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# Geologic Analysis and Evaluation of ERTS-A Imagery for the State of New Mexico

MMC-262

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## Introduction

The general objectives of this study as outlined in the original proposal are:

1. To study ERTS images with an emphasis on discovering and investigating previously unrecognized phenomena in New Mexico, and

2. To evaluate MSS imagery as a geologic tool by comparison with air photos, previous satellite photos, geologic maps, and topo maps.

The quality of the ERTS-A images we have received has greatly improved during the past year and geologic features can be seen in much greater detail. The cloud and snow cover problem plaguing the investigation in the early stages, has been almost entirely alleviated. Entirely cloud-free photographs, however, have not been received for north central New Mexico, but most clouds can be eliminated by making a mosaic of several images.

In recent months, Karl Vonder Linden, the principal active investigator, left the Bureau of Mines and so Michael Inglis and Sandra Feldman are now taking the active role in the investigation. Both individuals have followed ERTS investigations and have a knowledge of remote sensing techniques.

Accomplishments in This Reporting Period

In order to get an overview of geologic features in the entire state as seen from ERTS, and provide a base map for overlays, a photo mosaic was prepared at a scale of 1:1,000,000 using band 5 imagery. This band (along with band 7) was determined to be the most useful for studying geologic phenomena because of the high contrast. The images chosen for the mosaic are primarily from the spring and fall. Although we had originally hoped to use images from a single season we found that this was not feasible. The mosaic is now being processed by Koogle and Pouls Engineering and a working copy will be available almost immediately.

This will enable us to study the larger more prominent structures in the state which cross many individual image boundaries, such as the fault system along the Rio Grande trench and the relationship between the Cenozoic volcanics in the western part of the state and the isolated exposures in southwestern New Mexico.

In anticipation of the mosaic an area in south central New Mexico which covers two scenes was chosen for study. The geologic structure in a portion of the area has been mapped in detail while generalized maps exist for the remainder. Hence, sections could be accurately checked against existing geologic maps.

The area chosen extends from the western border of the San Andres Mountains to the Pecos River on the east. The northern limit is the Oscura and Capitan Mountains, and the southern limit, the Jarilla Mountains and San Augustine Pass. Figure 1 is an index map of the area.

Parts of two geomorphic provinces are present in the study area--the Basin and Range and the Great Plains. The boundary between the two provinces extends along the east slope of the Sacramento Mountains. The Pecos Valley section of the Great Plains Province is a lowland area dominated by highly soluble formations of limestone, dolomite and gypsum producing karst topography. Terrace development is also characteristic of the section. The area from the Sacramento Mountains, west to the San Andres is part of the Mexican Highlands section of the Basin and Range province. Here, dominantly north-south aligned fault block mountains are separated by graben basins (Jornada del Muerto and the Tularosa Basin).

Drainage is internal in the Tularosa Basin and numerous small lakes can be seen on band 7 (1189-17102-7) in the vicinity of White Sands. Gypsum is eroded from Permian formations in the mountains and transported to this extensive dune field which is located near the north-south midpoint of the basin. North of the playa in the Tularosa Basin is the Holocene Carrizozo lava flow. The Jornada del Muerto, west of the San Andres is a similar downfaulted basin or series of basins with its associated playas and lava flow.

Major normal faulting occurred along the east border of the San Andres and the west border of the Sacramentos. These bordering faults, however, are now covered by alluvium and their actual location has not been determined.

The San Andres Mountains contain formations that range in age from Precambrian to Permian. A small area of Cretaceous sediment has also been found to the north. (Kelley, 1955.) Tertiary alaskite was intruded into the sedimentary sequence and forms Salinas Peak. The strata of the range dip at about 10 degrees to the west.

The Sacramento Mountains consist of Precambrian to Permian eastward dipping formations interrupted by Tertiary intrusives. The Sierra Blanca Group at the northern extent comprises Tertiary extrusives (andesite to rhyolite breccia, tuff, and flows). Northeast of the Sacramentos lie the Capitan Mountains, an anomolous east-west striking laccolith. East of the Sacramento range, the San Andres Formation dips gently into the Pecos Valley and forms the Pecos or Sacramento slope.

For the study, images 1189-17102-5 and 1098-17043-5 on a scale of 1:1,000,000 were used to map and identify significant features. In some cases, it was found that snow cover enhanced structures in mountainous areas, especially in the Sacramento Mountains. Band 7 images and an additional band 5 image from a different orbit were always kept on hand to check anomolous features as well as to eliminate minor cloud cover. We also had available a color composite of the Pecos River area (1062-17042), in addition to Gemini and Apollo photographs and various maps.

We began the study by checking for image distortion which is a common problem with most aerial photographs and images. This was accomplished by photographically reducing the geologic map of New Mexico (1:500,000) to a scale of 1:1,000,000. Using a light table, we superimposed image 1189-17102-5 onto the original reduced map (not the xerox copy). We were surprised and pleased to discover that distortion was minimal. This will mean that overlays made on the state mosaic can be easily transferred to the reduced geologic or topographic map of the state.

Land Use

Another consideration prior to geologic examination was the identification of man-made features. Some of these features may have land-use implications applicable to other areas in the state; and some might otherwise be attributed to natural causes.

On 1189-17102-5 the most conspicuous man-made feature is a light circular pattern in the Jornada del Muerto northwest of Mockingbird Gap. It has also been cited by other workers from Apollo 9 (Nicks, 1970). This is the site of a radar installation (White Sands Missile Range) around which the vegetation and soil cover have been removed exposing the caliche subsurface. The feature is more clearly illustrated on an Apollo 9 photograph (3805-A). Additional circular type features which are ephemeral have been noted in the missile range; they appear only on some images of the area. These may be impact sites, but we do not as yet have ground truth information. A north-south aligned strip directly west of White Sands has been identified as an acceleration sled track.

A peculiar triangular vegetation pattern was noted directly south of White Sands; one side is formed by the southern extent of White Sands, another by the base of the alluvial fans at the foot of the San Andrés Mountains, and the third by U.S. 70. Along part of its length, the elevated highway appears to control the vegetation and most probably the drainage. On a 1941 Soil Conservation Service index sheet of the same area and on the individual photographs at a scale of 1:31,680, the vegetation change was not visible even though the highway was a paved road at the time. We plan to check with the Highway Department for information on U.S. 70 construction and improvements. It is possible that the vegetation pattern did not exist in 1941 or that images on the scale of ERTS-A are needed to bring out the pattern. From the topographic map, drainage in this triangle is to the northwest and a topographic low does exist, but one would not expect such a sharply delineated change without some other form of control.

Another possible vegetation control line has also been noted southeast of the one discussed above. The topographic map locates Orogrande Aqueduct along this line. Cultivated vegetation patterns have, of course, been noted, especially in the Pecos Valley but shall not be discussed here.

<u>Stratigraphy</u>

It was found that geologic units could be mapped where there was no major change in vegetation associations or life zones, or if such transition occurred at formation contacts. Consistent high relief also hampered formation recognition especially in the Sacramento Mountains. On image 1098-17043-5, the San Andres Formation, forming the Pecos or Sacramento slope, grades into Quaternary alluvium in the Pecos Valley. This boundary is evident on the image although somewhat sketchy. The alluvium appears darker in tone and more mottled than the limestone. The change in tone, however, also corresponds to a change in slope on the topographic map at about 4,200 feet, and presumably the transition from the Lower Sonoran to the Upper Sonoran Zone. Higher on the Sacramento slope, even darker tones can be seen, although there is no formation contact and the San Andres Limestone still predominates. The color composite shows an intense red, and we would assume that this boundary marks the change from a grassland and shrub association to a pinon-juniper association (at about 6,000 feet), governed by the elevation. Elevations in the Sacramento Mountains and Sierra Blanca rise above 9,000 feet and no differentiation can be made between the Sierra Blanca extrusive and the Sacramento sediments. However, differences in tone and relief mark the contact between the Yeso and the San Andres on the west side of the mountains, but the contact cannot be consistently recognized.

In the San Andres Mountains, formation contacts can be more easily distinguished. Here, elevations in general do not rise much above 7,000 feet and most of the range is included in the Upper Sonoran Zone. Contacts between various Pennsylvanian and Permian formations are clearly visible along the western extent; formation color changes aid in recognition. The change from west to east is from dark grey dolomite (San Andres Formation) to tan sandstone and gypsum (Yeso Formation) to redbrown sandstone, siltstone, and claystone (Abo) to dominantly limestone (Magdalena Group).

Structural Geology

In the study area, lineament patterns were drawn directly on images 1098-17043 and 1189-17102, using a magnifier. Some of these features are faults, others indicate fold trends or dikes and others are unidentified linears. The critieria used in their identification were offset, truncation of structure, straight stream segments, along with other indications of linear patterns. Figure 2 shows these lineations as an overlay on a reduced section of the geologic map of New Mexico. Dashed lines indicate area of known folding. The majority of these features are not found on the geologic map of New Mexico. Joint patterns would not, of course be shown on the map; faults were not shown on the state map unless they affected bedrock, hence little evidence of faulting is shown in alluvium. More detailed structural maps and discussions of parts of the study area were found in papers by Kelley (1955; 1971), Pray (1961), Otte (1959) and others. Specific comparision of plotted lineaments and faults recognized in the literature will not be included here.

Notable lineaments extending from the Pecos slope into the valley can be seen on the ERTS images, and some of these have no counterparts in the literature. Most are trending NE, with some trending almost due north. Structural zones of folding and faulting which have been previously identified here include the Border Hills Zone, the Six-Mile Hill Zone, the Y-O Zone and the K-M Zone. Unidentified lineaments appear to parallel or branch off from these major zones. South of the Y-O Zone, some of the lineaments most probably correspond to facies changes. North-south trends parallel the Tinnie Fold Belt (dotted area southeast of the Capitan Mountains) and may be related to folding.

Internal lineaments have been recognized in the Sacramento Mountains as well as border fault scarps in the southwest. Some of these have already been reported in the literature and Lowman (1972) has commented on the lack of dissection of the border scarp indicating relatively recent uplift. In May of 1968, an earthquake epicenter was located in the Sacramento Mountains with a local magnitude of 2.7 to 3.0 (Toppozada and Sanford, 1972), indicating this is still an area of seismic activity.

South of Rhodes Pass in the San Andres Mountains the dominant trend is northwest, while north of the pass, the fault and lineament trend is east-north-east. Numerous en echelon faults occur on the eastern border. An east-west line drawn through Rhodes Pass (where the change in strike occurs in the San Andres Mountains) and continuing east to the southern limit of the Sierra Blanca volcanics demarcates a change in lineament trends. North of the line the dominant lineament trend is east-northeast in both mountain ranges and to the south, it is north-northwest.

In addition to magnified image examination, we used a Digicol Viewer to see if structural features could be enhanced. We found that the information provided by the viewer did not supplement data we had already obtained with the magnifier, but that it might be useful in the future for a "first look" at other images.

Future Plans

We plan to obtain some ground truth information for the area discussed above and explore the consequences of the observed lineament trends. When the working mosaic is received we will concentrate on structural and seismic trends in the Rio Grande Valley and on mineralized areas within the state as outlined in the proposal.

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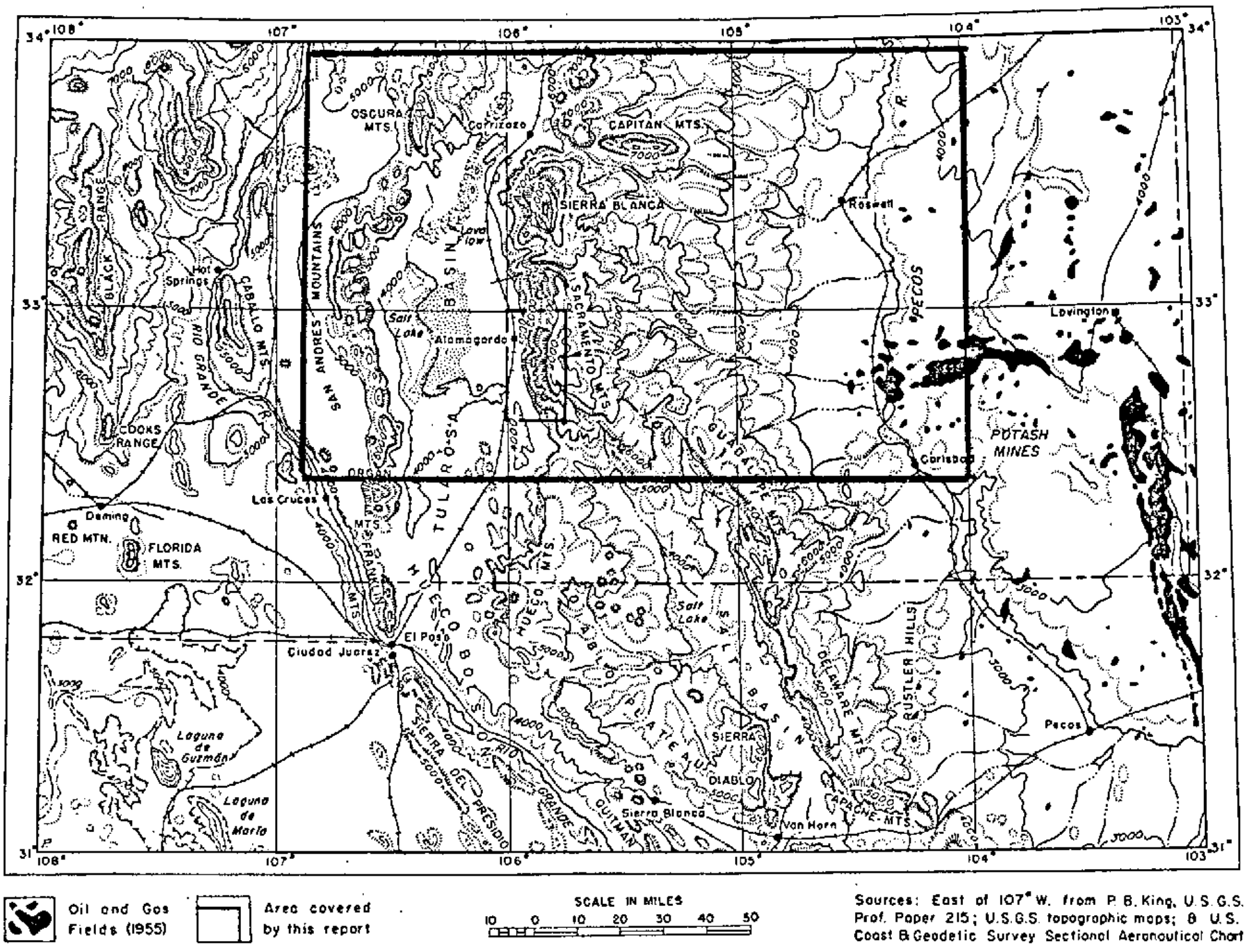


Figure 1

MAP OF SOUTHEASTERN NEW MEXICO AND ADJOINING PARTS OF WEST TEXAS AND NORTHERN CHIHUAHUA
(from Pray, 1961)

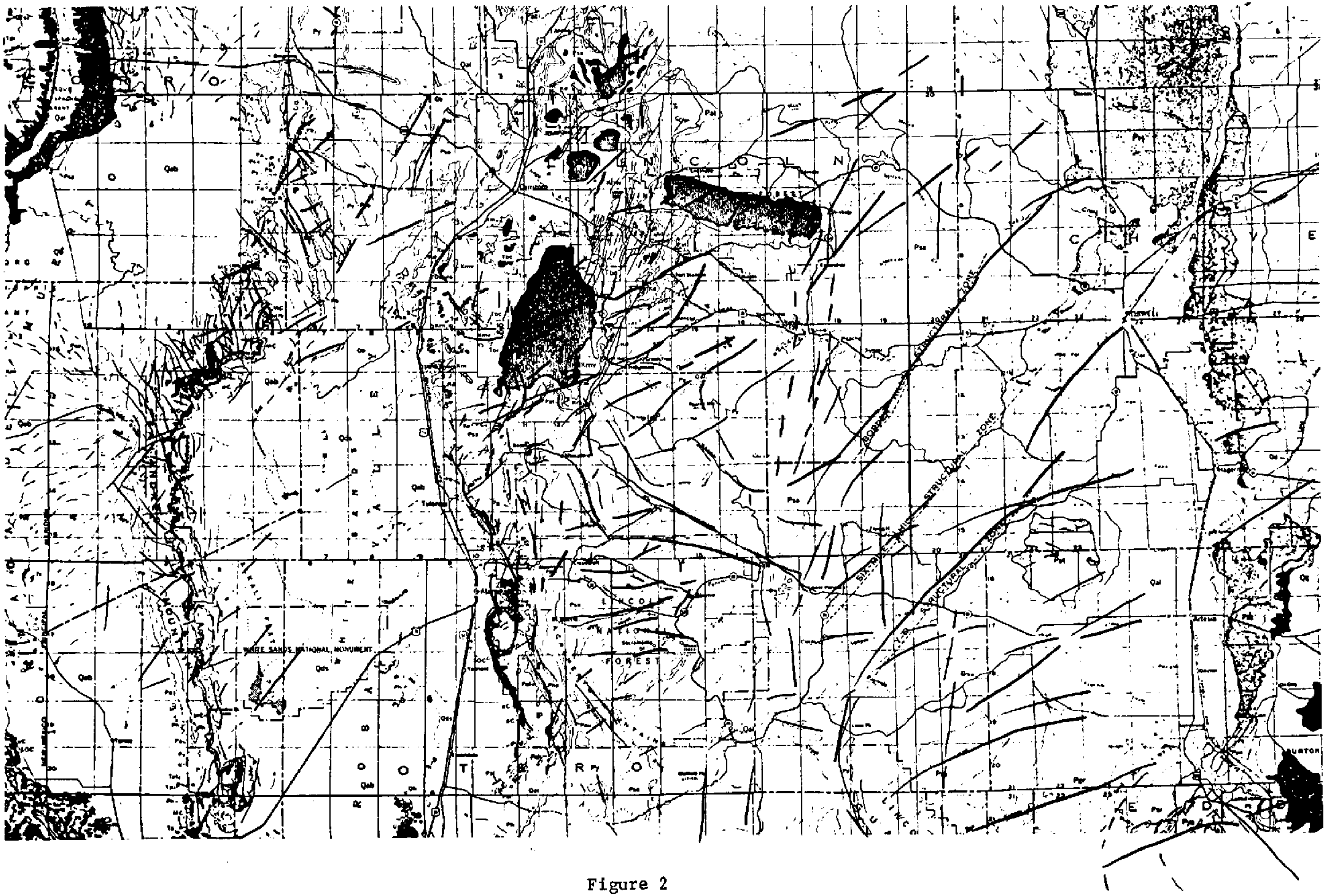


Figure 2

—— linear features
---- fold zones