

Agates - Rich in Fiber!

Sometimes chalcedony including agate is described as a fine-grained quartz, but the real case isn't quite this simple. There are lots of clues for this. Arrowheads and other stone tools are harder and more durable when made from chalcedony rather than coarse quartz. On the other hand, coarse quartz is better to grind up as a concrete additive than chalcedony. The chalcedony causes various chemical reactions in the concrete which can fail, while quartz is unreactive. With the advance of modern analytical tools, the reasons for these differences can finally be investigated.

Chalcedony has a microscopically fibrous structure, made of evenly spaced silica rods. More surprising is the fact that the fibers show a regularly alternating pattern of elongation -some parts being "length fast" and some parts "length slow". This means that in part of a particular fiber, light travels faster parallel to the long axis of the fiber. In other parts of the same fiber, the light travels slower parallel to the fiber length. This further implies that the silicon and oxygen atoms for some reason regularly twist or change in orientation as each fiber grew. Mineralogists are still trying to figure out why the fibers twist and what different forms of silica are intertwined with each other.

It is these intergrown fibers that gives chalcedony its great strength and durability. The peculiar structure also gives chalcedony its unexpected chemical reactivity in concrete.

One theory is for the growth of the fibers is being developed by two researchers (Yifeng Wang and Enrique Merino) at Indiana University. They envision agate as developing as fingers of silica growing progressively outward into a cavity filled with siliceous "media". They do not specify as to whether this "media" is a solution or a gel. The first step is the formation of a coating of silica around the cavity. The coating (this being the real world) won't be completely smooth. In some places, the coating will bulge out slightly into the "media". It is these bulges which will grow rapidly outward into the solution to form the fibers. Impurities in the solution (such as iron or copper) will slow the growth briefly until these impurities precipitate as their own minerals on top of or between the silica fibers. Once the impurity's concentration is briefly reduced in this manner, silica growth will proceed again. Withdrawal of silica makes the solution richer in impurities, causing them to form another layer. This rhythmic precipitation is repeated many times as the agate grows. These layers of impurities show up as the color banding that characterize agates.

- Dr. Bill Cordua, University of Wisconsin-River Falls

References:

Heaney, Peter J., D. Verlen and J. Post, 1994, "Structural disparities between chalcedony and macrocrystalline quartz", American Mineralogist, vol. 79, p. 452-460.

Wang, Yifeng and Enrique Merino, 1995, "Origin of Fibrosity and Banding in Agates from Flood Basalts", American Journal of Science, vol. 295, p. 49-77.