Mineralogy Boot Camp Session #6

Mineral Classification

Humans have always classified objects, so mineralogy in that sense is no different than anything else studied in nature. The very earliest mineral classification systems preserved in ancient texts typically relied upon either supposed mystical or medicinal properties, locations where minerals were found, or color. These systems resulted in groupings of minerals that were not particularly useful for study or identification, traits that are now considered important aspects to any viable classification system. By the 15th century the old ideas around mystical properties were changing over to more serious investigations that would eventually include preliminary work on the chemical nature and physical properties (particularly shape) of minerals. Alchemy was beginning to evolve into what we now call chemistry, which itself began to develop as a field of science during the 17th and 18th centuries.

Minerals have been classified using chemical composition since the middle 1800s, when chemistry was making additional rapid advances. This classification scheme, which is the most common classification system in use today, divides minerals into classes based upon the dominant anion or anionic group. Atoms can become either positively or negatively charged with the loss or addition of one or more electrons, which have a negative charge. Thus ions formed by the loss of electrons have a positive charge and are called *cations* [such as sodium (Na^{+1}), calcium (Ca^{+2}), and aluminum (Al^{+3})]. Ions formed by the addition of electrons have a negative charge and are called *anions* [such as chlorine (Cl^{-1}), oxygen (O^{-2}), and sulfur (S^{-2})] or *anionic complexes* [such as carbonate $(CO_3)^{-2}$, sulfate $(SO_4)^{-2}$, and silicate $(SiO_4)^{-4}$]. Examples of the anionic groups used in mineral classification will be discussed in greater detail in the next Boot Camp Session.

There are good reasons for using anionic groups for classification. Minerals with the same anions or anionic groups have what can be described as strong family resemblances, often in both chemical and physical properties. These properties are more pronounced than collections having just common cations. For example, the *sulfide* group minerals (those often composed of a metallic element combined with sulfur) tend to have lower hardness and higher specific gravities than most other minerals. Also, the sulfide group minerals often have distinctive streak colors. In comparison, the cation iron (Fe^{+2} or Fe^{+3}) occurs in at least 260 minerals, where the Fe cation can be attached to numerous different elements such as oxygen, sulfur, silicon, and phosphorous, just to name a few. Individual minerals in this large collection have widely different physical and chemical characteristics. Another reason for using anionic groups is that minerals with the same anion or anionic group tend to occur in similar geologic settings, thus are more likely to be found together. The *carbonate* group minerals, for example, tend to be deposited near the Earth's surface in water- and oxygen-rich environments (oceans, lakes, hot springs, etc.).

Minerals, however, are not properly characterized by chemical composition alone. The internal (atomic) structure is also important. Early naturalists noted that when minerals form as perfect crystals, there are certain reoccurring shapes to these crystals and therefore concluded that the internal structure must be important even though they couldn't see or measure it. The same was noted about how minerals tended to have reoccurring cleavage patterns, regardless of the size of the specimen. Scientists were finally able to see the atomic structure of minerals using the x-ray diffraction technique, which was developed in the early 20th century. This technique allowed them to accurately visualize the position of atoms and explain the external geometric shapes and consistent cleavage patterns.

The most widely-used system of mineral classification today relies on both chemical composition and internal structure. Using both of these gives a better representation of the physical properties of minerals within each of these anionic groupings. The primary classification divisions of minerals are called ***classes***, which is based mostly on chemistry with some structure. Mineral classes are further subdivided into ***families*** based on chemical types. Families are then subdivided into ***groups*** based on structural similarities. It is these groups that are most commonly known and will be discussed in more detail in the next Mineralogy Boot Camp session.