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ABSTRACT

An in-progress study demonstrates the utility of AIS data for unraveling the stratigraphic evolution of a North American, western interior foreland basin. AIS data are used to determine the stratigraphic distribution of mineralogical facies that are diagnostic of specific depositional environments. After wavelength and amplitude calibration using natural ground targets with known spectral characteristics, AIS data identify calcite, dolomite, gypsum and montmorillonite-bearing strata in the Permian-Cretaceous sequence. Combined AIS and TM results illustrate the feasibility of "spectral stratigraphy", remote analysis of stratigraphic sequences.

SUMMARY

Prior to 1982, inadequate spatial resolution and spectral coverage limited the utility of multispectral image data for stratigraphic studies. Thematic Mapper (TM) and Airborne Imaging Spectrometer (AIS) data now provide improved spatial and spectral resolution, geometric fidelity and spectral coverage. Evaluation of the combined utility of these data demonstrates that they can complement conventional geological and geophysical information for stratigraphic studies in a typical North American foreland basin.

TM and AIS data were acquired in the Wind River/Bighorn Basin area of central Wyoming. Combined photogeologic, image processing and spectral analysis methods were used to: 1) map strata, 2) construct stratigraphic columns, 3) correlate strata, and 4) identify mineralogical facies.

Photogeologic interpretation of a 1:250,000 scale TM image identified an appropriate locality for constructing an image-derived stratigraphic column. This "type locality" encompasses exposures of homoclinal strata in the Deadman Butte area of the Casper Arch, eastern Wind River Basin. A 1:24,000 512 x 512 pixel TM image of the Deadman Butte area provided a photogeologic base for mapping spectral, textural and geomorphically defined photogeologic horizons. The TM image geometrically matched U.S.G.S. 7 1/2' topographic maps. Thus, standard geologic map interpretation methods could be used to construct a stratigraphic column incorporating TM spectral characteristics, true stratigraphic thickness and resistance of the photogeologic units. This column was correlated with a conventional surface section measured 6 miles to the west. Thus, 38 image units were assigned to 11 formations ranging from the Permian Phosphoria to the Cretaceous Cody Shale. The Deadman Butte TM stratigraphic column

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was also correlated with a similarly constructed column from a structurally complex area in the southern Bighorn Basin and also with well logs from both the Wind River and Bighorn Basin.

Thirty-two channel, 2.1 μm -2.4 μm , AIS data acquired in October, 1983 were registered to the 1:24,000 scale Deadman Butte TM image to provide mineralogical information for TM defined stratigraphic units. Methods used to analyze the AIS data included: 1) empirical wavelength and amplitude calibration using natural ground targets with known reflectance spectra, 2) principal components analysis using 10 spectral bands selected on the basis of field and laboratory spectra of stratigraphically diagnostic minerals, 3) interactive sampling and mineralogical interpretation of image spectra, 4) automated mineralogical classification using a laboratory spectral library, and 5) along-track evaluation of spectral variability using residual processing.

Analyses revealed an approximate 4 channel wavelength shift from nominal and excessive noise in the last 5 channels. After correcting for these problems, AIS data revealed the stratigraphic distribution of dolomite (dolostones in the Phosphoria Formation), gypsum (anhydrites in the Dinwoody/Chugwater Formation transition), calcite (limestones in the Alcova Member of the Chugwater Formation), montmorillonite (bentonites in the Mowry Shale and Frontier Formation) and quartz (orthoquartzites throughout the section). This information was incorporated into the TM-defined stratigraphic column.

One hundred twenty-eight channel, 1.15 μm - 2.34 μm , AIS data were acquired on the same flightline in September, 1985. Comparison of image spectra to laboratory spectra (Fig. 1) confirmed results of the analysis of 1983 data. Residual processing of the data, using the same methods that were applied to the 1983 data, however, yielded unsatisfactory results. Refinement of the residual method is now in progress.

These results demonstrate the feasibility of using coregistered AIS and TM data for correlation of strata and for isopach and facies mapping. This stratigraphic information can be integrated with conventional surface, borehole and geophysical data for detailed stratigraphic studies of North American western interior sedimentary basins. When available, AVIRIS and SISEX data could provide images with sufficient spatial coverage and geometric fidelity to replace TM data as a photogeologic base for similar spectral stratigraphic studies.

REFERENCES

Wolfe, W.L., and G.J. Zissis (eds), 1978. The Infrared Handbook (Ann Arbor, Michigan: Environmental Research Institute of Michigan), pp. 5-88.

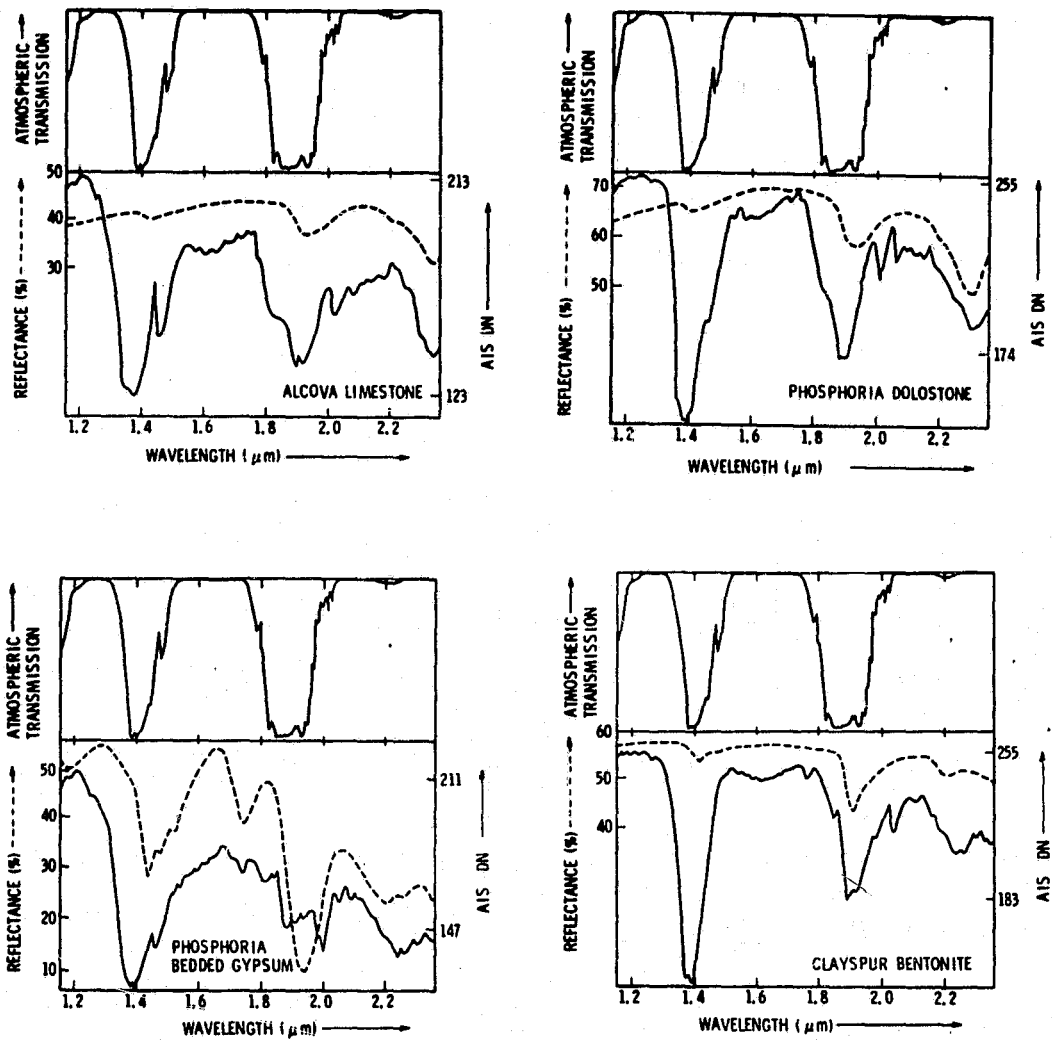


Fig. 1. Comparison of selected 3 x 3 pixel, flat-field corrected, AIS image spectra to laboratory spectra of samples obtained from same locations. Atmospheric transmission spectrum (after Wolfe and Zissis, 1978, pp. 5-88) is also shown. Data span 1.15 μm -2.34 μm wavelength interval. Absorption features include atmospheric CO_2 bands near 1.45 μm and 2.0 μm , and bands near 2.33 μm (calcite), 2.30 μm (dolomite) and 2.2 μm (gypsum and montmorillonite). Long wavelength shifts (~ 4 AIS channels) of 2.2 μm gypsum and montmorillonite bands in AIS spectra as compared to laboratory spectra are probably due to along-track differences in wavelength interval sampled by fourth grating position.