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Geologic Questions and Significant Results Provided by Early ERTS-1 Data

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Introduction

The U. S. Department of the Interior presently has 45 experiments involving over 150 people underway and jointly supported by NASA and the EROS Program, to evaluate the uses of Earth Resource Technology Satellite (ERTS-1) data of the United States and selected foreign areas. These studies are in the fields of cartography, land use and management, geology, hydrology, forestry and range management. Our NASA/EROS supported scientists have just begun to receive their satellite data from the Goddard Space Flight Center and we are confident that more detailed scientific analyses and results will soon be forthcoming.

We have also established a system to review data as it becomes available and distribute it to regional Department of the Interior experts who are not yet involved in the space program. The purpose is to solicit their assistance and knowledge of local areas in the interpretation of features seen on satellite images but not recorded on available maps. While the system has not yet been perfected, we are beginning to get some return on this effort.

First, we are bringing to the attention of our people the fact that ERTS-1 is in operation and bringing back excellent data. All

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recipients have been impressed by the synoptic view these data provide, the better-than-anticipated resolution, the spectral response of the individual bands and the overall information content that are contained therein. We have been flooded with requests from within the agency and without as to how people can get more data. In Sioux Falls, S. D., our EROS Data Center is ~~frantically attempting~~ working overtime to supply these requests.

In the few minutes that are available today, I would like to take this opportunity to briefly describe some highlights of the information we have extracted from data collected during the first two weeks after ERTS-1 was launched on July 23, 1972.

East Coast Area

ERTS-1 images of the Boston-Cape Cod Region (Fig. 1) have clearly shown the intricate bottom topography of the ocean ~~near~~ between Woodshole and ~~Nantucket Islands~~ Marthas Vineyard in band 5 (red) where the sea bottom at depths ~~up to~~ in excess of 70 feet are clearly visible. These features, however, are masked out in color composites of the same area, but the land features are enhanced.* Comparisons with aerial photography taken within the last few years show that changes in ocean bottom features have taken place. Some of these changes constitute navigational hazards not shown on existing hydrographic charts. It is believed that ERTS data can provide information useful in updating such charts as well as inventorying near-shore resources, such as sand, gravel and aquatic food sources.

*Perhaps some experimentation in color reproduction could be done to ensure that such information is not lost.

This color composite of the Gainesville, Florida, area (Fig. 2) shows the verdant vegetation of river valleys and swamps as pink. The drier areas, where water table is low, is shown as yellow to orange in color indicating that vegetation is dry or burned out by the late summer sun. Our local Water Resources Division geologists state that the two bright or highly reflective areas in the northeast quadrant of the scene are strip mining operations where titanium ores are being mined. These observations indicate that ERTS-1 data, recording the distribution of verdant vegetation throughout the seasons of the year, can be used as a guide for ground water exploration. It can also assist in locating, monitoring the extent of such operations, and, possibly, the effects of strip mining activities.

Central U. S. Areas

This scene of the Texas/Oklahoma area of the Ouachita Mountains (Fig. 3) is significant in that it contains two test sites that have been worked on for several years by USDI scientists. One is a geology test site at Mill Creek, Oklahoma, in the Arbuckle Mountains in the northwest quadrant. The other is Lake Texoma, a large reservoir in the southern half that is of interest to the Bureaus of Reclamation and Outdoor Recreation.

The most striking feature in the scene are the folded sedimentary rocks of Paleozoic age that crop out in the Ouachita Mountains.

The ERTS-1 infrared bands (5 and 6) ~~clearly~~ mark the contact between the Cretaceous and younger sedimentary rocks of the coastal plain in the south and their contact with the older rocks to the north. In addition, these bands ~~clearly~~ indicate the distribution of the younger sedimentary rock of the Mississippi Embayment to the south.

Western Mountain Areas

This scene of Pyramid Lake and Reno, Nevada, (Fig. 4) ~~clearly~~ shows a circular feature that is 25 miles in diameter. Although it needs to be studied in greater detail, our scientists in the area, suggest that it is a resurgent caldera; that is, an old volcanic extrusive center that has ~~risen~~ ~~and~~ uplifted and/or collapsed, or an eroded dome. Tertiary igneous rocks within the circle are overlain by younger sedimentary gravels and sandstones that are warped and tilted due to later movement. Hot springs are located in the southeastern part of the circle. Recognition of the feature as a single structural unit is new for it is not shown on existing maps of the area. It may be important in future studies of the distribution of mineral~~s~~ deposits or geothermal power sources of that region.

It is also interesting to note that in the color composite of this scene (Fig. 5) at the south end of Pyramid Lake, there is ~~a~~ noticeable vegetation or possibly an algae bloom which may be related to pollution coming downstream from the Reno area. Comparison with previous maps shows that the lake area has shrunk because of withdrawals from the Truckee River by California and Nevada. The Justice Department filed a suit on September 27, 1972 with the U.S. Supreme Court against California and Nevada on behalf of the Paiute Indians to raise the lake and thereby restore the yield of fish from the Paiute ancestral fishing grounds, their primary livelihood. (Treaty 1859)

This scene of Mt. Hood and Portland, Oregon, (Fig. 6) provides a view of the Cascade Range from the Columbia River to the south. Several circular and linear features have been identified that are not shown on recent geologic maps of the area. A small circle, about thirty miles due east of the town of Albany has been identified as Mt. Snow, a relatively recent volcanic cone superimposed on an older volcanic pile. The circle surrounding Detroit reservoir is related to an intrusive stock which may have uplifted the area into a dome (G. Walker, personal communication). The others, at present, are unexplained but could be domes or calderas somewhat similar to Crater Lake about 100 miles to the southeast. Our preliminary interpretations have been sent to our scientists in Menlo Park, California, and to the Research Center of Volcanology in Eugene, Oregon, for comment. The recognition of such features could be important to our current studies of geothermal resources and in unraveling the geologic history of the Cascade Range.

West Coast Areas

A preliminary analysis of the San Francisco Bay and adjacent central Great Valley area (Fig. 7) by Ernest Lathram shows three examples of geologic applications in the study of earth resources from space. These are:

1. Identification of known faults and linears that may be unsuspected faults.

2. Recognition of relation of vegetation growth to underlying materials.

3. Recognition of ultramafic rock bodies with which minerals of economic value are commonly associated.

Faults

Brief study of a false color ERTS image of the San Francisco Bay and adjacent central Great Valley area (Figure 6) shows three examples of geologic applications in the study of earth resources from space. These are:

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Faults

1. The trace of the northwest trending active San Andreas, Hayward and Calaveras faults can be clearly seen southeast of the Bay.

2. Northwest of the Bay, 4 nearly north-trending linears, expressed not only in topography but also in abrupt changes in vegetation growth in flatlands adjacent to the Bay, may be unsuspected faults as they are not shown on geologic maps of the area. The easterly linear, whose northern end, at Lake Berrgessa, coincides with the mapped Wragg Canyon fault, extends southerly to Carquinas Straits, and may extend across the Straits beneath the Port Chicago low-land area to the Calaveras Fault. If true, the Calaveras Fault may really extend from Hollister on the southeast

to Lake Berrgessa on the northwest, rather than terminating at Carquinas Strait as presently shown on geologic maps.

3. Both northwest and southeast of San Francisco Bay, between the Great Valley and Pacific Ocean, a series of northeast-trending linear features transect the dominant northwest-trending geologic structures. These may reflect crustal structures which, coupled with the known northwest-trending faults, may have controlled the location of uplifted blocks (i.e., Jura-Cretaceous strata of the Diablo Mountains) and downthrown blocks adjacent (i.e., Tertiary basin under San Francisco Bay).

~~Geologic Control of Vegetal Growth in the Great Valley~~

Vegetal growth, reflected by the intensity of reds on the photograph, exhibits distinct areal patterns which are related to the underlying materials. Areas of most intense red (1) and most vigorous growth, are underlain by silts and clays containing a high percentage of organic materials, deposited in basinal areas. Areas of less intense reds (2) and less vigorous growth, overlie more coarse grained sands and silts, which have less organic content and are better drained, and reflect alluvial deposits from erosion of the Coast Range Mountains and Sierra Nevada in Pleistocene time. Samller areas of less vigorous growth (3) are underlain by similar materials which may be even better drained, or are the sites of military reservations, ranch lands or in some cases, (Port Chicago) urban development. A distinctive area adjacent to the Sierras which shows poor vegetal growth (4) is underlain by the coarse sands and gravels (poor sub-soil) eroded from the Sierras in Late Tertiary and early Pleistocene time. These are the deposits in which rich placers of gold were found in the Sierra Foothills. One distinctive area (5) shows by a rectangular pattern the evidence of development, but poor vegetal growth. This area, the Mustang Hills, is dominantly ranchland, and is underlain by coarse stream deposits probably eroded from the highlands to the northwest.

Ultramafic Rock Bodies

Ultramafic rock bodies, some with associated mineral deposits rich enough to have been mined, are known in the areas of both the Coast Range and Sierra Foothills shown on the image. These bodies are difficult to identify in the Coast Range, but in the Sierra Foothills area, they have a distinctive purplish brown aspect. Known bodies of ultramafic rock can be readily identified (5). Similar areas (6) may also be ultramafic rocks but are not shown on the 1:250,000 scale geologic map of the area.

At (X) portions of the dike breached by the Sacramento River flood of 1972 can be seen; the dark water area here covers the still-inundated city of Isleton, California, and surrounding farmlands.

Alaska

Excellent data has been collected over parts of Alaska, generally from the Colville River area and to the south. This color composite (Fig. 7) is of the area near Kobuk, east of Kotzebue Sound and South of the Brooks Range. It is of great interest to our Bureau of Land Management because it shows a 50,000 acre forest fire in progress and they are responsible for this area of public land. It also shows the scars of an earlier burn. This data has permitted them to measure and assess, in preliminary fashion, the acreage damaged by such fires and estimate the value of the timber lost.

Conclusions

The multiband approach is extremely useful with each of the bands providing unique and useful information. There are difficulties, however, in handling the data if all 7 bands are considered. For most current applications, a two-band system (red and infrared) may be sufficient if this would reduce the cost of the satellite and the data reproduction problem. A thermal band, providing coverage on night-time passes over tropical, volcanic, geothermal and high latitude areas would be extremely helpful and should be considered for future systems.

The mid-morning ERTS-1 orbit has provided sufficient shadowing to enhance landforms for monoscopic viewing. Stereo viewing can be done in high relief areas of overlap and may be very useful as repetitive data is acquired.

The resolution of the images exceeds that which we anticipated and is satisfactory for a large range of applications. Of the multispectral bands, the red band (RBV 2 or MSS 5) is important for mapping cultural features, submarine features and vegetation distribution. The nearest infrared band (RBV 3, MSS 6) is good in mapping water body shorelines but can be fooled by shallow areas or heavy sediment loads in streams or lacks. The farther infrared band (MSS 7) is excellent for vegetation discrimination and infallible for mapping shorelines of oceans, lakes, wetlands, etc. Of the green band (RBV 1, and MSS 4) I have said very little. It is most affected by atmospheric conditions and best serves as an index of such conditions. Its water penetration capability for which it was designed appears hampered by the overwhelming effects of the atmosphere. It should be further tested, however, and studied critically before an attempt to discard it is made.

We are still relatively low on the learning curve with regard to the interpretation of ERTS-1 data. It is clear that in order to keep up with data production, to detect changes in repetitive coverage and to update maps, we must adopt automatic methods as soon as possible. In spite of initial difficulties we think that ERTS-1 is an unqualified success.