Identifying Materials by their Reflectivity 54

50%	78%
3%	30%

Material	Reflectivity
Snow	80%
White Concrete	78%
Bare Aluminum	74%
Vegetation	50%
Bare Soil	30%
Wood Shingle	17%
Water	5%
Black Asphalt	3%

When light falls on a material, some of the light energy is absorbed while the rest is reflected. The absorbed energy usually contributes to heating the body. The reflected energy is what we use to actually see the material! Scientists measure reflectivity and absorption in terms of the percentage of energy that falls on the body. The combination must add up to 100%.

The table above shows the reflectivity of various common materials. For example, snow reflects 80% of the light that falls on it, which means that it absorbs 20% and so 80% + 20% = 100%. This also means that if I have 100 watts of light energy falling on the snow, 80 watts will be reflected and 20 watts will be absorbed.

Problem 1 - If 1000 watts falls on a body, and you measure 300 watts reflected, what is the reflectivity of the body, and from the Table, what might be its composition?

Problem 2 - You are given the reflectivity map at the top of this page. What are the likely compositions of the areas in the map?

Problem 3 - What is the average reflectivity of these four equal-area regions combined?

Problem 4 - Solar radiation delivers 1300 watts per square meter to the surface of Earth. If the area in the map is 20 meters on a side; A) how much solar radiation, in watts, is reflected by each of the four materials covering this area? B) What is the total solar energy, in watts, reflected by this mapped area? C) What is the total solar energy, in watts, absorbed by this area?

Reflectivity Fingerprints! 55

Material	R(UV)	R(Vis)	R(NIR)
Snow	90%	80%	70%
White Concrete	22%	80%	73%
Aluminum Roof	75%	74%	68%
Vegetation	15%	50%	40%
Bare Soil	15%	30%	50%
Wood Shingle	7%	17%	28%
Water	2%	5%	1%
Black Asphalt	4%	3%	3%

The amount of light a body reflects isn't the same for all of the different light wavelengths that fall on its surface. Because of this, each substance can have a unique fingerprint of reflectivity at different wavelengths that lets you identify it. The table above shows the reflectivity of various common materials. For example, snow reflects 80% of the light that falls on it at visible light wavelengths (400 - 600 nm), but reflects quite a bit more at ultraviolet wavelengths (200 - 300 nm), and quite a bit less at infrared wavelengths (700 - 1500 nm).

Problem 1 - If 1000 watts falls on a body in the ultraviolet band, and you measure 150 watts reflected, what is the reflectivity of the body, and from the Table, A) what might be its composition? B) What other reflectivity measurements can you make to tell the difference between your choices?

Problem 2 - You are given the reflectivity maps in each of the three wavelength bands, UV, VIS and NIR at the bottom of this page. What are the likely compositions of the areas in the map?

UV

15	15	15
15	15	22
22	90	75

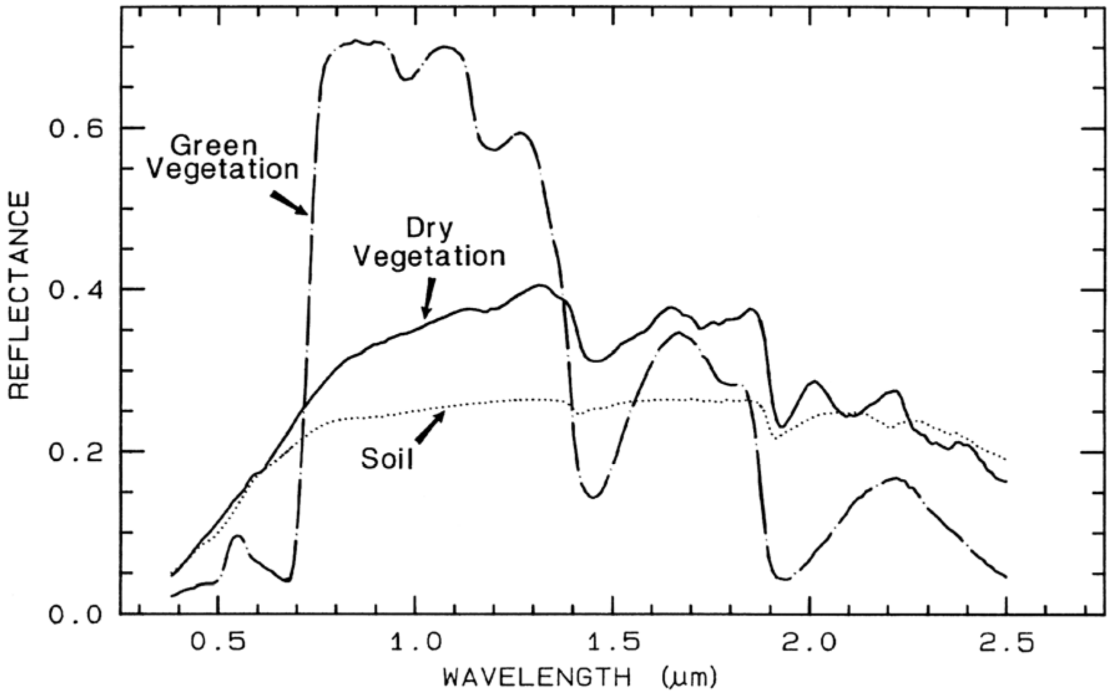
VIS

50	50	30
50	30	80
80	80	74

NIR

40	40	50
40	50	73
73	70	68

Graphical Reflectivity Measurements



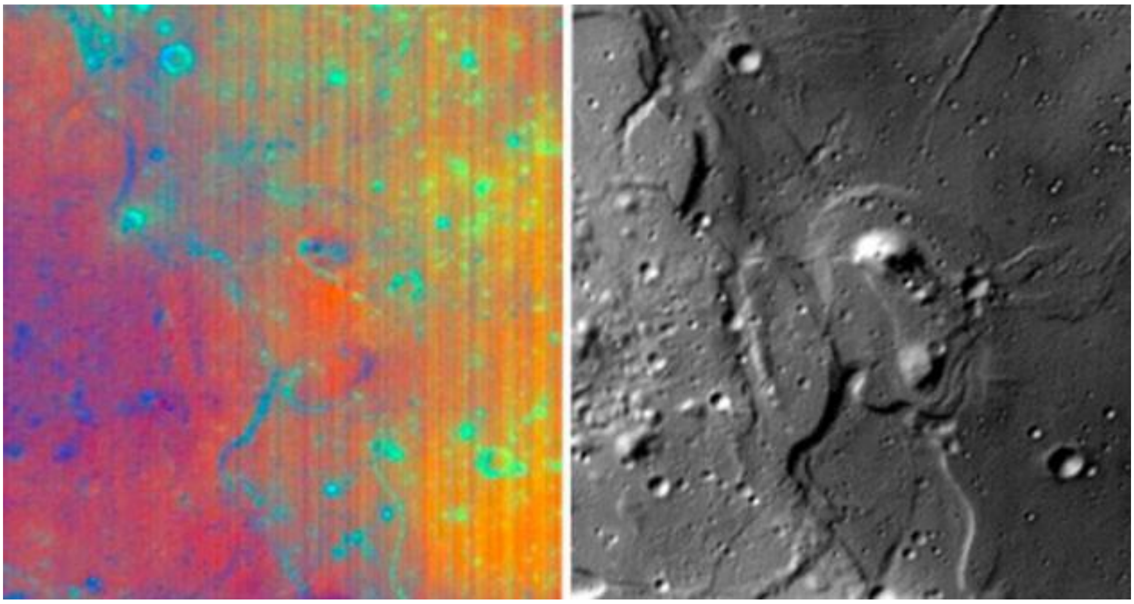
Very precise measurements can be made of the reflectivity of materials that more easily reveal their subtle differences. Above is a plot of the reflectivities of green vegetation, dry vegetation and soil between wavelengths of 0.4 and 2.5 micrometers. Scientists use graphs such as these to design instruments that help them discriminate between a variety of interesting materials and mineral deposits.

Problem 1 - An astronomer wants to map the surface of Mars with telescopes on Earth to search for plant life. What wavelength range would help her more easily discriminate between the martian soil and living vegetation?

Problem 2 - An earth scientist measures the intensity of light between two neighboring land areas at a wavelength of 2.0 microns and 0.7 microns. Spot A appears to be 5 times brighter than Spot B in the longer wavelength band, but nearly equal in brightness in the shorter-wavelength band. What may be the difference in substances between the two spots?

Problem 3 - The difference in the vegetation reflectivity between green vegetation and dry vegetation is that green vegetation still contains the molecule chlorophyll. What is the difference in absorption by chlorophyll molecules at a wavelength of 0.6 microns?

A Mineral Study of Mare Orientale



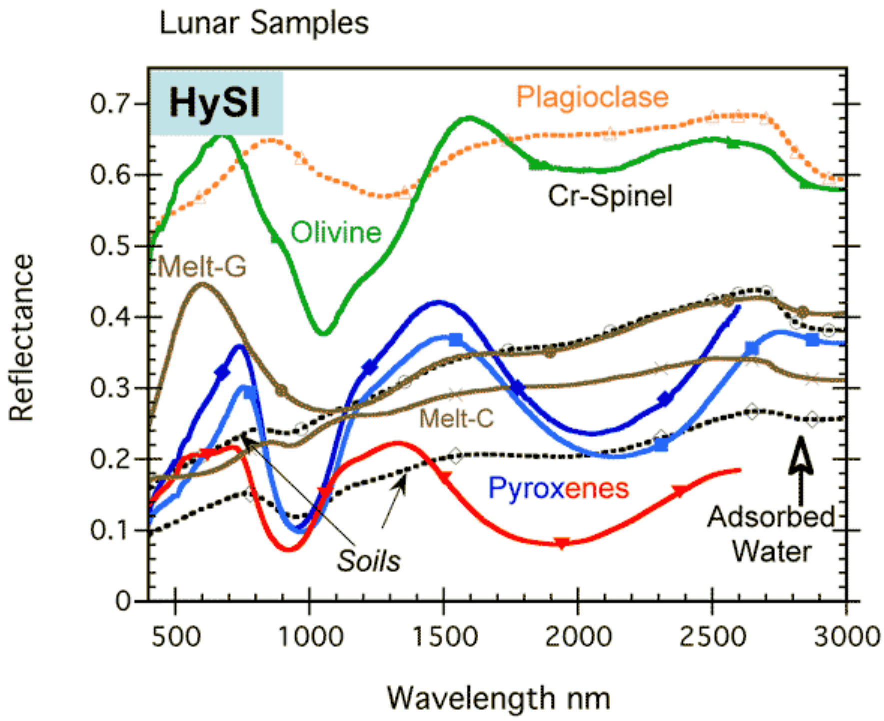
The Moon Mineralogy Mapper on India's Chandrayaan-1 satellite measures slight reflectivity changes within 261 wavelength bands from 430 to 3000 nanometers (0.43 to 3 microns) in the light reflected from the lunar surface. The images cover a small part of the Mare Orientale region, and are each 40 km wide. The left-hand image is a false-color, coded image based on 28 separate wavelengths of light reflected from the lunar surface. Green indicates iron-bearing minerals such as pyroxene (basaltic, lava-like material) commonly found in the mare regions. Blue indicates almost pure anorthosite rock commonly found in the lunar highlands.

Problem 1 - What is the scale of each image in meters/mm? What is the diameter of the smallest discernable crater in the right-hand image?

Problem 2 - What type of feature is pyroxene mostly associated with?

Problem 3 - The narrow, diagonal mountain escarpment that you see in the upper right corner of the right-hand image is not seen in the left-hand image. Why do you think this is the case?

Problem 4 - The visible-band reflectivity of pyroxene is about 25% and anorthosite is about 63%. How much sunlight will 5 square meters of each mineral absorb on the moon's surface if the sun delivers 1300 watts per square meter of energy?



Lunar rock samples brought back by Apollo astronauts have been carefully examined, and represent many basic classes of minerals. The two most common are the pyroxene-A (blue line) and pyroxene-B (red line), which are found in the extensive lava fields of the lunar mare (dark areas), and plagioclase (orange line), which is found in the mountainous lunar highlands. The above graph shows the reflectivity of these common minerals.

Problem 1 - A remote-sensing instrument, called a Multi-Spectral Reflectometer, is designed to measure the intensity of light between wavelengths of 1400 to 1500 nanometers (nm), and 2000 to 2100 nm. About what will be the reflectivity of plagioclase, Cr-spinel, Pyroxene A and B, and Melt-G in these two bands?

Problem 2 - Which mineral will be the brightest in each band?

Problem 3 - Which mineral has a reflectivity of 45% at 600 nm, and 26% at 1100 nm?

Problem 4 - Two minerals have the same reflectivity at 1100 nm, and reflectivities of 28% and 40% at 2300 nm. What are the two minerals?

Problem 5 - At 2000 nm, about 1300 watts of sunlight fall on every square meter of the lunar surface. For 3 square meters of surface area, what mineral will; A) Absorb the most solar energy in watts? B) Absorb the least solar energy in watts? and C) Which material will be the hottest on the surface?