

Agate Structures, Part 2:

Dendrites, Plume, and Moss Agate

There aren't any hard and fast rules that define and differentiate them, and in common practice appearance more than content defines one as “plume” and another as “moss” or “dendrite”. And, as some types of mosses, plumes and dendrites overlap or grade into one another along a continuum, a lot of latitude in labeling has to be expected. There are real differences among some of them however so I am going to sort them out into several groups based on how they appear and how they were formed, as best I can tell.

Scrap Moss, and other Nondescript Moss

Let me begin with a 'moss' that we know something about already – mineral exclusion bands. Many patterns we see in agate that appear on cut surfaces to be filaments or plumes are actually sheet like, albeit perhaps discontinuous and localized in extent. This San Carlos agate, which would probably be considered a '**moss agate**' contains a wild melange structures that appear to be, in large part, mineral exclusion bands. They would consist then of finely distributed non-silica material contained in the agate seam that was simply swept up into layers by countervailing crystallization fronts moving outward from an array of various nucleation surfaces.



San Carlos Agate, Mexico

That out of the way, let's begin our look at 'moss agate' with what seems the simplest of the moss agate structures, and one unrelated to the other structures known as 'moss'. **This type of moss consists of solid mineral matter that occupied part of the cavity prior to silica gel formation.** These are usually minerals of the chlorite and mica groups that form as unstable lava rock weathers, but could be any number of minerals. Both the mica and related chlorite minerals are platy and can roll up into long tube-like, or “worm like” structures, or they can simply be ragged shreds of some former sheet-like existence, so '**Scrap Moss**'.



Note in this specimen, Green Moss Agate from India, the stalactite-like chalcedony structures formed around the green mineral, and water level banding formed later in-between. The ragged green drapes obviously developed prior to any heavy polymerization of the silica solution or they wouldn't have settled into it.

The photo to the right of a weathered chunk of Woodward Ranch basaltic lava shows the development of “**celadonite**” on gas pocket faces. I put celadonite in quotes because I don't know the actual mineral content of the greenish crust. Celadonite has become a default label for a wide range of similar minerals that form in weathering basaltic rock. As you can see, it would be easy for this mineral crust to get into an agate as it formed.



Dendritic Moss and Plume

A very complex and fascinating type of “moss” and “plume” is composed of metallic compounds crystallizing into fantastic shapes and colors in the silica solution or gel. Some of these mossy plumes are very finely, even microscopically, crystalline and appear as 'veils' or thread-like to stringy inclusions. They often appear to show motion as if they formed in a moving fluid. Others are much coarser and rigid appearing although they may be intricately branching and must have formed with the support of a gel. **I'll call these “dendritic plumes and mosses”.**

Here too, is one of those confusing areas of overlap – this time with **sagenite agate**, which come a little later. But, generally speaking, sagenites are needle like crystals that form early in open voids, whereas 'dendrites' grow in a filled cavity. The growth, usually by diffusion from the outside, in a supportive medium allows dendrites to assume complex shapes. And, although 'dendritic' moss and plumes form from metallic solutions diffusing into silica filled voids, I am reserving the term 'diffusion' for plumes that lack a readily identifiable crystalline framework.

Then, in both cases, chalcedony grows around them. The crystallization of these agates is very similar and examination of the sagenite and plume thin-sections will help to understand it.

Volcanic areas are hot beds of metallic solutions (if you will pardon the pun). When these metallic solutions invade a cavity that offers the right conditions the enchantment begins – well, the enchanting natural process begins. Again, the exact mechanism is not fully known but it surely is similar to the process observed in the common grade school science demonstration kits sometimes known as “Magic Rock Gardens”.



Needle Peak Thistle Agate, Texas

In that case water soluble compounds of metallic chlorides and nitrates are placed in a solution of water and sodium silicate (NaSiO_3). The metal salts begin to dissolve immediately and react with the silica solution forming a semi-permeable coating of metal silicate gel around it. Inside the protection of the gel, the reaction continues, dissolving the original “magic rock” and precipitating out a new, insoluble, metallic compound in long thread-like, or bush-like, or plumey crystals.

The growing mineral aggregation, suspended in the slightly denser sodium silicate solution in its gel cocoon that grows along with it, has the freedom of practical weightlessness to assume whatever whimsical forms it wishes.

Well, that's not exactly right either, our growing aggregations are still bound firmly by the laws of chemistry and physics. In the science kits, the metallic stalagmites generally grow upward, subject to gravity that pulls down less on them than on the denser surrounding solution. In the agate world we do see much more whimsical expressions because they are different in several ways. The science kit “rocks” are concocted in the lab for rapid reaction and growth, before we kiddies grow bored and turn to something else. In nature, only God is watching, and He has infinite patience. While rapidly reacting metal salts are dropped directly into the solution in the kits, in nature, molecules of less rapidly reacting metal compounds may slowly seep into the silica solution, or diffuse into it from anywhere on the outside. Also to be reckoned with building agates in God's good time are the affects of changes in temperature and pressure, earthquakes, shifting ground under them, sudden influxes of minerals, water and steam... and who knows what else that give agates such incredible variety.

Let's go back to diffusion for a moment. Diffusion is a chemical process - we might call it a natural imperative, for the movement and mixing of fluids. We might liken it to this: A diverse group (representing a hydrous metal solution) is standing outside a crowded auditorium (representing a silica solution filled vug) trying to get in. One at a time, members (molecules) of this very polite group work their way into the auditorium finding open spaces as they go along and spread out, and don't push aside the people already there. Eventually, they are all inside and uniformly spread out, or diffused throughout the auditorium.

A seep might be described this way: A more aggressive group storms the auditorium door and begins shoving its way in three or four abreast. As those forced ahead of them become more concentrated and unable to move out of the way, the incoming stream is blunted and forced to clump together or veer off in a less congested direction.

I spend our valuable time on this simplistic illustration **because many of the dendritic structures we see in agates are classic diffusion patterns; albeit patterns of diffusion that has played out before completion and been frozen in time as well as in stone.**

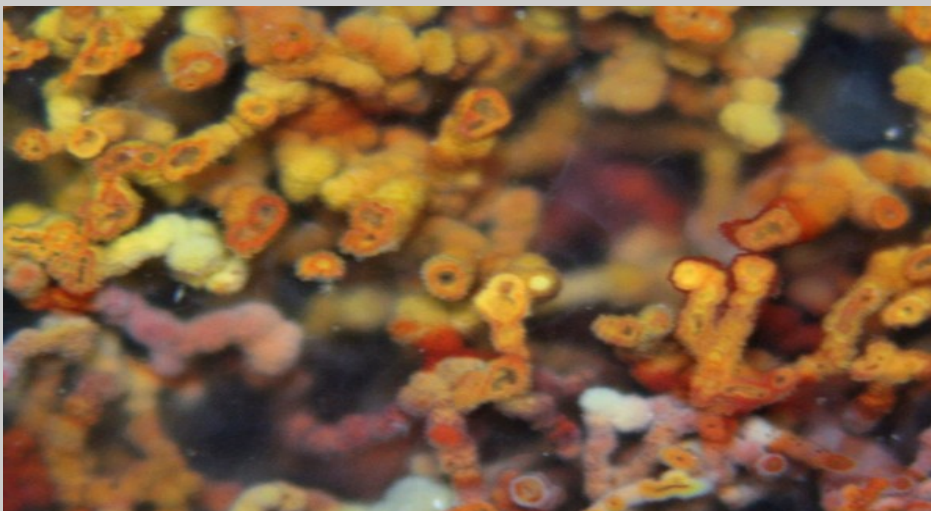
When you look at the small gallery of dendritic agate photos coming up shortly, notice how the dendrites grow in all directions and don't seem bound by gravity. That's all I'll say about diffusion here, but more is to come soon.

Some things we do not usually see in this metallic type of plume is initial wall banding that seals off the void, therefore we do not often see pressure release distortions in these agates – although some of them are mixed banded and plume and we may see pressure release structures in them.

Another thing we notice about them is that various types of plume and moss mix intimately together and we notice that some moss agates have sparse moss and a lot of, usually colorless, chalcedony or quartz while other moss and plume agates are jam packed. The availability of metal in the silica gel may have a great influence on its ability to form bands. Too much initially may lead to the growth of the metallic crystals rather than banding, but once the metallic crystals begin growing they rapidly consume most of the metal, leaving the gel depleted for band formation.

We can't leave dendritic moss and plumes without a bit more attention to the chalcedony encasing them. The dendrites seem to grow in a supportive heavily polymerized silica solution or gel. **There often is a thin reaction zone where the silica coating picks up coloration from the dendrites; not the color of the dendrite itself, which is usually metallic gray or black iron or manganese oxides and hydroxides, but the color of silicated metal oxide or hydroxide.**

Below is an extreme macro-photo of fine filaments of moss in a Mexican moss agate. **Notice that the 'moss' consists of tubes, or stalactites, around mineral fibers – dendrites.** I don't know what mineral forms the stalactites, or tubes, or cocoons, but they are surrounded by and suspended in clear chalcedony. Some of the most colorful minerals are metal silicates including garnets, tourmalines, rhodonite, epidote, and olivene to name but a few of the more common ones.



The dendrites, or their silicated coatings, serve as excellent nucleation surfaces and cocoons of fibrous chalcedony form around them. The cocoons vary in thickness but usually are quite thick in comparison to the dendrite itself. I suspect that every dendrite has some coating but it isn't visible on all. I am referring to the thick chalcedony coatings as 'cocoons' here but they are frequently referred to as 'stalactites', and 'tubes'. As they don't have quite the same nature as cave stalactites they are more properly labeled 'pseudo-stalactites'. Likewise, unless the original dendrite has dissolved away, it is not truly a tube. But as these structures resemble stalactites and tubes, it is perfectly appropriate to apply those terms in common usage.

In many cases, these chalcedony cocoons are of more interest than the dendrites, and sometimes they combine to fantastic effects. The fibrous chalcedony may continue forming and fill the agate with banded chalcedony, or as is more often the case, the remainder of the agate is filled with unbanded or water level banded granular chalcedony.

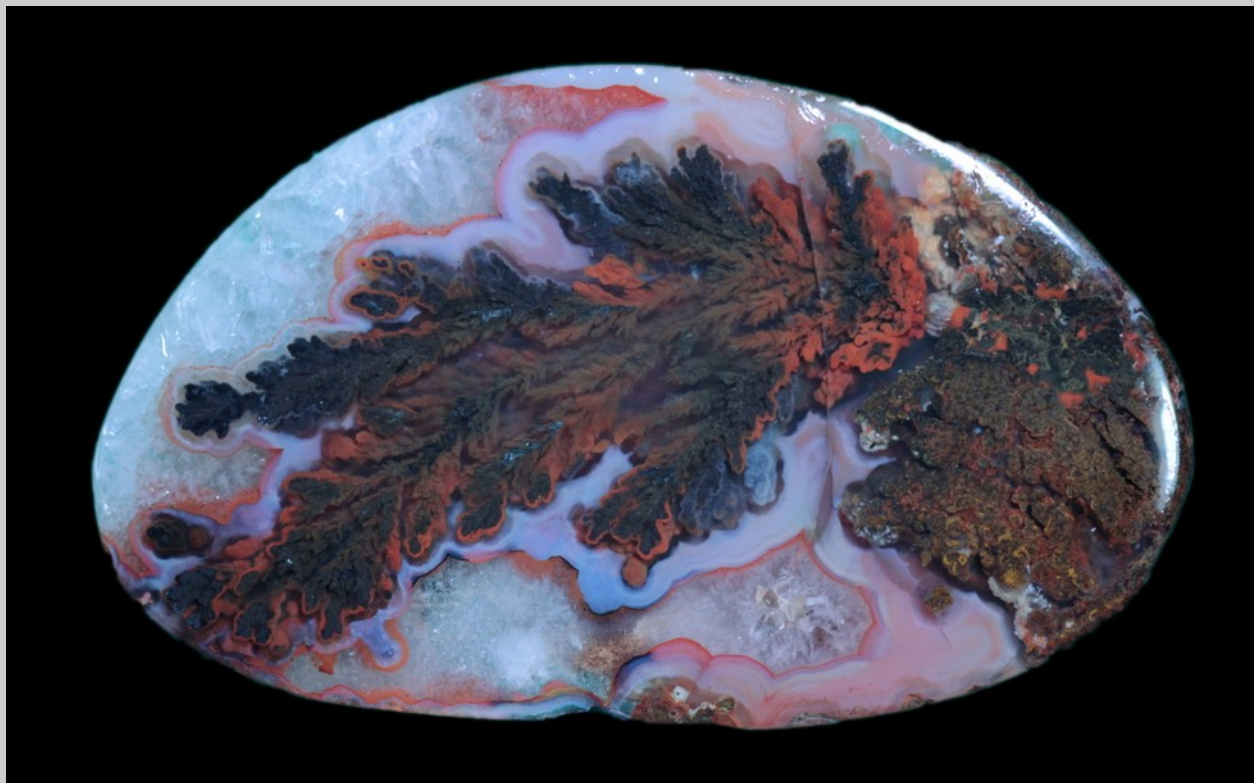
Here is a quite large and elaborate Woodward Ranch plume that shows a clear cocoon very well. Evidently this plume has a very thin reaction rim. In an unusual case, the plume is surrounded by macro-quartz.



Woodward Ranch Plume Agate

Notice two things going on here. In the Indian green moss agate, chalcedony formed around apparently static mineral strings suspended in the silica solution. Based upon their appearance alone, I am guessing them to be some form of the mineral chlorite, not a mineral salt that would be growing in the fashion described above but already formed by decomposition of the host rock. **The Woodward Ranch plumes however are metallic solutions that diffused into the vugs and grew into the arborescent (treelike) plumes** much in the way described above for the “Magic Rock Garden”.

Here is another very large, about 50mm, Woodward Ranch plume that shows the needle like dendritic nature of the plume better. The metallic dendrites have a thin red reaction rim coated with a clear chalcedony cocoon and surrounded with macro-quartz.



Woodward Ranch Dendritic Plume Agate, Texas

It strikes me how much these plumes are like human embryos growing in their own protective sacs. That should not be surprising as they both have the same Creator who uses the same patterns, with variations, over and over. Coincidentally though, come to think of it, both man and agate are made from the dust of the earth (Genesis 2:7).

The warrior king, singer and poet David, thousands of years ago, wrote this: ***“I will praise thee; for I am fearfully and wonderfully made: marvelous are thy works, and that my soul knoweth right well. My substance was not hid from thee, when I was made in secret, and curiously wrought in the lowest parts of the earth. Thine eyes did see my substance, yet being unperfect, and in thy book all my members were written, which in continuance were fashioned, when as yet there was none of them.”*** (Psalm 139:14-16 KJV)

The part about being ***“wrought in the lowest parts of the earth”*** seems a bit strange for us; quite true for agates though. The Psalms are Hebrew poetry. Unlike English poetry based on rhyming sound, Hebrew poetry is based upon poetic parallelism of thoughts and actions. The unknowable deep parts of the earth is a rhyming thought, so to speak, with the secret and unknown place that was, and to a degree still is, the womb.

You may have noticed that all the above plumes were formed in volcanic host rocks! Don't they form in sedimentary host rocks? Yes, they do, but rarely, due to the general lack of metals in limestone and shale formations. We saw a somewhat scrappy looking dendritic plume from Summerville back in in an earlier section and we'll take another look at it. First up in the Gallery below is a close-up of plumes in a Paint Rock Agate pictured in the Sedimentary Agate Gallery. These appear to be some form of iron mineral dendrites, now pseudo-morphed, if I may coin a term, into plumes suspended in a nearly clear to slightly amberish botryoidal chalcedony.

The limestone formation is overlain by a massive iron bearing sandstone that may be the source of both the silica and the iron.

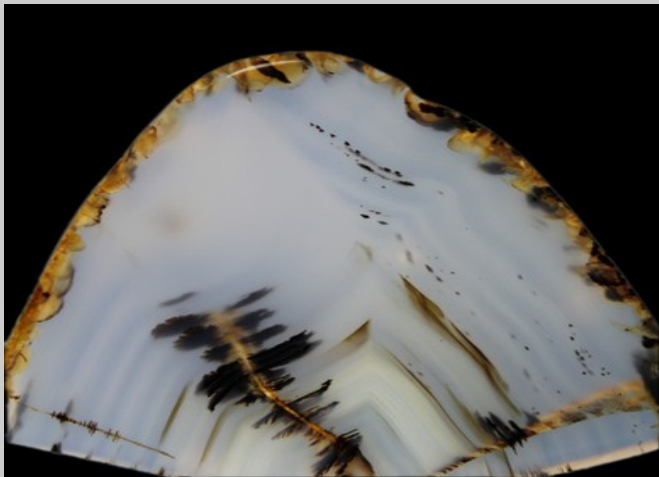
Click here for a small gallery of dendritic moss and plume agate photos:

[Dendritic Plume and Moss Gallery](#)

Capillary Plumes

Here is a type of structure somewhat different in character that I am sandwiching in between these sections. I'll call it **"capillary plume"**. In this type of dendritic plume or moss, metallic solutions, usually manganese, travel by capillary action along fractures or other planes of weakness, sometimes spreading out into cross fractures, or fanning out in between bands as in this Montana Moss agate. It might be thought of as two dimensional. Seen from above, these plumes would have the more familiar branching form.

An interesting thing about these dendrites is that the pathways often seem to disappear, leaving dendrites isolated in apparently solid chalcedony. You will notice in the blow-up that the long fracture is clear of the solution that it obviously fed out into the agate. That could be partly due to later percolation of water through the crack, dissolving away the mineral, but I am inclined to think capillary action drew most of the solution out of the relatively large fracture into very thin, perhaps somewhat dirty, spaces between chalcedony bands.



Montana Moss Agate

You will notice that most of the moss clumps line up in rows but don't show obvious feeders. Notice also the the colored bands, which are not of the same type as classic banded agate. It appears to have very strong fibrous wall banding but the predominant color banding, although it follows the wall banding, seems to be more of a secondary staining following the banding, but there are no obvious feeders.



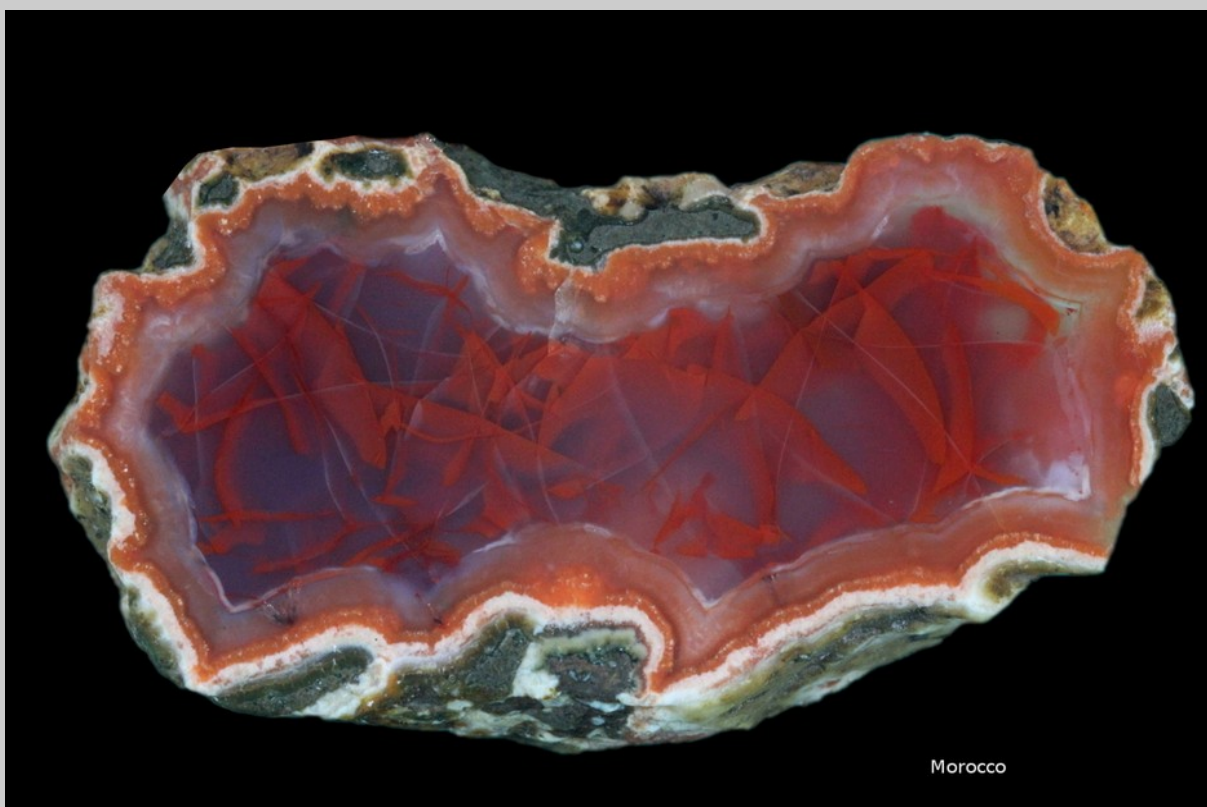
If the chalcedony was sufficiently fluid after emplacement of the dendrites, the channels could disappear.

When you come to the gallery of moss and plume agates, remember to look at the Montana Moss Agate.

To the left is another capillary dendritic 'agate', this one from Russia. In it, the dendrites clearly formed along fractures, but there is no apparent banding to follow. The dendrites seem to have simply diffused out into the surrounding granular chalcedony. Or, it seems more likely, into some gel precursor to chalcedony. Remember that **silica gels can be brittle**, as this must have been. This type of dendritic structure is often seen in common opal, some of it very attractive.



Below, in this agate from Morocco, coloring material appears to have invaded a series of fractures, probably by capillary action, but did not diffuse out into the surrounding chalcedony.



Diffusion Plumes: Billowing and Flaming

Now we come to the final grouping I've made for plume agates and perhaps the most diverse and difficult group to understand. Though it includes some of the most popular plume agate gemstones like Graveyard and Prudent Man[®], I have not been able to find much information on them – so, again I'm on my own.

One of first things we notice is that all the plumes originate at the contact of the vein filling with the host rock. The host rock was probably saturated with a super hot, super high pressure mineral bearing fluid that diffused into the silica filled vein. The sol/gel filling probably formed during a lull between volcanic events and some new activity nearby caused the new hydrothermal conditions. The growth and expansion of the plumes away from the edges is very obvious. But as they grew, each type assumed its own distinctive character based upon local physical and chemical conditions.

You might have jumped ahead of me and guessed that “Flaming” referred to Flame Agates; well, that's right. Since I am dealing with Flame Agates separately in the next pdf, I am not going into much detail in this section. **I am calling these plumes 'flames' because of their shape and content relative to 'dendritic' plumes with a metallic crystal framework covered in chalcedony, and plumes that present a billowing shape without an obvious crystalline framework.**



This **flame agate** from Mexico illustrates the source of the plume very well - the diffusion of an iron bearing solution out from a section of porous rock at the edge of the vein. In this case, the iron seems to be finely disseminated and distributed, very much in the way it is in the Crazy Lace Agate dissolving the hematite.

As in the other plumes we are coming to, the plume served as a nucleation surface for the formation of chalcedony in a silica saturated vein.

For lack of a better name (or perhaps lack of imagination), I will call the second group “**billowing plume agate**”. That may not be a catchy title that will sweep the rockhound/lapidarist community, but it is descriptive. All three types are produced by diffusion but they have very different appearances, with dendritic plumes having very obvious crystalline frameworks, while the flame and billowy plumes have little to no visible crystalline framework but very different plume shapes.

Appearance, then, is the basis of my distinction between these plumes – adequate for our purposes of informal classification. The visual differences have their origins in the nature of the plumes, however. I have subdivided the 'billowing plumes' in the little discussion following into lighter and darker plumes.

Darker billowing plumes are composed of metallic compounds very similar to the dendrites except in crystalline structure- and they may grade into one another. These colorful billows are composed of finely divided mineral matter first swept into the silica filled chamber in solution, then after forming minute crystals or floccules, being caught up by the chalcedony crystallization. Other billowing plumes are composed chiefly of hydrated silica - something like opal. In some, chalcedony crystallization and banding proceeds through the plume, at least the outer parts of the plume, whereas in the other plumes, crystallization begins outside the plume as in dendritic plumes.

This is about as basic a billowing diffusion plume as you can find; looks like a column of steam- which is pretty much what it is, or was. It is a close-up photo of a baby plume just forming on the edge of a Stinking Water Plume Agate. The upper part of the agate shows the better developed plume structure.



The differences in outcome with these diffusion plumes are the result of differences in the material, temperatures and pressures of the diffusion. The dendritic plumes consist primarily of crystallized metal oxides and hydroxides. The billowing plumes seem to consist largely of hydrous silicates with amounts of metals varying from considerable in the darker plumes like Prudent Man and Riviera to nearly nil in Stinking Water and Nyssa plumes.

Plumes can occur in any type agate, but here we're looking at vein agates found in volcanic areas that are doubtless related to hydrothermal activity. Recall our brief look at vein agates. I mentioned that in typical vein agates the plumes grew from the outside towards the center regardless of the orientation of the vein and that gives a hint of their complexity. Let's consider what that reveals. First, gravity is not the controlling factor, though very long plumes do tend to bow slightly to gravity. That tells us these are not what they first appear – merely a stream of one colored liquid flowing into another. These are primarily, I think, molecular diffusion plumes into a cavity filled with a polymerizing silica solution or full fledged gel.

The main component of the plumes, especially of the white plumes, is generally thought to be in-place altered silica minerals, similar to opal, rather than outside mineral components. Rather than a mass invasion we are seeing the result of migration of discrete molecules of water and metal ions from the outside into the silica solution or gel, hydrating the silica and forming billowing clouds of dispersed metal oxides and hydroxides. It is the force of diffusion, the impetus to migrate from higher concentrations to lower that causes the branching structures of all diffusion plumes. The gel supports the billowing plume in much the same fashion it supports the growth of dendrites.



Stinking Water Plume Agate Cross-Section

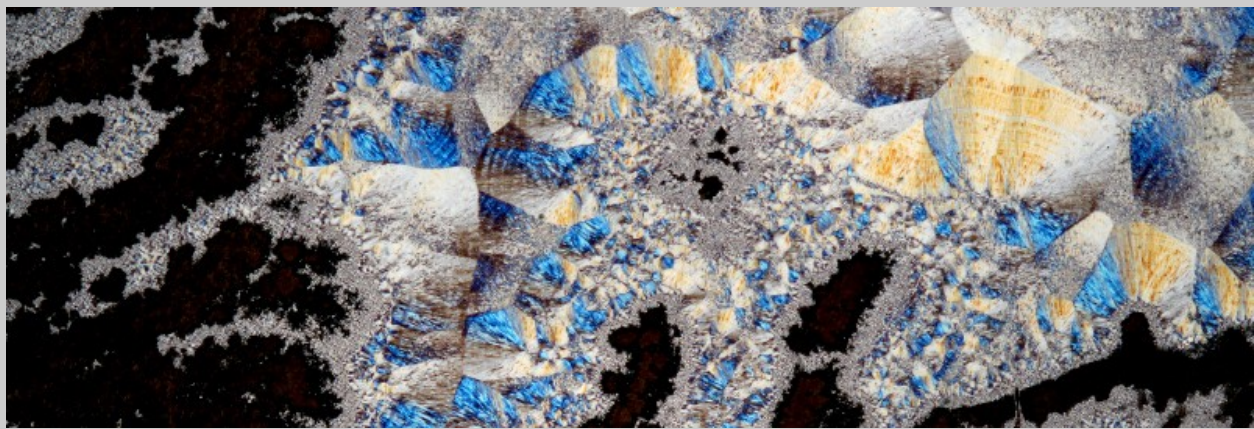
This Stinking Water Plume (above) developed in a fairly large cavity and affords us an unusually good look at the anatomy of these plumes. The cavity in which silica was collecting and polymerizing was subjected to a hydrothermal intrusion from all sides. All the silica available accrued to the cavity walls prior to, or simultaneously with the plume development. The exact relationships are puzzling to me too, but a couple of things seem evident. We see in the plumes a time dimension – growth from the outside edge towards the center of the void over time.

I think crystallization began after the plume was emplaced, otherwise the initial crypto-quartz would have blocked, or at least altered the plume. Crystallization of the outer bands may have shut off the diffusion prematurely.

We see, right, fibrous chalcedony conforming to the contours of the plumes. The plumes afford suitable continuous nucleation surfaces, not just random points. I think the polymerization, accrual to the walls, plume emplacement, and crystallization are interconnected phenomena occurring sequentially.



We see in this thin-section of a Nyssa Plume agate that the plumes serve as nucleation surfaces for granular chalcedony crystallization around the diffusing plume, followed by elaborate fibrous banding in nearly clear chalcedony.



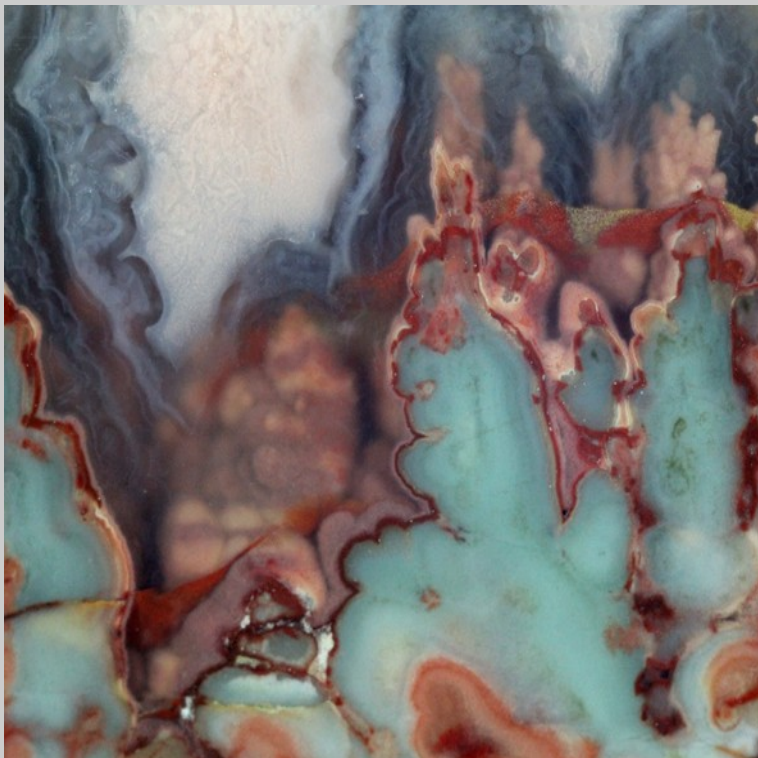
Diffusion is controlled by the concentration gradient and temperature gradient. If those remained stable in the cavity, which remained filled with a pressurized liquid, diffusion would go to completion and the plumes would disappear into a uniform solution. We may attribute some of the differences between the lighter and darker plumes to more complete diffusion as well as differing metal content. Obviously, the forces of diffusion play out, or are cut off, at different stages, and other forces take over, eventually the impetus for crystallization. I suspect that thermal energy input into the system and possibly pressure increase factor into the formation of the chalcedony.

Let's now examine a few examples of the darker plumes: Prudent Man[®], Wingate Pass/Death Valley, and Riviera agates:



The Prudent Man agate photo below, a close-up of the cut and polished cabochon pictured above, illustrates other aspects of banding. Notice the faint **color banding in the green color zone**. There is also a very noticeable **thin reddish-brown mineral exclusion layer** throughout the agate that is seen in cross-section on the face.

As chalcedony is semi-transparent, we can look a little way into this agate and see the layer rising and falling with plumes in the background. It takes a moment of concentration to fully understand that you are looking at the outside of what would be pseudo-stalactites in an open cavity.

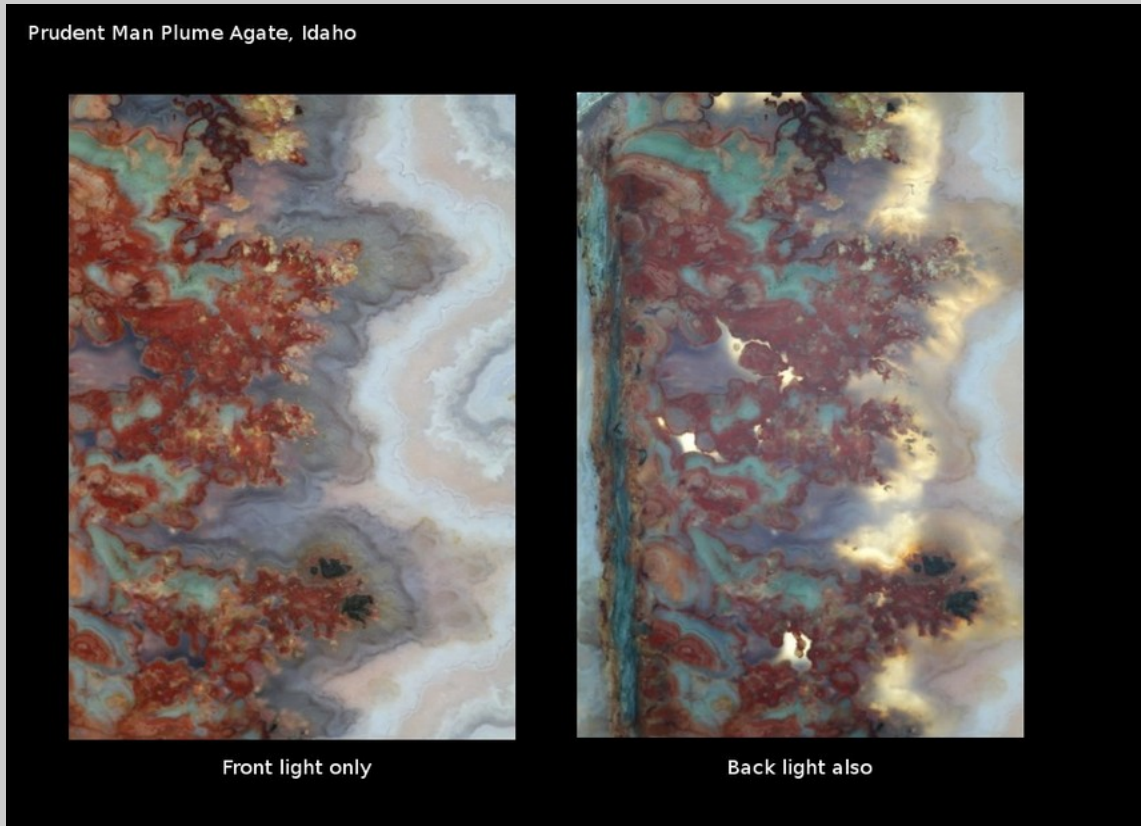


Prudent Man Plume Agate Close-up

If you look very closely, you can see tiny twinkles studding the brown band. Those are tiny diamonds, ripped out of an expensive polishing belt as this band of trash undercut.

As it is barely a hair's thickness it doesn't noticeably affect the beauty of the cabochon, however.

Recall the trashed stadium analogy again; in addition to the workers sweeping toward the center raising the ring of “trash” (iron oxides and other minerals in agates), other workers were blowing trash back toward the sweepers. We see that phenomenon here also. The dirty band pulled impurities into itself leaving a clear layer above it, as seen in this illustration where the photo on the right is back lit also. Everything above the dirty layer is much cleaner.



The lower plume also contains some crystallized iron compound, I guess you could call it “macro-iron”. The iron concentration in the band evidently reached critical mass and allowed some macro-crystallization. We see that frequently in the darker plumes, occasionally even in the white plumes. The colors above the brown layer are probably due mostly to changing oxidation states of very finely distributed iron compounds.

This Death Valley/Wingate Pass agate bears many similarities to the others but each agate is remarkably unique. The plumes arise from a porous looking rhyolite, through a heavily mineralized rim and billow out with a striking contrast in color between the metalized plume and the clear-blue chalcedony cocoon, or spire, surrounding it.



The outward structure of the agate follows the contours of the plumes. Apparently all the available silica in the seam accreted to these...let's call them spires, after Cathedral Agate...leaving the center of the vein/seam open, but probably still containing some high pressure fluid.

Examine this close-up of a Death Valley/Wingate Pass Plume. We see segregation of the mineral residue in the plume due to the banding of the chalcedony very much the same as in other banded agates – not as strongly and fully as in typical agate nodules but there it is - in plume agate.



Close-up of Death Valley/Wingate Pass Plume Agate

These plumes acted as nucleation surfaces for the formation of silica gel – probably as much because of energy input as for their physical substance. Recall another analogy from the distant past – silicic acid molecules bumping into each other. As long as both parties in the collision were free floating there wasn't enough force to hitch together. But if one molecule bumped into a receptor attached to the wall it could hitch, beginning a chain reaction. In this case, the high temperatures caused by the diffusing solution may have sped up the molecular movement resulting in more violent collisions and an effectively continuous nucleation surface. I think that may be even more important in the lighter plumes.

The Riviera, or Riviera Brothers, plumes are sometimes described as 'flat' plumes, possibly because they resemble lichens that form on trees (at least, to me they resemble lichens), and they are fairly opaque, not having the 3D appearance of some other plumes; **but they billow out from their points of origin in three dimensions. That is apparent when examining consecutive slices.**

They also develop distinctive color banding; or, because of the unique character of these plumes versus wall banded nodules, let's call them 'color zones'.

This color zoning, I think, results from the interplay of the diffusion forces of changing concentration and temperature gradients, oxidation states, and later, pretty much common color banding seen in 'true agates'.

Color banding both in the 'lichen-like' plume and in the surrounding agate can be seen in this close-up of another Riviera agate. If you will look very closely at the interspersed areas of obvious 'wall banded' agate, you will notice that some of the outer 'wall bands' continue through the plumes. So the whole plume phenomenon seems closely akin to common wall banding in nodular agates. The greater variability in the colors and structures is due, I think, to the more open and variable environment of the vein.

Riviera Plume Agate



I'll put a more complete picture in the following gallery so you can see better what I am talking about.

Click here for a small gallery of billowing plume agates:

[Billowing Plume Gallery](#)



I look at these plume agates in wonder. Some look like puffs of smoke or clouds in their own little patch of sky. They look like anything but what they are – hard, durable stone that will outlast the mountains that bred them. How can an empty space fill with water and turn to stone? How can a pile of jelly turn into a spire of agate? Surely, ***“This is the Lord's doing: it is marvelous in our eyes”*** (Psalm 118:23 KJV).

That reminds me of an even greater mystery – the mystery of faith expressed in Hebrews: ***“Now faith is the substance of things hoped for, the evidence of things not seen. By it the elders obtained a good report. Through faith we understand that the worlds were formed by the word of God, so that things which are seen were not made of things which do appear.”*** (Hebrews 11:1-3 KJV)

How can a mental abstraction like 'faith' have substance? It has taken me most of a lifetime to begin to understand faith as substance. Just recently, I happened to notice that the Bible translators were way ahead of me. The noun 'belief' is not used in most English translations of the Bible, except in one obscure case. No, 'faith' is the noun used as the counterpart of the various forms of the verb 'to believe'. A little research taught me that in the original Greek (the language of the New Testament), the word translated variously as 'faith' and 'believe' is the same word, or some form of the same word, for which there is no exact English counterpart. The Greek might be considered both a verb and an active noun, something unknown in English. 'Belief' is far too weak a noun to translate the Greek properly. 'Faith' on the other hand derives from a much more substantial old English term for a foundation or footing, but there is no verb form of 'faith'. So while I might believe the weather report that tomorrow will be rainy and carry an umbrella, I will arise to face the day with faith that the Sun also will rise, even if I can't see it for the clouds.

To believe and to have faith are two of the most important messages God has given us in His word. As we are told farther on in Hebrews: ***"...without faith it is impossible to please Him: for he that cometh to God must believe that he is a rewarder of them that diligently seek Him"*** (Hebrews 11:6 KJV)

Jesus said this: ***"For God so loved the world that He gave His only begotten Son, that whosoever believeth in Him, should not perish, but have everlasting life. For God sent not His Son into the world to condemn the world; but that the world through Him might be saved. He that believeth on Him is not condemned: but he that believeth not is condemned already because he hath not believed in the name of the only begotten Son of God. And this is the condemnation, that light is come into the world, and men loved darkness rather than light, because their deeds were evil."*** (John 3:16-19 KJV)

These admonishments are not about thoughts and opinions, or momentary convictions, or fulfilling some religious ritual. They are about transformation in one's inner being that determines the contours of life, something unchanging with moods and circumstances, something with substance like a rock.

So, how does this great transformative faith happen? I suppose there are as many stories of coming to Christ as there are people who have come to him over the centuries. But to many, especially those of us who came to faith as adults, the process is rather like agate forming, and we've looked at that. But there is a first step. An agate has to have space to grow in, but the first requirement for that space is that it be open to filling. A vug, or crevice, or cranny that is sealed off, even if it is perfectly empty and clean, will remain empty.

One of the most famous stories of coming to Jesus is the story of Charlotte Elliot and the writing of the words to the famous hymn "Just as I am". Though several variations on the story have arisen over the more than one and a half centuries since she wrote it, the core of the story remains this: Charlotte was an embittered middle aged invalid walled off from from God and mankind by bitterness and envy till she came to Jesus just as she was. She wrote "Just as I am" as a poem celebrating the new life she had received. She went on to write the words to around one hundred and fifty hymns over the next nearly forty years. Among her effects were found hundreds of letters from people thanking her and telling her of the influence of her hymns on their lives; and that was only the beginning. Charlotte is said to have claimed as her own the words of Jesus in John 6:37, "**... and him that cometh to me I will in no wise cast out.**"

But don't think you can truly come to Jesus and remain the same. "To ask that God's love should be content with us as we are is to ask that God should cease to be God... We are bidden to 'Put on Christ', to become like God. That is, whether we like it or not, God intends to give us what we need, not what we now think we want. Once more, we are embarrassed by the intolerable compliment, by too much love, not to little." C. S. Lewis, The Problem of Pain.



Sagenites and Psuedomorphs

Let's begin this section with another look at a sagenite agate in thin-section. As you recall, the mineral inclusion has disappeared in this thin-section but its presence is marked by an outline of granular chalcedony. That is rimmed in layers of banded fibrous chalcedony that constitutes the bulk of the rock; so, although the material has other mineral inclusions, it is mostly banded chalcedony – or 'agate'. Some sagenite and psuedomorph agates have much more non-chalcedony content and some less but it is chalcedony that characterizes the material.



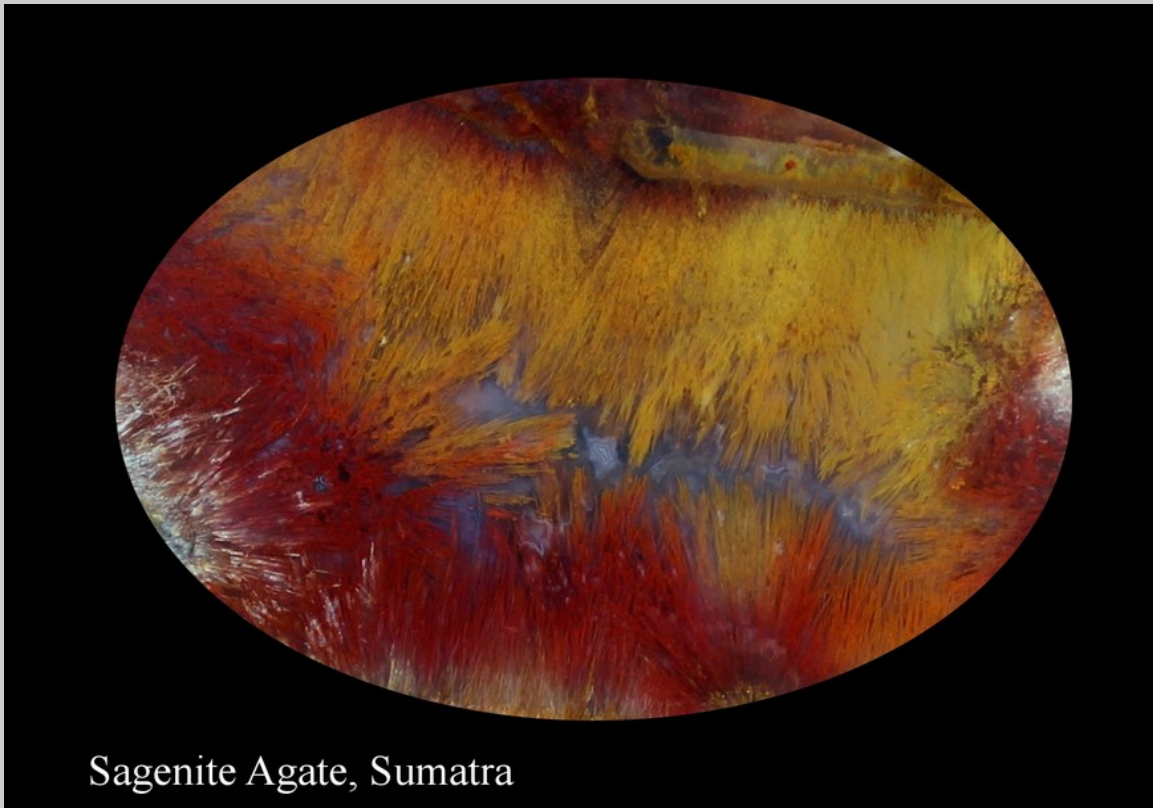
Properly speaking, if another mineral remains in an agate, it is called a 'mineral inclusion in agate'. If the mineral is replaced with chalcedony that keeps the shape of the other mineral, it is called a 'pseudomorph'. In many cases, it's difficult to tell whether the mineral is replaced or not, especially with silicates like zeolites; and often the mineral is only partially replaced. In common practice, agates with large numbers of small, needle like mineral inclusions or pseudomorphs are called 'sagenite agate'. The term 'sagenite' derives from the French for 'net' and was originally applied to rutilated quartz.

Now some of you are going to throw up your hands in confusion and say, “What's the difference between dendritic plumes and sagenites?” Good question. I'm sure they pass for each every day, and it doesn't really matter; but there is a difference in common usage however.

That difference doesn't have much to do with whether a mineral is replaced with chalcedony, in fact we didn't even consider that aspect when we looked at plumes, moss, and dendrites. We might note here, also, that sagenites are very rare in agates from sedimentary hosts. That's probably from a lack of acicular (needle-like) minerals. Pseudomorphs of carbonate and gypsum minerals do occur however.

'Sagenite', or 'sagenitic agate', usually refers to agate with visible, needle like mineral inclusions that developed prior to formation of the silica gel, and probably in many cases while the cavity was still filled with hot gases. Many types of metallic and silicate mineral crystals are found in open vugs in volcanic rocks. Frequently those are among the finest specimens of the minerals. Plentiful, small needle-like mineral inclusions that may or may not be replaced seems to be the defining characteristic of sagenite in common usage. There are, however, many exceptions to that usage and sellers and collectors both use a wide degree of latitude in labeling their material as sagenite, moss, or plume agate.

The sagenitic agate below is a classic of the type with needle-like mineral fibers radiating out into a chalcedony filled center. Are the needles replaced with chalcedony or are they an unaltered mineral, probably a zeolite? As they do present something of a dendritic pattern why don't I call this a dendritic plume? The only answer I can give to the first question is "I don't know, but does it matter as long as they both polish well?" (it takes a fine polish). To the second question I have to say either label would be correct, but to my eye the mineral fibers are slightly more needle-like than palmate or arborescent.



Sagenite Agate, Sumatra

'Pseudomorph', in common rockhound usage, usually refers to larger chalcedony replaced mineral crystals. These can be of any mineral, any shape, and can be enclosed in agate, or free standing. Any true sagenite may be technically a pseudomorph agate but the term 'pseudomorph' is usually not applied unless the replaced crystals are larger than, say, tooth pick size or thereabouts, – a much rarer occurrence.

Some of the most notable pseudo morph agates are coming out of Turkey; like the one to the right. The red shafts appear to be chalcedony replacements of another mineral, probably aragonite. Notice how they have tubes or cocoons around them. The larger of the pseudomorphs are matchstick size.



Pseudomorph Agate, Turkey

The terminology concerning these type replacements, or partial replacements, can be as confusing as the agates themselves. Many agates actually contain pseudomorphs – that is what many tubes, mosses and plumes are, but we don't usually call them pseudomorphs unless they constitute the most characteristic part of the stone, as is the case with this Turkish pseudomorphic agate. Then there are several other terms describing related structures that stem from chalcedony's unique character.

A 'perimorph' is a coating of one mineral by another mineral that takes the shape of the first mineral. Chalcedony is often the mineral covering and the perimorph may be an interesting part of an 'agate'.

On some occasions the original mineral dissolves away leaving the chalcedony coating, or perimorph, surrounding a void. In those cases, the void is simply called a 'crystal impression'.

Though these structures are not unusual in agates, it is a bit more unusual to see them all in one specimen, especially an attractive one. The colorful Polish Thunder Egg shown in the following page contains examples of pseudomorphs, perimorphs, and crystal impressions in a cluster at the bottom; along with a variety of color banding.

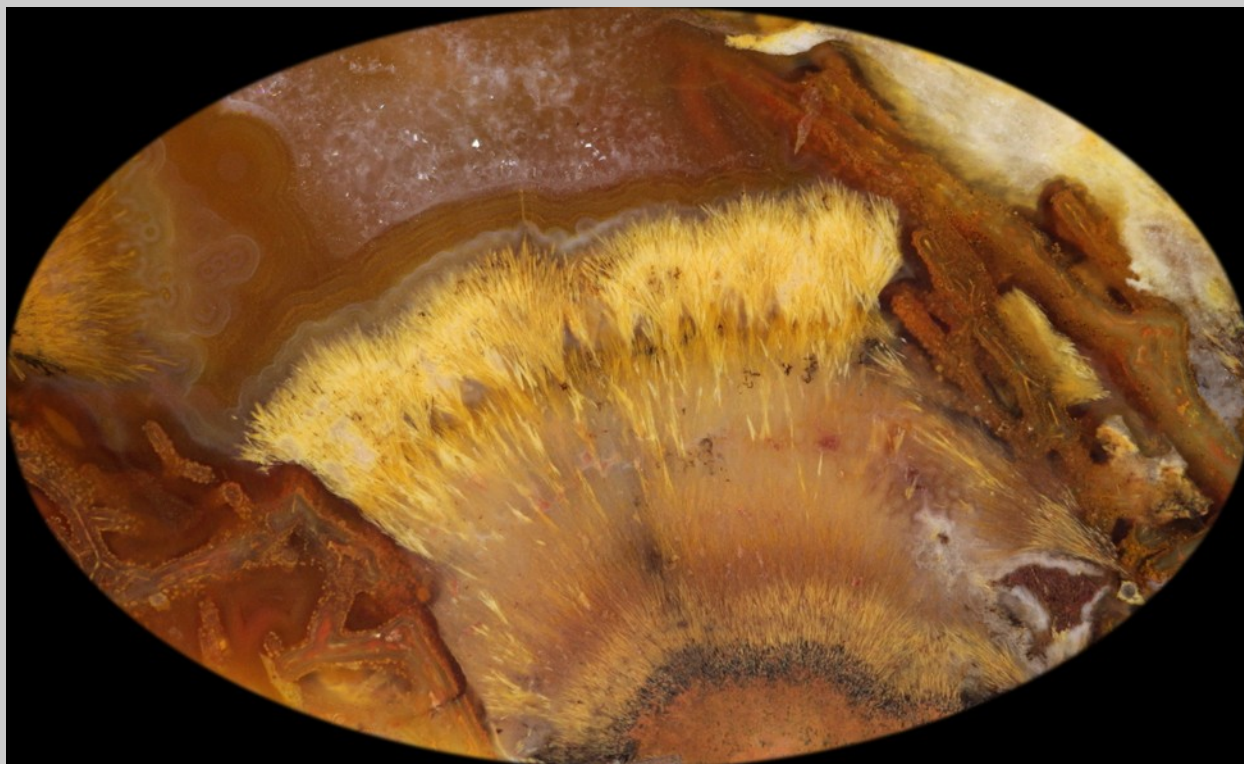


Thunder Egg, Poland

Agate lovers come in all persuasions, some are eclectic, loving all kinds of agate – banded, sagenite, fossil, etc. Others prefer only banded, or agates with inclusions. Sagenites have their particular champions also, and I have to admit, I am fond of some - the term 'sagenite' is applied to some remarkable agates.

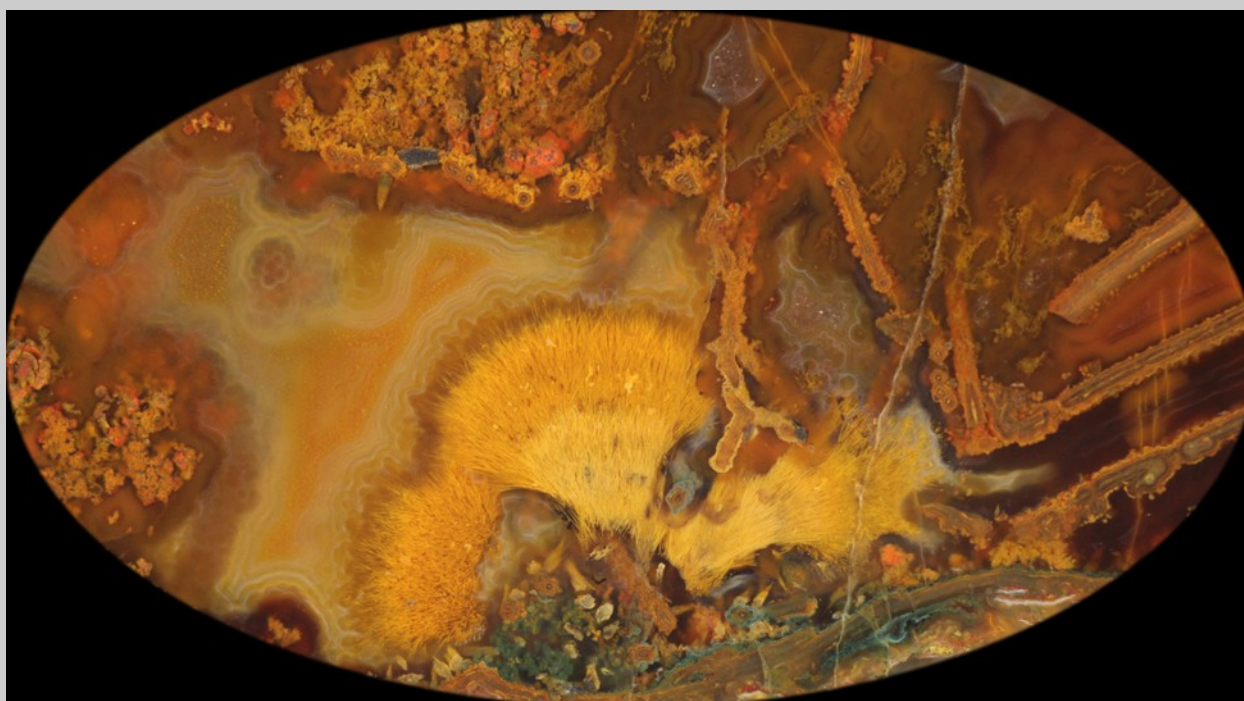
The two pictures below are from a large San Carlos agate I acquired some years in Big Bend country. I took one slice off, decided it was no good for cabs or display and sold it off cheap. Fortunately, I threw the nub end into a box of scraps that sat ignored for years. But when I became interested in macro-photography of agate I took a second, and closer, look at all my scraps, and wow! This is, I believe, a true sagenite, I don't believe the mineral crystals are replaced with chalcedony. These are also included in the Macrophoto Gallery.

How like God to give such a gift from such an unexpected, unappreciated source. Several of what I consider my best macrophotos came from agates that had little or no other value, and so I was able to get them for little or nothing.



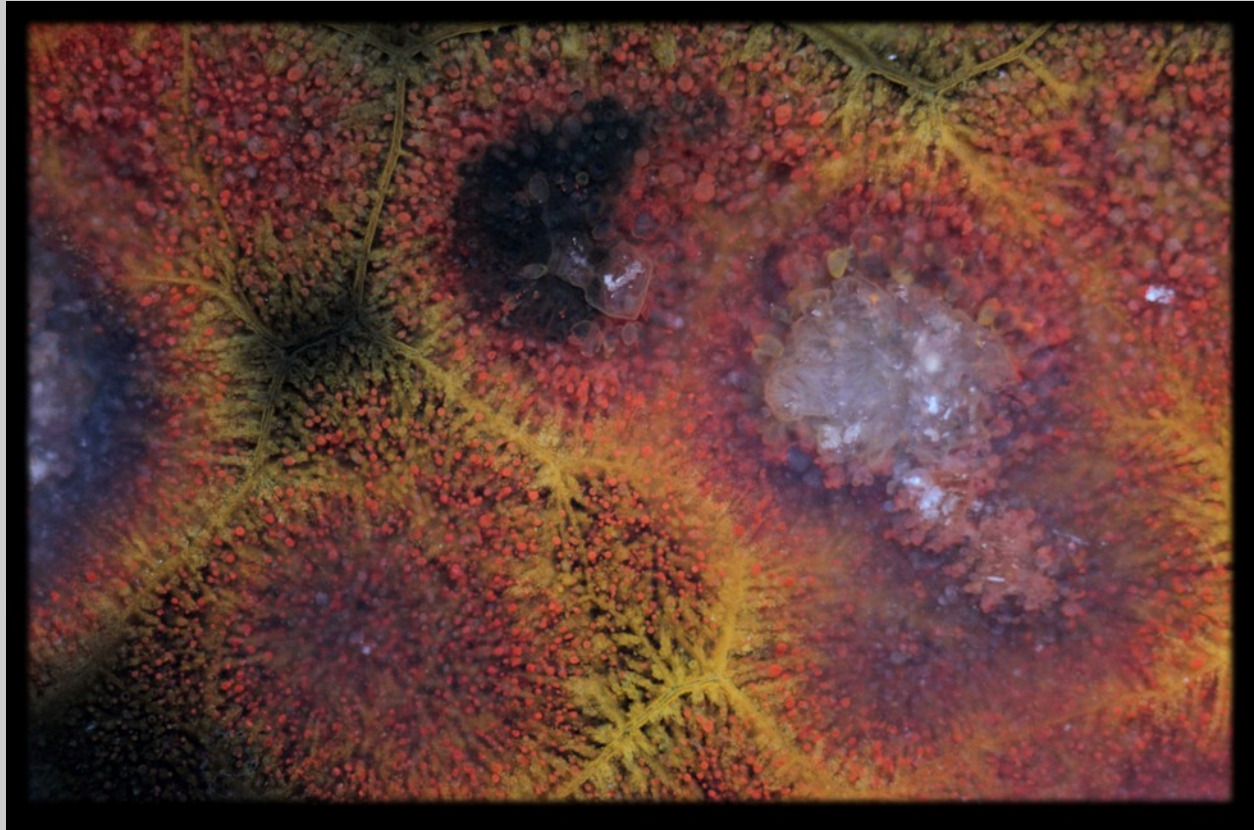
The photo above features a field of zeolite flowering, topped with banded agate. To the sides are rather rough chalcedony tubes.

The photo below, of a different part of the same slice shows a shock of zeolite and more tubes.



San Carlos Sagenite Agate Close-up 2

Of all the fabulously complex sagenites I have seen, this sagenite from near Ankara, Turkey is the most curious in my opinion. If I didn't know this formed in volcanic rocks, I would say it was of biological origin. But if we look very, very closely at this picture, we can begin to distinguish some familiar characteristics: what appears to be spherical structures crowded together, fibrous banding, dendritic filaments covered in colorful chalcedony.



Turkish Sagenite Macro-photo

The deeper we look into the mineral world, as in the biological world, the more astounding complexities we find. Surely the cosmos has an Intelligent Designer!

There is another picture of this sagenite and others in this gallery of sagenite agate photographs:

[Sagenite and Pseudomorph Gallery](#)

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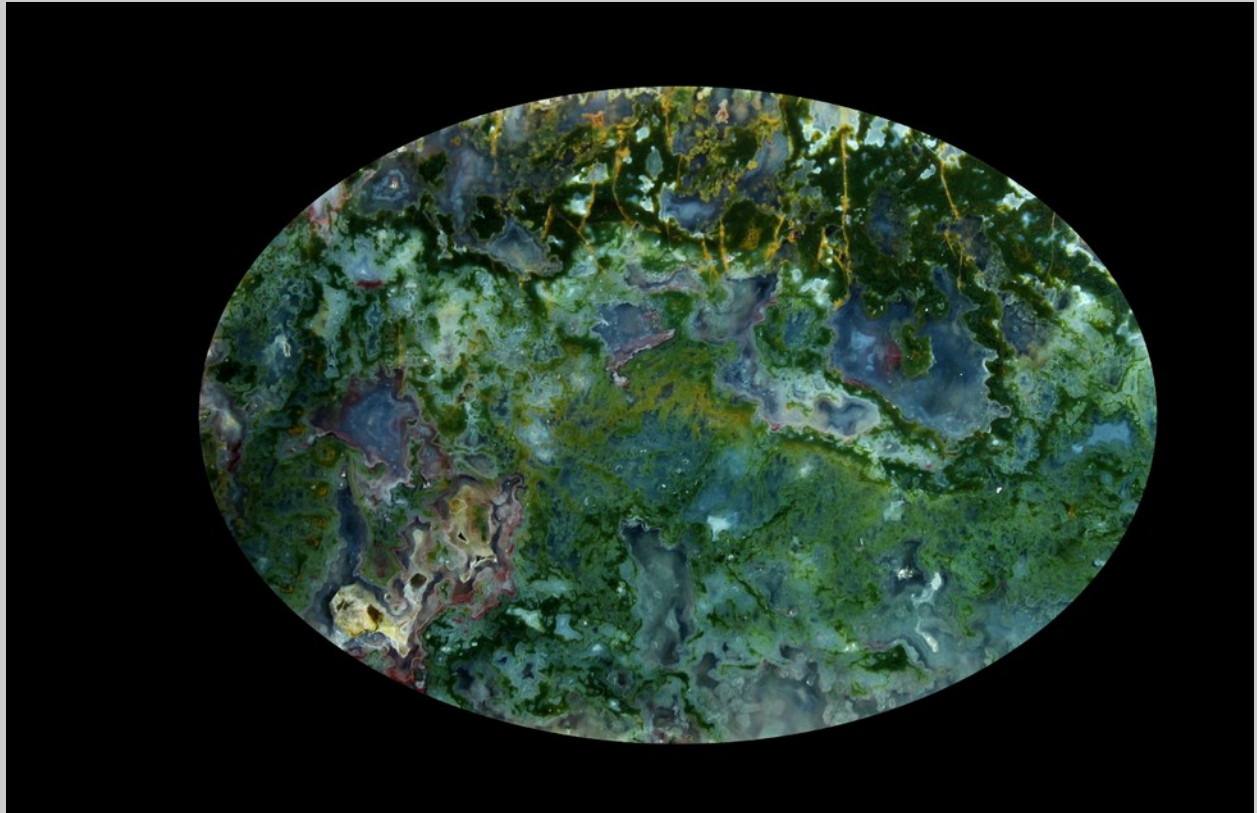
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Dendritic Plume and Moss Agate Gallery

Paint Rock Agate with Plume



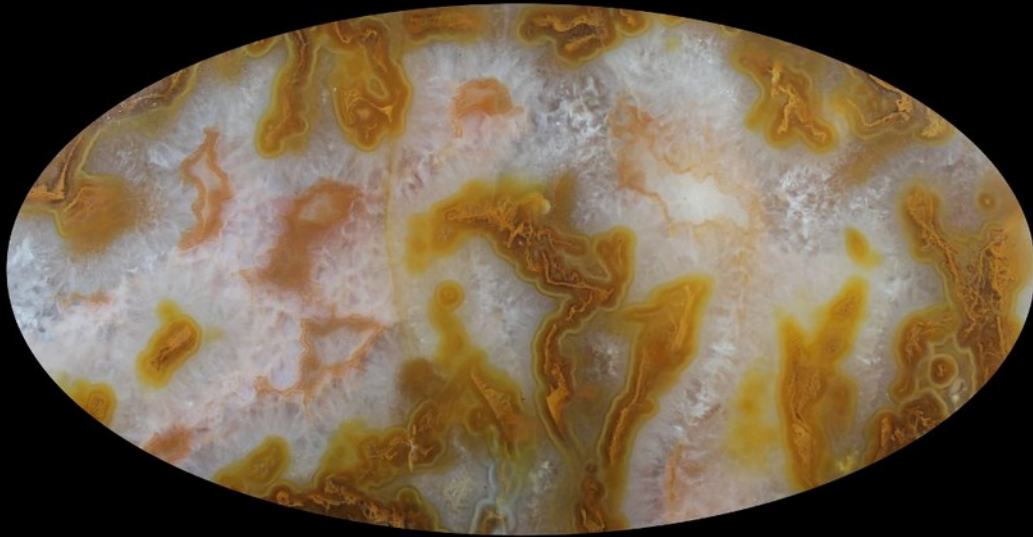
These dendritic structures appear, in just casual examination, to be partially silicified limonite pseudomorphs of some dendritic mineral inclusion. So, perhaps they should be included in the Pseudomorph Gallery. But since such dendritic inclusions are rare in sedimentary rocks, and since the structures are so well preserved in their chalcedony cocoons I have included it here. The metal silicate tubes, or cocoons, have progressed to form a botryoidal surface. I have ground away the tops of the 'grapes' to better expose the plumes, but you can still see the botryoidal chalcedony/agate structure.



Moss Agate, Matra Mountains, Hungary

This lovely vein agate is just full of mossy patterns and color. They appear to be a variety of dendritic and exclusion band, and perhaps other types as well.

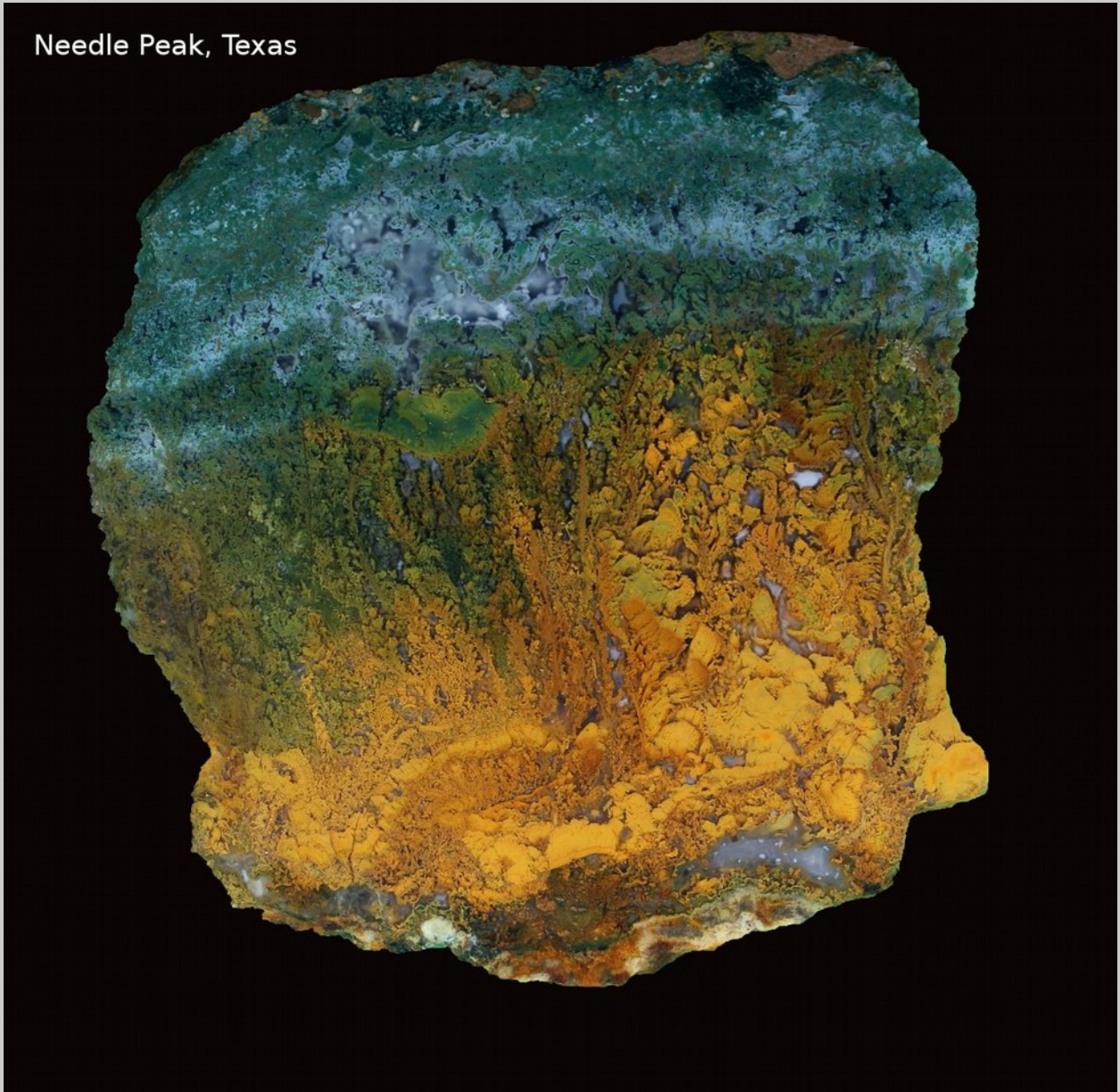
San Carlos Moss Agate, Mexico



Moss Agate, San Carlos Area, Chihuahua, Mexico

On the other hand, this equally lovely in its own way seam agate from northern Mexico is very sparing in moss and color. It's moss seems to be of the exclusion band type.

Needle Peak, Texas



Needle Peak Thistle Agate, Texas

I've never seen another with quite this much density of moss and plume material, and the colors are wonderful. These mineral filaments are largely, but not entirely, replaced with chalcedony.

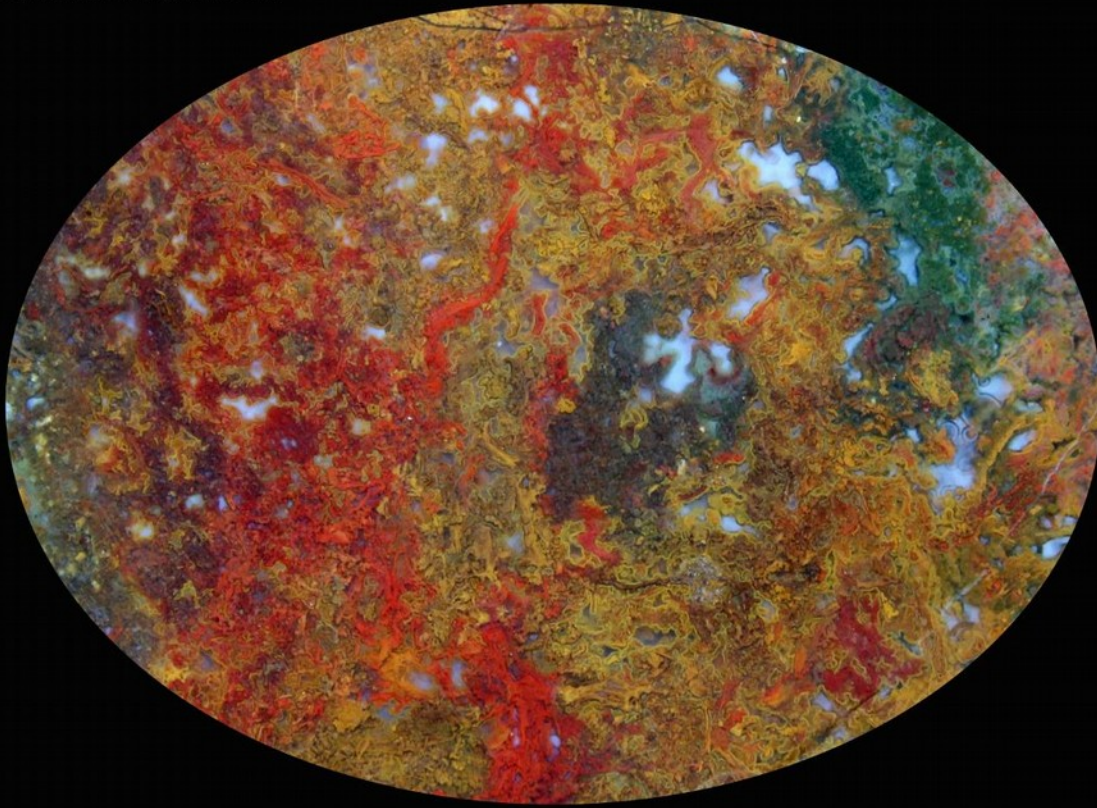
Moss Agate Rain Flower Pebble, China



Moss agate "Rain Flower", China

Agate is much the same wherever it is found – but always different. This one, as is customary, is not cut or polished but kept in water.

Bloody Basin Moss Agate, Arizona

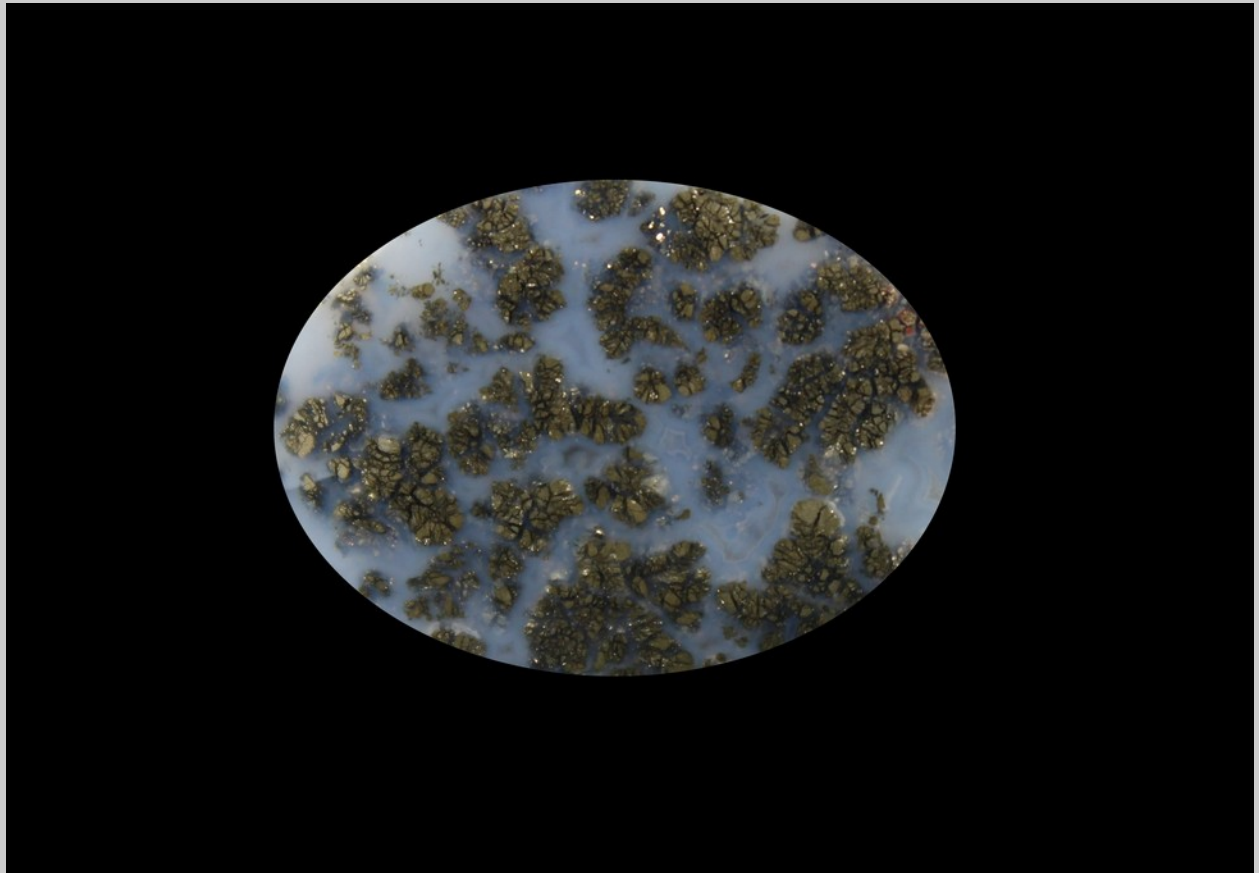


Busy, Busy, Busy. Bloody Basin produces a variety of mosses and plumes - some very fine.



Maury Mountain Moss Agate, Oregon

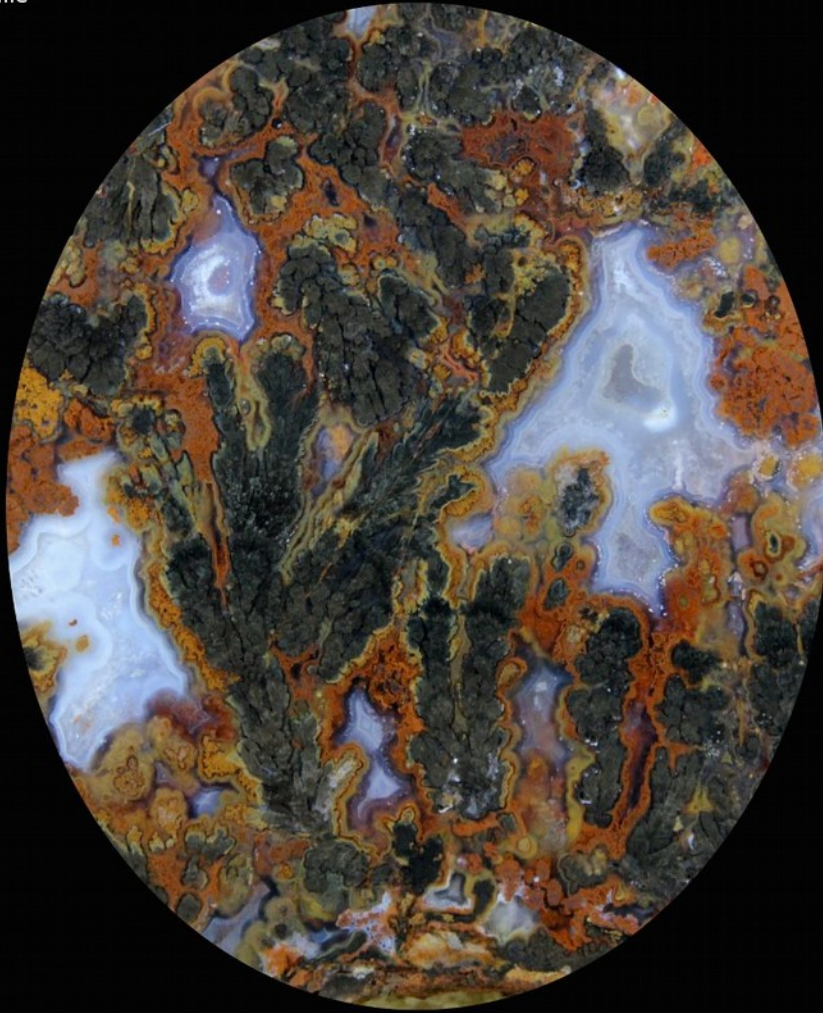
Even busier, with several different types of moss. This is one of the most common and popular moss agates.



Nipomo Marcasite Plume Agate, California

These metal sulfide plumes are rather blocky, awkward dendrites but it is to the dendritic plume group they best belong.

West Texas Black Plume



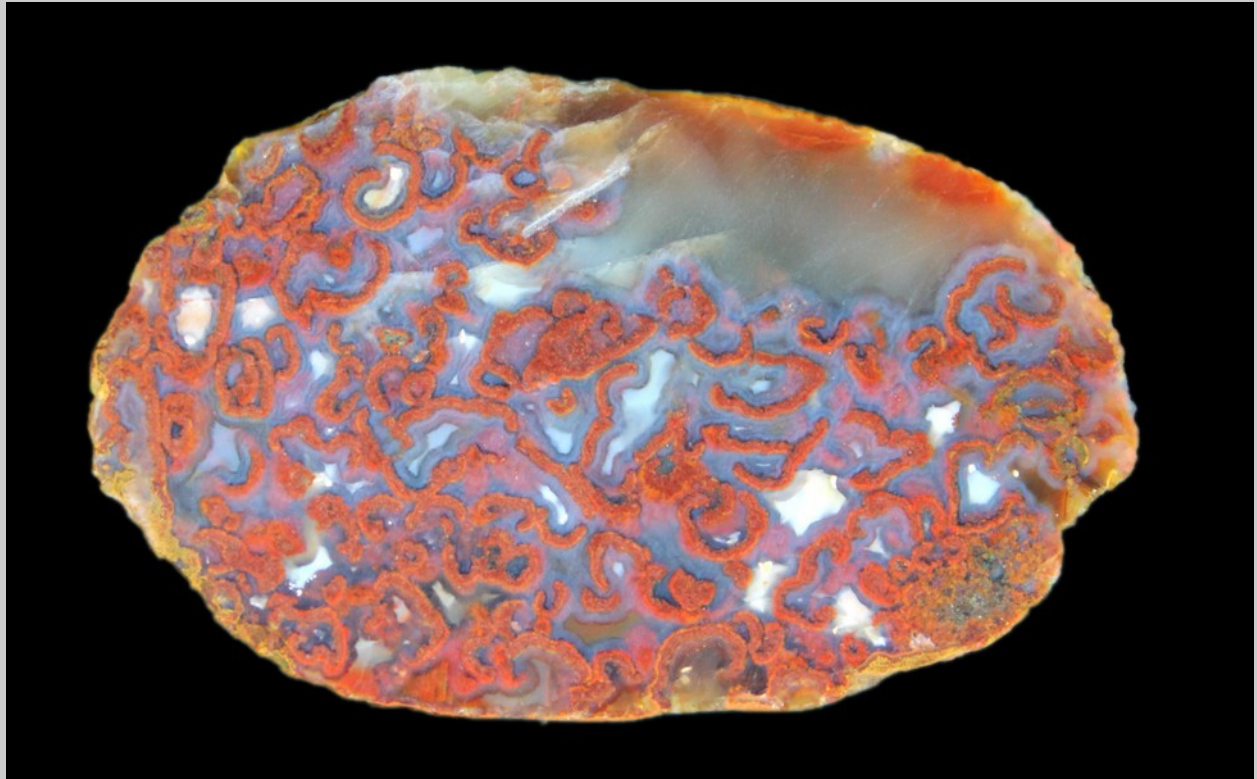
West Texas Black Plume Agate

These striking iron/manganese plumes are coated in a reaction rim and surrounded with banded agate.

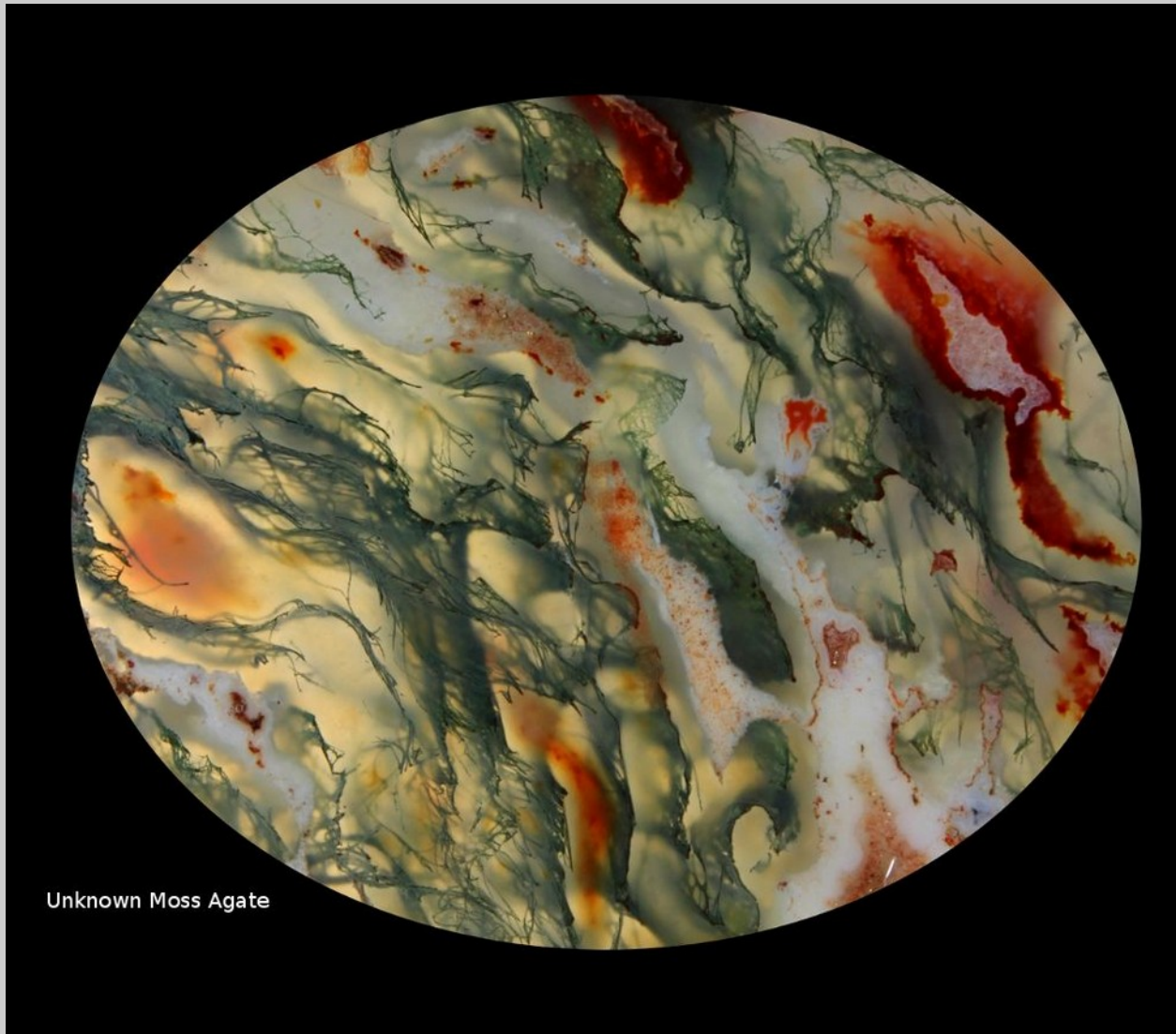
Sonora Plume Agate, Mexico



The cloudy chalcedony gives this plume agate an underwater effect not seen in all Sonora Plumes. These plumes seem quite agatized.

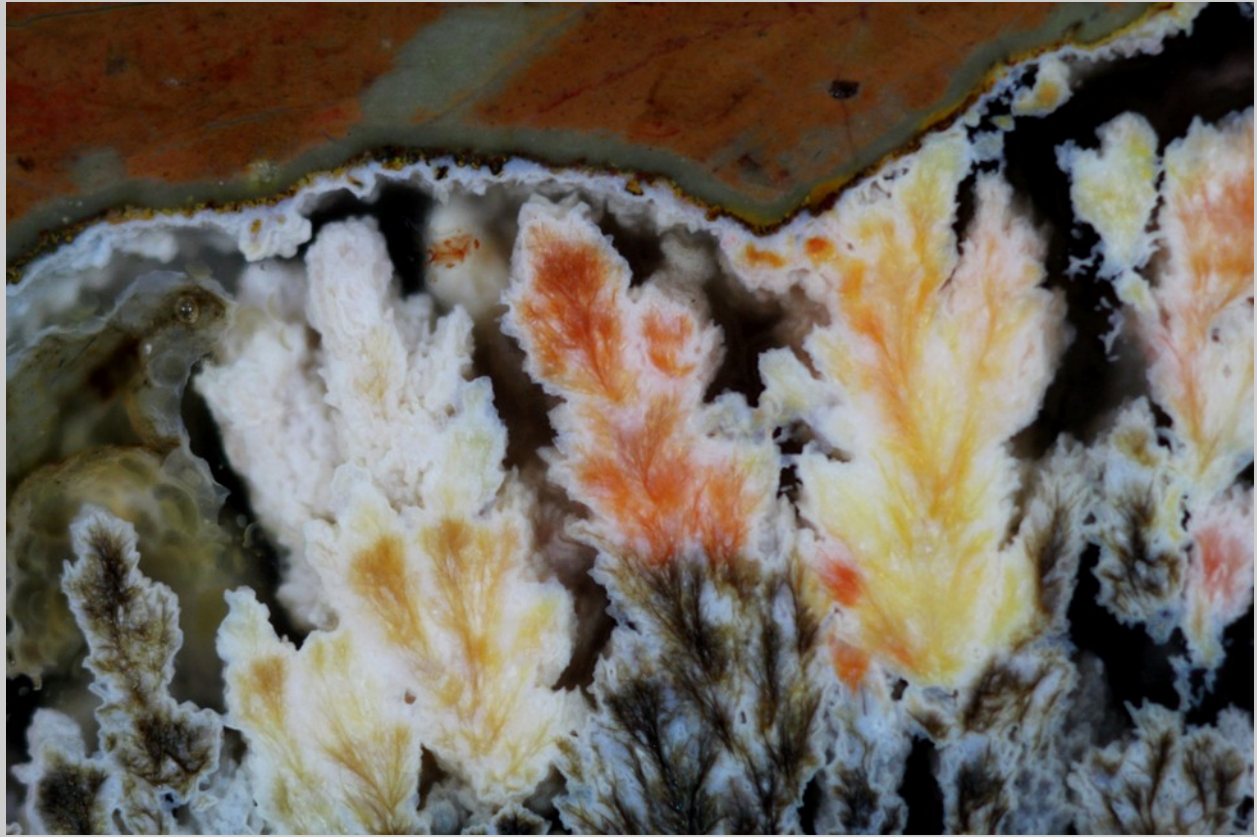


This little Laker contains moss of a type generally thought to be remnants of a crust lining the cavity that dried out, cracked and curled up, and then fell into the cavity. Later, the cavity filled with silica bearing water and chalcedony formed around the “moss”. That scenario seems plausible, although I am not 100 percent convinced. It's a working hypothesis for now though.



Unknown Moss Agate

This agate is probably from India and related to the green mosses.
What else can you say about this one, except “beautiful”.



Macro-photo of a Priday Ranch Plume Agate

This dendritic Priday Plume in its chalcedony cocoon grew a bit too big for its...egg. There is a big photo spread on this Thunder Egg agate in the macro-photo gallery on the web site, if you haven't seen it.

Priday Ranch Moss Agate



Macro-photo of Priday Ranch Moss Agate

Other things are found in old eggs also, like this creepy, gooey looking chalcedony confection.

Montana Moss Agate



Montana Moss Agate

The moss seems to be related to capillary action along now unseen pathways. The main coloration seems to follow the banding but not, I would say, as standard color banding but staining following the layer boundaries.



Summerville, Georgia Agate Plume

These scrappy red plumes in clear chalcedony support pseudo-stalactites. Plumes this well defined are extremely rare from this site and I don't consider these to be the main type structure found there – which we will look at later.

Wingate Pass/Death Valley Plume Agate, California



This gorgeous Death Valley, or Wingate Pass Plume shows a variety of plumes consisting of the same mineral with what appears to be 'billowy plumes' (which we will look at next) morphing into dendritic plumes. In the next gallery, of Billowing Plumes, another section of this slice will illustrate dendritic plumes turning into billowing plumes. The type plume depends upon the metal concentration and other factors that controlled the rate of diffusion and crystallization.



Bloody Basin Plume Agate, Arizona 2 of 2

Bloody Basin Plume Agate

This plume agate is another rare beauty and an outstanding specimen from this location; you've seen it before if you looked at the macro-photo gallery. You can see at least two dendritic forms here – moss and plume (which is just a coarser moss). The two types of plume seem to be of two different minerals. The plumes show the dendritic cores as dark specks.

The End of this Gallery – Back Home Now!

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Billowing Plume Gallery



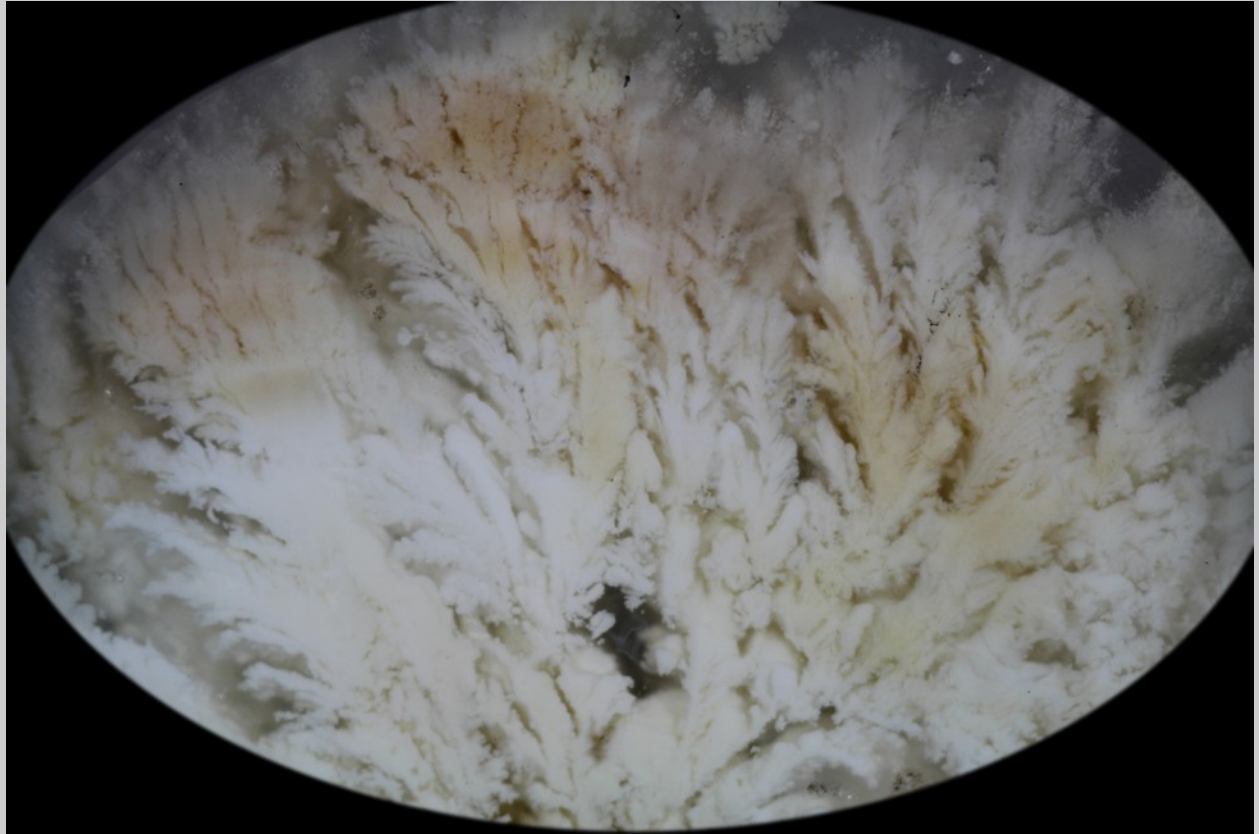
Graveyard Point Plume Agate, Oregon

This particular plume has a heavy concentration of metals and seems to have made a serious attempt, on the left side, at color banding.



Nyssa Plume Agate, Oregon

This plume you have seen in thin-section. The plumes have shed enough material during the crystallization to form a weak color band outlining the fibrous chalcedony colonies that formed on the plumes.



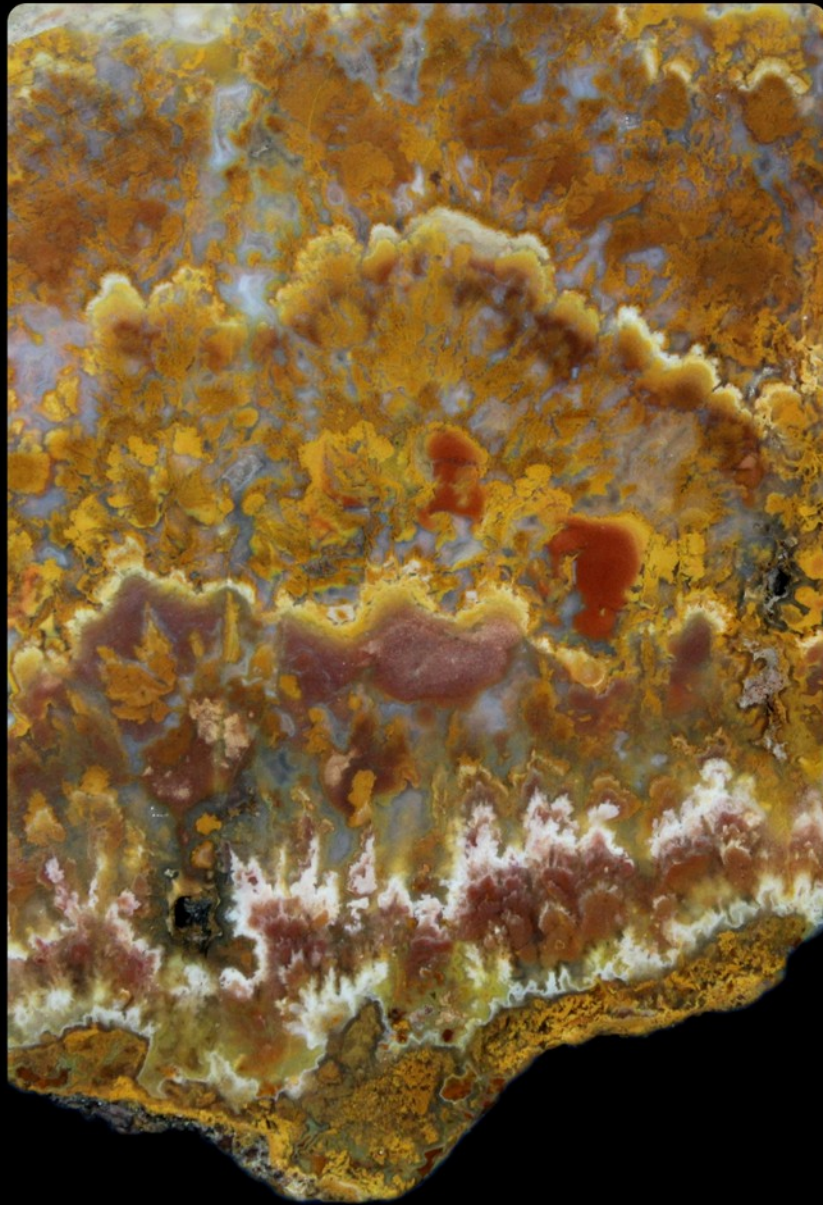
Stinking Water Plume Agate, Oregon

These plumes seem to consist almost entirely of hydrated silica and yet they are capable of initiating fibrous chalcedony banding.

Prudent Man Plume Agate, Idaho



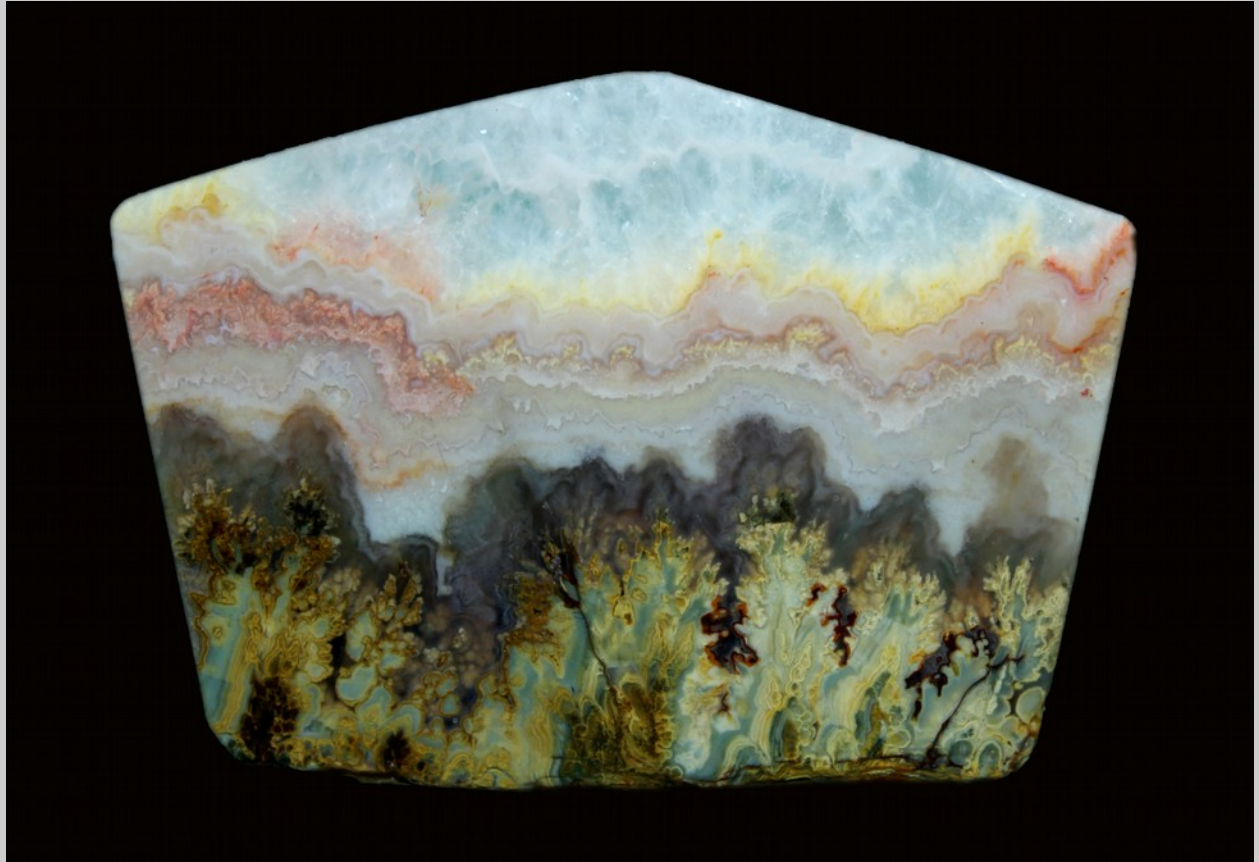
All of these plumes arise from the edges of the vein and grow inward. Remember that they are continuous surfaces, the bright browns and greens are the insides of plumes exposed by cutting a cross-section. Looking into the semi-transparent chalcedony we see the exterior surfaces of the plumes as knobby surfaces in the background. Notice the chalcedony cleaning itself progressively from the exterior.



Viewed in three dimensions these are wide billowing plumes. They are similar to the other vein agate plumes yet maintain their own individual characteristics.

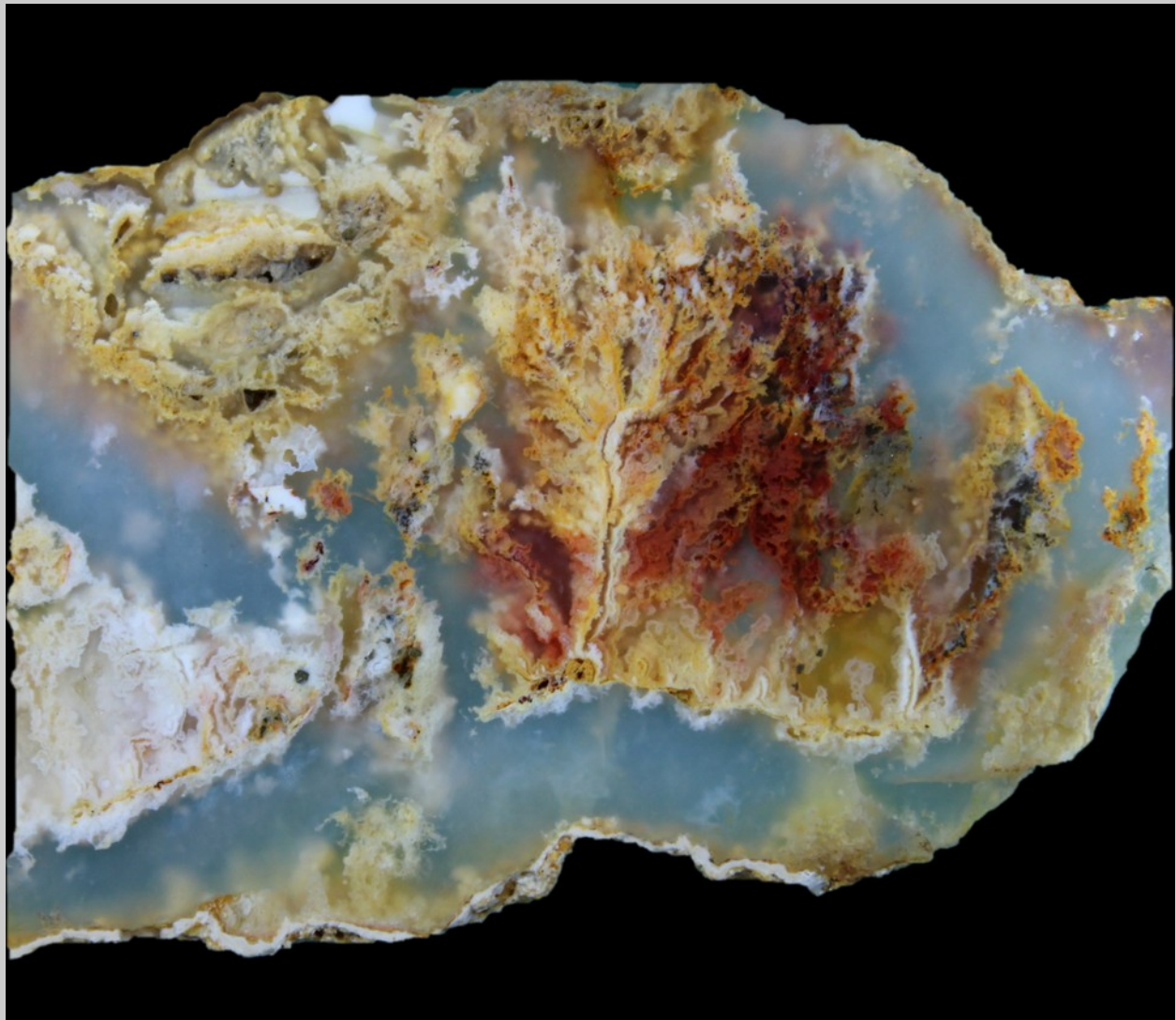


This large photo of the Riviera Plume agate more clearly shows the connection of wall banding in clear chalcedony with banding in the plumes. The banding, or color zones, in the plumes appear to be a form of mineral exclusion banding caused by rhythmic crystallization and probably controlled in large part by the non-silica mineral concentration.



Prudent Man Plume Agate, Idaho

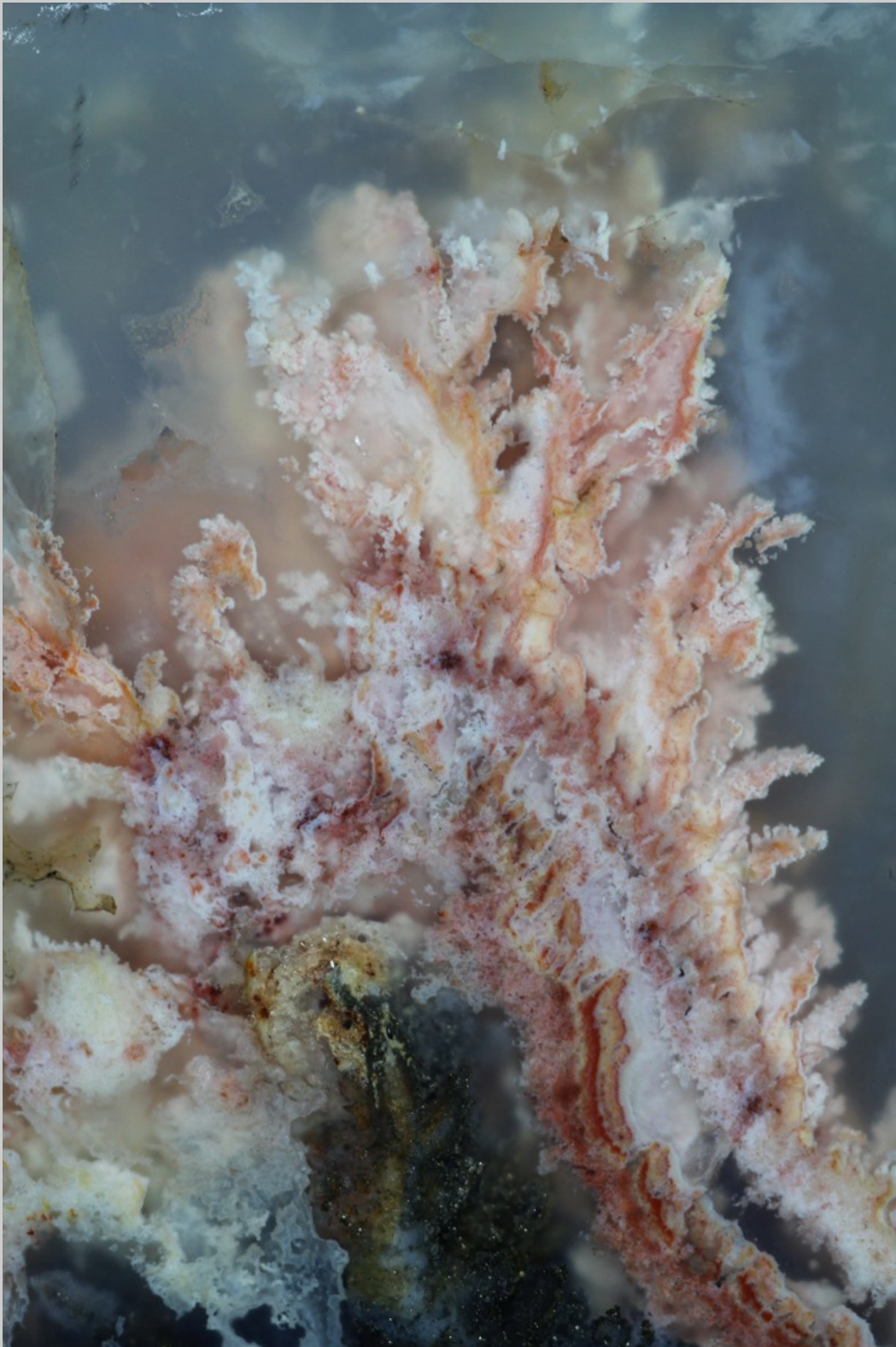
These plumes remind me of sunshine breaking through a cloudy, rainy day.



Regency Rose Plume Agate, Oregon

A curious thing about this agate is that the plumes originate in a still open crack. That indicates, I suppose, that the hydrothermal episode that caused the plumes began after crystallization had begun.

Graveyard Point/Regency Rose Plume Agate



This Regency Rose[®], a variety of Graveyard Point, is darker and somewhat intermediate between the two groups, but still has more of a cloud-like plume. This plume had enough iron to crystallize pyrite or marcasite at the bottom and initiate color banding around it, but the banding broke up and faded away upwards.

Stinking Water Plume Agate



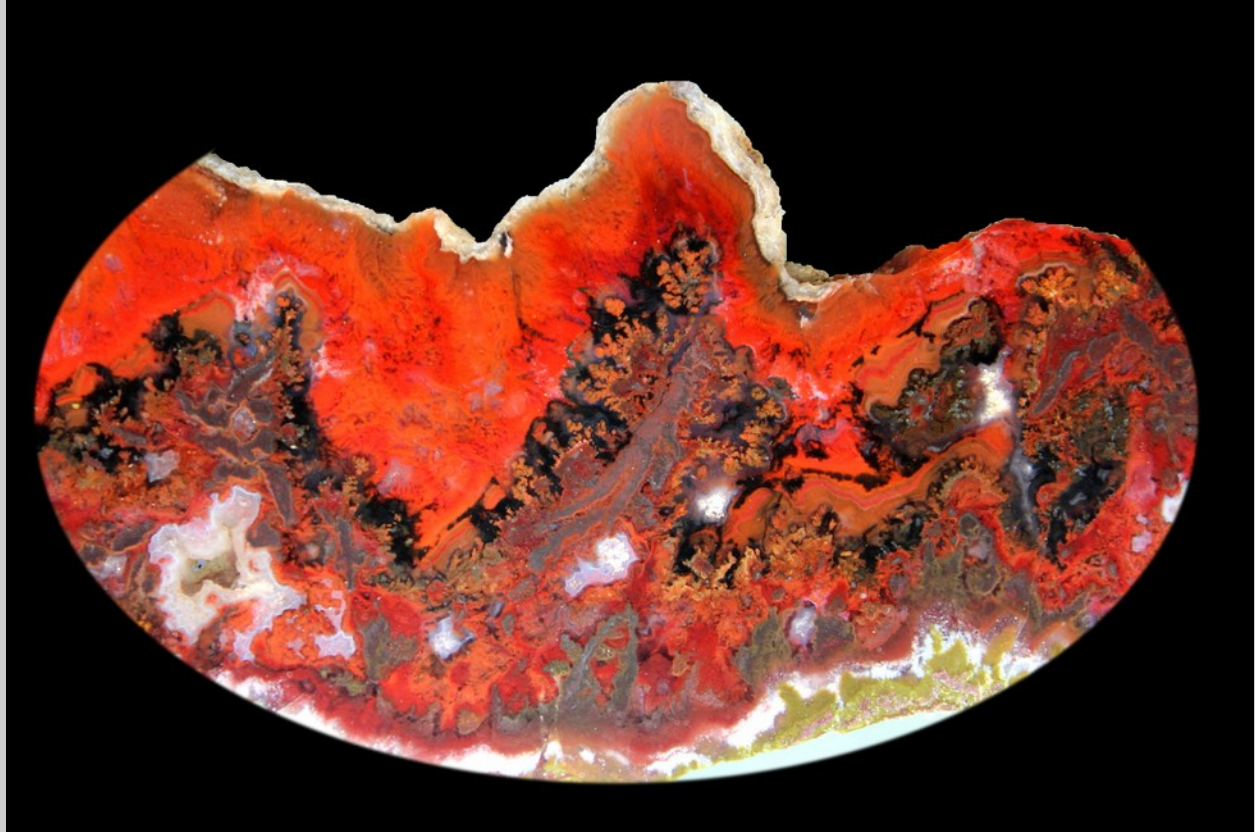
The Stinking Water Plume seems almost snow white. Faint banding seen outlining these plumes marks them as fibrous chalcedony. Unlike the Graveyard Point, however, these Nyssa and Stinking Water plumes don't seem to have color banding inside the plumes – just outside.

Death Valley/Wingate Pass Plume Agate



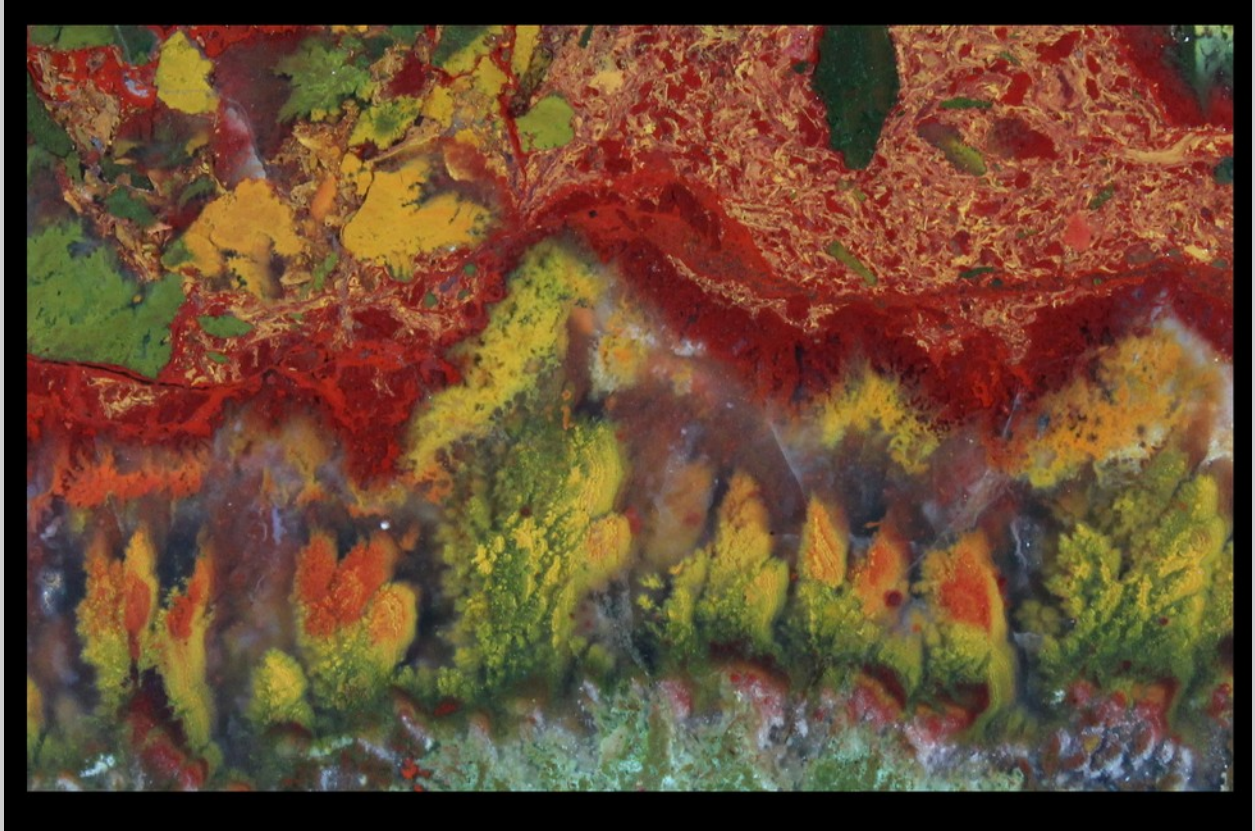
This Death Valley Plume Agate shows beautiful billowy plumes and illustrates that dendritic plumes can grade into billowing plumes, or end in dendrites.

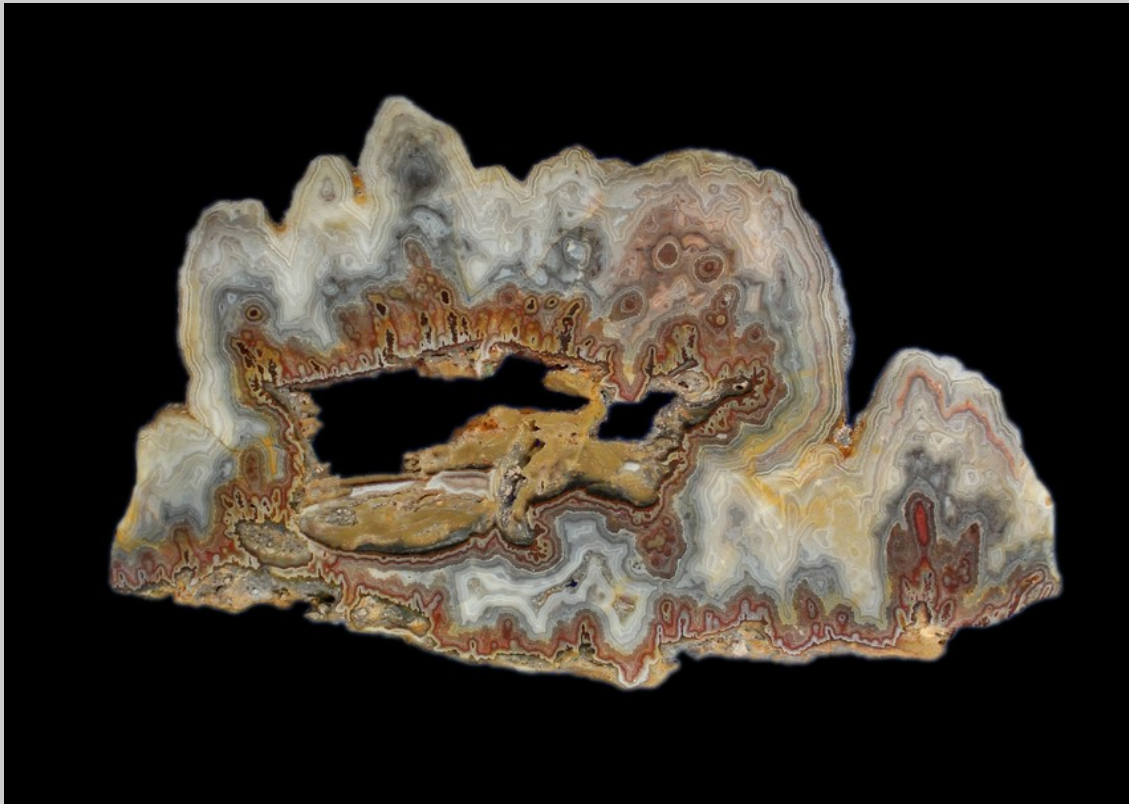
Bullion Mountain Plume Agate, California



This is certainly one of the most complex plume agates I have seen. This is a vein agate with billowing plumes arising from the outer edges. The included rock in the center, is, I think, connected with the outside of the vein and serving as a conduit of super hot, pressurized mineralized water into the silica saturated vein. Highly mineralized billowing plumes form around the inclusions, then at some distance from the conduits, the densely mineralized billows cease their growth and flame type plumes spring up. All the silica in the vein is accreted to these plumes.

This billowing plume is also from Bullion Mountain, and it illustrates the variety of material that can be found. Altered and brecciated rock associated with this vein is an integral part of its attractiveness.





Summerville, Georgia agate

Last on the list is this very unusual plume agate slab from Summerville, GA, and so it formed in “sedimentary” rocks. I put sedimentary in quotes because it formed in a silicated, or 'chertified' limestone that might have had some similarities to volcanic conditions. Hot, mineralized waters were forced out of the Appalachian core during the mountain building and this certainly has the look of plume agates that formed in hydrothermal conditions. It's a rather large slice, about 8 inches by 5 inches and shows diffusion plumes both arising from the bottom edge, and expanding in different directions from a hollow center. The plumes initiated gel formation which then accrued all the available silica into the spires surrounding the plumes. The initiating plumes are somewhat problematic for me to classify, but the overall appearance is certainly more of the billowing plume type.

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Sagenite and Psuedomorph Agate Gallery

Turkish Sagenite



This is a marvelously complex sagenetic agate that I don't have time, space, or expertise to fully explain; yes, the same one you saw in close-up above. It does seem to show rather coarse fibrous chalcedony colonies with a spectacular green color grading out into other mineral pseudomorphs. One of the confusing factors about it is that it appears (I bought it as a slice) to cut horizontally through sagenite bundles showing them from a plan perspective, whereas in the San Carlos sagenite the bundles are shown in a vertical cross-section.

Sagenite Agate, Mexico



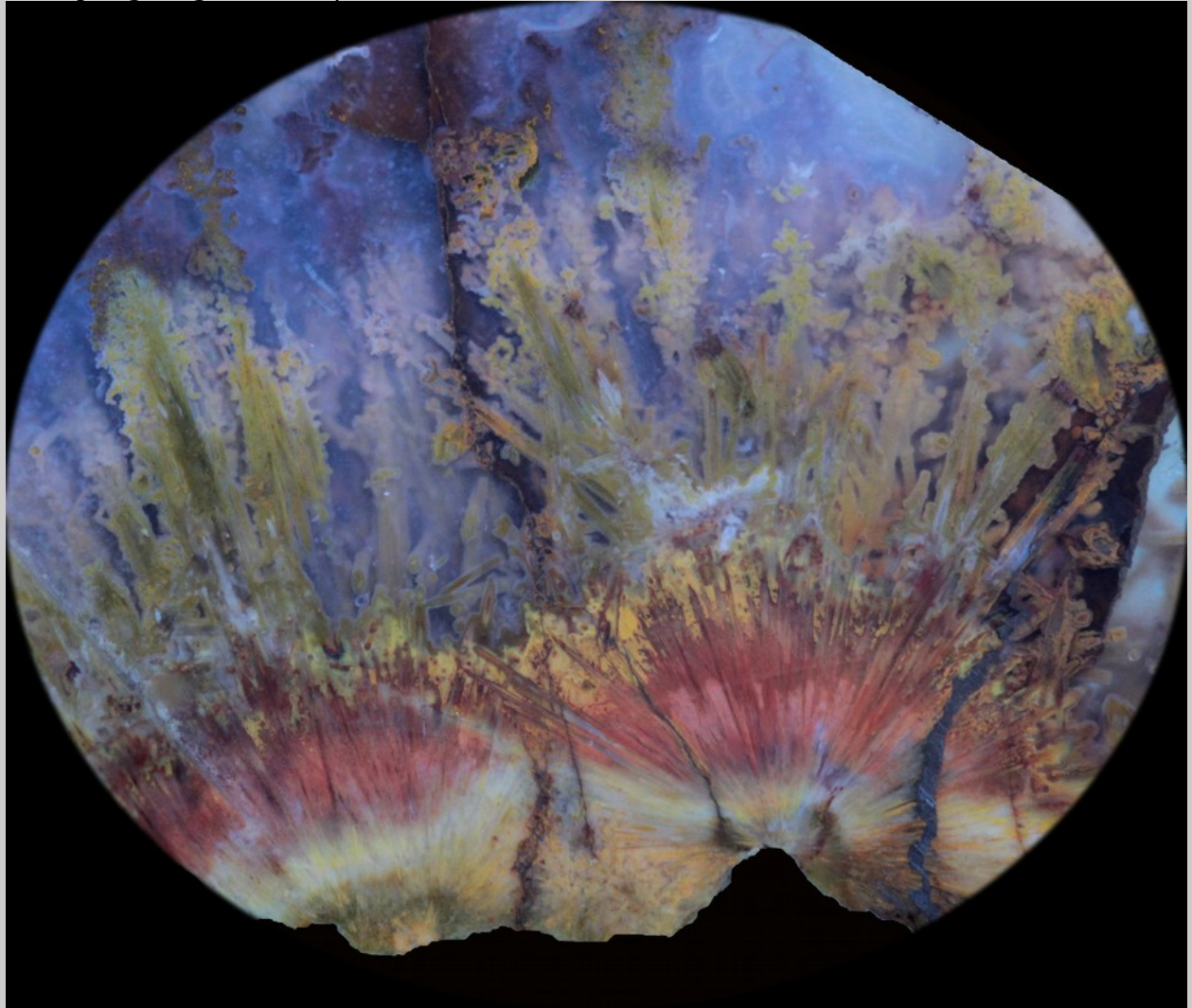
Plume or sagenite? Either or both, but it was sold to me as "sagenite".

Mexican Crazy Lace Agate



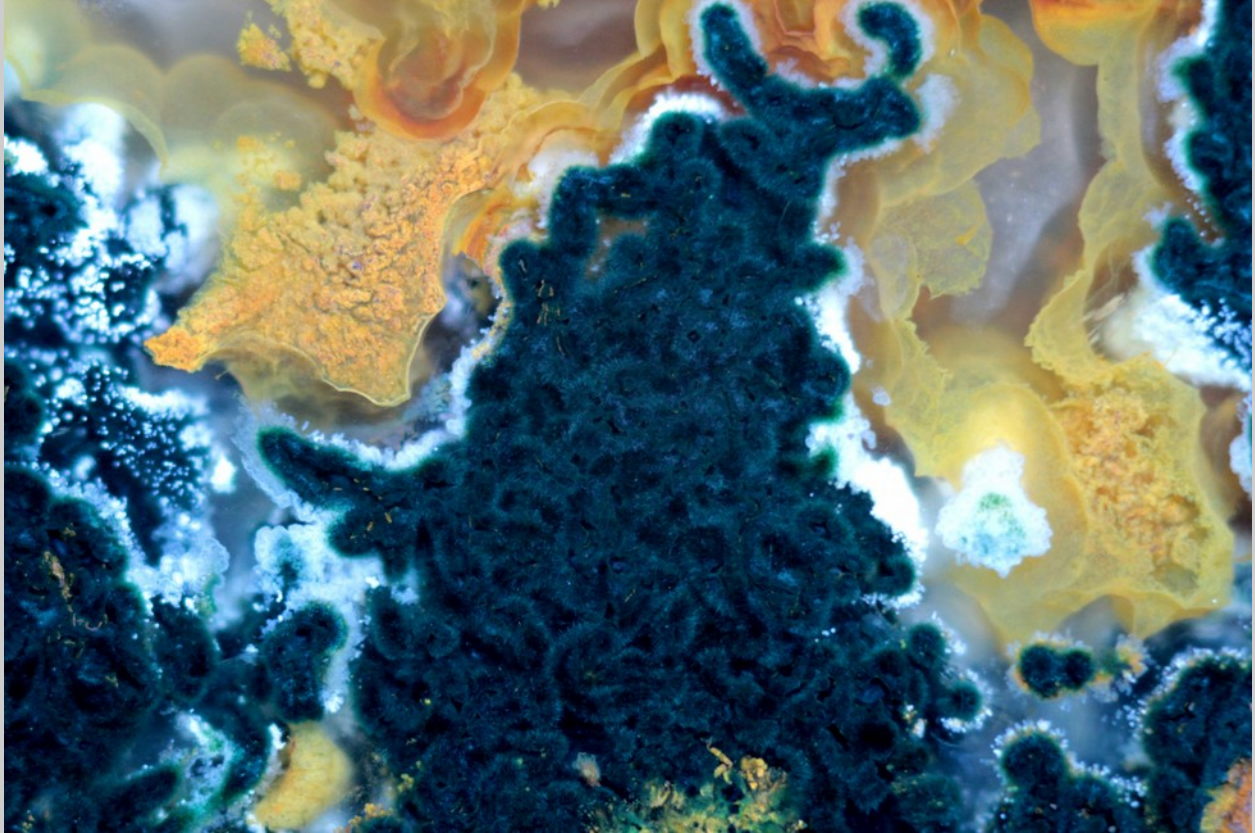
This agate is a difficult one to explain. The top banded agate formed over calcite crystals (as you can tell from the shapes) in an open seam. But then the calcite was dissolved away and replaced with a pseudomorphic crazy lace agate filling. The pyramidal agate fillings are pseudomorphs, and if you look closely, the fillings are composed of tubes and other pseudomorphic agate also. Quite a history, but not unusual in the northern Mexico area.

Owl Springs Sagenite, California



Nice looking little sagenite, like a strange sunken forest at the top.

Agate with goethite inclusion, Mexico

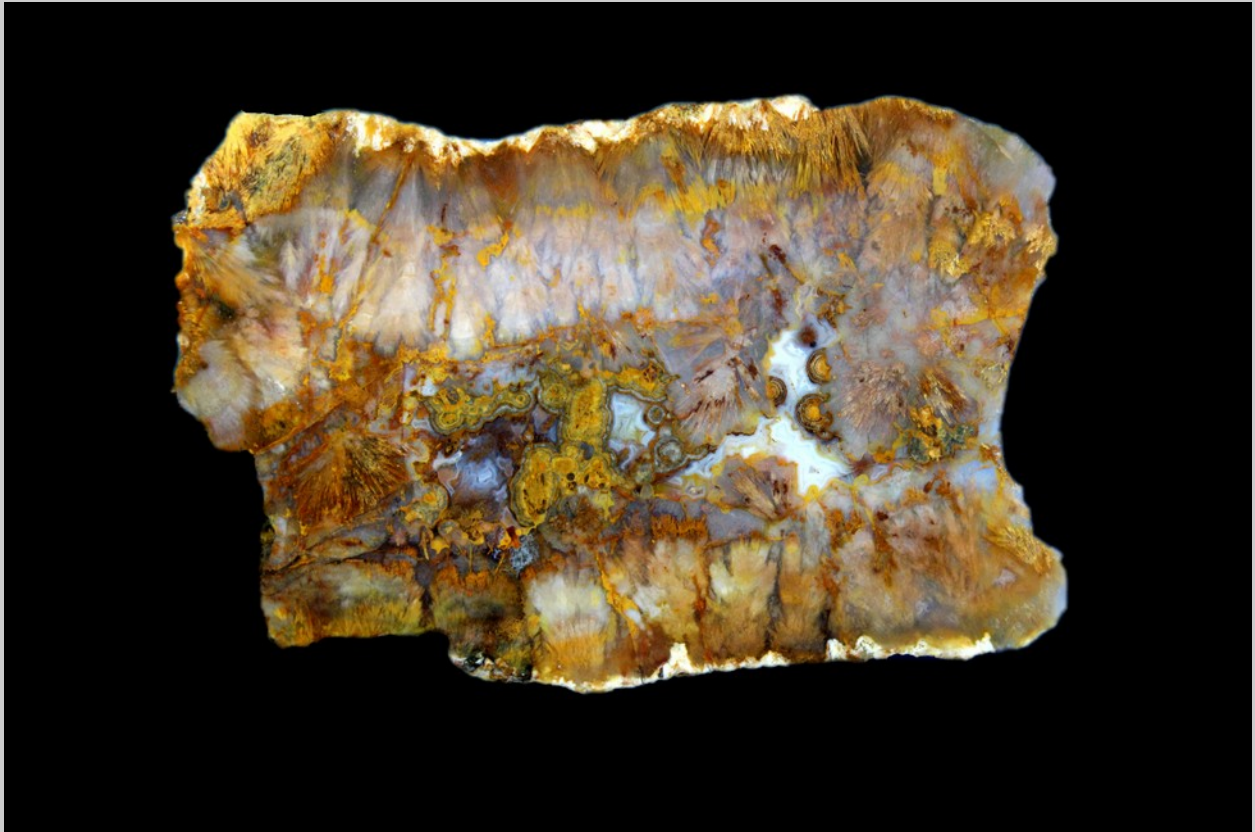


What to call this? I can't bring myself to call it a sagenite. And as the goethite crystals appear unaltered, pseudomorph doesn't seem quite right either. In this case I'll just have to go with the technical term – agate with mineral inclusion. Yes, the banding gives it away as fibrous chalcedony - or, in my book, agate.

Unknown Sagenite Agate with Star burst Pattern



This unknown sagenite, possibly a Nipomo sagenite from California, features a radiating spray of partially replaced acicular (needle-like) crystals.



Here is another difficult one – it is almost entirely 'sagenite'. It was once almost entirely a crowded mass of zeolite and other minerals but they seem to be largely or entirely agatized now. So what's the problem? I am inclined to call this one a replacement agate rather than an agate with included minerals as is the case with sagenitic agates.

Well, that's the end of this gallery, and this pdf. Continue on to the next one, if you wish (and I hope you do).

YES!

THE END!