# The Importance of Ilmenite in Interpreting Lunar Surface Composition from Spectroscopy

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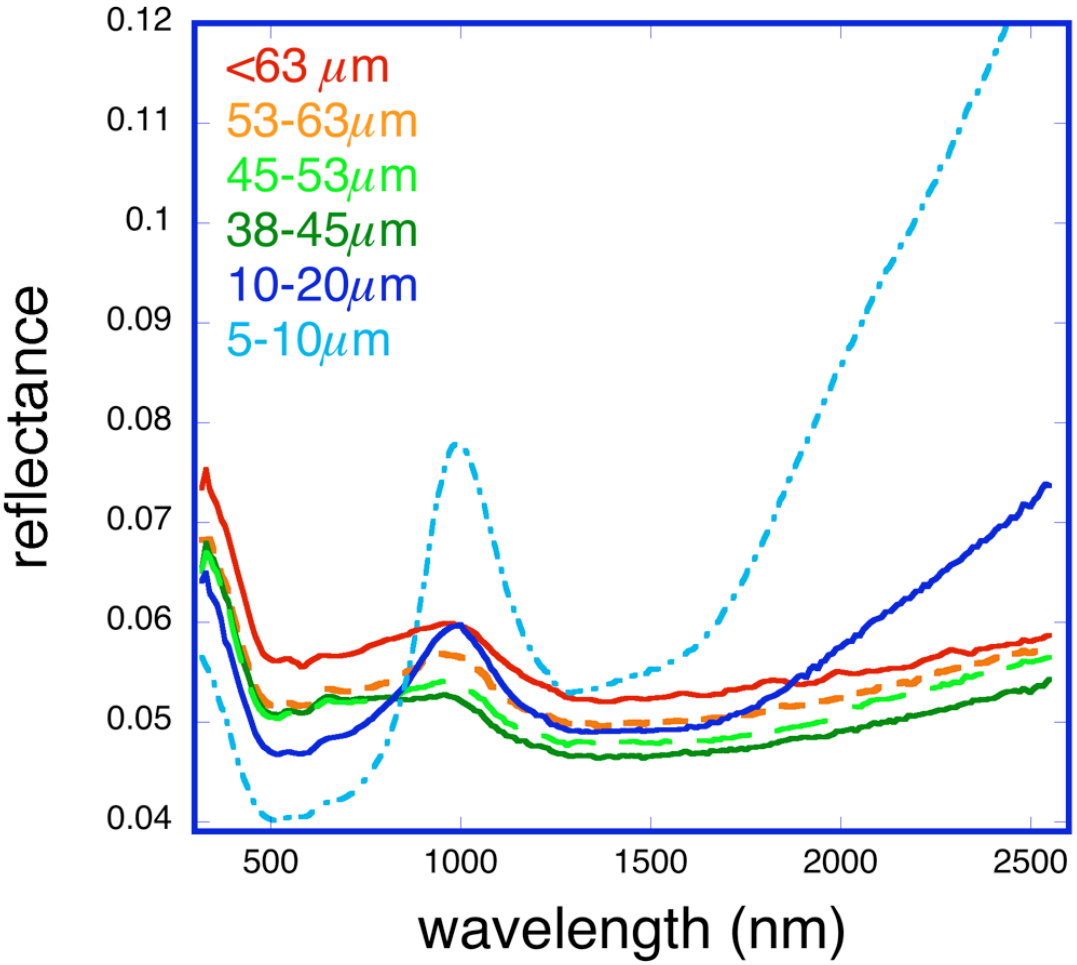
# Importance of Ilmenite

- Most abundant oxide on the Moon ($FeTiO_3$)
- Significant component of many mare basalts
- Major variation in mare basalts, used for classification
- Tracer of mantle composition and evolution
- In situ resource

# Ilmenite Grain Size

- Significant spectral variations with grain size



# Grain Size Variations

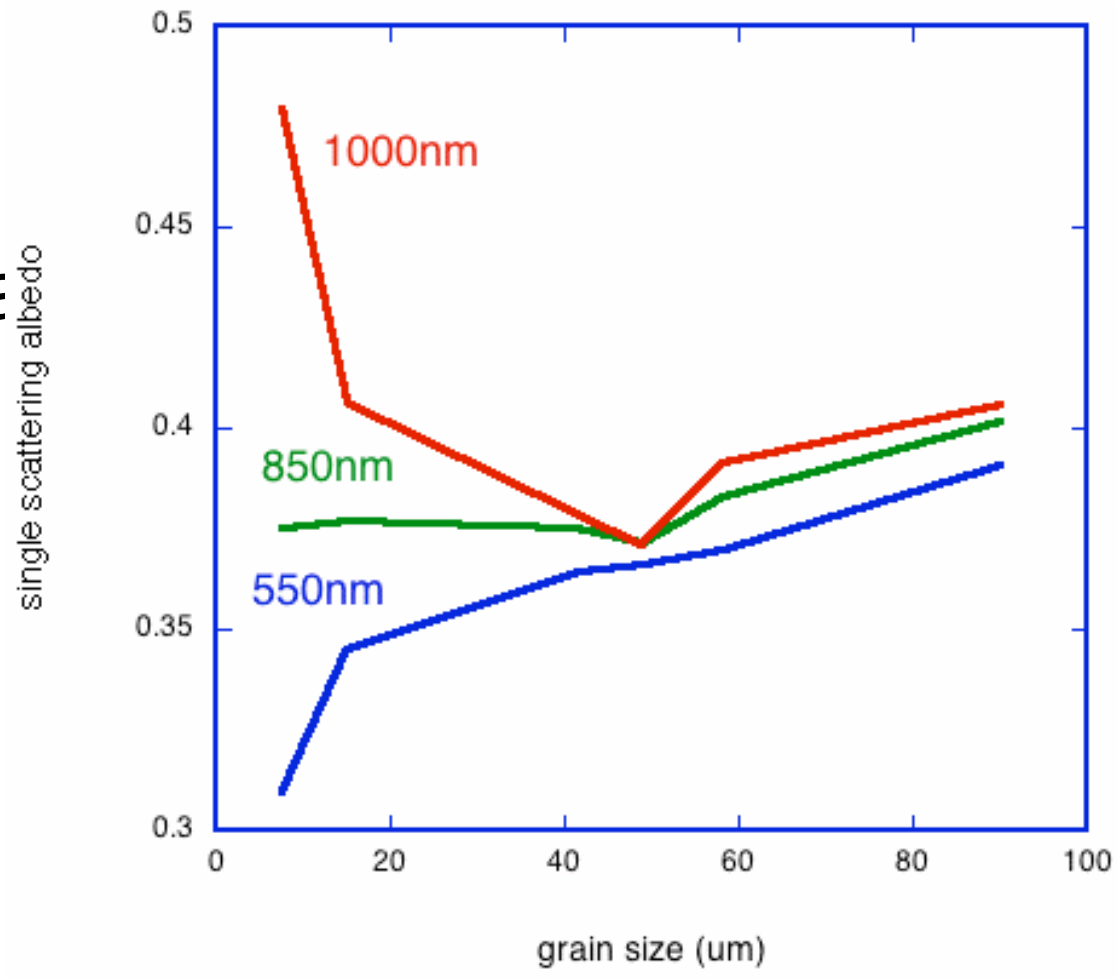
- Decreasing grain size of a transparent mineral causes it to get brighter
- Decreasing the grain size of an opaque mineral causes it to get darker
- Spectral variations with grain size can be used with Mie theory to determine the optical constants for ilmenite

# Optical Constants

- Optical constants n & k
- Complex index of refraction n + ik
- Inherent material property doesn’t change with grain size
- Not been determined for ilmenite

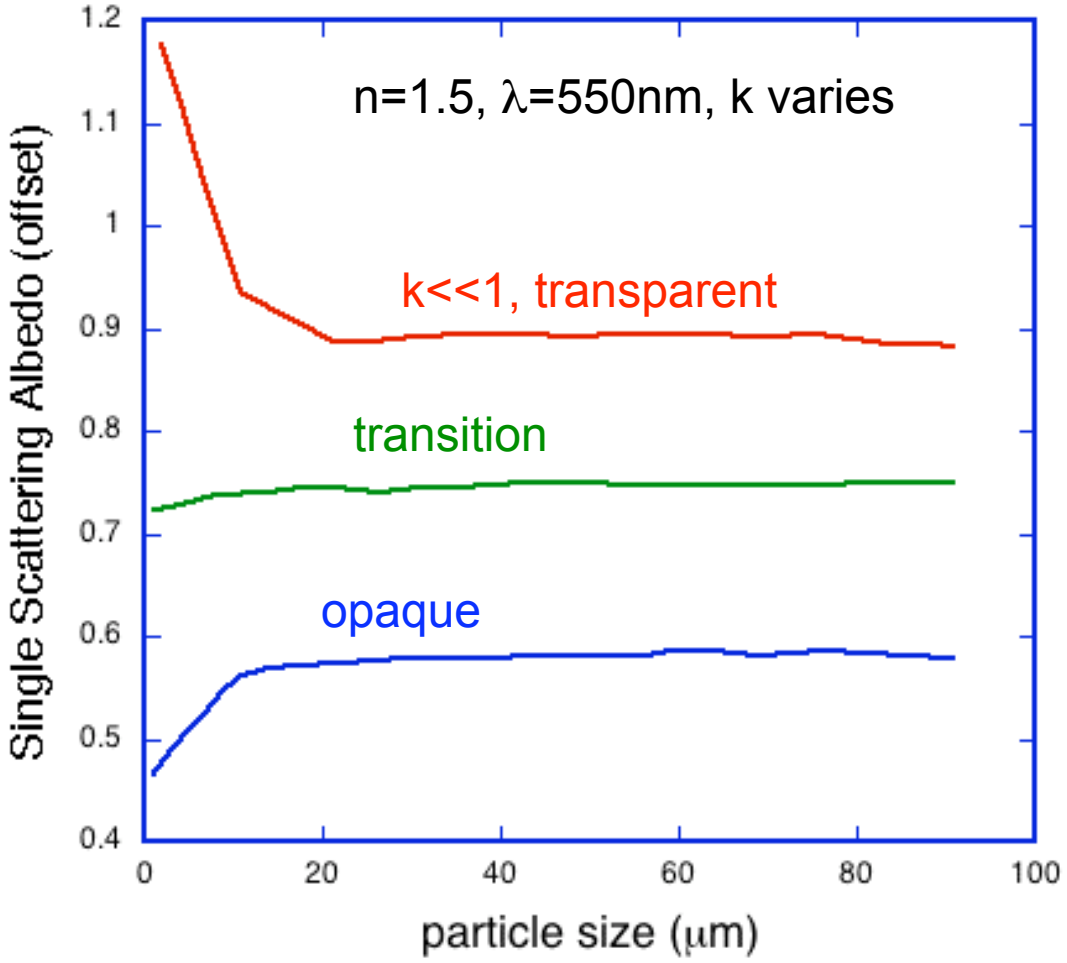
# Ilmenite Grain Size

- Single scattering albedo - probability of a photon surviving and interaction with a grain

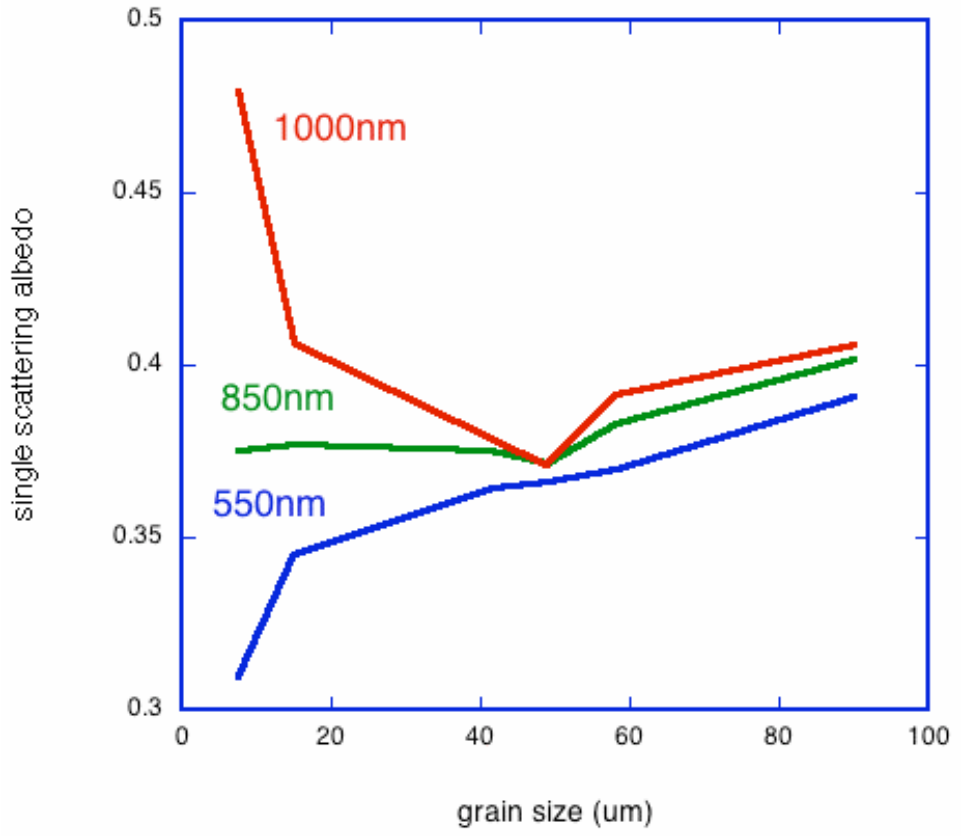


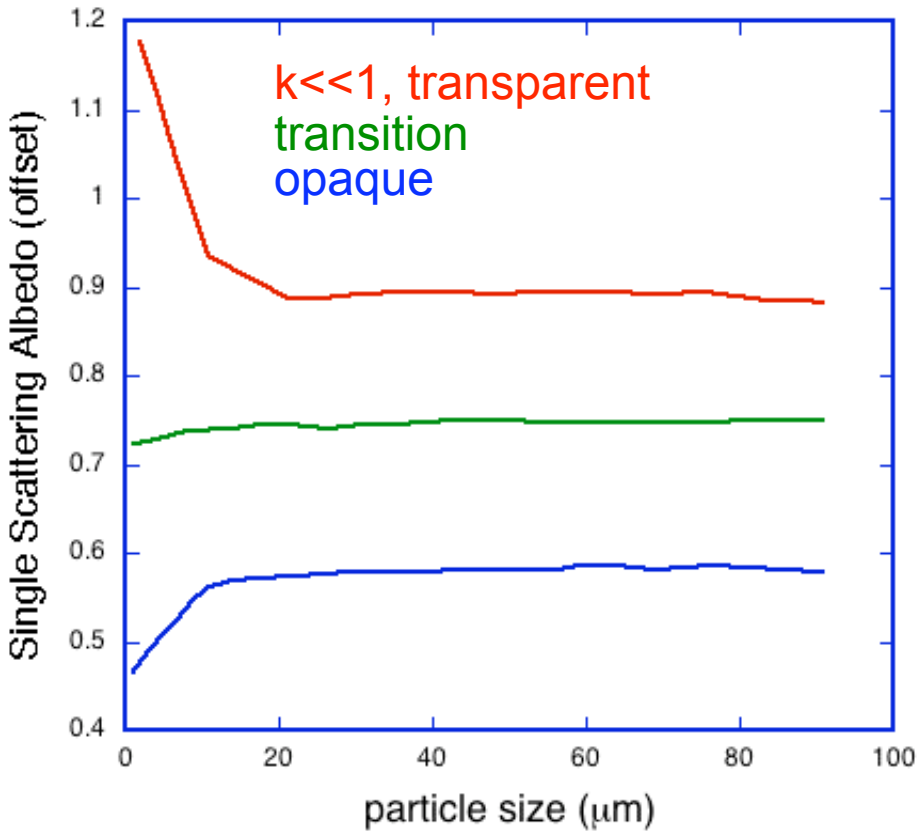
# Mie Theory

- Theoretical treatment of scattering by small particles
- Well developed & studied



# Observations - Mie Theory



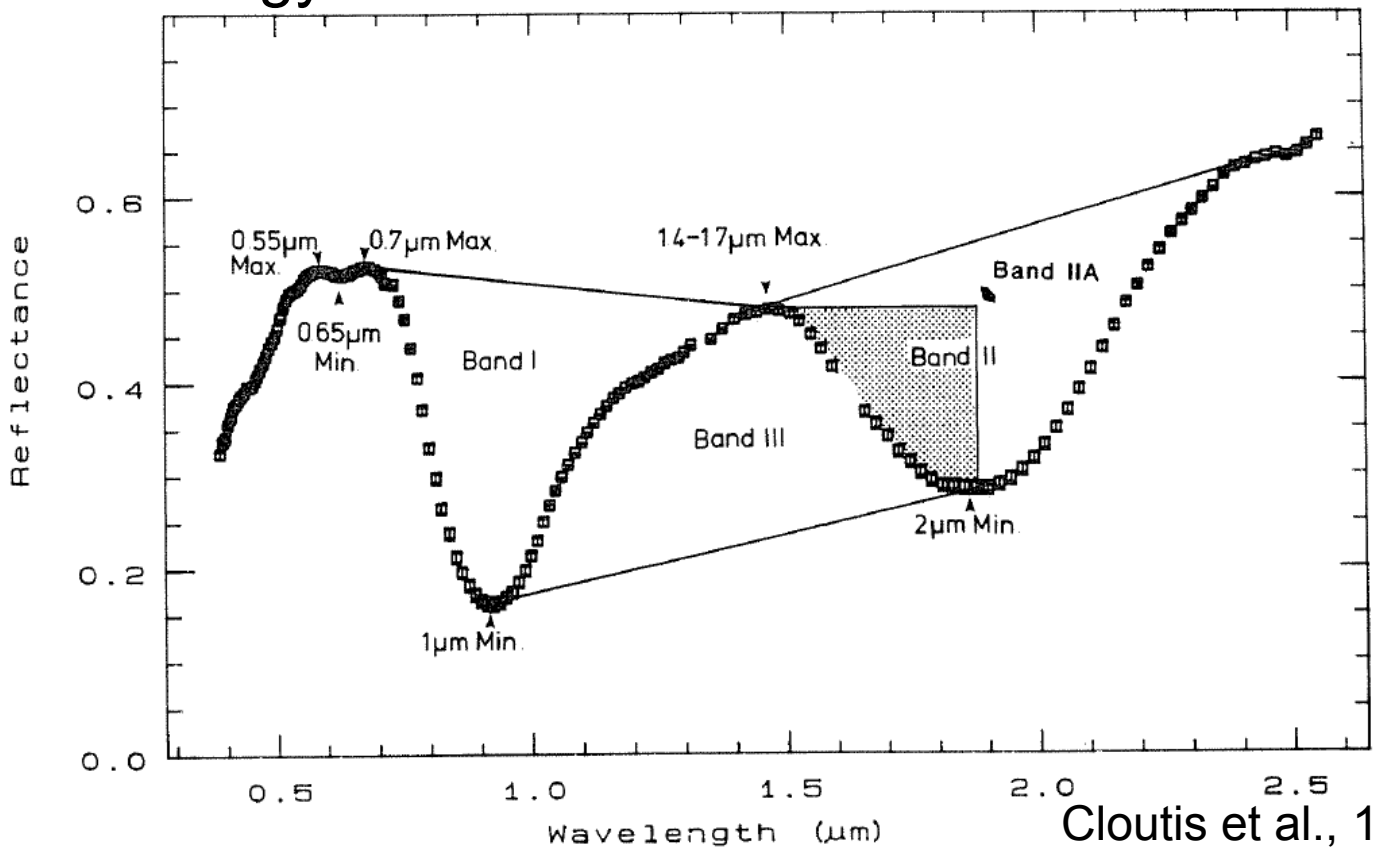

- Determine n & k at key wavelengths by matching single scattering albedo variation with grain size
- Ilmenite k<<1 for $\lambda$>850nm, Hapke model can be applied

# Hapke Model

- Commonly used to compute model spectra to match with observed spectra
- Limited to k<<1
- *Can* now use Hapke Model with ilmenite optical constants for $\lambda$>850nm

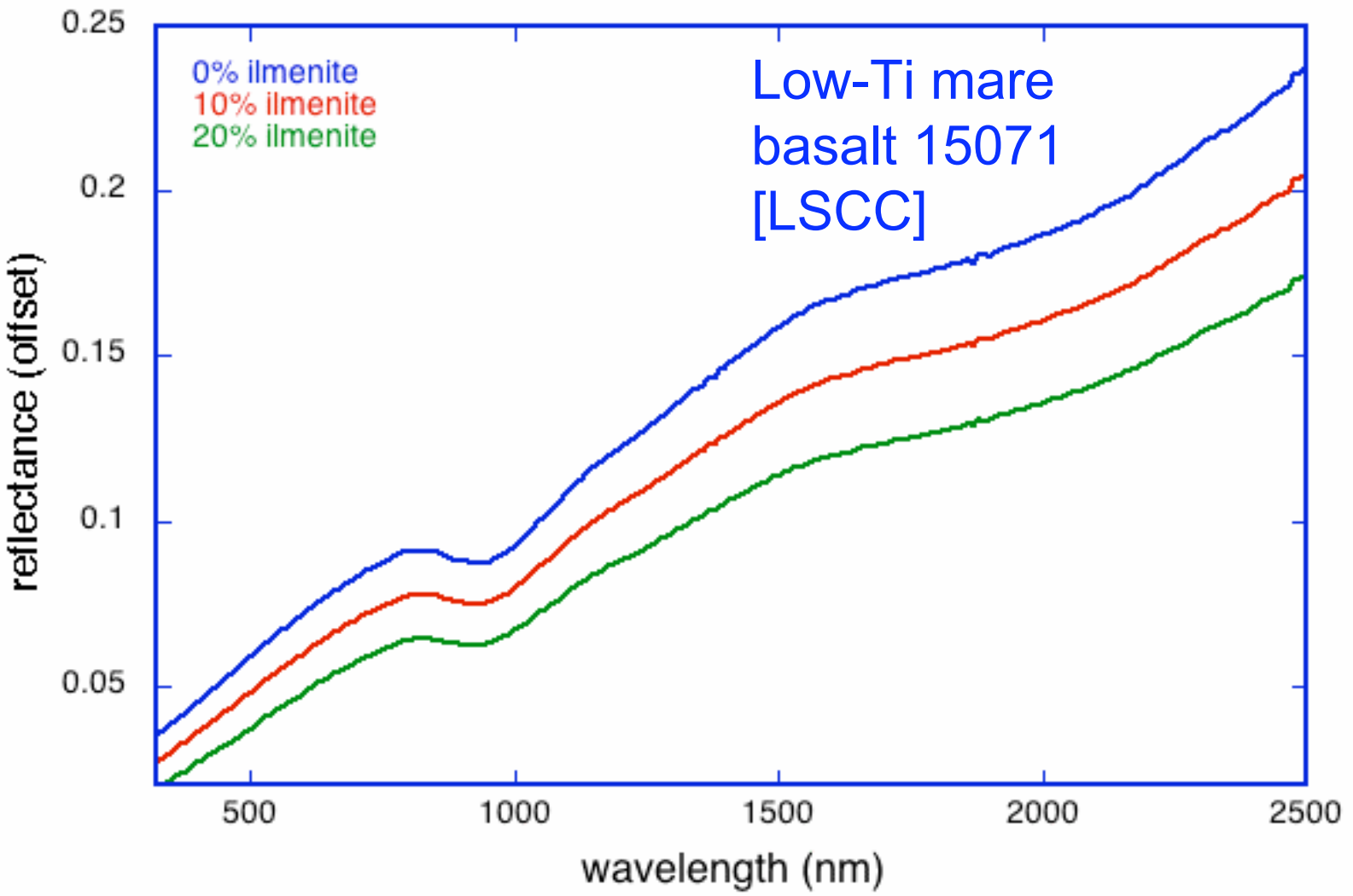
# Spectral Modeling

- Diagnostic absorptions at 1μm and 2μm
- Band depth, center and area used to determine mineralogy




Cloutis et al., 1986, Figure 1

# Mixture Models



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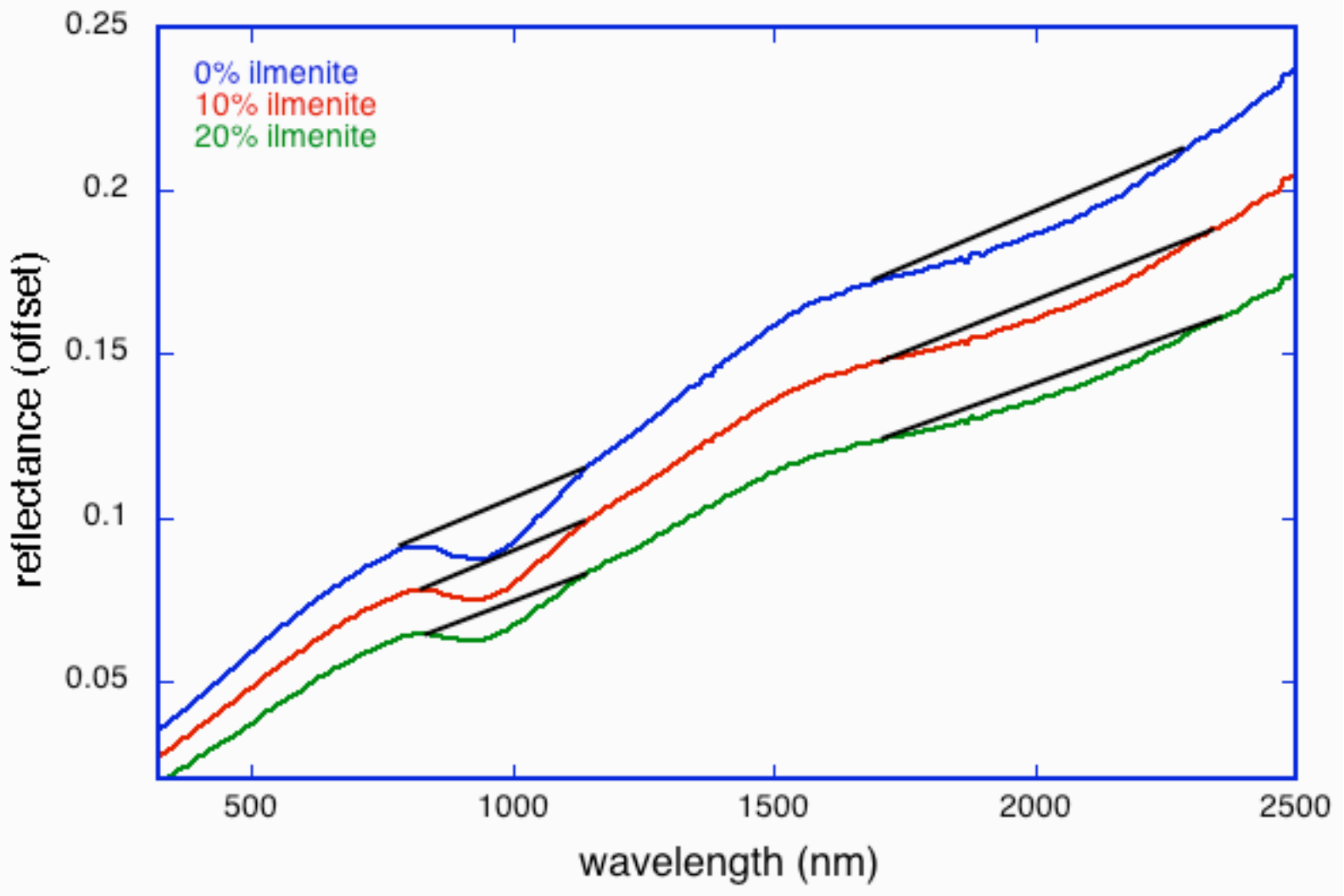
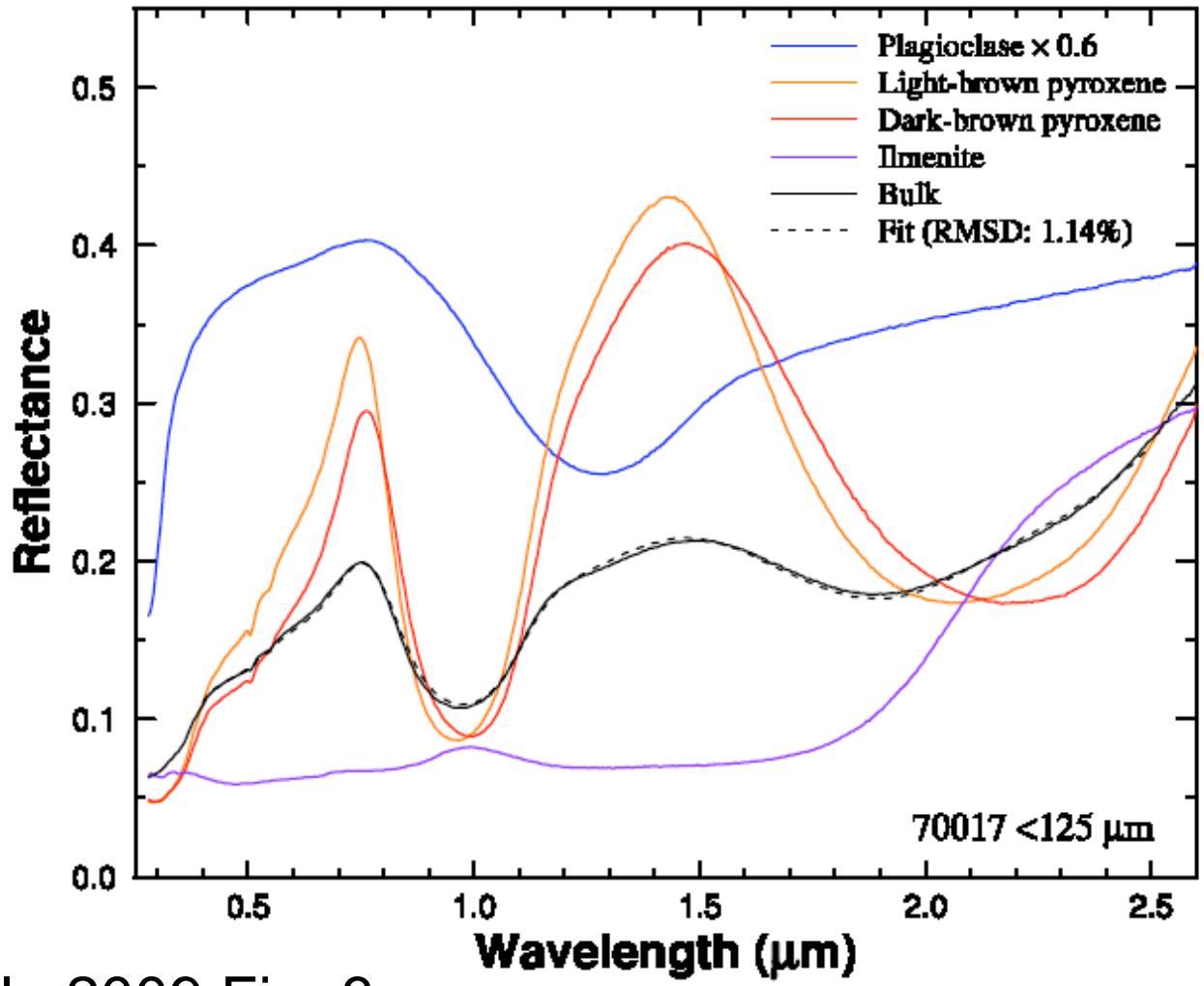
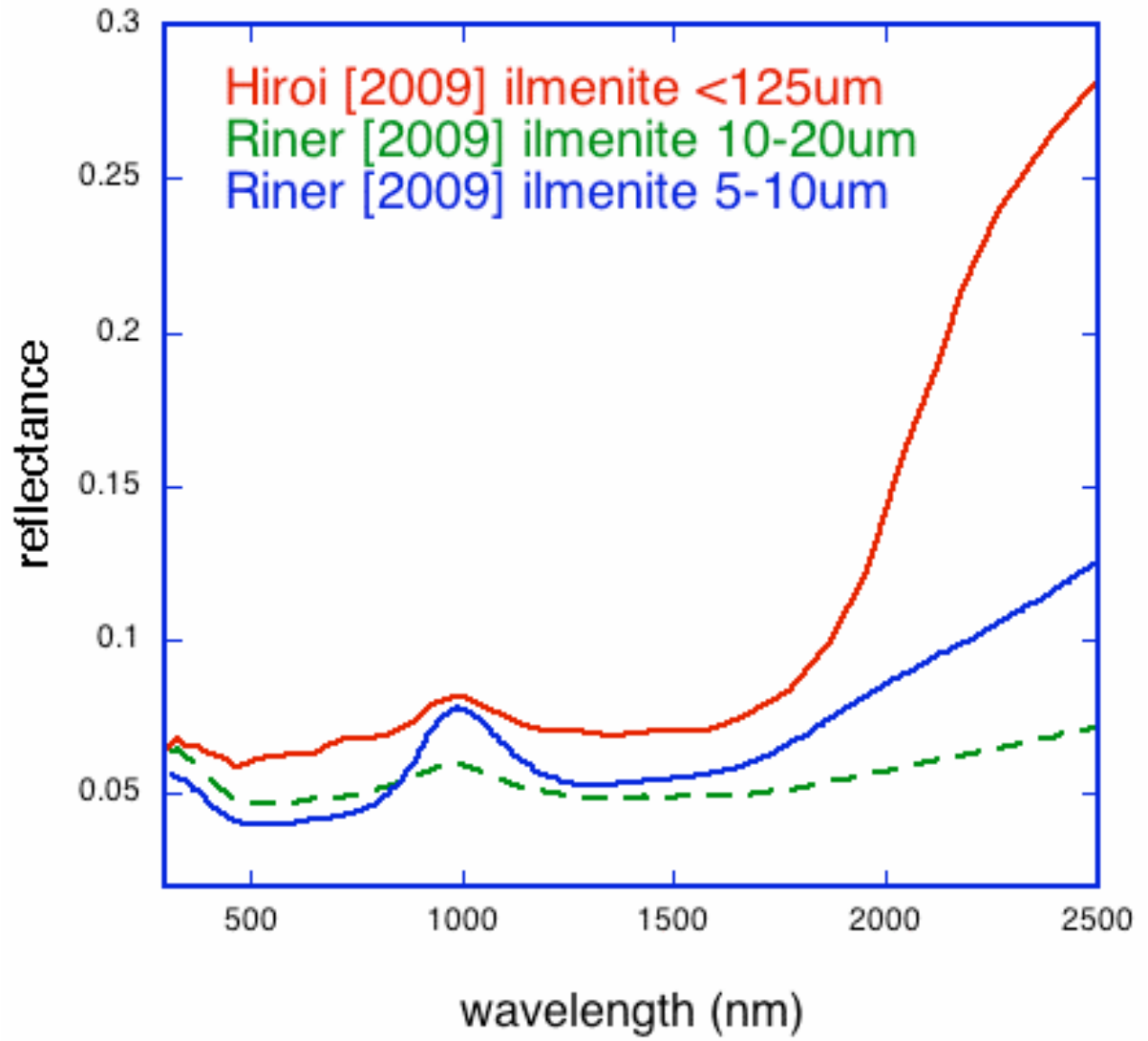


# Lunar Rock Separates




Hiroi et al., 2009 Fig. 3

# Natural vs. Synthetic Ilmenite



# Conclusions

- Ilmenite has important spectral variations with grain size
- Ilmenite spectral features influence inferred silicate mineralogy
- Optical constants determined for ilmenite via Mie Theory
- Ilmenite has $k \ll 1$ for $\lambda > 850$nm and Hapke model applies