American Mineralogist, Volume 100, pages 738–746, 2015

WHAT LURKS IN THE MARTIAN ROCKS AND SOIL? INVESTIGATIONS OF SULFATES, PHOSPHATES, AND PERCHLORATES

Akaganéite and schwertmannite: Spectral properties and geochemical implications of their possible presence on Mars†

Janice L. Bishop[1,*], Enver Murad[2] and M. Darby Dyar[3]

[1]Carl Sagan Center, SETI Institute, 189 Bernardo Avenue, Mountain View, California 94043, U.S.A.
[2]Bahnhofstrasse 1, D-95615 Marktredwitz, Germany
[3]Department of Astronomy, Mount Holyoke College, South Hadley, Massachusetts 01075, U.S.A.

Abstract

The ferric oxyhydroxide minerals akaganéite and schwertmannite are associated with acidic environments and iron alteration on Earth and may be present on Mars as well. These minerals have a tunnel structure and are crystallographically related. The extended visible region reflectance spectra of these minerals are characterized by a broad Fe^{3+} electronic transition centered near 0.92 μm, a reflectance maximum near 0.73 μm, and a shoulder near 0.59 μm. The near-infrared (NIR) reflectance spectra of each of these minerals are dominated by broad overtones and combinations of the H_2O vibration features. These occur near 1.44–1.48 and 1.98–2.07 μm (~6750–6950 and 4830–5210 cm^{-1}) in akaganéite spectra, while in schwertmannite spectra they occur at 1.44–1.48 and 1.95–2.00 μm (~6750–6950 and 5005–5190 cm^{-1}). Additional bands due to OH vibrational overtones are found near 1.42 μm (~7040 cm^{-1}) in akaganéite and schwertmannite spectra and due to OH combination bands in akaganéite spectra at 2.46 μm (4070 cm^{-1}) with weaker components at 2.23–2.42 μm (4134–4492 cm^{-1}). A strong and broad band is observed near 2.8–3.1 μm (~3300–3600 cm^{-1}) in reflectance and transmittance spectra of akaganéite and schwertmannite due to overlapping OH and H_2O stretching vibrations. H_2O bending vibrations occur near 1620 cm^{-1} (~6.17 μm) in akaganéite spectra and near 1630 cm^{-1} (~6.13 μm) in schwertmannite spectra with additional bands at lower frequencies due to constrained H_2O molecules. OH bending vibrations occur near 650 and 850 cm^{-1} (~15.4 and 11.8 μm) in akaganéite spectra and near 700 cm^{-1} (~14.3 μm) in schwertmannite spectra. Sulfate vibrations are observed for schwertmannite as a ν_3 triplet at 1118, 1057, and 1038 cm^{-1} (~8.9, 9.5, and 9.6 μm), ν_1 at 982 cm^{-1} (~10.2 μm), ν_4 near 690 cm^{-1} (~14.5 μm), and ν_2 at 608 cm^{-1} (~16.5 μm). Fe-O bonds occur near 410–470 cm^{-1} (μm) for akaganéite and schwertmannite. Both minerals readily absorb H_2O molecules from the environment and adsorb them onto the mineral surfaces and incorporate them into the tunnels. If akaganéite and schwertmannite were present on the surface of Mars they could enable transport of H_2O from the near-surface to the atmosphere as the partial pressure of H_2O varies diurnally.

Keywords: Iron oxide, iron oxyhydroxide, reflectance spectroscopy, IR spectroscopy, Mars