Absorption Bands in Spinels: Comparisons of Laboratory and Asteroid Spectra. J. M. Sunshine[1] (sunshinej@saic.com) and E. A. Cloutis[2] (ed.cloutis@uwinnipeg.ca), [1]Advanced Technology Applications Division, Science Applications International Corporation, 4501 Daly Drive, Chantilly, Virginia, USA 20151, [2]Department of Geography, University of Winnipeg, Winnipeg, Manitoba, Canada R3B 2E.

Introduction: Spinel-group minerals are present in meteorite samples [1] and have been identified, based on the presence of absorptions in telescopic spectra, as components on the surface of at least two S-type asteroids [2]. In order to better constrain the composition of spinels on these asteroids and to understand their relationship to meteorite samples, we have begun to systematically examine spinel spectra as a function of composition. The modified Gaussian model (MGM) [3,4] is used to model and deconvolve the complex absorption features in spinel spectra, with a particular emphasis on absorptions near 2 µm. The primary goal of these efforts are to quantify changes in the number and characteristics of absorptions in spectra of different compositions of spinels. In addition to establishing a basis for inferring the compositional spinel from their spectra, a secondary goal of this analysis is to determine ways to distinguish spinel absorption from those in pyroxene, which also occur in the 2 µm region.

As described below, initial efforts have focused on modeling spectra of spinel compositional endmembers and comparing these with spectra of calcium aluminum-rich inclusions (CAI's) in Allende [2] and the spectra of asteroids 387 Aquitania and 980 Anacostia [2]. Our results reveal that the 2 µm feature in spinel is complex and that it is composed of three absorption bands which vary in relative strength as the spinel composition changes. The central absorptions (near 1.8 µm) appear to vary the most as a function of iron content. Comparisons to spectra of CAI's are hindered by the presence of pyroxene absorptions. Preliminary comparisons with the absorptions in the "spinel-rich" asteroid are also complex and provide no simple compositional interpretations. However, as this study progresses, we are hopeful that it will be possible to make inferences about the composition of spinel on the surfaces of 387 Aquitania and 980 Anacostia.

Spinel Endmember Spectra: A suite of spinels spanning the range of compositions from magnetite (Fe_3O_4), chromite ($FeCr_2O_4$), gahnite ($ZnAl_2O_4$), hercynite ($FeAl_2O_4$), to spinel itself ($MgAl_2O_4$) have been gathered for analysis. Bi-directional reflectance spectra of <45 µm particles of these samples were collected using the RELAB facility [5]. Micro-probe analysis were also carried out on these samples to determine their compositional makeup. Representative spectra for compositional endmembers from this suite are shown in Figures 1 and 2. The majority of the spinel spectra are characterized by Fe^{+2} absorptions in the region near 2 µm [6], with the exception of the iron-rich chromites and the magnitites. In addition to this major absorption feature, the spinel spectra include a variety of minor absorptions from 0.4-1.4 µm. These various absorption features are indicative of the presence of transition group elements. Chromites, for example, have an absorption band near 1.3 µm that is significantly weaker or absent in spectra of other compositions of spinel. As can be seen by comparing Figures 1 and 2, the presence of iron in spinel increases the strength of absorptions and reduces the overall albedo.

Figure 1: Spectra of Fe-Poor Spinel Endmembers

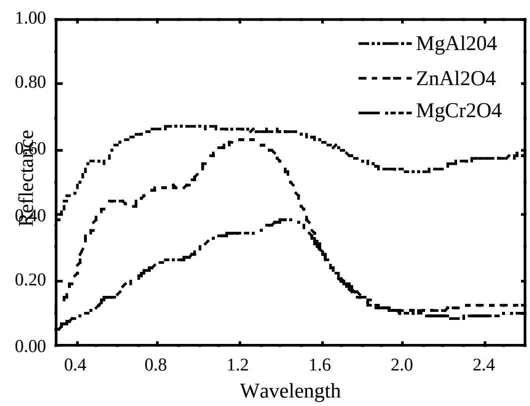
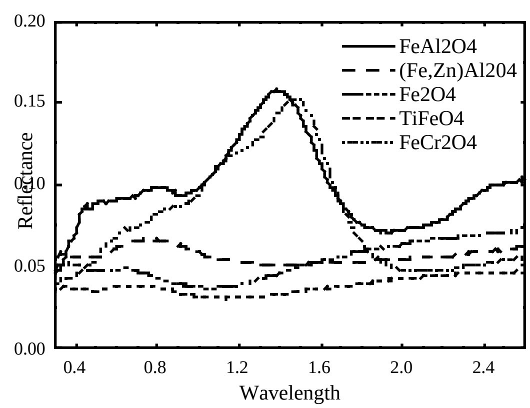


Figure 2: Spectra of Fe-Rich Spinel Endmembers



Absorption Band Analyses: Visual comparisons among the spinel spectra indicate variations in the absorption feature near 2 µm as the composition of spinel changes. To facilitate such comparisons, we have used the MGM to resolve the 2 µm feature in spinels into its constituent absorption bands. Due to the lack of obvious absorptions near 2 µm in magnetite and iron-rich chromite spectra, these samples were not examined in this preliminary analysis. The 2 µm features in spectra of the other spinel compositional

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endmembers are generally found to consist of three absorptions centered near: 1.8, 2.3, and 2.6 µm, as can be seen in Figure 3. (Attempts to model these spinel spectra using less than three absorptions in the 2 µm regions resulted in unacceptably poor fits with high residual errors.) The iron-poor spinels ($MgAl_2O_4$) have substantially weaker absorptions and do not include absorption bands at 1.8 µm. For all compositions of spinel examined to date, the 1.8 µm absorptions increase with increasing iron content and is found to be the primary contribution to changes in the overall 2 µm feature in spinel spectra.

Comparison to Meteorite and Asteroid Spectra: Several meteorites include spinel [e.g. 1]. In particular, the CAI's in Allende have been suggested as possible analogs for asteroids 387 Aquitania and 980 Anacostia [2]. Gaffey [2] measured the spectra of several CAI's in Allende. However, efforts to compare these spectra to the suite of spinel spectra are complicated by the presence of pyroxene (as is clearly indicated by the presence of diagnostic pyroxene absorptions in the 1 µm region). The spectra of asteroids 387 Aquitania and 980 Anacostia (Figure 4) unfortunately lack the signal-to-noise and spectral resolution to uniquely resolve three absorption bands in the 2 µm region. This additional complication is similar to the problems encountered in attempts to model the three absorption bands that comprise the 1 µm feature in olivine-rich asteroids [7, 8]. Using constraints established from analyses of laboratory olivine spectra, it was possible to model spectra of olivine-rich asteroids with the MGM and to provide quantitative estimates of their olivine composition. Similar efforts, after further quantification of variations in laboratory spinel spectra, should provide a means to remotely infer the chemical composition of spinels and thus allow for more detailed links to be established between asteroids such as 387 Aquitania and 980 Anacostia and the samples in our meteorite collection.

Figure 3: Modified Gaussian Model Fit to Gahnite Spinel Endmember ($ZnAl_2O_4$)

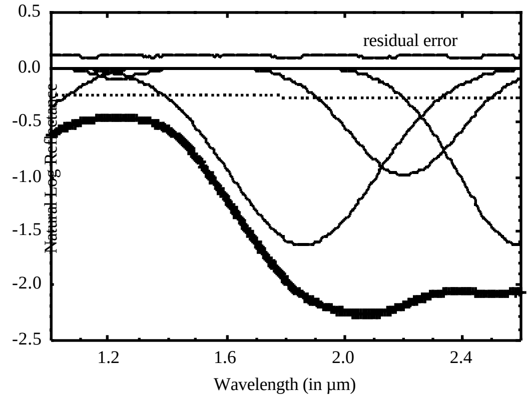
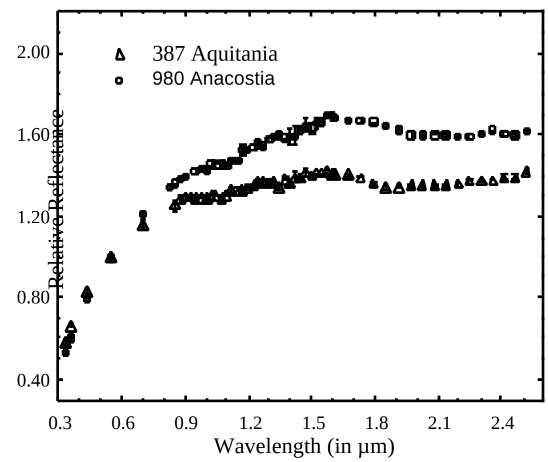


Figure 4: Telescopic Spectra of Spinel-Rich Asteroids [after Burbine, Gaffey, and Bell, 1992]



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