The Earth formed from the same cloud of matter that formed the Sun, but the planets acquired different compositions during the formation and evolution of the solar system. In turn, the natural history of the Earth caused parts of this planet to have differing concentrations of the elements. The mass of the Earth is approximately \(5.98 \times 10^{24}\) kg. In bulk, by mass, it is composed mostly of iron (32.1%), oxygen (30.1%), silicon (15.1%), magnesium (13.9%), sulfur (2.9%), nickel (1.8%), calcium (1.5%), and aluminum (1.4%); with the remaining 1.2% consisting of trace amounts of other elements.

Figure \(\PageIndex{1}\): Abundance (atom fraction) of the chemical elements in Earth's upper continental crust as a function of atomic number. The rarest elements in the crust (shown in yellow) are not the heaviest, but are rather the siderophile (iron-loving) elements in the Goldschmidt classification of elements. These have been depleted by being relocated deeper into the Earth's core. Their abundance in meteoroids is higher. Additionally, tellurium and selenium have been depleted from the crust due to formation of volatile hydrides.

Figure \(\PageIndex{1}\) illustrates the relative atomic-abundance of the chemical elements in Earth's upper continental crust, which is relatively accessible for measurements and estimation. Many of the elements shown in the graph are classified into (partially overlapping) categories:

1. rock-forming elements (major elements in green field, and minor elements in light green field);
2. rare earth elements (lanthanides, La-Lu, and Y; labeled in blue);
3. major industrial metals (global production \(\gg 3 \times 10^7\) kg/year; labeled in red);
4. precious metals (labeled in purple);
5. the nine rarest "metals" (the six platinum group elements and Au, Re, and Te) are in the yellow field.

<table>
<thead>
<tr>
<th>Element</th>
<th>Amount</th>
<th>Compound</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>44.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td>22.8</td>
<td>SiO(_2)</td>
<td>46</td>
</tr>
<tr>
<td>Si</td>
<td>21.5</td>
<td>MgO</td>
<td>37.8</td>
</tr>
</tbody>
</table>
Most metals are found as types of rock in the Earth's crust. These ores contain sufficient minerals with important elements including metals that can be economically extracted from the rock. Metal ores are generally oxides, sulfides, silicates (Table 1) or "native" metals (such as native copper) that are not commonly concentrated in the Earth's crust, or "noble" metals (not usually forming compounds) such as gold (Figure 1). The ores must be processed to extract the metals of interest from the waste rock and from the ore minerals.
Metallurgy

Extractive metallurgy is a branch of metallurgical engineering wherein process and methods of extraction of metals from their natural mineral deposits are studied. The field is a materials science, covering all aspects of the types of ore, washing, concentration, separation, chemical processes and extraction of pure metal and their alloying to suit various applications, sometimes for direct use as a finished product, but more often in a form that requires further working to achieve the given properties to suit the applications. The field of ferrous and non-ferrous extractive metallurgy have specialties that are generically grouped into the categories of mineral processing, hydrometallurgy, pyrometallurgy, and electrometallurgy based on the process adopted to extract the metal. Several processes are used for extraction of same metal depending on occurrence and chemical requirements.

Contributors and Attributions

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