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A GEMINI MOSAIC ALONG THE THIRTY-SECOND DEGREE OF LATITUDE FROM BAJA CALIFORNIA TO CENTRAL TEXAS*

by

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PREFACE

This report, written by a member of the Remote Sensing Evaluation and Coordination Staff (RESECS) of the U. S. Geological Survey is designed to assist all potential users of the mosaic described herein. Under the NASA Earth Resources Survey Program the mosaic provides a base for mapping soils and other surficial deposits as well as structural features as part of the Ground Truth Investigations Task (160-75-01-44-10) of the Geologic Applications Program. It will also be used as a base for analyzing Land use from space photography (Task No. 160-75-01-32-10) under the Geographic Applications Program.

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ABSTRACT

A series of 39 overlapping photographs of the southwestern United States and adjacent areas of Mexico was obtained as part of an experiment of the Gemini IV mission. Twenty-four of these pictures plus one from the Gemini III and four from the Gemini V mission were used to construct a 1:1,000,000-scale, black and white, semi-controlled mosaic. This mosaic covers about 150,000 square miles and extends along the 32d parallel of north latitude from the Pacific Ocean to the 100th meridian in west-central Texas, and averages about 150 miles in width. Many of the individual rectified photographs can be enlarged to a scale of 1:250,000 with little or no loss of resolution; such enlargements will be of great value to earth resources studies. If the angle of tilt is more than 35 degrees, some detail in the background of the photograph is lost. The U. S. Geological Survey is currently conducting several small research projects in which this 1:1,000,000-scale mosaic and the individual photographs are the prime research tools.

INTRODUCTION

After completion of the 1:1,000,000-scale Peruvian mosaic from Gemini IX space photographs (MacKallor, 1967, 1968), the Geological Survey decided to make another 1:1,000,000-scale, black and white, semi-controlled mosaic from space photographs. The area selected was the southwestern United States and adjacent parts of Mexico. This area is of considerable economic and scientific interest to both nations, is readily accessible, and a large number of excellent photographs from several space missions were available. This mosaic was made in cooperation with Dr. Paul D. Lowman, principal investigator for the Gemini photographic experiment, the National Aeronautics and Space Administration, and the Raytheon Company.

As shown by figure 1, 24 photographs used in constructing this mosaic were taken on the Gemini IV mission. On the Gemini IV mission the highest photographic priority was given to the southwestern United States, where thirty-nine overlapping nearly vertical photographs were taken of areas from the Pacific Ocean to central Texas. McDivitt oriented the spacecraft while White took pictures at approximately 5-second intervals (Lowman and others, 1967, p. 1-2). This was the only time during the flight of Gemini IV that fuel and power were allocated to maneuver the spacecraft for a photographic experiment.

One photograph from Gemini III and five from two orbits of Gemini V were also selected for rectification; but photograph V-1-13, which presented a clear but oblique view of the Salton Sea, could not be rectified satisfactorily. Most of the photographs were taken from

a height of just over 100 statute miles (87 nautical miles). All photographs were taken with a hand-held Hasselblad 500-C camera with a Zeiss planar f2.8 lens, 80 mm focal length. A haze filter was used. Photograph V-4-69 was taken on Anscochrome D-50 film, but all the other photographs were taken on Ektachrome MS (SO-217) film.

All photographs used in preparing the mosaic have been published in color by the National Aeronautics and Space Administration (1967), and high quality color reproductions of several of the photographs are described by Lowman (1966).

The area covered by the mosaic averages about 150 miles in width along latitude 32° N., and extends from the Pacific Ocean eastward to longitude 100° W. (figure 1).[1/] The photographs all were taken during the middle part of the day but not during the same month (table 1). The angle of tilt ranged from 6 to 52 degrees from the vertical, and the photographs were taken from 86 to 112 nautical miles above sea level.

1/ The Salton Sea is cloud-covered and is not visible on photograph III-1-5.

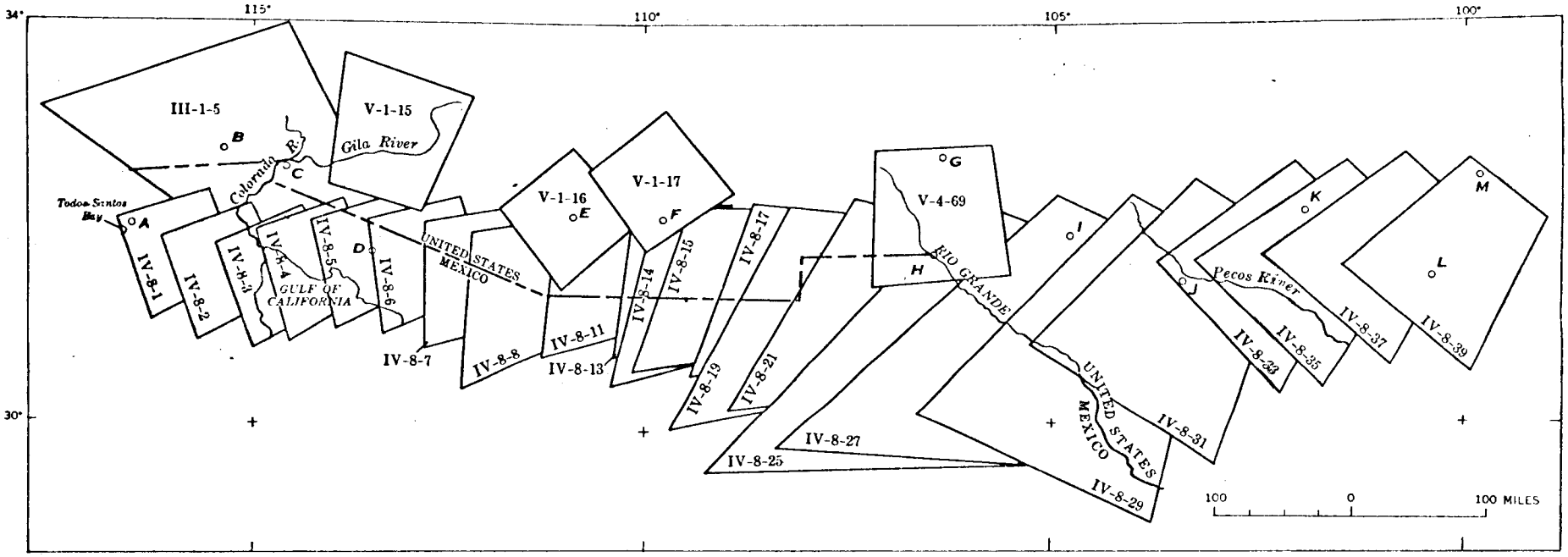

FIGURE 1.—INDEX TO GEMINI PHOTOMOSAIC OF PART OF THE SOUTHWESTERN UNITED STATES AND NORTHERN MEXICO.

Photographs are identified by Gemini mission (Roman number), magazine (second number), and frame (third number). Lettered points locate geographic features.

A - Ensenada, Baja, Calif.

B - Imperial Valley, Calif.

C - Yuma, Ariz.

D - Pinacate volcanic area, Sonora

E - Tucson, Ariz.

F - Willcox Playa, Ariz.

G - White Sands, New Mex.

H - El Paso, Tex. and Juarez, Chih.

I - Guadalupe Peak, Tex.

J - Pecos, Tex.

K - Midland, Tex.

L - San Angelo, Tex.

M - Abilene, Tex.

TABLE 1

Approximate time, elevation, and tilt of Gemini photography

Photo Number[1]	Date and GMT Time[2]		Elevation above Sea Level in Nautical Miles[3 & 4]	Tilt[4]
III-1-5	March 23, 1965	1727	88	49°
IV-8-1	June 5, 1965	1741	88	14°
IV-8-2	Ditto	1741	90	15°
IV-8-3	"	1741	87	20°
IV-8-4	"	1741	86	21°
IV-8-5	"	1742	88	15°
IV-8-6	"	1742	88	20°
IV-8-7	"	1742	90	24°
IV-8-8	"	1742	86	32°
IV-8-10	"	1742	86	27°
IV-8-11	"	1742	89	30°
IV-8-13	"	1743	88	31°
IV-8-14	"	1743	89	36°
IV-8-15	"	1743	90	35°
IV-8-17	"	1743	90	37°
IV-8-19	"	1743	88	43°
IV-8-21	"	1743	89	43°
IV-8-25	"	1744	89	50°
IV-8-27	"	1744	91	50°
IV-8-29	"	1744	82	52°
IV-8-31	"	1745	99	43°
IV-8-33	"	1745	97	36°

TABLE 1 (cont.)

Approximate time, elevation, and tilt of Gemini photography

Photo Number 1/	Date and GMT Time 2/		Elevation above Sea Level in Nautical Miles 3 & 4/	Tilt 4/
IV-8-35	June 5, 1965	1745	92	40°
IV-8-37	Ditto	1745	88	38°
IV-8-39	"	1745	90	37°
V-1-15	Aug. 22, 1965	1700	93	27°
V-1-16	Ditto	1701	91	9°
V-1-17	"	1701	94	6°
V-4-69	Aug. 26, 1965	1614	112	15°

1/ See Figure 1.

2/ Time of photography obtained from National Aeronautics and Space Administration (1967). To convert Greenwich Mean Time to local time, subtract 6 hours for Central, 7 hours for Mountain, and 8 hours for Pacific Standard Time.

3/ One nautical or air mile equals 6080.2 feet.

4/ Determined from computer operations for vertical rectification of photographs.

PREPARATION OF MOSAIC

Rectification and mosaicing were done under the direction of Dr. Gordon Gracie of the Autometric Operation of the Raytheon Company. The same techniques were used in preparing this mosaic as for the Peruvian mosaic (MacKallor, 1967, 1968). Geographic coordinates of control points on the Peruvian photographs were obtained from 1:1,000,000-scale World Aeronautical Charts (Lambert Conformal Conic Projection) and these charts were used as a base for preparing the 1:1,000,000-scale photomosaic. For determining the coordinates of 102 control points on photographs used in the mosaic of the southwestern United States, Gracie (oral communication) found that 1:250,000-scale, two-degree topographic maps were superior to larger scale topographic maps and to the 1:1,000,000-scale World Aeronautical Charts.

The considerable tonal contrast among the many prints somewhat marred the overall appearance of the original mosaic of the Southwest, but by rematching prints, dodging, and masking, the Geological Survey greatly reduced the tonal contrasts between prints. Twenty-nine Gemini photographs were used for the 150,000 square miles covered by the mosaic of the Southwest whereas only twelve photographs were used for the 250,000 square miles of the Peruvian mosaic. Such a large number of photographs were used in the southwestern mosaic in order to use the best photograph available for each area and to obtain maximum coverage with the mosaic. The individual rectified photographic prints are excellent, and many have been enlarged to a scale of 1:250,000 with little or no loss of detail.

EFFECTS OF ALTITUDE AND TILT

By comparing figure 1 and table 1, one can get an idea of the effects of altitude and tilt upon the area covered. Photographs V-1-15 and V-4-69 each cover 8,000 to 10,000 square miles and can be satisfactorily enlarged to a scale of 1:250,000. The former was taken at an altitude of 93 nautical miles with 27 degrees of tilt from the vertical; the latter at 112 miles with 15 degrees of tilt. Photographs V-1-16 and V-1-17, taken at the same or lower altitudes and with less tilt each cover only about 5,600 square miles. Using the same photographic system as used in obtaining the Gemini photographs, the most useful photographs for regional studies of earth resources will be obtained from altitudes of not less than 100 nautical miles, even if the tilt is as much as 25 or 30 degrees from the vertical, and from not more than 125 to 150 nautical miles, even if the tilt is only a few degrees. At an altitude of about 100 nautical miles a tilt of 35 degrees (Photograph IV-8-15) is acceptable, but photographs taken with more tilt lose some detail in the background.

CONTINUING INVESTIGATIONS

The mosaic of the southwestern United States and adjacent parts of Mexico will be of considerable value to the scientific community, and preliminary work by the U.S. Geological Survey indicates that the rectified prints of individual space photographs at a scale of 1:250,000 may be of even more value. The Geological Survey is investigating methods of deemphasizing the distracting match lines

on the mosaic and is seeking an economical method of reproducing high quality copies of the mosaic and of the rectified prints at various scale. Roger Morrison and Warren Hamilton, U.S. Geological Survey, are using color prints, the 1:1,000,000 mosaic, and enlarged 1:250,000-scale prints to study, respectively, soils and tectonics on a regional basis. Norman J.W. Thrower, supported by a NASA contract, is preparing a 1:1,000,000-scale geographic photomap for the Geographic Applications Program of the U.S. Geological Survey.

The first earth resources observation satellite as envisioned by the Geological Survey will furnish imagery comparable to the 1:1,000,000-scale mosaics prepared from Gemini photographs. An economic analysis by the Westinghouse Defense and Space Center (1967, p. v) indicated that an initial satellite with repetitive 3-week coverage will have a $70 million gross benefit per year to the Department of the Interior, and a sampling of certain interests (mining, petroleum, and private irrigation districts) closely associated with the Department's activities indicated an annual value of more than $400 million to those sectors of the private economy. The report further identifies more than 70 specific applications (p. B2-4) of satellite data.

The National Aeronautics and Space Administration has distributed color prints of Gemini photographs, and the Geological Survey has distributed prints of the Peruvian mosaic and of the rectified prints. The Geological Survey recently released the mosaic of the southwestern United States. In order to more fully evaluate the

usefulness of imagery obtained from satellites, the staff of the EROS Program of the U.S. Geological Survey would like to be informed of experiments and applications of the mosaics and rectified prints of Gemini photography. Both positive and negative results are solicited.

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