# Mineralogy Boot Camp Session #21

## *Mineraloids and Synthetic Minerals*

Unlike all the other sessions of Mineralogy Boot Camp, this session is devoted to *non-minerals*: those materials that might appear to be a mineral but fail to meet the definition. Recall from Session #1 that to be a mineral, a substance must be a naturally-occurring solid, inorganic in origin, with a well-defined chemical composition and a highly-ordered atomic structure (*crystalline*). *Mineraloids* is a name used to describe those materials that lack a highly-ordered structure (so are *non-crystalline* or *amorphous*) and often have a poorly-constrained chemical composition. *Synthetic minerals* are those materials grown in a lab, so are clearly not naturally-occurring even if they mimic a mineral in every other characteristic.

### Mineraloids

There are a number of inorganic natural solids that are amorphous like glass. Typically these materials form at or near Earth's surface under conditions of relatively low temperature and pressure. A good example is *opal* (Figure 1), which has the general formula of $SiO_2 \cdot nH_2O$, where $n$ stands for a variable number of water molecules. Some references list the most common range of water content in opal to be 4% to 9%. Opal is not stable over geologic time spans, slowly losing the water and crystallizing into quartz. Physical features of opal used to distinguish it from quartz are a lower hardness (5 to 6 on Mohs scale) and lower specific gravity (about 2.0). Precious opal displays an internal play of colors. Opal occurs in hot springs, sometimes in voids within volcanic rocks, and in deep sea sediments from the accumulation of microscopic organisms that use silica for protective shells.


Figure 1. Hot springs can be one environment where opal accumulates, such as this example from Esmeralda County, Nevada. The hot fluids emerging from the spring often contain large quantities of dissolved silica, which can precipitate as opaline sediments as the fluids cool. Color variation in the layers is likely caused by changes in the fluid composition as the silica is precipitating. The irregular polygons on the top surface are formed by cracking as the gel fully solidifies.

Iron, one of the most abundant elements on Earth, is very reactive in the presence of oxygen. Since oxygen accumulated in our atmosphere to a critical level a billion years ago, native iron is no longer stable at the surface. When iron is exposed at Earth's surface, either as human-made objects (Figure 2) or released during the weathering of other minerals, it immediately combines with oxygen to form what we commonly call "rust". This material may be in the form of iron oxide (hematite), iron hydroxide (goethite), or frequently iron mineraloids (which are a mixture of iron, oxygen, and often a small variety of other elements).

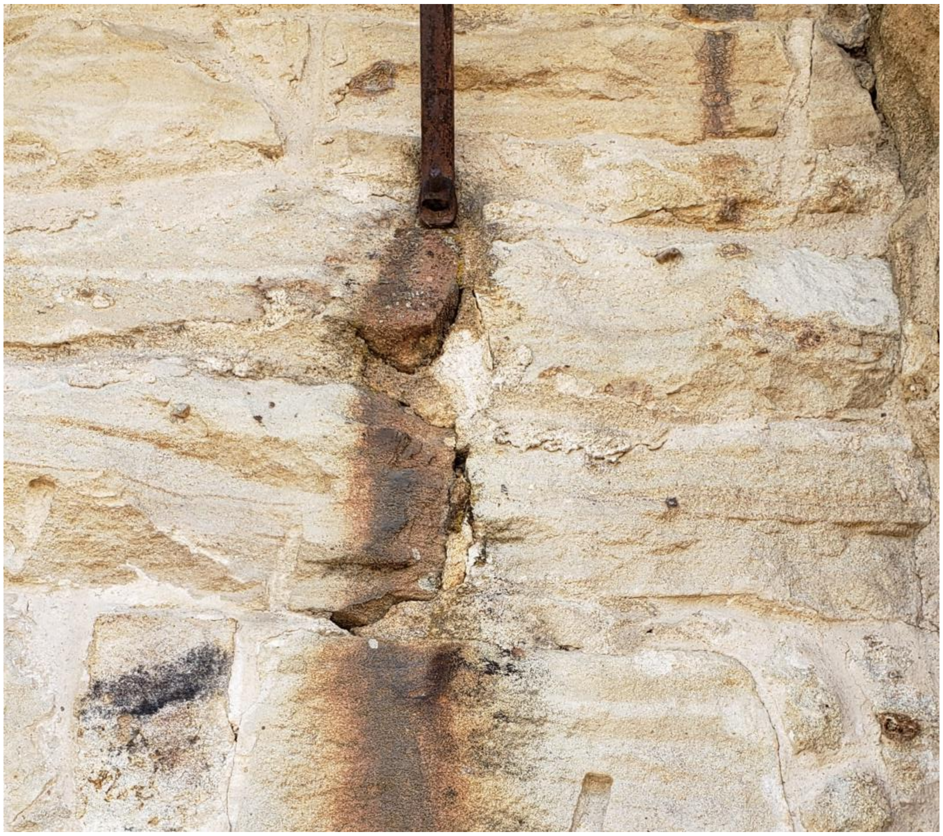

Figure 2. Staining of reddish-brown iron mineraloids is often visible whenever manufactured iron material is exposed to the atmosphere, such as below where the support rod in the upper part of this photo is attached to the wall. After decades of weathering, a noticeable stain trail can develop even in a dry climate such as this example (from Boise, Idaho). Vertical field of view for photo is approximately 4 feet.

*Desert varnish* or *rock varnish* is a term used to describe a thin coating commonly developed on exposed rock surfaces in desert climates (Figure 3). This coating, which is less than a millimeter thick, is created by bacteria that live on the rock surface and use the contained iron and magnesium in the rock. These bacteria slowly break down the mineral surface as well as capture microscopic particles blown by the wind, deriving energy from the released iron and magnesium, and re-depositing these ions as iron and magnesium oxides, hydroxides, and associated mineraloids. During the process, clay minerals transported by the wind are often incorporated into the coating. Color variations of the varnish are related to their relative composition: black varnishes tend to be high in magnesium, and red to orange varnishes tend to be high in iron. Brown coatings typically have more equivalent amounts of magnesium and iron. Petroglyphs drawn by Native Americans make use of the thin, easily scratched nature of this varnish, creating pictures or symbols that can last for thousands of years.

Figure 3. This photo shows a boulder of basalt with a desert varnish coating in central Nevada. A portion of the varnish (beneath the blue hammer handle) has been broken off, exposing the true color and texture of the basalt. The color of this varnish (dull gray-to-black) suggests it is high in magnesium. Raised spots on the left side of the boulder, ranging white to red-brown, are modern *lichens*, a composite organism of fungi and algae.

## Synthetic minerals

During the 20$^{th}$ century great progress was made in understanding how minerals grow, and thus how to grow minerals in a laboratory setting. Such *synthetic minerals* are now routinely manufactured for a variety of reasons (for example, see Figure 4). In the chemical industry, the need for some high-purity minerals (such as *zeolites*, which are silicate minerals used in water softeners) led the industry to create nearly all of the mineral material currently consumed. With the development of radios in the early 20$^{th}$ century, the quartz oscillator became an important component in the electrical industry. During the Second World War, the demand for high-purity optical quartz for the domestic war effort began to out-strip the availability of natural sources to meet the need. Large laboratory-grown high-purity quartz crystals were soon produced.


Figure 4.  This purple crystal is an example of a lab-grown (synthetic) mineral created to be sold for its specimen value.  The label with this specimen suggested it is some kind of potassium-chrome mixture, but the exact mineral it is trying to imitate is unclear.  Odd internal features, gaps and bubbles within the interior, and inconsistent crystal faces all suggest this to be an artificially-produced material.

The best known examples of synthetic minerals are in the gemstone business, where gems such as ruby, sapphire, emerald, diamond, turquoise and opal have been successfully grown in labs and are now routinely produced and sold (for example, see Figure 5).  Quality of these artificially-produced gems has improved so much that detection of a lab-grown stone is proving to be challenging, even for experts.  There are also manufactured diamond *simulants* (substitutes), like cubic zirconia, which mimic diamond only in some of their physical properties but chemically are completely different.


Figure 5.  This jewelry store is quite upfront about having synthetic diamonds in their inventory, and should be commended for being truthful in its advertising.  The appeal of synthetic diamonds is their price, which is frequently much less than natural diamonds of the same size and quality.