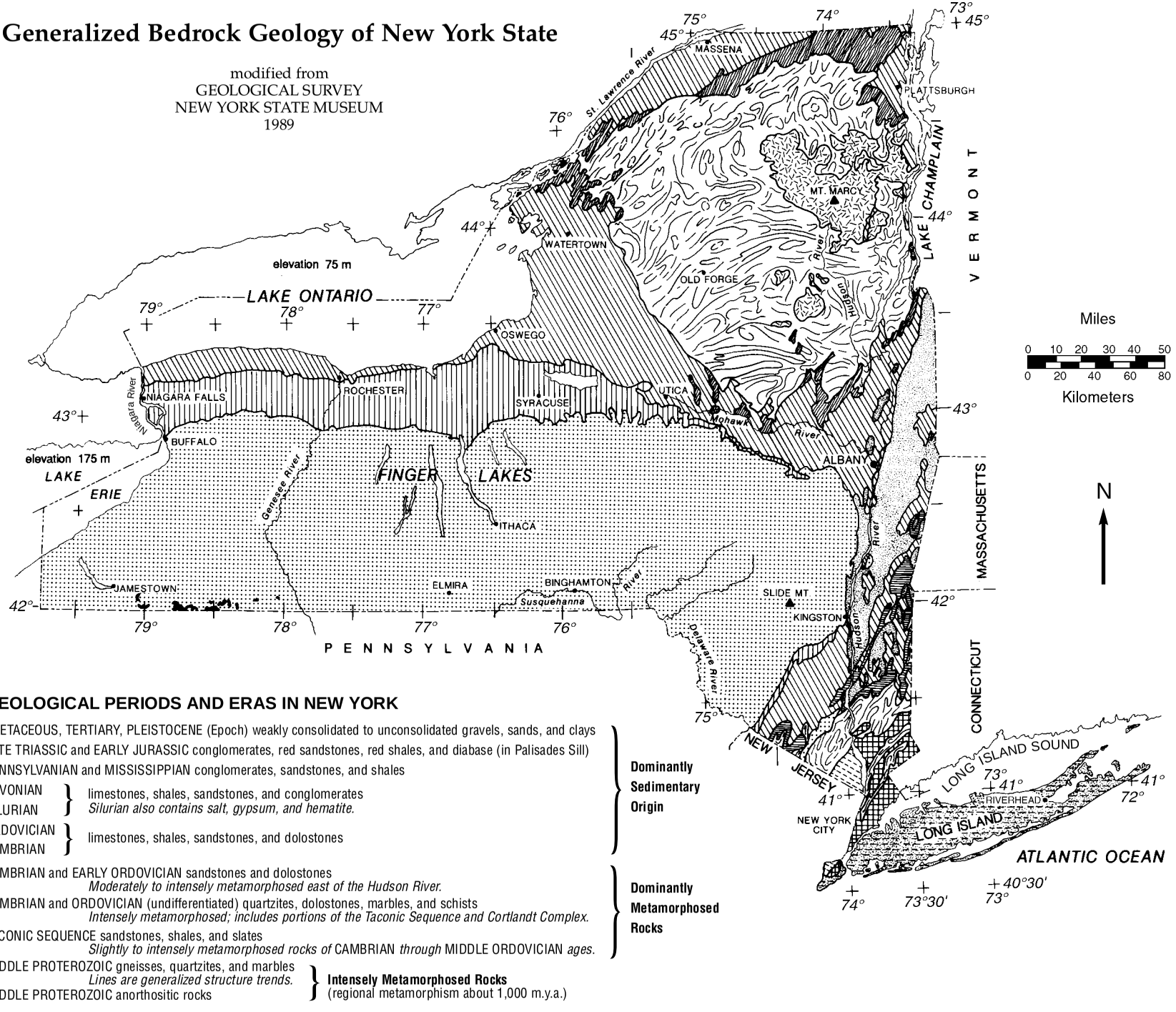
94-095 ESRT pdf 1,2 CDC

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

Dominantly Sedimentary Origin

- CRETACEOUS, TERTIARY, PLEISTOCENE (Epoch) weakly consolidated to unconsolidated gravels, sands, and clays
- LATE TRIASSIC and EARLY JURASSIC conglomerates, red sandstones, red shales, and diabase (in 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

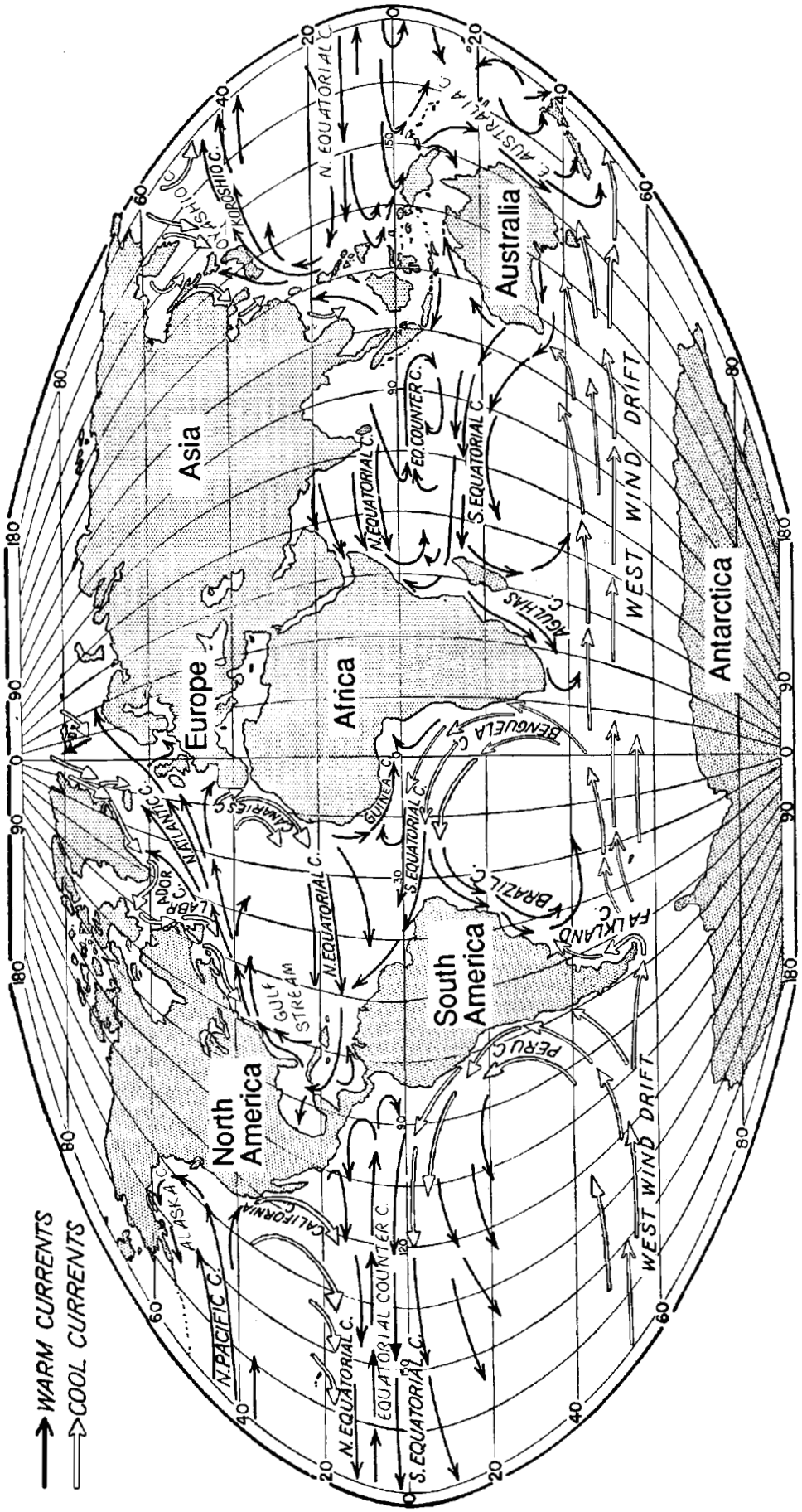
Dominantly Metamorphosed Rocks

- 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.*

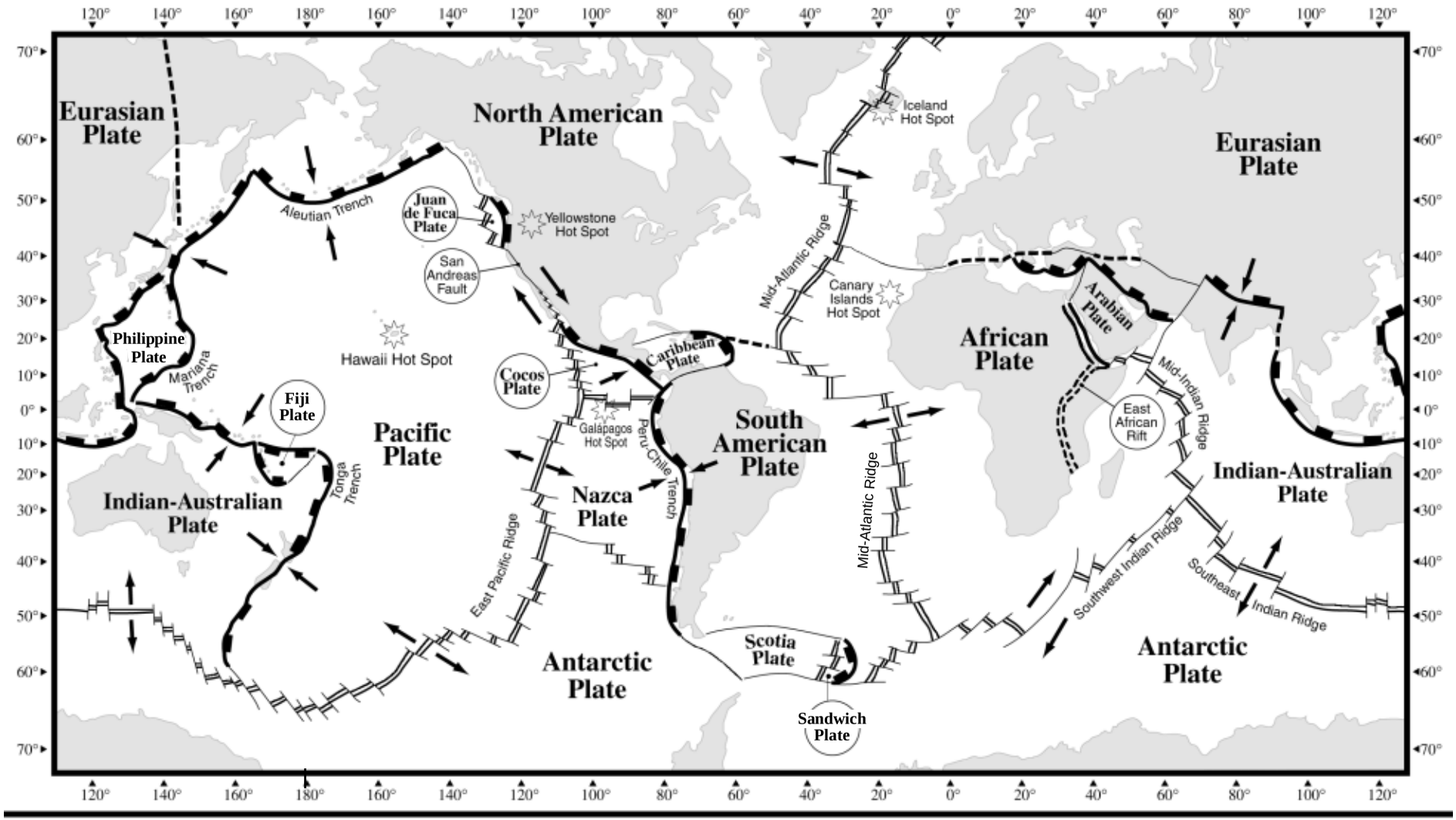
Intensely Metamorphosed Rocks (regional metamorphism about 1,000 m.y.a.)

- MIDDLE PROTEROZOIC gneisses, quartzites, and marbles
  Lines are generalized structure trends.
- MIDDLE PROTEROZOIC anorthositic rocks

Surface Ocean Currents



Tectonic Plates



KEY:

Divergent Plate Boundary (usually broken by transform faults along mid-ocean ridges)

Mid-Ocean Ridge

overriding plate

subducting plate

Convergent Plate Boundary (Subduction Zone)

Transform Plate Boundary (Transform Fault)

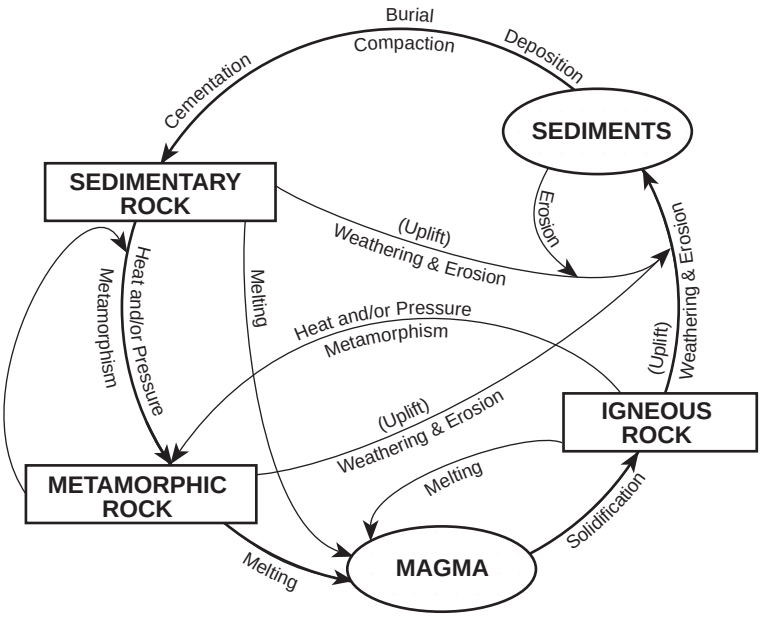
Complex or Uncertain Plate Boundary

Relative Motion at Plate Boundary

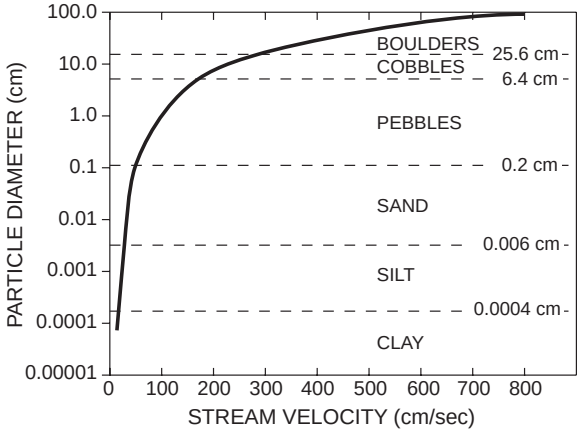
Mantle Hot Spot

NOTE: Not all plates and boundaries are shown.

Rock Cycle in Earth's Crust

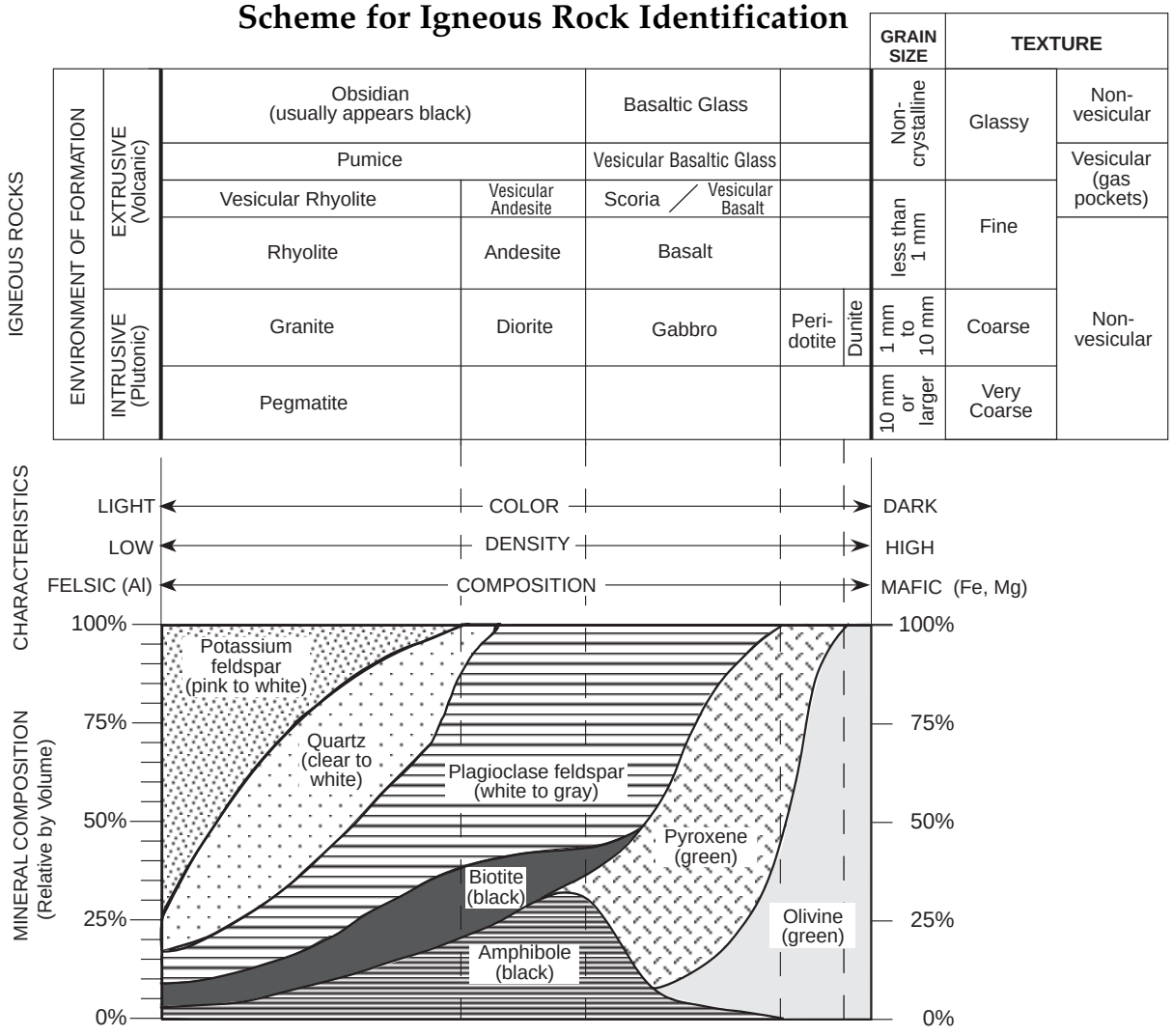


Relationship of Transported Particle Size to Water Velocity

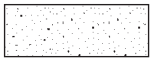
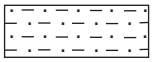
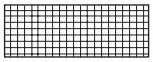
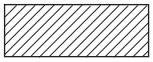
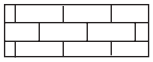


*This generalized graph shows the water velocity needed to maintain, but not start, movement. Variations occur due to differences in particle density and shape.

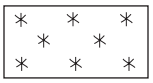
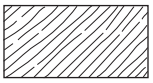
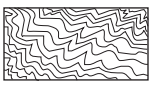
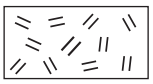
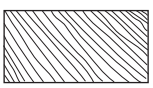
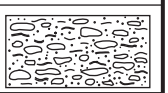
Scheme for Igneous Rock Identification



Scheme for Sedimentary Rock Identification

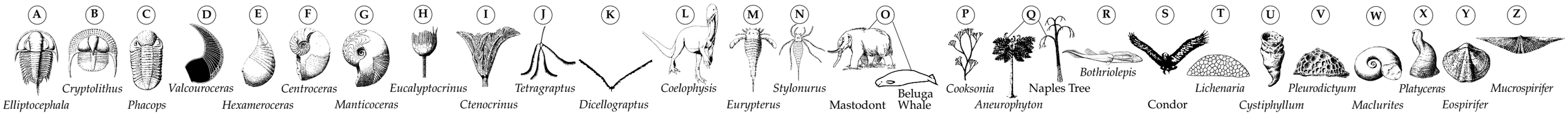
INORGANIC LAND-DERIVED SEDIMENTARY ROCKS					
TEXTURE	**GRAIN SIZE**	**COMPOSITION**	**COMMENTS**	**ROCK NAME**	**MAP SYMBOL**
Clastic (fragmental)	Pebbles, cobbles, and/or boulders embedded in sand, silt, and/or clay	Mostly quartz, feldspar, and clay minerals; may contain fragments of other rocks and 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	
					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	Millions of years ago	Life on Earth
PHANEROZOIC	CENOZOIC	QUATERNARY	HOLOCENE	0	
			PLEISTOCENE	0.01	Humans, mastodonts, mammoths
		TERTIARY – NEOGENE	PLIOCENE	1.6	Large carnivores
			MIOCENE	5.3	Abundant grazing mammals Earliest grasses
		TERTIARY – PALEOGENE	OLIGOCENE	24	Large running mammals
			EOCENE	33.7	Many modern groups of mammals
			PALEOCENE	54.8	
	MESOZOIC			65	Extinction of dinosaurs and ammonoids
		CRETACEOUS	LATE		Earliest placental mammals Climax of dinosaurs and ammonoids
			EARLY		Earliest flowering plants Decline of brachiopods Diverse bony fishes
				142	
		JURASSIC	LATE		Earliest birds
			MIDDLE		Abundant dinosaurs and ammonoids
			EARLY		
				206	
		TRIASSIC	LATE		Modern coral groups appear
			MIDDLE		Earliest dinosaurs and mammals with abundant cycads and conifers
			EARLY	251	Extinction of many kinds of marine animals, including trilobites
	PALEOZOIC	PERMIAN	LATE		First mammal-like reptiles
			EARLY		
				290	
		CARBONIFEROUS – PENNSYLVANIAN	LATE		Earliest reptiles
			EARLY		Extensive coal-forming forests
				323	
		CARBONIFEROUS – MISSISSIPPIAN	LATE		Abundant sharks and amphibians
			EARLY		Large and numerous scale trees and seed ferns
				362	
		DEVONIAN	LATE		
			MIDDLE		Earliest amphibians, ammonoids, sharks
			EARLY		Extinction of armored fish, other fish abundant
				418	
		SILURIAN	LATE		Earliest insects Earliest land plants and animals
			EARLY		Peak development of eurypterids
				443	
		ORDOVICIAN	LATE		
			MIDDLE		Invertebrates dominant – mollusks become abundant Diverse coral and echinoderms
			EARLY		
				490	Graptolites abundant
		CAMBRIAN	LATE		Earliest fish Algal reefs
			MIDDLE		Burgess shale fauna
			EARLY		Earliest chordates, diverse trilobites Earliest trilobites Earliest marine animals with shells
				544	
PROTEROZOIC				580	Ediacaran fauna
					Soft-bodied organisms
ARCHEAN				1300	Stromatolites

Millions of years ago: 0, 500, 1000, 2000, 3000, 4000, 4600

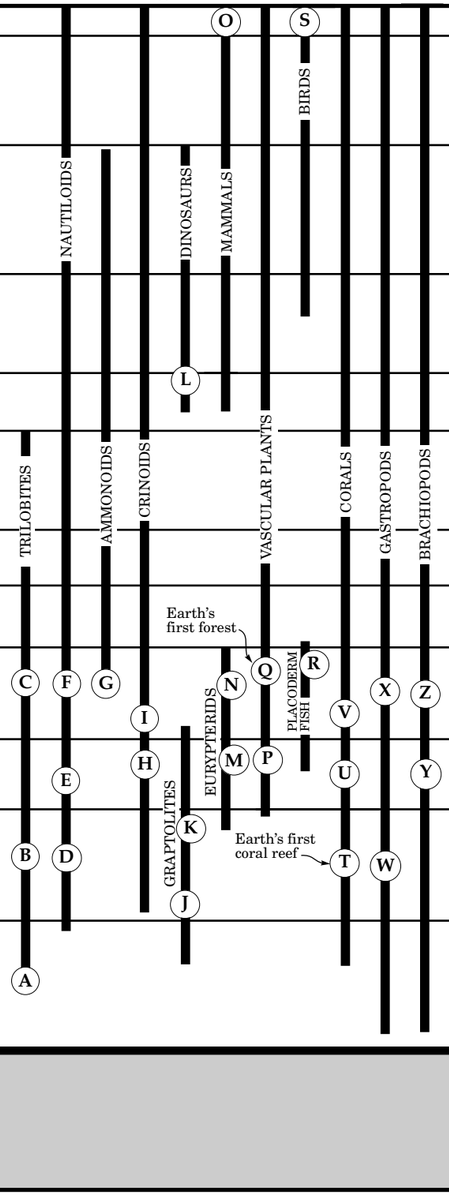
PROTEROZOIC: LATE — Oldest multicellular life; MIDDLE — First appearance of sexually reproducing organisms; EARLY — Transition to atmosphere containing oxygen

ARCHEAN: LATE — Oldest microfossils; MIDDLE — Geochemical evidence for oldest biological fixing of carbon; EARLY — Oldest known rocks

Estimated time of origin of Earth and solar system

Time Distribution of Fossils (Including Important Fossils of New York)

Lettered circles indicate the approximate time of existence of a specific index fossil (e.g. Fossil (A) lived at the end of the Early Cambrian).



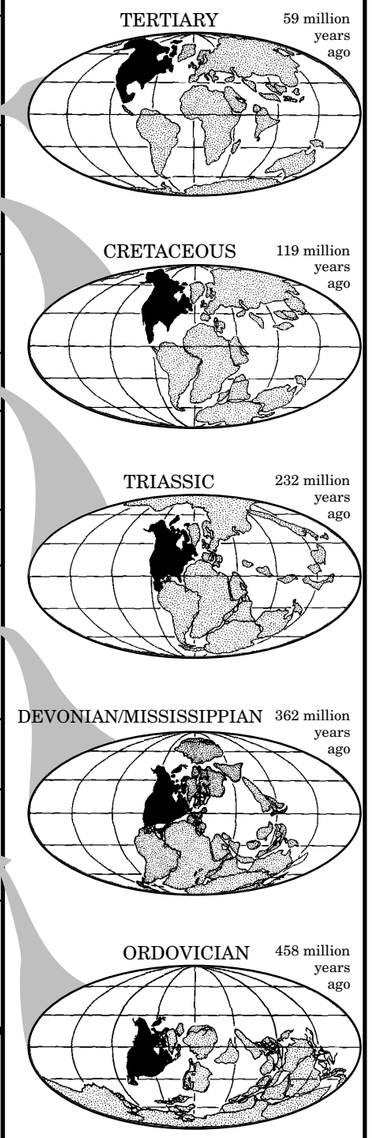
Tectonic Events Affecting Northeast North America

Rifting
Passive Margin
Subduction
Continental Collision
Transform Collision

Important Geologic Events in New York

- Advance and retreat of last continental ice
- Uplift of Adirondack region
- Sands and shales underlying Long Island and Staten Island deposited on margin of Atlantic Ocean
- Development of passive continental margin
- Initial opening of Atlantic Ocean
  North America and Africa separate
- Intrusion of Palisades sill
  Pangea begins to break up
- Extensive erosion
- **Appalachian (Alleghanian) Orogeny** caused by collision of North America and Africa along transform margin, forming Pangea
- 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
- Iapetus passive margin forms
- Rifting and initial opening of Iapetus Ocean
  Erosion of Grenville Mountains
- **Grenville Orogeny:** Ancestral Adirondack Mtns. and Hudson Highlands formed

Inferred Position of Earth's Landmasses



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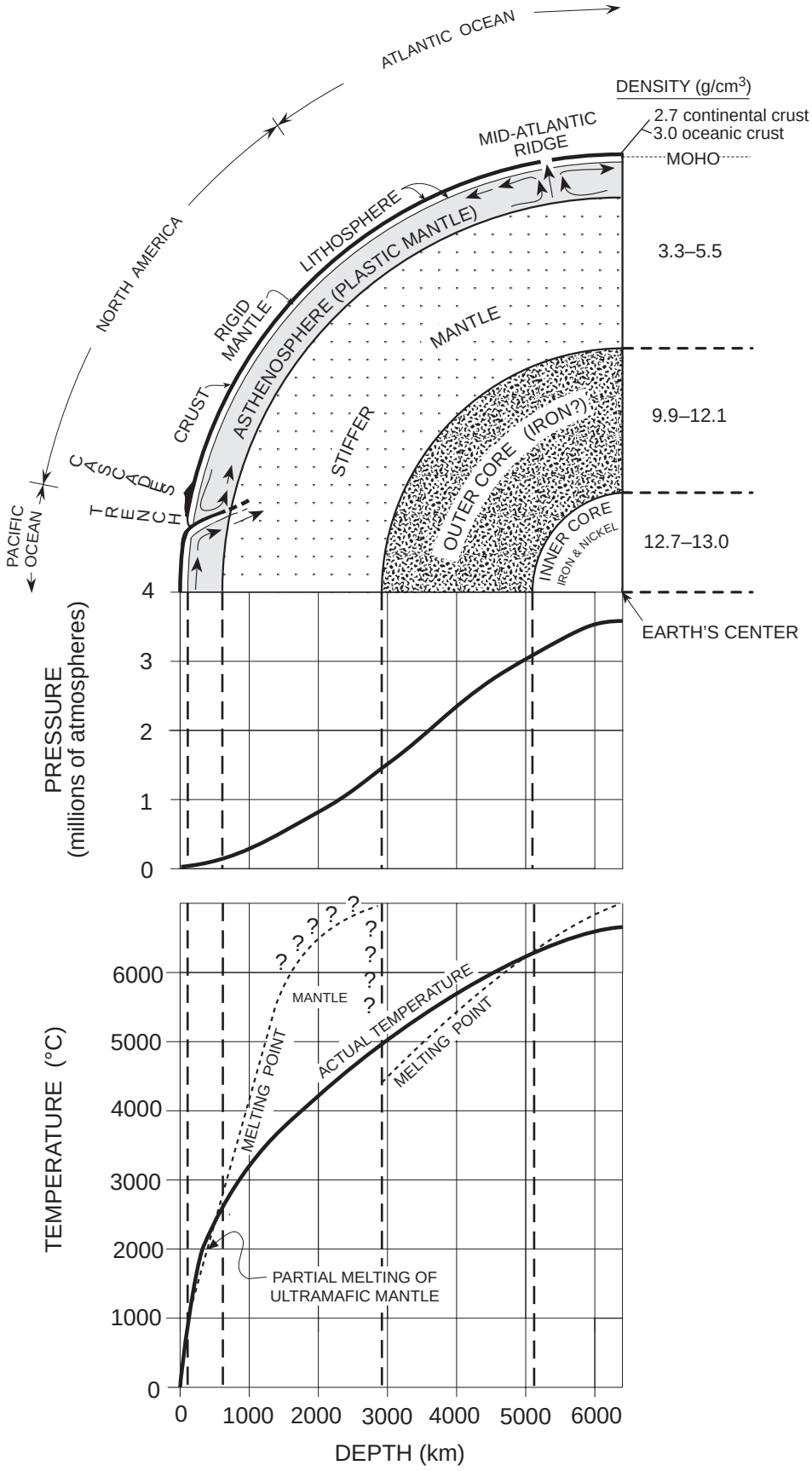
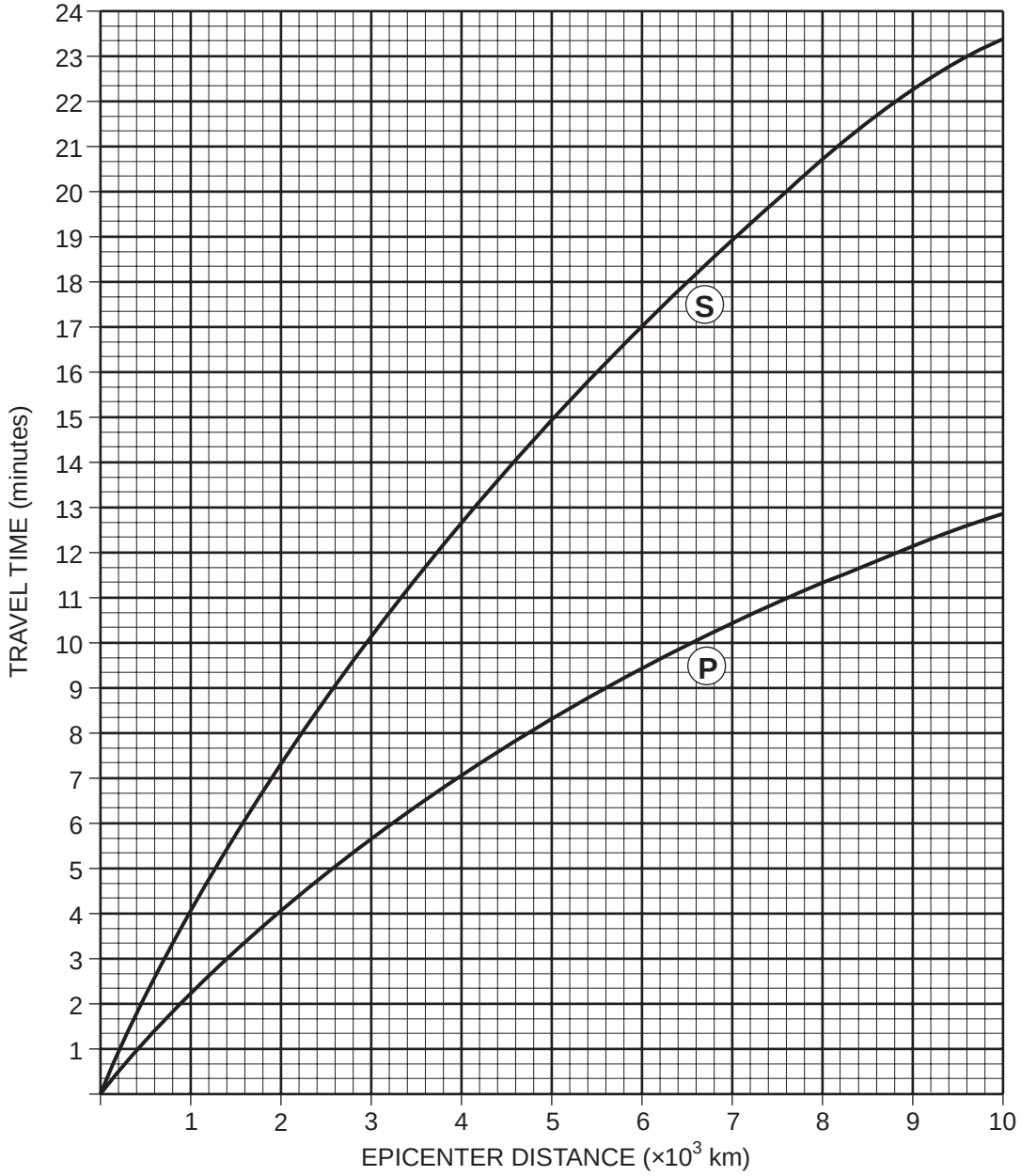
Inferred Properties of Earth's Interior



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



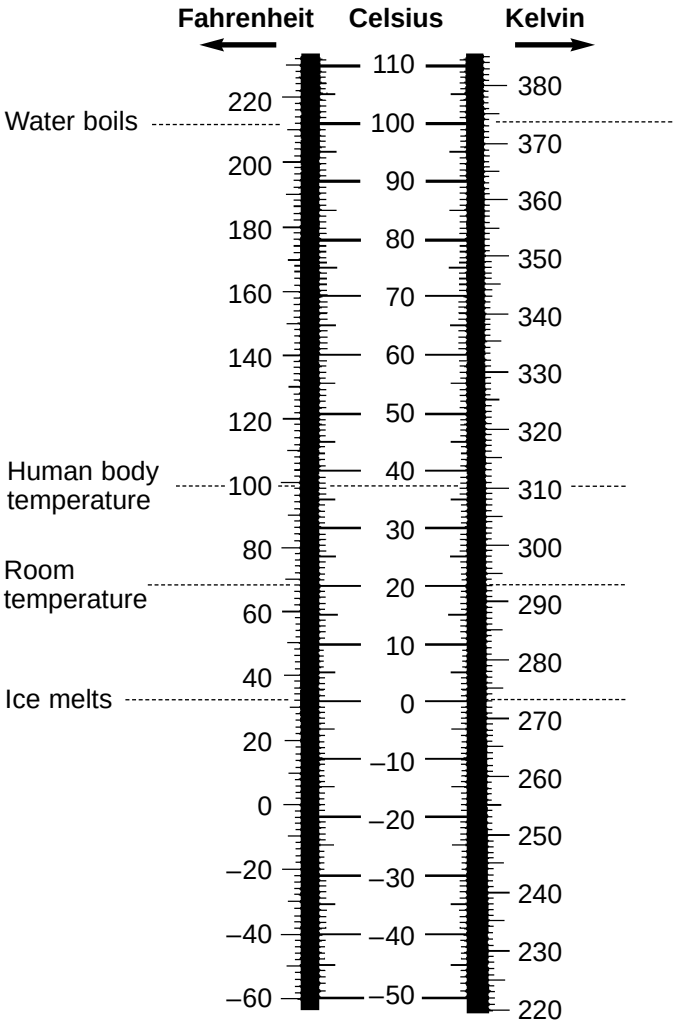
Dewpoint Temperatures (°C)

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

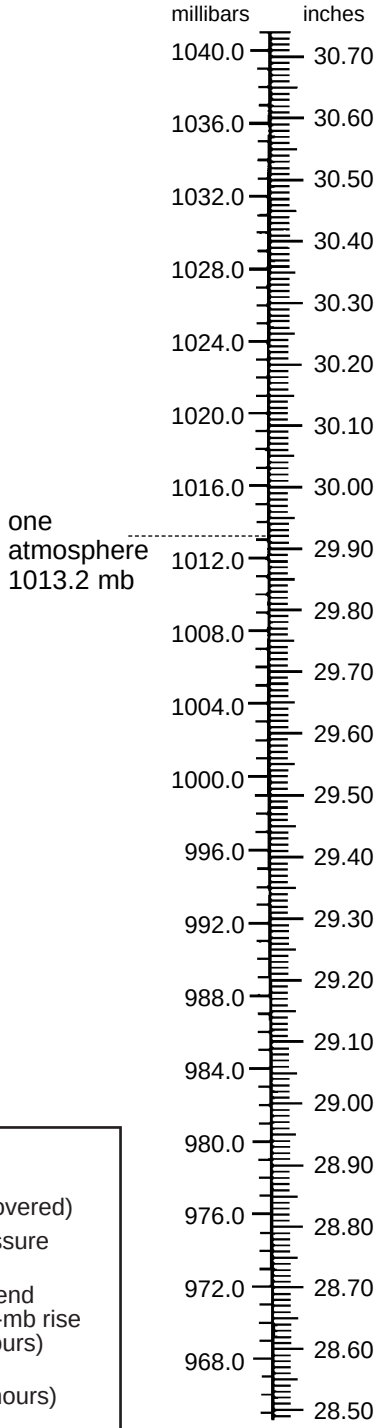
Relative Humidity (%)

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

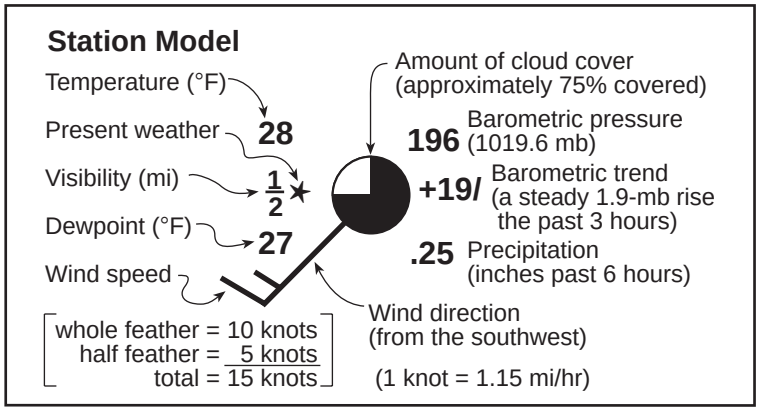
Temperature



Pressure



Weather Map Symbols



Present Weather

Drizzle, Rain, Smog, Hail, Thunder-storms, Rain Showers

Snow, Sleet, Freezing Rain, Fog, Haze, Snow Showers

Air Masses

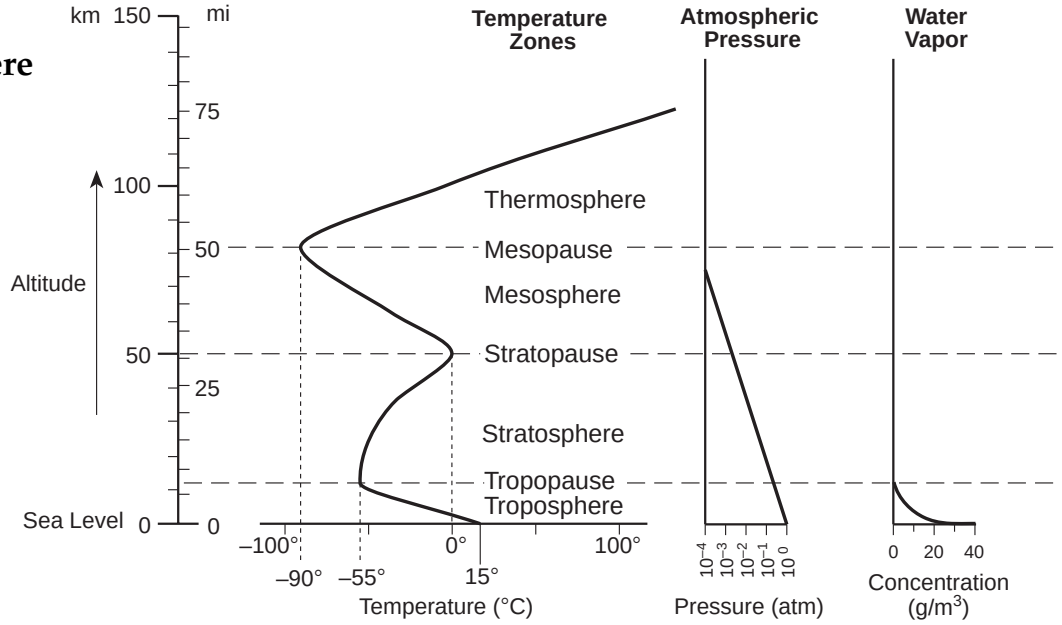
cA	continental arctic
cP	continental polar
cT	continental tropical
mT	maritime tropical
mP	maritime polar

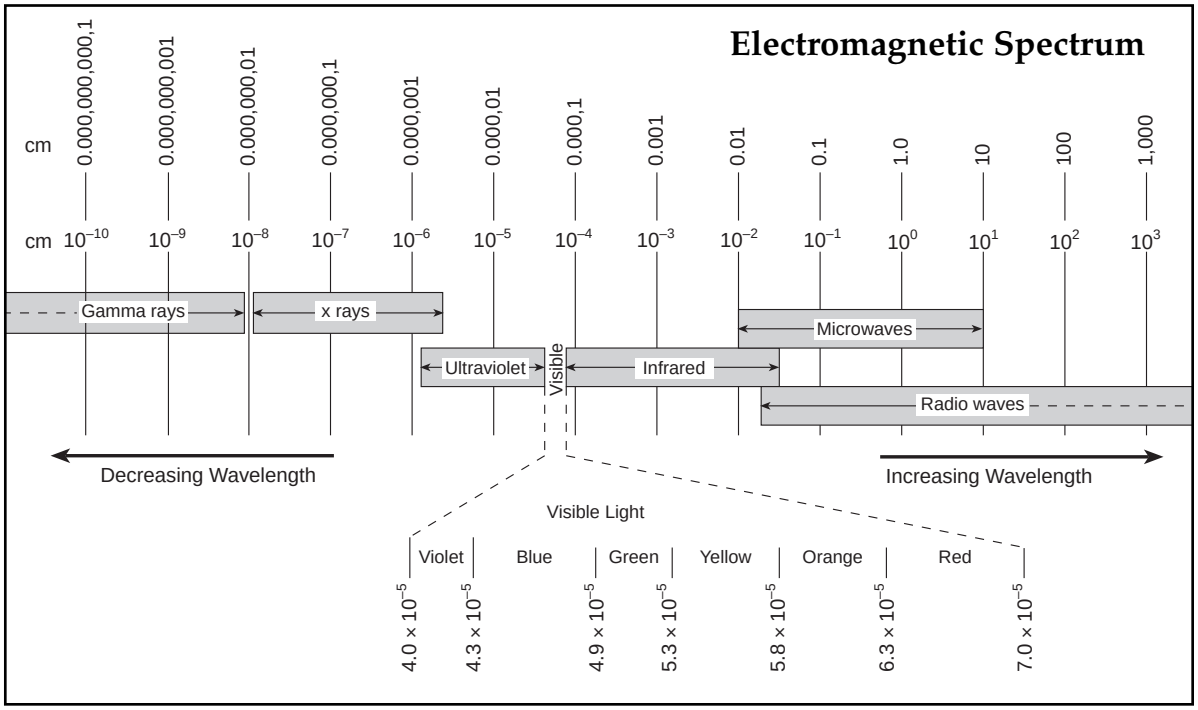
Front Symbols

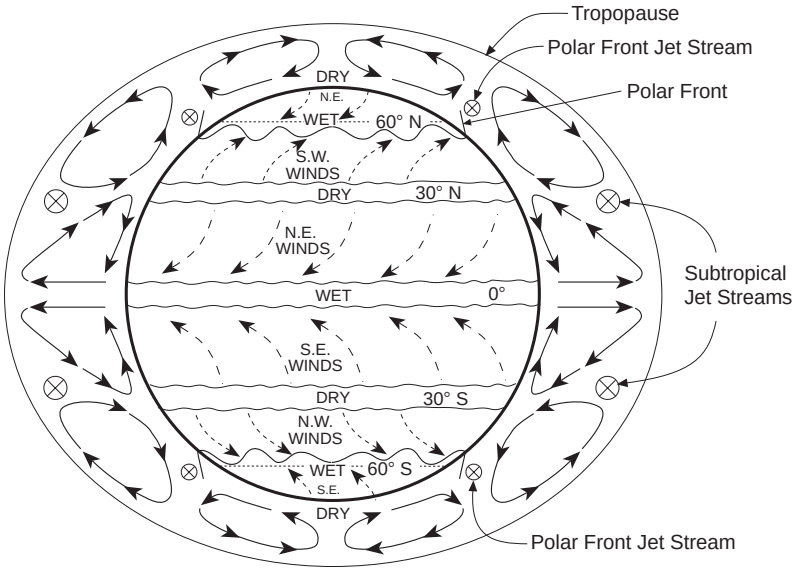
Cold, Warm, Stationary, Occluded

Hurricane

Selected Properties of Earth's Atmosphere





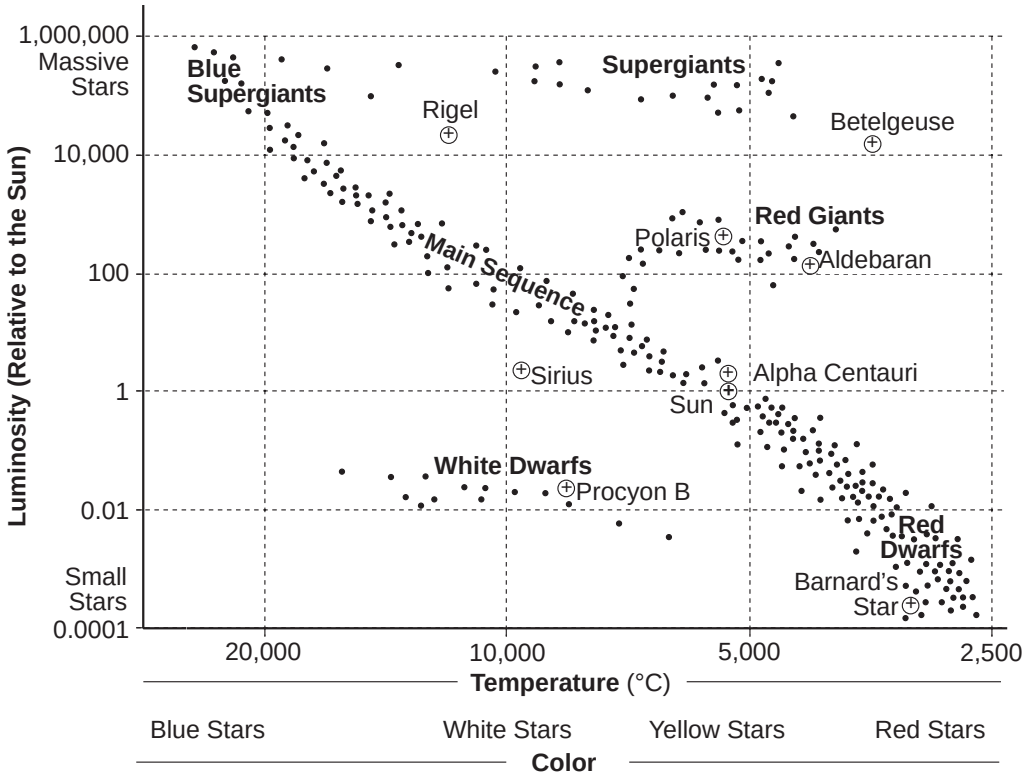


Planetary Wind and Moisture Belts in the Troposphere

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 ⊕)

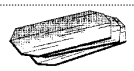
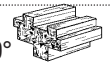


Luminosity is the brightness of stars compared to the brightness of our Sun as seen from the same distance from the observer.

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^3)	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
PLUTO	5,900	247.7 years	6 days 9 hr	0.250	2,300	0.0025	2.0	1
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	HARDNESS	CLEAVAGE	FRACTURE	COMMON COLORS	DISTINGUISHING CHARACTERISTICS	USE(S)	MINERAL NAME	COMPOSITION*
Metallic Luster	1–2	✔		silver to gray	black streak, greasy feel	pencil lead, lubricants	**Graphite**	C
	2.5	✔		metallic silver	very dense (7.6 g/cm^3), gray-black streak 	ore of lead	**Galena**	PbS
	5.5–6.5		✔	black to silver	attracted by magnet, black streak	ore of iron	**Magnetite**	Fe_3O_4
	6.5		✔	brassy yellow	green-black streak, cubic crystals 	ore of sulfur	**Pyrite**	FeS_2
Either	1–6.5		✔	metallic silver or earthy red	red-brown streak	ore of iron	**Hematite**	Fe_2O_3
Nonmetallic Luster	1	✔		white to green	greasy feel	talcum powder, soapstone	**Talc**	$Mg_3Si_4O_{10}(OH)_2$
	2		✔	yellow to amber	easily melted, may smell	vulcanize rubber, sulfuric acid	**Sulfur**	S
	2	✔		white to pink or gray	easily scratched by fingernail	plaster of paris and drywall	**Gypsum** (Selenite)	$CaSO_4 \cdot 2H_2O$
	2–2.5	✔		colorless to yellow	flexible in thin sheets 	electrical insulator	**Muscovite Mica**	$KAl_3Si_3O_{10}(OH)_2$
	2.5	✔		colorless to white	cubic cleavage, salty taste 	food additive, melts ice	**Halite**	NaCl
	2.5–3	✔		black to dark brown	flexible in thin sheets 	electrical insulator	**Biotite Mica**	$K(Mg,Fe)_3 AlSi_3O_{10}(OH)_2$
	3	✔		colorless or variable	bubbles with acid 	cement, polarizing prisms	**Calcite**	$CaCO_3$
	3.5	✔		colorless or variable	bubbles with acid when powdered	source of magnesium	**Dolomite**	$CaMg(CO_3)_2$
	4	✔		colorless or variable	cleaves in 4 directions	hydrofluoric acid	**Fluorite**	CaF_2
	5–6	✔		black to dark green	cleaves in 2 directions at 90° 	mineral collections	**Pyroxene** (commonly Augite)	(Ca,Na) (Mg,Fe,Al) $(Si,Al)_2O_6$
	5.5	✔		black to dark green	cleaves at 56° and 124° 	mineral collections	**Amphiboles** (commonly Hornblende)	$CaNa(Mg,Fe)_4$ $(Al,Fe,Ti)_3$ $Si_6O_{22}(O,OH)_2$
	6	✔		white to pink	cleaves in 2 directions at 90°	ceramics and glass	**Potassium Feldspar** (Orthoclase)	$KAlSi_3O_8$
	6	✔		white to gray	cleaves in 2 directions, striations visible	ceramics and glass	**Plagioclase Feldspar** (Na-Ca Feldspar)	$(Na,Ca)AlSi_3O_8$
	6.5		✔	green to gray or brown	commonly light green and granular	furnace bricks and jewelry	**Olivine**	$(Fe,Mg)_2SiO_4$
	7		✔	colorless or variable	glassy luster, may form hexagonal crystals 	glass, jewelry, and electronics	**Quartz**	SiO_2
	7		✔	dark red to green	glassy luster, often seen as red grains in NYS metamorphic rocks	jewelry and abrasives	**Garnet** (commonly Almandine)	$Fe_3Al_2Si_3O_{12}$

*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