

SPECTRAL CHARACTERISTICS OF FE-PHYLLOSILICATES: COMPARISON TO MURCHISON AND MURRAY

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We are modelling the reflectance spectra of CV and CM chondrite meteorites using a new approach that is based upon the known chemistry, mineralogy, and grain size distributions as determined by TEM and other analytical techniques. The first step in this approach is to spectrally characterize the individual mineral phases that have been identified in CV and CM chondrites. Anhydrous silicates such as olivines and pyroxenes, commonly found in CV chondrites, have been previously well characterized spectrally [1,2]. The CM chondrites show significant alteration of primary minerals, resulting in compositions dominated by aqueous alteration products such as phyllosilicates, sulfates, oxides, hydroxides and carbonates [e.g., 3]. The phyllosilicates top the list of abundant phases, and in the CM chondrites in particular, Fe-rich serpentines are the most common phases [e.g. 4]. King and Clark [1989] [5] have characterized the Mg-serpentines and chlorites, noting certain spectral similarities between chlorites and CI1 and CM2 chondrites. We present the results of an examination of the reflectance spectra of Fe-serpentines and two varieties of chamosite (chlorite group). We find these minerals can provide a reasonable spectral match to features seen in certain CM chondrites and by extension, the dark asteroids.

We have measured the reflectance spectra of several different high-iron phyllosilicates. Samples were primarily obtained from the National Museum of Natural History (NMNH) with one extremely high iron chamosite known as thuringite provided by the University of Münster. Samples were hand picked under a microscope, ground to size fractions less than a few hundred micrometers, and measured in bidirectional reflectance from 0.3 to 25 μm . Samples were also characterized by x-ray diffraction (XRD) and found to contain varying amounts of secondary minerals, most of which do not significantly alter the measured reflectance. In the serpentine group we have measured samples of greenalite $(\text{Fe}^{2+}, \text{Fe}^{3+})_{2-3}(\text{Si})_2\text{O}_5(\text{OH})_4$, berthierine $(\text{Fe}^{2+}, \text{Fe}^{3+}, \text{Mg})_{2-3}(\text{Si}, \text{Al})_2\text{O}_5(\text{OH})_4$, and cronstedtite $\text{Fe}_2^{2+}\text{Fe}^{3+}(\text{Si}, \text{Fe}^{3+})\text{O}_5(\text{OH})_4$. In the chlorite group we have measured two different samples of chamosite $(\text{Fe}^{2+}, \text{Mg}, \text{Fe}^{3+})_5\text{Al}(\text{Si}_3, \text{Al})\text{O}_{10}(\text{OH}, \text{O})_8$. We have measured an additional Mg-serpentine amesite $\text{Mg}_2\text{Al}(\text{Si}, \text{Al})\text{O}_5(\text{OH})_4$, which was not examined by King and Clark [5]. (Chemical formulas cited reflect the ideal given in [6].)

As seen in Figure 1 the Mg-serpentines are characterized by abundant narrow absorption features particularly at 1.4, 2.0, and 2.2–2.4 μm . These are typical of hydroxyl (OH) and Mg-OH vibrational modes. Additionally there is fine structure in the 3- μm fundamental absorption OH/H₂O and a broad feature from 0.6 to 1.8 μm typically with several minima at 0.7, 0.9, and 1.1 μm . The broad feature from 0.6 to 1.8 μm is attributed to ferrous iron, and the multiple minima are caused by $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+}$ intervalence charge transfer transitions [7]. In contrast, the most dominant features in the Fe-serpentines, the broad absorption from 0.6 to 2.0 μm characteristic of Fe^{+2} , and the 3- μm water absorption both lack any secondary minima. Narrow features from 2.2 to 2.4, 3.3 to 3.5, and 3.8 to 4.2 μm in the berthierine are caused by the calcite contamination noted in the XRD analysis. The chlorite spectra exhibit variations according to increasing iron content from clinocllore (Mg-endmember) to thuringite. The clinocllore exhibits spectral characteristics similar to the Mg-serpentines, including narrow absorptions at 1.4 and 2.2–2.4 μm , and the broad band from 0.6 to 2.0 μm with secondary minima. As the iron content increases in the chamosite sample these secondary minima tend to disappear and the reflectance level in the visible drops so that the prominent spectral feature is the strong absorption from 0.6 to 2 μm , as is also seen in the Fe-serpentine spectra. The thuringite is so iron rich that

the reflectance level is less than 5%, and there is a peak in reflectance between the strong iron charge transfer absorption shorter than $0.5 \mu\text{m}$ and the ferrous absorption centered on $1 \mu\text{m}$. While the thuringite sample still exhibits the minimum at $0.7 \mu\text{m}$, the spectral features from 1.0 to $4.0 \mu\text{m}$ are completely suppressed except for the strong $3\text{-}\mu\text{m}$ fundamental water absorption. Additionally some of the Mg-bearing samples of both serpentine and chlorite (all of which contain some iron) exhibit narrow features at $0.4 \mu\text{m}$ assigned to Fe^{+3} [7].

The reflectance spectra of Murchison and Murray exhibit the broad triangular $3\text{-}\mu\text{m}$ water absorption seen in the phyllosilicates and have a downturn in the visible typical of all the layer silicates we measured. Additionally, these meteorites have the reflectance peak near $0.6 \mu\text{m}$ as is seen most clearly in the Fe-serpentines and the thuringite.

In the infrared the spectra of CM chondrites Murray and Murchison are quite similar, with absorptions at $3 \mu\text{m}$ and $6.2 \mu\text{m}$ and a peak near $12 \mu\text{m}$; however, all these features are weak. The Mg-serpentines have two strong reflectance peaks at approximately 10 and $20\text{--}23 \mu\text{m}$. The Fe-serpentines have spectral features that are a great deal more subdued than those of the Mg-serpentines and can contribute to those seen in the CM chondrites.

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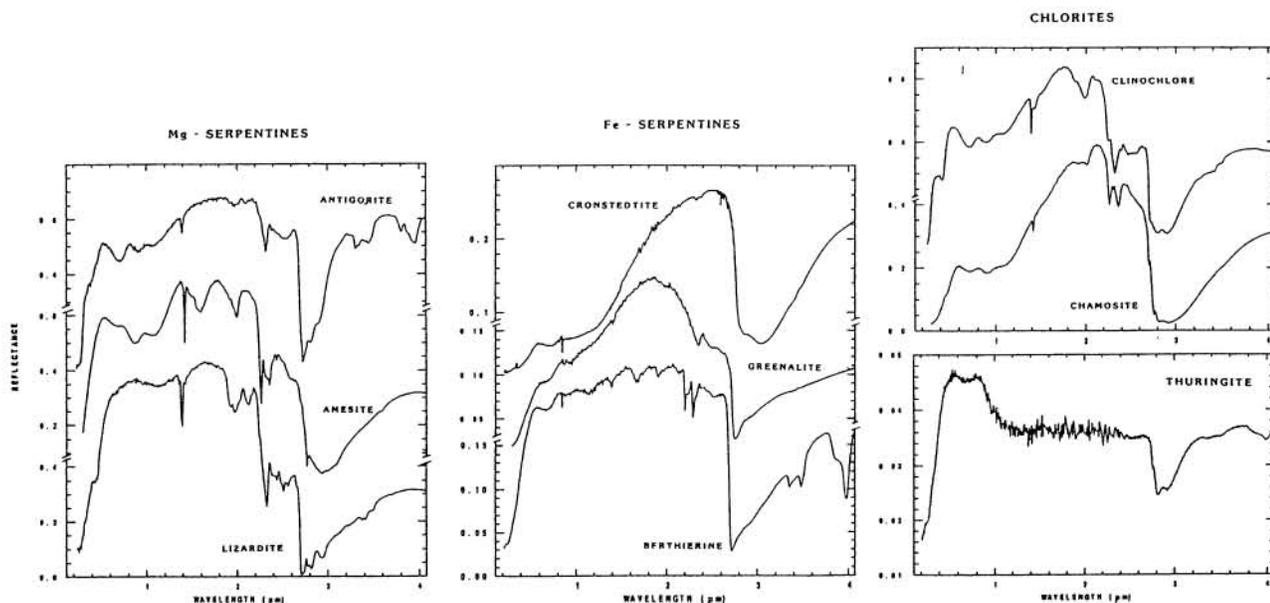


Figure 1: Reflectance spectra of Mg- and Fe-bearing phyllosilicates.