# Weathering-made pisolites: Analogue for Martian blueberries

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Scattered hematite 'blueberries' 1 cm across occur in sulfate-cemented silicate/sulfate sediments in Meridiani outcrops photographed on Mars. We propose that *pisolites* made on earth during weathering of any parent rock regardless of climate may be a close analogue for the genesis of the Martian blueberries. Earth's pisolites start at the bottom of the saprolite as small diffusse patches, which become darker, rounder, more sharply defined, and more concentrically layered as they 'climb' within the profile. Pisolites in a particular weathering profile consist of one or two oxides/oxyhydroxides: gibbsite in bauxites, iron oxides in laterites and terra rossas, calcium carbonate in calcretes, manganese oxides in Mn-rich laterites, quartz in silcretes.

The Martian blueberries could have formed by reaction of descending water through a clastic deposit consisting of iron sulfide and silicate grains at moving coupled reaction fronts similar to those accounting for lateritization on Earth (Merino et al, Amer J Sci 1993; Wang et al, GCA 1995), as follows.

First, at level A, pyrite would be oxidized to sulfate by the $H^+$ in the water (reaction 1), and the H+ released by that oxidation would dissolve olivine according to (2):

$$\mathbf{FeS_{2(pyr)}} + 8H_2O = 2SO_4^{--} + 2H^+ + 7H_2(gas) + Fe^{++} \text{, (1)}$$

$$\mathbf{MgFeSiO_{4(s)}} + 4H^+_{(aq)} = SiO_{2(aq)} + Mg^{++} + Fe^{++}_{(aq)} + 2H_2O \quad (2)$$

Then the $Fe^{++}_{(aq)}$ generated by (1,2) would be advected downward to level B, where it would drive *replacement* of fresh grains of olivine and pyrite by hematite according to:

$$\mathbf{MgFeSiO_{4(s)}} + 2Fe^{++}_{(aq)} + 2.5H_2O = 1.5\mathbf{Fe_2O_3} + SiO_{2(aq)} + 1.5H_2 + 2H^+_{(aq)} + Mg{+}{+}, \quad (3)$$

$$5/4\mathbf{FeS_{2(pyr)}} + 3/4\, Fe^{++} + 8H_2O = \mathbf{Fe_2O_{3(hem)}} + 5/4SO_4^{--} + 6H_{2(gas)} + 4H^+, \quad (4)$$

respectively. These *scattered* hematite replacements would be the starting stage of the future blueberries. In both (3,4) $Fe^{++}$ is oxidized by H+, which is reduced to $H_2$. The two redox replacements (3,4) are adjusted conserving both electrons and solid volume. The olivine and pyrite left unreplaced by reactions (3,4) in level B will become reactants for reactions (1,2) when the oxidative dissolution front A reaches today's level B. Areas of Mars without surface hematite could be accounted for if water had occurred only in a few areas. The $SO_4^{--}$ released by (1,4) and the $Mg^{++}$ released by (2,3) could make $MgSO_{4(s)}$ or $MgSO_4.H_2O_{(kieserite)}$ as cement.