The Great Rivals to Volcanic Agate.

Agates That Form in Sedimentary Rocks

Limestones are the main sedimentary rocks that offer up fine agates like Fairburn, Dryhead, Teepee Canyon, Paint Rock, and Kentucky agates. Agates such as Union Road and Keokuk Geodes are found in shaley dolostones and shales in the Midwestern US and can sometimes be quite attractive. These agates may be wall banded, appearing similar to volcanically derived agate. Indeed, the agate forming processes must be nearly identical though the source of silica may be different. These agates point to the conclusion that the impetus for agate formation, including banding, lies in the chemistry of silica, not the geological environment.

Tee Pee Canyon Agate, SD

An agate from Argentina, known variously as 'Puma' and 'Samyta', is said to come from a sedimentary host rock but I cannot discover any further information about it. Some of the Pumas strongly resemble Kentucky agate. Others, like the one pictured in the gallery linked below, are unique. That one has a thick rind of macro-quartz followed by chalcedony, then more macro-quartz in the center. The chalcedony shows some slight fibrous banding but the predominant color patterns seem more related to Liesegang banding, a purely staining phenomenon such as seen in jasper.

All these I would describe as pocket agates, or even nodular agates though the mode of their formation is not in gas bubbles in lava rock. In fact, the origins of the spaces in which the chalcedony/agate grew is a matter of dispute. Many of the sedimentary agates (agates that form in sedimentary rocks) are clearly agatized fossils or fossil casts – those will be considered separately below. For others, however, an origin is not clear. I won't drag us too deeply into that argument and will just note, as a reminder, the great proclivity of silica to accrete more and more silica to itself under many kinds of circumstances. That may be the genesis of some agates also.

Just as volcanic hosts produce agate in veins and seams, so do sedimentary rocks; and the processes appear very similar, while the agates themselves are sometimes almost indistinguishable. Geologic forces not attributable to volcanic activity cause stress and strains that fracture the host rock, and may produce hot, mineralized waters that have the same effects as volcanic activity. Those effects will be studied later on in sections on structures of agates.

One of the most surprising agates I have encountered is found in the Summerville, Georgia area. In fact, on seeing some pieces, I mistook them for Mexican Lace agate and had to make a trip to the site to be convinced of the source. This agate is found in seams and veins in the weathered residuim of a silicified limestone occurring in the folded and faulted Valley and Ridge Province of the Appalachian Mountains, but very near the low grade metamorphic rocks of the Blue Ridge. That somewhat tortured geologic history accounts for the similarities with agates from volcanic areas.

Missouri Lace Agates formed in veins or seams in highly mineralized carbonate rocks and are now found in the weathered residium. Although they typically have little color, they are in many ways also similar to Mexican Lace agates.

The beautiful blue lace agate from Namibia and South Africa occurs, as best I can determine, in thin seams in a dolomite (a carbonate rock similar to limestone but containing more magnesium). I suspect it, too, has experienced some degree of metamorphism.

As far away as Louisiana, ash falls from the west Texas volcanism precipitated the silicification, or agatization, of wood and other materials down to, and including mud and dinosaur dung. Although found in sedimentary rocks, and recognizing some remarkable overlaps, I am including all such 'agatized' material in the 'replacement agate' category also coming up.

Sedimentary Agate Gallery

Fossil Agates and Agatized Fossils

This discussion of agatized fossils is, of necessity, embracing both the conventional agate genesis and treading into the third category of basic types – replacement agate. The two types can be found in the same specimens and it is often difficult to distinguish between them, but although we will be considering them both in the following paragraphs, I have tried to make a clear distinction between them – as they are very different in the detail of their genesis. **One is a filling of an existing cavity with agate, the other is the removal and replacement of existing material by some crypto-crysatlline silica species.**

'Yellow Cat' Petrified Wood, Utah

Sedimentary rocks yield up many fine fossil agates. The formation of some fossil agates is pretty much like any other agate – a cavity, except in this case formed by decay of organic material, fills with silica, etc. The "petrified wood" to the right is simply a wall banded agate that formed in a cavity left by a tree limb in volcanic rock. Other fossil agates are more complex chalcedony fillings of organic remains showing the gross structure of the original, a 'relict' structure.

Obviously then, calling the Yellow Cat agate "petrified wood" is not technically correct, it is a fossil cast, not a true replacement. But it is popularly known as "petrified wood" and for informal use, that is fine. "Petrified wood" of one kind or another occurs all over the US and most of the world. We'll see examples of both types in the upcoming photo galleries.

There are the many beautiful fossil agates and agatized fossils that form in marine environments also – corals especially. There is a question as to where the silica for these agates came from – whether from volcanic ash settling into the sea sediments, or derived from the silica skeletons of untold trillions of marine micro-organisms that settle into the sediments.

Then, there is this, as the Preacher of Ecclesiastes said: ***"All the rivers run into the sea; yet the sea is not full; unto the place from whence the rivers come thither they return again."*** It's true, the rivers run into the sea carrying their loads of gravel, sand, silt, suspended and dissolved minerals. The water evaporates and returns unto the hills to begin its journey again, but the minerals deposited in the sea remain there and accumulate. Just as with salt or any other mineral, when silica reaches its saturation point in sea water, it precipitates out.

As we know, polymerizing silica solutions have a great ability to accrete more silica and grow, and conditions in buried coral and other organic remains seem particularly conducive to silica accretion. Whatever the source or exact mechanism, silicated or even well agatized coral and other marine fossils are fairly common. Really beautiful ones are rare, but that is true of all agate types.

Marine fossils, corals especially, offer cavities for the accumulation of agate and may sometimes show traces of coralline structure (relict structure) but not really qualify as agate replacement fossils. Other coral fossils are certainly replacement agates. The fossil agate photo gallery linked below shows a Paint Rock Agate with faint relict structure of coral very similar to the Tampa Bay coral which has a clear coralline structure. I would not call either replacement agates however. The horn coral from Utah clearly is a fossil replacement agate, however; as is the colonial coral from Indonesia.

The term 'petrified wood' simply means wood replaced by mineral matter of some type, sometimes very surprising minerals. Lapidarists are more interested in 'agatized wood' which is a crypto-crystalline quartz replacement of the wood. Agatized wood runs the gamut from drab colors and poor wood grain preservation up to rainbow colors and almost perfect preservation of wood's cellular structure.

Agatized dinosaur bone is another favorite lapidary material. Like agatized wood, the bone's cellular structure is often preserved in marvelous detail. But in many cases, the cells are simply mini-voids in which banded agate forms. It's amusing to think that the remains of these once mighty “rulers of the earth” are now cut and polished to decorate necklaces, ear rings, and belt buckles. It seems a foretaste of Jesus' prophecy that the meek will one day inherit the earth (Mathew 5:5).

The exact mechanism of crypto-crystalline replacement of organic matter leaving intact the cell structure is not well understood. The best idea I have seen on fossil replacement agate is by analogy to silica replacement of other minerals. You've already seen an example of this phenomenon in the solution and wicking away of iron oxide by chalcedony in the Mexican Crazy Lace. We will be looking into that in more depth just a little farther on.

There are are many mysteries in the workings of God's creation still to be unraveled, but however it happens, the 'agatization' of organic matter has created a tremendous storehouse of beauty brought to us literally out of the grave – not only of agatized wood and bone, but almost anything from algae to ...well, I can't think of a 'z', but I'm sure there is something.

The beauties of this mystery remind us of another beautiful mystery, for as St. Paul said:

Behold, I show you a mystery; We shall not all sleep, but we shall all be changed, In a moment, in the twinkling of an eye, at the last trump; for the trumpet shall sound, and the dead shall be raised incorruptible, and we shall be changed. For this corruptible must put on incorruption, and this mortal must put on immortality. So when this corruptible shall have put on incorruption, and this mortal shall have put on immortality, then shall be brought to pass the saying that is written, Death is swallowed up in victory. O death, where is thy sting? O grave, where is thy victory? (I Corinthians 15:51-55 KJV)

Resurrection! The hope of all Christians – not reincarnation, that's a totally different concept. The idea of reincarnation is that man is essentially a spirit being; to some, he's just a chip off the old cosmic block that flits endlessly between one physical form and another. The truth given in God's word is that man is a physical creation given spirit by God, forming a one of a kind human being. Though man's spirit exists in some form after the death of the mortal body, it is the reunion of the two in a glorified physical existence that is the ultimate destiny of Christ believers. Jesus went to great lengths to assure His followers that He had returned in a physical body. He ate with them, and invited them to touch Him, feel the scars. Yet it is a body that will never age and die, is capable of miraculous things, and most important of all, it can stand in the presence of God Himself.

If God, through His natural processes can give a new body, that will never more see decay, to a stump buried in a field in Mississippi, how much more can we be certain that man, made in His image, has a future beyond the grave?

Fossil Agate Gallery

Fossilized Stone

Another type of replacement 'agate' is a replacement of other minerals and rocks. Chalcedony, or other crypto-crystalline silica species, can replace another mineral entirely and still retain its form. These occur as secondary mineralizations of individual crystals, or mass replacements of rock. It is somewhat easier to visualize one mineral taking over the form of another mineral than of an organic material, although when you get right down to it, without the God given spark of life, organic tissue is only a structure of hydrocarbon molecules - only another mineral.

The ability to dissolve away and replace other materials while preserving their form and volume requires a perfect balance between the forces of dissolution, transport, and crystallization. The best explanation I've seen is that the force of crystallization on the material it is replacing causes it to go into solution. Therefore, the rate of crystallization would set the pace for solution, but the availability of space for crystallization and the ionic concentration at the crystal front would control the rate of crystallization, bringing the whole system into balance.

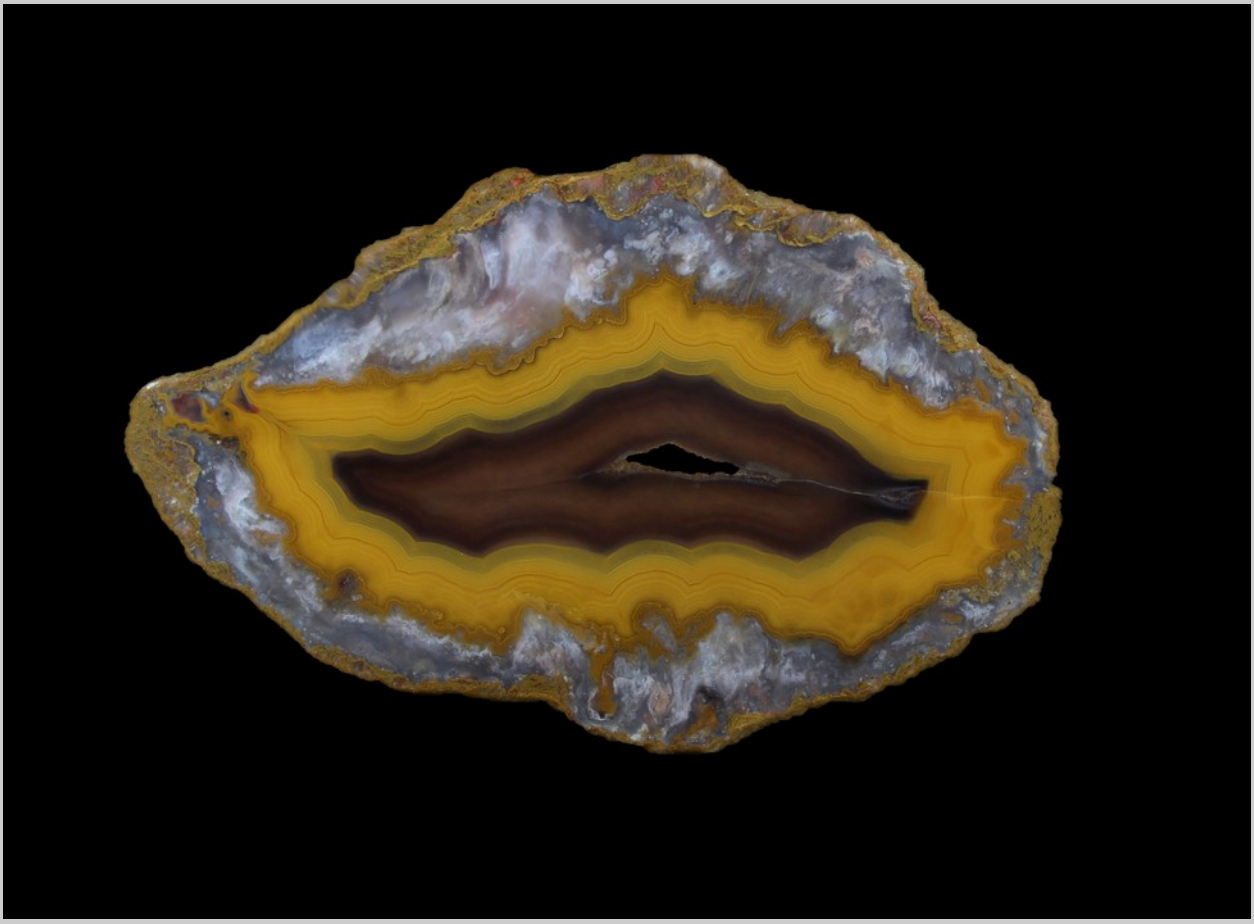
The pressure of a porous crypto-crystalline front, with crystals barely above molecular size, pressing on the existing material causing it to go into solution (pressure increases solubility), porous chalcedony allowing the solution to wick away and be replaced with silica solution drawn to the growing crystal front, that in turn precipitating further micro-crystalline growth, pressure, etc. may be the process that produces the near perfect replacements we see. Other factors and general conditions would also have to be favorable I would think.

This group, mineral replacement agate, includes some very popular and sought after material. Tiger eye, or tigerite, is a popular form of 'agate' replacement gemstone. It is a replacement of the fibrous mineral crocidolite, which in its unaltered state is one of the asbestos minerals. Chalcedony or other crypto-crystalline quartz variety can also replace massive rocks such as in the “Turitella Agate” beds of Wyoming (pictured below). Often volcanic rocks are replaced with crypto-crystalline silica although it is unclear to what degree they are replaced or just infused with extra silica – silicified. but we usually call those 'jasper' or 'jaspagate'. Like other replacement agates, these are not technically true agates and because jasper is such a broad subject in itself, I barely mention it here.

Mostly, we think of mineral replacement agates in terms of sagenite and psuedomorph agate – replacements of clusters or individual mineral crystals with chalcedony, usually within a matrix of chalcedony. These, sagenites and psuedomorph agates, are dealt with in the next section - agate structures.

Agatized Rock and Mineral Gallery

Sedimentary Agate Gallery

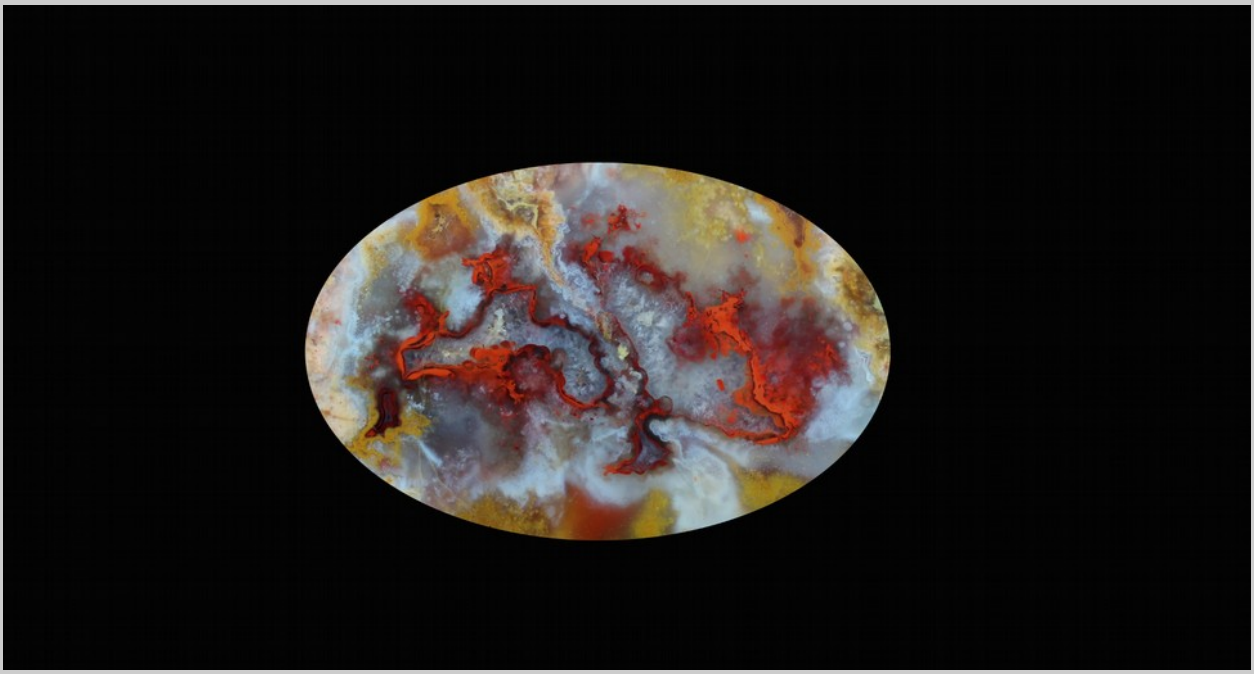


Kentucky Agate

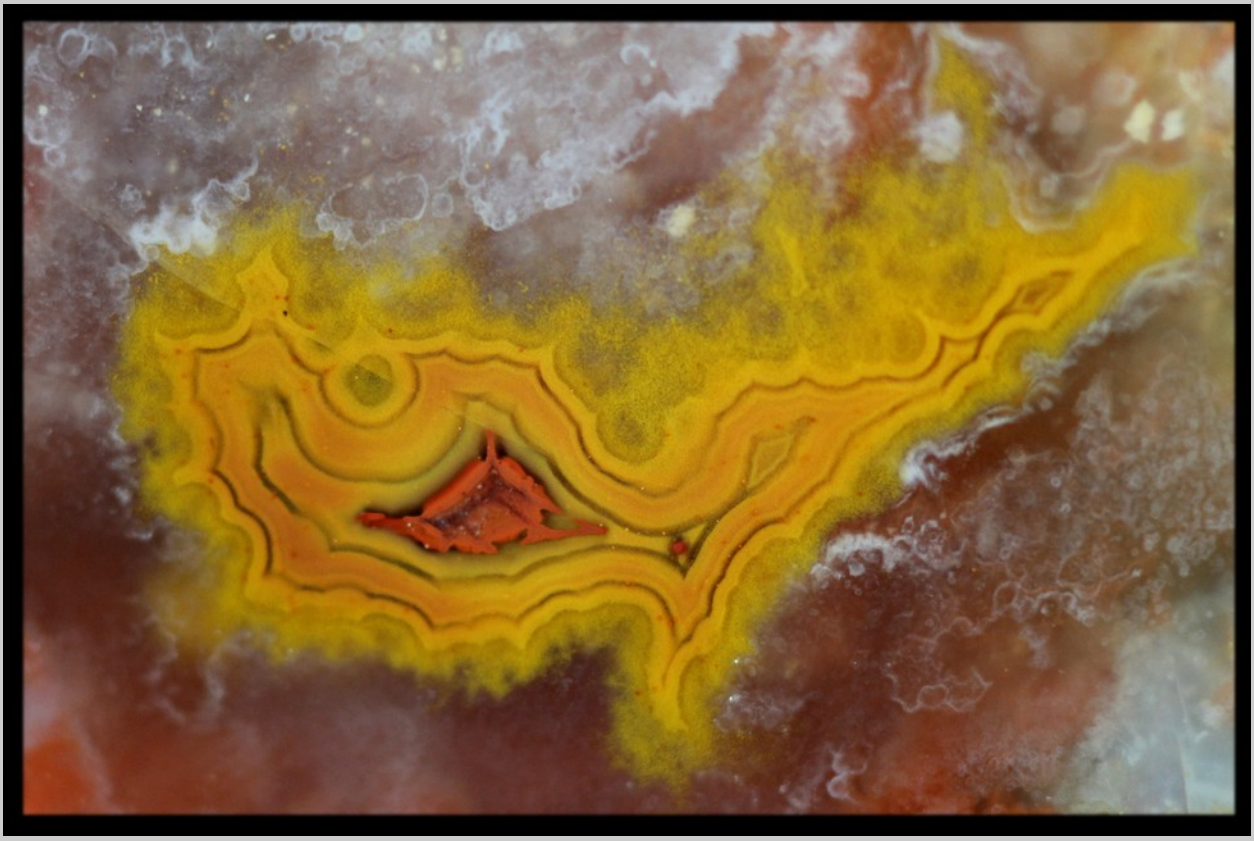
This striking agate, out of a limestone formation in the central Appalachian Mountains far from volcanism, displays characteristics almost identical to nodular volcanic agates. The outer chalcedony shell is a bit different perhaps, but the banding is very familiar, even to the pressure release structure.

Dryhead Agate, Montana

These beautiful agates form in odd pockets in limestones perhaps formed in weathering. They have a silicated limestone shell very reminiscent of thunder egg shells. This one appears in a gallery on the web site where I dubbed it “Picasso's Drooling Dragon” - but perhaps that's just my imagination.



Close-up of Paint Rock Agate #1



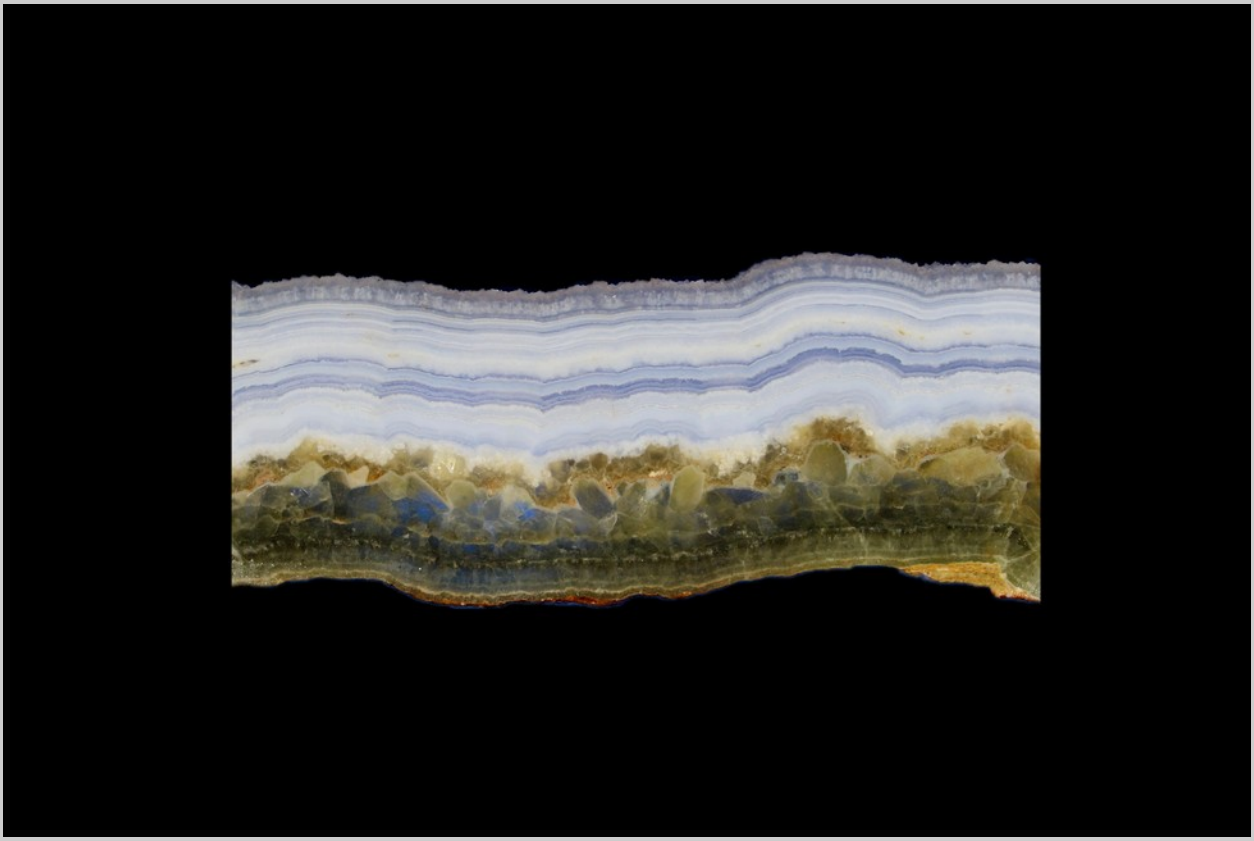
Close-up of Paint Rock Agate #2

Sedimentary agate forms and patterns can vary widely as these show. The second agate shows the transition from colorless granular chalcedony to fibrous banded agate.

Lace Agate, Missouri

Missouri Lace Agate Close-up

This agate seemed to have formed around carbonate pinnacles in cavities that later dissolved away. These agates occurred from secondary processes long after formation of the enclosing bedrock. The agates are recovered as a waste rock product of mining.



Blue Lace Agate, South Africa

Information on these agates that occur in the same formation in Namibia and adjoining South Africa is hard to come by but I believe them to form in seams in a dolomite subjected to low grade metamorphism. The banded blue agate, topped by small quartz crystals, is underlain by a layered gypsum.

Samyta Agate, Argentina

These are striking, but real oddballs that a strict definition might not recognize as an agate. This typical structure has radial quartz crystals around the outside with what appears to be a ring of granular chalcedony with just a couple of bands, and a macro-quartz center. Coloration does not follow the normal banding style. We see radial quartz growing from nucleation points around the edge.

Keokuk Geode, Illinois

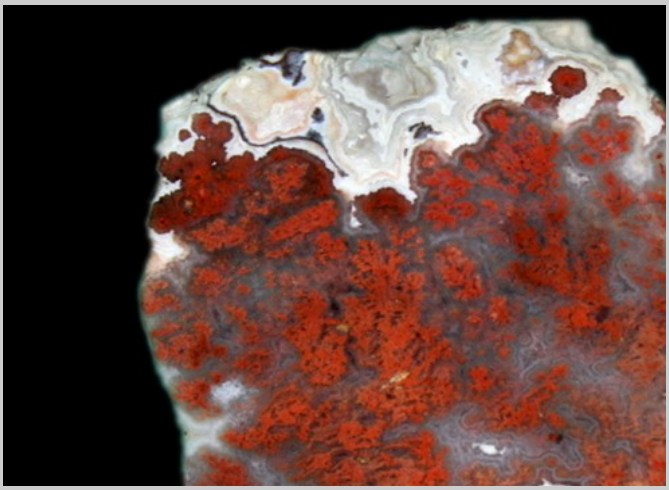
These geodes are found in the clayey dolostone Warsaw Formation, a rock unit similar to limestone but with more magnesium and less calcium, and a very high content of clay shale. The nature of the geodes has been subject to a lot of research, and controversy. The origin of the cavities is open to dispute – whether biological or mineral.

All Keokuks have the thin chalcedony skin, but few have a thick banded chalcedony interior, this one with a botryoidal surface. And that is the point I want to make – the banded chalcedony here is virtually the same as in rocks formed in lava vugs or any other host. The lack of color in the banding is due to a lack of iron or other colorants in the sediment. The macro-quartz rind is characteristic of a lot of sedimentary hosted agates however.

These, often large, geodes form in the same geologic horizon as the Keokuks but perhaps with less clay shale and more dolomite (magnesium carbonate). The banded interior appears to be more of a chert than a chalcedony but it is classic wall banding that is not in chert's repertory. Chalcedony may be partially or completely altered to some other crypto-crystalline quartz species. The center is lined with very clear macro-quartz. Once again we see here the macro-quartz rind very similar to the Keokuk. The Woodbury geodes' rough macro-quartz rind outer surfaces are often likened to a 'cauliflower' surface. Some researchers attribute that to replacement of a form of gypsum crystals. They appear to me, however, to more resemble chalcedony “conchos” and “roses”. But again, it is not the origin of the cavity that we are dealing with, but the formation of banded chalcedony in sedimentary rock.

Above, a slabbed piece of seam agate from Summerville, GA displaying banding and plumes very similar to agates found in volcanic host rocks. Now that I am familiar with the material, I can clearly see traces of the sedimentary host rock that I did not notice at first.

To the right is a photo of mossy plumes found in one small piece of the agate. The vast majority of the agate from this site is virtually colorless.



The whole of the formation in that site is shot through with thin, convoluted veins and seams, the terminology of which will be discussed in the section on structures.

Here is a large Paint Rock Agate, roughly 6 x 6 inches, composed largely of granular chalcedony, but fibrous in part. It shows banding only in small areas, but has what is probably a relict fossil structure.

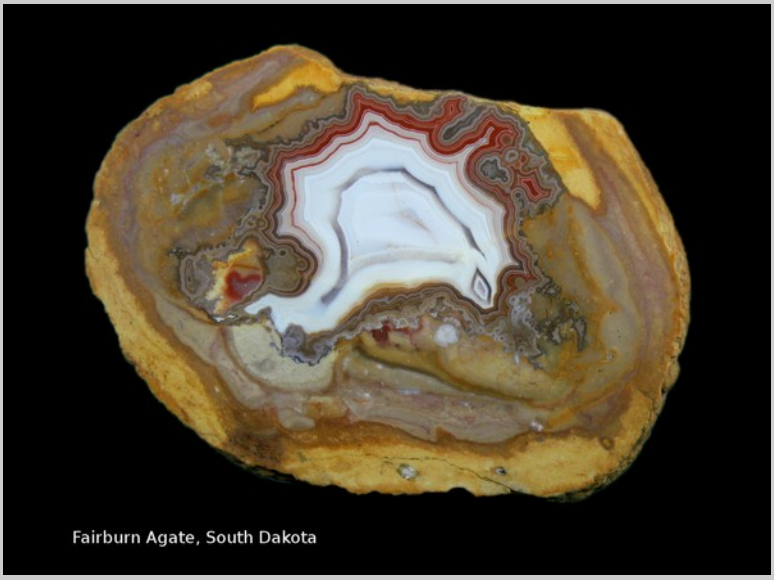
Alabama Seam Agate

Here's another proof that 'agate', as we are using the term, can form just about anywhere. This material, known as “Alabama Seam Agate”, comes from thin, horizontal layers in a hard, silicated zone in generally soft marine rocks of the Gulf Coast. It appears to be entirely granular chalcedony, and perhaps someone could get by calling it 'carnelian' if he just had to put a class name on it. Mostly of a browner color, it is a popular lapidary material.

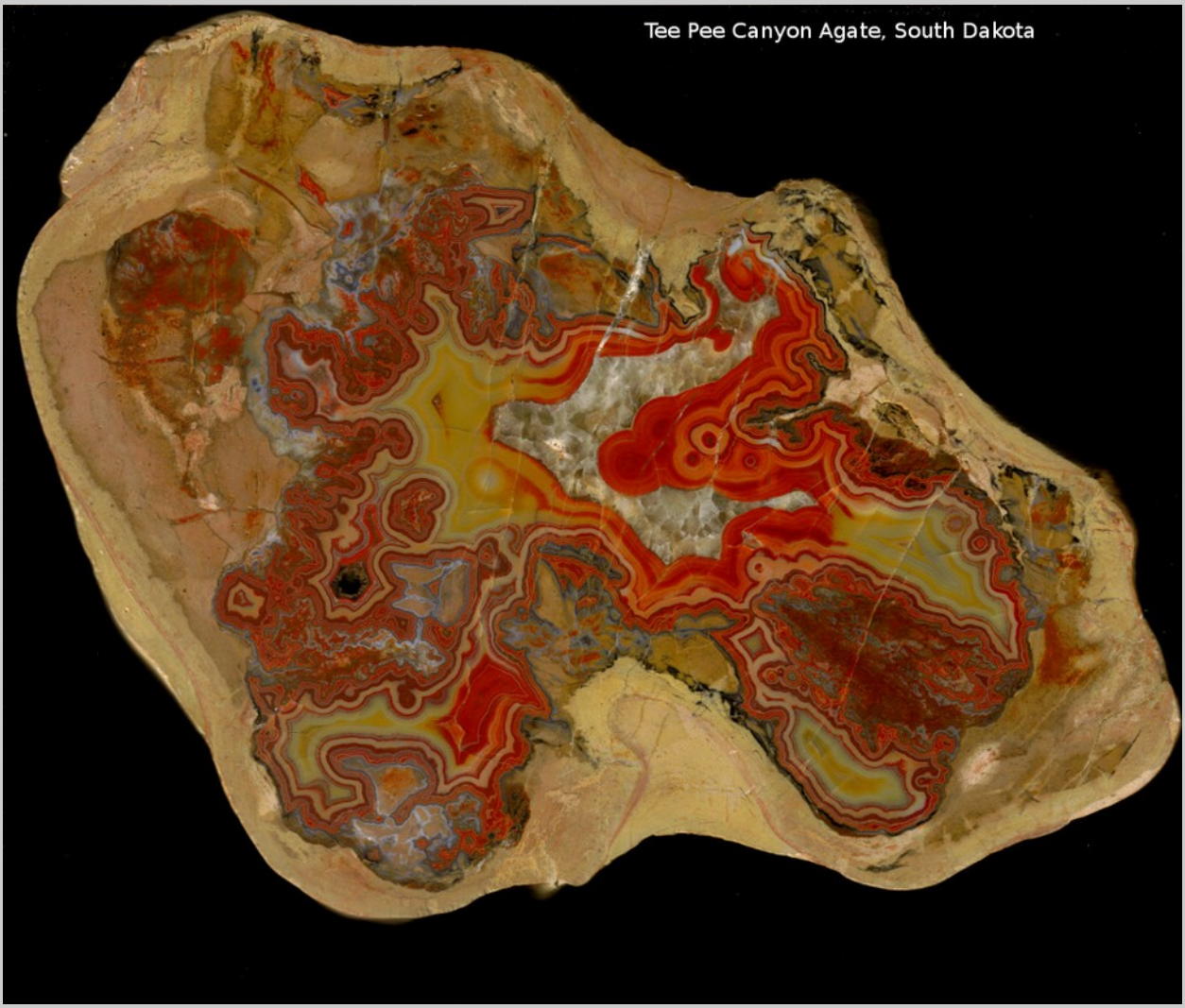
Fairburn and Black Hills Fairburn Agates

The well known Fairburn agates of the South Dakota and Nebraska prairie gravel beds have their source in limestone beds in the Black Hills. Where the agates are found in place in the limestone, or in stream beds and banks in the Hills, they are called "Black Hills Fairburn agates", unless they are tied to a well known location like Tee Pee Canyon.

And when found in the gravel outwash of the hills, usually largely or completely free of the silicated limestone husk, they are called simply "Fairburn" agates, after the semi-ghost town of Fairburn, SD where they were first identified. This agate (below) was found in the vast gravel deposits coming out of the Black Hills. The agate pattern is exposed on the outside of the stone, showing the classic "holly leaf" pattern diagnostic of Fairburns.



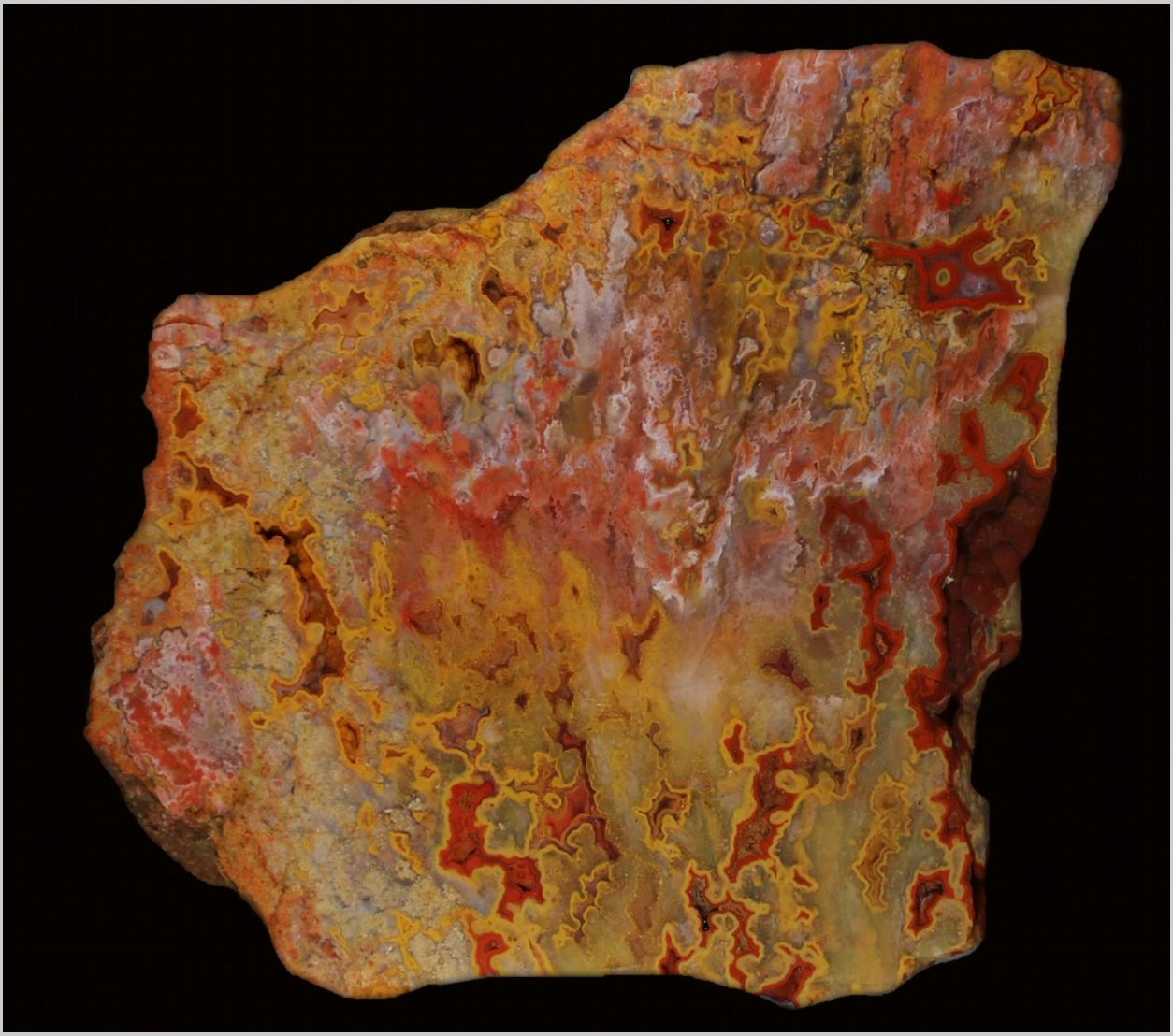
This beautiful agate with unusual amethyst color also comes from the limestone beds in the Black Hills. The agate is about six inches across and is surrounded with a silicated husk. The collector of this specimen did not want to reveal its source so I can only identify it as a Black Hills Fairburn. Its fractured condition indicates that the nodule was laboriously broken out of the limestone by hand.



Tee Pee Canyon Agate, South Dakota

I am closing out this gallery with one of the largest and finest Tee Pee Canyon agates I have ever seen, and that I was privileged to own for a few years. It is a Black Hills Fairburn agate also, but when definitely tied to Tee Pee Canyon that is the preferred name. This one appears to have suffered greatly from fracturing during weathering out of the limestone formation. Internally, the agate is in many ways identical to volcanically formed agate. The color and banding are comparable to the finest volcanically derived agates and it shows pronounced 'chromatography'. There is a small center filled with calcite crystals, which also fills larger cracks.

Fossil Agate Gallery



Paint Rock Agate, AL/TN Border

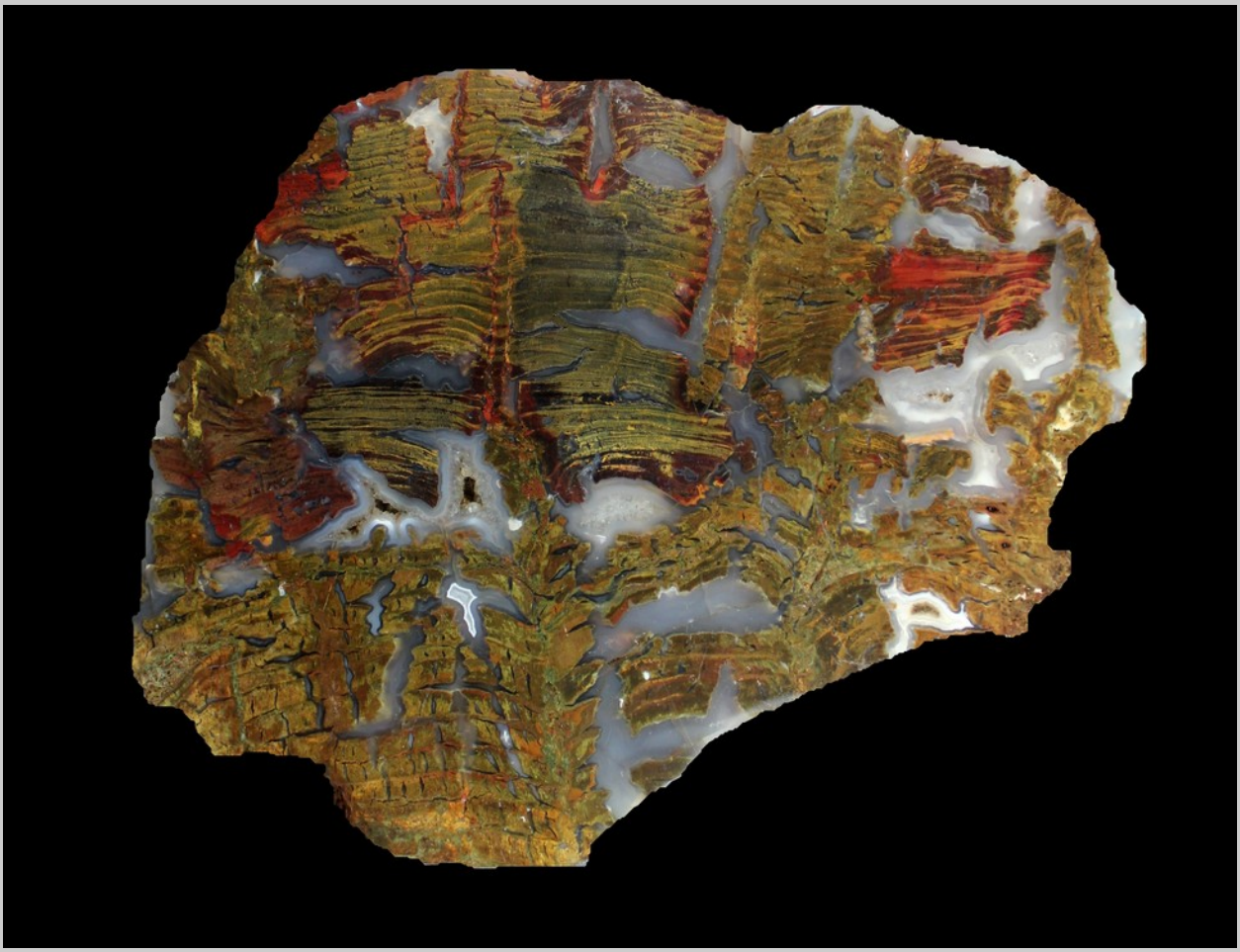
This is a very colorful Paint Rock agate weathered out of a limestone in the rugged mountainous area along the Alabama-Tennessee line. It displays, I am convinced, the relict structure of coral very similar to some found in Florida. Unfortunately it is badly shattered but photographing it underwater improves its appearance greatly. Although, as I think, this contains some hint of a fossil structure, it is not a true replacement agate.

Tampa Bay Coral

This is a lovely coral cast coming out of the marine limestones beneath the Tampa area. It has chalcedony stalactites on one side and a cavity lined with clear quartz crystals on a white chalcedony background on the other. I sawed the flat bottom, which is shown in the next picture – that section showed the coraline structure best.

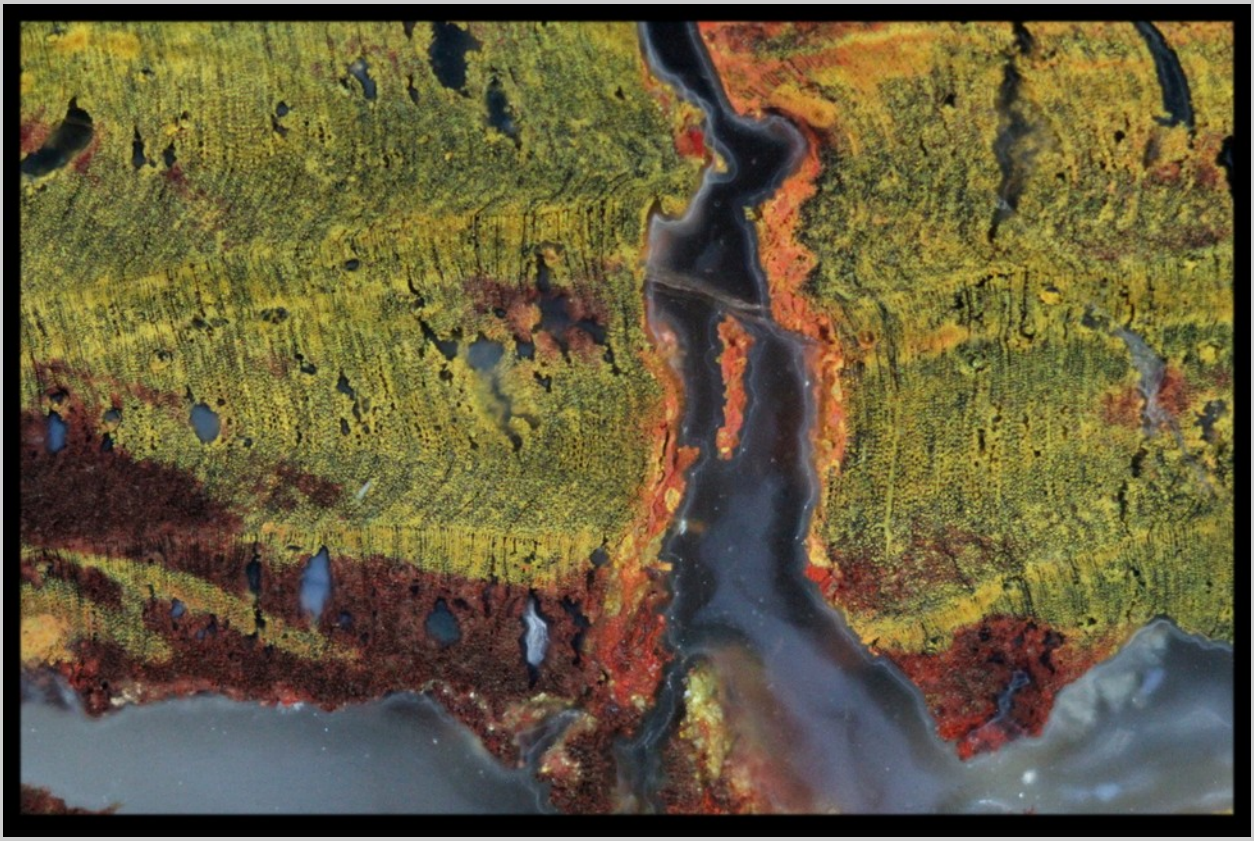

Slice off "bottom" of preceeding Tampa Bay Coral showing coraline structure.

This Tampa Bay coral head fossil is essentially just a chalcedony shell that formed in the cavity left by the coral. It displays relict coral structures but should not be considered a replacement agate either.



Petrified Wood, Hampton Butte, Oregon

This specimen, I could call it 'petrified wood' or 'agatized wood', contains highly articulated replacement 'agate' interspersed with banded chalcedony – agate. It seems to me to very clearly picture decaying wood filling with polymerizing silica leached from surrounding volcanic rock. A close-up photo follows.



Close-up of Hampton Butte Petrified Wood

Considering the decaying condition of the wood, the preservation of the cellular structure is remarkable. The color contrast is increased just a little to show the structure better.

Large Slab of Arizona Petrified Wood

The Arizona Petrified Forest is the best known petrified wood in the US, and probably in the world. Private lands outside the park produce large amounts of wood like the large, unpolished, slab I am holding. It shows the growth rings and other gross structure of the wood but no cellular structure. This piece contains a high amount of chalcedony and certainly deserves the term 'agatized wood'.

The close-up is of another slice of Arizona wood that gives just a hint of cellular structure. It is seldom, if ever, that Arizona petrified wood shows the detail commonly seen in wood from the Pacific Northwest. That perfect preservation of detail is often far greater than in the Hampton Butte specimen that I chose for its color and pattern.

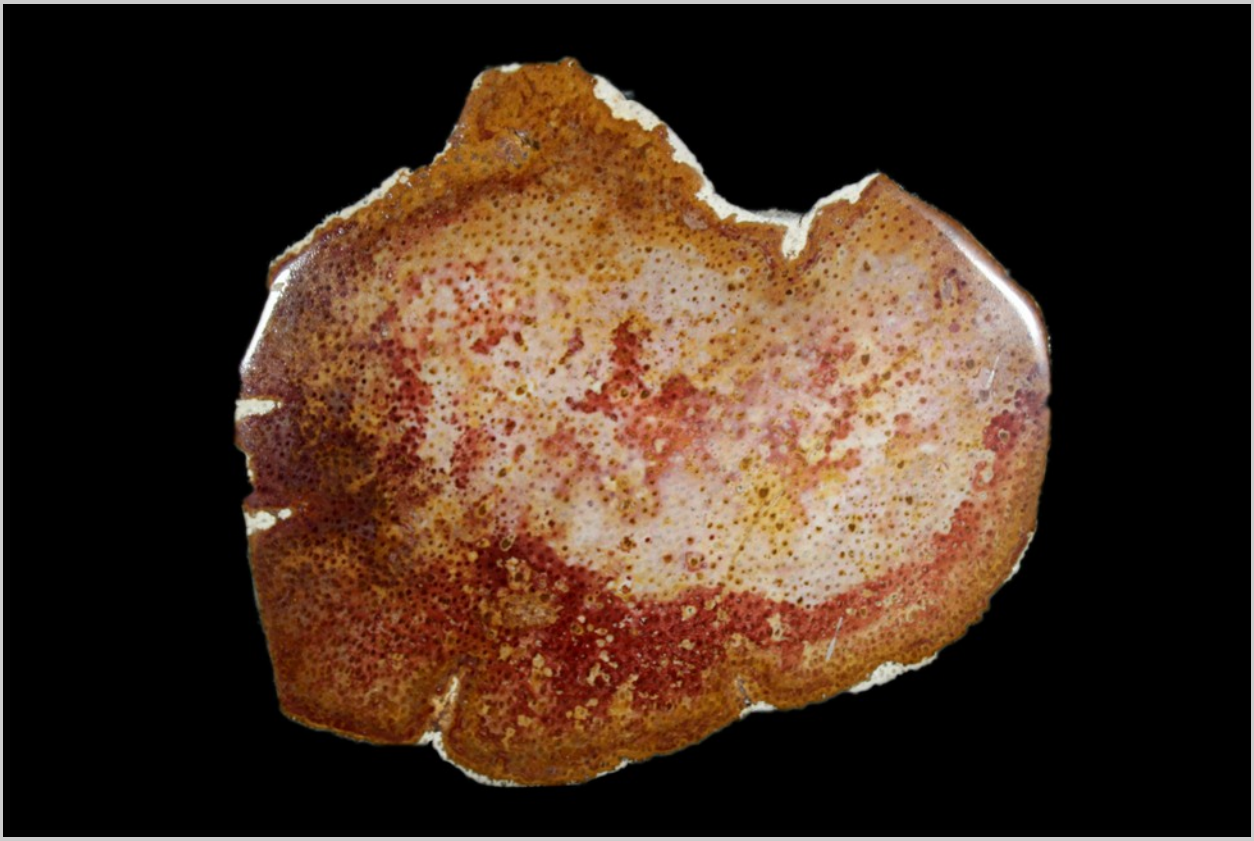
Petrified Stump, Mississippi

This remarkably well preserved tree stump was plowed up in a Mississippi field. It is a highly silicified (rings like steel when struck) replacement fossil. The silica apparently derived from the high silica soil. The woody structure was replaced by crypto-crystalline quartz. Because it lacks any areas of agate such as the Hampton Butte piece has, I wouldn't call it 'agatized' however; just petrified, or silicified – a great specimen though.

Close-up of stump wood edge.

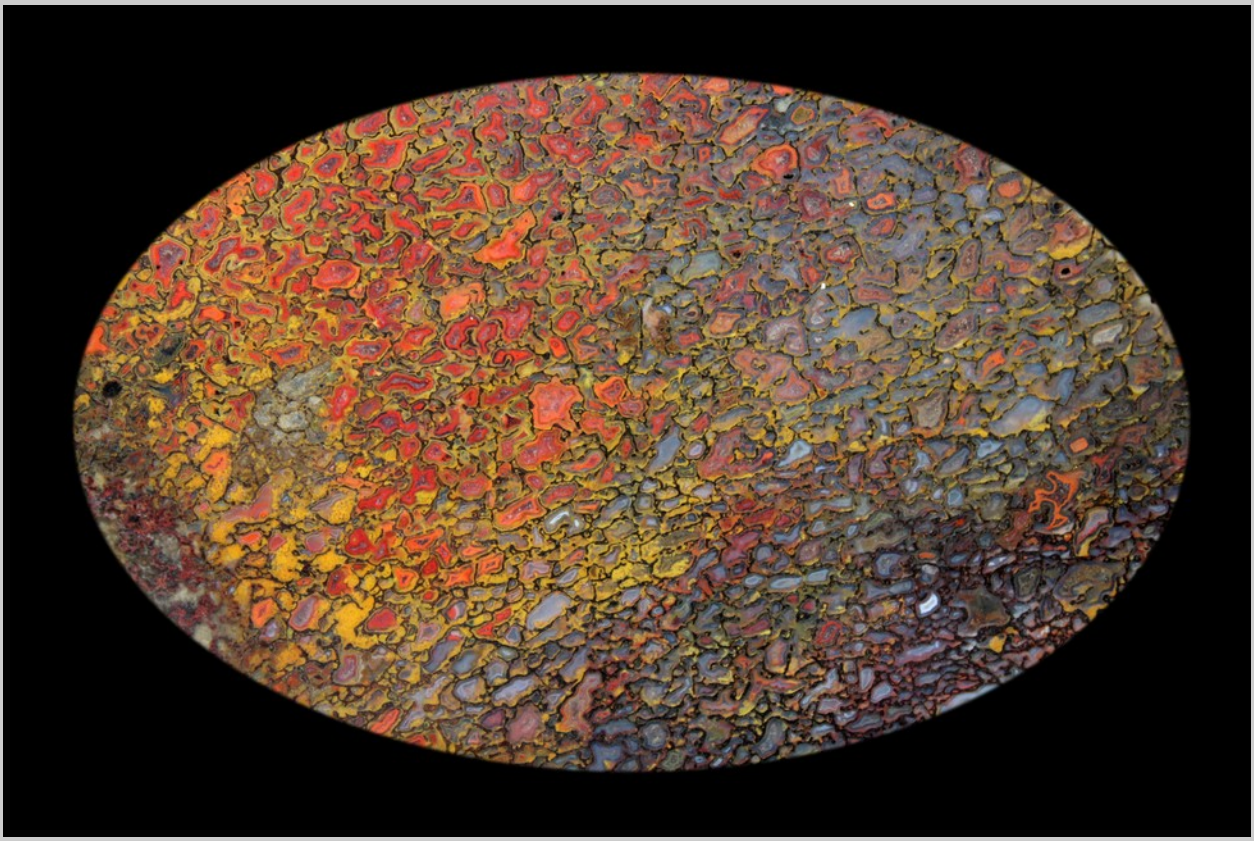
Petrified Wood, Hell's Canyon, Oregon

This is an unusual material and no longer available for collecting as the source was flooded years ago. It is solidly silicified but has very little translucency and, to my limited knowledge, no recognizable agate pockets.



Petrified Palm Wood, TX/LA Border

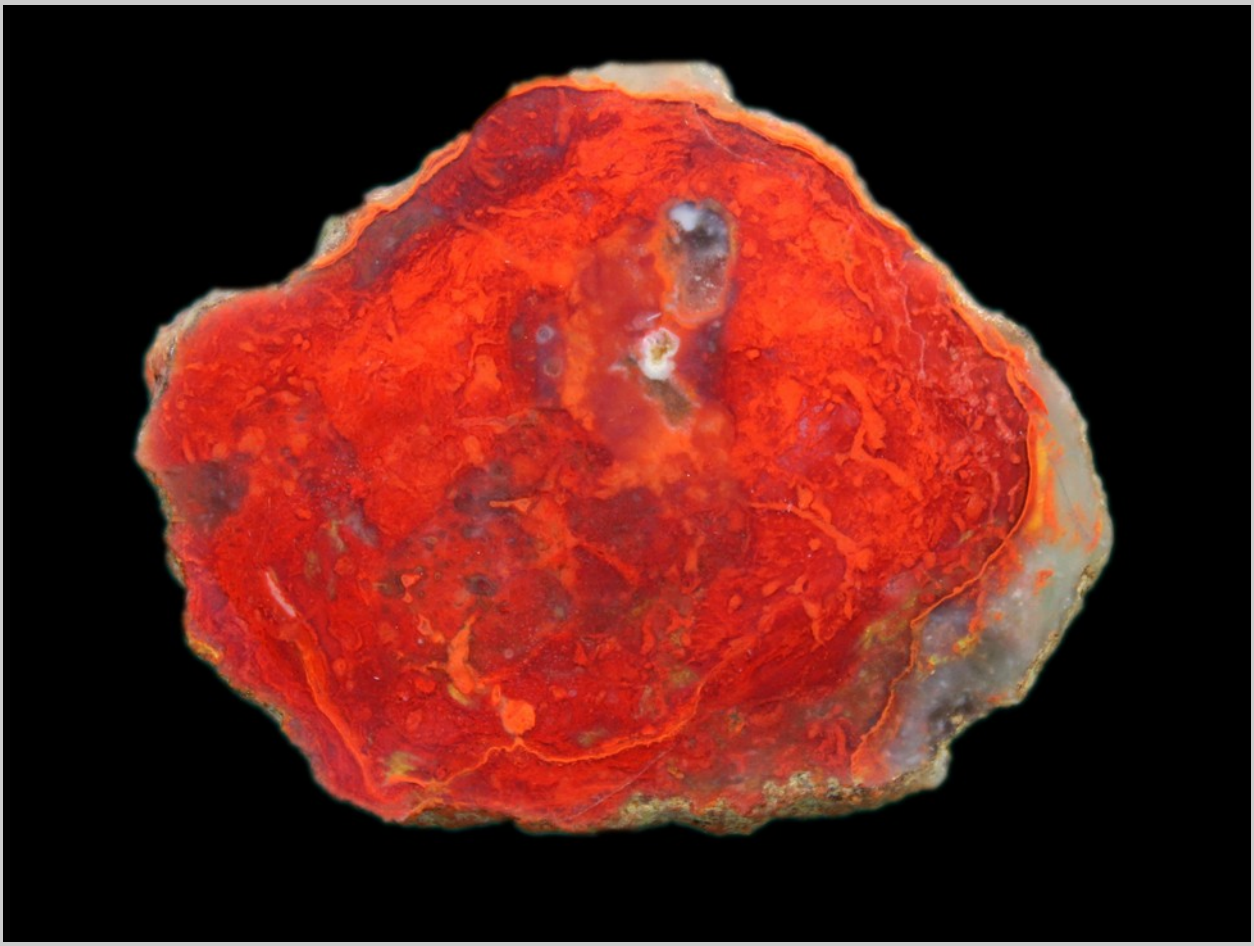
Like the material above, this petrified palm wood is highly silicified and preserves the palm wood structures very well. Both these materials are popular for lapidary use but are not, strictly speaking, 'agates'. Volcanic ash drifting over from the Big Bend volcanoes seems to be the source of the silica.



Agatized Dinosaur Bone, Utah

The cells of this dino bone have become little agate nodules and geodes making it a very complex fossil of part replacement and part cast. An unusual, but not exceedingly rare type of dinosaur bone agate well suited for lapidary use.

Dino Bone Close-ups



Coprolite, Utah

This is (purportedly) 'agatized', or at least silicified, dinosaur dung – a 'coprolite', meaning 'dung rock'. Just about anything that finds itself buried in silica containing lava, ash, or clay soil is susceptible to silica replacement – that includes mud and rock also. In the world of rocks and minerals, geochemistry is destiny.

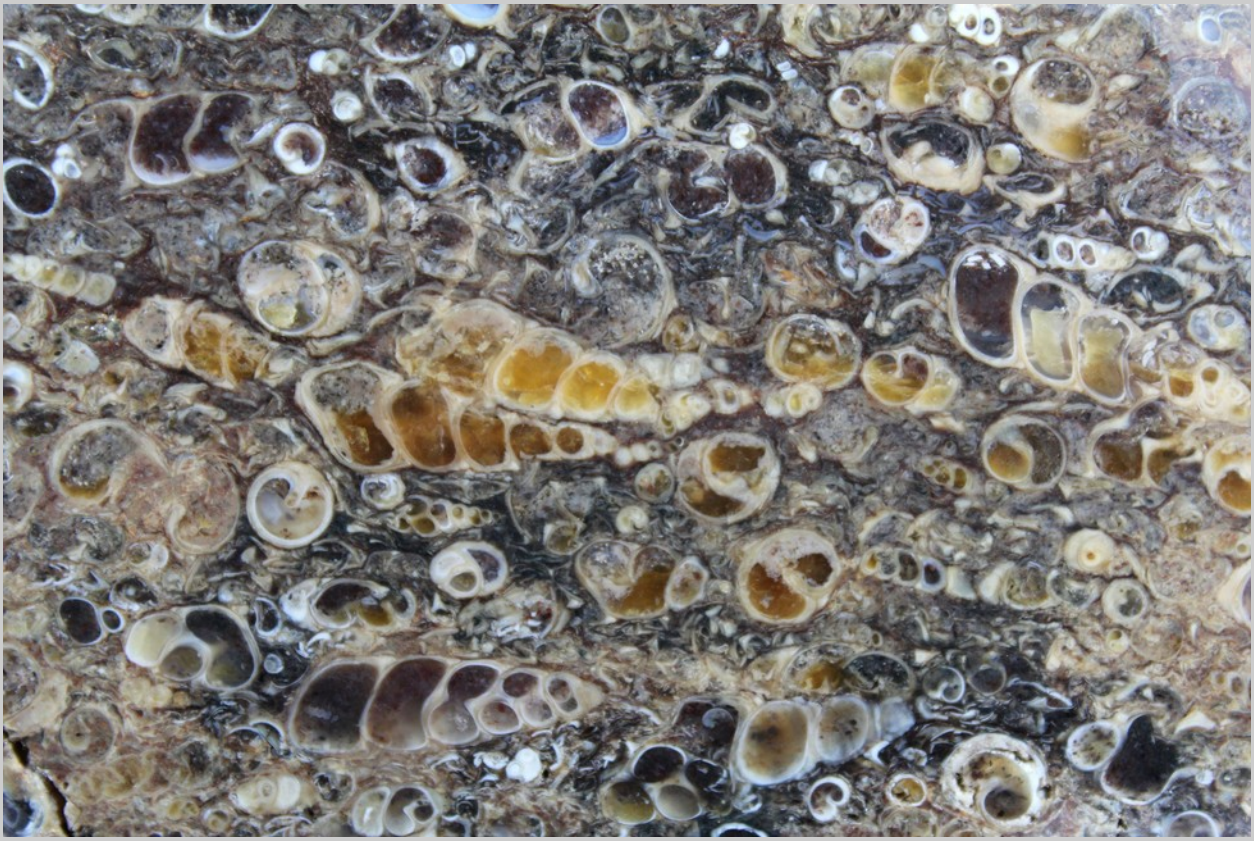
This solitary coral is a very well defined replacement fossil. Because of the color and quality of the crypto-crystalline silica I would have no difficulty calling it an agate, although it would not meet the technical definition. Only the coral is silicified, the surrounding limestone is not. Again, geochemistry is destiny. The difference in solubility must have made the difference in one being agatized and the other not agatized.

This fossilized colonial coral appears to be a three dimensional structure, and indeed it once was. But now the structure has been replaced with a colored chalcedony and the formerly open spaces filled with a clear chalcedony making it a solid chalcedony – or 'agate', highly popular for lapidary use.

Gallery of Agatized Rocks and Minerals

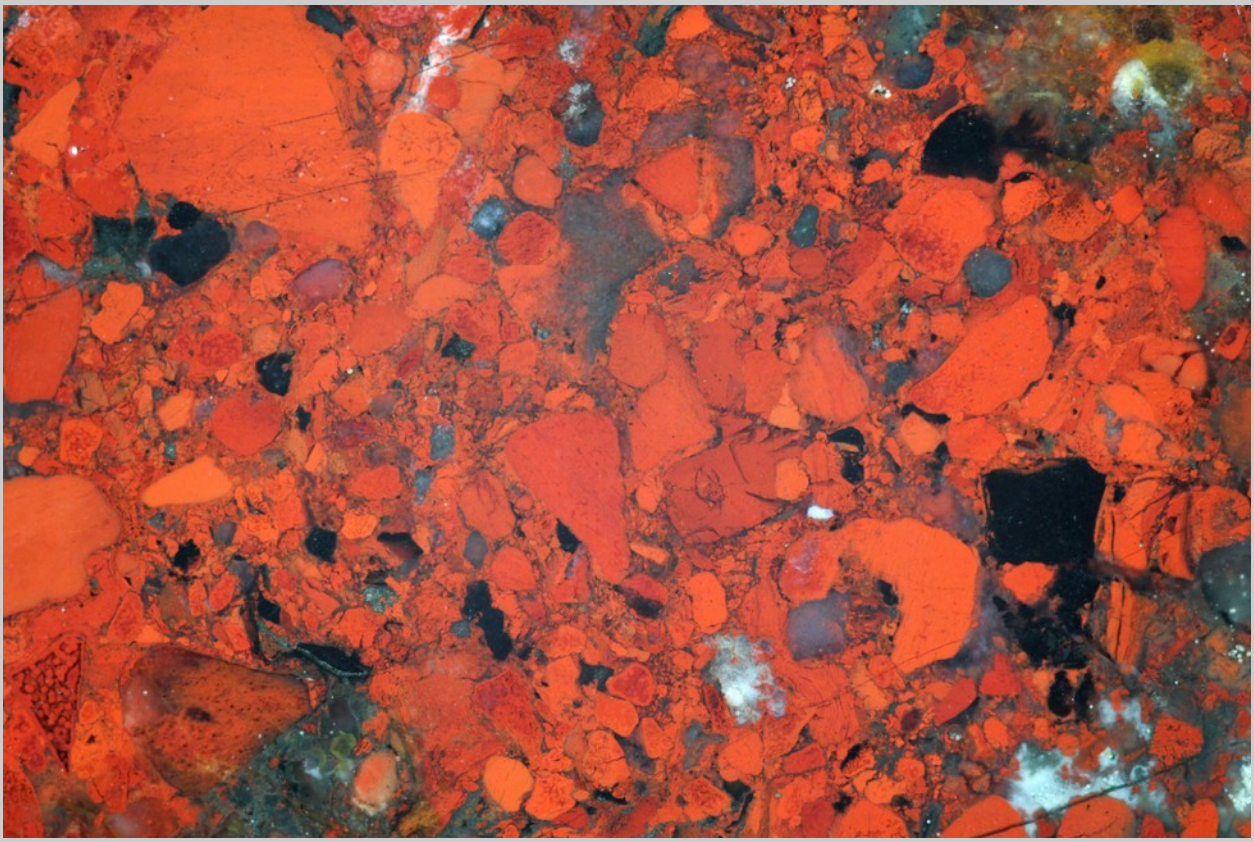
Tigerite, South Africa

This popular lapidary stone results from the dissolution of a vein of fibrous asbestos and replacement with crypto-crystalline silica. The replacement 'agate' is no longer fibrous, in the sense of the threadlike asbestos, but does retain the fibrous appearance giving it chatoyance, or cat's eye effect when cut correctly.



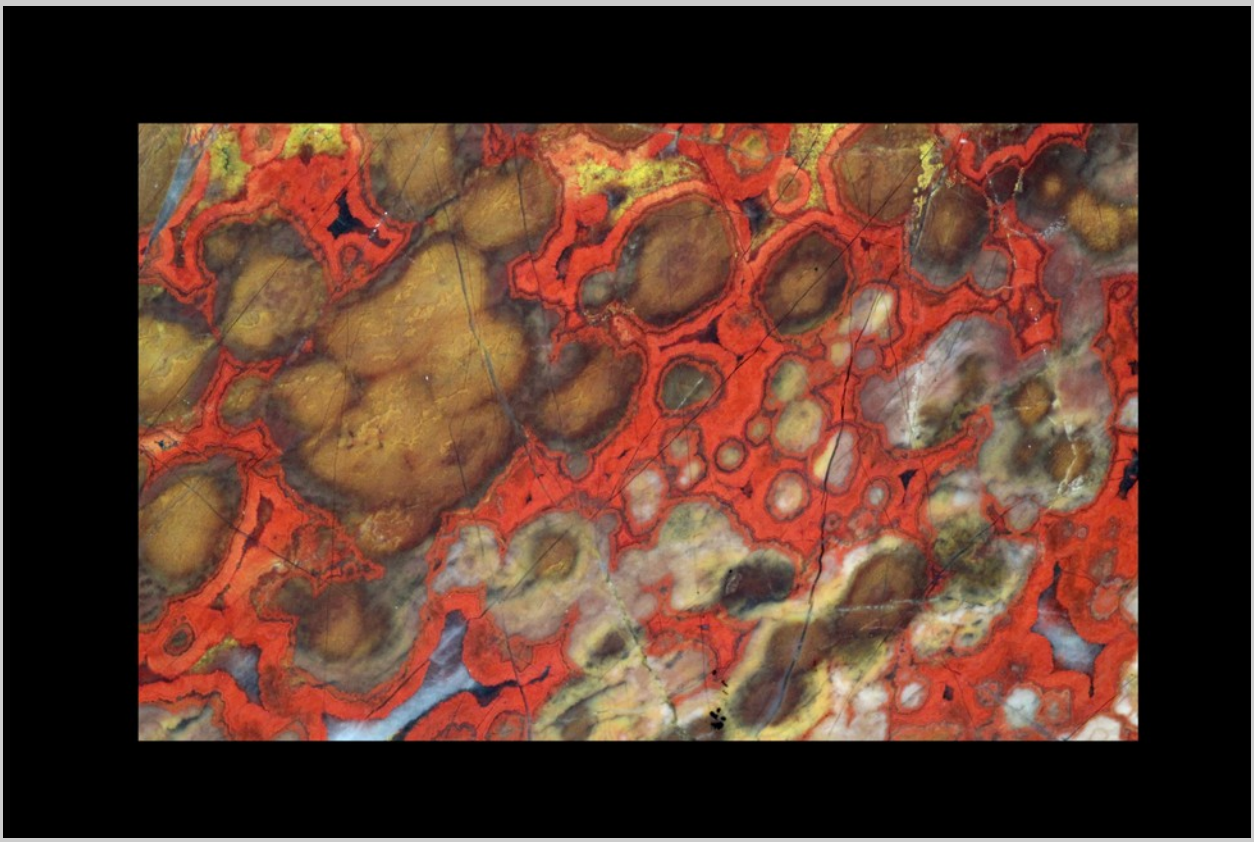
Turritella Agate, Wyoming

This is a crypto-crystalline silica replacement of a fossiliferous limestone. Technically it is not an agate, nor is the fossil correctly identified as a turritella species, but in common usage it is 'Turritella agate'. Except for the inside of some of the shells, which are an amber colored calcite, the material is quite well silicified.



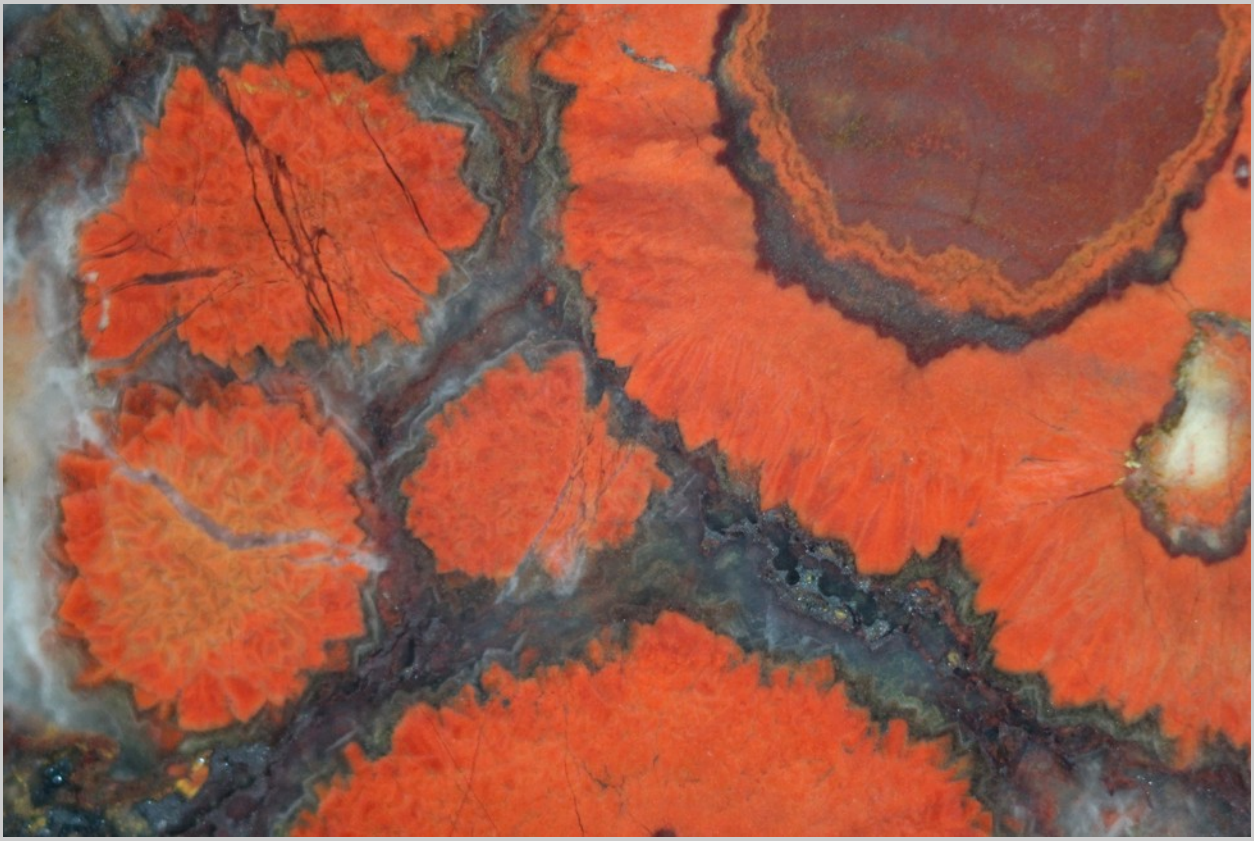
Jasper Breccia

This is a brecciated rock of unknown (to me at least) origin that now seems to be 'petrified' into a largely uniform crypto-crystalline rock known to rockhounds and lapidarists as 'jasper'. There are many such 'jaspers' and 'jaspagates' found in California and this is probably one of them.



Unknown Jaspagate

This is an interesting piece I dug out of a box of unknown slabs. It may well be Morgan Hill “Poppy Jasper”: but I don't consider it to be what I would normally call 'poppy jasper'. Probably a volcanic rock originally, it appears to have been invaded by chalcedony/agate, not an unusual occurrence. It also appears that the agate has been recrystallized into another crypto-crystalline quartz form; for simplicity, I'll call it jasper.



Poppy Jasper, California

“Poppy Jaspers” are very popular with lapidarists. Typically they originate as a 'bird's eye rhyolite' a volcanic rock with orbicular mineral formations. These rhyolites are often sold as 'jasper' and the better grades of the material are highly silicated, 'jasperized' we might say, rather than 'agatized'. The one above seems to have formed as mineral orbs surrounded by radiating quartz crystals floating in a chalcedony-like matrix, which we will see more of later. Admittedly without benefit of thin section analysis I believe this specimen and the one before have been recrystallized by heat and pressure into another quartz species, one without the characteristics of chalcedony – translucency, conchoidal fracture, greasy lustre - one that can be lumped in the catchall term 'jasper'.