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Popular Myths of Agate Formation

1. Agates are 97 to 99.9% quartz. Agates as whole rock specimens contain as little as about 40% silica. Agates contain opal-C, opal-CT, opal-C, as well as opal-Q, opal-BQ, and opal-BC proposed by the author. They also have alpha- and beta-quartz, alpha- and beta-moganite, melanophlogite (cubic quartz), commonly contain carbonates such as calcite, dolomite, and sometimes aragonite and siderite, and contain clays such as bentonite, kaolinite, celadonite, nontronite, chlorite, and glauconite. They commonly contain iron and manganese mineralization, some formed with the agate, and sometimes intruding with groundwater later. This 99% number comes from scientists who bash agates to pieces, pick out the quartz, study that, and find it is 99% pure quartz. That is not an analysis of the whole specimen ever, so the number is deceptive and dogmatic. Dr. Terry Moxon out of England is particularly notorious for promoting this misinformation.
2. Agates contain zeolites. No zeolites have been found by the author using spot sample reflectance infrared studying agate structures and inclusions, in an archive of 30,000 spectral graphs. Zeolites do occur with quartz and opal, but not agate. Probably the zeolite preferentially scavenges the silica, making agate formation impossible. Almost without exception, acicular fan (sagenite) structures in agates are calcite and rarely dolomite or aragonite, but never zeolite minerals.
3. Agates are a variety of quartz with banding. Agates are rocks of mixed composition. They are calcite-clay-silica-hydrate rocks. As such they are not varietal quartz. Chalcedony is a granular quartz. Chert is a chalcedony. Agate does not contain granular quartz, and as such, is not a chalcedony.
4. Agates form from weathering. Agates form in volcanic systems including lava voids and ash flows and veins systems and along faults, but in no other type of void or geologic system regardless of how much water and silica is available. There are no agates in granite voids, for example. Quartz wears down to the beaches, while the beaches of the world are not made of agates. High rainfall regions such as the Tropics, have virtually no agates. Agates are never found forming in soil weathering profiles. From an infrared standpoint the lack of humic acid in agates shows that the water in agates does not come from groundwater in contact with plant mater that forms humic acid. Opal-A is the only opal formed exclusively by weathering and surface hydrothermal deposition. Yet opal-A is not found in any agate or jasper in the world. Agates only contain the other opals listed in item 1. The other opals, particularly opal-CT are only found in volcanic rocks, and are reported in the literature in some metamorphically altered sea floor sediments.
5. Agates form at low temperatures. Agates cannot form without Brazil twinning. While geologists don't seem to understand it, ceramic engineers and foundry glass engineers full understand that to make optically pure quartz you must prevent Brazil twinning. This is done by keeping the growing quartz seed crystals at high temperature, but under the supercritical temperature of 374 C and under the beta-moganite temperature of 354 C. Temperatures under supercritical cannot form Brazil twinning, at least on short time scales. As for long time scales? The agate is totally different. They become tiny as in millimeters in size to microscopic. Large agates visible to the naked eye form in volcanic systems at high temperatures on short time scales.
6. Agates have no geochemistry. Agates form in specifically constrained geochemical systems. Agates only form in alkaline systems, with very low salt, and under 2 kbars pressure, in volcanic systems or specific high temperature metamorphic silica reactions. The upper temperature limit for an agate systems are geodes that form up to 575 C. They form in volcanic rocks over 374 C, which is supercritical fluid, a special state of water with high solubility and no surface tension.
7. Agates and cherts form from opal, derived from radiolaria. No diatom or radiolaria chalk deposit on Earth is associated with an agate-bearing site. The Monterrey formation of California has immense chalk beds, with no agates in them. This proposed link is unfounded, while some radiolaria are found is oceanic host rock agates. In the same way, cherts are never formed from radiolaria, they form from volcanic ash. That ash in the ocean made the radiolarian blooms and chert, both.
8. Agates form by infiltration channels bringing in silica to voids. In sedimentary rocks, agates form by accretion of cristobalite microsphere clusters. Agates never have these tubes in waterline agates, or chevron agates (non-wall-banded agates), or agates with dense inclusions or multiple banding centers. Microscopic banding centers never have microscopic tubes. The lower limit to finding an infiltration/exit channel in an agate is about ½ inch. While it can be missing in the cut for one or two, when this is never observed in thousands of specimens, we can presume they do not exist in small agates. This model is kept alive by exclusion of key specimens found worldwide.
9. Agates form by wall banding accretion of silica. No physics explains how weathering makes water with silica stick to void walls, and presumably does not exist. Wall banding occurs by supercritical fluid vapor deposition, which occurs over the range of 374 C to 575 C, and explains why agates are only found in lava systems that have achieved these temperatures. All agates of the world contain an outer silica layer which may or may not be banded due to this temperature exposure. There are no wall-to-

wall horizontally banded agates anywhere in the world, the only type that could form by weathering infiltration and settling of water and silica.

10. Agates form in playa lakes. Not only are they never formed or found in playa lakes, but no salts, borates, or other saline evaporites are found in them anywhere on Earth regardless of what Dr. Peter Heaney promotes. You have to collect for yourself to understand where agates form! While milky quartz can have 75% salt in fluid inclusions, the upper limit to agate fluid inclusions is 1.25% salt.
11. Agates form from magadiite. Magadiite forms in saline lake systems. Agates are never formed in saline conditions and the limit for cherts is 4% salt. No magadiite has been found in any agate or chert, identified with infrared, Raman, or X-ray spectroscopy.
12. Opal-A makes opal-CT makes opal-C makes agate. This progression comes only from oceanic drill cores where radiolarian ooze is buried and compacted, altering over a geologic age to other opal forms from metamorphic exposure. Others find that this sequence is not found in continental volcanic systems. Agates form directly from a gel precursor. The author finds that there is no opal-A in agates, and opal-C is only rarely found in geode waterlines, which is not a good basis for a sequence of formation generically making agates. Opal-BC (opal-beta-cristobalite that the author has identified) may being confused with opal-C in the literature, but in infrared key spectral bands are different.
13. Moganite makes agate. Infrared spectroscopy shows that microspheres in agate are moganite, and likely beta-moganite. The agate banding is alpha-quartz and alpha-moganite. Their infrared graphs of alpha- and beta-moganite are different in infrared, but are the same in Raman infrared that is the standard to identify moganite. Alpha-moganite is found in sedimentary systems vein systems, and agate banding, and beta-moganite is found in pyroclastic rocks, geodes, and some agate cores. The two moganites lumped together due to resolution problems of Raman to distinguish them has led to a range of bad assumptions of moganite rock formation. Beta-moganite rocks as identified by the author are never associated with evaporites, the presumptive formation occurrence for alpha-moganite. Tubes-of-escape have beta-quartz and beta-moganite. These mineral species in agates are cogenetic (formed at the same time). Beta-moganite is immiscible in banded agates and accounts for many rocks from volcanic systems sold as jaspers. Beta-moganite rich jaspers are finely granular and not banded.
14. Agates form from quartz dissolution. Quartz breaks down to clay, not agate. Agates form from silica derived from certain geochemical reactions and from volcanic ash. Quartz in sandstone and quartz in granite, for example, has no geologic link to agate occurrences. The number one master model of agate formation is the relationship to volcanic ash. This is because surface area matters, because agate forms from a gel precursor. Ash has 800 times the surface area of granular quartz, so reactions with ash to make agate occur very fast.
15. Agates form over millions of years. To form over such long periods, many complex types of depositional mineral layers should be found intermixed with agate banding. This does not occur. Calcite is more common in groundwater than silica by many orders of magnitude, but we can still get silica-only agates. The only source of water with silica yet without calcite is from magmatic water. This would mean the reactions to commonly form agates are hot and therefore fast on the order of days to 30,000 years, more likely in the range of hundreds of years. We never find agates forming today in soil or weathered rock profiles, so they are not forming from weathering.
16. Agates form in any pH (acidity) conditions. Agates only form in alkaline systems. There are no agates with lead or stibnite inclusions, for example. The proposition that Trent, OR vein agate has stibnite is a myth not supported by actual study of the specimens with microscopy and infrared spectroscopy. Most sulfide minerals form only in highly acid systems. Agates are not found in sulfur vents or sulfide ore bodies. Sulfur is exceptionally rare and only microscopic as an inclusion in agates, typically intruded as contaminants in ash flows. No inclusion formed in conditions under pH 6.5 can be confirmed in an agate. Sulfides such as pyrite and marcasite found in agates do so in conjunction with carbonates that neutralize the acid on a millimeter scale.
17. Agate inclusions only form after the agates are made. Agate banding occurs around complex inclusion structures only. The inclusions come prior to agate formation, during agate formation, and some come after. The porosity of opal and the occurrence of opal in agate allows groundwater leaching of iron and manganese minerals. The minerals infiltrate along fractures. Very old agates on the scale of Permian agate at 340 million years old are infiltrated by kaolinite leaching into the fiber silica bands only, from weathering. Weathering produces granular intrusions and dendrite and sagenite structures only. Tubes and plumes and discs and most sagenites occur before or during agate formation and the banding forms around them.
18. Fine tubes and mosses in agates and jaspers are proof of microbial life (cyanobacteria). Some are and some are not. All fine, dense tubes or mosses in geodes, for example, scan in infrared as the clay mineral celadonite, but is sometimes the clay minerals nontronite or glauconite. These are strongly linked to volcanic ash intrusions. Yet, jaspers clearly have microbial structures from some sites, seen by the stacking structures and interstitial sand between stromatolite stacks. Not only can cyanobacteria make tubes, but so can hydration reactions as wet clays intrude silica masses in tectonic events.