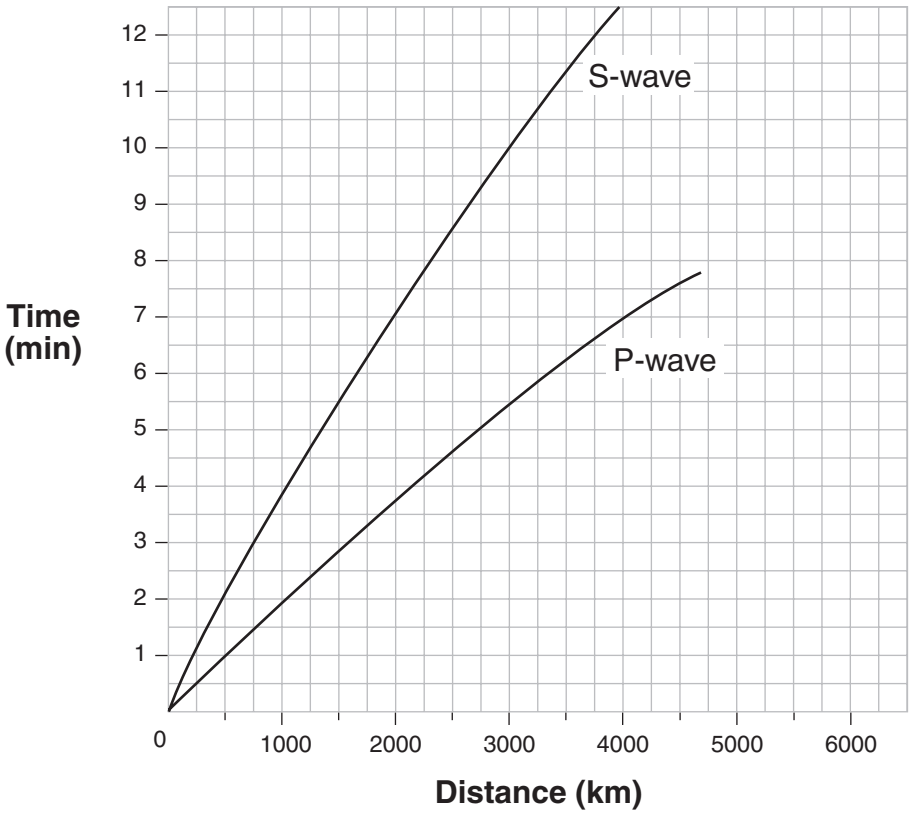
P and S Seismic Wave Travel Time Grap

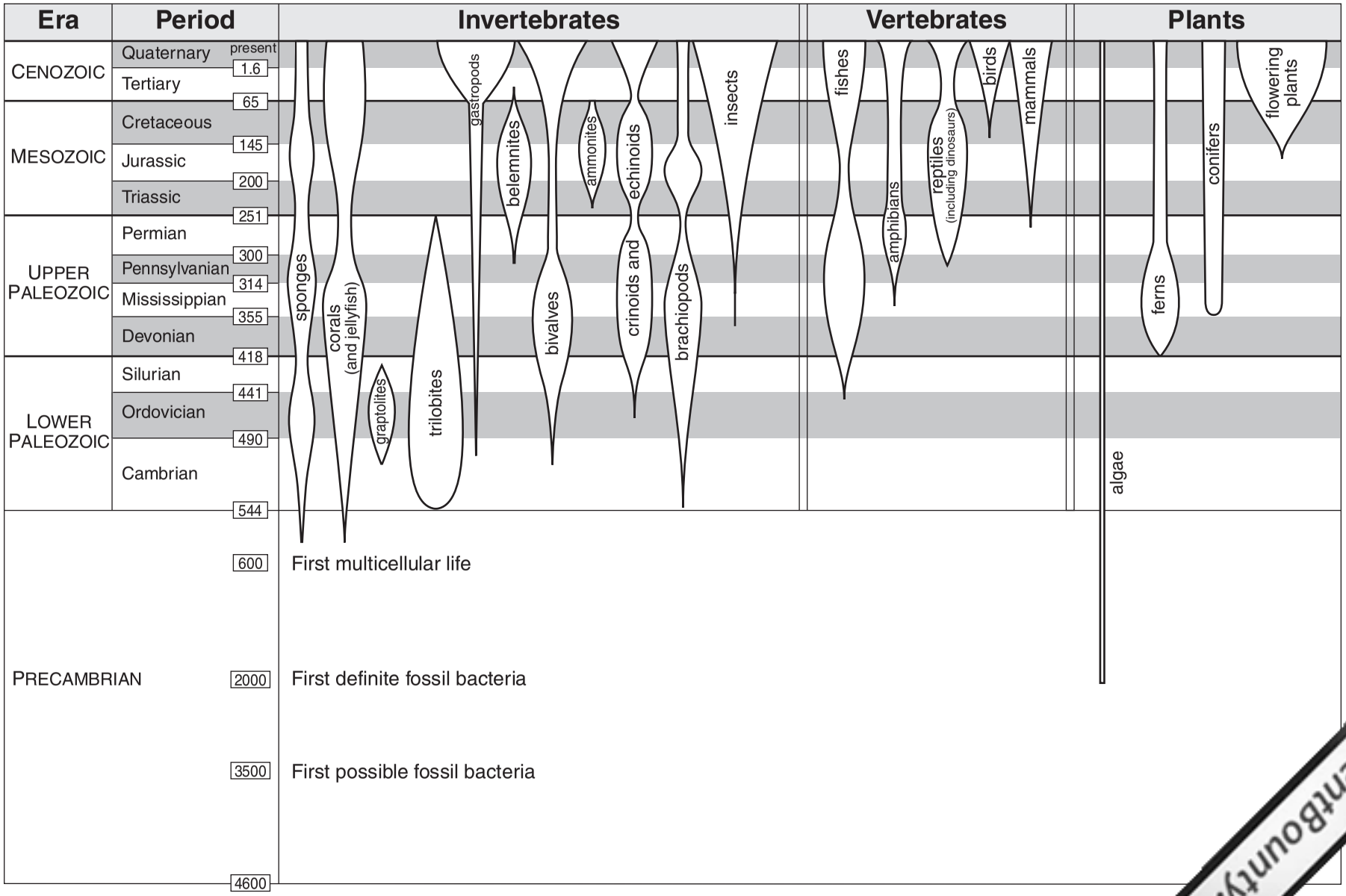


Modified Mercalli Scale

Rating	Description
I	Barely felt.
II	Felt by a few sensitive people, some suspended objects may swing.
III	Slightly felt indoors as though a large truck were passing.
IV	Felt indoors by many people, most suspended objects swing, windows and dishes rattle, standing autos rock.
V	Felt by almost everyone, sleeping people are awakened, dishes and windows break.
VI	Felt by everyone, some are frightened and run outside, some have trouble walking, some chimneys break, some furniture moves, slight damage.
VII	Considerable damage in poorly-built structures, felt by people driving, most are frightened and run outside.
VIII	Slight damage to well-built structures, poorly-built structures are heavily damaged, walls, chimneys, monuments fall.
IX	Underground pipes break, foundations of buildings are damaged and buildings shift off foundations, considerable damage to well-built structures.
X	Few structures survive, most foundations destroyed, water moved out of banks of rivers and lakes, avalanches and rockslides, railroads are bent.
XI	Few structures remain standing, total panic, large cracks in the ground.
XII	Total destruction, objects thrown into the air, the land appears to be liquid and is visibly rolling like waves.

Development of Life through Time

The life-span of each group is shown. The species abundance of each group is shown by the thickness of the column.



Time shown in millions of years before present

Geological Time Scale

Era	Period		Epoch	Time (m.y.)
Cenozoic	Quaternary		Holocene	0.01
			Pleistocene	1.6
	Tertiary		Pliocene	5.3
			Miocene	24
			Oligocene	34
			Eocene	55
			Paleocene	65
Mesozoic	Cretaceous			145
	Jurassic			200
	Triassic			251
Paleozoic	Permian			300
	Carboniferous	Pennsylvanian		314
		Mississippian		355
	Devonian			418
	Silurian			441
	Ordovician			490
	Cambrian			544
Precambrian				4600

Dates according to Geological Time Scale, 1999. Geological Survey of Canada Open File 3040.
It is recognized that there is some variation in the dates given in the literature.

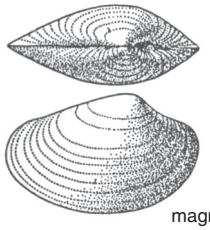
Isotope Pairs Used for Radiometric Dating

Isotope		Half-life of Parent (years)	Effective Dating Range (years)
Parent	*Daughter*		
Uranium-238	Lead-206	4.5 billion	1 million to 4.5 billion
Rubidium-87	Strontium-87	48.8 billion	10 million to 4.5 billion
Potassium-40	Argon-40	1.3 billion	10 000 to 3 billion
Uranium-235	Lead-207	715 million	10 million to 4.6 billion
Carbon-14	Nitrogen-14	5 730	< 100 000

Source: Carl Zimmer, National Geographic, September 2001

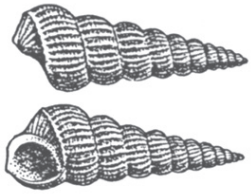
Fossil Samples

1 Tertiary (Miocene)



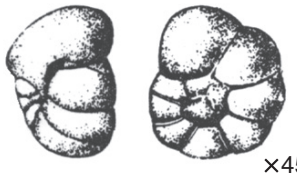
× $\frac{1}{2}$ magnification

2 Tertiary (Oligocene)



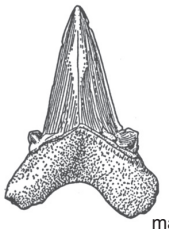
×1 magnification

3 Tertiary (Eocene to Holocene)



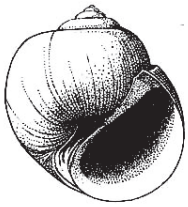
×45 magnification

4 Tertiary (Eocene)



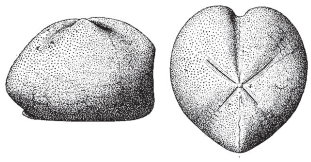
× $\frac{1}{2}$ magnification

5 Tertiary (Paleocene)



×1 magnification

6 Cretaceous

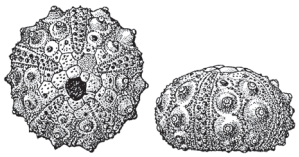


×3 magnification

7 Jurassic to Holocene

× $\frac{1}{2}$ magnification

8 Jurassic

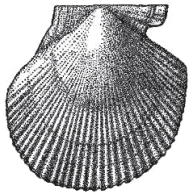


× $\frac{1}{4}$ magnification

9 Triassic

× $\frac{1}{2}$ magnification

10 Permian



× $\frac{1}{2}$ magnification

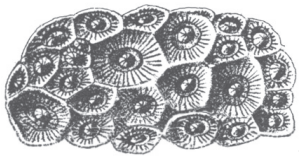
11 Permian

× $\frac{1}{2}$ magnification

12 Pennsylvanian

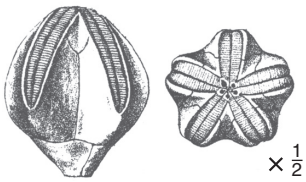
× $\frac{1}{2}$ magnification

13 Mississippian



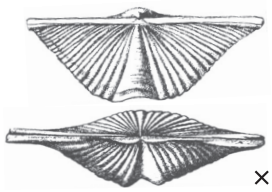
× $\frac{1}{2}$ magnification

14 Mississippian



× $\frac{1}{2}$ magnification

15 Devonian

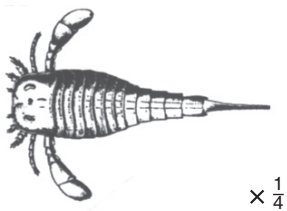


× $\frac{1}{2}$ magnification

16 Devonian

×1 magnification

17 Silurian



× $\frac{1}{4}$ magnification

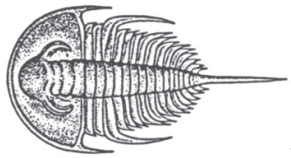
18 Ordovician to Devonian

×25 magnification

19 Ordovician

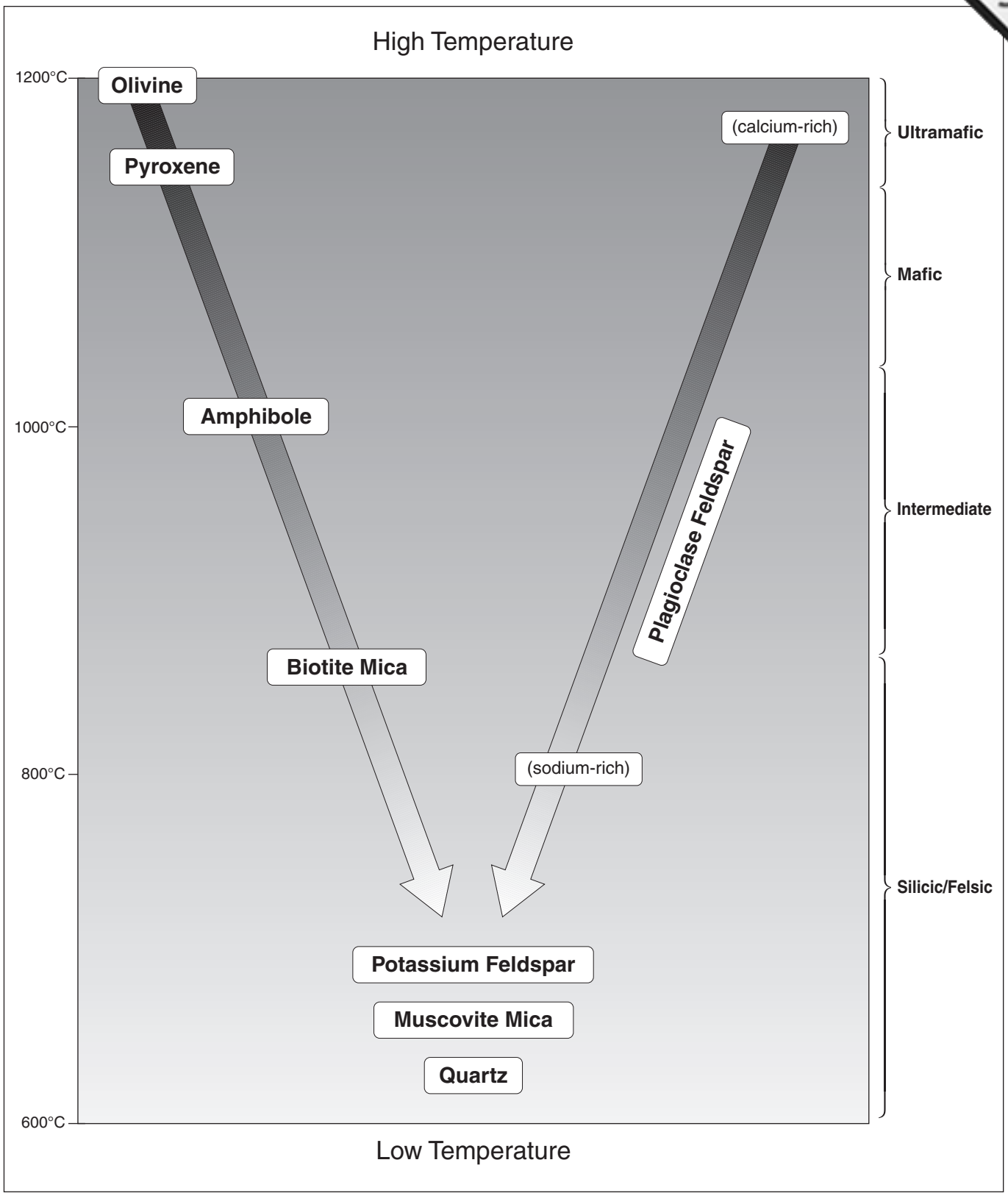
× $\frac{1}{2}$ magnification

20 Cambrian

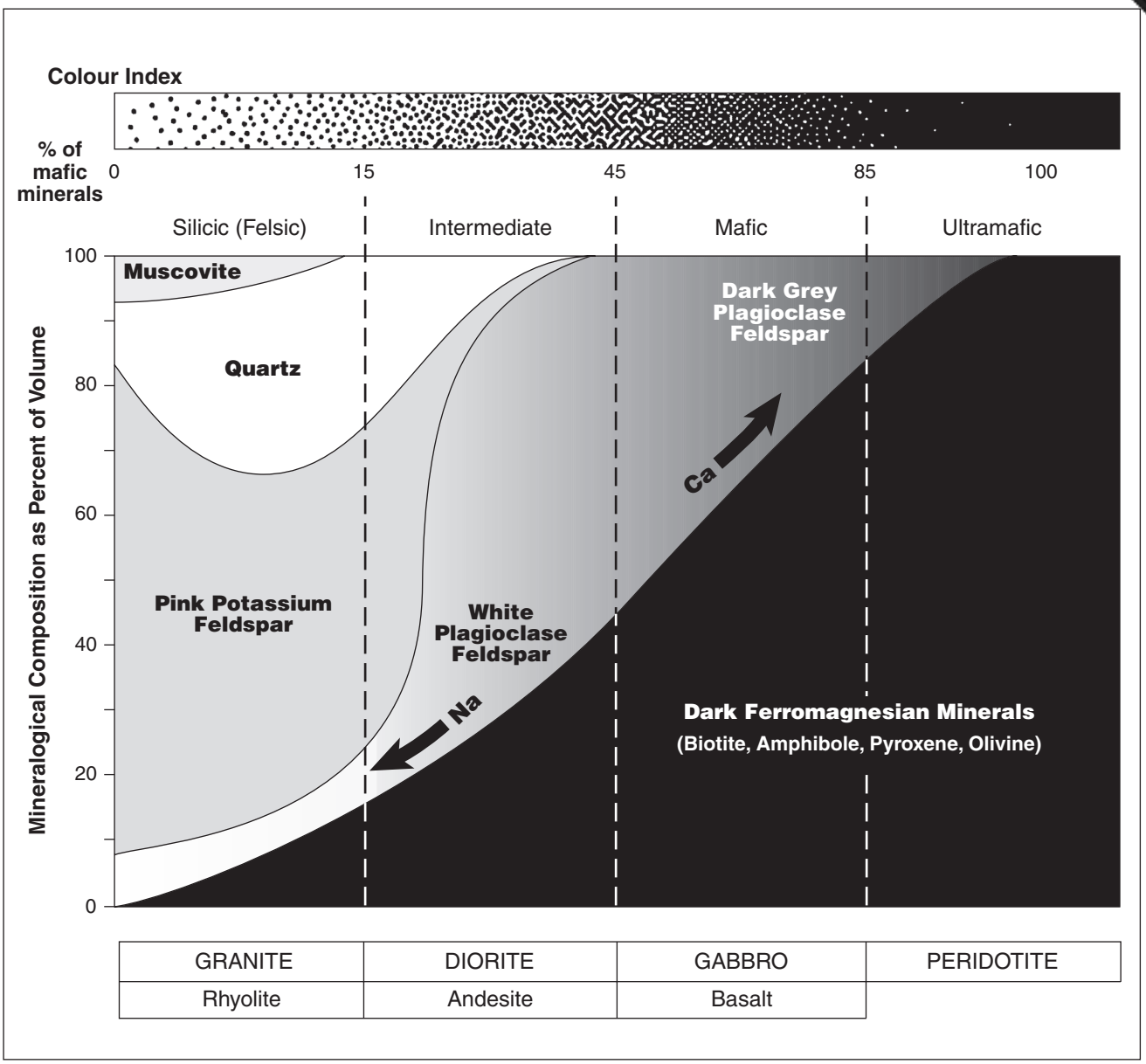


× $\frac{1}{2}$ magnification

Bowen's Reaction Series



Percentage of Minerals in Igneous Roc



GRANITE	DIORITE	GABBRO	PERIDOTITE
Rhyolite	Andesite	Basalt	

Table of Hardness

Object	Mohs Scale of Hardness
Glass or steel knife	5.5
Wire nail	4.5
Copper penny	3.5
Fingernail	2.5

Properties of Common and Important Minerals

Mineral	Colour	Streak	Lustre	Form and Other Properties	Cleavage	Hardness	Density (g/cm^3)
Amphibole (hornblende)	dark green to black	white-grey	vitreous	long crystals, grains	2 excellent at 56°	6	3.0 – 3.4
Apatite	usually green	white	vitreous	hexagonal crystals	1 poor, conchoidal fracture	5	3.1
Asbestos	green or black	none to white	waxy	fibrous or silky masses	none	2.5 – 5.0	3.1
Azurite	blue	pale blue	earthy–vitreous	earthy mass or tiny crystals, fizzes in acid	seldom visible	3.5 – 4.0	3.8
Bornite	iridescent blue, purple	grey-black	metallic	dense brittle masses	none	3	5.0
Calcite	white, pink or yellow	white-grey	vitreous	rhombohedral crystals, granular, fizzes in acid	3 perfect, not at 90°	3	2.7
Chalcopyrite	golden-brassy yellow	black	metallic	tetrahedral crystals or fine-grained masses	1 poor	3.5 – 4.0	4.2
Chlorite	green to dark green	pale green	vitreous–earthy	scaly masses	1 perfect	2.5	2.6 – 3.3
Feldspar (plagioclase)	white to grey	white	vitreous	tabular crystals, grains	2 excellent at 90°	6	2.6 – 2.8
Feldspar (potassium)	white or pink	white	vitreous–pearly	stubby crystals, grains	2 excellent at 90°	6	2.7
Fluorite	variable: green, purple	white	vitreous	cubic crystals, massive, fluorescent	4 excellent, octahedral	4	3.0 – 3.3
Galena	lead-grey	grey-black	metallic	cubes or massive	3 perfect at 90°	2.5	7.6
Garnet	variable: commonly red	white/pale red	vitreous	12 or 24 faced crystals	none	7	3.6 – 4.0
Gold	gold yellow	yellow	metallic	flakes, grains, malleable	none	2.5 – 3.0	19
Graphite	black	dark grey	metallic	scaly masses, finely crystalline	1 perfect	1 – 2	2.1
Gypsum	colourless or white	white	vitreous to pearly	tabular crystals or finely crystalline	1 excellent, 2 good	2	2.3
Halite	colourless, white	white	vitreous	cubes, finely crystalline, granular, salty taste	3 excellent at 90°	2.5	2.2
Hematite	steel grey, earthy red	red-brown	metallic or earthy	scaly or earthy masses	none	1 – 6	5.2
Limonite	brown to yellow	brown	earthy	earthy masses, granular	seldom visible	1 – 5.5	3.0 – 4.0
Magnetite	black	black	metallic	commonly finely crystalline, magnetic	seldom visible	5.5 – 6.5	5.0
Malachite	bright green	pale green	earthy	flakes or earthy masses, fizzes in acid	seldom visible	3.5 – 4.0	3.6 – 4.0
Mica (muscovite)	white, yellow	white	vitreous	flakes, scaly masses	1 perfect	2.0 – 2.5	2.8
Mica (biotite)	black or brown-black	grey, brown	vitreous	flakes, scaly masses	1 perfect	2.5	2.9 – 3.4
Molybdenite	lead grey, bluish tinge	bluish grey	metallic	scaly masses, flakes	1 perfect	1.0 – 1.5	4.7
Olivine	olive green, olive brown	white, grey	vitreous	granular masses, grains	none	6.5	3.3
Pyrite	brass yellow	greenish black	metallic	cubic crystals or finely crystalline	1 very poor	6.0 – 6.5	5.0
Pyroxene (augite)	dark green to black	white-grey	vitreous	stubby crystals	2 excellent at 90°	6	3.3
Pyrrhotite	bronze yellow	grey-black	metallic	finely crystalline, granular, weakly magnetic	none	3.5 – 4.5	
Quartz family includes amethyst, flint, agate	variable: clear, white	white	vitreous	prismatic crystals, granular, some forms are microcrystalline	none – conchoidal fracture	7	
Sphalerite	brown to yellow	yellow to brown	resinous/metallic	tetrahedral crystals, finely crystalline	6 perfect	3.5 –	
Talc	white	white	silky, greasy	microcrystalline masses, fibrous	1 perfect		– 2.8

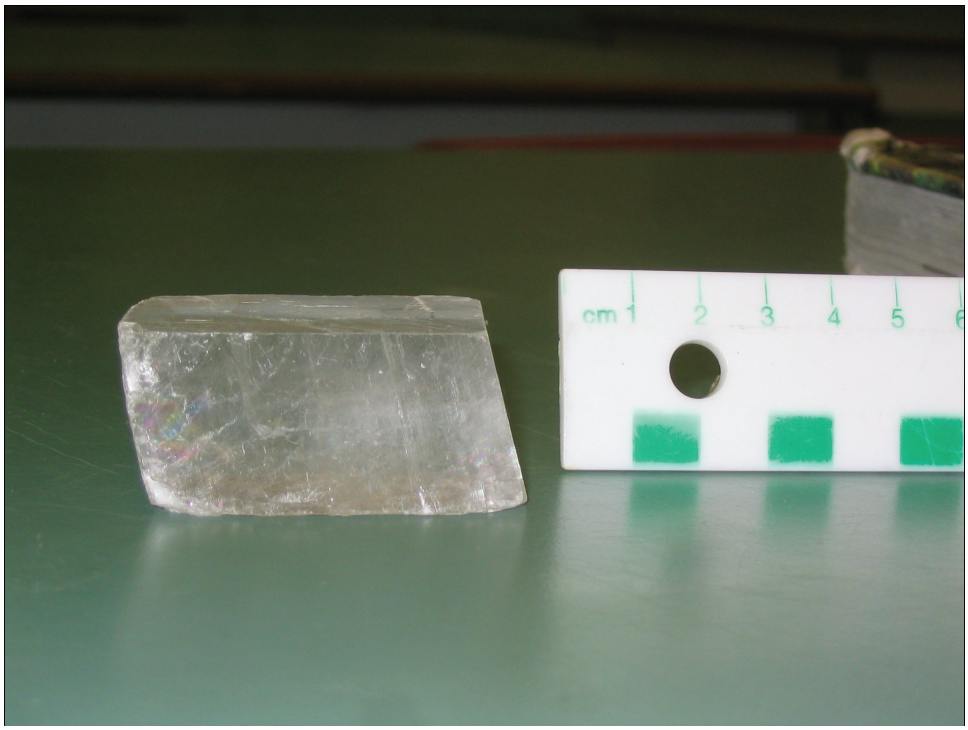
Solar System Data Table

Solar System Object	Average Distance to Sun (x 10^6 km)	Equatorial Radius (km)	Mass Relative to Earth (planet mass/ Earth mass)	Density (g/cm^3)	Basic Composition	Magnetic Field Strength Relative to Earth	Number of Moons	Average Surface Temperature (°C)	Inclination = orbital angle to ecliptic plane** (degrees)	Rotation Period on axis (hours)
Mercury	57.9	2 440	0.055	5.43	silicate & iron	0.01	0	427/–183	7	1 407.6
Venus	108.2	6 052	0.815	5.24	silicate & iron	none	0	467	3.4	5 832.5
Earth	149.6	6 378	1.0	5.52	silicate & iron	1.0	1	15	0	23.9
Earth's moon	—	1 738	0.012	3.34	silicate & iron	none	—	127/–173	5.1	655.7
Mars	227.9	3 397	0.107	3.93	silicate & iron	none	2	–65	1.9	24.6
Asteroid belt	most from 300 to 600 but some close to Earth	range from 1 to 500 km	total mass of all is less than 0.001	varies	silicate & iron	none	at least one asteroid has a moon	—	from 0.5 to 35	from 3 to 417.7
Jupiter	778.6	71 492	317.8	1.33	H and He	13.9	63	–110	1.3	9.9
Saturn	1 433.5	60 268	95.2	0.69	H and He	0.68	47	–140	2.5	10.7
Uranus	2 872.5	25 559	14.5	1.27	H and He	0.74	27	–195	0.8	17.2
Neptune	4 495.1	24 764	17.1	1.64	H and He	0.46	13	–200	1.8	16.1
Pluto*	5 870.0	1 195	0.0021	1.75	H and He	unknown	3	–225	17.2	153.3
Kuiper Belt*	4 500 to 10 000	range from 1 to 750	0.1	low	rock and ice	unknown	—	–240	varies	—

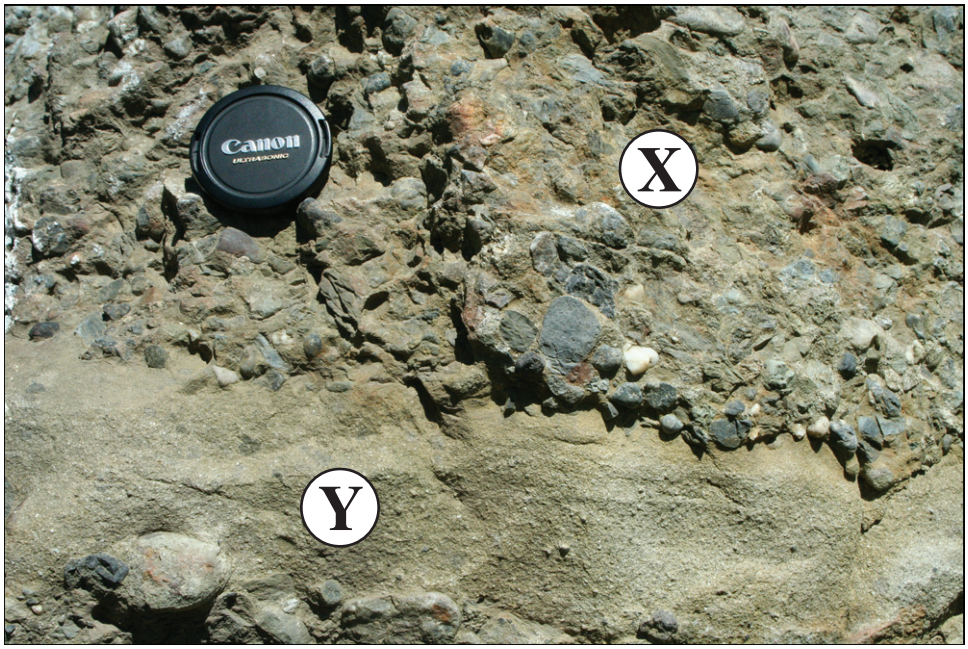
Pluto, Sedna and Quaoar are part of the Kuiper Belt of 70 000+ objects that are found outside Neptune's orbit and beyond.
*The ecliptic plane is defined as the imaginary plane containing the Earth's orbit around the Sun.
Data based on 2004 information from NASA – http://nssdc.gsfc.nasa.gov/planetary/factsheet/

Photographs

photograph 1



photograph 2



photograph 3

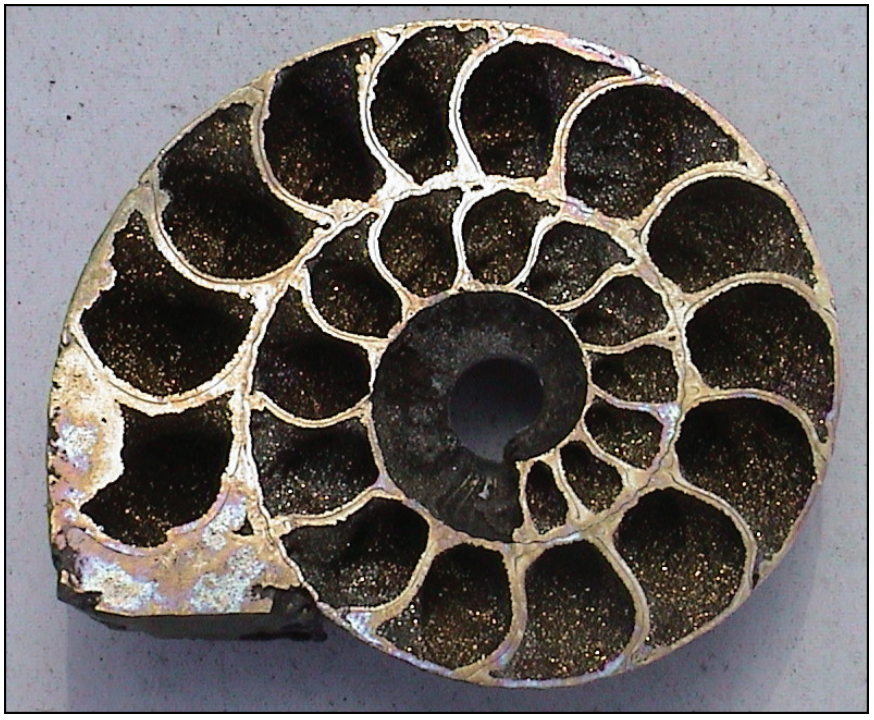
photograph 4

Image courtesy United States Geological Survey, AGI Earth Science World Image Bank

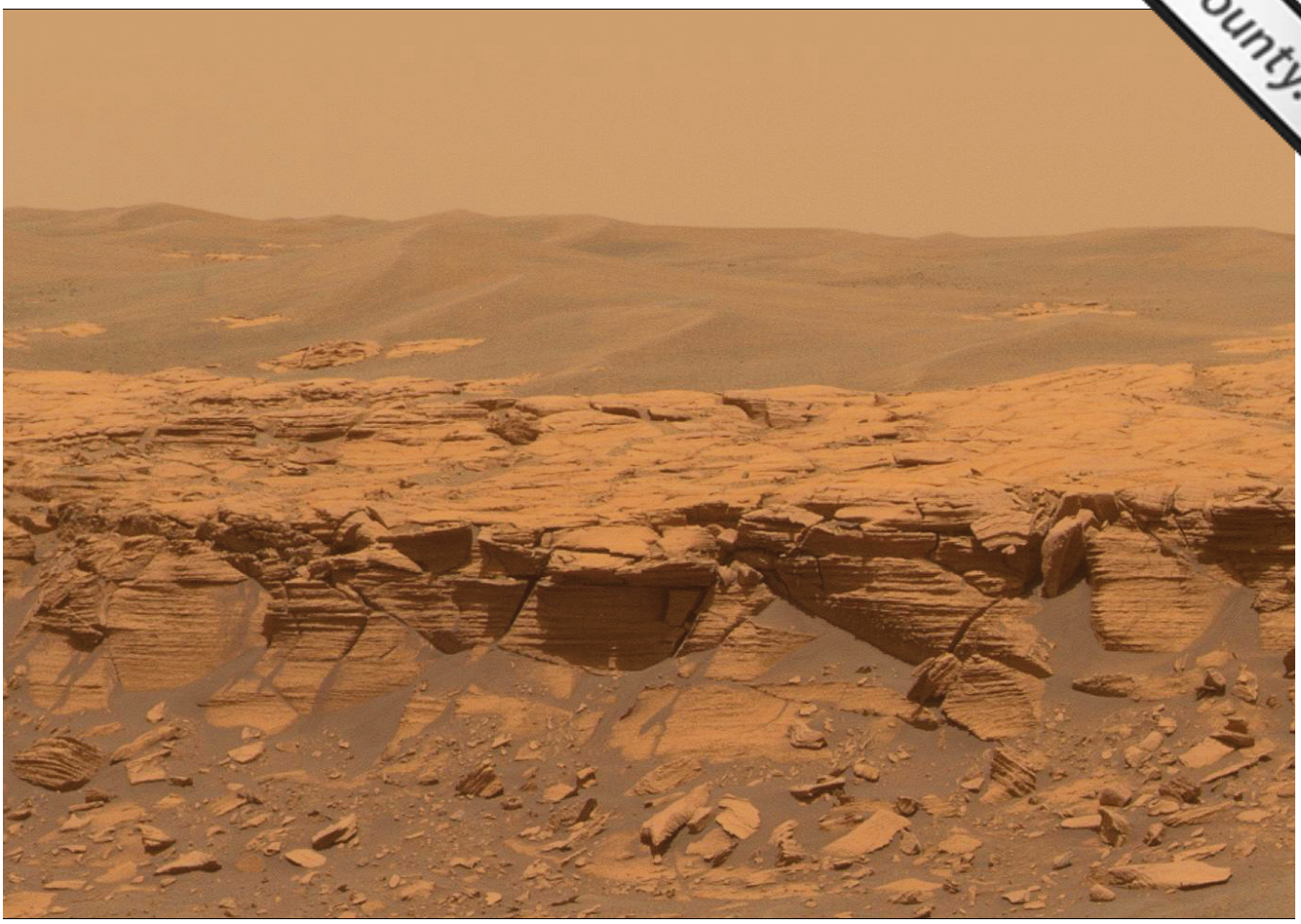
photograph 5

Image courtesy Barry Marsh
School of Ocean and Earth Science, University of Southampton, UK

photograph 6



photograph 7



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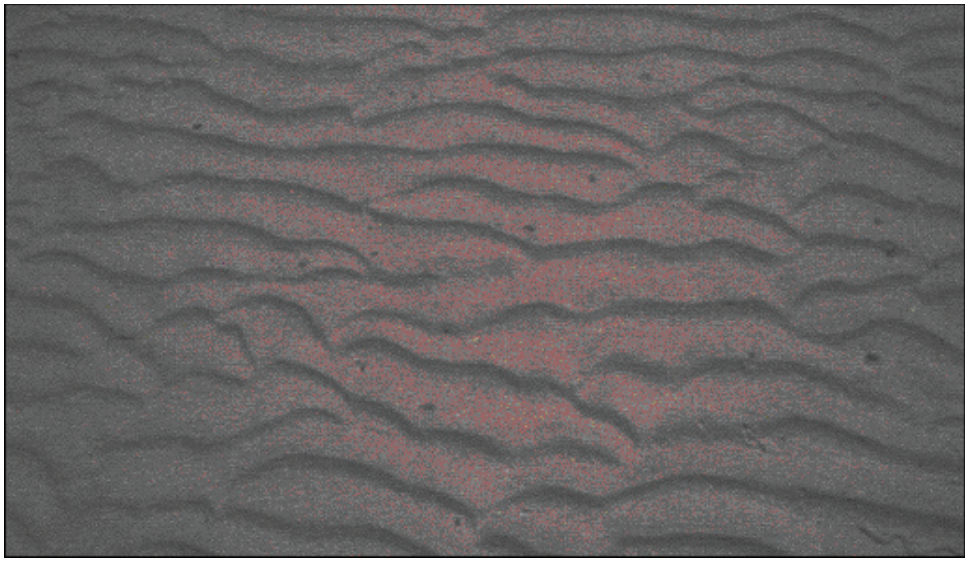

photograph 9

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photograph 10

Photographer Bruce Molnia, Terra Graphics, AGI Earth Science World Image Bank