2 FOCUS ON

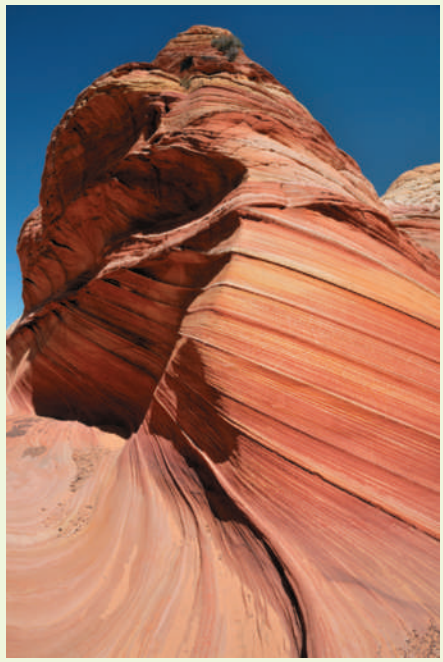
Occurrence and Abundances of the Elements

What is the most abundant element? This seemingly simple question does not have a simple answer. If we consider the entire universe, hydrogen accounts for about 90% of all the atoms and 75% of the mass, and helium accounts for most of the rest. If we consider only the elements present on Earth, iron is probably the most abundant element. However, most of this iron is believed to be in Earth's core. The currently accessible elements are those present in Earth's atmosphere, oceans, and solid continental crust. The relative abundances of some elements and common materials containing these elements are listed in the table below.

Not all the known elements exist in Earth's crust. Trace amounts of neptunium ($Z = 93$) and plutonium ($Z = 94$) are found in uranium minerals, but for practical purposes, elements with atomic numbers higher than 92 can be produced only artificially by nuclear processes. Moreover, most of the elements do not occur *free* in nature—that is, as the uncombined element—only about 20% of them do. The remaining elements occur only in chemical combinations with other elements.

We cannot assume that the ease and cost of obtaining a pure element from its natural sources are necessarily related to the relative abundance of the element. Aluminum is the most abundant of the metals in Earth's crust, but it cannot be produced as cheaply as iron can. This is partly because concentrated deposits of iron-containing compounds—iron ores—are more common than are ores of aluminum. Some elements whose percent abundances are quite low are nevertheless widely used because their ores are fairly common. This is the case with copper, for example, whose abundance in Earth's crust is only 0.005%. On the other hand, some elements have a fairly high abundance but no characteristic ores of their own. They are not easily obtainable, as in the case of rubidium, the 23rd most abundant element.

In later chapters, we will describe the ways in which elements are obtained from natural sources: oxygen, nitrogen, and argon from the atmosphere; hydrogen from natural gas; magnesium and bromine from seawater; sulfur from underground and underwater deposits and from hydrogen sulfide in natural gas; sodium and chlorine from ordinary rock salt; and several metals from their ores.



▲ Iron is one of the most abundant elements in Earth's crust. Iron compounds give soils a characteristic red color, as in the Navajo Sandstone Paria Canyon Wilderness Area of Arizona.
(Sandra vom Stein/iStock)

Abundances of the Elements in Earth's Crust[a]

Element	Abundance, Mass (%)	Principal Materials Containing the Element
Oxygen	49.3	Water; silica; silicates; metal oxides; the atmosphere
Silicon	25.8	Silica (sand, quartz, agate, flint); silicates (feldspar, clay, mica)
Aluminum	7.6	Silicates (clay, feldspar, mica); oxide (bauxite)
Iron	4.7	Oxide (hematite, magnetite)
Calcium	3.4	Carbonate (limestone, marble, chalk); sulfate (gypsum); fluoride (fluorite); silicates (feldspar, zeolites)
Sodium	2.7	Chloride (rock salt, ocean waters); silicates (feldspar, zeolites)
Potassium	2.4	Chloride; silicates (feldspar, mica)
Magnesium	1.9	Carbonate; chloride (seawater); sulfate (Epsom salts)
Hydrogen	0.7	Oxide (water); natural gas and petroleum; organic matter
Titanium	0.4	Oxide
Chlorine	0.2	Common salt (rock salt, ocean waters)
Phosphorus	0.1	Phosphate rock; organic matter
all others[b]	0.8	

[a]Earth's crust is taken to consist of the solid crust, terrestrial waters, and the atmosphere.
[b]This number includes C, N, and S—all essential to life—and less abundant, although commercially important, elements such as B, Be, Cr, Cu, F, I, Pb, Sn, and Zn.