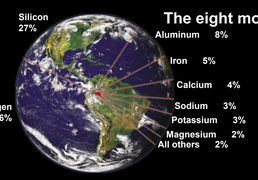
# the Blue Marble

## where the elements we use come from

There are 92 natural elements and they are the ingredients used to make everything we find on Earth.

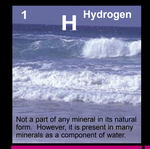
**Radioactive elements (blue box)**— a white border around the box indicates that the element is not found naturally or occurs in such minute amounts that it does not reasonably exist on Earth.

EARTH - THE BLUE MARBLE
Image created by Reto Stockli with the help of Alan Nelson, under the leadership of Fritz Hasler




**The eight most abundant elements on Earth, by weight.**

### 1 H Hydrogen



Not a part of any mineral in its natural form. However, it is present in many minerals as a component of water.

### 2 He Helium

Obtained from natural gas deposits. There are no helium bearing minerals.

### 3 Li Lithium

Mined primarily from **spodumene**. Others include amblygonite, lepidolite and petalite. Found in small amounts in nearly all rocks.

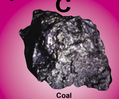
### 4 Be Beryllium

Obtained from **beryl** and bertrandite. Others include chrysoberyl, gadolinite and herderite.

### 5 B Boron

Chiefly found in ulexite, and colemanite. Others include borax, calcilite and **kernite**.

### 6 C Carbon



**Coal**
Many carbon-bearing minerals including all fossil fuels and all carbonate minerals. Pure carbon minerals are graphite and diamond.

### 7 N Nitrogen

Chiefly obtained by liquefying air. Minerals are uncommon but include nitratine (sodium nitrate), nitrammite (ammonium nitrate), nitrocalcite (barium nitrate), nitrocalcite, and nitromagnesite.

### 8 O Oxygen

The most common element on the surface of the Earth, occurring as a gas, in water, and oxide minerals or in combination with numerous other minerals.

### 9 F Fluorine

Chiefly obtained from calcium fluoride (fluorite or fluorospar). Other minerals include apatite and cryolite.

### 10 Ne Neon

Mainly from liquefying air. There are no neon-bearing minerals.

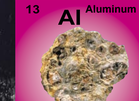
### 11 Na Sodium

Most by electrolysis of **sodium chloride** (halite, *on left*) and from **trona**. Occurs in many minerals, including amphibole, zeolite and cryolite.

### 12 Mg Magnesium

Chiefly by electrolysis of magnesium chloride. Also from **dolomite**, magnesite, kieserite and brucite.

### 13 Al Aluminum



Chiefly from **bauxite** but present in many minerals, including diaspore, gibbsite and corundum (rubies and sapphires) and topaz. Present in clay and mica.

### 14 Si Silicon

Hundreds of silicon minerals, including **quartz**, the most common mineral on Earth, also from mica and talc.

### 15 P Phosphorus

Obtained from apatite and **fluorapatite**. Also phosphophyllite, turquoise and vivianite.

### 16 S Sulfur

Many sulfur-bearing minerals. Also near volcanoes and hot springs, and in oil-producing regions. Other sources are pyrite and hydrogen sulfide gas distilled from natural gas wells.

### 17 Cl Chlorine

Obtained by electrolysis of sodium chloride solutions. Abundant in the oceans. Present in small amounts in many minerals. The most common mineral is sodium chloride (**halite**).

### 18 Ar Argon

Obtained from liquefying air. There are no argon-bearing minerals.

### 19 K Potassium

Most from potassium chloride (sylvite). Also from alunite, carnallite, and **potash**. Orthoclase feldspar is a common potassium-bearing mineral.

### 20 Ca Calcium

Minerals are very common. Chiefly from **calcite**, dolomite and gypsum. Also calcium sulfate (anhydrite) and calcium carbonate (aragonite and calcite).

### 21 Sc Scandium

Rare, extracted from uranium ore tailings and from **euxenite**, gadolinite and thortveitite.

### 22 Ti Titanium

Chiefly from ilmenite and rarely from beta-titanium dioxide (anatase). Others include perovskite, alpha-titanium dioxide (**rutile**), sphene and titanite.

### 23 V Vanadium

Occurs in many minerals in minute quantities. Some minerals include carnotite, descloizite, vanadium sulfide (patronite) and **vanadinite**.

### 24 Cr Chromium

Chiefly obtained from **chromite**.

### 25 Mn Manganese

In many minerals. obtained from pyrolusite and romanechite. Others include bixbyite, **manganite**, manganese carbonate (rhodocrosite) and rhodonite.

### 26 Fe Iron

Common in many minerals: goethite, iron oxide (hematite), lepidocrocite, iron oxide (magnetite) and iron corbonate (siderite).

### 27 Co Cobalt

Generally from the **cobaltite** and cobalt arsenide (smaltite). Others include erythrite, glaucodot and cobalt sulfide (linnaeite).

### 28 Ni Nickel

Primarily from garnierite and **pentlandite**. Others include nickel sulfide (millerite) and nickel asenide (nickeline).

### 29 Cu Copper

Most from **chalcopyrite** (left), **malachite** and **azurite (right), and** chalcanthite. In many minerals. Other common include bornite, chalcocite, chrysocolla, and cuprite.

### 30 Zn Zinc

Zinc carbonate (smithsonite), zinc sulfide (**sphalerite**), hemimorphite and zincite. Others include calamine and willemite.

### 31 Ga Gallium

Obtained as a by-product of zinc and copper processing, and as an impurity in **bauxite**, sphalerite, and coal. Gallite is a common mineral.

### 32 Ge Germanium

**Sphalerite**
Like gallium, germanium is obtained as a by-product of processing copper and zinc. Argyrodite and germanite are other minerals.

### 33 As Arsenic

Obtained from the processing of other minerals. Common minerals include arsenopyrite, conichalcite, enargite, loltingite, olivenite, and **realgar**.

### 34 Se Selenium

**Malachite** (a copper ore)
Most obtained as a by-product of copper ore processing. Occurs in the rare minerals clausthalite and crookiste.

### 35 Br Bromine

Found in seawater and in evaporate deposits. The only common mineral is silver bromide (bromargyrite).

### 36 Kr Krypton

There are no krypton-bearing minerals. Obtained from liquefying air.

### 37 Rb Rubidium

No rubidium-based minerals are known, but it occurs as an impurity in **pollucite**, leucite and zinnwaldite.

### 38 Sr Strontium

Obtained from strontium carbonate (strontianite) and strontium sulfate (**celestite**).

### 39 Y Yttrium

Obtained from **bastnasite**, fergusonite, monazite, samarskite and xenotime. Other minerals include gadolinite and polycrase.

### 40 Zr Zirconium

Chiefly obtained from zirconium dioxide (baddeleyite) and **zircon**.

### 41 Nb Niobium

Present in many minerals, but mostly betafite, **columbite** and samarskite and as a by-product of tin processing.

### 42 Mo Molybdenum

Chiefly from **molybdenite** and wulfenite. Also as a by-product of copper and tungsten processing.

### 43 Tc Technetium

**Does not exist in the Earth's crust**

Technetium has a fairly a short half-life, so any naturally occurring technetium (on Earth) has long since disappeared. It was the first artificially produced element.

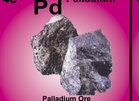
### 44 Ru Ruthenium

**Nickeline**
Generally produced as a by-product of nickel processing. Ruthenarsenite is one of the few minerals.

### 45 Rh Rhodium


Most obtained as a by-product of copper and nickel processing. Rhodplumsite is a somewhat common rhodium-bearing mineral.

### 46 Pd Palladium



**Palladium Ore**
**Platinum Group Metals (PGMs)**
Generally found only in pure form. Obtained as a by-product of copper and zinc processing.

### 47 Ag Silver

Often found in pure form. Also from silver sulfide (acanthite) and stephanite, silver chloride (chlorargyrite) and polybasite.

### 48 Cd Cadmium

**Smithsonite** (zinc ore)
Minerals are very rare. Obtained as a by-product of zinc processing. Some minerals include cadmoselite, greenockite and otavite.

### 49 In Indium

**Galena** (lead ore)
Most obtained as a by-product of lead and zinc processing. Occurs in only few minerals, such as indite

### 50 Sn Tin

Chiefly from tin dioxide (**cassiterite**). Tin is rare in other minerals.

### 51 Sb Antimony

Sometimes found in pure form. Also from antimony sulfide (**stibnite**). Other minerals include stibiconite, tetrahedrite and ullmannite.

### 52 Te Tellurium

Tellurium is obtained as a by-product of copper processing. Other minerals include tellurium oxide (**tellurite**) and sylvanite.

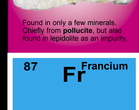
### 53 I Iodine

Minerals of iodine are rare. Primarily obtained from seawater, old salt brines and salt wells. Some from seaweed. Silver iodide (iodargyrite) and lautarite are two of the more common minerals.

### 54 Xe Xenon

There are no xenon-bearing minerals. It is obtained from liquefying air.

### 55 Cs Cesium



Found in only a few minerals. Chiefly from **pollucite**, but also found in lepidolite as an impurity.

### 56 Ba Barium

Chiefly obtained from barium sulfate (**barite**) and barium carbonate (witherite)

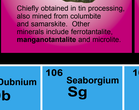
### 57-71 Lanthanide Series

Often called the Rare Earths, our ability to recover these elements is fairly new, making them available for modern technological uses.

### 72 Hf Hafnium

**Zircon**
Minerals are very rare. Chiefly obtained as a by-product of zirconium processing

### 73 Ta Tantalum

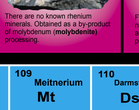


Chiefly obtained in tin processing, also mined from columbite and samarskite. Other minerals include ferrotantalite, **manganotantalite** and microlite.

### 74 W Tungsten

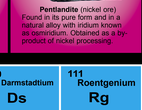
Chiefly obtained from scheelite and **wolframite**. Also found in ferberite and huebnerite.

### 75 Re Rhenium



There are no known rhenium minerals. Obtained as a by-product of molybdenum (**molybdenite**) processing.

### 76 Os Osmium

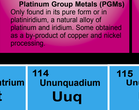


**Pentlandite** (nickel ore)
Found in its pure form and in a natural alloy with indium known as osmiridium. Obtained as a by-product of nickel processing.

### 77 Ir Iridium

**Platinum Group Metals (PGMs)**
Found only in its pure form and in osmiridium, a natural alloy of indium and osmium

### 78 Pt Platinum

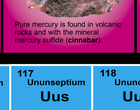


**Platinum Group Metals (PGMs)**
Only found in its pure form or in platinoiridium, a natural alloy of platinum and iridium. Some obtained as a by-product of copper and nickel processing.

### 79 Au Gold

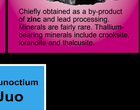
Primarily found as the pure metal, often embedded in igneous quartz veins. Sylvanite is a gold-bearing mineral.

### 80 Hg Mercury



Pure mercury is found in volcanic rocks and with the mineral mercury sulfide (**cinnabar**).

### 81 Tl Thallium



Chiefly obtained as a by-product of **zinc** and lead processing. Minerals are fairly rare. Thallium-bearing minerals include crookslite, lorandite and thalcusite.

### 82 Pb Lead

In many minerals. Chiefly obtained from lead sulfide (**galena**). Other common minerals include anglesite, boulangerite, cerussite, minnil and pyromorphite.

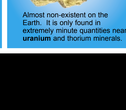
### 83 Bi Bismuth


Often found in pure form. Chiefly obtained as a by-product of copper and lead processing. Also bismuthinite, bismite and bismutite.

### 84 Po Polonium

A decay product of **uranium**. It is found in minute amounts in uranium ore.

### 85 At Astatine



Almost non-existent on the Earth. It is only found in extremely minute quantities near **uranium** and thorium minerals.

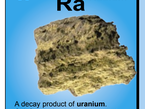
### 86 Rn Radon

A decay product of **uranium**, thorium and radium. Occasionally found dissolved in certain hot spring waters.

### 87 Fr Francium

Almost non-existent on Earth. It can be produced by particle bombardment of radium or thorium.

### 88 Ra Radium



A decay product of **uranium**. Chiefly obtained as a by-product of uranium processing.

### 89-103 Actinide Series

All Actinides are radioactive metals and most are not found in nature but are created in laboratories.

### 104 Rutherfordium Rf

Obtained by particle bombardment of californium or curium.

### 105 Dubnium Db

Obtained by the particle bombardment of californium or berkelium.

### 106 Seaborgium Sg

Obtained by the particle bombardment of curium or californium.

### 107 Bohrium Bh

Obtained by the fusion process of bombarding bismuth with chromium.

### 108 Hassium Hs

Obtained by the fusion process of bombarding lead with iron.

### 109 Meitnerium Mt

Obtained by the fusion process of bombarding bismuth with iron.

### 110 Darmstadtium Ds

Obtained by the fusion process of bombarding lead with nickel.

### 111 Roentgenium Rg

Obtained by the fusion process of bombarding bismuth with nickel

### 112 Ununbium Uub

Obtained by the fusion process of bombarding lead with zinc.

### 113 Ununtrium Uut

Reported and awaiting confirmation.

### 114 Ununquadium Uuq

Obtained by the fusion process of bombarding plutonium with calcium

### 115 Ununpentium Uup

Reported in 2004 and awaiting confirmation.

### 116 Ununhexium Uuh

Originally reported in 1999; confirmed in 2004.

### 117 Ununseptium Uus

Has not yet been discovered.

### 118 Ununoctium Uuo

Reported in 1999, deleted in 2002. Reported again in 2006.

### 57 Lanthanum La

Most are found in the minerals **monazite** and bastnasite. Other minerals include allanite and cerite.

### 58 Cerium Ce

Chiefly obtained from **monazite** and bastnasite. Also found in allanite, cerite, samarskite and the titanium mineral perovskite.

### 59 Praseodymium Pr

Chiefly obtained from **monazite** and bastnasite.

### 60 Neodymium Nd

Chiefly obtained from **monazite** and bastnasite.

### 61 Promethium Pm

Any natural promethium the Earth possessed has long since disappeared. It is generally obtained from fission products in nuclear reactors.

### 62 Samarium Sm

Obtained from **monazite**.

### 63 Europium Eu

Chiefly obtained from **bastnasite** and monazite.

### 64 Gadolinium Gd

Chiefly obtained from **bastnasite** and monazite, also gadolinite.

### 65 Terbium Tb

Chiefly obtained from **monazite**, also in cerite, xenotime and gadolinite.

### 66 Dysprosium Dy

Chiefly obtained from **bastnasite** and monazite. Other minerals include euxenite, fergusonite, gadolinite and polycrase.

### 67 Holmium Ho

Chiefly obtained from **bastnasite** and monazite, also occurs in gadolinite.

### 68 Erbium Er

Chiefly obtained from **bastnasite** and monazite.

### 69 Thulium Tm

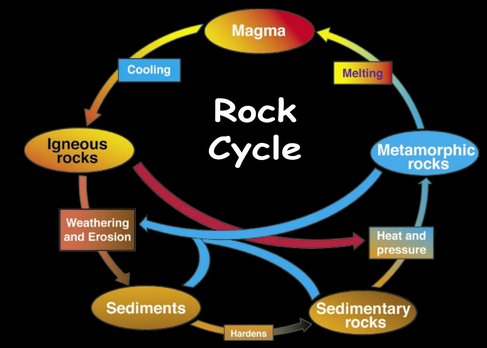
Chiefly obtained from **bastnasite** and monazite.

### 70 Ytterbium Yb

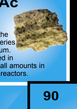
Chiefly obtained from **euxenite** and xenotime.

### 71 Lutetium Lu

Obtained from **bastnasite** and monazite. Small amounts in any mineral containing yttrium.




### 89 Actinium Ac



Part of the decay series of uranium. Produced in very small amounts in nuclear reactors.

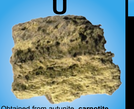
### 90 Thorium Th

Obtained from monazite and thorium dioxide (**thorianite**), and as a significant impurity in zircon, titanite, gadolinite and betafite.

### 91 Protactinium Pa

A decay product of uranium. It can be extracted from uranium minerals.

### 92 Uranium U



Obtained from autunite, **carnotite**, monazite, samarskite, and uranium dioxide (uraninite, also called pitchblende). Other common minerals are betafite and torberite.

### 93 Neptunium Np

Obtained by particle bombardment of uranium.

### 94 Plutonium Pu

Obtained by particle bombardment of uranium.

### 95 Americium Am

Obtained by particle bombardment of plutonium.

### 96 Curium Cm

Obtained by particle bombardment of plutonium.

### 97 Berkelium Bk

Obtained by particle bombardment of plutonium.

### 98 Californium Cf

Obtained by particle bombardment of plutonium.

### 99 Einsteinium Es

Obtained by particle bombardment of plutonium.

### 100 Fermium Fm

Obtained by particle bombardment of plutonium.

### 101 Mendelevium Md

First obtained by particle bombardment of einsteinium.

### 102 Nobelium No

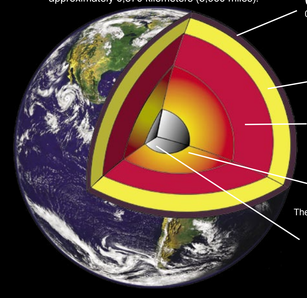
Obtained by bombarding californium or curium with carbon.

### 103 Lawrencium Lr

Obtained by bombarding californium with boron or bombarding berkelium with oxygen.

## Everything Is Made From Something and that Something is our Natural Resources

## . . . most are contained within our rock and mineral resources



Distance from Earth's surface to center is approximately 6,370 kilometers (3,960 miles).

**Crust**
0 to 70 kilometers thick (0 to 44 miles)

**Upper Mantle**
Approximately 700 kilometers thick (440 miles)

**Lower Mantle**
Approximately 2,100 kilometers thick (1,300 miles)

**Outer Core**
The thickness of the core is approximately 3,500 kilometers (2,175 miles).

**Inner Core**

All mining occurs in the crust of the Earth, usually within a thousand feet of the surface.

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## the ULTIMATE Periodic Chart

36" x 54"

**Two different charts on 2 sides includes photographs of the elements**


Printed on a paper almost as indestructible as the elements themselves