JOHN'S CORNER:

MINERALS - The Elements and What They Do (Part 2)

by John Ferguson

Today we continue with our study of all the minerals, what they do, with a look at elements number 4, 5, and 6 on the Periodic table. See the October 21, 2016 Newsletter for a list of references and introduction.

4) Beryllium (Be) - Beryllium is the first or lightest of the elements known as the "alkaline earths" which include calcium, magnesium, strontium, etc. It is found in many minerals but most often found in the mineral beryl (beryllium aluminum silicate) which is a source of this element. It is a metal used in nuclear reactors, aerospace, and electronics. If we add a few atoms of chromium to the crystal structure of this mineral we get the gemstones we call emeralds. Change a few other atoms and we get the gemstone aquamarine. We find beryllium in igneous rocks at 2-8 ppm, shale at 3 ppm, and only 0.1 for sandstone or limestone. It accumulates in coal and can often reach 330 ppm with some levels as high as 2,000 ppm in some deposits.

Beryllium is found in fresh water at 0.001 ppm and seawater at 0.0000006 ppm. For land plants, it is less than 0.1 ppm and even less in land animals. If the human body has plenty of selenium then we rid ourselves of excess beryllium as too much would disrupt the calcium-magnesium relationships or cause berylliosis in our lungs. If beryllium is in a salt form like beryllium chloride ($BeCl_2$) or beryllium sulfate ($BeSO_4$), it is very soluble in water and toxic to plants.

Notice that beryllium is in the same column on the periodic table as calcium (Ca) and magnesium (Mg), which means it has similar chemical properties. Since it is chemically similar to magnesium and calcium, plants easily absorb beryllium. If there is too much in our soils, it will substitute for magnesium (Mg) and cause antagonistic interactions with several metabolic processes. It can also substitute for magnesium in human enzymes and cause them to malfunction. If levels in the soil reach 2-16 ppm it can prevent seed germination, inhibit the uptake of calcium (Ca), magnesium (Mg), and to some degree phosphorous (P) along with degrading some proteins and enzymes. In high amounts, it is

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toxic to many life forms. However, in very small amounts beryllium has been found to stimulate the growth of certain microbes and plant species.

5) Boron (B) - Boron is an element that is known as a "metalloid" as it has properties of both metals and non-metals. Boron is found in igneous rocks at 30 ppm, 96 ppm in clays and 145 ppm in limestone, in seawater at 4,500 ppm and in fresh water 2-150 ppm. Boron is an anion, which means it has a negative electrical charge when ionized.

Boron is often found in nature as boric oxide (B_2O_3). It is also found in feldspars and micas, which are common minerals in clay soils or as the insoluble mineral tourmaline, a semi-precious gemstone. In tourmaline, the boron is chemically locked up and not in an available form until actions by microbes breaks the molecule apart and release the boron.

Boron is used in pesticides, cosmetics, and fertilizers. Combine boron with nitrogen and we get cubic nitride crystals that are almost as hard as diamonds and more heat resistant, hence, they are commonly used for abrasives in many industries. When boron is combined with iron and neodymium, it forms one of the strongest magnets known. Boron is found in household products from Silly Putty to Borax cleaning agents. As a result, boron is a major source of pollution in streams as it comes from the sewage sludge where all these chemicals are dumped and accumulate. Soil contamination with excess boron is now a worldwide problem.

Many forms of boron minerals or ions are readily absorbable by plants. Boron is an essential element for microbial and plant growth, however all the functions and relations are not fully understood. Mycorrhizal plants have a greater need for boron than non-mycorrhizal plants.

A shortage of boron in the soil is associated with increased insect and fungal damage, and stunting in some plant species while other species seem unaffected. Boron deficiency is often associated with the death of the terminal bud, light green coloring, splintering, or cracking of tubers. An adequate amount of available boron in the soil is a strong disease fighter since it helps the plants immune system become resistance to disease. It is associated with the prevention of many plant problems; cracked stems in celery, internal cork in apples, black heart in beets and turnips, yellowing of alfalfa leaves, etc.

Other signs of boron deficiency are; tips of growing plant turns inward and dies, buds becomes light green, roots are brown in center, flowers do not form, leaves are small crinkled deformed with irregular areas of discoloration. Boron deficiency is most likely to occur on sandy soils, soils low in organic matter and in areas of high rainfall or frequent watering.

This element is involved with carbohydrate transportation, it is required for certain physiological processes such as enzyme and co-enzyme systems, it influences plant growth in many ways but not fully understood. It also helps plants use nitrogen efficiently. Studies have found that it is associated with the translocation of sugars in plants hence closely related to quality and taste of foods. Boron regulates flowering and fruiting, cell division, salt absorption, hormone movement and pollen germination, carbohydrate metabolism, water use, nitrogen assimilation and other aspects of plant growth.

Boron interacts in the uptake of other nutrients by plants as it influences membrane permeability and cell colloids. This element is associated with energy transformation reactions, carbohydrate transport, blossom retention, and critical for root elongation.

If there is low levels of zinc (Zn) in the soil, some plants absorb boron to toxic levels, especially in the roots. Boron has an antagonistic relation of silicate ions for absorption sites of boron. Too much calcium (lime) will induce boron deficiency in acid soils. Too much phosphorus (P) ions will decrease boron mobility in the soil and absorption. Uptake and distribution of phosphorous in plants is dependent on the boron concentration in the soil as too much boron prevents the roots from absorbing phosphorous. However, adequate boron assists plants with potassium (K) uptake.

Boron is used as structural element in the cell walls of plants as it strengthens them, but elevated levels of boron hurt citrus plants like oranges and lemons. Using grey-water that has cleaning agents with boron in them can lead to a buildup of this element in the soil.

Olives will not set fruit if boron levels are too low, and plants grown in soils with insufficient levels are more susceptible to insects and disease. Some believe that boron may function as a natural insecticide since boric acid is toxic to many insects. Some plants like hyacinths require boron to produce their fragrance which contains a boron compound.

However, excess boron in the soil restricts growth, causes sickly green color often mistaken for nitrogen deficiency, associated with root deterioration and poor yields. One of the problems with using artificial fertilizers is that there is a very narrow range of boron in the soil that decides whether it is toxic or beneficial. Water-soluble artificial fertilizers just dump the boron into the soil even if it is not needed causing toxicity problems.

Watering with the affluent from septic systems can also be a source of excess boron in the soils as with grey-water mentioned above.

In humans, boron has an important role in mineral and hormone metabolism, cell membrane function, and enzymes function. Boron affects osteoporosis, heart trouble, diabetes, and senility. Its effects are more marked when vitamin D_3 and magnesium (Mg) are deficient. It protects men against deadly prostate cancer (it selectively kills prostate cancer cells while leaving healthy cells unharmed) as it lowers PSA (Prostate Specific Antigen), elevated PSA has been found to be causative factor in prostate cancer progression. Boron has been found to fight inflammation and decrease joint swelling as it inhibits lipoxygenase (LOX) an enzyme that triggers the inflammatory cascade to increase inflammatory leukotrienes. Boron is essential to promoting strong healthy bones. Most conventionally grown foods do not provide enough boron. Life Extension, November 2015 pp. 33-38.

Boron regulates the absorption of calcium, and it is used in making estrogen. A lack of boron leads to increased menopause symptoms in women and a lack of testosterone in men.
Apples, plums, grapes, avocados, most vegetables, nuts, and legumes are our major food sources of boron (if it is in the soil in sufficient quantities for plants to absorb).

6) Carbon (C) - "Carbon stands supreme as having the chemical properties on which all life depends", John Emsley. Carbon is found in many forms from pencil lead to the gemstones we call diamonds. Carbon is the main component of coal and hydrocarbons that our society depends on for energy. It is also a major component of natural gas in the form of methane (CH_4). Carbon can be found in igneous rocks at 200 ppm, shale's at 15,300 ppm, sandstones at 13,800 ppm, and limestone's at 113,500 ppm. In marine plants, carbon increases to 345,000 ppm and in land plants to 454,000 ppm.

When carbon is combined with oxygen (O_2), it forms carbon dioxide (CO_2) which is directly linked to global warming. When carbon dioxide freezes, it becomes dry ice and if dissolved in rainwater it forms carbonic acid with a pH of 5.7.

Carbon is the element most used by plants as between 45-56% of a plants compounds are structured with carbon. Carbon is the basic building block for all organic materials and the key to life, as we know it.

Carbon is frequently referred to as the energy of the soil. For example, when we burn wood in our fireplace energy is released in the form of heat and light. The carbon in the wood is combined chemically with oxygen (O_2) in the air releasing energy. Alternatively, when carbon in gasoline is combined chemically with oxygen (O2) in the air releasing energy that powers our cars. Hence, the carbon in organic matter in the soil provides the energy to grow soil life from microbes to earthworms, release nutrients from rocks and minerals, create soil structure, etc.

If we look at the major components of most terrestrial plants, they can be broken down into glucose, cellulose, lignin, and some proteins. The amount of these compounds varies between species, for example a tree will have more lignin than a annual flower. Additionally, all plants have water (H2O) in their cells, roots and stems that are not part of the plant. If the water is removed and we look at what is left they are primarily molecules made of carbon chains. A few examples are:

Glucose C6H12O6 - has six carbon atoms as its base units
Cellulose (C6H10O5)n - has six carbon atoms as its base units
Lignin (C32H34O11)n - - has 32 carbon atoms as its base units
Proteins are composed of amino acids that all have carbon as their base unit.

We can look at the vascular tissue, the cambium layers, and the bark of the plant all of which are composed of molecules based on chains of carbon atoms.

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Typically, for trees we see the following breakdown: 50% Carbon, 42% Oxygen, 6% Hydrogen, 1% Nitrogen, and 1% other.

When we look at all the atoms that compose a plant or tree, carbon is the most common element. As mentioned, carbon in decaying organic matter is the energy source for microbes and other soil life, carbon is the base unit for humus that is so critical for good soil health. Plants can get carbon from the air via photosynthesis or be absorbed via their roots. Note that the character of the nitrogen source governs carbon availability and carbon becomes deficient if too much nitrogen is available.

Researchers have found that healthy, fertile soils with low insect, disease and weed pressure have 30 carbon atoms for every nitrogen atom what is known as a thirty to one ratio (30:1). This ratio is common in natures from microbes, to earthworms, to birds and mammals including mankind.

Good sources of carbon for gardeners are compost, native mulches, leonardite, humates, and coal.