Martian Spheres Resemble Biological/Terrestrial Soil Concretions

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Abstract

Many of the features associated with the surface spheres photographed on Mars can be explained by soil-based processes found on Earth. Many resemble soil concretions/iron-Mn nodules/pisolites in size and abundance. On Earth, these concentrate as lag deposits where soil erosion has been active. They are composed of both hydrated and anhydrous iron-oxide minerals. Iron bacteria and filamentous fungi may play a role in their formation. There is evidence of mud, water, moisture, and water-ice on Mars. It is not difficult to interpret that Mars could have been subjected to wet/dry cycles or shifting redox boundaries similar to conditions that form these soil-based structures on Earth. Soil concretions are often bound together by microorganisms including algae and fungi. Terrestrial spherical hematite is also often infiltrated by various organisms. It is possible the spheres of Mars include hematite, hydrated crystals, and lapilli that may harbor life.

Key Words: Mars, Soil Concretions, Water, Mud, Life on Mars

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1. Soil Concretions, Lapilli, Tektites, Hematite, Fungi

The spectral signature of "hematite" had been tentatively identified on the Martian surface in 1998 by NASA's Mars Global Surveyor spacecraft's infrared Thermal Emission Spectrometer. The spectra was interpreted to represent what was believed to be fine or coarse grains of crystalline hematite (Christensen et al. 2004; Morris et al. 2004; Squyres et al. 2004). The hundreds of thousands of spheres upon the surface, however, were unexpected (Joseph 2021). NASA and its rover teams have speculated that the spheres consist of hematite (Christensen et al. 2004; Klingelhöfer et al. 2004; Soderblom et al. 2004; Squyres et al. 2004). Other investigators argue in favor of mineralized hydrated crystals fashioned by bolide impact (Knauth et al. 2005; DiGregorio 2004; Royer et al. 2008), or the accretion of lapilli following volcanic eruption (DiGregorio 2004) or the growth of living organisms, fungal puffballs, or lichens attached to rocks (Joseph et al. 2020, 2021; Joseph 2021).

The surface spheres are rather uniform in shape, with collections ranging in size from 3mm to 6mm in some areas of Mars, or less than 1mm in size (DiGregorio 2004; Joseph 2021; Knauth et al. 2005). This uniformity is troublesome for the hematite hypothesis as collections of hematite have a variety of shapes and size and may be quite large. Another oddity is these surface spheres were initially described as "yellow" "orange" and "purple" (Soderblom et al. 2004), although in later publications they were described as "gray." These colors are not associated with hematite which is usually red or dark red. Admittedly, there is a similarity to lapilli and tektites (DiGregorio 2004; Knauth et al. 2005; Royer et al. 2008), which, however, are not associated with hematite.

If there are grains of hematite on the surface as reported by NASA's Opportunity team and if these spheres contain hematite, then we can rule out lapilli and tektites (DiGregorio 2004). If they are not spherical fungi that may have precipitated and/or colonized hematite as hypothesized by Joseph et al. (2020, 2021; Joseph 2021); then what else might they be?

2. Soil Concretions & Biology: Observations and Hypotheses

The smaller marble-like spheres at Eagle Crater on Mars strongly resemble structures called soil concretions/nodules/pisoliths on Earth. Examining these mostly <1cm in size structures in more detail could enhance the search image for similar processes on Mars. The evidence supporting this interpretation includes minerals and metals including Fe-Mn (Treiman & Essen 2011; Vaniman et al. 2014) and evidence of moisture (Martin-Torres et al. 2015; Steele et al. 2017; Martinez et al. 2015) that has been detected, including what may be mud attached to the rover aluminum wheels (Joseph et al. 2019). It is well known that fungi, bacteria, polysaccharides bind aggregates of soil which adhere to metal surfaces (Bazaka et al. 2011; Ceasar-Tonthat, 2002; Chen et al. 2014; Robbins et al. 1992). There is also evidence of wind, weathering, erosion, and prolonged dry spells. In combination, all these variables may bind and form concretions.

Scatterings or carpets of soil concretions occur in places where erosion has left behind lag deposits of these hard structures formed in the soil profile but exposed when the softer sediment eroded. In Alexandria Virginia, Robbins et al. (1992) interpreted that the Fe-Mn concretions formed at a shifting redox boundary where the water table in a wetland rose and fell seasonally. In the Kampong Thom Province of Cambodia, Mitsuchi (1976) interpreted that the Fe-Mn concretions formed in soils having seasonal wet and dry cycles.

Biological components have been found in the Earth-based concretions. Robbins et al. (1992) found mineralized cocci and filamentous rods in the concretions in Alexandria Virginia. Schulz et al. (2010) found fungal hyphae in Santa Cruz California concretions. Ongoing analyses of soil concretions in San Diego California shows that mineralization is concentrated around structures that resemble former holdfasts and capsules of the iron bacteria *Leptothrix discophora* and *Siderocapsa* sp. (Robbins, 2021).

Robbins and Iberall (1992) have suggested that mineralized chemlithotrophic iron bacteria may have played a role in catalyzing the precipitation of iron oxide minerals on Mars. Almost 30 years later, Joseph (2021) has arrived at similar conclusions and hypothesized Martian organisms may be feasting on and may be supersaturated with iron.

Mineralogy of concretions, however, is not uniform. Robbins et al. (1992) analyzed romanechite and ferrihydrite. Mitsuchi (1976) found hematite, maghemite, and goethite. Current research on San Diego Pleistocene terrace redbed concretions shows hydrated (goethite, ferrihydrite, lepidocrocite) and anhydrous (hematite) FeO minerals (Waychunas et al., 2005) on enclosed quartz and magnetite grains (Robbins, 2021). These minerals have all been detected on Mars (Treiman & Essen 2011; Vaniman et al. 2014) and supports the strong possibility the smallest spheres are soil concretions.

3. Conclusions

Even though we lack actual samples to analyze from Mars, it is not difficult to interpret that the carpets of spheres could be soil concretions formed or infiltrated by a variety of organisms. It is believed that Mars has been subjected to numerous wet/dry cycles which would have favored the formation of biologically-catalyzed concretions as well as contributing to soil formation. Iron oxide minerals that precipitated under wetter conditions (goethite, ferrihydrite) probably would have dehydrated to anhydrous hematite. If the smaller Martian spheres are soil concretions they may help address the question of current and past life on Mars.

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