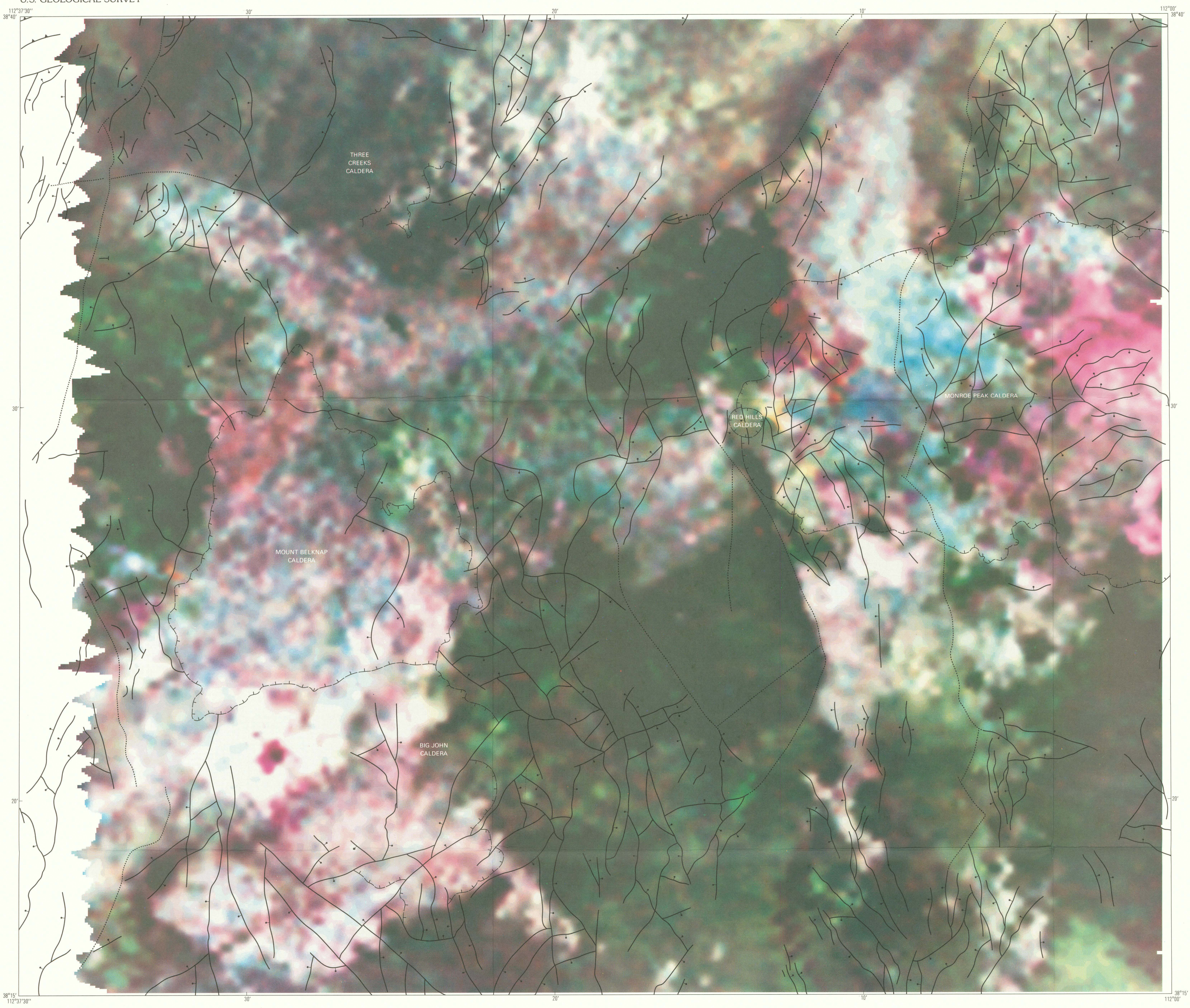
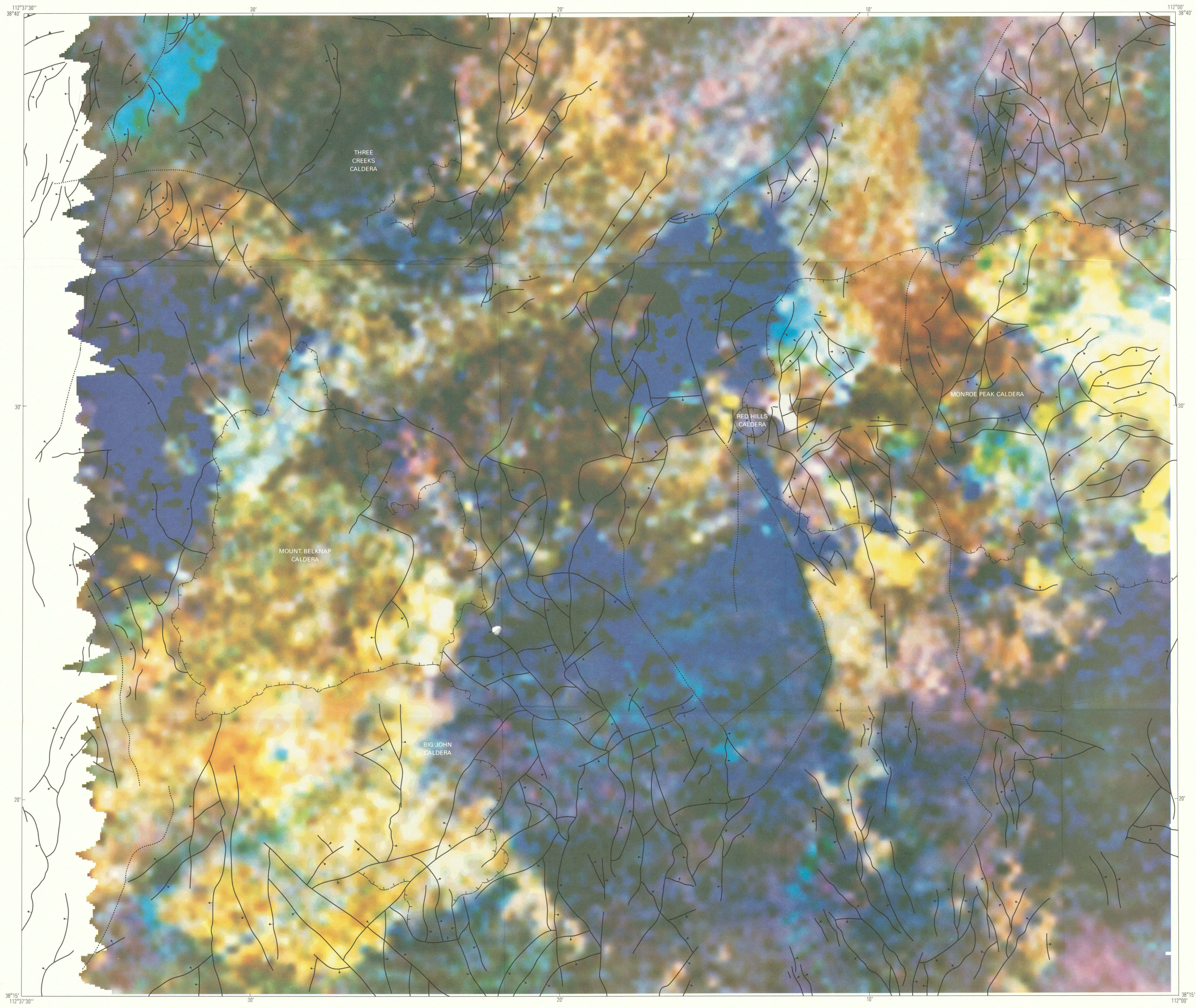
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS INVESTIGATIONS SERIES
MAP I–1430–H

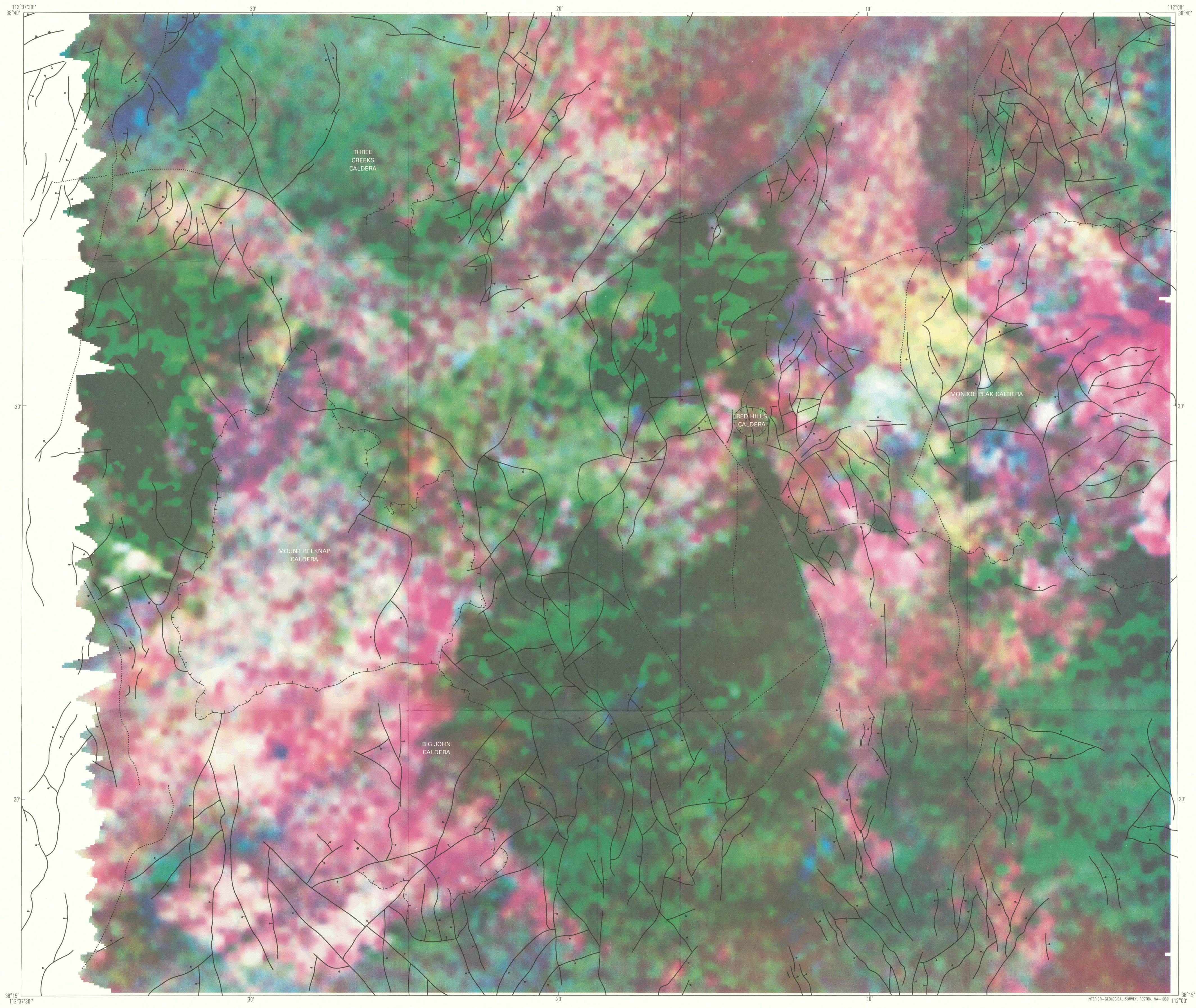


Map *A*.—Element composite-color map

Map *B*.—Potassium composite-color map



Map *C*.—Uranium composite-color map



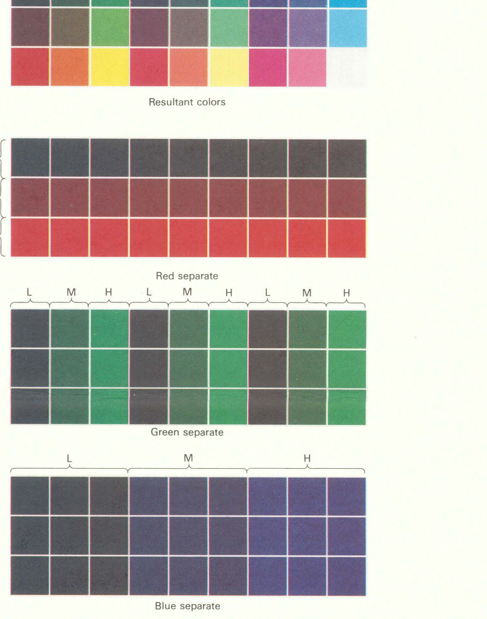
Map *D*.—Thorium composite-color map

SCALE 1:100 000

Geology modified from Cunningham and others (1983)
Manuscript approved for publication, January 20, 1988

EXPLANATION

The color scale shown here illustrates the resultant colors formed by combining various levels (low, medium, and high) of the primary colors. The multicolor scale at the top shows all possible combinations of these color levels. When all three gamma-ray parameters used to make the map are high, the resultant color is white. When two parameters are low and the third is high, the result is the corresponding primary color, red, green, or blue. The red, green, and blue separates shown below the resultant colors indicate the color levels that were combined. For the color separates, the low color level represents values near zero, the medium level represents values near the middle of the data range, and the high level represents the highest values. Because the actual inks used to print this map are magenta, cyan, and yellow, the colors produced by the additive color scheme chosen are not intuitive and the primary colors are not perfectly reproduced.



Fault—Dotted where faults bounding major fault blocks are covered by significant alluvial deposits. Bar and ball on downthrown side

Thrust fault—Teeth on upper plate

Approximate margin of a caldera

INTRODUCTION

Gamma-ray composite-color maps (CCM's) of the Tushar Mountains and adjoining areas, Marysvale volcanic field, Utah, were prepared from aerial gamma-ray spectrometric data obtained as part of the U.S. Department of Energy (DOE) National Uranium Resource Evaluation (NURE) program (DOE, 1982). The CCM's are color-coded ternary maps that present the surface and near-surface distributions of the natural radioelements potassium, uranium, and thorium, and of their ratios, in a form that is particularly useful for comparison with mapped geology (Cunningham and others, 1983).

Aerial gamma-ray spectroscopy provides estimates of the near-surface (0 to about 30 cm depth) concentrations of percent potassium (K), parts per million equivalent uranium (ppm eU), and parts per million equivalent thorium (ppm eTh). The eU and eTh data are described as equivalent concentrations because the eU and eTh measurements detect radioactive daughter nuclei that are separated from the parent nuclei by chemically distinct, long-lived daughters. This fact can result in radioactive disequilibrium, and therefore the concentrations are denoted as equivalent concentrations.

Calculating all possible ratios of the three element (K, eU, eTh) concentrations results in a total of nine radiometric parameters. Duval (1983) developed a technique that combines any three of the radiometric parameters as varying shades of the primary colors (red, green, and blue) to make so-called "composite-color maps." Of the CCM's presented here, Map ***A*** is an element CCM that combines the three elements, with eU as shades of red, K as shades of green, and eTh as shades of blue. Map ***B*** is a potassium CCM, with K as shades of red, K/eU as shades of green, and K/eTh as shades of blue. Map ***C*** is a uranium CCM, with eU as shades of red, eU/K as shades of green, and eU/eTh as shades of blue. Map ***D*** is a thorium CCM, with eTh as shades of red, eTh/eU as shades of green, and eTh/K as shades of blue. These maps are designed so that areas with relatively high values of all three parameters are white and areas with relatively low values are dark. The explanation shown on the map illustrates how low, medium, and high values of the parameters combine to produce different colors, and serves as a standard to show possible deviations in relative color balance reflecting varying amounts of the parameters. Because of the complexities of color reproduction, the colors on Maps ***A–D*** reflect the parameter values only in a general, qualitative way and should not be used for quantitative purposes. These maps provide a synthesis of the radiometric data, showing at a glance a partial geochemical signature of the surface materials, as well as the distribution of areas of similar and dissimilar geochemical compositions.

DATA SOURCES AND PROCESSING

The aerial gamma-ray data used to produce these maps were taken from a detailed survey of part of the Marysvale volcanic field (DOE, 1982) obtained as part of the NURE program (1975–1983). The survey was flown under contract with DOE by Geodata International Inc., using a high-sensitivity gamma-ray spectrometer equipped with 39.3 liters of sodium-iodide detector crystals. The nominal survey altitude was 122 m above ground level. The flight lines were flown east-west at a nominal line spacing of 400 m; three north-south tie lines were spaced 12-20 km apart. The data were fully corrected by the contractor for background radiation, altitude variations, and airborne bismuth-214 radiation. Using the DOE calibration pads at Grand Junction, Colo. (Ward, 1978), and the DOE dynamic test strip at Lake Mead, Ariz. (Geodata International, Inc., 1977), the gamma-ray system was calibrated so that the measurements were expressed as the apparent surface concentrations of percent K, ppm eU, and ppm eTh.

To prepare Maps ***A–D***, the NURE spectrometric data were further processed. The tie lines were removed and the coordinates were projected using a polyconic projection with a base latitude of 38.25° and a central meridian of 112.29°. To correct for a leveling problem present in the original data, the uranium data for some of the flight lines were multiplied by a factor of 0.75. The flight-line data were then filtered using a nine-point Gaussian filter to reduce noise and other high-frequency variations. The data were gridded using a minimum curvature algorithm (Briggs, 1974; Webring, 1981) with a grid interval of 200 m, which is one-half of the flight-line spacing, and were then regridded to a 100-m interval to achieve the correct map scale. The gridded data were additionally filtered using a strike filtering technique to remove short-wavelength features that were parallel to the flight-line direction. After the final gridded data were obtained, the ratios eU/K, eU/eTh, K/eU, K/eTh, eTh/eU, and eTh/K were calculated. To avoid computational artifacts that might result from dividing by a number that is nearly zero, the eU and eTh values were increased by a small increment equal to one-quarter of the respective population means before computing the ratios. A histogram-equalization scheme was used to assign the 254 available intensities uniformly over the data range of each parameter. Each parameter was then assigned a color as described above, and the three color intensity maps were superposed to produce the CCM's. Because the composite-color technique brings out differences as small as 10 percent, the CCM's still show some residual east-west lineations caused by flight-line differences that could not be removed.

For a typical aerial gamma-ray survey of the type made here, each spectrometric measurement reflects average concentrations for a surface area on the order of 60,000 m^2 to an average depth of about 30 cm. Because the gamma-ray sensor detects sources from an area of this size below the flight line, and because the flight lines are themselves separated by 400 m, particular radiometric anomalies may be shown on Maps ***A–D*** at a position that is shifted somewhat from that of the source rocks on the ground. The maximum shift of this kind is probably on the order of about 200 m. Because of the regridding process, the colored picture elements on the CCM's correspond to an area on the ground that is 100 m by 100 m.

Also shown on Maps ***A–D*** are the topographic walls of calderas and the pattern of faults in the survey area, generalized from the geologic map (Cunningham and others, 1983). On preliminary versions of these maps, we tried a number of more complete overlays showing geologic units as well. Those overlays pointed up many interesting correlations between rock types and CCM colors, but in general so cluttered the maps that the color patterns we wanted to show were obscured. The simpler overlay used here provides a reference for orientation and location, but the geologic map should be consulted to locate specific geologic features associated with color patterns shown on the CCM's.

REFERENCES CITED

Briggs, I. C., 1974, Machine contouring using minimum curvature: Geophysics, v. 39, no. 1, p. 39–48.

Cuningham, C. G., Steven, T. A., Rowley, P. D., Glassgold, L. B., and Anderson, J. J., 1983, Geologic map of the Tushar Mountains and adjoining areas, Marysvale volcanic field, Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I–1430–A, scale 1:50,000.

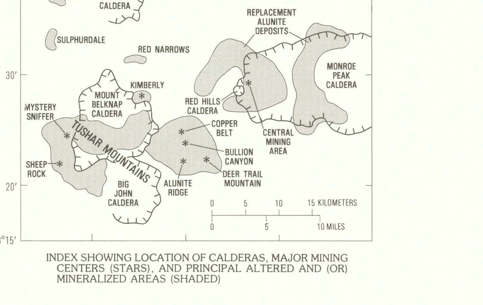
Duval, J. S., 1983, Composite color images of aerial gamma-ray spectrometric data: Geophysics, v. 48, no. 6, p. 722–735.

Geodata International, Inc., 1977, Lake Mead dynamic test range for calibration of airborne gamma radiation measuring systems: U.S. Department of Energy Open-File Report GJBX–46(77), 83 p.

U.S. Department of Energy, 1982, Aerial radiometric and magnetic survey, Marysvale detail survey, Richfield national topographic map sheet, Utah: U.S. Department of Energy Open-File Report GJBX–99(82), v. 2, 64 p.

Ward, D. L., 1978, Construction of calibration pads facility, Walker Field, Grand Junction, Colorado: U.S. Department of Energy Open-File Report GJBX–37(78), 57 p.

Webring, M., 1981, MINC: A gridding program based on minimum curvature: U.S. Geological Survey Open-File Report 81–1224, 41 p.



INDEX SHOWING LOCATION OF CALDERAS, MAJOR MINING CENTERS (STARS), AND PRINCIPAL ALTERED AND (OR) MINERALIZED AREAS (SHADED)

For sale by U.S. Geological Survey Map Distribution, Box 25286, Federal Center, Denver, CO 80225

GAMMA-RAY COMPOSITE-COLOR MAPS OF THE TUSHAR MOUNTAINS AND ADJOINING AREAS, MARYSVALE VOLCANIC FIELD, UTAH

By
Thomas A. Schutter, Joseph S. Duval, David L. Campbell, James A. Pitkin, Thomas A. Steven, and Charles G. Cunningham

1989