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FIELD UTILIZATION AND ANALYSIS OF AIS 128-CHANNEL IMAGERY USING MICROCOMPUTERS: APPLICATION TO YERINGTON, NV FIELD AREA

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ABSTRACT

As geologists in exploration we need to be able to determine the mineral composition of a given outcrop, and then proceed to another in order to carry out the process of geologic mapping. Since April 1984 we have been developing a portable microcomputer-based imaging system (with a "grey-scale" of 16 shades of amber), which we demonstrated during the November 1984 GSA field trip in the field at Yerington, NV. We have recently also demonstrated a color-version of the same technology, at this AIS Workshop, at JPL. The portable computer selected is a COLBY 10-Megabyte, hard disk-equipped "repackaged-IBM/XT", which operates on either 110/220 VAC or on 12VDC from the cigarette lighter in a field vehicle. (See Figure 2: upper). A COMPAQ PLUS or an IBM Portable will also work on modified software.

Our software was internally developed and owes much to Dr. Andy Green, CSIRO, North Ryde, NSW, Australia, and follows his ideas of LOG-RESIDUALS (see associated paper in this issue by A. A. Green and M. D. Craig). The underlying concept is that the atmospheric transmission and surface albedo/slope terms are multiplicative, relating the spectral irradiance to the spectral "color" of the surface materials - the end result we wish to examine in the field. Thus the spectral color of a pixel remains after averaged log-albedo and log-irradiance have been estimated. All these steps can be carried out on the COLBY micro-computer, using 80 image lines of the 128-channel, 12-bit imagery.

Results are shown for such an 80-line segment, showing the identification of an O-H bearing mineral group (of slightly varying specific characters) on the flight line. (See Figure 2: lower.)

GEOLOGY OF THE SITE (After Proffett & Dilles, 1984)

The Jurassic plutonic rocks (granodiorite and quartz monzonite) and associated porphyritic quartz monzonite dikes were intruded as a 7-km deep section. This rock sequence was deeply eroded (2 km) in late Mesozoic to early Tertiary times, and left a high-relief terrain with 0.5 km (2000 ft) peaks. Upon this rough terrain were laid a thick series of Oligocene and early Miocene ash-fall tuffs (ignimbrites) with a total thickness of about 2 km (7500 ft). Rotational tilting of the whole area occurred continuously during this deposition, so that the originally-flat basal tuffs (Guild Mtn. member, Tgm) now have 70° west dips, while the uppermost (Miocene) hornblende andesite tuffs of Lincoln Flat (Tha) dip only 20-30° west (Proffett & Proffett, 1976).

Significantly for this remote-sensing application, south of the Singatse Fault, in the Ann Mason area, the originally vertical section through the porphyry-copper "plumbing" is now displayed in a near-horizontal outcrop. Top is to the WNW, the base is to the ESE, and over 5 km (16,000 ft) of almost continuous outcrop traverses the Singatse Range.

AIS IMAGERY, YERINGTON,NV, 28 JULY 1984

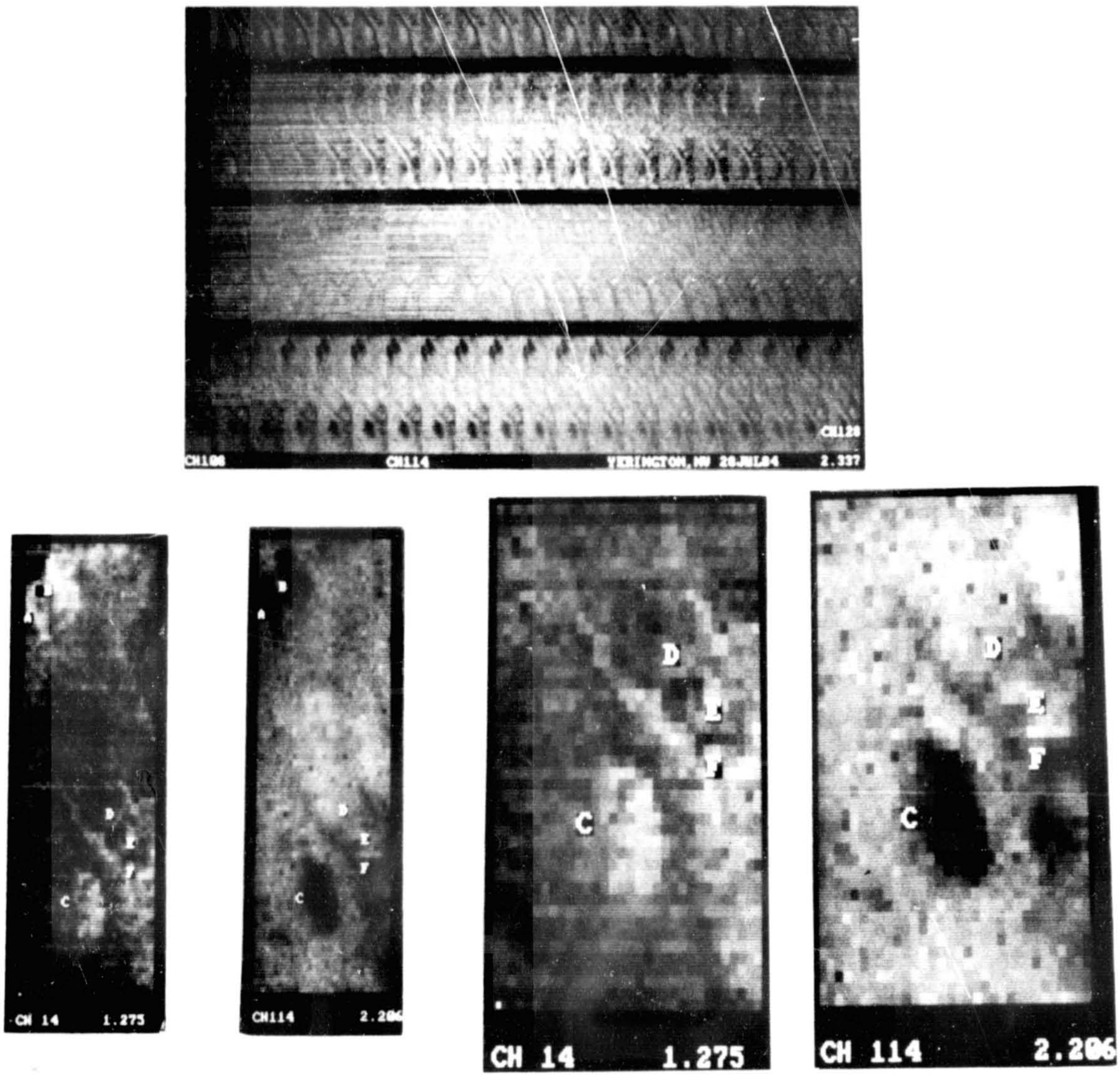
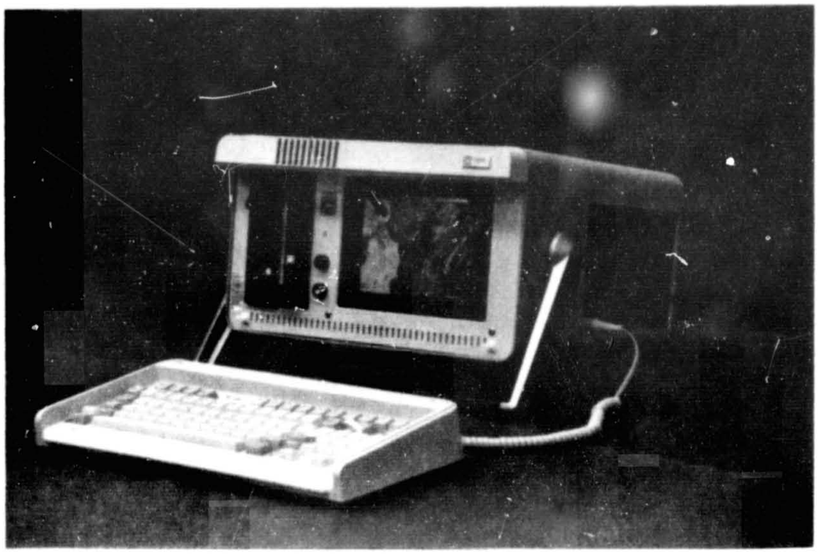


FIGURE 1. **(Upper)** Display of 80 channels, each of 80 flight lines, for Run 407, commencing at line 750. Top left is channel 48 (1.60μm). Left to right covers 20 channels, each differing by 9.3nm. Notice lower right set commences at CH108 (2.15μm). Targets are blacker in CH110-118,reaching a maximum around CH 114 (2.206μm). Flight data over Yerington,NV,taken 28 July, 1984

(Lower Left pair). Displays of 80 line segments, for channels 14 (1.275μm) and 114 (2.206μm), respectively, at 2x enlargement on the CRT. Notice specific pixels A-F. **(Lower right pair)** 4x enlargements of the lower portion of the scene, showing localities C-F. **Black on channel 114 is indicative of O-H absorptions, probably due to sericite alteration products.**

AIS IMAGERY, YERINGTON,NV, 28 JULY 1984



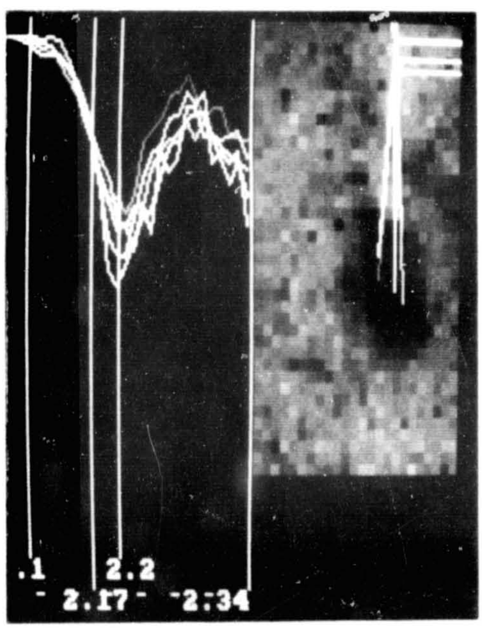


FIGURE 2. **(Upper)** COLBY Portable computer, as used for the field analysis of AIS flight data (Demonstrated at JPL AIS Workshop, 4/85). Present image on 16-level gray scale (Amber) is of a U-2 TMS image, over Yerington,NV. Black area is the water-filled old pit, white areas are the dumps of q.monzonite used for AIS calibration.

(Lower) AIS image of CH 114 (2.206μm), wherein O-H absorptions are black, showing the pixel-by-pixel analysis, and their associated spectra. **Originals are colored in seven colors. Notice the variability of the O-H absorptions, in detail.**

Ann Mason Area

M. Einaudi and his students (Einaudi, 1977; Carten, 1981; Harris and Einaudi, 1982) studied the area in great detail, during the period 1975-1982. The recent extensive mineralogical study of J. Dilles (Ph.D thesis, 1983), however, provides most of the background materials for the AIS flight-calibration mineralogies.

U-2 TMS Flights - 1983-85

Although the Stanford Remote Sensing Lab (SRSL) has been studying these sites since 1972 (SKYLAB), the major breakthrough occurred with the acquisition of the 12-channel (TMS) digital imagery over the Singatse Ra., in April 1983. For the first time it was possible to locate "clay-alteration" areas (O-H bond absorptions, near 2.2 μm) in spatially-coherent patches with the expected locations and trends observed in our fieldwork. Both the Ann Mason (Singatse Peak) and the northern MacArthur areas were imaged in a single 30,000-wide strip down the length of the Singatse Ra.

These imaged data were shown to John Dilles in that month, as he was completing his Ph.D thesis research (Dilles, 1983). He confirmed that the 1.6/2.2-μm "anomalies" indeed very closely maped his "Late-Stage" alteration, identified from thin-section and XRD studies as tourmaline-sericite-pyrite assemblages. In addition we feel, that by careful matching of these, 1983 ratio-images showed the possible detection of this even-more subtle potassic (hydrothermal) alteration (chlorite-hydrobiotite) which occurred lower (deeper) into the original dike swarm, below the late-stage (geothermal) sericite-pyrite capping.

AIS-Flight, 28 July 1984

After three clouded-out attempts the NASA/ARC C130 was able to gather 128-channel spectral images over five specially designed flight runs, each 700 ft wide, crossing the previously identified "clay anomalies". Two lines (407, 409) paralleled the WNW trend of the dike swarms, flying up the "plumbing system" of the mineralization, from the base to the top of the erosion surface. Another line (#410) crossed these at right angles over the sericite-pyrite zone, while (#408) traversed close to (but unfortunately not over) the MacArthur deposits to the north.

Pre-Processing of the AIS Data

Our SRSL-AIS pre-processing package consists of three units;

AIS2 - a program which accesses the 1600 BPI, 9-track CCT tapes, images a 400-line segment, displaying 16 adjacent wavelength bands, so that one can identify locations on the left and right margins of the flight on the associated 35mm B/W photographs (roughly along the center third of the prints). In a second part of the program, files may be created for the any 80 lines of the scene, 128-channels deep, on to the COLBY (IBM/XT) 10-Mb hard disk. These files are given the extension *.AIS.

ANDYAIS - the next program which forms the main pre-processing step in the SRSL package. The program presently operates only on the 80-line segment (later to be the whole flight line of approximately 2000 lines), and performs the following steps;

(i) Takes natural logarithms of all the imagery digital data

(ii) AVERAGES all wavelengths for a given pixel, to yield a single scalar (A)

(iii) AVERAGES all pixels for a given wavelength plane (80x32), for 128 planes, yielding a 128-element vector (H-bar)

(iv) AVERAGES all the H-bars to give a single (global) scalar (G).

For each pixel of the image, the program takes its given LOG-DIGITAL NUMBER (Log-DN), subtracts in turn its H-BAR, subtracts A, and adds G-BAR. The resultant LOG RESIDUAL (R) is saved as the final "SPECTRAL-IMAGE" set, designated *.NDY.

DESTAIS - cleans up the vertical striping, by forcing each of the 32 detector elements (vertical lines on the image displays) to have the same area-under-the-curve. This is performed 128 times, once on each image plane. The resultant file is designated *.DES.

Display Programs for the AIS-Imagery

The AIS-display package consists of three units:

a. MULTI - presents 80 channels, for 80 image lines, starting at channel N = 1,,48, in a single selected linear stretch for all 80 channels. (See Figure 1: upper, for 1X, and lower, for 2X and 4X enlargements, to show specific localities. Pixel size is 8X8 m.)

b. TVAIS - (or CAIS, on the B/W field unit.) The user selects any one channel (N = 1,,128) for display at a 4X scale. ANY of the pixels are cursor selectable, and alongside the indicated pixel either a color-coded residual is shown as a horizontal "color-bar", or the spectrum of the log-residual is graphed in one of seven colors, as a graphics plot. (See Figure 2: lower.)

c. ANDY - (or CANDY, on the B/W field unit.) A version of TVAIS to color-plot, or color-code, any digitized spectrum, for n = 128, or 256 data points, as from a published database, field spectra from the flight lines, etc.

STATUS

Results are shown for such an 80-line segment, showing the identification of an O-H bearing mineral group (of slightly varying specific characters) on the flight line. (See Figure 2: lower.) Active studies are in progress, the completion of which are entirely dependent upon available funding.

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