

**INTERPRETING THE ORIGINS AND EVOLUTIONS OF MARTIAN BASALTS FROM PYROXENE COMPOSITION: I. ORTHOPYROXENES;** V. E. Hamilton and P. R. Christensen, *Department of Geology, Arizona State University, Tempe, AZ 85287-1404*

**Introduction.** Visible and near-infrared spectroscopic studies [1-4] have identified pyroxenes on the martian surface ranging in composition from augite to low-Ca orthopyroxene, or pigeonite. Pyroxenes are primary minerals in basaltic rocks; if two or more are present, they may be used to establish pressure and temperature conditions of the basaltic melt. The Thermal Emission Spectrometer (TES) on the Mars Global Surveyor spacecraft will provide mineralogical data about the surface materials of Mars, and will allow for studies of individual minerals such as pyroxenes. Thus, a clear understanding of the thermal infrared (~3 to 50  $\mu\text{m}$ ) spectral properties of various pyroxene compositions will be of great value in the interpretation of the origins of martian basaltic rocks. Laboratory spectroscopic studies of pyroxenes will be carried out in order to (1) characterize the spectral effects of compositional variations among pyroxenes, and (2) establish the minimum compositional difference detectable in pyroxenes through vibrational spectroscopy.

In the thermal infrared spectral region, absorption features are due to the characteristic stretching and bending of molecular bonds. The advantage of vibrational spectroscopy over other spectroscopic methods is that unique minerals may be identified and their relative abundances determined, providing vital petrologic information. Previous studies of the middle infrared characteristics of pyroxenes have typically focused on endmember compositions and their differences with respect to other silicate minerals [5-9]. Additionally, virtually all of these studies collected transmission spectra, which differ markedly from emission spectra, and no systematic investigations of pyroxene compositional variations have been done using emission methods.

The first phase of this study focuses on quantifying the effect of Mg-Fe cation substitution on orthopyroxene vibrational spectra. Studying orthopyroxene compositions severely limits the contribution of Ca-related vibrations, allowing us to focus on the subtleties of Mg-Fe substitution effects.

**Sample preparation and procedure.** Pyroxene samples ranging in composition from  $\text{MgSiO}_3$  (enstatite) to  $\text{Fe}(\text{Mg})_2\text{Si}_2\text{O}_6$  (ferrosilite) are crushed and sieved to particle sizes between 710  $\mu\text{m}$  and 1 mm. Microprobe analysis is used to verify mineral identification and establish the purity of each sample. Samples are heated to 80°C and an emission spectrum of each is acquired with a Mattson Cygnus 100 interferometer/spectrometer. Prior to analysis, raw spectra are processed to take into account the effects of instrument response, atmospheric influences, and additional environmental energy sources present during the sample run [10, 11].

**Analysis.** Microprobe analyses of several samples are forthcoming, thus preliminary results focus on spectral differences between the major orthopyroxene endmembers. On the basis of spectral differences alone, it is possible to distinguish among major orthopyroxene compositions (Figure 1). Orthopyroxenes with higher Fe content tend to display fewer and shallower absorptions than more Mg-rich minerals. Furthermore, in the 1250 to 833  $\text{cm}^{-1}$  (8 to 12  $\mu\text{m}$ ) region, Fe-rich orthopyroxenes display absorption features which are shifted to shorter wavelengths as compared to absorptions in the spectra of Fe-poor minerals.

While major differences in pyroxene composition are reasonably easy to detect, the most prevalent compositions in nature tend to fall within a few well-defined regions of the ternary. Thus it is desirable to be able to discern finer differences in composition (e.g., among enstatites), in order to yield more accurate estimations of conditions of formation. A major portion of this study will therefore include not only the spectral characterization of major compositional differences among pyroxenes, but also the subtle variations in an attempt to distinguish the minimum compositional difference detectable by mid-infrared emission spectroscopy. Once microprobe data is acquired of all samples, detailed analysis of spectral differences between minerals of similar chemical composition will be undertaken.

**Associated studies and future work.** Because most minerals are acquired as bulk samples, we have the opportunity to spectrally analyze unprepared pyroxenes. Despite surficial contaminants, our samples display spectral features generally similar to those of prepared minerals, reaffirming the application of this method to non-laboratory situations. When possible, samples with both fresh and Fe-oxidized surfaces were also analyzed. Spectra of oxidized surfaces consistently displayed a shift of major absorptions to shorter wavelengths (Figure 2), resembling the shift observed between Fe-rich and Fe-poor orthopyroxene endmembers. Additionally, in order to have chemically "ideal" pyroxenes for spectral comparisons, synthetic orthopyroxene endmembers stable at ambient conditions will be produced and analyzed. Once spectral analysis of orthopyroxene compositions is completed, our focus will turn to clinopyroxenes so that the mid-infrared spectral effects of substitution of Ca cations into the pyroxene structure can be quantified. Ultimately, laboratory spectral studies of basaltic rocks will provide a true test of our ability to distinguish among pyroxenes in nature.

**Conclusion.** Knowledge of basaltic type provides information about the environment of magma generation (i.e., mantle or crust derived), and can provide important clues about the nature of volcanism and differentiation processes on remotely sensed bodies such as Mars. The ability to distinguish between subtle variations in pyroxene

## DISTINGUISHING ORTHOPYROXENES IN MID-IR SPECTRA: Hamilton and Christensen

composition, in conjunction with petrologic information will allow us to draw conclusions about the origins and evolutions of basaltic magmas. By establishing a comprehensive library of pyroxene spectra and determining the limits of distinguishing differing compositions, a foundation will exist for interpreting the geologic data acquired by thermal infrared instruments such as the TES.

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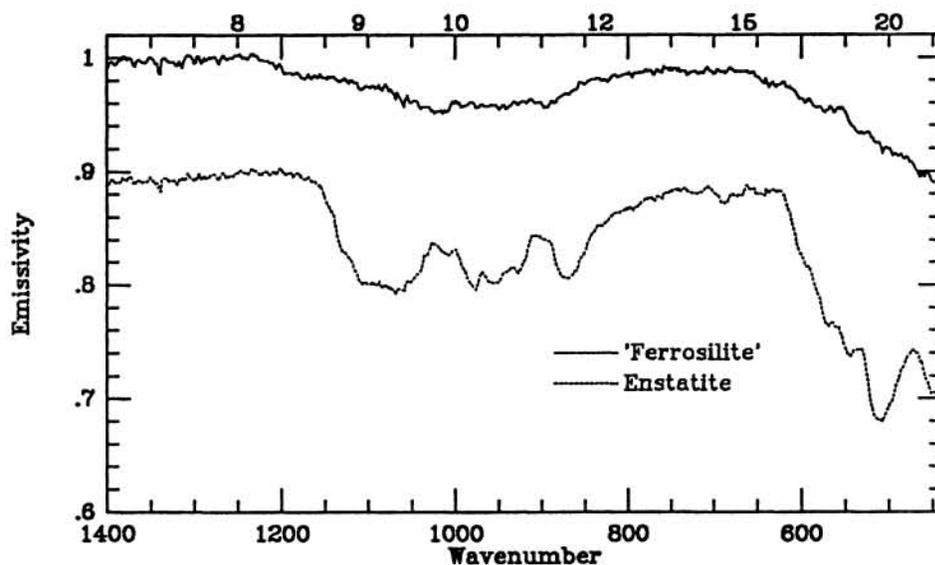


Figure 1. Emission spectra (offset) of  $MgSiO_3$  (Enstatite) and  $Fe(Mg)_2Si_2O_6$  ('Ferrosillite').

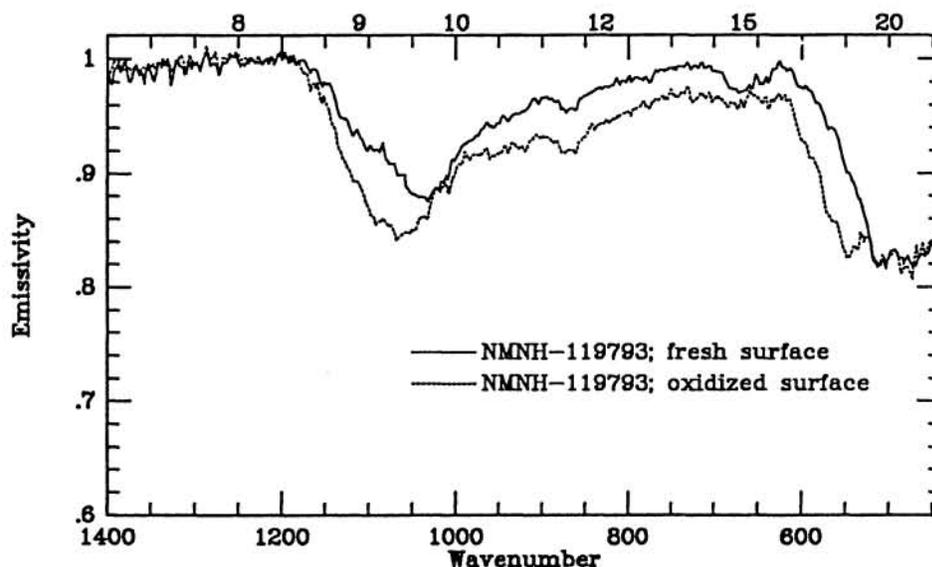


Figure 2. Bulk sample NMNH-119793, fresh and oxidized surfaces.