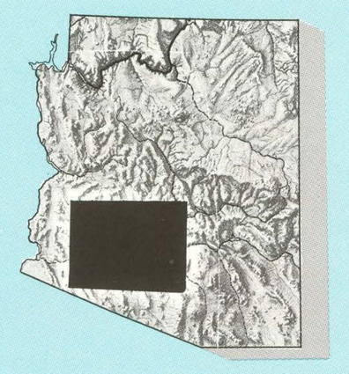
I-1941

LANDSAT AND SPOT IMAGE DISPLAY
PHOENIX, ARIZONA AREA

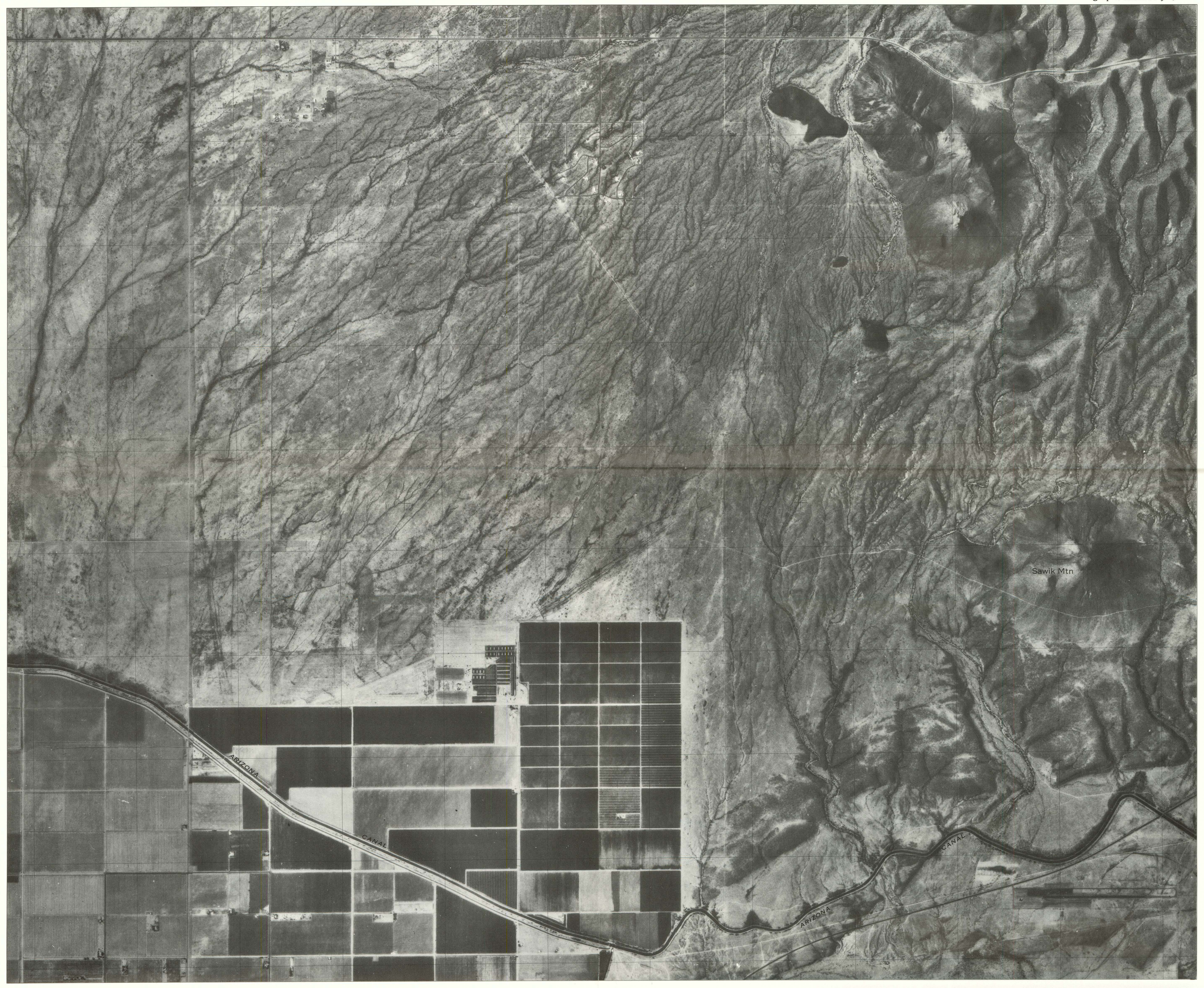


- Landsat Multispectral Scanner (MSS)
- Landsat Thematic Mapper (TM)
- SPOT Multispectral
- SPOT Panchromatic
- Topographic Map
- Orthophotoquad

GEOLOGICAL SURVEY
1987

1:24,000-SCALE from
SAWIK MOUNTAIN ORTHOPHOTOQUAD

Photographs taken July 1, 1971



INTRODUCTION

For over a decade, the U.S. Geological Survey has produced multicolor satellite image maps from Landsat imagery. The majority are based on multispectral scanner (MSS) data received by Landsat satellites 1, 2, and 3, which were placed in Sun-synchronous polar orbit at a nominal altitude of 918 km (570 statute miles) starting in 1972. The MSS sensor records a nominal pixel ground dimension of 79-meters square and records each successive pixel every 57 meters. This oversampling improves the ground resolution to about 75 meters which provides acceptable image mapping products at a scale of 1:250,000.

Landsat 4 and 5, launched July 16, 1982, and March 1, 1984, respectively, at a nominal altitude of 705 km (440 statute miles) each contained an MSS sensor and a more advanced Thematic Mapper (TM) scanner having better spectral, radiometric, and geometric properties than its predecessors. The TM's 30-meter ground resolution provided the opportunity to produce image map products at a scale of 1:100,000. This led to the experimental editions of the Dyersburg, Tennessee and Washington, D.C. and Vicinity Landsat image maps at this scale during 1983 and 1984.

The French SPOT satellite was launched February 22, 1986, at a nominal altitude of 832 km (517 statute miles). Its higher resolution imaging systems provide multispectral data at 20-meter ground resolution and panchromatic data at 10-meter ground resolution. This increased resolution capability has created interest in producing larger scale image maps, potentially to a scale of 1:24,000. The larger scales are achieved with the 10-meter SPOT panchromatic data, which may be merged with lower resolution multispectral data of either the SPOT or Landsat sensor systems.

On April 5, 1986, Landsat recorded the Phoenix, Arizona area using both MSS and TM. Two days prior SPOT covered the same area in both panchromatic and multispectral forms. Thus, four satellite sensor-data records, ranging in resolution from 75-m to 10-m pixel size became available. Moreover, the Landsat and SPOT data were acquired within one hour of the same time-of-day (10:29 and 11:18 a.m. MST respectively), providing a near-ideal data base for image presentation in a wide variety of scales and forms, including combinations of SPOT and TM data.

DISPLAY FORMAT

On the front side of the display, the major portion of a standard quadrangle (Sawik Mountain) of 1:24,000 scale is portrayed in topographic, orthophoto (aircraft acquired), and SPOT panchromatic forms.

The reverse side of this display presents Landsat and SPOT data in image form at scales ranging from 1:24,000 to 1:1,000,000. The optimum scale at which each data form should be printed depends on the amount of detail a map user expects to see, as well as the area of coverage that needs to be portrayed. This display demonstrates how each data form can be presented by the mapmaker, leaving the determination of optimum form and scale up to the designer of the image map.

At the smaller scales the entire city of Phoenix is generally covered, but at the 1:50,000 and 1:24,000 scales only selected portions are shown. The Sky Harbor International Airport and Sun City areas were selected for large-scale portrayal. A locator map relates these features to Phoenix.

PROCEDURES

On the front side the SPOT panchromatic data have been reproduced at 1:24,000 scale for comaprison with an orthophotoquad prepared from aircraft photographs acquired in 1971. The SPOT panchromatic data of the Sawik Mt 1:24,000-scale quadrangle had to be geometrically rectified before presentation. Fifteen control points were selected, matching ground features from the panchromatic scene with 1:24,000-scale topographic maps. These control points were used in a first-order transformation to rectify the data. To reduce the blocky appearance at 1:24,000-scale, the data were resampled to 5-meter pixels using a cubic convolution resampling during the transformation process. Following the transformation, the Sawik Mountain quadrangle was extracted from the SPOT scene and registered to its corresponding topographic map sheet. The 50-point verification process resulted in a root-mean-square error (RMSE) of 12 meters. The data were enhanced using a multipoint linear contrast stretch prior to lithographic reproduction.

On the reverse side, because the same basic data are shown at such a wide variety of scales, different resampling procedures have been applied to the data sets. To reduce the blocky appearance of the imagery at larger scales, the data were resampled to a smaller pixel size. The majority of sampling sizes are consistent for a particular scale, 1:24,000 sampled to 5.76-meter pixels, and 1:250,000 sampled to 28.5-meter pixels. At a scale of 1:500,000 and 1:1,000,000, the data were used at original pixel size. Specific pixel sizes were also chosen to facilitate attaining proper scales through the reproduction process. Resampling was accomplished using Restoration (USGS algorithm) on all MSS and TM data. A Sinx/x resampling was used for all SPOT merge products.

All images on the reverse side of the display were enhanced using a large window spatial filter then contrast stretched using a multipoint linear technique. The conversion from digital data to analog film was accomplished on a MacDonald Dettwiler Color FIRE 240 recorder. Several of the larger scale images involved merging SPOT panchromatic and multispectral data. The data merge was accomplished by performing an image-to-image registration between the panchromatic and the multispectral data (either Landsat TM or SPOT), then combining the two using a hue-intensity-saturation (HIS) approach. Fifteen image-to-image control points were visually selected between the SPOT panchromatic band, which was used as the base, and the resampled multispectral data. A representative spectral band was resampled to 10-meter pixels using cubic convolution (USGS algorithm) to provide the operator with similar-sized pixels for control selection. The resulting control point grid file was then rescaled and applied to the original multispectral data. During this rectification process the multispectral data were resampled using cubic convolution to match the 10-meter panchromatic data. The data merge was accomplished by transforming a contrast-enhanced spectral image into HIS color space. The panchromatic data were stretched to match the distribution histogram of the spectral intensity channel, then substituted for the intensity channel to create a hybrid HIS data set. The hybrid HIS data set was then transformed back into red, green, and blue components. This process created an image that retains spectral quality of the multispectral data while adding the spatial quality of the 10-meter panchromatic data.

The original color transparencies from the Color FIRE 240 recorder were further contrast enhanced by contact printing onto Kodak 6118 Ektachrome film. The resulting second-generation transparencies were scanned on a Hell CP 340 graphic art scanner, which output at final scale cyan, magenta, yellow, and black lithographic separates using a 175-line per inch screen. The lithographic separates were printed along with the collar information according to standard USGS practice.

FRONT SIDE

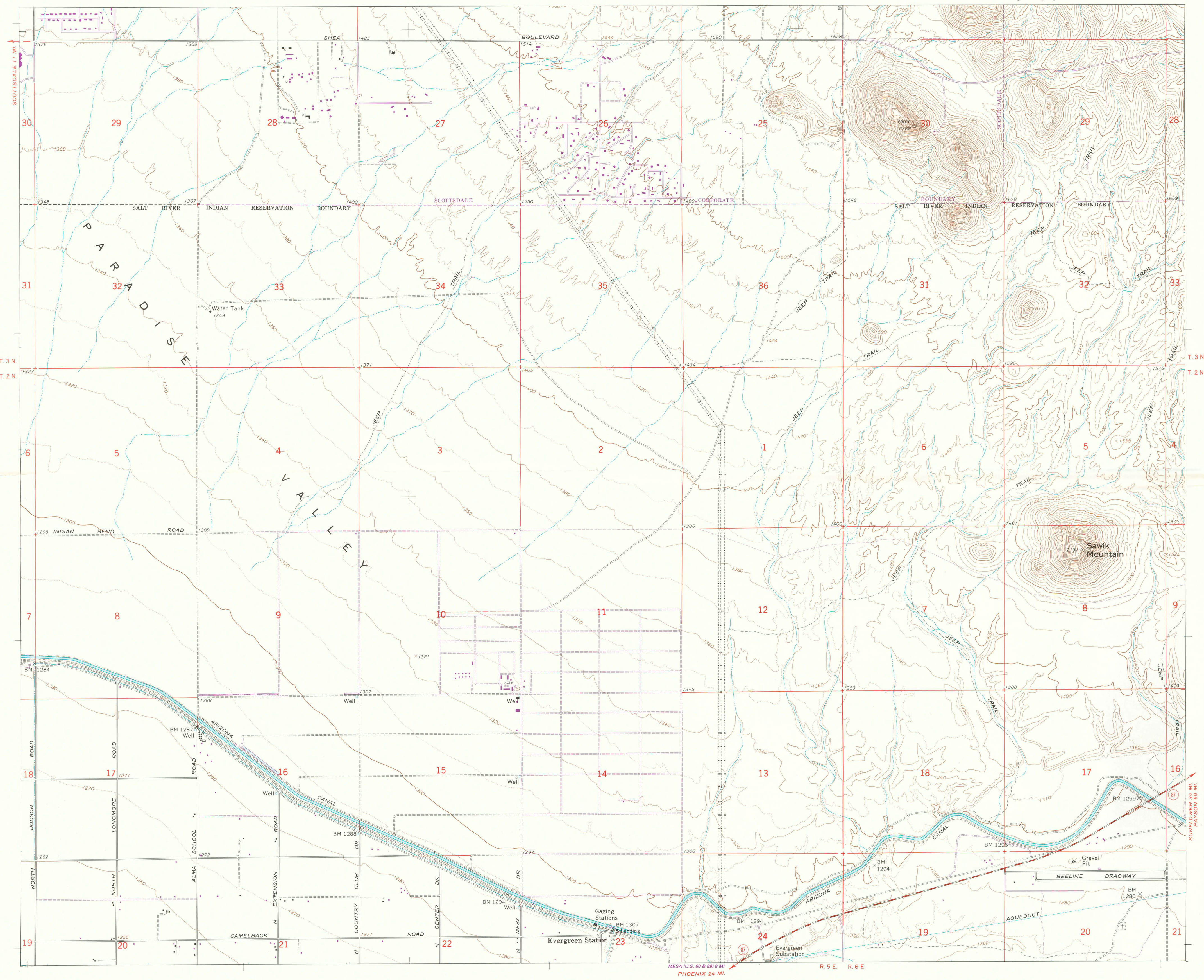
The three graphics all cover the same portion of the Sawik Mountain 1:24,000-scale quadrangle. They present SPOT panchromatic data, an orthophotoquad prepared from aerial photographs, and the standard topographic map sheet. The Sawik Mountain quadrangle is northeast of Phoenix and can be located in either the 1:250,000 or 1:500,000-scale MSS or TM images on the reverse side. The aerial photographs for the orthophotomosaic were acquired on July 1, 1971, from an altitude of 39,000 feet above mean ground resulting in a scale of approximately 1:78,000. The SPOT data, acquired 15 years later on April 3, 1986, show extensive changes within the quad area. Although it does not have the high resolution of the aircraft image, the 10-meter satellite data depict many features valuable for line map revision and for portrayal in image-map form.

REVERSE SIDE

- Row 1 consists of images produced from Landsat Multispectral Scanner (MSS) data, Scene ID 85076517293X0 acquired at 10:29 a.m. (MST) 4/05/86 reproduced at scales ranging from 1:50,000 to 1:1,000,000.
- Row 2 consists of images produced from Landsat Thematic Mapper (TM) data. Scene ID Y5076517293X0 acquired at 10:29 a.m. (MST) 4/05/86 reproduced at scales ranging from 1:50,000 to 1:500,000.
- Row 3 consists of images produced from the SPOT Panchromatic and SPOT Multispectral data, Scene ID's 15542838604031818251P and 15542838604031818271X respectively, both acquired at 11:18 a.m. (MST) April 3, 1986 merged and displayed at scales ranging from 1:24,000 to 1:100,000.
- Row 4 consists of images produced from Landsat TM data acquired April 5, 1986 merged with SPOT panchromatic data acquired two days earlier on April 3, 1986 using the HIS merge technique described in the text. Scales displayed are identical to row three.

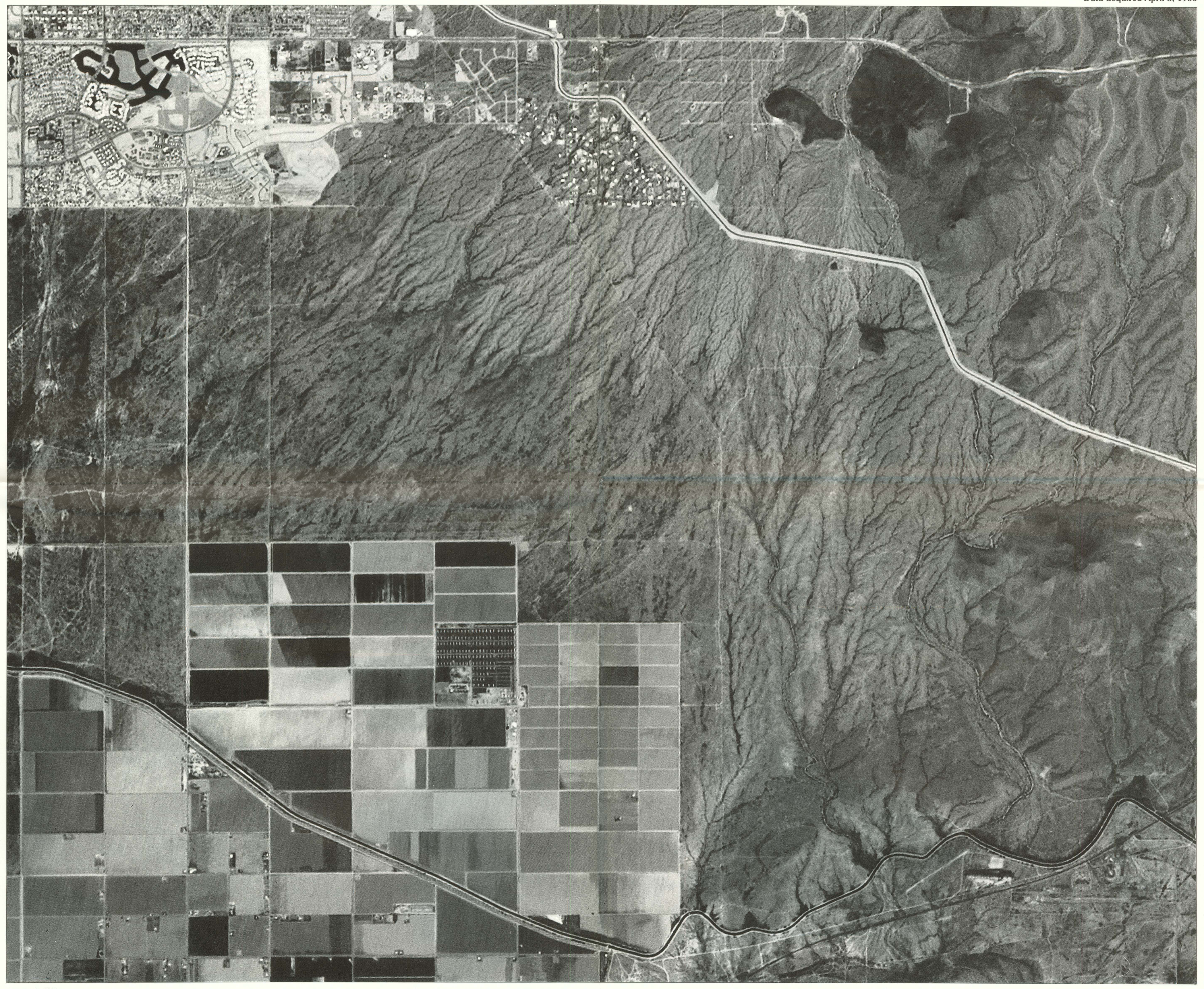
1:24,000-SCALE from
SAWIK MOUNTAIN TOPOGRAPHIC MAP

Edition of 1964. Revised from aerial photographs taken 1978 and other sources



1:24,000-SCALE from
SAWIK MOUNTAIN SPOT PANCHROMATIC

Data acquired April 3, 1986



WAVE BANDS AND COLORS

Landsat MSS	Band 1* (4)†	Visible (green)	0.50–0.60 μm
	Band 2* (5)†	Visible (red)	0.60–0.70 μm
	Band 3 (6)†	Near IR	0.70–0.80 μm
	Band 4* (7)†	Near IR	0.80–1.05 μm
Landsat TM	Band 1*	Visible (blue)	0.45–0.52 μm
	Band 2	Visible (green)	0.52–0.60 μm
	Band 3*	Visible (red)	0.63–0.69 μm
	Band 4*	Near IR	0.76–0.90 μm
	Band 5	Near IR	1.55–1.75 μm
	Band 6	Thermal	10.4–12.5 μm
	Band 7	Near IR	2.08–2.35 μm
SPOT Multispectral	Band 1*	Visible (green)	0.50–0.59 μm
	Band 2*	Visible (red)	0.61–0.68 μm
	Band 3*	Near IR	0.79–0.89 μm
SPOT Panchromatic*		Visible (green-red)	0.51–0.73 μm

*Bands used in this project
†MSS bands 4, 5, 6, and 7 were redesignated 1, 2, 3, and 4 respectively for Landsats 4 and 5

Information on SPOT data may be obtained through SPOT Image Corporation, 1897 Preston White Drive, Reston, Virginia 22091

Information on indexing, cost, and availability of Landsat data may be obtained from U.S. Geological Survey EROS Data Center, Customer Services, Sioux Falls, South Dakota 57198

FOR SALE BY U.S. GEOLOGICAL SURVEY
DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092

LOCATOR MAP