Big Band Theory: A New Explanation of Band Formation in Nodular Agates

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Review by Donald Kasper, based on reflectance infrared spectroscopy, microscopy, and polarizing microscopy study of the actual composition and structures of agates. 7/15/2019, updated 12/29/2019.

Overview: Venuti denies basic observational problems with his model of agate formation and insists that things exist to make agates that cannot be observed such as agates formed anywhere in soils from weathering, agates found in and near water sources, and agate formed by silica gel sticky physics which no one has documented existing. In other words, his model is fantastical and superstitious, and not based on actual gel chemistry and geology that has been observed so far.

Story and Photos by Marco Campos-Venuti

Among all agates, the nodular, banded variety, with their wonderful shapes and colors, is probably the most desired by collectors and the most intriguing to scientists. The magnificent geometry of banded agates is associated with a certain chaos that makes each of the nodules unique and ignites our imagination.

Despite the abundance of nodular agate specimens in museums and private collections around the world, there is no universally accepted theory that describes their origin. Many theories have been proposed, but most are devoid of any foundation in geology and do not account for the other varieties of crystalline silica, such as jasper and opal.

Formation of Banded Agate

In a book published in 2012, this author proposed a new theory that explains the formation of the three phases of microcrystalline silica—jasper, chalcedony and opal—with a unique geological process. According to this theory, each of these is formed by the filling of cavities within soils, at surface temperature and pressure.

*** Agates are not formed in soils. They are formed in volcanic rocks only. In limestones, they are formed from volcanic ash events dumped on top of the limestone, then the silica penetrates weak joints of the limestone. Therefore, there is no basis to say they form at the surface.

Microcrystalline silica forms from colloidal solutions and silica is in the form of polymer, a state of matter in which atoms aggregate in large molecules without three-dimensional ordering on atomic length scales, as happens in crystals. (Glass and plastic are polymers, but most rocks and minerals are crystalline.)

In light of this new theory, this article will explain, step by step, the formation of banded agates, interpreting the structures present in common specimens that are accessible to any collector. This explanation employs nothing more than an inductive-deductive method and no high-tech, expensive analysis.

Step 1: Most agates are found in volcanic rocks, and for this reason some authors have proposed a high-temperature origin, but there are also agates inside fossils. These occurrences show that the environment agates form in is not inside the magma, but inside the soils, at ambient temperature and pressure. The physics of soils is complex, but the phenomena that affect them are very familiar to us. Soils will moisten with the rains and dry up in the summer.

Step 1: Banded agate developed inside a fossil gastropod (89 mm) from Dakhala (Sahara), Morocco. From the Cretaceous Period (~120 million years ago).

*** This is defective logic. 100% of all agates are only found in volcanic rocks and volcanic ash in contact with other rocks. Contact conditions confuse some, but all agates in limestone systems still have celadonite, a clay mineral that is only found in volcanic rocks that includes lava and ash. Since celadonite absolutely cannot form in soil profiles from weathering, ever, this presumption is false. Ash dumped into shallow seas can engulf all kinds of organic matter does not prove surface temperature origin.

Step 2: Chalcedony coated the walls of the cavities, whatever their shape, in concentric layers. To remain stuck to the walls of the cavity, it had to be in the form of a dense solution. There are two types of dense solutions in nature: the "sol", which is like honey and is fluid, and the "gel", which is like a jelly and behaves rather like a solid.

Step 2: The polyhedral shape of this agate with concentric bands (77 mm) from Paraiba, Brazil, is due to a cast pseudomorph growth between large, lamellar calcite crystals.

*** Agates form in horizontal bands that are not concentric, chevron agates that are not concentric, moss agate banding is around included clay structures, have orbicular forms related to nucleation on radiolarians, as well as concentric wall banding. An agate model has to consider all of these mechanisms. Remember, in vein agates (which are very common in Southern California volcanics) there are never any tubes of entry/escape.

If chalcedony remains stuck to the walls of the cavity, then we can say for sure that it was once in the form of gel. Moreover, the presence of gel is further evidence of a genesis at low temperature because, when heated, gel will liquefy. The presence of gel also indicates that the silica was once in the form of a polymer because gels are usually constituted by polymers.

*** Gel silica does not stick to walls and is not deposited concentrically. It will slop to a puddle at the bottom of any void. Only one state of silica can bind upside down to walls and that is vapor-phase deposition in a supercritical fluid.

Presence of Stalactites

Step 3: In some agates, the bands formed stalactites, from which we can infer that the layers of gel that were stuck to the cavity roof were dripping down. We know that a gel can turn into a sol when water is added to it, so it is clear that this type of agate specimen suffered a partial dilution of its concentric bands. In the lower portion of these agates, there are often horizontal bands, which are clearly derived from the dripping stalactites. We can infer that concentric bands, in the state of a gel, have been diluted and have dripped down, forming a kind of lake. Typically, the stalactites are found in elongated cavities that resemble small caves.

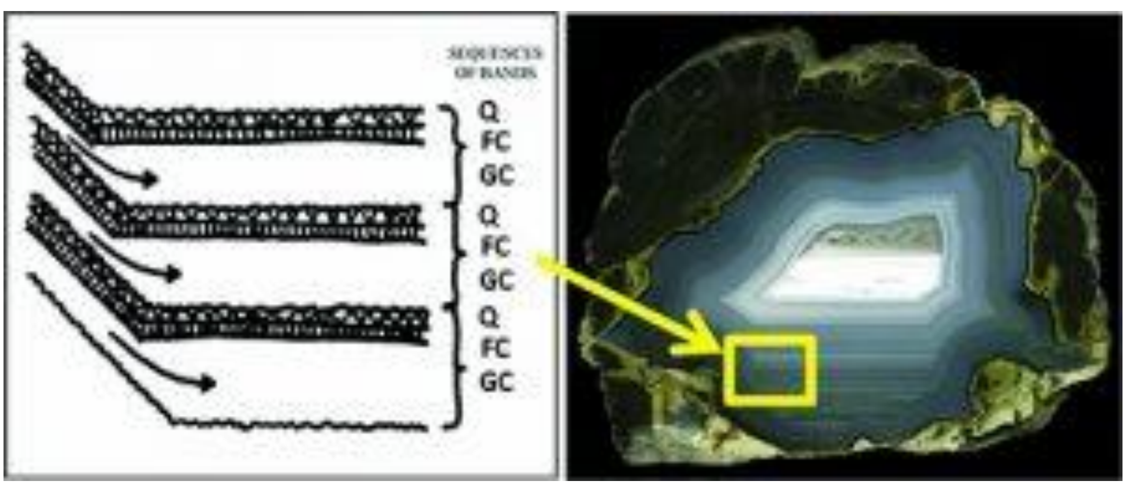
Step 3: A thunder egg (143 mm) from Maiskoje, Kazakhstan, contains stalactites of chalcedony. The cavity is filled by horizontal banding at the base and concentric banding above.

*** As a supercritical fluid goes subcritical, there can be a flash to boiling where fluid goes up the walls and down the center. The remainder puddles at the floor and forms horizontal bands. Horizontal bands exist all the time without stalactites.

*** 100% of all horizontal banded agates have outside wall lining silica. You cannot have two states in a solution or gel. So, one previous state formed in different conditions. The first state can be a vapor state. Subcritical after a vapor state will produce residual water and silica to make horizontal bands inside the wall bands.

*** We also have vent cones and quartz crystal stalactites in agates. The crystal stalactites and the vent cones are linked to wall breach channels. If the silica enters by a channelway, it makes a mound of silica, which we find in some specimens. If it spreads out flatter from high internal pressure, it forms wall chalcedony buttons (chalcedony roses), that in cross section are called disrupted or hurricane agate banding. This is not concentric banding. An example are the Brazilian Ochos agates.

Step 4: In some agates, bands form a concentric portion and a horizontal portion at the same time. If we look in more detail, we can see that some bands become thicker in the horizontal portion, while others have a constant thickness. This means that the bands are not all the same; some have a plastic behavior. As in the case of the stalactites, the chalcedony of these bands first adheres to the cavity walls concentrically as a gel, and then is partially diluted and flows by gravity as a sol. If the dilution was stronger, there will be only horizontal bands. Stalactites did not form in more rounded cavities because the chalcedony was allowed to flow laterally instead of dripping from the roof.



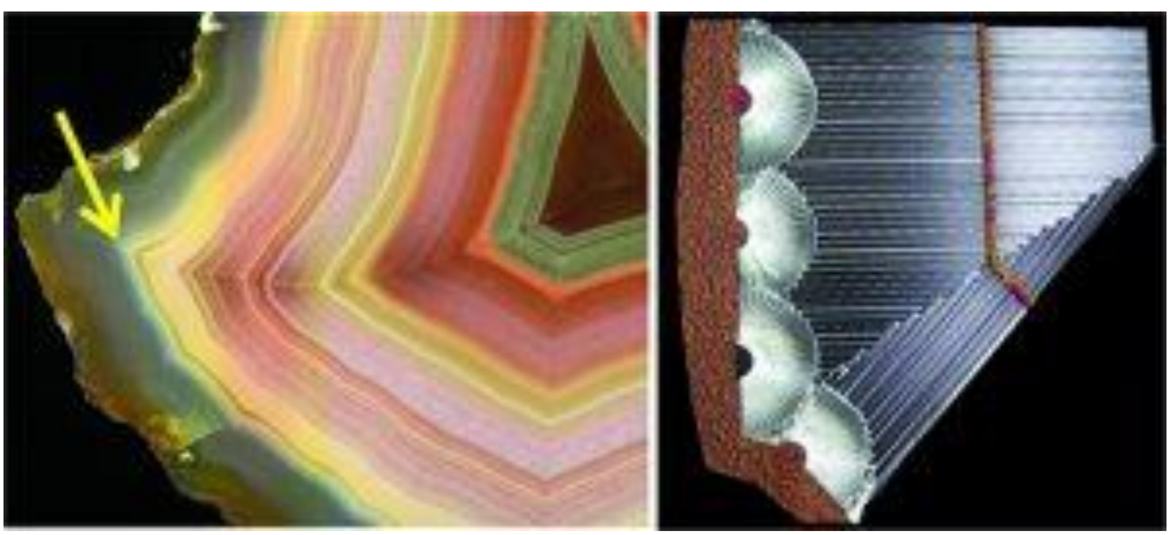
Step 4: In a thunder egg (117 mm) from Secret Ridge, Oregon, concentric bands are in continuity with horizontal bands. The diagram shows the thickness variations of different bands that highlights which one had a plastic behavior (Q = quartz; FC = fibrous chalcedony; GC = globular chalcedony).

*** The inference that there is silica sticky physics when it does not exist or rather at least has never been found, is a baseless proposition. Gels and solutions do not stick to walls.

*** The only place you can find opal-C is in agate waterlines, so there is no equivalence of a bunch of gel that may stick to walls and may slop to the bottom.

*** There are also branching channel tubes and on a smaller scale tube mosses that fill agates as a hash and did not drip down. They branch and are connected to the walls everywhere. Such a model does not explain them. Furthermore, the tubes are coated in opal-CT, so they have zoned composition are not in any way a quartz slopped around to and fro. Some tubes have celadonite clay cores and so are not even quartz. Celadonite is a silicate clay mineral.

Step 5: In some nodules, called fortification agate, concentric bands are not continuous, but follow broken lines. The highly curved fold in this type of agate corresponds with the point at which the cavity has the greatest curvature. Some bands have a fibrous structure, with fibers appearing perpendicular to the band. At the crest of the curve, the fibers are reoriented, creating two domains of crystallization separated by a visible joint. The presence of the joint is a clear demonstration that some bands have a rigid behavior.



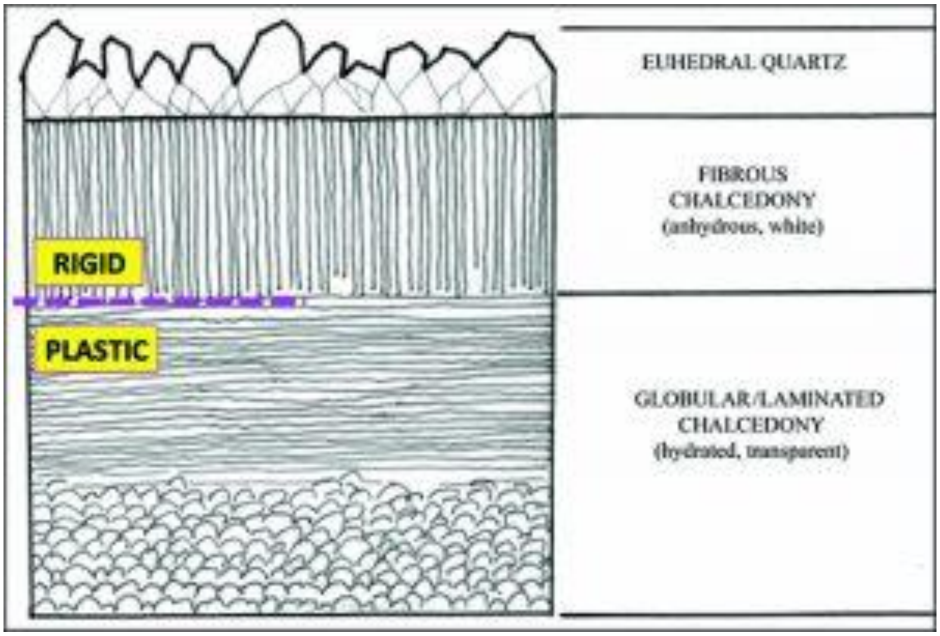
Step 5: Laguna agate (102 mm) from Chihuahua, Mexico, shows crystallization domains separated by joints. At the right is a diagram of the organization of fibrous chalcedony forming a joint.

*** The agate "bands" are continuous, just sometimes have sharp changes of direction. Fan formation is originated on hemispherical wall accumulations as nucleation points and is not just from curved walls. No agates have disjoint banding without brecciation or supercritical intrusion etching out the bands.

*** There is no such thing as a wall "band" in the strict sense because the fibers from the walls to interior are continuous unless there are quartz crystal layers. This model does not account for the alternation of fiber and quartz crystal layers. The so-called fiber "bands" are from periodic light extinction from fiber twist and from minerals deposited at the extinction points. There is no successive deposition of bands because there are no quartz bands. If fiber banding stops and restarts, you see a hemisphere layer where the silica nucleated and restarted growth. This is very rarely found.

Identifying Sequence of Bands

Step 6: We can identify a sequence of bands made up of three main types of bands: the clear globular chalcedony that is plastic and fluid, responsible for the formation of stalactites and horizontal banding (Steps 3 and 4); the fibrous white chalcedony that is rigid and caused the formation of domains of crystallization (Step 5); and the crystalline quartz, which is obviously rigid, too.



Step 6: The three kinds of bands that are present in an agate are ordered in a sequence of crystallization (M. Campos-Venuti, 2012).

We can interpret the sequence as a sequence of crystallization. At the beginning, we have a dense colloidal solution from which the globular chalcedony separates. Gradually, the solute is subtracted and the solution becomes more diluted, which leads to the crystallization first of the fibrous chalcedony, and then of the quartz.

Step 7: A sequence of crystallization is the result of the drying of the

Step 7: The stages of deposition of a sequence of crystallization of bands as the result of a wet-dry cycle can be compared to the gel lining and liquid milk inside a green coconut (bottom right). (M. Campos-Venuti, 2012).

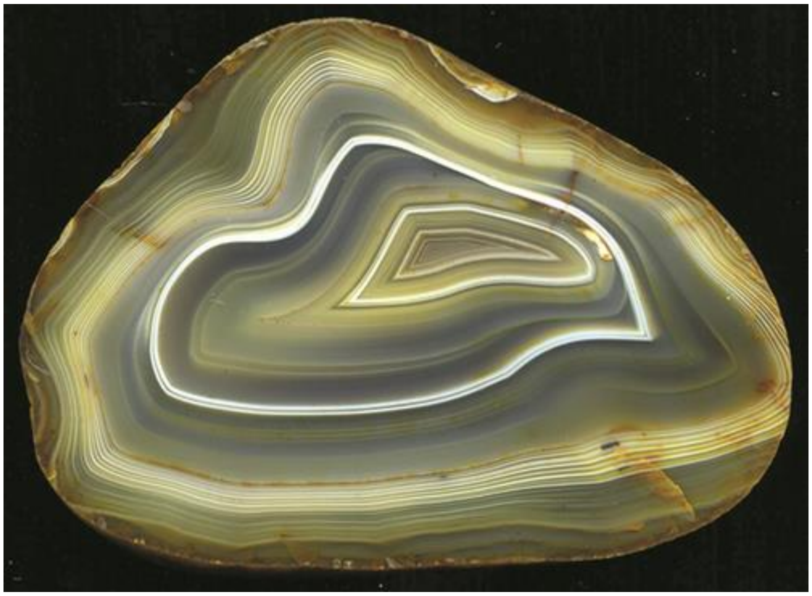
cavity. First, a colloidal solution rich in silica in the form of polymer separates against the walls of the cavity (globular chalcedony). At the center of the cavity, a diluted solution remains, from which first the fibrous chalcedony and then the quartz crystallized. It is a very similar situation to a green coconut, in which a gel on the walls, which will become the pulp, and a liquid center, the coconut milk, coexist. When quartz crystallizes, the solution is fully diluted and the quartz band represents the end of the sequence or the completion of the drying of the cavity. When the cavity is filled again by water, the process begins again. The formation of a sequence of bands is the result of an annual wet-dry cycle.

*** There is no drying cycle and it is not annual. Fibers can grow straight to the void core from the walls. If silica is coming in solution from weathering you have many problems. 1. All agates must be rich in humic acid. This is not observed. This is the acid picked up in soil with water leaching plant matter. 2. All agates must be rich in water in the structure. This is not observed. Only the outside shows a water signature. Most of the time in infrared there is no detectable water anywhere in an agate specimen. 3. The agates must be all calcite and barite and trace silica (caliche) because carbonate is several thousands of times more soluble in solution than quartz. Caliche as an inclusion in the banding of agates is not found in nodular agates. It is found in some vein agates and vein systems can be in contact with surface fluids. It must be the main inclusion in all agates, but it isn't. Only the outer weathering shell of an agate has water. The nodular agate interiors never do. Only empty agate voids fractured from weathering, have caliche, but the agate won't internally. 4. Quartz is almost totally insoluble. It does not dissolve easily and does not move to and fro without hyperalkaline conditions of pH 12 to 14 to get it into solution. The beaches of the world have quartz not agate because quartz is not soluble and does not weather at a level that is geologically identifiable. It simply abrades and breaks up from weathering to get to the beaches. 5. There are no channelways in the host rock seen to transport this silica and if there is fluid movement, the channels will cause wall rock alteration where it is easy to see. Ore body vein systems are identified this way by the host rock alteration.

*** Inclusions suspended throughout agates prevents the idea of successive deposition of silica as well as wall breccia structures suspended in agates (stone clasts).

They could only be deposited at the agate bottom and certainly not on the top and walls.

Step 8: Since the bands are formed one at a time, it is clear that the convolute concentric bands that do not follow the shape of the cavity are primary, meaning that they form with a twisted shape, without secondary deformation.



Step 8: Black River agate (106 mm) from Argentina has convolute concentric banding. The shape of the bands does not follow the shape of the cavity.

In some areas, bands grow thicker, and in other areas, thinner. Scientists have thought that convolute concentric bands are the result of a deformation of the bands after their formation. But as examples have shown, only bands of globular chalcedony are plastic, while bands of fibrous chalcedony and quartz are rigid, and therefore undeformable.

*** A gel goes through syneresis, a dewatering process where it hardens. Before thixotropy (irreversible hardening) sets in, they are gels at rest and turn into sols (sticky solutions) with force, hence they are called sol-gels for this reason. While plastic, silica banding can be compressed due to internal heat of crystallization forcing the internal water out. This internal water is linked to infrared identification of beta-moganite and beta-quartz by the reviewer. Beta-moganite forms at 354 C and beta-quartz forms at 575 C. These are only found in the core quartz and tubes-of-escape and certain banding microspheres. The remaining agate banding has alpha-quartz and alpha-moganite. The opaque white microspheres in agate banding is only beta-moganite.

*** Iris agate forms near the agate cores in dense agates without large voids, dominated by quartz crystals in the cores. Quartz crystal core formation causes compaction of banding around the core when it is still flexible. The banding is narrower as seen in polarizing microscopy, and the reviewer has identified Japan Law twinning in those bands with infrared. A number of agates in hydrothermal systems have Japan Law twinning from infrared identification by the reviewer. This can only form in a supercritical fluid and cannot form from weathering. This is known in ceramics. To make pure quartz you cannot heat the quartz above supercritical (374 C) or you get Japan Law twinning which muddies the optical quartz. So, we know some agates had supercritical exposure from beta-moganite and beta-quartz occurrence and from Japan Law quartz identification. If an agate does not have waterline banding, it formed at a subcritical temperature.

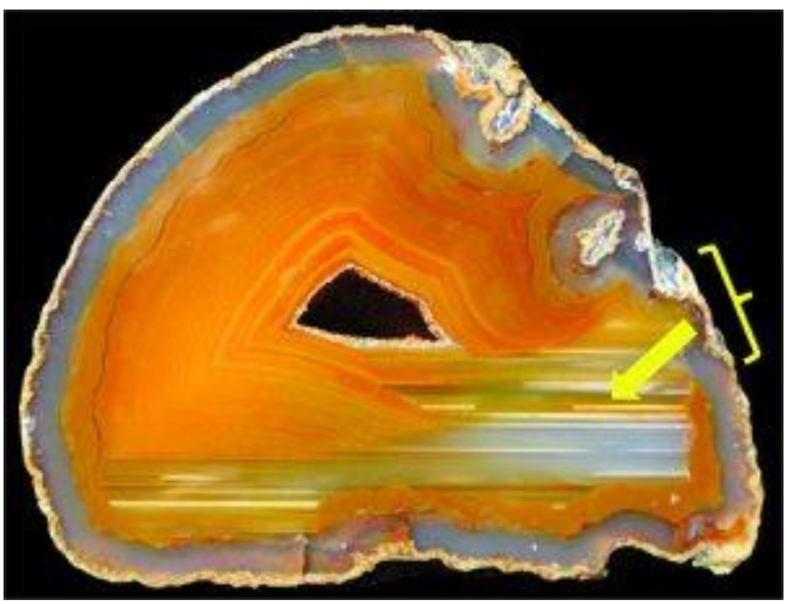
Understanding Connective Channels

Step 9: A connective channel is also a primary structure and has not been formed by deformation of the bands. This channel is simply a small interruption of the bands where water flowed quickly into the cavity, as opposed to seeping slowly through the porous first chalcedony layer. For that reason, the terms "outflow channel" and "inflow channel" are wrong and result from the erroneous perception that the channel was formed by deformation of the bands from the inside to the outside, or vice versa.

Step 9: This Parcelas agate (53 mm), from Durango, Mexico, has a well-structured connective channel.

*** The infrared graphs of the cores of tubes-of-escape is not the same as wall banding a millimeter away. Again, since no host rock has these channels and the agates form up to 900 meters depth in lava flows where capillary action is impossible, the concept of water leaching into voids depositing silica is absurd, and geochemically and physically impossible. The idea is infinitely unpluggable micron channels fill up big voids somewhere else when in reality the channels are smaller and will plug up first. Don't forget, at 30 ppm silica in solution, to fill a 2.5 cm (one inch) voids takes tens of thousands of liters of water to move through the micron channels to find a void to deposit on. This is called gibberish physics. It is not remotely reasonable. For a capillary tube to go 900 meters will take millions of PSI of water pressure force, assuming it could be done at all, which is impossible. Friction on such a small scale is a very strong action on water, and prevents its migration.

Step 10: In some samples, some bands have a concentric structure on one side of the agate, but a horizontal structure on the other side. On the side with horizontal bands, there is always an interruption of the bands at the cavity walls, which allowed a greater influx of outside water from this side. Dilution was very slight in these samples and was not able to reach across the nodule.

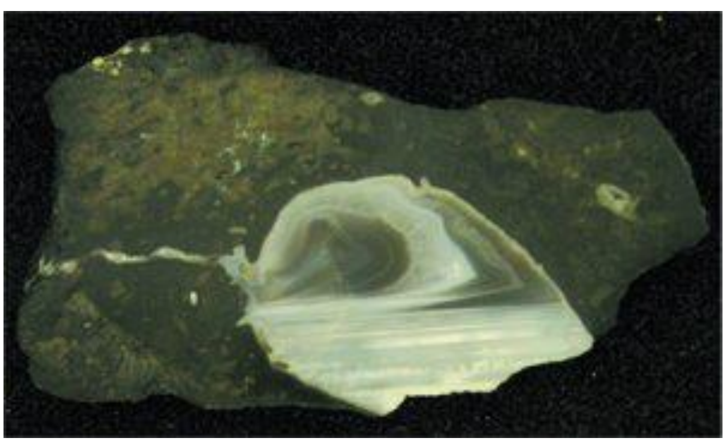


Step 10: Concentric bands in an agate nodule (90 mm) from Rio Grande do Sul, Brazil, switch to horizontal (arrow). An interruption of the bands (brackets) allowed a partial dilution.

Only the part near the interruption of the bands was diluted, which prevented the gel formation necessary for the bands to remain stuck against the wall of the cavity on this side.

*** Hard to follow, yet 100% of all horizontal banding has wall banding on the outside layers against the wall. There is no such thing as wall-to-wall horizontal banding which would be expected from weathering, and expected to be the typical case. Wall banding, by comparison, would be impossible. The horizontal banding would also be discontinuous which is never the case in an agate.

Step 11: The Scottish specimen pictured in Figure 12 is a rare sample of an agate in its basaltic host rock that shows its feeding fracture. In the agate nodule, horizontal bands formed in the lower portion at an earlier stage, then the concentric bands formed above. It is evident that the presence of the fracture in the host rock facilitated the entry of water into the cavity, causing dilution, which in turn was responsible for the formation of horizontal bands. When, however, the horizontal banding reached the level of the fracture, the access of water into the cavity was stopped, thereby preventing dilution. At this point, concentric bands could finally adhere to the walls of the cavity. However, corresponding to the fracture, an interruption of the bands remained that developed a connective channel.



Step 11: The feeding fracture of this agate nodule in basalt (82 mm) from the Isle of Skye, Scotland, has been filled by chalcedony.

*** Intrusion channels are voids meaning silica deposits on the walls, which we can see. Therefore, undepositable channels filling large voids is nonsense. Also, there are no agates in any granite voids of this planet, lots of quartz, and lots of rainfall, so this model is invalid. There are no agates in schist or metamorphic rock voids. No agates in coal bed voids. No agates in sandstone voids (only eroded out agates in sands and gravels). No agates in shale voids. No agate in serpentine voids. Just volcanic rock and ash voids, and in limestones with volcanic ash mixed with chert. Since weathering and water is all the same regionally regardless of rock type, weathering is not the common denominator.

Fractures Found

Step 12: From Step 11, we learned that the presence of fractures in the host rock interferes with the growth rate of the bands. In many agates, there are areas in which bands have grown faster and areas that have remained without bands for a longer time. The latter must have corresponded to fractures in the host rock, where the bands could not be formed due to the penetration of water. Only later, when the gap between the bands closed, could concentric bands grow more uniformly. Knowing this, we can speculate where fractures were present in the host rock for any loose nodule.

*** Water brings in silica to make agate, but then again it doesn't. I cannot follow this. Distinguishing fractures from freeze-thaw weathering after formation is not a basis of agate formation.

Our mystery is solved! Investigating few specimens that every collector can have in their house and without any technological instrument except for our brain, we were able to investigate, step by step, the logical arguments that allow us to understand many complex phenomena in agate band formation.

*** With no understanding of agate structural and inclusion formation, you cannot understand the conditions of agate formation. This author has no compositional inclusion data. Calcite is the most common inclusion in agates. Dolomite is also found. Dolomite cannot form in surface conditions. It only forms in reducing (oxygen-depleted) conditions.

Summation

Agate bands are concentric because they form first in a gel state, but this state is easily destroyed by the sudden arrival of new water—for example, from rainfall—and then chalcedony can flow to form structures such as stalactites or horizontal banding. A stronger dilution would lead to the formation of quartz.

The bands are of three types: clear globular chalcedony, white fibrous chalcedony, and crystalline quartz. Fibrous chalcedony and quartz are not deformable and this underlies the formation of the joints of crystallization. The complex geometry of the bands is caused by differing porosity in the host rock, mainly due to the presence of fractures that intersect the cavity. A connective channel is formed at this intersection and is active as a channel until its obstruction.

*** The only way hundreds of meters of solid rock is porous is in supercritical fluid conditions, also called medium grade metamorphism, also called fluid-rock alteration. Fluid moving through rock alters its chemistry. Since no rock alteration from the surface to agates is documented, we know there is no surface water migration until the agates stopped forming in the lava flow and the rock is fractured and broken down from weathering including freeze-thaw and rain mixed with humic acid. Fractures in agates from weathering after formation moves ions in and out of the banding because it is porous and changes the coloration, but involves no mechanism to deposit or leach out silica.

A sequence of bands is the result of an annual wet-dry cycle. During the wet phase, water carries silica in solution into the cavity. During the dry season this solution is drying, making the solution denser and transforming it into colloidal up to crystallize. Next wet cycle, a new solution comes in carrying new silica, which adds to what already was inside. To this simple depositional cycle, numerous phenomena are superimposed that take place inside the cavity during filling and hardening of chalcedony.

*** Silica in solution never makes a silica gel. Typical surface water silica at 30 ppm is tens of thousands of times too low of concentration to make a gel. If it did, aiming a garden hose at the wall of a house would deposit agate. This is not observed because the author has no concept of the parameters of silica gel formation.

*** Water wetting/drying transport deposits caliche, not quartz. Caliche is calcite, barite, and trace silica. Since agate cores do not contain caliche, there is no such process involved in their formation. Even trace barite or calcite inclusion water can be identified in infrared, but the hard scale barite is not common in agates. The dominant mineral in solution of groundwater or surface water is not silica, it is calcite so to say this water makes pure quartz instead of depositing mostly calcite is nonsense.

*** Most agates are found in the driest deserts of the world. Agates are not found in tropical rain forests. Agates in Paraguay during formation in Tertiary were in a desert zone when formed and moved into the tropics later from plate tectonics. Agates are not found near rivers, lakes, the water table, springs, or any other sources of water. Therefore, there is no agate-water connection.

If a sequence of bands is formed in a year, then it is clear that the filling of the cavity is a short phenomenon, on the order of a few years. In the millions of years that followed after the nodule hardened, numerous other secondary phenomena affected the final appearance of the stone.

Varve Definition

From a geological point of view, a sequence of bands can be considered a varve, or rhythmite. In geology, varves are thin, sedimentary layers that originate from a repeated—usually annual—phenomenon, mainly dependent on climatic factors. The accumulation of varves can produce thick deposits like most lacustrine or deep-sea deposits. In a broad sense, the laminas of polar ice and the rings of stalactites or trees can also be considered varves.

*** Wall vapor-phase deposition and horizontal banding are continuous because as the supercritical fluid goes subcritical at 374C, the supercritical fluid converts to water vapor and liquid water. The silica in the water vapor makes the horizontal bands. Since quartz crystals cannot form from weathering and typically are found by fluid inclusion studies for formation around 150C to 250C, this is not weathering; it is hydrothermal fluid. To make quartz crystals in a lab, they use pressure autoclave ovens at supercritical temperatures only. No quartz crystals are made at 10 C (surface temperature), yet this is the claim here.

*** Yeah, and varves are only horizontal, and discontinuous, but agates are not typically horizontal and the banding is 100% of the time continuous. Valves make lensatic pods where banding starts and stops. Think chert. Limestone stalactites are caused by highly soluble calcite moving in solution, however, silica is almost totally insoluble in solution.

In conclusion, the environment of agate formation is occasionally flooded soil that is able to dry off completely, thanks to a climate with distinct seasons. The area of formation of agates is a zone inside the soil that goes from above the water table during the dry season to below the water table in the rainy season, also called the zone of intermittent saturation. Every single rainy event can alter this balance and leave traces in the nodule formation.

*** Agates don't form in soils, are not found in dirt unless eroded and dumped there, and do not increase in size with depth in the weathering profile (older soil at depth would then have larger agates). This is simply not true and is made up gibberish. Agates are almost exclusively found in deserts, so claiming lots of water and drying is double gibberish. Agates are not found at zones of saturation, called the water table, ever, so this is triple gibberish. Apparently, this author has never collected agates for himself.

*** Nodules are formed by accretion in seasonally wet/dry soil. For example, goethite and manganese and chert nodules. This has never been observed for agates. It occurs for low temperature silica rocks like nodular cherts, but those don't have banded quartz, they are granular quartz. So, the author is confusing chert and agate formation. I know, it is all just a bunch of quartz to him.

If we're digging a deposit of agates, we must bear in mind that we are in a fossil soil. Then the understanding of the original groundwater position can give us important information on where to continue excavations.

*** Yeah, and when he collects for himself he will dig on faults, around volcanoes, and in and under basalt flows, but as a rule, never in soils.

Climate's Active Influence

Obviously, the climate has a strong influence on the type of agate, and we can recognize the paleoclimate of an area from the agates that are formed in it. The more humid the weather is, the more horizontal bands, fibrous chalcedony, and quartz will form. In more arid climates, concentric, convolute bands are more common. The presence of moss in an agate is an indicator of moisture—but that's another topic.

*** The humidity in the Mojave Desert of California where I live has more agates than anywhere in the world, and an average humidity of 25%. So, this is just climate bunk gibberish.

The type of host rock also has some influence on the agate nodules. For example, agates in sedimentary rocks never have connective channels. This is because the sedimentary rocks are extremely porous, compared to glassy volcanic rocks, so the intrusion of water into the cavity after a rainfall happens suddenly and causes the formation of quartz. The presence of a fracture in the host rock that intersects the cavity is totally useless and so connective channels or horizontal bands never form.

*** Agates with ash and limestone form at very low temperatures, subcritical, so they don't have tubes-of-escape or waterlines. TOE structures are supercritical structures. "Sedimentary rock" is misleading slang because there are many kinds of these rocks, but only ash dumped on limestone makes cherts and agates. No shales, no sandstones, no coal beds, no mudstones, no chalks, no sedimentary rock of any kind except limestone and ash have agates. Why? Agates are calcite-silica rocks and form by the pH balancing of carbonates with alkaline ash which allows the silica to dissolve into solution. The pH drop in contact with carbonate forces the silica out of solution. So, the conclusion agate can form in any sedimentary rock is false as no such occurrences have been found so far.

*** Exactly, the fracture near the agate has been filled with agate, which means it could not fill the right void with agate. Since the fracture is a small percentage of the size of the nearby void, the fracture would have filled first. If this did not take place, then Venuti is citing unobservable sticky physics binding silica to walls sometimes, that never occurs at other times, and does not reconcile this difference.

The formation of color in agate can be a primary process, which is when the colors originate at the same time as the agate is formed and from the same solutions, or a secondary process, after the agate solidifies in geologic time and from different fluids. In the first case, the colors are concentrated at the center of the nodule, and in the second case, they are located on the outer edge.

The formation of a banded agate nodule is a closed—or almost closed—system. Solution must pass through the first chalcedony layer that isolates the cavity from the host rock in order to infiltrate the cavity. This layer acts as a filter, and only few elements can cross it besides silicon. Iron and manganese are the most common elements in the soils that give color to an agate. They are called chromophores, and they are incompatible with the crystallization of chalcedony, so they accumulate inside the cavity.

*** The problem of universal diffusion in through rock from all directions, and simultaneous universal diffusion out is absurd and is invented physics no one has created in a lab. Metals are deposited in agates because they act as silica deposition catalysts and are by no means incompatible with agate formation while triggering agate formation. Metals are important in gels to initiate hardening.

Transparency of Bands of a Nodule

For that reason, the first, or more external, bands of a nodule are transparent. Gradually, the bands accumulate on the walls of the cavity and, as the years pass, the concentration of chromophores within the cavity increases until they are forced into the globular chalcedony, which has water molecules inside.

*** Globular chalcedony as eluded to here would be identified as quartzine in infrared spectroscopy and would only be in waterlines. Quartzine is related to marine influence, dolomite, and presence of magnesium. Quartzine-rich Namibia blue vein agate has no wall banding at all with continuous solution structures perpendicular to the overall layers, crossing multiple bands. Dolomite rhombs replaced with silica form the outer layer of Namibia blue agates.

Iron and manganese may begin to manifest their colors at different times, but overall color intensity increases in the latter stages of the nodule's filling. Primary colors are common, for example, in Laguna agate. Chromophores never enter fibrous chalcedony or quartz bands, which are anhydrous. This is why these bands remain white.

*** Incorrect. The quartz crystal bands have no mineralization because it is not taken up in the crystal structures, which is why the agate quartz bands are always transparent.

Agates that formed in limestone or basalt are generally low in primary colors, because limestone is very poor in chromophores and basalt cavities are coated with a green patina of celadonite, the early result of the devitrification of basaltic glass, which is impermeable.

*** Tube structures in agates are celadonite. It is not just coating the walls of some agate, namely those that don't have hematite or goethite shells.

However, with a bit of luck, these deposits can be affected by solutions rich in chromophores long after the formation of agates. Slowly, over time, initially grey agate may acquire secondary coloring from water intrusions. Secondary colors are common, for example, in Condor agate.

*** The most common colorant of agates is from humic acid that comes from ground water leaching through plant matter after agate formation.

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*** There is nothing about a weathering model or agate based on gel theory that is new.