How Do Scientists Determine the Composition of Rocks They Can't Touch?

Our eyes are pretty good reflectance spectrometers for measuring the visible light portion of the electromagnetic spectrum. However, some things that are very different, such as coal and basalt, look the same to us — both are black rocks. How can we tell them apart if we cannot touch and analyze them? Special instruments, spectrometers, detect wavelengths of electromagnetic radiation beyond what our eyes detect. This additional information helps distinguish different materials.

Spectrometers onboard spacecraft collect spectral data reflected from the surfaces of planets or moons. Scientists compare the "mystery" planetary spectra with reflectance spectra collected in the laboratory from known materials to decipher what rocks, minerals, and elements are on the planet's surface.

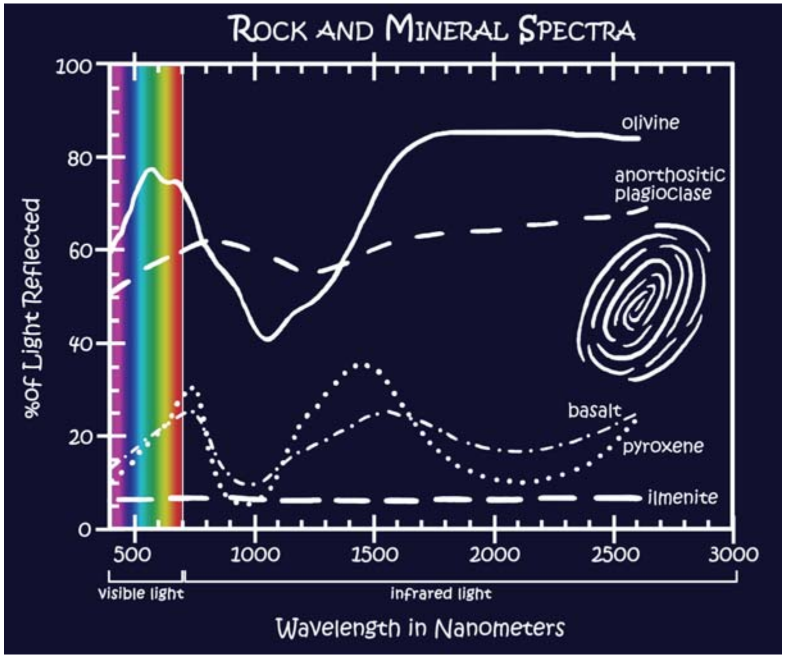
The minerals that make up rocks have defined chemical compositions and rigid atomic structures. When sunlight strikes the rock's surface, the composition and atomic structure of the different minerals control the wavelengths they absorb or reflect. Because each mineral absorbs and reflects electromagnetic radiation at unique wavelengths, each mineral has a characteristic spectral "fingerprint" or reflectance spectrum.

Detectors in a spectrometer measure specific, narrow ranges of wavelengths reflected from a surface. Each detector measures a different portion of the spectrum. One detector may measure the amount of reflection of wavelengths of visible red light between 630 to 650 nanometers from a particular place on a planet's surface, while another may measure the amount of reflection of infrared wavelengths between 900 and 1000 nanometers from that same place. For any location, scientists can construct a spectrum by plotting the brightness — how much radiation was reflected from the surface — for each of the ranges of wavelengths.

Scientists examine this planetary reflectance spectrum and compare the shape of the curve to reflectance spectra of known minerals. The low areas on the curve are where particular wavelengths of light have been absorbed. The peaks are where light has been reflected. Scientists can use spectra collected from Earth samples and the rocks brought back by the Apollo astronauts to help them identify the composition of areas on the Moon.

Rocks are made of several minerals. Scientists combine the spectra of known minerals to acquire a curve that fits the planetary reflectance spectrum. Through this process they determine the amount of each mineral — and the elements that form that mineral — present in the rock.

A spectrum from a known place on a planet helps to identify the rocks, minerals, and elements for that particular place. Scientists use spectra from across a planet's surface to map the distribution of these materials without actually sampling the rocks!



This graph shows reflectance spectra of several minerals common on Earth and the Moon, and a lunar basalt. The spectral fingerprint of the basalt is a result of combining different amounts of the mineral spectra. Its shape is similar to the shape of the pyroxene spectrum, indicating that the basalt contains a large amount of pyroxene. The basalt also contains plagioclase, and minor amounts of olivine and ilmenite. Ilmenite, a dark mineral, has a low reflectance; when light strikes this mineral most is absorbed and little is reflected. The presence of ilmenite in basalt contributes to the low reflectance of basalt.