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Agates from Morocco: Gemological Characteristics and Proposed Origin
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Review of "Agates from Morocco: Gemological Characteristics and Proposed Origin," by Donald Kasper, 2016

This paper on agate genesis from a study of Moroccan agates is online from the Gemological Institute of America (GIA). It shows some basic study of samples using Raman, X-ray spectroscopy, and cathodoluminescence. I study agates with infrared spectroscopy, but it is not that far from Raman. The two can generally be correlated. The paper has a review of the literature and repeats a number of myths about agates that this paper propagates. They studied some samples providing some useful information, and making several very serious mistakes. I will focus on the mistakes:

1. There is no feldspar and no pyroxenes is any agate or opal of this planet. Some rocks sold as jasper have trace sanidine. This is fairly rare. They studied an implosion structure that brought in volcanic ash (rhyolitic lava), that are not an agate compositional structure. Trace rutile (titanium) does occur in some agates if you have a microscope. It is probably the low temperature form, ilmenite. These are usually dumped in the agate open vug cores in a last vapor phase.
2. Their assay shows opal-CT. Armed with a huge archive of mineral samples over 30,000 in number, I find zero opal-CT in hydrothermal systems. They have opal-A and opal-CTA, but no opal-C, and no opal-CT. So the Moroccan agates did not form from hydrothermal action and the opal they contain proves it. Opal-C and opal-CT is only found in pyroclastic rocks, and is found in the cores of geodes. Geodes are agates with rhyolite, dacite, or andesite lava shells.
3. They state that agates are comprised of alpha-quartz and moganite. This is wrong and needs to stop being perpetuated. Agates are calcite-silica-clay-hydrate rocks. They are full of clays, carbonates, and many silica species including alpha- and beta-moganite, alpha- and beta-quartz, melanophlogite, opal-C, opal-CT, opal-Q, opal-BQ, and opal-BC. Q means quartz, and B means beta forms. Why can the authors not see these opals? Because opals cannot be reliably identified with X-Ray spectroscopy, their standard for identifying minerals. Raman has problems with fluorescence, so only works in far-infrared out of range of most opal bands. Infrared can study opals all day long, and they don't use infrared, so there you go. Wrong technology. The clay present in agates is typically bentonite, but also includes glauconite, celadonite, and chlorite. Carbonates include calcite, dolomite, and rarely aragonite, siderite, and ankerite. This is not from guessing, this is from identification using spot reflectance infrared and getting graphs correlated to reference mineral specimens where I have observed this. So agates are not varietal quartz. This is dogma, belief not based on facts. Agates are rocks. Now if you bash the specimens to bits and pick out the quartz, it is 99% pure quartz as people like Dr. Moxon out of England have found. So what. The whole structure is vastly complex. Plumes and tubes are opals. Discoids and spheroids are beta-moganite. A universe of complexity reduced to banal generalizations by these authors. This is 1800's thinking they want to perpetuate. Geology by slogan, cliché. and buzzword writing.
4. Agates are not formed in cycles by weathering. They have no humic acid found in groundwater exposed to plant matter. They have no opal-A, not one in the world has that, which is the only opal formed by weathering. They contain beta-moganites all the time which forms at 354 C. They contain chlorites all the time, which is medium grade metamorphism around 425 C. The outer depositional layer is universal that cannot occur with weathering. Weathering only makes silica laminar layers. This outer coating of the void

core forms in supercritical fluids (over 374 C) by vapor deposition. There is no physics that exists to explain this wall-lining depositional layer by weathering. The dominant mineral in groundwater is not silica, it is calcite. Silica is virtually insoluble in groundwater. Agates are not found in granite, schist, or sandstone, all with quartz, or in tropical areas with water. They are only found in lava rocks, commonly in deserts. This is not weathering. This is volcanic activity that makes agates.

5. Agates are not formed with infiltration canals. They are pressure induced exit canals, rich in beta-quartz and beta-moganite for those that bother to look, making extrusion structures when formed in soft host rock.
6. There is no timing of fluid influxes. The exsolution of lava that occurs as it cools, separating out feldspar and quartz is key to agate formation. The author finds that only K-feldspars occur in the shells of geodes. These are highly prone to exsolution (silica-feldspar separation), particularly for albite. This does not occur in the plagioclase feldspars. There are no plagioclase feldspars in geode lava shells. If the silica was coming from someplace other than the melt, any feldspar would be found in geode shells, which is not the case.
7. Agates do not contain barite. This is false. Barite occurs in jaspers only. There are no barite crystals in agates. There is no gypsum in agates. These intrude in groundwater from weathering through rock fractures such as the agate fractures formed by sitting 75 million years in the ground near the surface exposed to annual freeze-thaw. The calcite, gypsum, and barite are commonly deposited in the remaining agate central voids, but calcite can form early on the void walls, later engulfed in silica.
8. Episodic deposition of calcite and silica is exceptionally rare, but must be common to be a method of agate formation from weathering. Currently, only the vein agates of Big Diggins (sic), New Mexico have internal calcite crystals on agate banding planes on a noticeable scale. Since calcite is much more soluble in water than silica, this must be a dominant feature if agates form from weathering but does not occur. How does the water get so pure? It is magmatic water that comes out of the melt as the lava rises to the surface and degasses.
9. The so-called infiltration channels or osculums are supercritical fluid tunneling structures. They are not linked to anything in terms of banding planes other than deflections of the banding planes around them. They pierce the banding planes. Exit tubes have banding deformation that is warped parallel to the tube that does not occur in osculums. Exit tubes/tubes of entry to some, are not osculums. They show high temperature exposure.
10. Cathodoluminescence shows pyroxene in the banding. This is absurd and CL is bunk science. The colors cannot be competently attributed to mineralization and the pyroxene identification proves it. Pyroxenes form at temperatures over 870 C, while they said a few sentences before they believe circulating groundwater over time (presumably 10 C) forms agates. That is an error in understanding of 860 C. No agate would survive that temperature. It would form a silicate metamorphic mineral. The carbonates they found in the agates would all oxidize to calcium oxide above 600 C. Likewise, pyroxenes cannot form at 10 C.
11. They do show in Figure 1, several prasiolites. The author's scan of a prasiolite from Poland, and one from Santa Barbara, CA show some indication of beta-quartz which is exposure to 575 C. Prasiolite coloration can be induced in a lab at 400 C. 374 to 575 C are supercritical fluid conditions.
12. The authors conclude all sorts of mineralization by finding single bands and then quoting a source that said it was attributable to a certain mineral. This is not competent infrared or Raman spectral analysis. ALL THE MINERAL BANDS MUST MATCH. ONE IS NOT AN IDENTIFICATION. Now, in Raman, the appearance of a 501 cm band is called moganite. It cannot discern alpha and beta-moganites, so everyone has come to think that band is alpha-moganite. This is based on guessing. But in regular infrared, comparison of Raman to reflectance infrared shows two types of infrared graphs map to 501 cm moganite. We have found two polymorphs of moganite. One alpha, one beta. In the meantime, all these other single bands are not identification at all.
13. The 769 and 686 cm Raman bands assigned to anorthite feldspar, 671 cm bytownite, in regular infrared spectroscopy is called quartz. The 1240 and 1076 cm Raman bands assigned to anorthite feldspar, in regular infrared spectroscopy is called quartz. These are the two main quartz bands.

14. The 1606 and 1330 cm Raman peaks, in regular infrared spectroscopy is called a calcite doublet band. This is the main calcite peak. They do not prove carbonaceous matter, but the 1606 band being very tall is linked by the author to carbon bound in calcite structure.
15. They claim that algae of marine origin likely contributed to the carbonaceous matter found, ignoring the problem that agates are not found in marine systems. They can form by pyroclastic flows onto beaches, and when they do, they contain foraminifera, not found in these agates. Agates are not found with salts, and do not form in saline playa lakes. This presumption, common in the literature is disproven by the author's field collection in the Western U.S. and study of its many playa lakes.
16. Their conclusion that agates take tens of millions of years to form, when they are being dug out of deserts, and claiming groundwater circulation made them when they are only found in desert basalts for the amygdules, is dogma, not science. It could be claimed that earlier conditions were wetter, but as you look around the world, the world's agates are dominantly found in deserts, and never in tropical climates. The southern Brazil agates are in wet climate, but they formed 135 million years ago when plate tectonics put Brazil to the southeast in a desert climate zone. The German geodes are Permian over 340 million years old in another climate regime to the south. Agates are commonly found where there is no water currently, and to say that they always were wetter for every site worldwide is flimsy theory and unproven. You cannot go to lakes, rivers, seashores, or rainforests and dig to see agates being formed. They do not exist in sites with water preferentially compared to desert sites. So a model of groundwater making them is failure to take into account all the observations of their geologic settings.
17. Observation of chlorine in the agates is an observation of desert weathering that also includes intrusion of sulfates and salts, titanium, and iron oxides. Agates are porous, stained by these minerals.

Conclusions:

The Gemological Institute of America (GIA) paper on Moroccan agates is based on Raman study of ash implosion structures that do not define the composition related to how agates form. They studied only a half dozen specimens, insufficient for worldwide generalization of agate genesis by at least 3 order of magnitude (10,000 times). This contaminated their analysis with feldspar associated with quartz, but not agates.

There are alpha and beta-moganites. Only the alpha form is deposited associated with evaporite systems, and yet their paper cannot distinguish between the two types with X-ray or Raman spectroscopy. There is zero pyroxene and feldspars found in agates. This was speculated based on substandard spectral analysis.

The conclusion that all moganite in Raman analysis is alpha-moganite and proves marine origin of agates is substandard science. Cross-correlation of two spectral types of moganite in infrared, then scanned in Raman, only shows a 501 cm Raman peak, yet the two infrared graphs have different bands affected. One band is enlarged and the other is suppressed with higher moganite concentration. Out of 2000 specimens the author studied, 8 have both bands affected. There is no series of transitional forms found. The peaks do not drift between these two types. The author has proposed one is alpha-moganite, the other is beta-moganite. The beta-moganite is exclusively found in ignimbrite rocks, while the alpha-moganite is in agate banding and sedimentary rocks exposed to temperatures up to 150 C. The author's comparison to one of Dr. Heaney's Gran Canaria Island master reference moganites from the batch he used to define and publish about moganite, graphs in infrared as a beta-moganite not found in sedimentary or evaporate rocks studied by the author over 6 years. Why did Dr. Heaney claim his mineral is alpha-moganite after digging it out of a pyroclastic flow on the flank of a volcano, and claiming it was of evaporite origin, we may never understand. Raman being unable to distinguish the two moganite polymorphs has led to a perpetuated confusion in the literature and false diagnosis of the origins of silica formation with moganites.