False Forms

You can't always tell a book by its cover or mineral by its shape. Most people know that minerals can replace organic material while preserving the organic structure (such as quartz reserving wood). One mineral can also replace another mineral, preserving the outer form of the original mineral. Such replacements are called pseudomorphs (literally, "false forms"). These replacements indicate changes in the physical and chemical environment during a rock's history, hence tell an interesting story about the specimen. When describing or labeling pseudomorphs one mentions both minerals, saying for example "malachite after(or replacing) azurite.

In some pseudomorphs there are no chemicals in common between the minerals involved. An example is a sample I found near Hazel Green, Wisconsin having galena (PbS) replacing calcite($CaCO_3$). The galena which ordinarily forms cubes, had instead the outer shape of a calcite rhombohedron. How could such a change occur? One possibility is that fluids dissolved away the original calcite, leaving a rhombohedron-shaped hole in the rock. This hole was filled by galena precipitated from later fluids.

In many pseudomorphs the two minerals have some chemicals in common. The replacement represents a gain or loss of some of the chemicals. A common case is when pyrite (FeS_2) or marcasite (FeS_2) are replaced by goethite ($HFeO_2$). This replacement occurs readily when the sulfides encounter oxygen and water near the earth's surface. It is, in effect, rusting. The exact shapes and even the striations on the pyrite or marcasite crystals are often preserved. The tarnish that forms on many minerals is the starting phase of such reactions. Probably the most beautiful pseudomorphs are those formed by the replacement of rich blue azurite ($Cu_3(CO_3)_2(OH)_2$)by bright green malachite ($Cu_2(CO_3)_2(OH)_2$). This is a rather fast reaction. Azurite was often used as the base of blue pigment in paints. One can recognize paintings in which this was done because they now show green, rather than blue skies. China clay after feldspar, chlorite after garnets and gypsum after anhydrite are other common examples of these sorts of pseudomorphs.

Finally in some pseudomorphs, both minerals contain exactly the same chemicals but have different internal crystalline structures. A good example is calcite ($CaCO_3$) after aragonite ($CaCO_3$). Aragonite forms under a rather restricted range of conditions. Once formed, it inverts slowly but progressively to calcite. Many specimens sold as aragonite are really calcite. One can tell by looking for calcite's distinctive rhombohedral cleavage on any broken edges of the sample. Quartz also changes from a high temperature (the mineral high quartz) to a low temperature structure (the mineral low or common quartz). This change occurs virtually instantly at 573 C at 1 atmosphere pressure. This internal change introduces a lot of internal flaws (called transformation twins or Dauphine twins). Quartz that is being grown synthetically for use in watches or radios must not experience temperatures over 573 C because the flaws that would result as it cooled down would impair its use as an oscillator.

Pseudomorphs thus tell interesting stories about minerals, and are a lot more common than people think. In fact, while driving around a few days ago, I spotted a sample of rust pseudomorphs after a Chevrolet.

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