Mon. Feb. 12, 2018

- Landsat Orbits
- Landsat Instrument Overview
- Landsat interpretation
  - Bands and typical uses
  - Various display options
  - Thermopolis
  - Atlas Mountains – details
  - Arabian Arch (see also pg. 346-355)

Landsat Spacecraft

- Landsat 1, 2, 3 First generation (1972, 1975, 1978)
  - Multispectral Scanner (MSS)
- Landsat 4, 5, (6) Second generation (1981, 1984, 1993)
  - Thematic Mapper (TM)
  - #5 Will be retired shortly -- has problems.
- Landsat 7   Second+ generation (1999)
  - Enhanced Thematic Mapper ETM+
  - Still running, with some hardware glitches
- Landsat 8   (Landsat Data Continuity Mission =LDCM)
  - Launched Feb. 2013. Nominal 5 year life

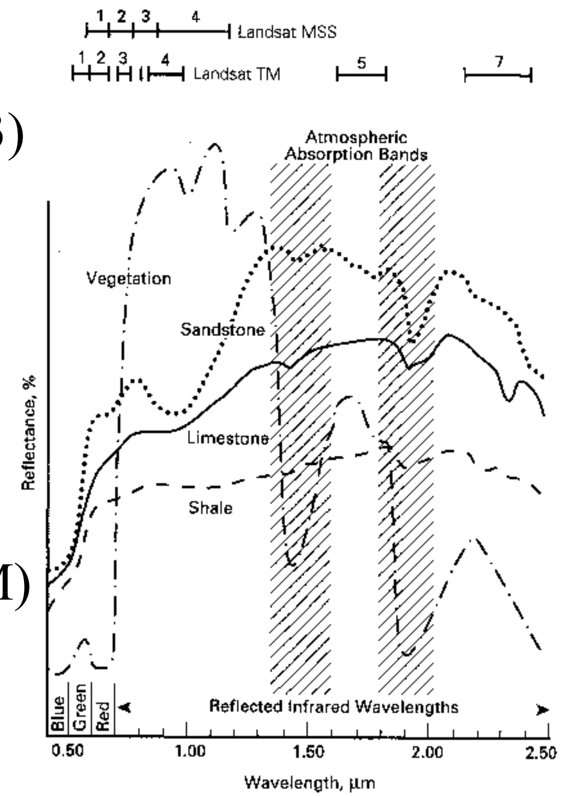
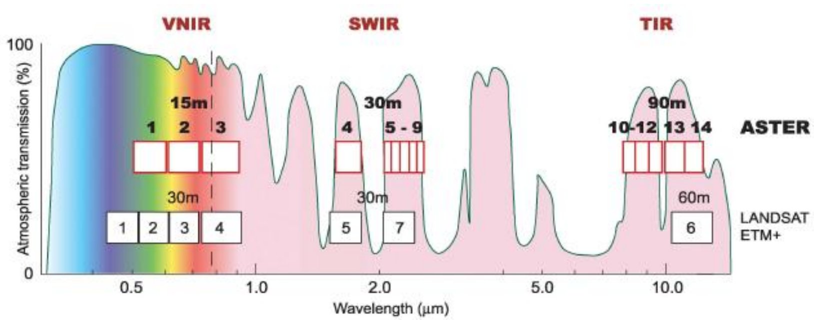
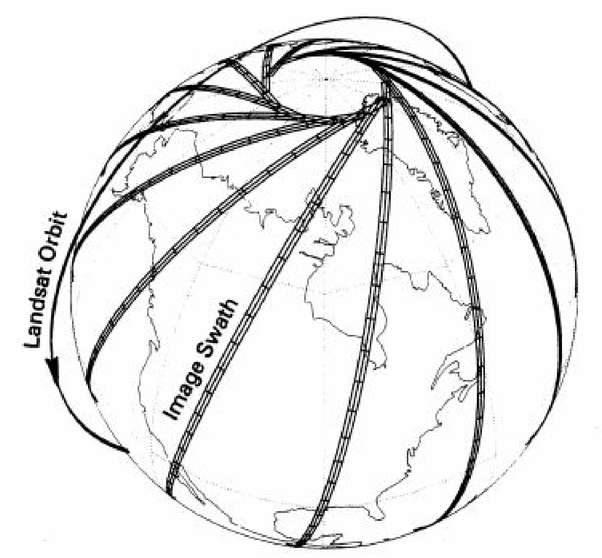
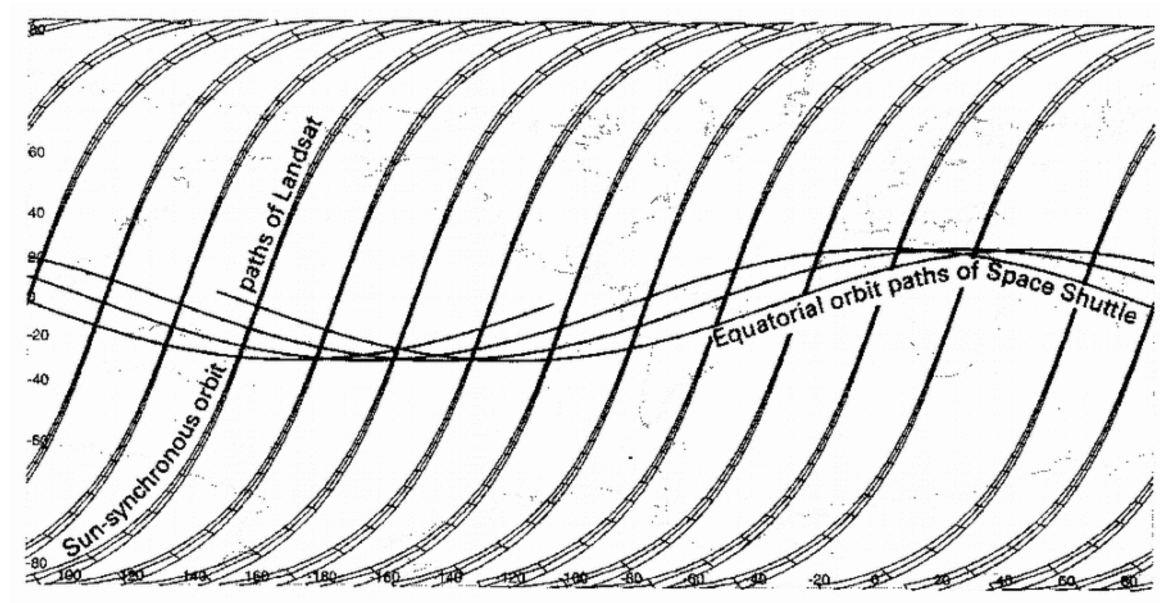


Figure 3-1 Reflectance spectra of vegetation and sedimentary rocks, showing spectral ranges of Landsat MSS and TM bands.



Landsat Orbits





Sabins, Fig. 03-12 & -13

- Near-Polar – so it covers all the earth
- Sun synchronous (precesses once per year to keep local time constant)
  - Landsat passes S over US ~10 AM
  - Many other satellites in the “AM Constellation” or “AM Train”
  - Others in the “PM” Train

Landsat Path and Row

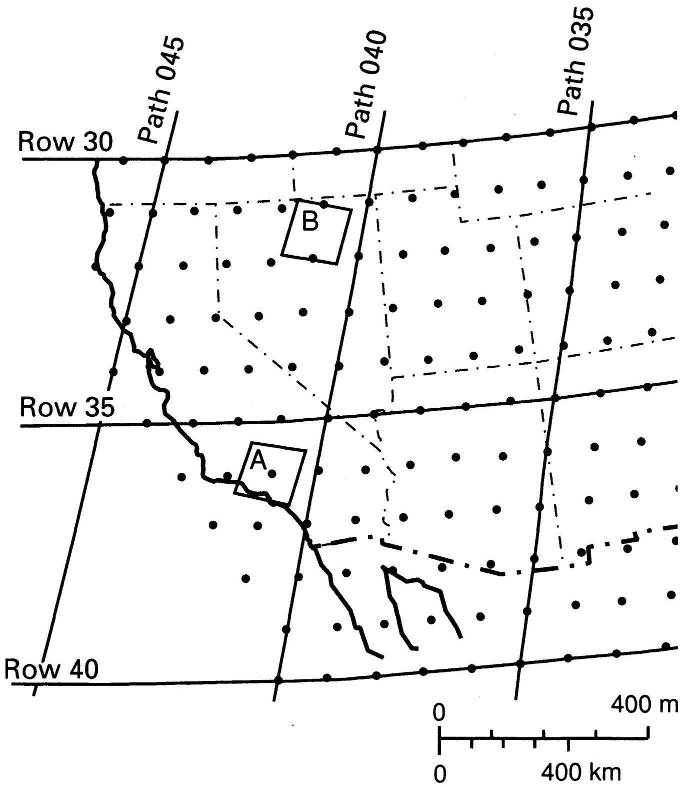


Figure 3-14 Path-and-row index map of the southwestern United States for Landsats 4 and 5. Image A at path 41, row 36 covers Los Angeles. Image B on path 40 between rows 31 and 32 is located with an optional shift of 50 percent to the south.

Sabins, Fig. 03-12 & -13

- Earth rotates E by
  ~100 min × 1000 MPH = 1700 miles
  ~ 2700 km between orbits.
- Landsat has swath width of ~185 km
- Over 16 day cycle it fills in gaps between the orbits, so it covers all the earth
- Number of paths:
  233 ≈ 16 days × 14.5 orbits/day
- Spaced at ~165 km to provide ~7.6% overlap at equator, more at higher latitude
- Renumbered "PATHS" increase consecutively to the W
-

  N/S data "continuous" but break into "ROWS" also spaced at 165 KM
- Given PATH,ROW specifies given location on earth: LA: Path 41, Row 36
- Orbits (and PATH,ROW system slightly different for earliest 3 Landsats

Thermopolis Landsat
Sabins Plate 2

A. Normal color. Bands 1-2-3 = BGR.

B. IR color. Bands 2-3-4 = BGR.

C. All IR color. Bands 4-5-7 = BGR.

D. IR plus visible color. Bands 2-4-7 = BGR.

Plate 2 Color combinations of Landsat TM bands, Thermopolis, Wyoming.

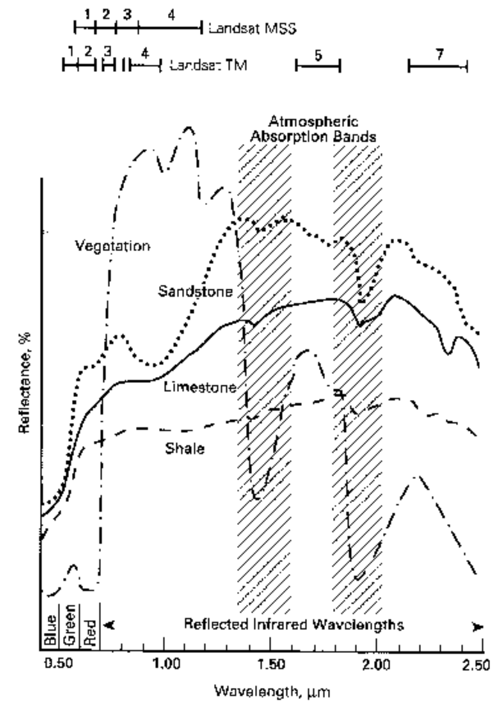
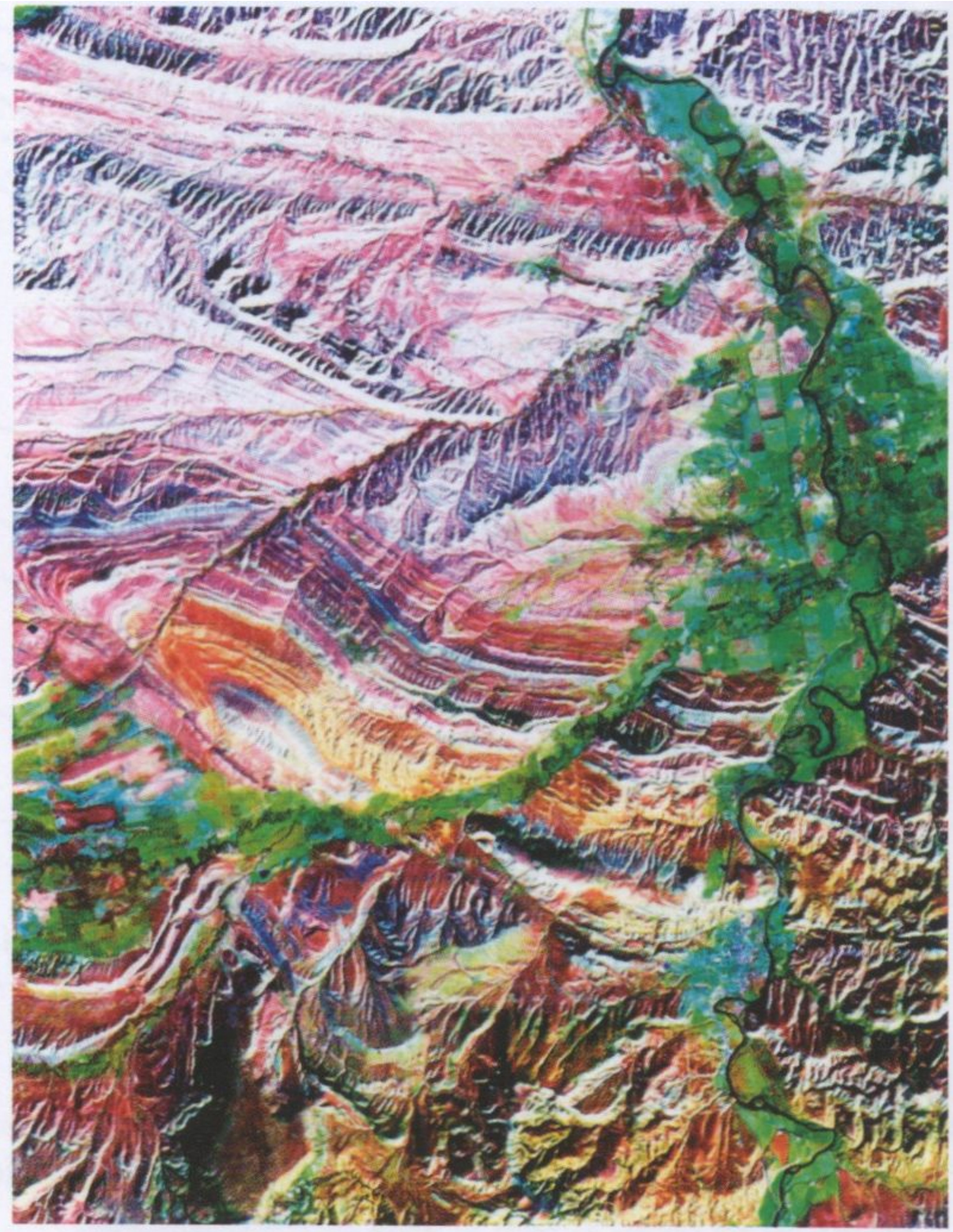


Figure 3-1 Reflectance spectra of vegetation and sedimentary rocks, showing spectral ranges of Landsat MSS and TM bands.

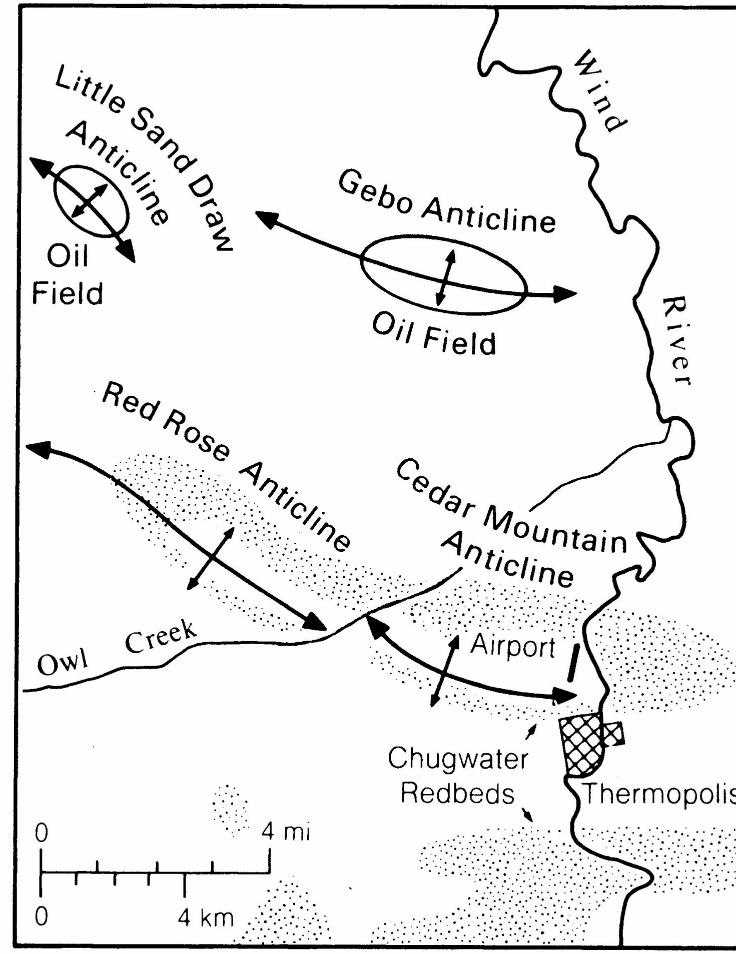
*Display colors**	*Advantages*	*Disadvantages*
1-2-3	Normal color image. Optimum for mapping shallow bathymetric features.	Lower spatial resolution due to band 1. Limited spectral diversity because no reflected IR bands are used.
2-3-4	IR color image. Moderate spatial resolution.	Limited spectral diversity.
4-5-7	Optimum for humid regions. Maximum spatial resolution.	Limited spectral diversity because no visible bands are used.
2-4-7	Optimum for temperate to arid regions. Maximum spectral diversity.	Unfamiliar color display, but interpreters quickly adapt.

*TM bands are listed in the sequence of projection colors: blue-green-red.

Thermopolis Landsat 2-4-7 = RGB Display

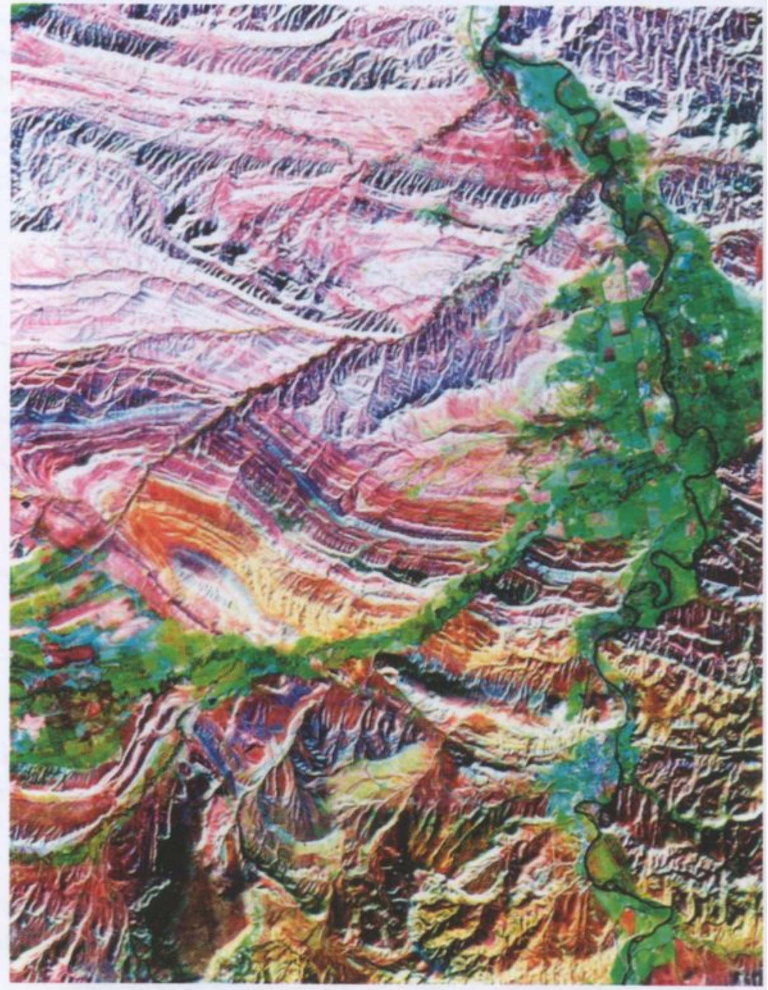


D. IR plus visible color. Bands 2-4-7 = BGR.



H. Interpretation map. Stippled areas are outcrops of Chugwater red beds.

Thermopolis Landsat 2-4-7 = RGB Display

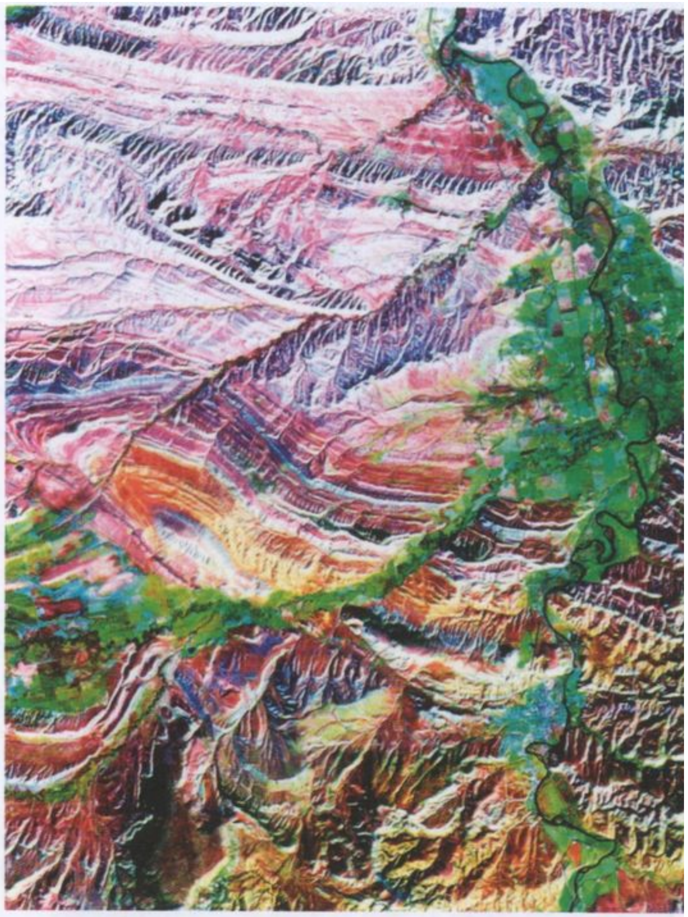


D. IR plus visible color. Bands 2-4-7 = BGR.

Table 3-6 Formations in the Thermopolis TM 2-4-7 subscene

Formation	*Age*	*Lithology*	*Image signature*
Alluvial deposits	Quaternary	Soil in floodplains of major streams. Flat valley floors with irrigated fields.	Bright green.
Fort Union Formation	Early Tertiary	Resistant sandstone with minor shale beds. Prominent, eroded dipslopes.	Dark pink.
Meeteetsee and Lance Formations	Late Cretaceous	Nonresistant shale and sandstone. Broad valley with minor ridges.	Medium pink.
Mesaverde Formation	Late Cretaceous	Resistant sandstone with shale and coal beds. Alternating ridges and valleys.	Medium pink.
Cody Shale	Late Cretaceous	Nonresistant shale. Broad valley with minor ridges.	Light pink.
Frontier Formation	Late Cretaceous	Alternating sandstone and shale. Narrow ridges and valleys.	Dark pink.
Cloverly, Mowry, and Thermopolis Formations	Early Cretaceous	Resistant and nonresistant shale. Mapped as a single unit. Narrow ridges and valleys.	Light blue and dark pink.
Undifferentiated Formations	Early Cretaceous	Alternating sandstone and shale. Narrow ridges and valleys.	Dark pink and light blue.
Chugwater Formation	Triassic	Red sandstone and siltstone. Alternating ridges and valleys.	Yellow and orange.
Phosphoria Formation	Permian	Resistant carbonate rocks. Crops out in cores of Red Rose and Cedar Mountain anticlines.	Very light blue.

Thermopolis Landsat Detailed Map



D. IR plus visible color. Bands 2-4-7 = BGR.

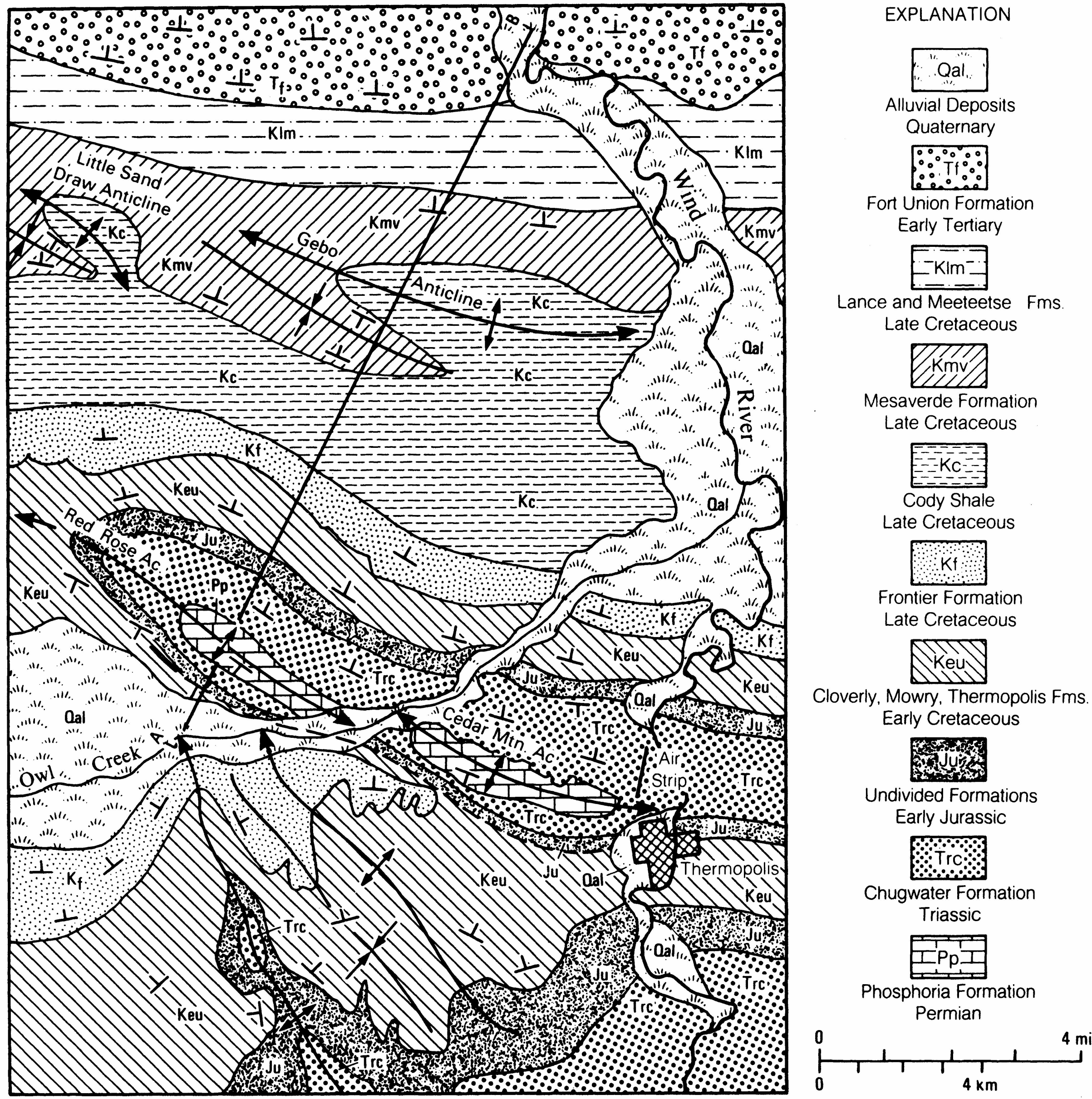


Figure 3-8 Interpretation map for the Thermopolis subscene.

Thermopolis Landsat Detailed Map

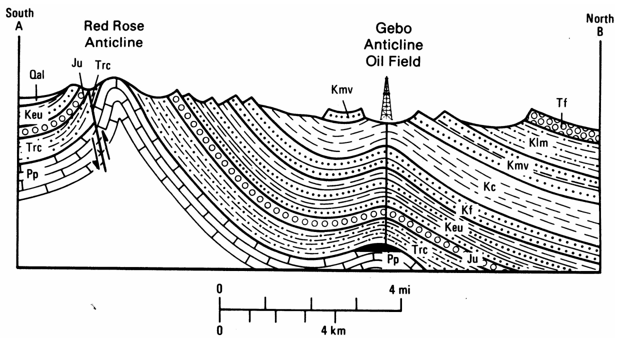


Figure 3-9 Cross section of the Thermopolis subscene. Location and formation symbols are shown in Figure 3-8.

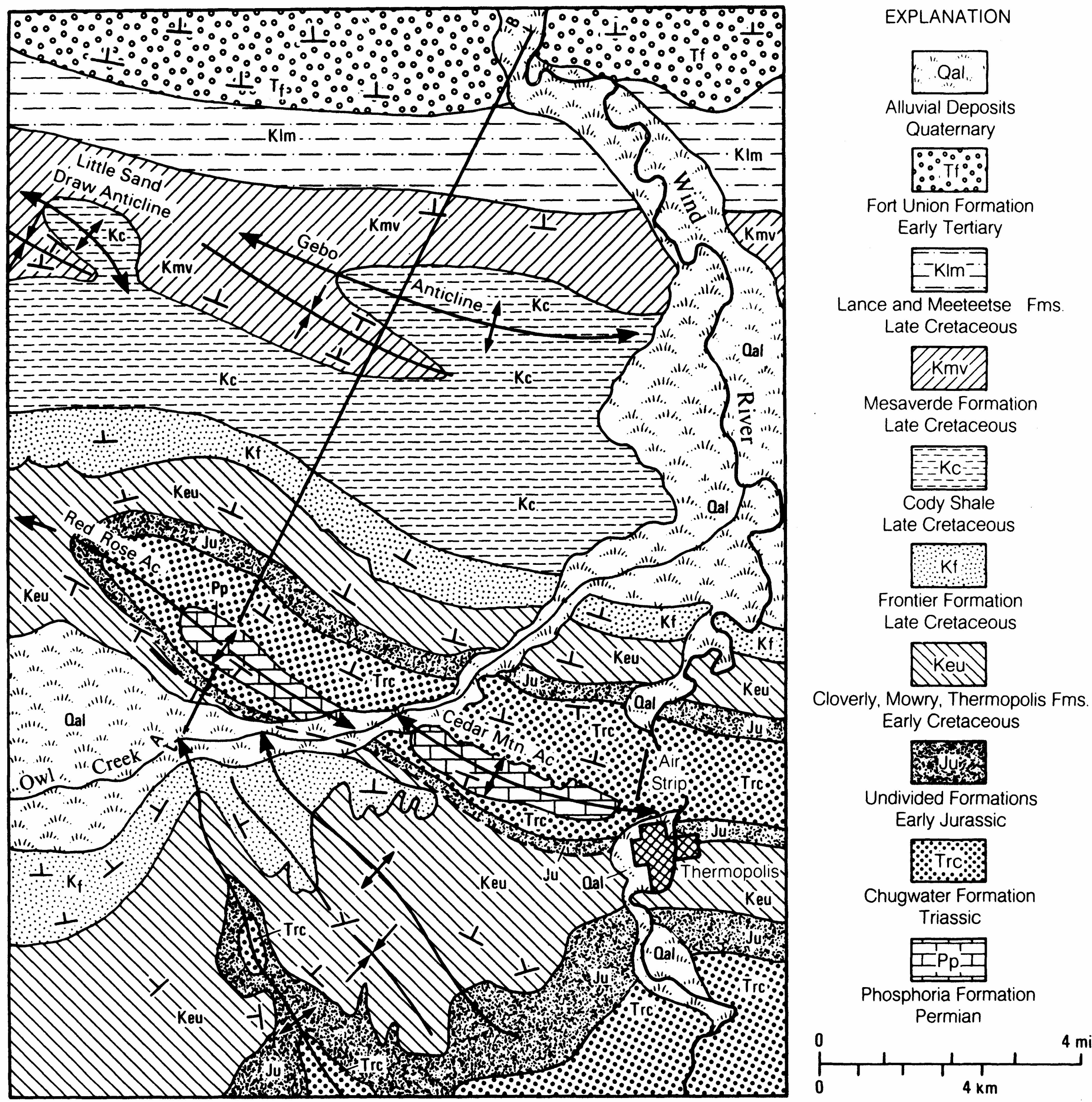


Figure 3-8 Interpretation map for the Thermopolis subscene.

Atlas Mountains
TM 2,4,7 Plate 6

Atlas Mountains
TM 2,4,7   Plate 6

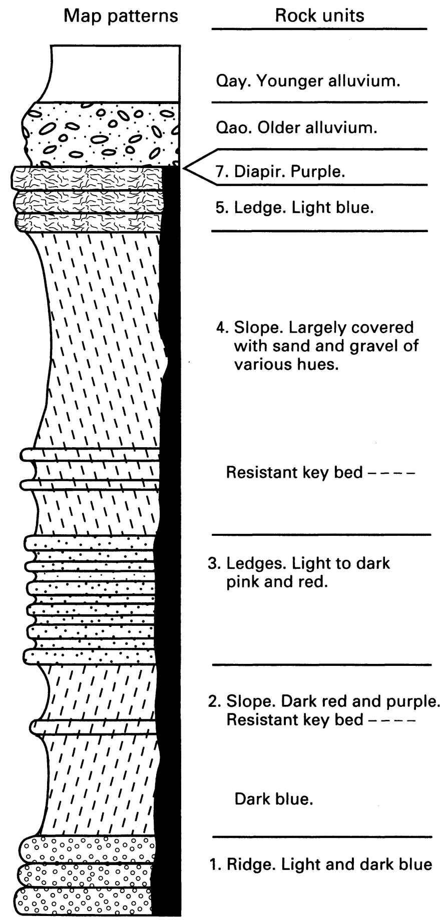


Figure 3-17 Stratigraphic column for interpreting the TM image in the Saharan Atlas Mountains, Algeria.

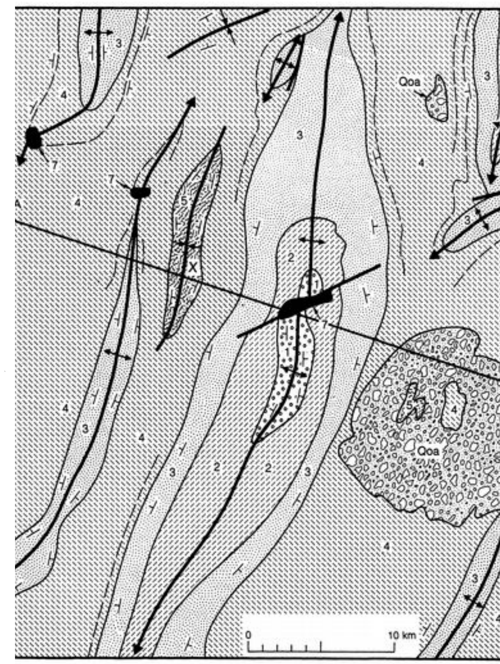


Figure 3-18 Detailed interpretation map of the TM image in the Saharan Atlas Mountains, Algeria. Numbers are keyed to Figure 3-17.

Interpretation Steps

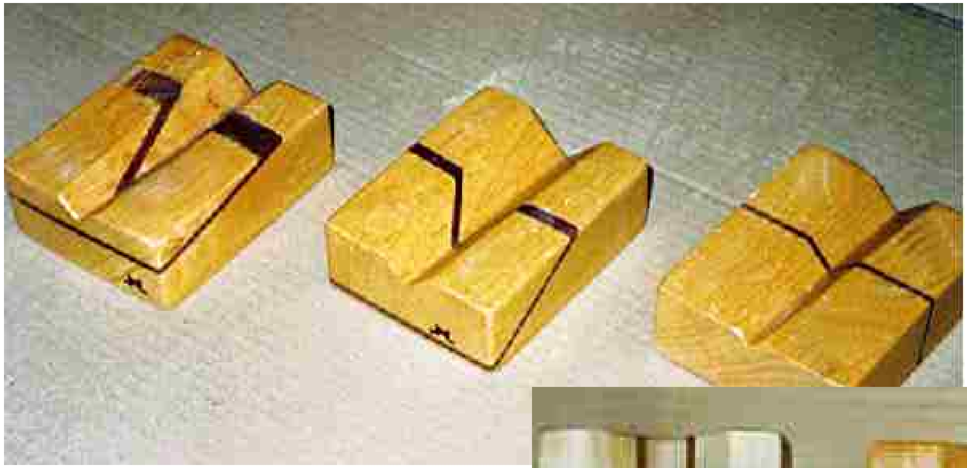
1. Establish sequence of mappable units, from literature or directly from image.
2. Determine attitude of beds (dipslopes, antidip scarps, etc.)
3. Interpret folds and faults (based on outcrop patterns and attitudes)
4. Prepare cross section to accompany interpretation map
5. Check interpretation in the field.

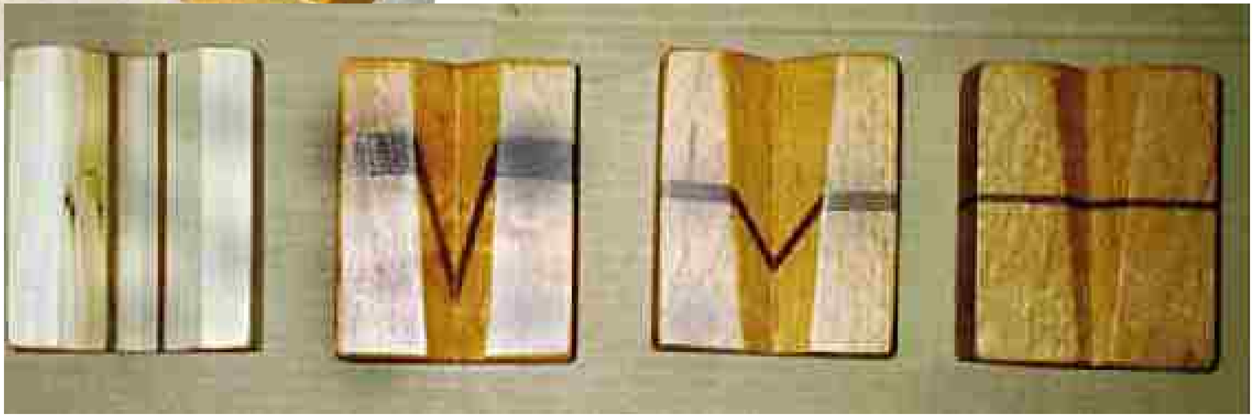
(from Sabins, pg. 89)

Rule of V's

- Block images from Marli Miller's website at University of Oregon
  - <http://pages.uoregon.edu/millerm/>
- Block models originally by John Lewis at Colorado College

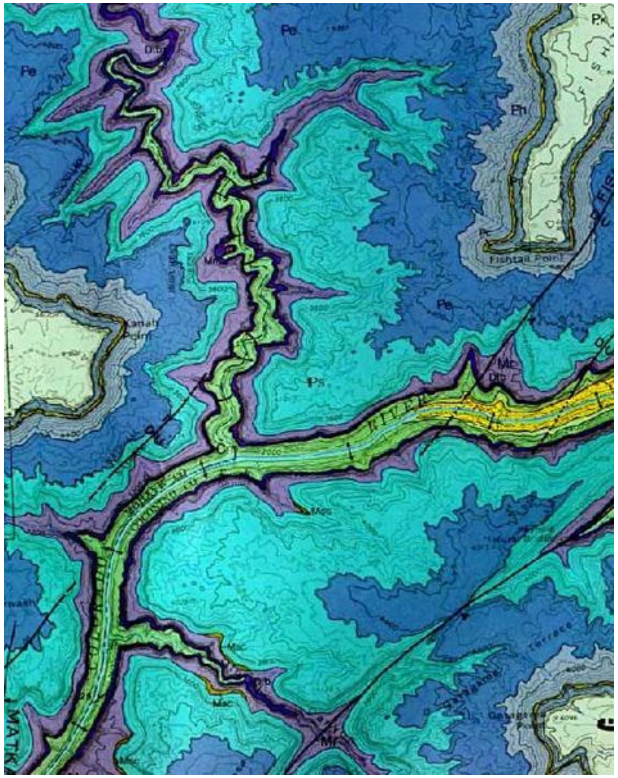
- In a “constant profile” valley across otherwise flat terrain:
  - A horizontal bed would show as two lines along the side of the valley
  - A vertical bed would show as a straight line
  - A dipping bed would show a v pointing in the direction of dip

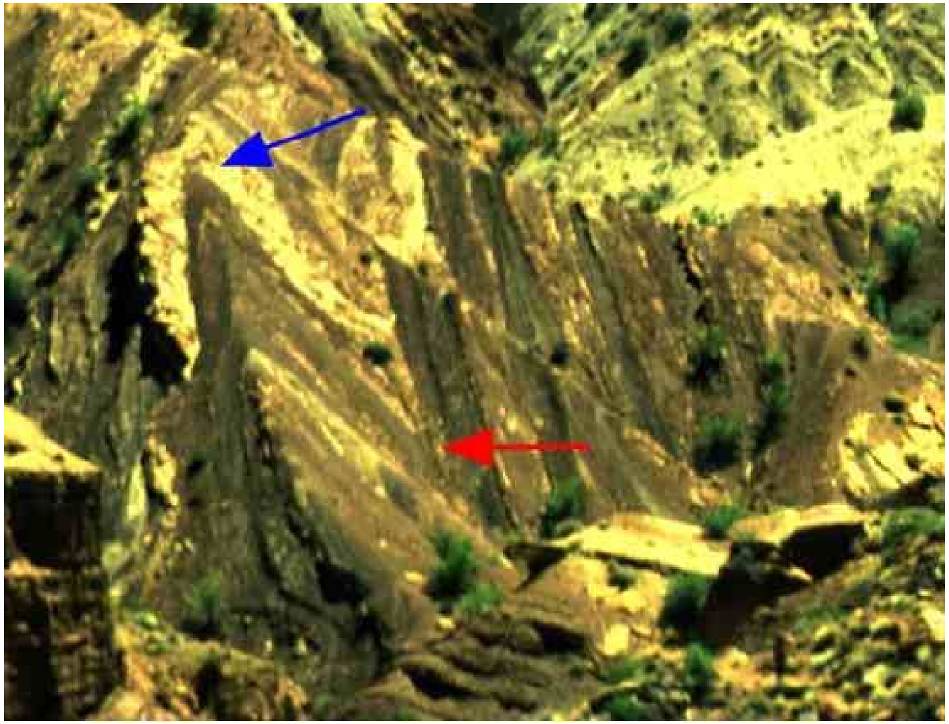




Rule of V's

- Often we have steep topography here
  - If beds are horizontal then as seen from above outcrops look like contours
    - The v will point upstreem on tributaries
  - Becomes a question of whether dip of bed is steeper or shallower than the surface slope
  - Following also from <<http://pages.uoregon.edu/millerm/>>





Central Arabian Arch
TM 2,4,7 Plate 4

Plate 4 Analog mosaic of the Central Arabian Arch compiled from Landsat TM 2-4-7 prints.

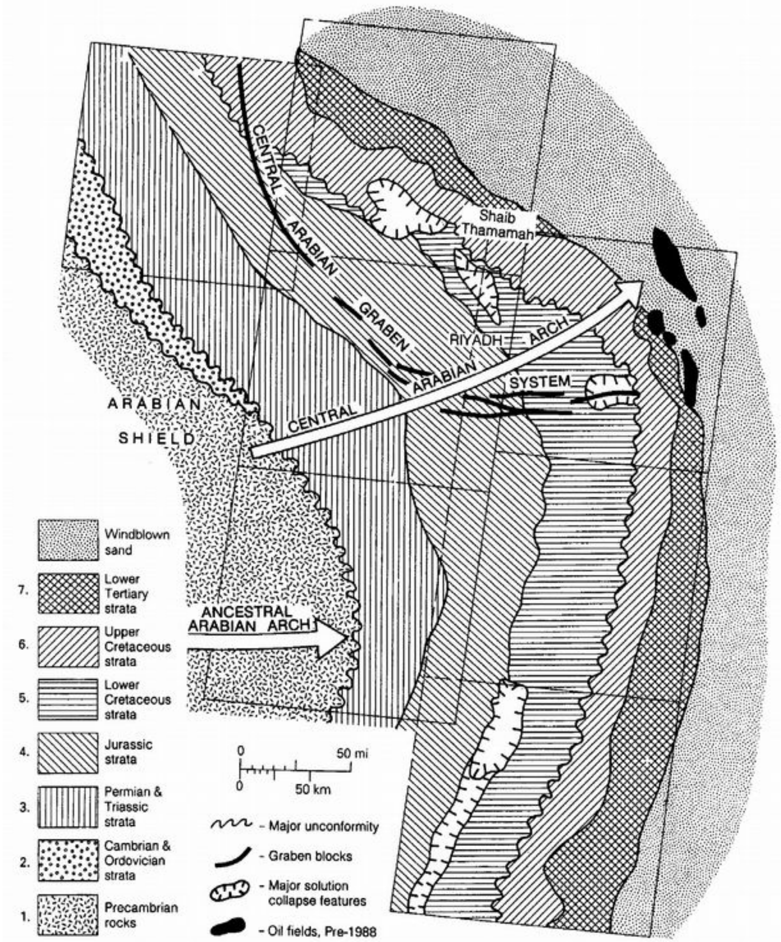


Figure 3-15 Regional interpretation map from a Landsat mosaic of the Central Arabian Arch.

See also pg. 346-355

Interpretation Steps

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(from Sabins, pg. 89)

TM band combinations

Table 3-4 Landsat thematic mapper (TM) spectral bands

Band	*Wavelength, μm*	*Characteristics*
1	0.45 to 0.52	Blue-green. Maximum penetration of water, which is useful for bathymetric mapping in shallow water. Useful for distinguishing soil from vegetation and deciduous from coniferous plants.
2	0.52 to 0.60	Green. Matches green reflectance peak of vegetation, which is useful for assessing plant vigor.
3	0.63 to 0.69	Red. Matches a chlorophyll absorption band that is important for discriminating vegetation types.
4	0.76 to 0.90	Reflected IR. Useful for determining biomass content and for mapping shorelines.
5	1.55 to 1.75	Reflected IR. Indicates moisture content of soil and vegetation. Penetrates thin clouds. Provides good contrast between vegetation types.
6	10.40 to 12.50	Thermal IR. Nighttime images are useful for thermal mapping and for estimating soil moisture.
7	2.08 to 2.35	Reflected IR. Coincides with an absorption band caused by hydroxyl ions in minerals. Ratios of bands 5 and 7 are used to map hydrothermally altered rocks associated with mineral deposits.

*Display colors**	*Advantages*	*Disadvantages*
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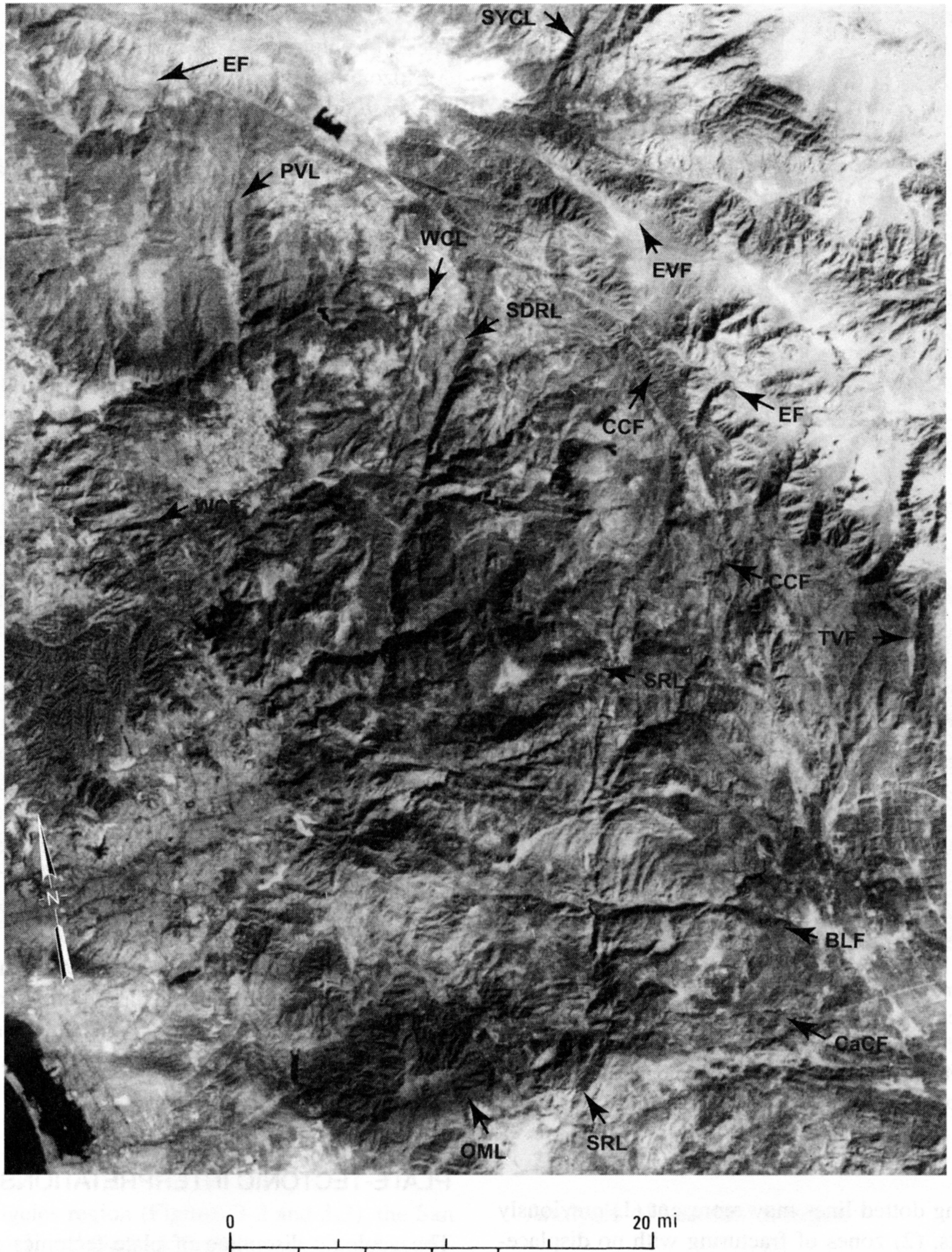


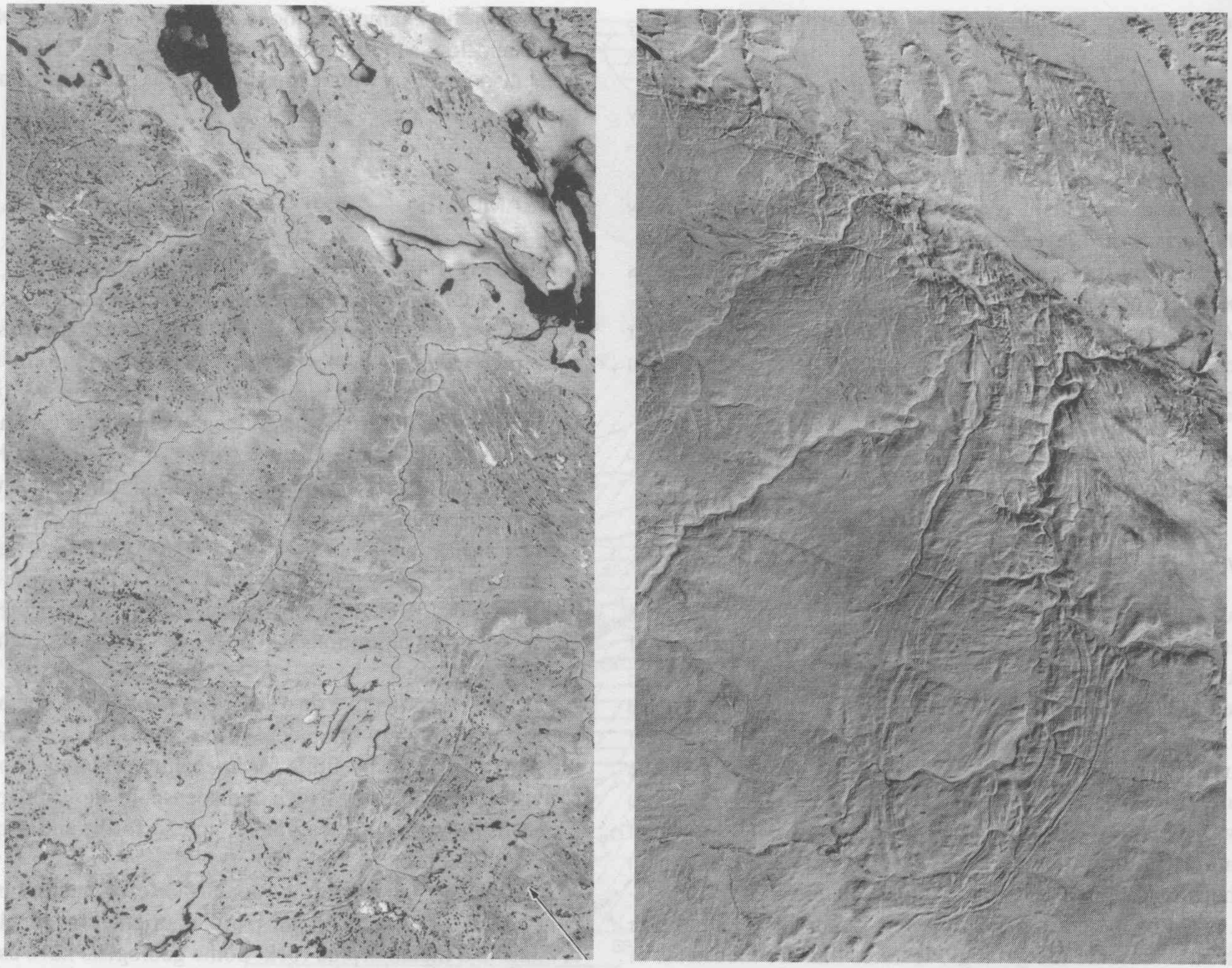
Figure 3-24 Landsat MSS band 4 image of the Peninsular Ranges, southern California. From Lamar and Merifield (1975, Figure 3). Courtesy P. M. Merifield, UCLA.

Linear Features

– Linear: Adjective
– Lineation: 1-D fabric in a rock
– Lineament: Linear or curvilinear feature on a map or image

Albedo vs. Topography

– Snow cover can actually improve study of structure, by suppressing albedo effects.



A. Summer image acquired June 18, 1973, with a 45° sun elevation.

B. Winter image acquired April 2, 1974, with a 27° sun elevation.

Figure 3-22 Landsat MSS band 4 seasonal images of Bathurst Inlet, Arctic Canada.