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GEOLOGY OF UTAH AND NEVADA BY ERTS-1 IMAGERY

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Abstract

Repetative ERTS-1 imagery covering Utah and Nevada is being studied as an aid in structural geology, mineral exploration, and limnological and hydrological aspects.

Limnological features of algal blooms and varying biological activities in Utah Lake and the Great Salt Lake are grossly evident on the imagery with more subtle details detected on the different bands.

Major structural breaks, lineages, or trends are abundant throughout the area of study. The correlation of positive aeromagnetic anomalies with the trends suggests near surface intrusive bodies, not yet exposed at the surface, that can be tested for possible associated mineralization by collecting soil-gas at the surface which is analyzed for mercury that is (1) apparently associated with mineralization, (2) escapes as a vapor, and (3) can be readily measured in extremely low amounts of less than 1 ppb by absorbtion.

Initial studies are proving that the ERTS images show lineament trends and some of these lineaments do release anomalous Hg contents and are prime zones for further mineral exploration study.

Introduction

The prime objectives of NASA ERTS-1 Contract UN 113, of which I am the Principal Investigator, pertain to mineral resources and exploration, and structural geology. Limnological observations are also proving to be interesting. The area of coverage is large extending over all of Utah, most of Nevada, and portions of California and Wymoning. The boundaries of this rectangular area are from 37° to 42° N latitude and from 109° to 119° W longitude.

Geologically and physiographically, the area includes diverse provinces, viz., Colorado Plateau, Uintah Mountains, Wasatch Mountains, Green River and Uintah basins, a portion of the Sierra Nevada and all of the northern portion of the Basin and Range province. The diversity of mineral and oil deposits, ages of formations and igneous rocks, and the variation in structural features provide a vast potential for the practical application of multispectral imagery to the study of this area. Specific areas of more detailed study are indicated.

Imagery

Only bulk MSS imagery is being used in all four bands. The initial study is greatly enhanced by viewing with a Nikkon binocular microscope mounted over a light table and used to view the positive transparent films at 10X to 80X. The former magnifications is best as it offers a larger area of study but still with retention of details on the imagery.

Those images that provide areas or features of greatest initial interest are further enhanced when printed in B & W but enlarged four tim[illegible] a scale of about 1/250,000. Interestingly enough, little detail is lost with the enlargement and numerous geological maps of the area are available at the same scale A prime example is Humboldt County, Nevada, where regional structural trends, basin and range normal faults, transverse (essentially E-W) faults and specific lithologic types can be recognized on the imagery while some are not noted on the geological map. The enlarged ERTS-1 image is perfectly adequate as a base map and could have served readily as a field base map for mapping.

A simple method of producing color composites and single-color band-images is being used. This involves the use of Diazochrome color films in an Ozalid contact copier. The method is rapid, simple, and relatively inexpensive. The superposed films result in a color transparency which can be re-photographed by 35 mm or other cameras to produce excellent projection materials. The superposed films can be used directly on overhead projectors or viewed with light tables. We find that some experimenting is required with this technique because of the variations in the density of the imagery and the need to use the proper color of diazochrome with specific bands. Generally, the lighter pastel colors provide far better false color enhanced imagery. Examples will be shown with 35 mm colored slides.

Hydrologic Features

Two ancient watercourses have been observed on ERTS-1 imagery. These lie in the Waterpocket Fold area, north of the Marble Canyon section of the Colorado River, in Arizona and Utah. The old watercourse appears to have been northward flowing, following the Waterpocket Fold west of the Henry Mountains, across the present Fremont River and other drainages have captured portions of the system. The watercourse can be observed on image No. 1032-17370. A cutoff meander on the Colorado River, still above the present level of Lake Powell, appears to be of similar age and possibly related to the ancient watercourse. The major part of the path of the watercourse appears to be structurally controlled. The tributaries generally flow northwestward and northeastward and intersect the major rivers with the acute angle as if the major streams still flowed northward rather than southward.

A second old watercourse can best be seen in the vicinity of Long Ridge and the San Juan River on image No. 1031-17313.

A remarkable correlation of the annual precipitation on the Uintah Basin is evident by comparing image No. E 1121-17312-4 with a computer generated shaded map (Fig. 1) of the same area. The remarkable similarity of the boundaries of the lowest precipitation are evident.

Limnological Features

Image No. 1051-17414 contains some very useful information concerning the hydrology, sedimentology, and biology of Great Salt Lake and Bear Lake in Utah. The greater penetration of wavelengths in band 4 of the MSS imagery yields much information about sediment plumes and water depth. Band 5, with lesser penetration, gives more information about surface phenomena, including algal populations, etc. The infrared bands provide information about shallow water in marsh areas where the water is hidden from shorter-wavelength bands by vegetation. In Great Salt Lake, there is a sharp line between the portion of the lake north of the railroad causeway, which is essentially a rock and earthern dam, and that south of the causeway (Fig. 2). There is a marked difference in salinity across the causeway, and this is reflected in different algal species, plainly visible in band 5. A reddish algae occupy the north limb, while blue-green varieties occupy the south limb. The negative water budget in the north limb causes brine concentration in that area, accompanied by northward surface flow through the two narrow openings in the causeway. This flow can be seen in band 5. The high density in the northern limb results in density-current counterflow at depths, and this can be seen in band 4. The sediment plumes from inflowing rivers are plainly visible on bands 4 and 5. These features are enhanced in the false color images as shown by 35 mm studies.

Image No. 1051-17420 contains part of Great Salt Lake and all of Utah Lake. The latter displays a very interesting surface pattern which is probably due to an algal bloom which has been swirled into a spiral by the circulation of the lake. This was a short-lived phenomenon observed on the September 12 overpass only which has not been observed on other imagery to date. The algal nature of the phenomenon is not yet proven but is to be studied in cooperation with ERTS-1 limnologists of the National Oceanic and Atmospheric Administration who first noted this feature as shown in Fig. 3.

Geological Features

The prime geological features that are most obvious in the area are major structural trends, lineaments, or structural breaks. These are most prevalent in the Wasatch and Basin and Range provinces. The majority have never been recognized before ERTS-1 imagery and they provide an exploration potential of major significance. This is the application of geochemical and geophysical study over trends that extend into alluvial or volcanic areas that are post-mineralization in age and hide evidence of potentially mineralized areas below the overburden.

As there is significant evidence that mercury vapor escapes from mineralized zones, soil-gas samples are collected in the post-ore blankets over the inferred extension of mineralized trends using a hood equipped with a fan that forces the air through 80 mesh silver screen. The amalgon is later heated in the laboratory and the quantity of released Hg is measured by an atomic absorption instrument. Such studies have been done over known mineralized zones with significant Hg amounts of about 400 ppb to > 1000 ppb have been measured while samples collected over presumably mineral barren zones assay generally in the range of < 300 ppb of Hg.

It is our desire to locate Hg soil-gas anomalies in post-ore covered zones and perform cursory induced polarization surveys over the amonalies with the hope of detecting sulfide mineralization at depth. The practical significance of this application of ERTS-1 imagery in correlative studies with known geotechnics is quite obvious.

Interestingly enough, besides the evident mineralization exposed in bed rock adjacent to the alluvial filled valleys, aeromagnetic maps are also used as additional ground truth and are of aid in correlating the lineages and trends with positive aeromagnetic anomalies. This is especially true in north central Nevada where intrusives have presumably given rise to mineral deposits in favorable carbonate rocks underlying major thrust faults. The overlying rocks of the thrusts consist of essentially siliceous and volcanic formations that are comparatively non-reactive to mineralizing fluids.

In conclusion, therefore, structural breaks detected on ERTS imagery may target trends that correlate with positive aeromagnetic anomalies where anomalous Hg content in soil-gas further delineate where induced polarization surveys should be done with the hope of detecting sulfide deposits for which there is no surface evidence other than the ...ience on the ERTS imagery.

CLASS INTERVAL	CATEGORY	SYMBOL
0 - 6 inches	1	.
6 - 10	2	-
10 - 14	3	+
14 - 18	4	=
18 - 22	5	0
22 - 26	6	θ
26 - 30	7	ø
30 - 34	8	⊖
34 and above	9	■

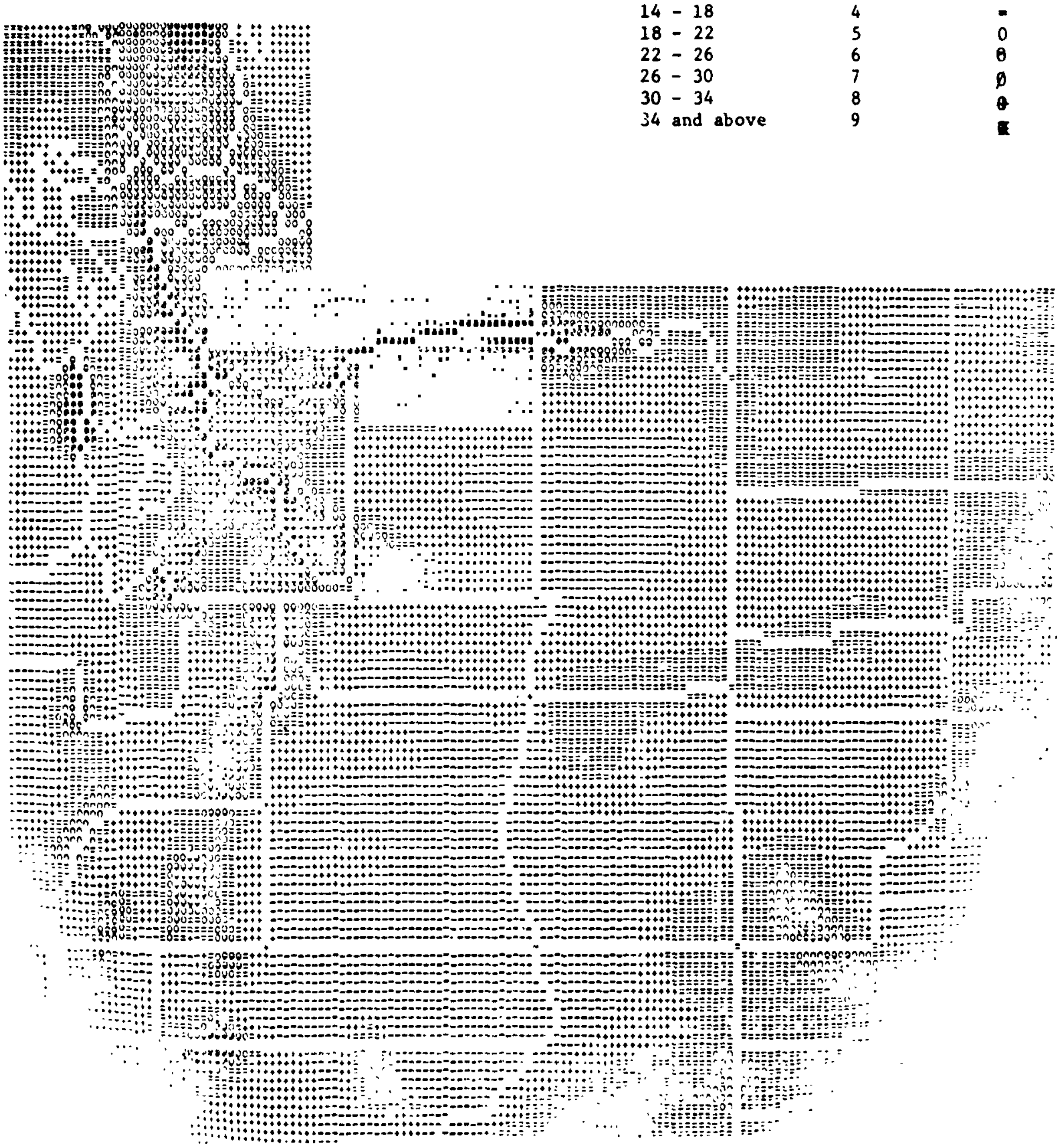

Figure 1


W114-00
W113-30
W113-00
W112-30
MSS 6 D SUN EL45 AZ142
NASA ERTS E-1052-17472-6

Figure 2

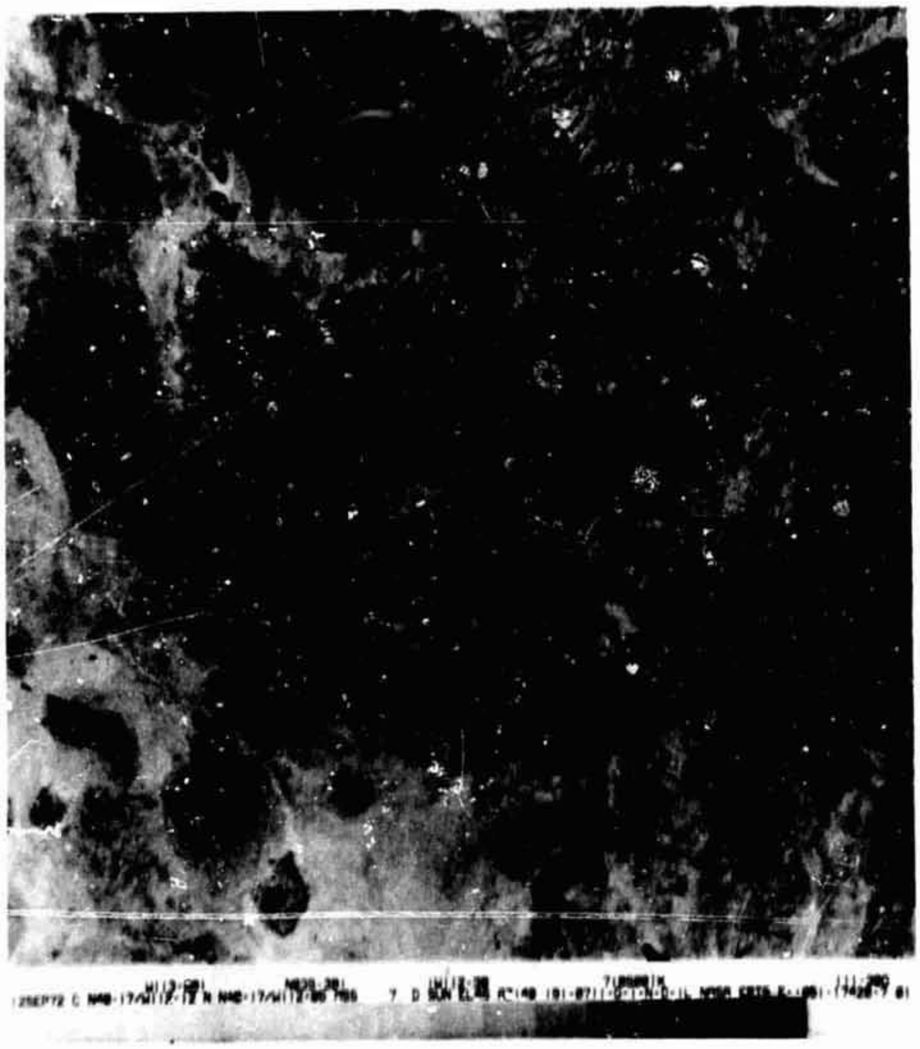

Figure 3