How and Where Gems Form, Part 2 of 2

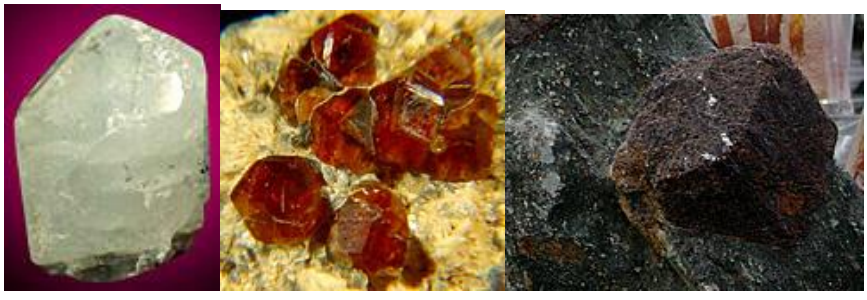
In Part 1 of "How and Where Gems Form," we learned that gems, in nature form from solutions by precipitation. In Part 2, we see that gems also form from melts by crystallization and from vapors by condensation.

Melt/Crystallization Formation

As magma cools various minerals form, depending on the temperature and pressure at a particular location and time. As each type of mineral forms it reduces the concentration of, or removes, some of the elements required for its formation. Thus, as the mix of elements present and the physical conditions change, so do the minerals which form.

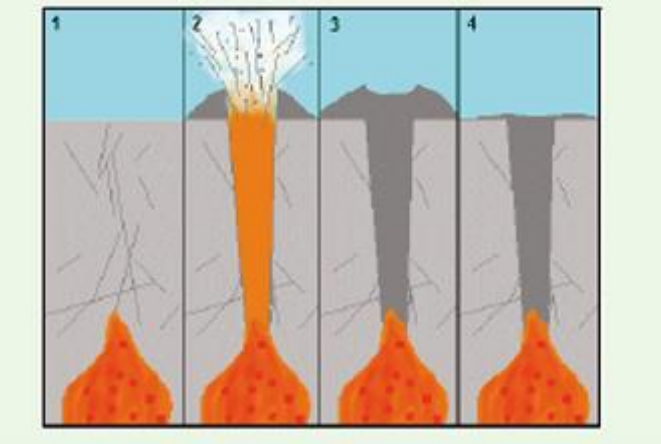
Intrusive: Gems usually form in intrusive igneous rocks where the slow rate of cooling favors larger crystals. Generally, though, we do not mine the original formation sites of these gem-containing rocks, but instead gather the weathered-out gems which have been released when these intrusive rock bodies are uplifted to the surface, or erosional processes reveal them. Corundum and topaz are examples of gems which form in intrusive rocks.

Extrusive: Extrusive igneous rocks would generally not be expected to hold large crystals. Occasionally, though, some large crystals will form deep underground, but before crystallization of other minerals is complete and a typically large grained intrusive rock is produced, the magma suddenly finds its way to the surface. Under these new conditions, the rest of the magma (carrying the large crystals from below) quickly solidifies to become fine grained rock. In such extrusive igneous rocks we find larger gem crystals *in a matrix of finer grained rock*. (See mantle gems, below). Corundum, moonstone, garnet and zircon are examples of gems that can be formed and brought to, or near, the surface in this way.



[Topaz crystal from China, Spessartite garnet crystals in microcline matrix from China: Images courtesy of Treasure Mounting Mining, a huge, non-gem quality garnet crystal in host rock: Image courtesy of Las Vegas Jewelry and Mineral]

Gems formed in the mantle: Peridot crystals form in magma from the upper mantle (20 to 55 miles deep), and are brought to the surface by tectonic or volcanic activity where we find them in extrusive igneous rocks. Diamonds were formed many millions of years ago, deeper in the mantle (around 100 - 150 miles below the surface), at extreme temperatures and pressures. These diamond forming magmas would later erupt (still holding the diamonds) to form rocks called kimberlites and lamproites.



[Diagram courtesy of The International Gem Society and Don Clark, www.gemsociety.org]

The scenario goes something like this: 1) magma, containing diamond crystals, suddenly and explosively finds a path to the surface. 2) As the lava (orange) rises, some of it cools and solidifies underground forming a carrot shaped formation of kimberlite rock in which the diamond crystals are "frozen". 3) & 4) The volcanic cone has eroded away leaving diamonds at the surface, and underground in the kimberlite (or lamproite) "pipe" (gray).

[Diamond crystal in kimberlite rock from Russia: Image courtesy of www.irocks.com, peridot crystals in basalt from Arizona: Image courtesy of www.mtlilygems.com]

Pegmatites: As magma, which contains dissolved minerals in water under pressure, begins to rise through cracks and cool down, crystallization begins. The magmatic water, along with the dissolved minerals which require lower temperatures for their crystallization, becomes more and more concentrated. In the end phases of crystallization of the magma, the water is expelled as vapor, and the highly concentrated magma remnants crystallize near the surface in a distinctive geologic formation known as a *pegmatite*. The magmas from which pegmatites form often contain high concentrations of rarer elements like beryllium and boron. Gems commonly

found in pegmatites are emerald, topaz, tourmaline, rose quartz, chrysoberyl and spodumene, and they can be very large.

[World class aquamarine crystals from N. Pakistan pegmatite: Image courtesy of www.irocks.com, pink tourmaline rough from a pegmatite formation in the Stewart Mine in California, emerald crystals: Image courtesy of Las Vegas Jewelry and Mineral, rose quartz from a Brazilian pegmatite mine: Image courtesy of www.irocks.com]

***Check the Web: One of the most famous pegmatite mines in the US is the Stewart Tourmaline Mine in Pala, California. This famous deposit, most noted for its bubble gum pink tourmaline, consists primarily of pegmatite formations of a type called dikes. Visit this link to take a virtual tour of the mine: http://www.mmmgems.com/stewart/minetr2.htm*

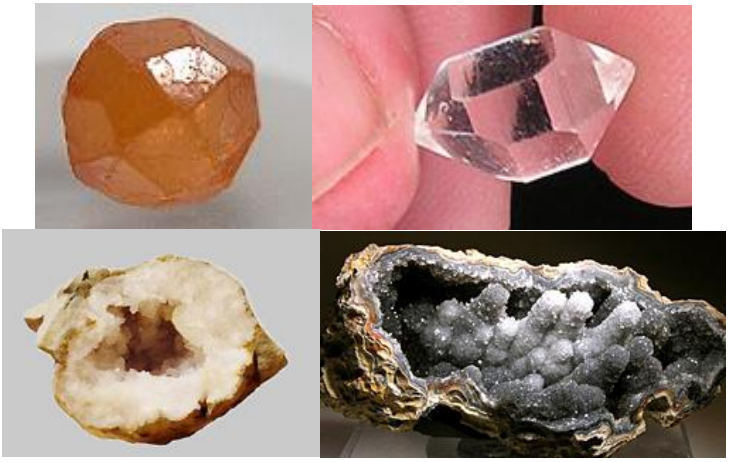
Vapor/Condensation Formation

It might be a little difficult to imagine vapors condensing to form crystals, as it seems somewhat foreign to every day experience. And it's true that at normal atmospheric pressures and common ambient temperatures, this doesn't happen very often. But there's one good example that we can all look to: frost which forms on our windowpanes or car windshields. Frost is, in fact, precisely a situation of a vapor (water vapor) condensing to a solid crystal (ice). The next time you get a chance, use your loupe to examine that frost: beautiful! Given the extreme environments created by some geological events, such as an eruption of magma, conditions can be ideal for such condensation processes, and they are relatively common events.

Vugs: When magma (a fluid with dissolved liquids and gases) is suddenly released from the pressures containing it (as when it erupts or spreads into surface fissures), gases are freed and liquids quickly vaporize to gas, which creates gas-filled bubbles and pockets in the lava called "vugs". (We experience a similar phenomenon every time we open a carbonated beverage).

Gems cans crystallize from these vapors which are trapped and concentrated inside the openings. Often they form singly, without attachment to the surrounding surface. When we see a *doubly terminated crystal*, or one that is perfectly formed with no attachment point (called a "floater"), often it has formed in just such a gas pocket. One of the most famous deposits of these doubly terminated crystals is the rock crystal quartzes formed in Herkimer, NY, and known as "Herkimer Diamonds".

Other pockets which do not produce crystals from gases, may *later* be invaded by surface water, or hydrothermal fluids, and become filled or lined with small or large crystals forming geodes or other similar formations.



[Spessartite garnet "floater" crystal from Namibia, doubly terminated rock crystal quartz ("Herkimer Diamond") from New York, igneous vug lined with hydrothermally derived quartz crystals, vug from Germany, containing stalagtites covered with tiny quartz crystals: Image courtesy of www.irocks.com]

Crystal growth from solutions or vapors can also exploit fortuitous openings as seen below. This ancient clam's death, and subsequent fossilization, created a space in the surrounding rock which later became home to the beautifully formed calcite crystals in this prize specimen.

[Fossil clam shell with calcite crystals, from Okeechobee County, Florida]

Source: http://www.bwsmigel.info/lesson10/de.gem.formation.html
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