Igneous Rocks--Cool Stuff

Earth Science Essentials

by Russ Colson

Candy Crystals

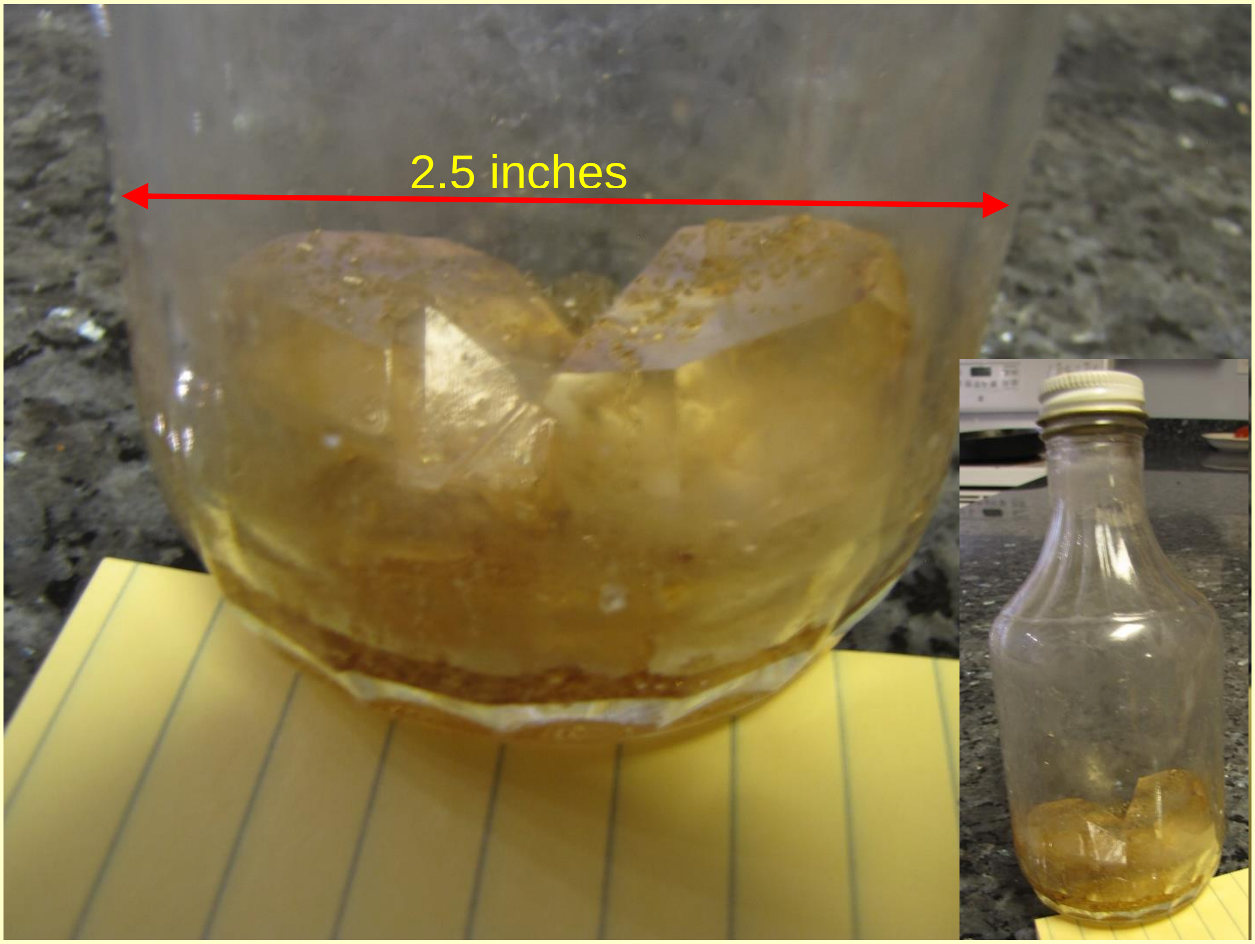
Cooling liquids, on their way to becoming solids, develop a microscopic primary texture called a *crystalline* texture in which many tiny crystals interlock with each other as the liquid freezes. Some candies begin as liquid syrups and cool to solids with undesirable crystalline igneous textures forming. The authors of the 1964 book *Joy of Cooking* note:

> "When we were inexperienced, we were constantly baffled by the tendency of smooth promising candy sirups to turn with lightning speed into grainy masses."[1]

Can you figure out what might be the problem? In this case, nucleation sites for crystals to get started growing on is probably more important than cooling rate.

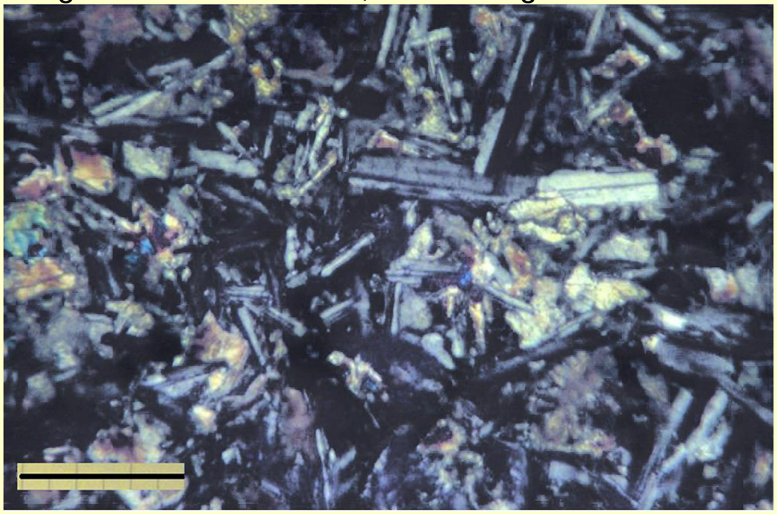
If you are willing to wait a long time (months) you can grow big sugar crystals! My wife Mary grew the crystals below in a Mason jar filled with sugar water. Notice the interesting pattern of the crystal faces, like little roofs. This crystallographic form is called a sphenoid.

If you are willing to wait even longer (years) you can grow even bigger crystals in a bottle (even better than ships in a bottle)! The crystals below grew in a bottle of maple syrup as the water gradually evaporated out the closed lid over many years. It makes an interesting display because people can see that the crystals had to grow inside the bottle since they are too big to get through the top.

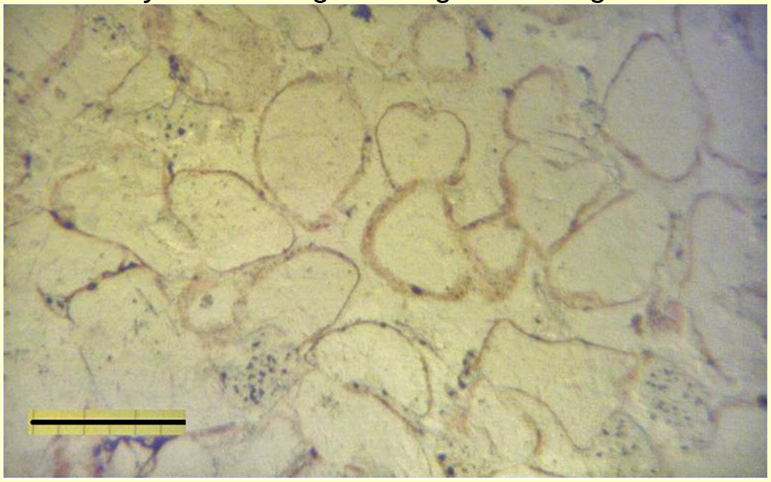


Interlocking Crystals

Igneous rocks have formed by cooling of a molten liquid. A microscopic view of a thin slice of basalt-like diabase (with polarizing lenses crossed, scale bar = 0.3mm) shows the graininess of the rock, a stained-glass window of interlocking crystals.



This crystalline texture is quite different from the texture seen in rocks formed by processes other than freezing from a liquid state. For example, compare the basalt with a thin slice of sandstone below (in plane light, scale bar = 0.3mm). The texture of the two rocks, one interlocking and one stacked, reflect how the two rocks formed. In the sandstone, the rounded sand grains lay against each other like marbles in a jar, and are stuck together by different minerals that act like a cement or glue. In the basalt, the mineral crystals have grown together filling all the available space.



The interlocking nature of the crystals in an igneous rock is a characteristic of a material that has crystallized from a liquid state, a process we can duplicate in a candy maker's kitchen, in a geology laboratory, or, of all places, in a Scottish glass-making foundry.

Fire in a Crucible

Glassmakers in the 1700s handled the largest volume of human-made lava available, and Scottish geologist Sir James Hall (1761-1832) happened to see the results when an accident at the Leith Glass Works caused a batch of molten glass to cool slowly. The resulting lump bore no resemblance to glass. Instead of glass, the liquid cooled to a white, opaque, crystalline rock-like material. But, when Hall remelted the material and cooled it quickly, he got glass again.

Both Hall and his friend and mentor, James Hutton (1726-1797), developed their understanding of the origin rocks among the non-layered rocks of the Scottish landscape. Hutton took on the role of charismatic point man for the Vulcanists, when he proposed that basalt (and also granite) formed from the cooling of molten rock. Hall, along with the rest of the Neptunistic world, was initially skeptical of Hutton's interpretation of the Scottish rocks. But because of his experience at the glassworks coupled with high regard for Hutton, Hall set out to experimentally test Hutton's views in a laboratory crucible.

Hutton, in like fashion, was skeptical of Hall's belief that laboratory experiments could be a means to learn about rocks of the Earth. He ridiculed the attempt to understand Earth through study in a crucible:

> "there are superficial reasoning men who, without truly knowing what they see, think they know those regions of the earth which can never be seen, and who judge of the great operations of the mineral kingdom from having kindled a fire and looked into the bottom of a little crucible."[2]

Undeterred by his friend's skepticism, Hall proceeded to melt basalt and cool it at different rates. He found that fast cooling produced a glass, but that slower cooling produced a crystalline rock with interlocking crystals like those in the basalt he started with. Slower cooling yet produced a rock with larger crystal grains. Hall's experiments with small pots of magma earned him notoriety as the founder of experimental petrology.

Babylonian Basalt

Archeological evidence indicates that Sir James Hall was not the first experimental petrologist, but that the Babylonians had their own geologic experimentalists. Artifacts from second millennium B.C. Mesopotamia indicate that the Babylonians may have manufactured building stone by melting mud from Mesopotamian rivers.[3] Pieces of gray-black vesicular rock resembling basalt were excavated at a site 80 kilometers south of Baghdad, Iraq. The chemical composition of the rock artifacts is unlike basalt but similar to the Mesopotamian river muds. Under the microscope, the basalt-looking rock is made of interlocking crystals, suggesting that the Babylonians were able to melt the muds and then cool them at a rate that allowed the interlocking crystals of the basalt-like material to form producing stone that was much stronger than river mud!

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[1] Rombauer, I.S. and Becker, M.R., 1964, Joy of Cooking, Bobbs-Merrill Co., Inc., Indianapolis, p 726
[2] Geike, A., 1962, The Founders of Geology, Dover Publications, Inc., New York, p 319, 486 pgs.
[3] E. C. Stone, D. H. Lindsley, V. Pigott, G. Harbottle, and M. T. Ford, (1998) From Shifting silt to solid stone: The manufacture of synthetic basalt in ancient Mesopotamia, Science, v. 280, 2091-2093.