Twenty-seven years of imaging spectrometry of the Earth

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This paper outlines the birth and early development of the technique of Earth imaging spectrometry, these days called hyperspectral imaging. The development of imaging spectrometry of the Earth grew out of the need, in geologic applications, for identification of surface materials rather than just classification into separable units. The latter was possible with multispectral imagers such as Landsat MSS. The recognition of the possibilities resulted from the development of the first portable reflectance spectrometer covering the 0.4-2.5 μm region and a series of measurements in the Goldfield Mining District, NV in 1974. The variety of iron minerals seen in the 0.8-1.0 μm region and the many OH- bearing minerals identifiable in the 2.0-2.5 μm region showed that an imaging spectrometer with 10 nm resolution would be able to identify essentially all of these minerals remotely. Other important and abundant minerals such as quartz and feldspars do not have characteristic absorption features in the 0.4-2.5 μm region.

The next step was The Shuttle Multispectral Infrared Radiometer (SMIRR) developed at JPL to fly on the second flight of Shuttle (STS-2) in 1979 but delayed until 1981. The purpose of the experiment was to test the feasibility of direct mineral identification from Earth orbit. The instrument was designed as a profiler to acquire radiance values in 10 spectral bands along a 100 m wide track beneath the spacecraft. Three closely-spaced 10 nm wide filters centered around 2.2 μm were designed for the identification of clays. The instrument consisted of a spare Mariner Venus-Mercury mission telescope with a spinning filter wheel in front of an HgCdTe detector in the focal plane. Two 16 mm fighter-aircraft gun cameras recorded the ground track. The experiment was successful and resulted in the first direct identification of soil minerals from orbit (Goetz et al., 1982).

In 1979 the first hybrid focal plane array became commercially available. This two-dimensional detector array consisted of a matrix of HgCdTe detectors bonded to a matched silicon charge-coupled device (CCD) readout array. Although the first detectors contained only 32x32 elements they enabled the construction of an imaging spectrometer that covered the spectral region beyond the 1.1 μm cutoff of silicon arrays. Gregg Vane and the author proposed successfully to use internal JPL funds for the development of the Airborne Imaging Spectrometer (AIS) (Vane et al, 1994). The result was a direct identification of the minerals kaolinite and alunite in the Cuprite Mining District, NV (Goetz et al., 1985).

This success led to the development of an imaging spectrometer program that included AVIRIS, the Shuttle Imaging Spectrometer Experiment (SISEX) and the High Resolution Imaging Spectrometer (HIRIS). Of the three, only AVIRIS was brought to fruition and it remains the premier, optical airborne imaging system to this day.

The early vision of imaging spectrometry was not fully realized until the technology in optics, detectors, computing, software and field instrumentation caught up to the point

where high signal-to-noise ratio, fully atmospherically corrected data could be analyzed by undergraduate students on desktop machines and validated with field measurements. The only missing link is a high performance imaging spectrometer in orbit, which may take another decade to materialize, but only with the dedication and insistence of the scientific and applications community. The author hopes to see the benefits of this effort in his lifetime.

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