

# Mineralogy Boot Camp Session #1

## *What is a mineral?*

Different groups of people define and use *mineral* in different ways. For example, nutritionists describe minerals as essential nutrients important to sustaining life. In the geosciences, there are five criteria a substance must meet in order to be classified as a mineral. Each criterion is discussed below, with examples to illustrate the concept.

### **1) Must be a naturally occurring substance**

In order to be defined as a mineral, a substance must occur in nature without human involvement, thus substances grown in labs, such as gemstones like diamonds, are not considered to be a true mineral even if they meet all the other criteria. This requirement is often modified to specify that any human involvement must be *inadvertent*. For example, *ice* is a mineral, so the frost that grow on your windshield during the winter is a true mineral (you didn't leave your car outside just to have to scrape it off...) but those ice cubes you make in your freezer are *not* minerals (you like your beverages cold...).

### **2) Must be a solid at the Earth's surface**

This criterion is meant to exclude liquids and gases. Even though a substance might abundantly occur in one of those forms (for example, water), only the solid state of that substance (ice) is considered a mineral. Native mercury (often called *quicksilver*), which is a liquid, has been found on rare occasions associated with the mercury sulfide mineral *cinnabar*, but most mineralogist would not consider native mercury a true mineral. Mineral collectors, on the other hand, don't care.

### **3) Must be inorganic in origin**

More controversy surrounds this criterion than any of the others. "Usually" is a good modifier for this criterion, because many pure crystalline substances which are formed by organisms are now considered to be minerals. A good example of this is the mineral *calcite*, which is the most abundant mineral in limestones. While calcium carbonate can be precipitated inorganically out of seawater, much of the calcite owes its origin to biological organisms that live in the ocean and extract calcium carbonate to use in their shells and other structural elements. Nearly all mineralogists consider the calcite in limestone to be a mineral. The gemstone *pearl*, because it is formed by an oyster, is considered to be a mineral by some and a nonmineral by others. Coal, which owes its existence solely to organic activity typically in a swamp environment, is considered a *rock* but *not* a mineral, yet the pyrite found within the coal *is* considered to be a mineral despite being formed by bacterial activity.

### **4) Must have a well-defined chemical composition**

This definite chemical composition must be expressed by a distinct chemical formula. These formulas can have a range in elemental composition, but that range must be defined. For

example, the mineral *olivine* can have iron (Fe) and magnesium (Mg) substituting for each other in the crystalline structure and thus is represented by the formula:  $(\text{Mg, Fe})_2\text{SiO}_4$ . The limit of variability is typically set to specify that the range of chemical composition must not be so large as to significantly affect the physical properties of the mineral.

### **5) Must have a highly ordered atomic arrangement**

This ordered atomic arrangement expresses itself in the substance by having a repeating crystalline structure. Prior to the 20<sup>th</sup> century, this was assumed because of well-formed single crystals, where the crystal faces always have the same precise angular relationship to each other. In the early 20<sup>th</sup> century, the x-ray diffraction technique was developed whereby the actual tiny distances between the atomic layers can be directly measured. Eliminated by this criterion are amorphous materials, like volcanic glass (*obsidian*), which are not considered a mineral because the atoms are not highly ordered relatively to each other. Another example is the gem variety of silica known as *opal*, which fails the mineral criteria because its crystalline structure is very poorly ordered, plus it contains a variable amount of water in its structure and thus does not have a well-defined chemical composition.