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GEOLOGIC MAPPING AND MINERAL RESOURCE INVENTORY BY ERTS-1
SATELLITE DATA IN SOUTH AMERICA

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Type I Progress Report for Period 15 January 1973-30 April 1973

Prepared for:

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Greenbelt, Maryland 20771

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Type I Progress Report ERTS-1

- a. Title: Geologic Mapping and Mineral Resource Inventory
in South America
ERTS-A Proposal No.: SR 189
- b. GSFC ID No. of P. I.: IN-012
- c. Statement and explanation of any problems that are impeding
the progress of the investigation:

Delay in approval of the project until January 15, 1973, created problems in negotiating with and shipping data to South American counterparts. It also delayed getting supporting assistance from U. S. co-investigators. Mr. George Stoertz and Mr. Kenneth Segerstrom are now both on board as of May 1, 1973, and Mr. Stuart Marsh is helping as a part-time scientific aid. Data have been supplied from acquisitions beginning about December 15, 1972. No retrospective orders have yet been sent to GSFC but some prior data were purchased through EDC, Sioux Falls, S. D. The impact of the loss of the MSS tape recorder is gradually being assessed.

- d. Discussions of the accomplishments during the reporting
period and those planned for the next reporting period:

(1) Cataloguing of all data received has been nearly completed. None of the 12 areas selected have complete cloud free coverage. However, several have sufficient coverage to consider partial mosaic development.

(2) Most data for in-country counterpart geologists have been shipped (Colombia, Venezuela, Bolivia, Peru, Brazil and Argentina). Chile has not yet named a counterpart investigator and, therefore, no data have yet been shipped to that country.

(3) Several areas have been studied in detail by U. S. geologists.

a) W. D. Carter studied the structure of the Rio Ventuari area, Amazonas Territory, Venezuela (E1174-1409-7) defining 4 sets of lineaments in the Precambrian granite complex, that should be good guides for prospecting. Major rivers are more accurately located on the ERTS image than on the existing ONC Charts. Color composites made by the simple diazo process revealed agricultural slash-burn clearings in the jungle as the only indication of habitation of the area. Two ages of burn clearings appear to be present. Sr. Luiz Gonzales, Venezuelan counterpart, reports that a carbonatite pipe, found by interpretation of radar images in the Ventuari area, is now being explored on the ground.

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b) George Stoertz, studying primarily the high Andes of northern Chile, Argentina and Peru, has mapped the extent of salar deposits, identified most of the volcanic centers and mapped major structural features. Stoertz has presented two reports in NASA Symposia on ERTS-1, describing these results.

c) W. D. Carter, G. P. Eaton, and J. N. Rinker have analyzed ERTS-1 and aircraft data acquired over the Managua, Nicaragua, earthquake area. While the ERTS-1 data did not show the devastation of the city of Managua, due to local cloud cover, they were able to define five sets of linear features, three of which appear to have played important roles in the earthquake disaster. A northwest set comprises the alignment of all the major recent or active volcanoes in Nicaragua. This line is offset 15km at Managua by a prominent north-trending linear system, best recognized north of Lake Managua. A northeast -trending set, recognized in the scene, is roughly parallel to strike-slip faulting recognized by ground survey teams in the city as offsetting roads, sidewalks, curbs and walls.

While this study was not originally part of the S-189 experiment, it contributes to a general understanding of the Andean mountain chain and may have provided useful information to those more directly involved in earthquake assessment.

- e. Discussion of significant scientific results and their relationship to practical applications or operational problems include estimates of cost benefits of any significant results (abstract of 200 words or less).

ERTS-1 data clearly provide significant contribution of new information on the remote areas of South America. Salar deposits have been measured and compared with those shown on World Navigation Charts; remarkable differences have been found in shape, size, number and distribution. Repetitive coverage should enable us to develop an index of seasonal and annual environmental trends that can be compared with those of the Northern Hemisphere. New lineations, many of which are probably faults, have been found in Venezuela, Bolivia and northern Argentina. Circular features, some of volcanic origin, have been recognized that are not shown on existing maps. The courses of several rivers have been revised and our Venezuelan counterparts report that a major new river has been recognized and charted. Large mining operations, such as the open pit copper mine of Chuquicamata in northern Chile, are recognizable and can be studied in their regional context.
(Category 3A, 3K)

f.

Papers Published or in Press

- Carter, W. D., 1972, Geologic Questions and Significant Results Provided by Early ERTS Data: NASA Symposium Proceedings on Earth Resources Technology Satellite-1, September 29, 1972, Goddard Space Flight Center, Greenbelt, Maryland, p. 77-87.
- Carter, W. D., 1973, Status of Geologic Mapping and Mineral Resources Inventory by ERTS-1 Satellite Data in South America (73-225): In Proceedings of the American Congress on Surveying and Mapping: 33rd Annual Meeting, March 11-16, 1973, Washington, D. C., (Abstract), p. 221.
- Stoertz, G. E., and Carter, W. D., in press, Hydrogeology of Closed Basins and Deserts of South America, ERTS-1 Interpretations: NASA/GSFC Symposium on Significant Results Obtained from ERTS-1, New Carrollton, Md., March 5-9, 1973, 11 pages.
- Carter, W. D., and Eaton, G. P., in press, ERTS-1 Image Contributes to Understanding of Geologic Structures Related to the 1972 Managua Earthquake: NASA Symposium on Significant Results Obtained from ERTS-1, March 5-9, 1973, New Carrollton, Md.
- g. Recommendations for practical changes in operations: None
- h. Changes in Standing Order Forms: None
- i. ERTS Image Descriptor Form: None
- j. Listing by date of any changed Data Request Forms submitted to GSFC/NDPF during period: None
- k. Status of Data Collection Platforms: Not applicable

ERTS-1 IMAGE CONTRIBUTES TO UNDERSTANDING OF
GEOLOGIC STRUCTURES RELATED TO THE 1972 MANAGUA EARTHQUAKE

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ABSTRACT

ERTS-1 imaged the western portion of Nicaragua on December 24, 1972, one day after the central part of the city of Managua was devastated by a major earthquake which measured 5.6 on the Richter scale. ERTS-1 images reveal four sets of lineaments which may reflect fault systems along any one of which movement could have taken place. One set, trending N 50° W, includes a line of active volcanoes that parallels the coast and constitutes the southwestern edge of the Nicaraguan Depression, a regional graben which cuts obliquely across the Central American isthmus. This trend is offset approximately 10 km in a right lateral geometric sense just west of the city of Managua. A parallel lineament, north of Lake Managua, marks the northeast edge of the graben. A second set, trending due N-S to N 25° W, extends northward to northwestward from the mouth of the Rio Grande (Viejo) north of Lake Managua and can be projected southward across the lake to Managua. It is this set along which geometric offset of the volcanic lineament appears to have taken place. It is paralleled by a belt of young pit craters at the west edge of the city. A third set of linears trends approximately N 50°-60° E across the Nicaraguan trench. The fourth set, which is less conspicuous, is represented by only three identified members within Nicaragua. Two others, which are subparallel, are visible on the image in the area of Honduras, to the northwest. This set is notable for the fact that it extends from the coast entirely across the Nicaraguan Depression. Its trend is N 25°-45° E. Aerial photographs and field studies in the city of Managua by other U. S. Geological Survey personnel (Brown, Ward, and Platker, 1973) indicate that this fourth set is represented by four currently active, left-lateral, strike-slip faults and a narrow belt of aftershock epicenters. Instrumental data indicate that the aftershock earthquake foci are of shallow depth (<10.0 kilometers).

HYDROGEOLOGY OF CLOSED BASINS AND DESERTS
OF SOUTH AMERICA, ERTS-1 INTERPRETATIONS 1/

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ABSTRACT

Images from the Earth Resources Technology Satellite (ERTS-1) contain data useful in studies of hydrogeology, geomorphology, and paleoclimatology. Sixteen Return Beam Vidicon (RBV) images and 15 Multi-Spectral Scanner (MSS) images were studied. These covered deserts and semidesert areas in southwestern Bolivia, northwestern Argentina, northern Chile, and southeastern Peru from July 30 to November 17, 1972. The study area is bounded by latitudes $16^{\circ}30'$ and $27^{\circ}30'$ South and by longitudes $66^{\circ}30'$ and $70^{\circ}30'$ West. During the first 4 months after launching, high-quality cloud-free imagery was obtained over approximately 90 percent of the region of interior drainage, or a total area of about 170,000 square miles.

Features interpreted from the images include: (1) principal types of salt crusts on major salars (salt-encrusted playas), some of which are subject to modification by seasonal floodwaters; (2) extent of floodwaters and lakes on the floors of more than 120 closed basins, thus providing a basis for more accurate mapping of hydrologic features in the central Andes; (3) prominent former lake shores of Pleistocene lakes; (4) mid-winter snow cover in the high Andes, data essential to the appraisal of water resources and runoff; (5) volcanoes and volcanic craters numbering more than 500 in the study area, of which 13 are reportedly active and many believed to be associated with playa-type borate deposits and sulfur deposits; and (6) major faults such as the Atacama fault and other prominent geologic structures.

No single source of data previously has permitted identification of all of these features, and observation on synoptic snow cover was not possible prior to ERTS. ERTS thus provides an invaluable data base for earth resources surveys and development in this large and relatively undeveloped area.

1/ Publication authorized by Director, U.S. Geological Survey.