Geochemical Reactions for Agate, Jasper, Opal, and Chert Formation

1. Calcite concretions replacement.
2. Bentonite clay nodule alteration and infill.
3. Fossil replacement (carbonate activated).
4. Lapilli (volcanic glass clasts) alteration.
5. Phase change from cristobalite.
6. Cristobalite growth. Oolitic cherts appear to be cristobalite.
7. CO_2 release forcing SiO_2 precipitation.
8. Silica exsolution (with supercritical water) from lava melt.
9. SO_4 bacteria precipitation.
10. Fe^{3+} bacteria precipitation.
11. Mn^{3+} bacteria precipitation.
12. Dolomite replacement.
13. Silica concretions.
14. Volcanic glass content.
15. Volcanic glass decomposition (in ash, lava).
16. Calcite forcing precipitation (pH buffering).
17. Feldspar reaction byproduct.
18. Bentonite + feldspar to illite, chlorite reaction.
19. Zeolite byproduct (clinoptilolite, mordenite).
20. Hydrothermal precipitation.
21. Gypsum replacement (evaporites).
22. Barite replacement (evaporites).
23. Limestone chert deposition.
24. Silcrete probably silica-caliche contact.
25. Formation in bogs, acidification of alkaline systems precipitating silica, acidic bog interface contact with alkaline waters and ash falls.
26. Sulfide interaction (carbonate neutralization).
27. CO_2 release in lava (exsolution). Includes supercritical CO_2.
28. Clay byproduct (bentonite, kaolinite, illite, halloysite, sepiolite, saponite).
29. Serpentine alteration. Genesis of poppy jaspers.
30. Epigenetic vein deposits.
31. Eruptions through carbonate deposits.
32. Petrified wood formation, a process of decay acidification of alkaline-silica waters forcing silica precipitation.
33. Saline or playa-fresh water contact.
34. Chlorite to chloritoid byproduct.
35. Carpholite byproduct.
36. Pyrophyllite byproduct.
37. Epidote byproduct.
38. Scolecite byproduct.
39. Clinochlore byproduct.
40. Anorthite dissolution.
41. Sericite metamorphism (feldspar decomposition to illite and silica).
42. Prehnite dissolution.
43. VMS (volcanogenic massive sulfide) vents. Outer sericite aureole for agates and jaspers.
44. Smokers (chimneys). Marcasite-silica, jaspers.
45. Andalusite alteration.
46. Siliceous argillite (metamorphosed claystone).
47. Augite dissolution.
48. Acid neutralization with carbonate to anhydrite.
49. Olivine to rhodochrosite byproduct.
50. Olivine to iddingsite (a rock compound).
51. Pumice to allophane (opal) in eruptive systems.
52. Phreatomagmatism—the creation of ultra-supercritical water by the flow of lava over wet ground. This creates basalt flow basal void formation.
53. Apatite nodules (marine) replacement.
54. Ballen-quartz structures (large volcanoes) producing hemi structure accumulations (Biggs, Bruneau-type jaspers).
55. Sepiolite byproduct (brackish water, lagoonal) associated with ash fall over limestone (Mexican Lace).
56. Silica supersaturation from caldera collapse, tectonics, or other loss of overburden causing pressure loss and boiling. Makes more crystalline quartz than agate.
57. Transition below supercritical water (374 C) causing silica supersaturation.
58. Transition below ultra-supercritical water (575 C) causing silica supersaturation.
59. Vein formation from shrinkage via lava cooling and faulting causing overpressured water release, boiling, silica supersaturation.
60. Volcanic glass quenching on flow bottoms with pyrrhotite.
61. Opal in volcanic tuff, perlite, pitchstone as hydrothermal byproduct.

62. Olivine to orthopyroxene, magnetite; further orthopyroxene decomposition.
63. Inversion of coesite to cristobalite, chalcedony, and opal. Found with coesite inclusions in Alps pyrope garnet.
64. Clinoptilolite, stilbite, mordenite (zeolites) dissolution.
65. Laumontite decomposition.
66. Redox boundary in groundwater migration—jasper-iron deposition.
67. Retrograde metamorphism of riebeckite making agate pseudomorph after riebeckite. Related to riebeckite to iron minerals and agate.
68. Perlite alteration to illite, smectite, zeolites. Enormous silica release.

Marginal agate silica contribution

1. Siliceous ooze (microscopic banding).
2. Radiolarians decomposition (opaque banding).
3. Foraminifera – calcite and calcite/silica shells (large orb structures).

Acidic Weathering to Opal

4. Common opal from granitic weathering (never precious opal, agate, jasper).
5. Volcanic soil weathering with humic acid to allophane, opal (never agate, jasper).
6. Opal speleothems (cave structures) from quartzite and sandstone, stromatolite mediated.

Saline-Alkaline Formation of Opal

1. Opal from vitric glass decomposition and zeolite (clinoptilolite, mordenite, phillipsite, analcime) dissolution. Forms in playa lakes and oceanic basalts.
2. Clinoptilolite and phillipsite to analcime (all zeolites). Analcime is related to saline systems, and so is not found in agates.

Chert, Chert-Agate Formation

1. Sediment-water interface with volcanic ash altered to glauconite for chert, glauconite mobility with continental exposure to illite (illitization).
2. Sea shelf volcanic ash deposition.
3. Radiolarian contribution.
4. Interstitial grain space cristobalite accumulation (oolitic chert-agate). A process of oolite banding aggregation to form banding centers.
5. Agate replacements within cherts due to continental exposure, ash overburden deposition, mobilizing silica. Often sponge replacements at chert nodule cores.
6. Chert at montmorillonite-halloysite contact with cave speleothems (limestone stalagmites), Guadalupe Caves, NM.
7. Cyanobacteria. Common for cherts (very small oolites).

Invalid Formation Mechanisms

1. Granite, sandstone, and other quartz rock weathering to sand. The beaches are full of sand and have no agates. No agates in granite voids.
2. Hydrothermal vents. Hydrothermal venting itself produces sinters, which are porous, not agates. Deposition is opaline mixed with carbonates.
3. Rainwater with silica deposited in voids. No schist or granitic systems with weathering and high silica waters have agates. No acid soil systems have agates. It cannot be explained why non-lava voids never fill with agates with this model.
4. Spontaneous alteration of opal to agate or quartz. (So-called Opal-A to Opal-CT to Agate to Quartz alteration pathway). Opal decomposes to clay with weathering.
5. Magadiite and kenyaite loss of sodium and water to release silica, esp. for chert. Source minerals highly saline. No evaporites and no salts are found in agates. Agates are never found in playa lakes.
6. Phytolith dissolution. Plant opal structures. Not seen in agates.
7. Sponge spicules. Found intact in fine cherts.

Alteration to Quartz

1. Jasperoid (quartz, pyrite, alunite, pyrophyllite, etc.) in acid volcanics. Does not involve cristobalite, silica, agate.
2. Rapid source melt lava decompression linked to quartz formation, instead of agates.
3. Hypersaline systems produce massive quartz, not banded agate.