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INITIAL EVALUATION OF THE GEOLOGIC APPLICATIONS OF ERTS-1 IMAGERY FOR NEW MEXICO

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ABSTRACT

Coverage of approximately one-third of the test site, the state of New Mexico, had been received by January 31, 1973 and all of the images received were MSS products. Images recorded during the first two months of the ERTS-1 mission are of poor quality, owing largely to high ground reflectance. Later images are of better quality and MSS bands 5 and 7 have proven to be particularly useful. Features noted during visual inspection of $9\frac{1}{2}$ x $9\frac{1}{2}$ prints include major structural forms, vegetation patterns, drainage patterns and outcrops of geologic formations having marked color contrasts. The Border Hills Structural Zone and the Y-O Structural Zone are prominently reflected in coverage of the Pecos Valley. A study of available maps and remote sensing material covering the Deming-Columbus area indicated that the limit of detection and the resolution of MSS products are not as good as those of aerial photographs, geologic maps, and manned-satellite photographs. The limit of detection of high-contrast features on MSS prints is approximately 1000 feet or 300 meters for linear features and about 18 acres for roughly circular areas.

TEXT

The New Mexico State Bureau of Mines and Mineral Resources is a state agency whose function is to provide basic information to explore, evaluate, develop and manage the State's natural resources. Over the past 20 years, bureau geologists have made considerable use of conventional aerial photographs for geologic field mapping. The staff also recognized the potential usefulness of satellite photography while studying photographs of southern New Mexico taken during the Apollo and Gemini programs. Subsequently, the Bureau submitted to NASA an ERTS-1 proposal, the objectives of which are as follows:

1. To study ERTS-1 images with emphasis on discovering and subsequently investigating previously unrecognized geologic phenomena in New Mexico.

2. To evaluate RBV and MSS imagery as a geologic tool by comparing the quality of ERTS-1 images with aerial photographs, manned-satellite photographs, geologic maps, and topographic maps of the same area.

The data forms requested from NASA were $9\frac{1}{2}$-inch by $9\frac{1}{2}$-inch black and white prints and 70-mm black and white negatives. Quarterly coverage of the entire State was requested for all MSS bands and maximum cloud cover was specified at 30 percent or less.

By late January, we had received coverage of approximately one-third of our test site, the State of New Mexico. All images received were MSS products. The quality of the earlier products was very poor; the prints appeared to be considerably overexposed. Communications with other ERTS product users indicated this problem was not uncommon to images taken in much of the southwestern U. S. and the poor quality was largely due to high ground reflectance. Fortunately, the quality of the coverage of our test site improved markedly with the arrival of imagery recorded in October and November.

Parts of New Mexico having reasonably good-quality coverage include the northwest corner, the entire Rio Grande Valley, the Estancia Valley, the southwest corner in the Lordsburg-Deming area, and the southern part of the Pecos River Valley, including the adjacent parts of the High Plains and the Guadalupe Mountains (Figure 1). We are particularly interested in the mountainous regions of the state, but we have not yet received coverage of most of the Datil-Mogollon volcanic region, in the southern, west-central part or of the Sangre de Cristo Mountains in the north-central part.

Predominant features noted during unaided visual inspection of the better quality $9\frac{1}{2}$-inch x $9\frac{1}{2}$-inch prints include major structural forms, drainage patterns, vegetation patterns and outcrops of geologic formations having marked color contrasts. MSS bands 5 and 7 have been the most useful, although bands 4 and 6 are not without value to geologic studies. In a gross sense, band 5 is probably the best available for determining lithology while band 7 appears to be best-suited to structural features. Man-made features are more readily identifiable on band 7 imagery, perhaps because of a pronounced difference in the heat-retention properties of natural and artifical materials.

Geologic contacts between bedrock and unconsolidated bolson (valley-fill) deposits are evident along the Rio Grande Valley (1010-17143, 17145, and 17152*) and in the southwestern corner of New

* Numbers refer to NDPF identification numbers of images illustrating feature(s) described.

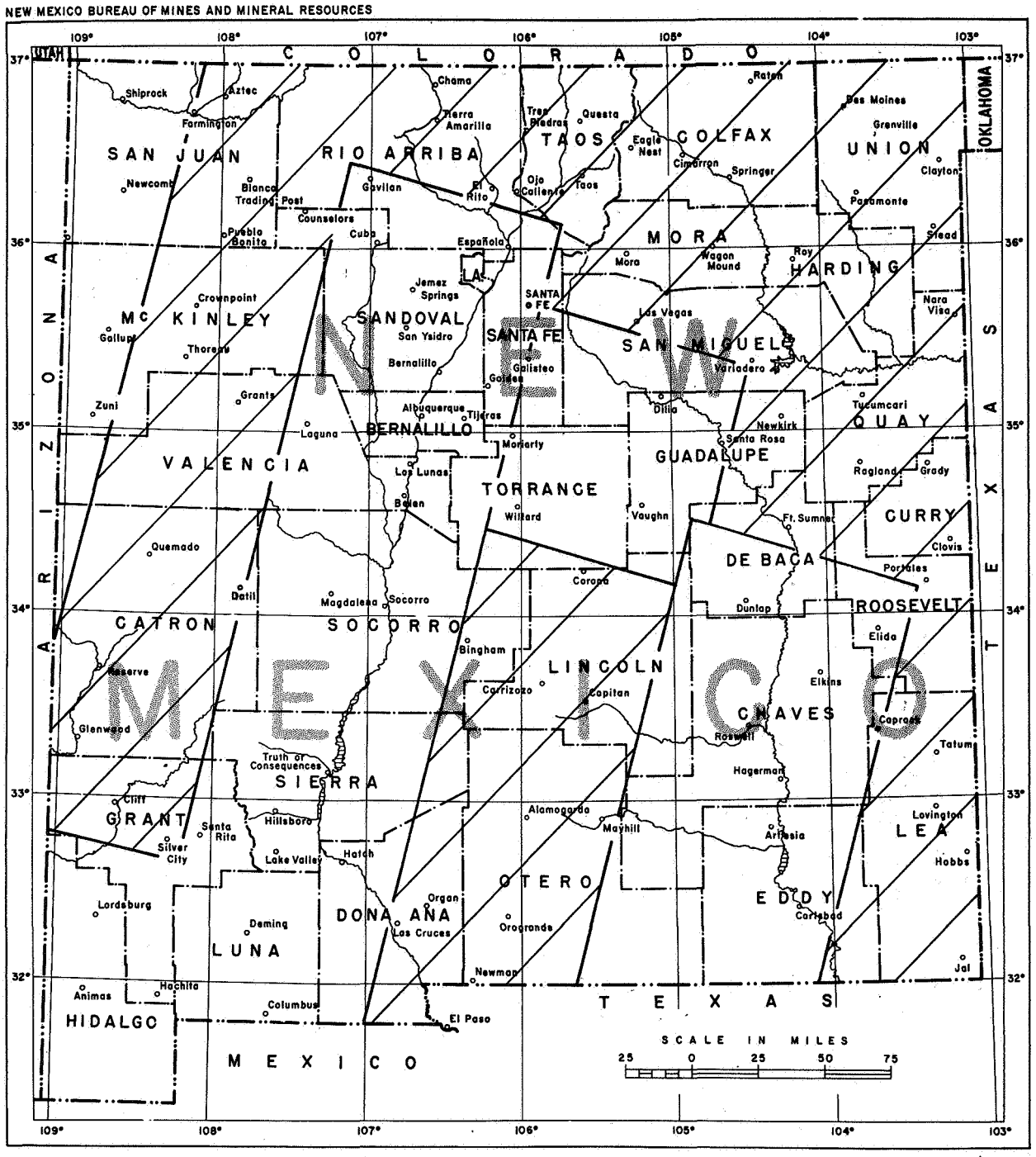

Figure 1. ERTS-1 Coverage of New Mexico as of January 21, 1973
Areas not hachured represent usable coverage

Mexico (1029-1713). Sedimentary contacts between grayish marine units and reddish-brown continental units also have been identified on ERTS imagery. They are particularly conspicuous east of Socorro where the continental Permian Abo Formation overlies the marine Pennsylvanian Madera Limestone (1010-17145 and 1063-17092). Unfortunately, coverage of the west-central part of the state, an area characterized by numerous Cenozoic volcanic units, has not been received, hence we cannot report on the ability to distinguish individual flow units.

Vegetation patterns of the two major types found in New Mexico are clearly shown by ERTS data. Extensive stands of forest in the more mountainous regions are visible on all MSS bands, but they are particularly prominent in color composites (1010-17143). Cultivated lands are restricted largely to major river valleys (1010-17143, 17145 and 17152 as well as 1062-17042) and the High Plains area of the eastern and southeastern parts of the state (1062-17033). The regular shapes of cultivated tracts are particularly useful features for identification.

Structural features identified on ERTS-imagery include volcanic forms, sedimentary forms, faults and areas that have undergone severe folding and shattering. The huge Jemez (or Valles) Caldera in northern New Mexico is shown with surprising detail and the outlines of the basalt-capped Mesa Prieta and Black Mesa can be readily identified (1010-17143). The mid-Tertiary volcanic complex of Mt. Taylor and its three associated peripheral flows is depicted as a classic "volcanic stereotype." The sedimentary structure of the Guadalupe Mountains in southeastern New Mexico has been recorded in marked detail (1062-17042). The 40-mile long, southeastern-facing Permian reef front is clearly shown southwest of Carlsbad as are the shallow-water marine and evaporite facies stretching northwestward from the crest of the reef.

The north-south trending Nacimiento Fault, west of the Jemez Caldera (1010-17143) had been thoroughly mapped prior to the launch of ERTS-1, but subsequent study of MSS imagery indicated a previously unreported, clearly defined lineament extending southward from the mapped portion of the fault for a distance of about 60 miles (1010-17143 and 17145).

The central Rio Grande Valley, particularly between Albuquerque and Socorro, is a seismically active structural depression. Fortunately, no significant seismic event has taken place in this area since the launch of ERTS-1, hence we cannot describe any new fault scarps. The geologically recent fault-line scarps bordering the Magdalena Mountains and Socorro Peak are visible however (1010-17145).

In the Pecos Valley of southeastern New Mexico, the Border Hills Structural Zone and the Y-O Structural Zone are prominent, even in places where these faulted and folded linear features are difficult to see on the ground surface (1062-17040).

One of the uses planned for our ERTS-1 investigation was to monitor the progress of strip mines in the state; specifically land disturbed around the active pits and revegetation programs. The large Navajo Mine, west of Farmington, is clearly visible, largely because the operators strip about 400 acres of overburden each year in a relatively level and unvegetated area. However, the visual contrast between the disturbed ground and the undisturbed, barren landscape is not too great (1030-17260).

The McKinley Mine near Gallup is located in a highly dissected and relatively vegetated area (1030-17262). Individual pits are small and the contrast between mined and unmined land is not great. The York Canyon Strip Mine has been opened on a heavily timbered plateau west of Raton. We have not received coverage of this area yet, but we anticipate that the strip pits will contrast sharply with the wooded, unmined areas.

In summation, we feel we have met with moderate success regarding the first objective of our investigation. Although our limited work with ERTS so far has not revolutionized New Mexico geology, it has pointed out some new insights on previously known features. We are optimistic that the receipt of better quality imagery and complete coverage of the state will add more geologic information.

The second phase of our investigation is a comparative evaluation of ERTS-1 imagery with aerial photographs, Apollo and Gemini photographs, and geologic maps. The most extensive coverage of these latter type data depict the southwestern part of New Mexico; the area west of El Paso, Texas, and generally south of Interstate Highway 10. Coverage of all or most of this area was obtained during the missions of Gemini IV and Apollo VI as well as by RB-57 aircraft using several sensors. Additional sources of coverage were provided by the New Mexico State Geological Map and Sheet 2 of the Apollo VI Photomap series published by the U. S. Geological Survey.

The RB-57 imagery, particularly color photography using 2448 film, provided the lowest limit of detection of any of the photographic data used. Color prints of film taken during Gemini IV was second as far as definition of geologic features was concerned. Film products from Apollo VI were far inferior to both the RB-57 and Gemini IV photographs. The sharp contrast between the Gemini and Apollo

photographs was due in no small part to the larger scale of the Gemini shots.

ERTS-1 coverage of the southwestern part of the state was recorded by the MSS only on two separate passes (1010-17154 and 1029-17213). Unfortunately, frame 1010-17154 is of extremely poor quality and all four MSS bands are far inferior to any of the comparative data. Frame 1029-17213 is one of the best we have received and it is clearly comparable, if not superior, to Apollo VI coverage of the same area. Although the limits of detection of this frame are not as low as those of Gemini IV and the RB-57 output, the larger area covered is a definite advantage in studying regional geology.

Although no RBV data have been available for our study site, we have established some quantitative values for the limits of MSS imagery. The limit of detection for high-contrast features on MSS prints is approximately 300 meters for linear features and about 18 acres for roughly circular areas.