400 nm

What is the Color of the Lower Mantle?

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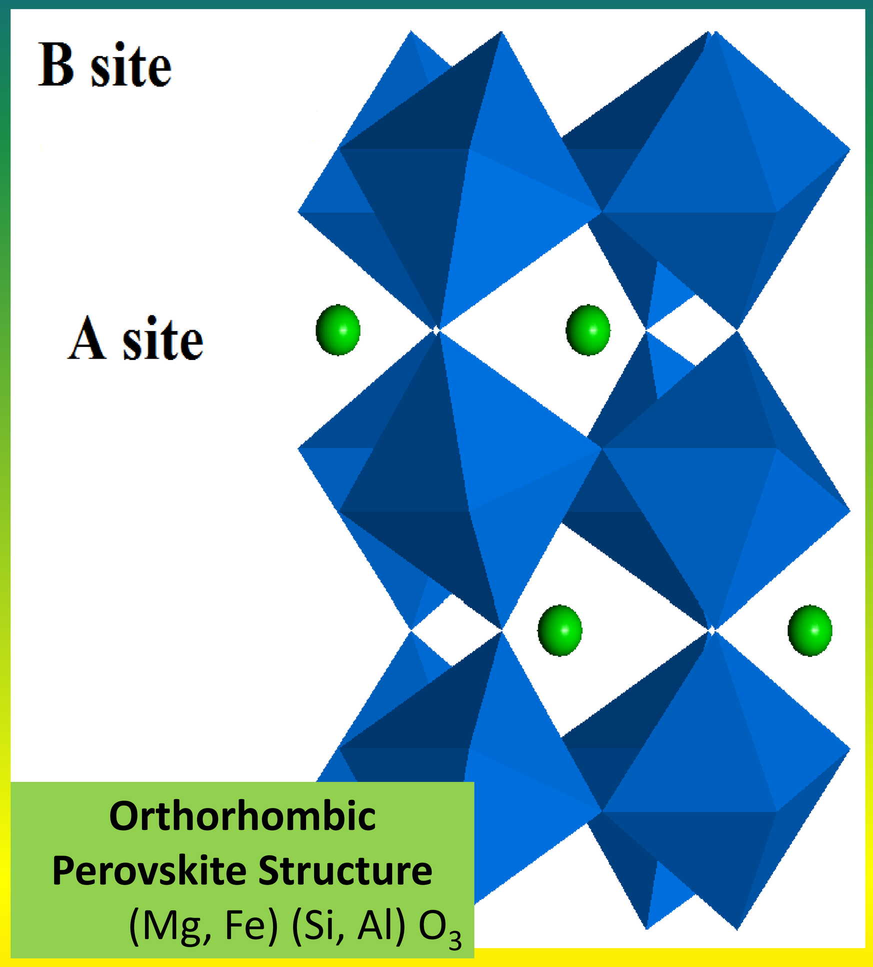
Introduction

Magnesium silicate perovskite is a lower mantle mineral thatcan accept the substitution of ferric and ferrous iron in its structure. Ferric iron (Fe^{3+}) enters silicate perovskite as a coupled substitution with Al^{3+}. These substitutions can change the mineral's physical and chemical properties. Investigating how the color mineral changes between the ferric and ferrous end members of magnesium silicate perovskite can lead to indications of how the mineral transfers radiative energy through the crystal lattice.

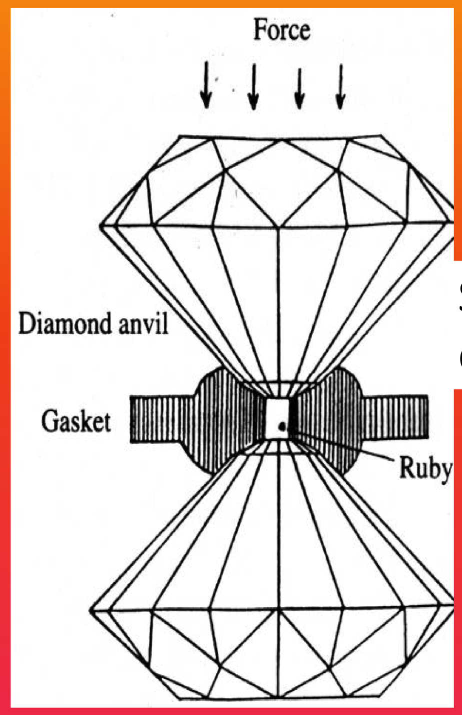
500 nm



Hypotheses

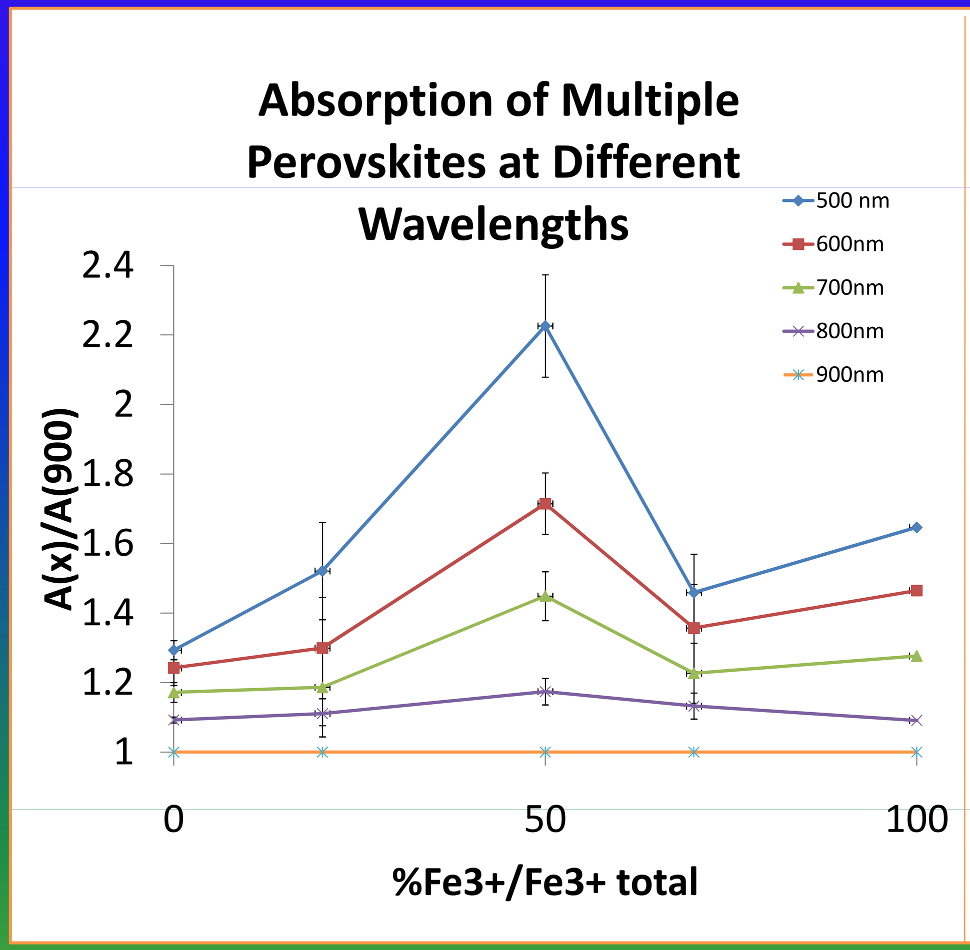
•Substituting Fe^{2+} with Fe^{3+} in the A site of magnesium silicate perovskite will cause its optical absorption spectrum to change.
•Optical absorption will vary linearly with the change in Fe^{3+}/Fe_{total}.

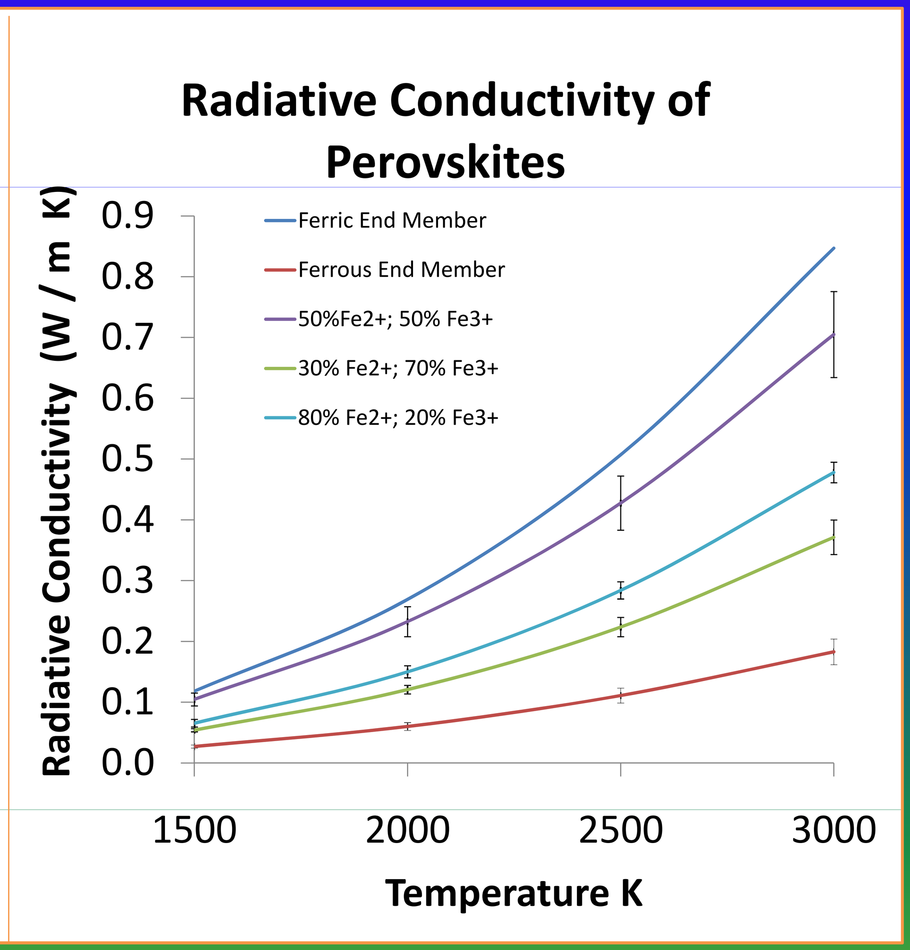
600 nm

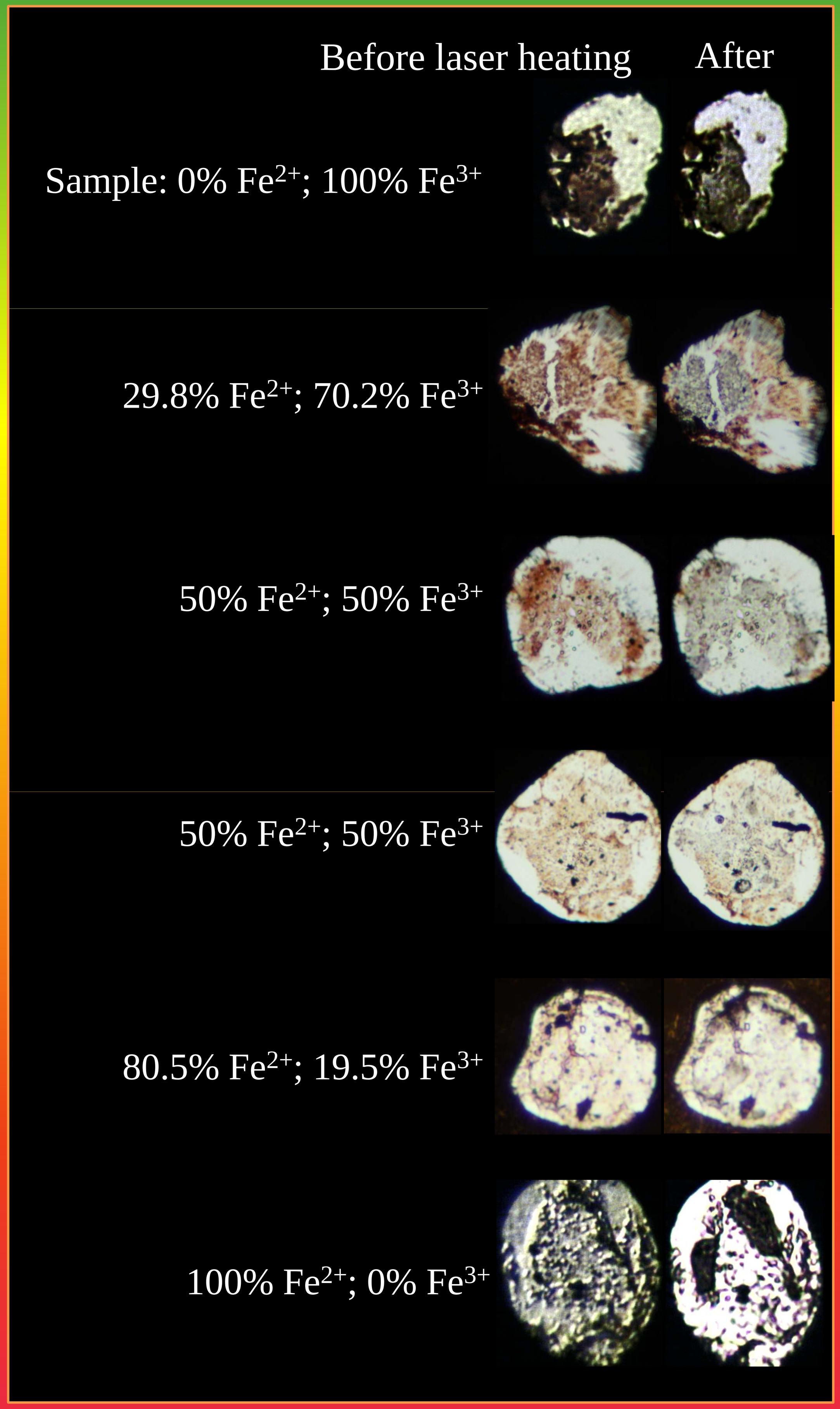


Side view of a diamond anvil cell

700 nm







Results & Analysis

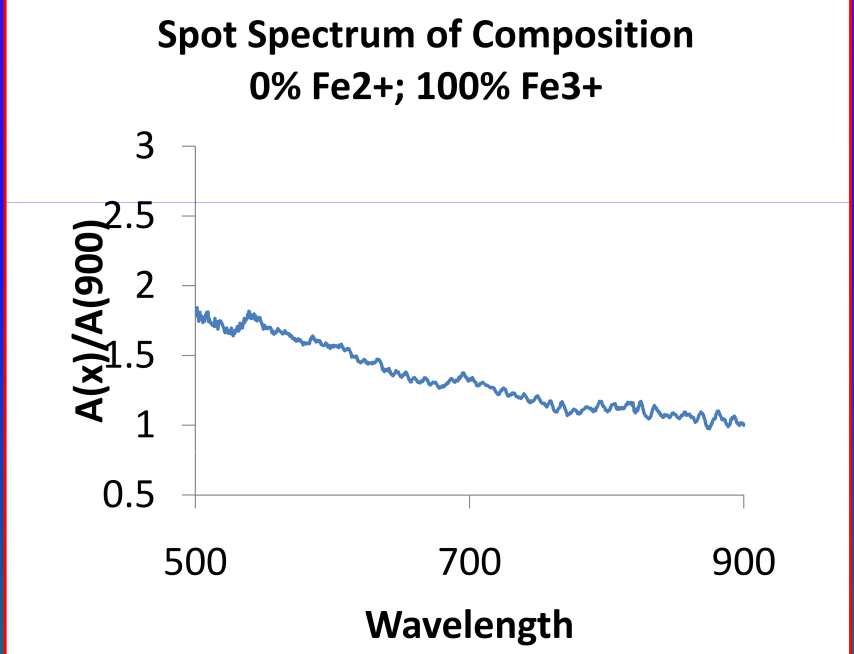
To compensate for the color of each sample being influenced by thickness, there are multiple measurements made on each sample and these spectra are normalized to one wavelength. This is used to make error bars that show the accuracy and reproducibility of the results between each sample. The end result of comparing different compositions as Fe^{3+}/Fe_{total} over various wavelengths shows that the relationship is not linear and is complicated.

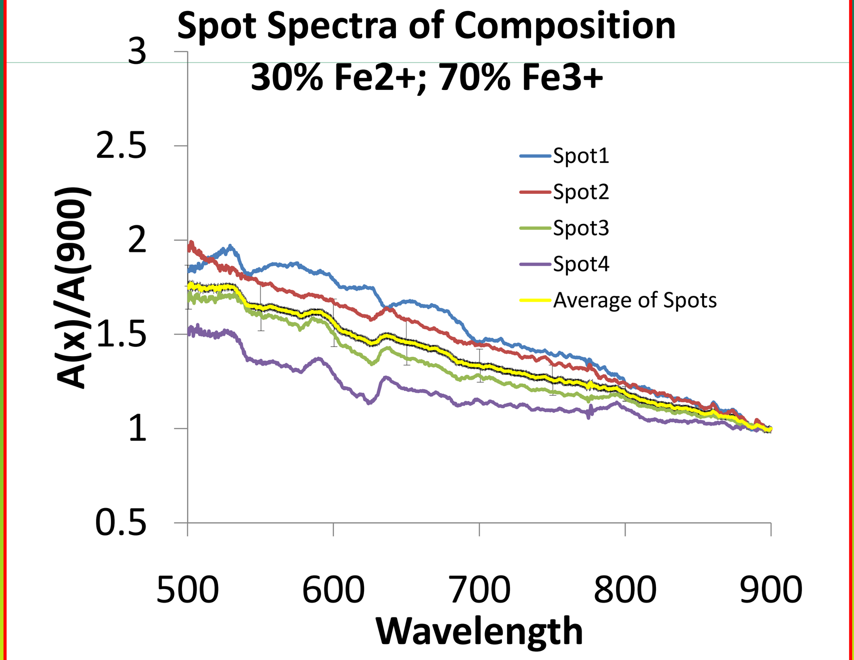
Beer-Lambert Law

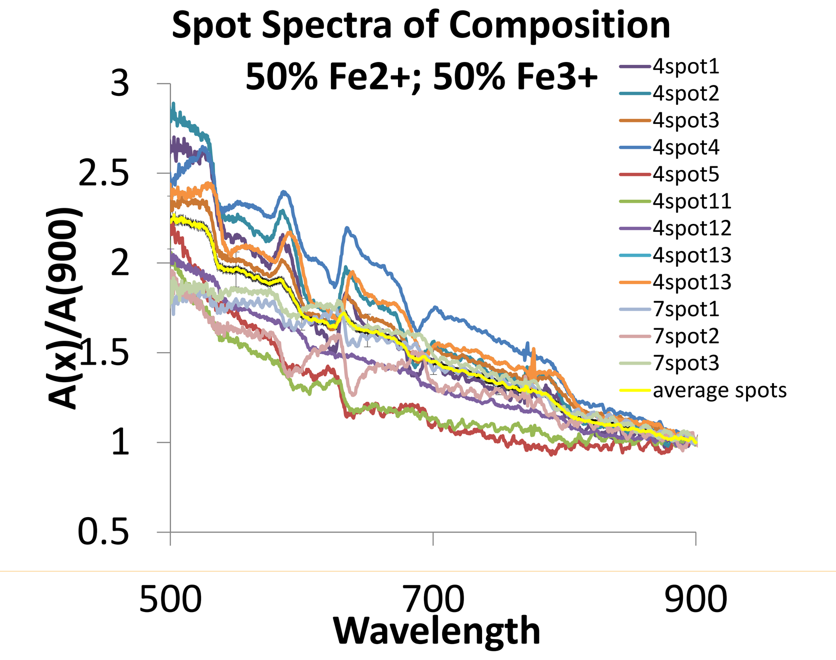
$$I_t = I_0 e^{-Ad} \qquad Ad = \ln \frac{I_0}{I_t}$$

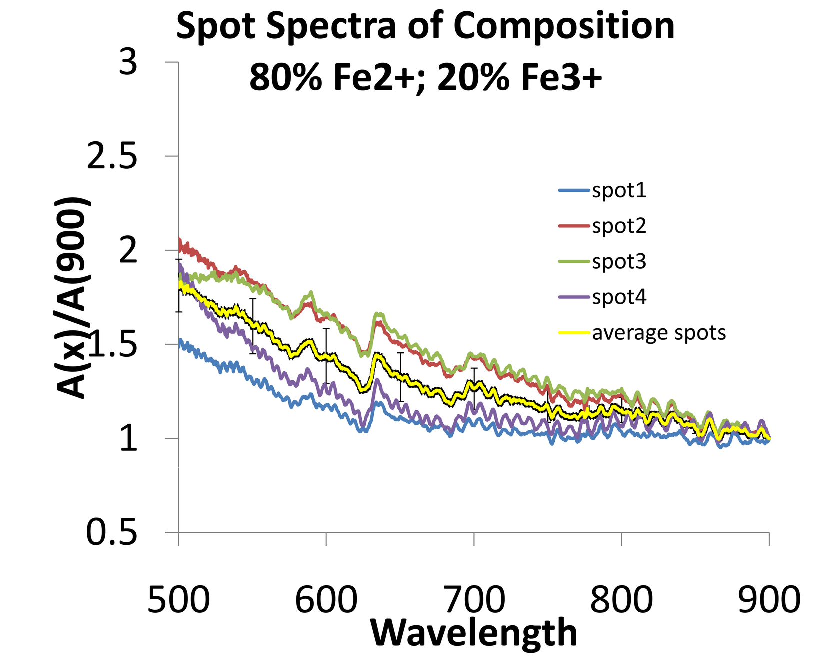
$$k_R = \frac{16 n^2 \sigma T^3}{3 \alpha_R}$$

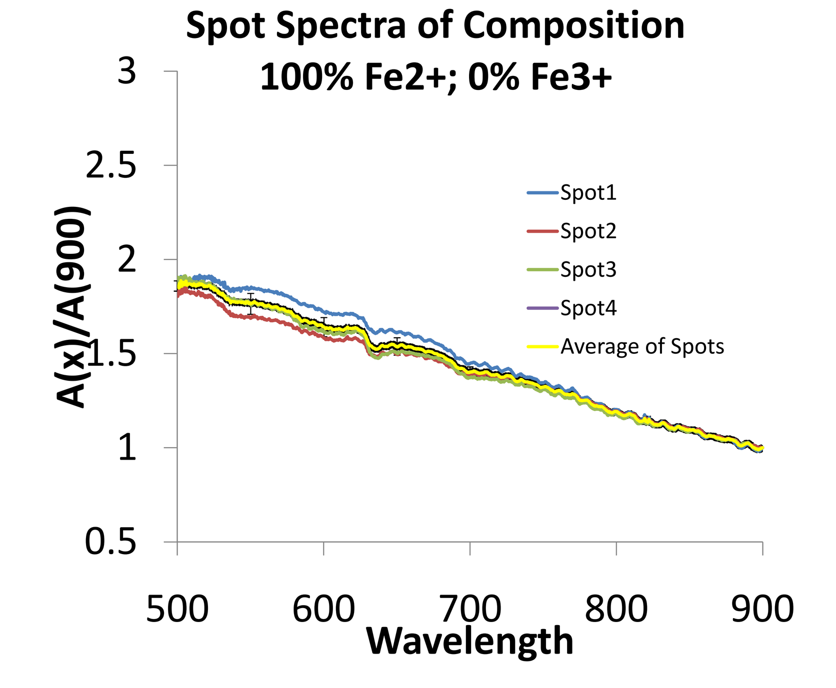
The radiative coefficient is dependant on the index of refraction, the Stephan-Boltzmann constant, and the Planck radiation function. From taking the integral of all values of optical absorbance, a value of the radiative coefficient is found.











Methods

•The two end member samples were made from following these formulas:
$(1\text{-}y)\ MgO + y\ Fe_{(1-x)}O + xy\ Fe^0 + SiO_2 \leftrightarrow (Mg_{(1-y)}Fe_y^{2+})SiO_3$
$(1\text{-}y)\ MgO + y/2\ Fe_2O_3 + y/2\ Al_2O_3 + (1\text{-}y)\ SiO_2 \leftrightarrow (Mg_{(1-y)} Fe_y^{3+})(Si_{(1-y)}\ Al_y)O_3$
•Powders were loaded inside a diamond anvil cell
•Sample under pressure of ~30GPa
•Temperature of synthesis ~1800K
•Optical absorbance is measured by a spectrograph at a range of 400 nm to 1400 nm

Conclusions

•There is a difference in optical absorption properties between Fe^{2+} and Fe^{3+} end member perovskites.
•The optical absorption properties between intermediate compositions are complicatedly related in a nonlinear way.
•Radiative conductivity values depend on the composition of the mineral

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