Classification and Distribution of Elements in Earth Crust

The mass-abundance of the nine most abundant elements in the Earth's crust is approximately: oxygen 46%, silicon 28%, aluminum 8.3%, iron 5.6%, calcium 4.2%, sodium 2.5%, magnesium 2.4%, potassium 2.0%, and titanium 0.61%. Other elements occur at less than 0.15%. For a complete list, see abundance of elements in Earth's crust. The graph at right illustrates the relative atomic-abundance of the chemical elements in Earth's upper continental crust—the part that is relatively accessible for measurements and estimation.

Many of the elements shown in the graph are classified into (partially overlapping) categories:

rock-forming elements (major elements in green field, and minor elements in light green field); rare earth elements (lanthanides, La-Lu, and Y; labeled in blue); major industrial metals (global production >~3×107 kg/year; labeled in red); precious metals (labeled in purple); the nine rarest "metals" – the six platinum group elements plus Au, Re, and Te (a metalloid) – in the yellow field. These are rare in the crust from being soluble in iron and thus concentrated in the Earth's core. Tellurium is the single most depleted element in the silicate Earth relative to cosmic abundance, because in addition to being concentrated as dense chalcogenides in the core it was severely depleted by preaccretional sorting in the nebula as volatile hydrogen telluride.

There are two breaks where the unstable (radioactive) elements technetium (atomic number 43) and promethium (atomic number 61) would be. These elements are surrounded by stable elements, yet both have relatively short half-lives (~4 million years and ~18 years respectively). These are thus extremely rare, since any primordial initial fractions of these in pre-Solar System materials have long since decayed. These two elements are now only produced naturally through the spontaneous fission of very heavy radioactive elements (for example, uranium, thorium, or the trace amounts of plutonium that exist in uranium ores), or by the interaction of certain other elements with cosmic rays. Both technetium and promethium have been identified spectroscopically in the atmospheres of stars, where they are produced by ongoing nucleosynthetic processes.

There are also breaks in the abundance graph where the six noble gases would be, since they are not chemically bound in the Earth's crust, and they are only generated by decay chains from radioactive elements in the crust, and are therefore extremely rare there.

The eight naturally occurring very rare, highly radioactive elements (polonium, astatine, francium, radium, actinium, protactinium, neptunium, and plutonium) are not included, since any of these elements that were present at the formation of the Earth have decayed away eons ago, and their quantity today is negligible and is only produced from the radioactive decay of uranium and thorium.

Oxygen and silicon are notably the most common elements in the crust. On Earth and in rocky planets in general, silicon and oxygen are far more common than their cosmic abundance. The reason is that they combine with each other to form silicate minerals. In this way, they are the lightest of all of the two-percent "astronomical metals" (i.e., non-hydrogen and helium elements) to form a solid that is refractory to the Sun's heat, and thus cannot boil away into space. All elements lighter than oxygen have been removed from the crust in this way, as have the heavier chalcogens sulfur, selenium and tellurium.

Rare-earth elements

"Rare" earth elements is a historical misnomer. The persistence of the term reflects unfamiliarity rather than true rarity. The more abundant rare earth elements are similarly concentrated in the crust compared to commonplace industrial metals such as chromium, nickel, copper, zinc, molybdenum, tin, tungsten, or lead. The two least abundant rare earth elements (thulium and lutetium) are nearly 200 times more common than gold. However, in contrast to the ordinary base and precious metals, rare earth elements have very little tendency to become concentrated in exploitable ore deposits. Consequently, most of the world's supply of rare earth elements comes from only a handful of sources. Furthermore, the rare earth metals are all quite chemically similar to each other, and they are thus quite difficult to separate into quantities of the pure elements.

Differences in abundances of individual rare earth elements in the upper continental crust of the Earth represent the superposition of two effects, one nuclear and one geochemical. First, the rare earth elements with even atomic numbers (58Ce, 60Nd,) have greater cosmic and terrestrial abundances than the adjacent rare earth elements with odd atomic numbers (57La, 59Pr,). Second, the lighter rare earth elements are more incompatible (because they have larger ionic radii) and therefore more strongly concentrated in the continental crust than the heavier rare earth elements. In most rare earth ore deposits, the first four rare earth elements – lanthanum, cerium, praseodymium, and neodymium – constitute 80% to 99% of the total amount of rare earth metal that can be found in the ore.

More over Distribution of Elements in Earth Crust

A new calculation of the crustal composition is based on the proportions of upper crust (UC) to felsic lower crust (FLC) to mafic lower crust (MLC) of about 1:0.6:0.4. These proportions are derived from a 3000 km long refraction seismic profile through western Europe (EGT) comprising 60% old shield and 40% younger fold belt area with about 40 km average Moho depth. A granodioritic bulk composition of the UC in major elements and thirty-two minor and trace elements was calculated from the Canadian Shield data (Shaw et al., 1967, 1976). The computed abundance of thirty-three additional trace elements in the UC is based on the following proportions of major rock units derived from mapping: 14% sedimentary rocks, 25% granites, 20% granodiorites, 5% tonalites, 6% gabbros, and 30% gneisses and mica schists. The composition of FLC and MLC in major and thirty-six minor and trace elements is calculated from data on felsic granulite terrains and mafic xenoliths, respectively, compiled by Rudnick and Presper (1990). More than thirty additional trace element abundances in FLC and MLC were computed or estimated from literature data.

The bulk continental crust has a tonalitic and not a dioritic composition with distinctly higher concentrations of incompatible elements including the heat producing isotopes in our calculation. A dioritic bulk crust was suggested by Taylor and McLennan (1985). The amount of tonalite in the crust requires partial melting of mafic rocks with about 100 km thickness (compared with about 7 km in the present MLC) and water supply from dehydrated slabs and mafic intrusions. At the relatively low temperatures of old crustal segments MLC was partly converted into eclogite which could be recycled into the upper mantle under favourable tectonic conditions. The chemical fractionation of UC against FLC + MLC was caused by granitoidal partial melts and by mantle degassing which has controlled weathering and accumulation of volatile compounds close to the Earth's surface

Distribution of Elements in continental crust:

The continental crust has an average composition similar to that of andesite. The most abundant minerals in Earth's continental crust are feldspars, which make up about 41% of the crust by weight, followed by quartz at 12%, and pyroxenes at 11%.[6] Continental crust is enriched in incompatible elements compared to the basaltic ocean crust and much enriched compared to the underlying mantle. Although the continental crust comprises only about 0.6 weight percent of the silicate on Earth, it contains 20% to 70% of the incompatible elements.

Most Abundant Elements of Earth's Crust Approximate % by weight

O	46.6
Si	27.7
Al	8.1
Fe	5.0
Ca	3.6
Na	2.8
K	2.6
Mg	1.5

Oxide	**Percent**
SiO_2	60.6
Al_2O_3	15.9
CaO	6.4
MgO	4.7
Na_2O	3.1

Fe as FeO	6.7
K_2O	1.8
TiO_2	0.7
P_2O_5	0.1

All the other constituents except water occur only in very small quantities and total less than 1%. Estimates of average density for the upper crust range between 2.69 and 2.74 g/cm3 and for lower crust between 3.0 and 3.25 g/cm3