

COMPARISON OF VNIR REFLECTANCE AND MIR EMISSIVITY SPECTROSCOPIC CHANGES FOR IMPACT-ALTERED PHYLLOSILICATES. L. R. Friedlander¹, T. Glotch¹, J.R. Michalski², ¹Geosciences Department, Stony Brook University (255 Earth and Space Sciences Building, Stony Brook, NY 11794-2100, lonia.friedlander@stonybrook.edu), ²Planetary Science Institute.

Introduction: Based on their locations, crater counts, and association with other geological layers, clays on Mars are thought to be mostly early-to-mid Noachian in age [1-6]. As a result, clay mineral deposits on Mars are likely to have been altered by meteor impacts. Impacts directly affect clay mineral structures and related spectroscopic signatures [7, 8]. To investigate the effects of impacts on clay mineral structure and spectroscopy, we sent five phyllosilicates to the flat plate accelerator (FPA) at NASA's Johnson Space Center and exposed them to experimental impacts over a range of six pressures each between 10 – 40 GPa. The returned samples were analyzed by vibrational spectroscopy at the Vibrational Spectroscopy Laboratory at Stony Brook University. This abstract reports a summary of these results.

Materials and Methods: The materials used were selected as representative samples of each of the listed clay minerals. Our experimental impact technique separated shock from other impact processes (such as heating and melting) as much as possible.

Sample preparation. The five phyllosilicates used in these experiments (Table 1) were ground to the < 2 μm size fraction, pressed into low-porosity disks, and exposed to experimental impacts between 10 – 40 GPa peak-pressure at the FPA facility at JSC.

Sample	Formula	Type
Kaolinite (KGa-1b)	$\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$	DiOct
Nontronite (NAu-1)	$(\text{Na})\text{Fe}^{3+}_2(\text{Al},\text{Si})_4\text{O}_{10}(\text{OH})_2 \bullet n\text{H}_2\text{O}$	DiOct
Saponite (SapCa-2)	$(\text{Ca})\text{Mg}_3(\text{Al},\text{Si})_4\text{O}_{10}(\text{OH})_2 \bullet n\text{H}_2\text{O}$	TriOct
Serpentine/antigorite	$(\text{Mg},\text{Fe})_3\text{Si}_2\text{O}_5(\text{OH})_4$	TriOct
Chlorite	$(\text{Mg},\text{Fe})_4(\text{Al})(\text{Al},\text{Si}_3)\text{O}_{10}(\text{OH})_8$	TriOct

Table 1. Five phyllosilicates exposed to laboratory experimental impacts during our shock-recovery experiments. DiOct = dioctahedral and TriOct = trioctahedral clay.

Laboratory impact experiments. We used shock-reverberation techniques to achieve controlled peak pressures in our impact experiments while limiting the enthalpy differential across our samples [9]. The experimental setup at the FPA also enabled us to calculate peak pressures directly from the shock impedances of the flyer plate and sample holder assembly materials using the Rankine-Hugoniot equations [10-12].

Vibrational spectroscopic techniques. The shock-

recovery experiments produced ~0.15 g of shocked material for each sample at each pressure. The recovered samples were analyzed by visible near-infrared (VNIR) reflectance, mid-infrared (MIR) emissivity, and attenuated total reflectance (ATR) spectroscopy. Each technique probes a different part of the clay mineral structure [13] and, as a result, can provide information on the structural changes induced in phyllosilicates of different types by impact shock. We conducted VNIR reflectance between 350 and 2500 nm ($28571 \text{ cm}^{-1} - 4000 \text{ cm}^{-1}$) on an ASD Instruments (now PANalytical) Field Spec 3 Max Spectroradiometer fitted with an 8-degree field of view foreoptic. Emissivity spectra were collected using a Nicolet 6700 FTIR spectrometer purged of CO_2 and water vapor with the attached Globar IR source switched off and emitted radiation from the heated samples measured directly.

Results: The vibrational spectroscopic results for three of the five tested clays have been previously presented. The nontronite [7, 13] and kaolinite [14] results were discussed in detail, while the saponite results were only partially presented [15]. This abstract is a summary of our vibrational spectroscopy results not presented elsewhere.

MIR emissivity results. MIR emissivity (~200-2000 cm^{-1}) probes the tetrahedral sheet of the phyllosilicate structure providing information on the bonding between Si-O and metal-O in clays. Loss of characteristic vibrational bands in the MIR indicates structural deformation [7,13]. Comparing the MIR emissivity results for four clay samples (Figure 1) reveals a broad trend in increasing structural deformation with increasing impact shock pressure. Phyllosilicates with fully occupied octahedral sheets (trioctahedral structures) have previously been observed to be more thermodynamically stable than those with partially occupied octahedral sheets (dioctahedral structures) [16-18]. Our results appear to follow this trend with dioctahedral clays (Figures 1A,B) generally more susceptible to structural deformation by impact shock than trioctahedral clays (Figures 1B, C), as detected by changes to their MIR emissivity spectra.

VNIR reflectance spectroscopic results. VNIR reflectance spectra of clays are dominated by metal-OH, metal-O, and bound/adsorbed H_2O combination and overtone bands. These data provide information about the hydration state of phyllosilicates as well as their

octahedral sheet structure. Again, there is a general trend of increasing structural disorder with increasing impact shock (Figure 2).

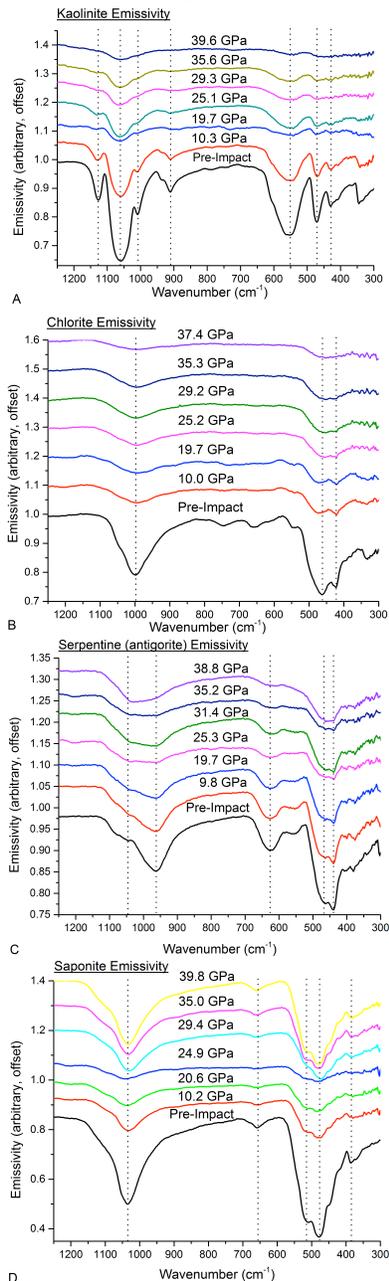


Figure 1. Emissivity spectra. Dioctahedral (A) and Fe²⁺-rich clays (B) are more susceptible to structural deformation than trioctahedral or non iron-bearing clays (C,D).

Dioctahedral clays show an increased susceptibility to structural deformation relative to trioctahedral clays. In addition, the chlorite sample, which contains the most Fe²⁺, loses its Fe²⁺ absorption feature at the lowest shock pressure, consistent with Mossbauer results showing that all Fe in chlorite is oxidized at low shock pressures [19].

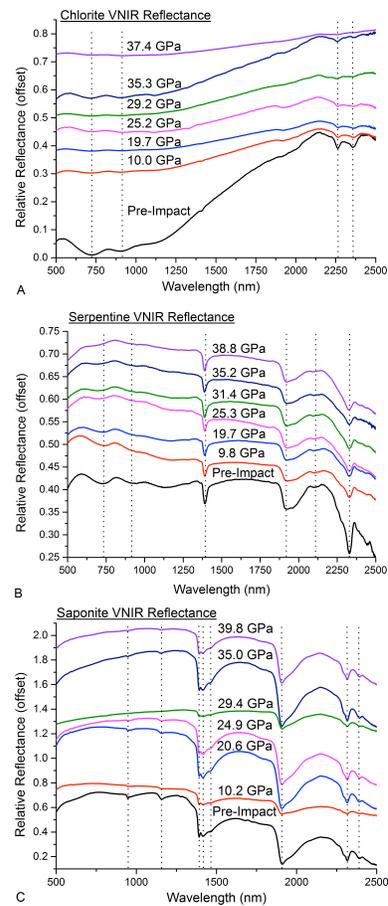


Figure 2. VNIR reflectance spectra. Iron-rich trioctahedral samples (A) are more susceptible to structural deformation than other trioctahedral clays (B, C).

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