Radar remote sensing of a semi-arid environment: a case study in central tunisia.

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Radar Remote Sensing of a Semi-arid Environment: A Case Study in Central Tunisia.

In two volumes.

Volume 2.

By

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Thesis submitted for the degree
of Doctor of Philosophy,
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Department of Geography

December 1988

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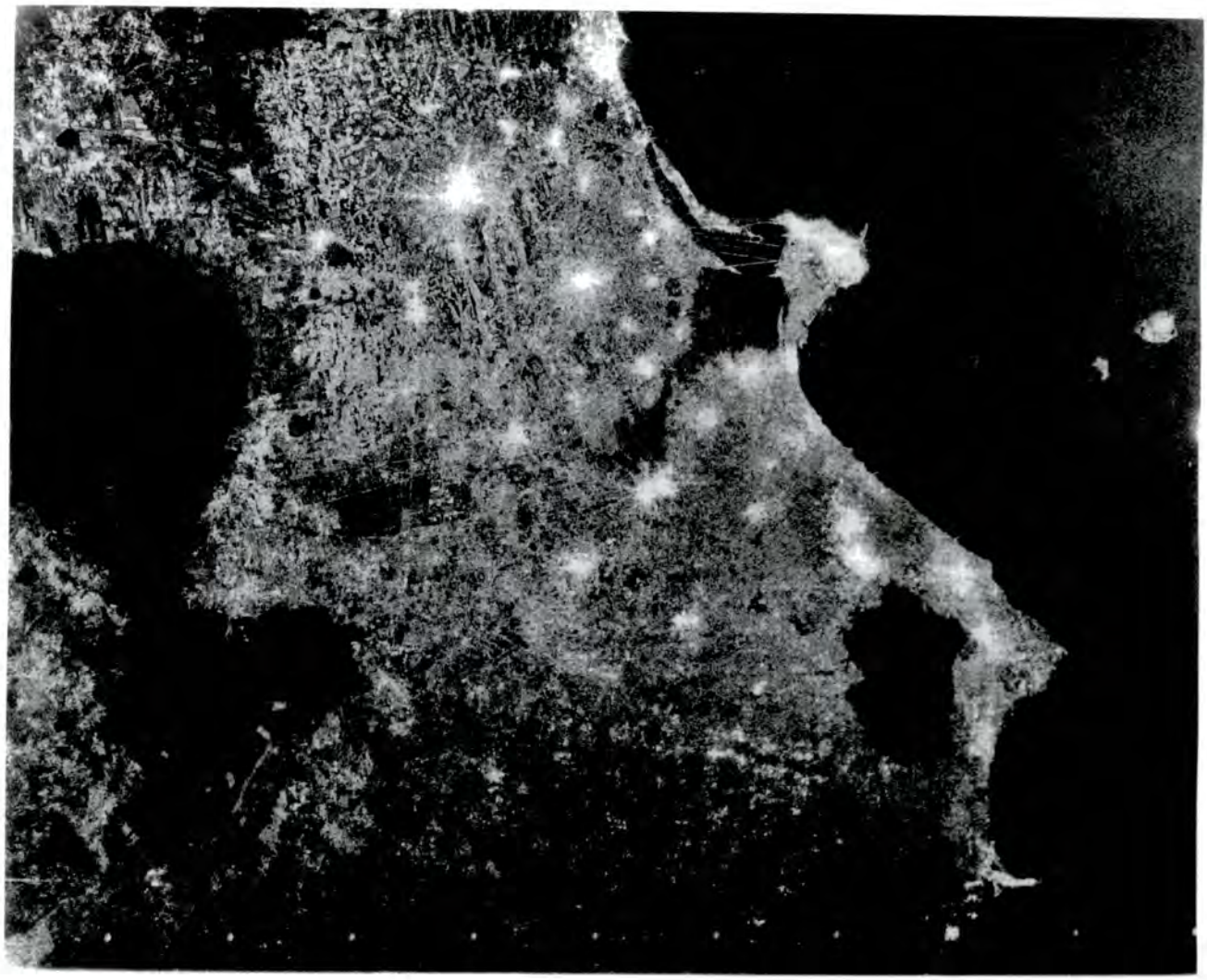

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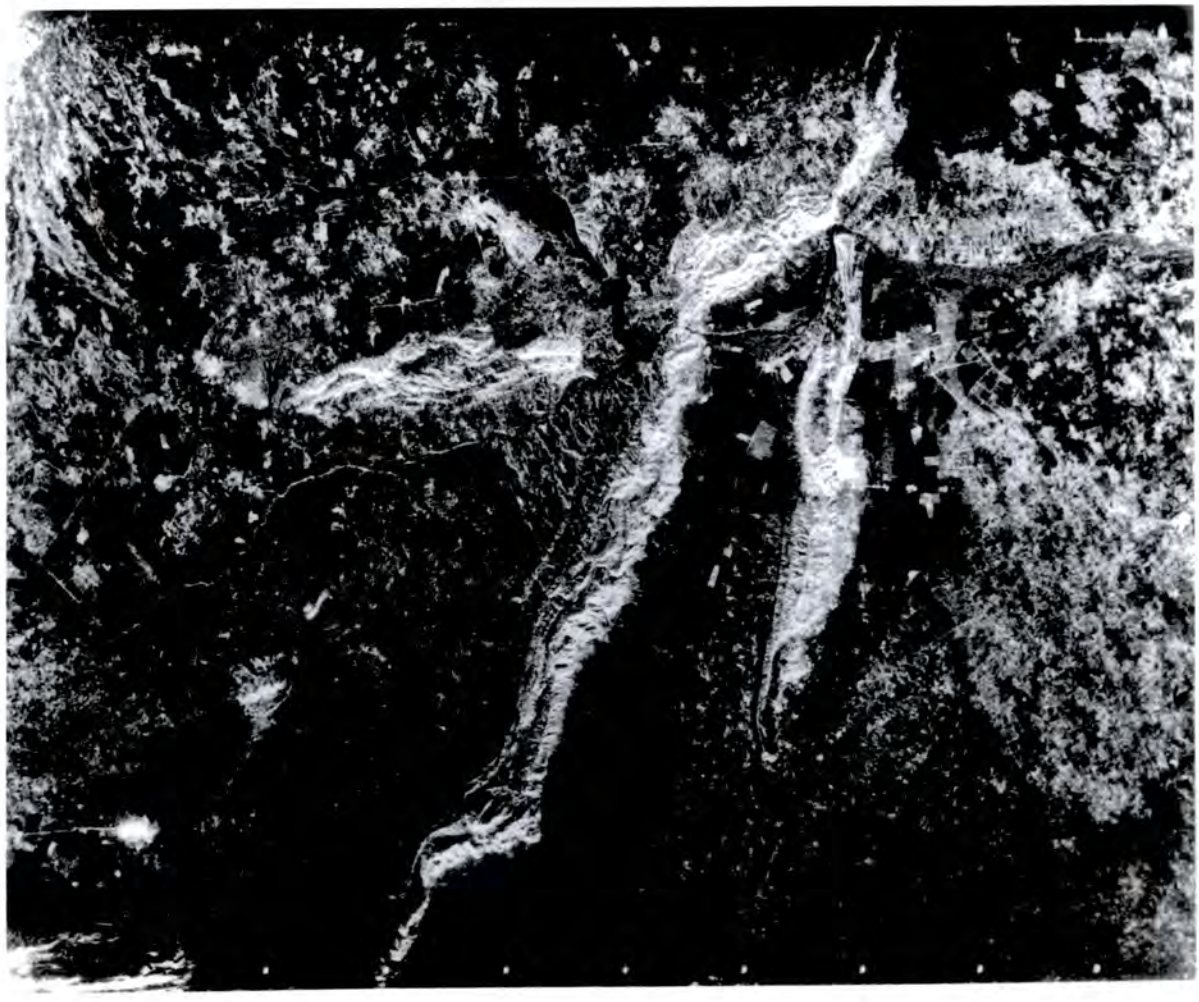

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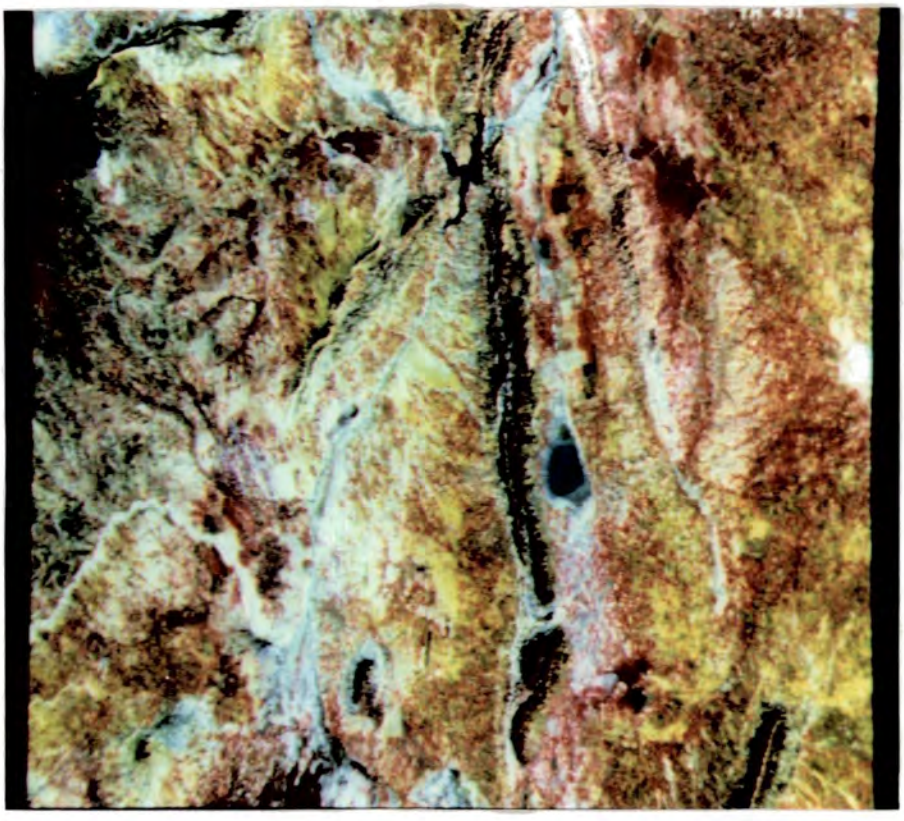


Plate 5.3 False-colour composite image of western study area produced from Landsat TM bands 4, 3 and 1. All three bands are sensitive to the variations in soil and vegetation conditions in the area, producing a wide variation in tone on the image.

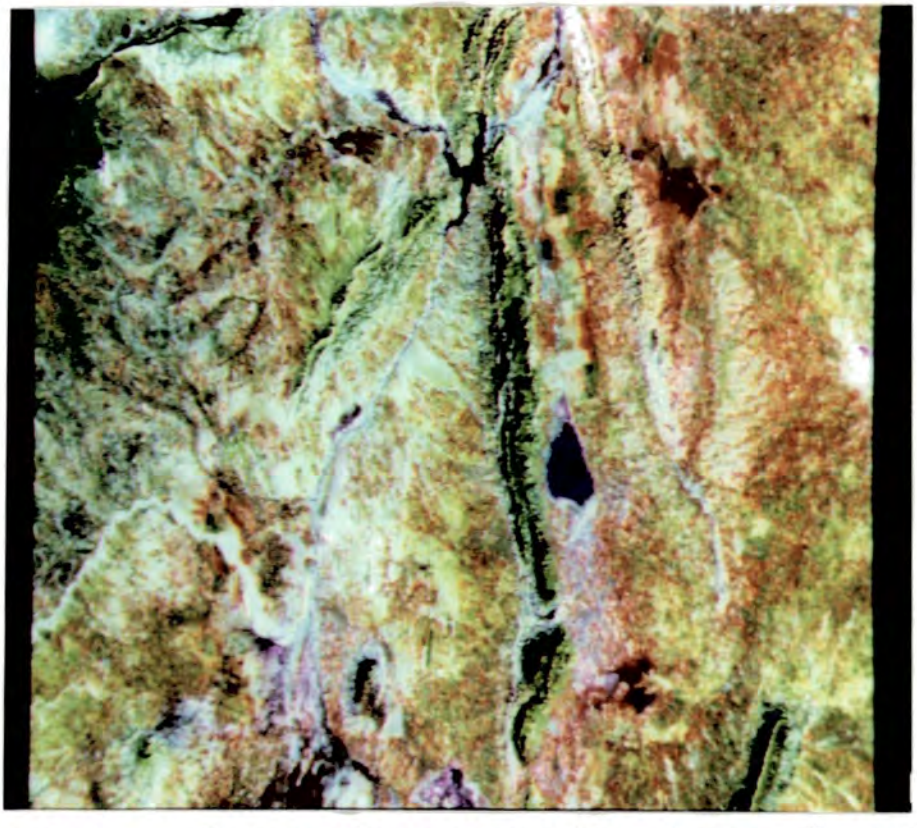
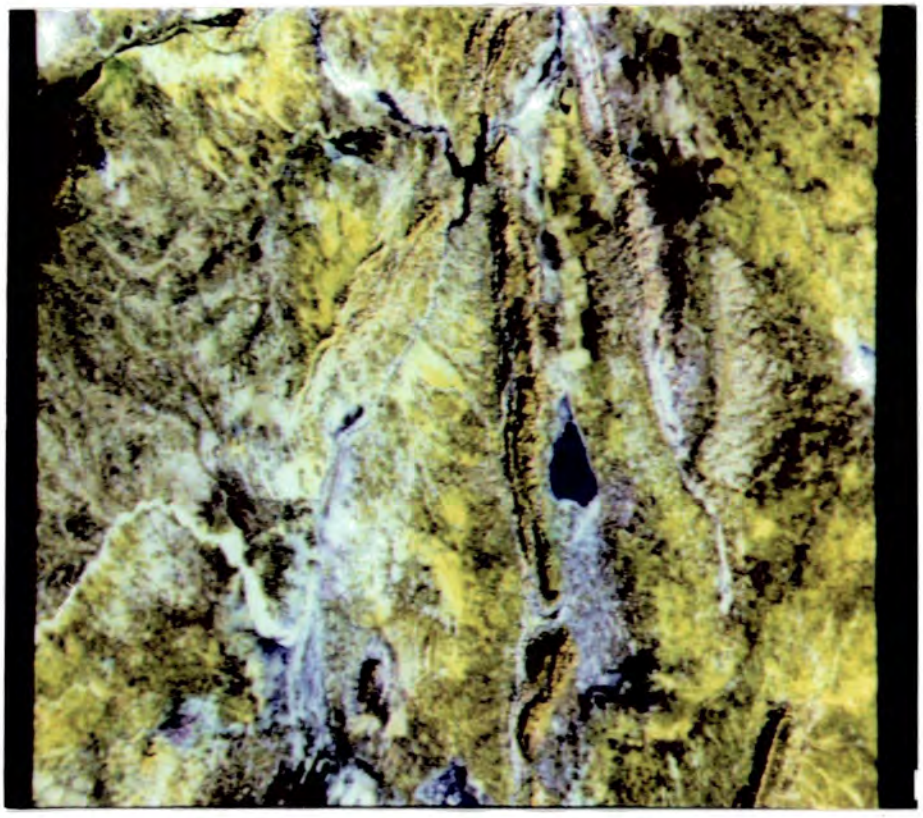


Plate 5.4 False-colour composite image of western study area produced from Landsat TM bands 4, 5 and 2. Once again, this image is useful for the discrimination of agricultural and soil conditions.



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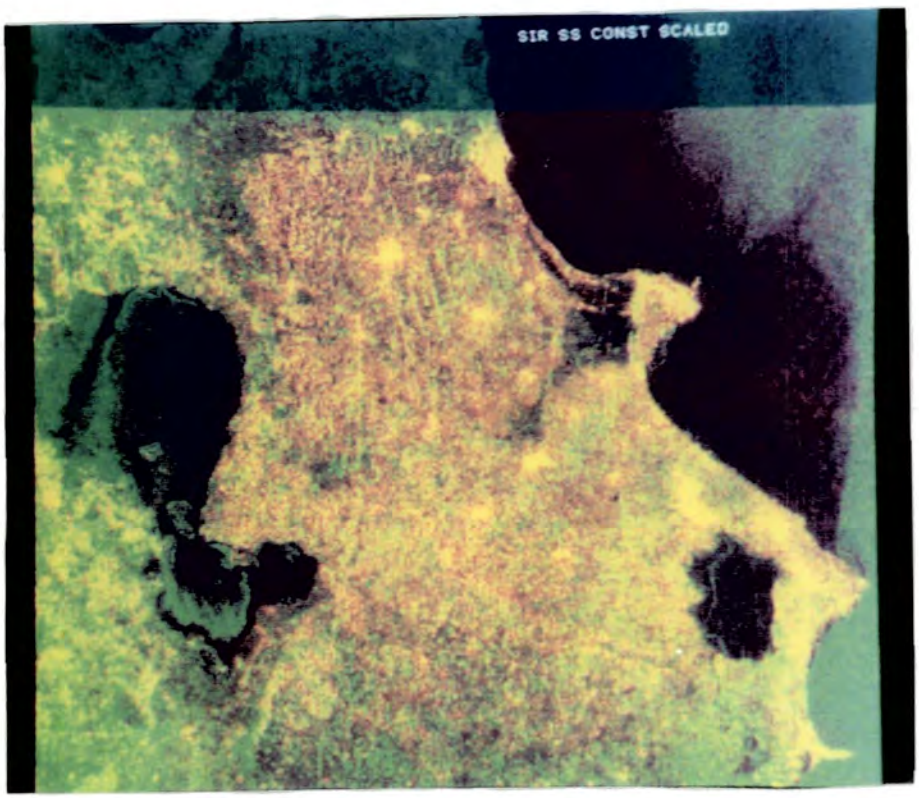

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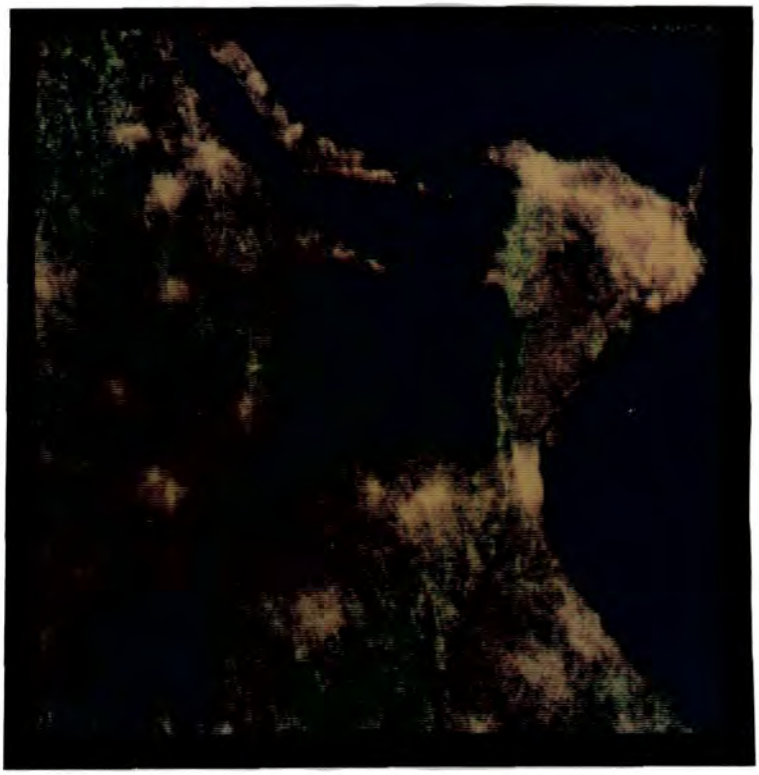

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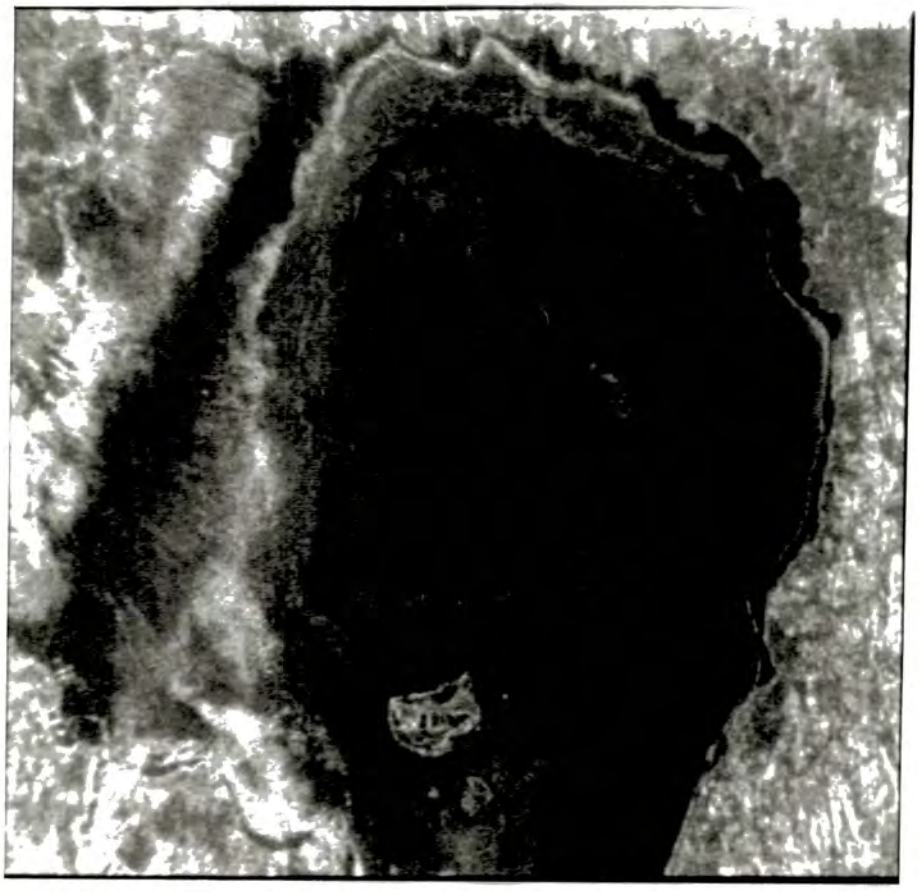
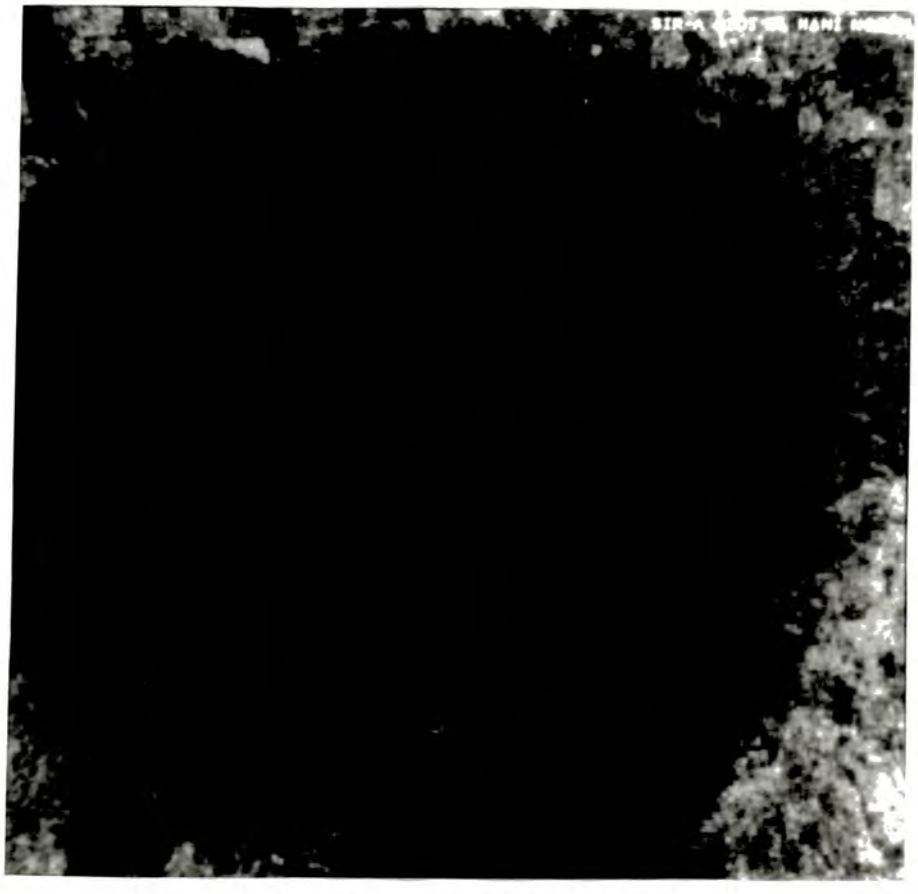


Plate 5.13 Seasat subscene of the northern part of Sebkha Sidi el Hani. The image reveals considerable information about the soil and/or roughness conditions of the sebkha.



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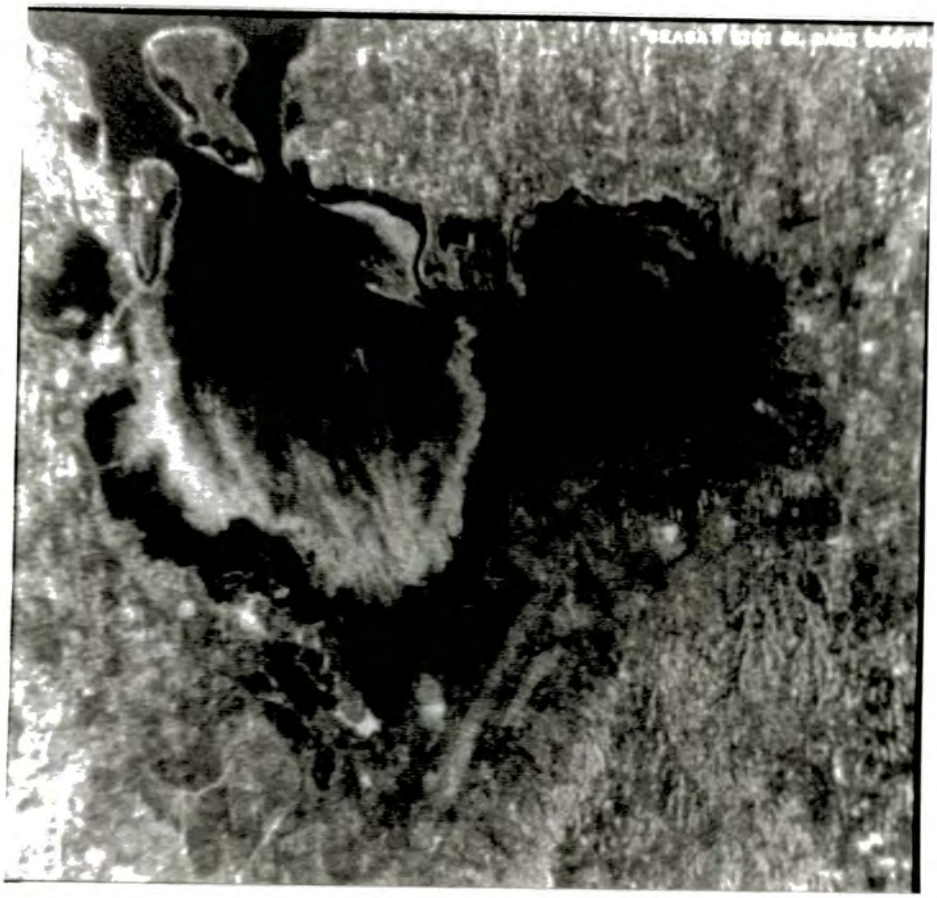
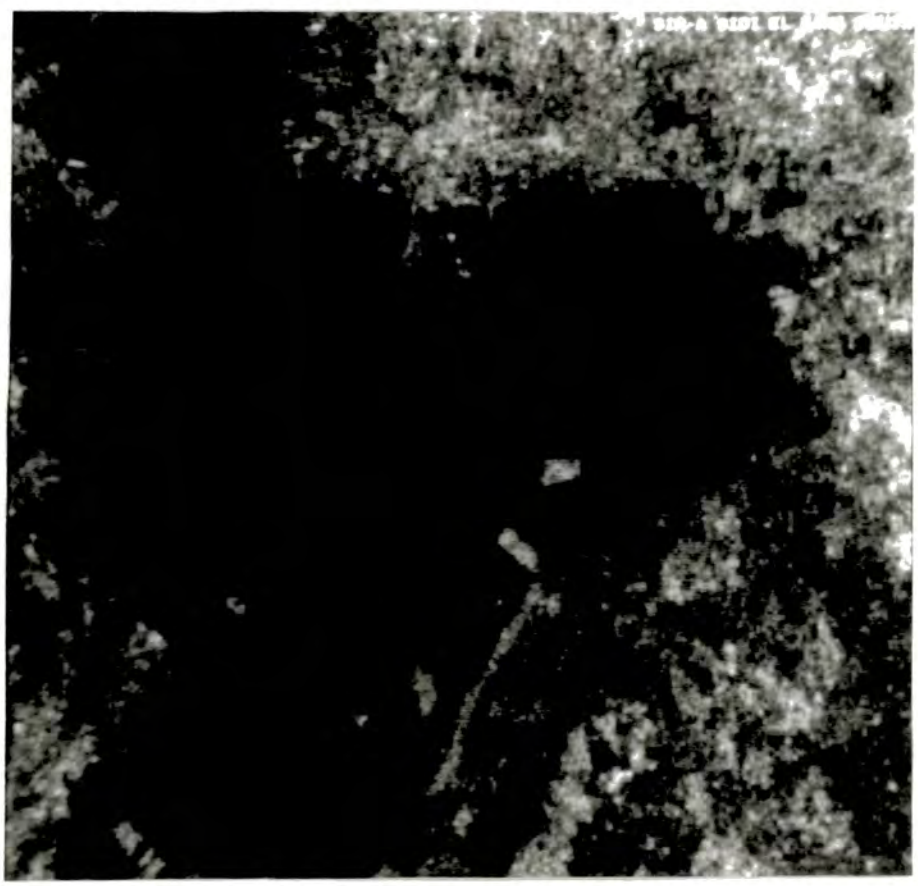


Plate 5.15 Seasat subscene of the southern part of Sebkha Sidi el Hani. Once again, the image reveals variations in surface conditions on the sebkha.



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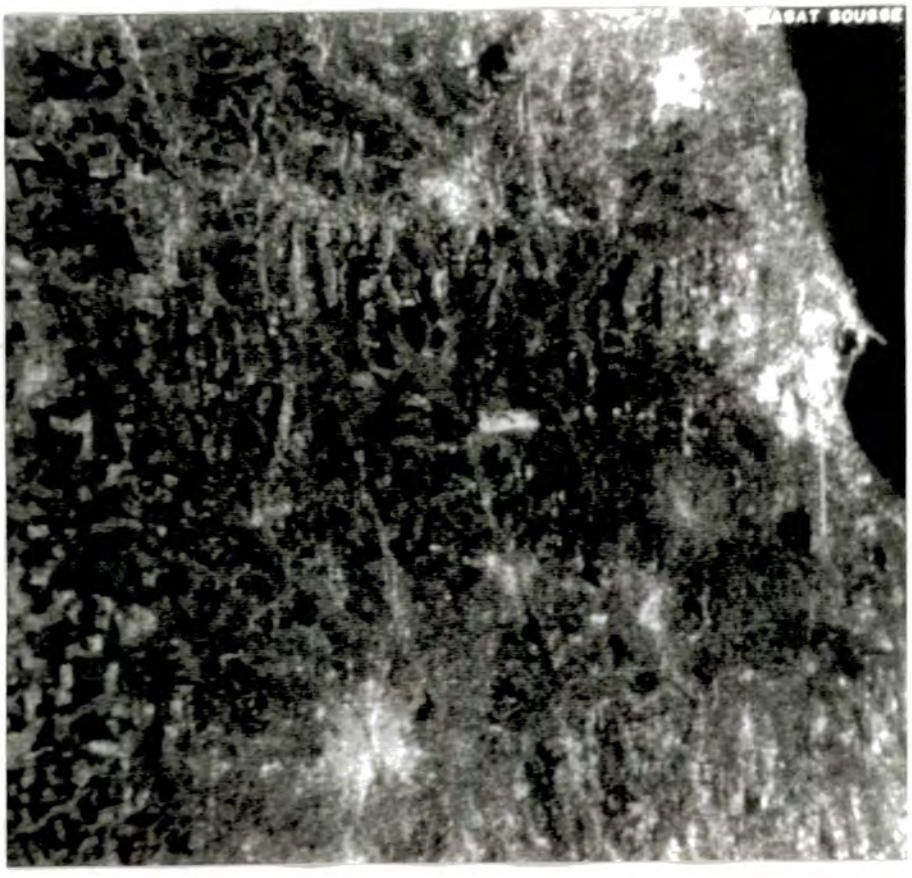

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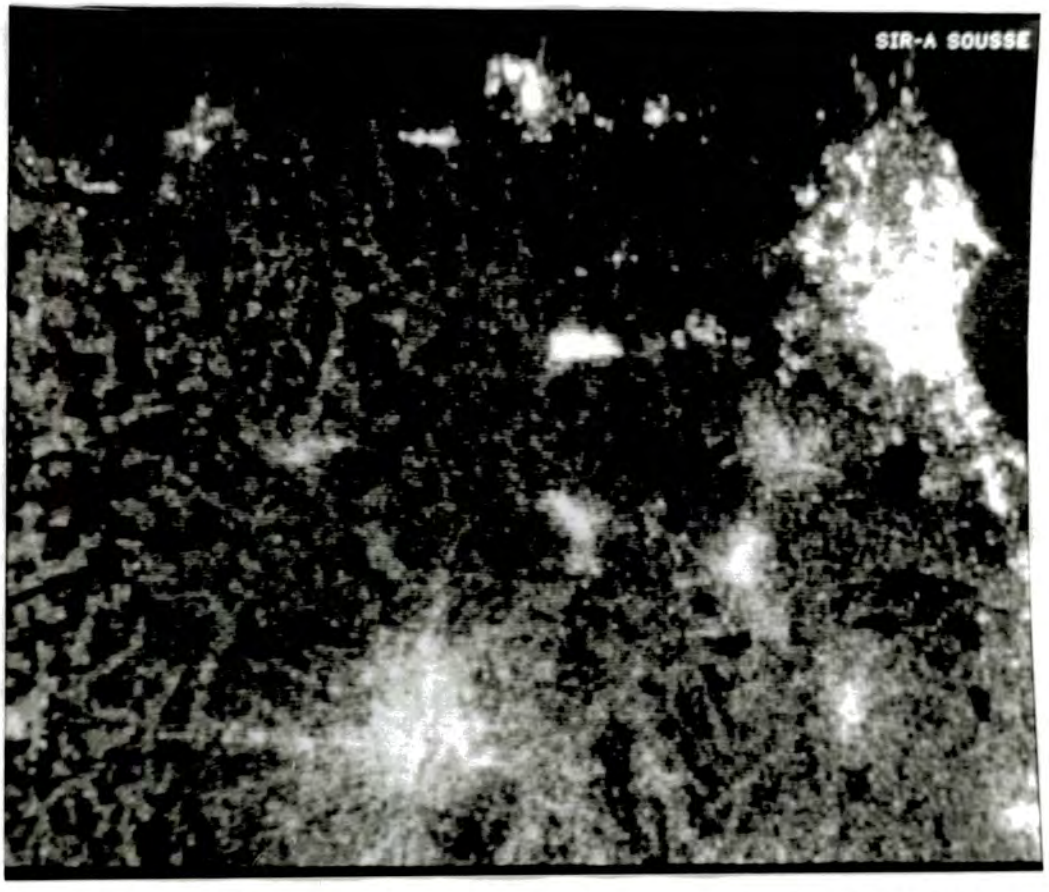
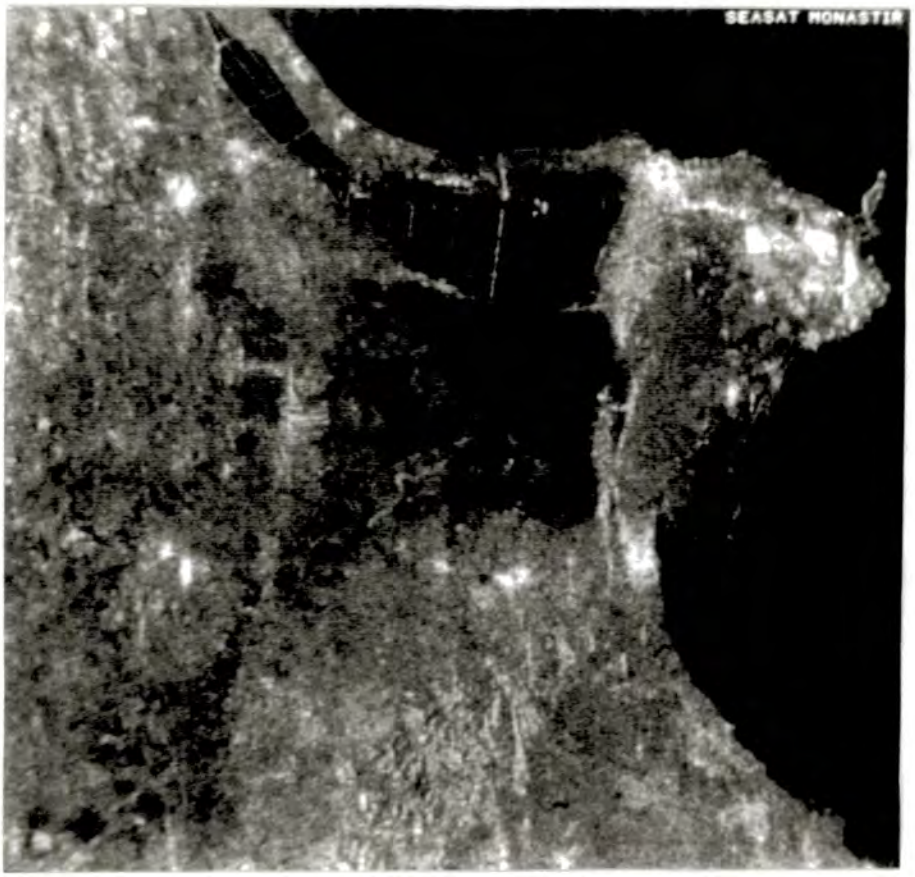


Plate 5.18 SIR-A subscene of the environs of Sousse. The towns and villages have a particularly bright response due to the action of corner reflectors.



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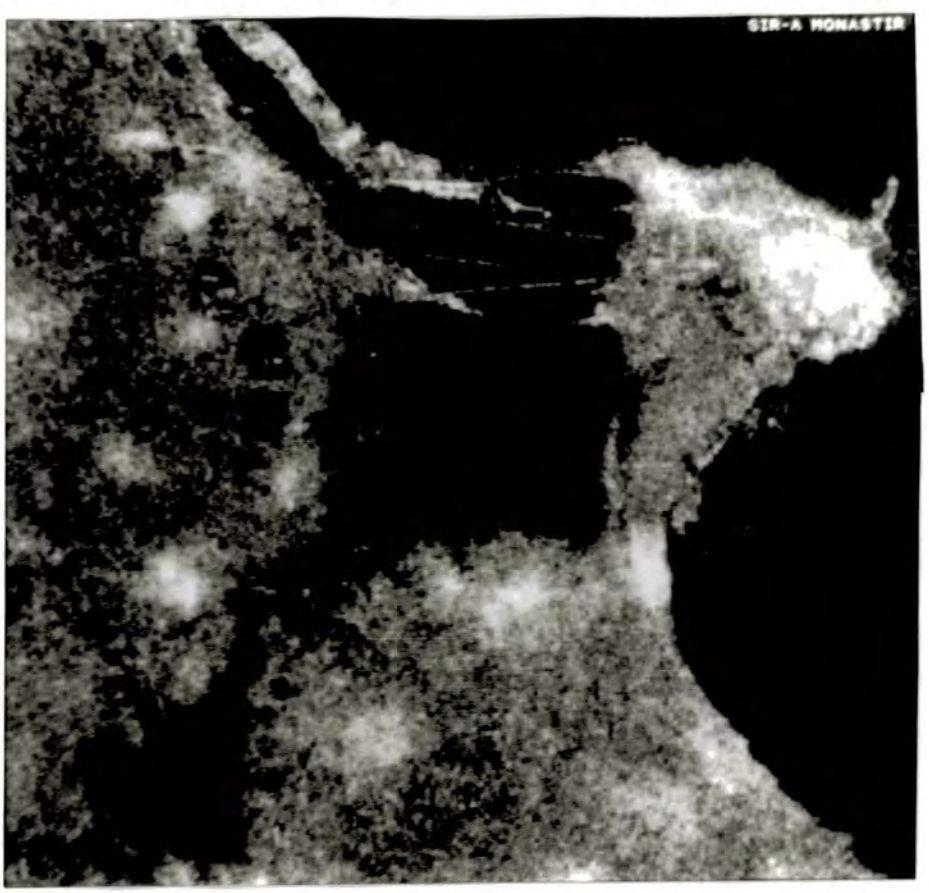


Plate 5.20 SIR-A subscene of the ancient coastal sebkha at Monastir. The settlements and E-W oriented raised bar features contrast well with the dark response from the smooth sebkha surface.

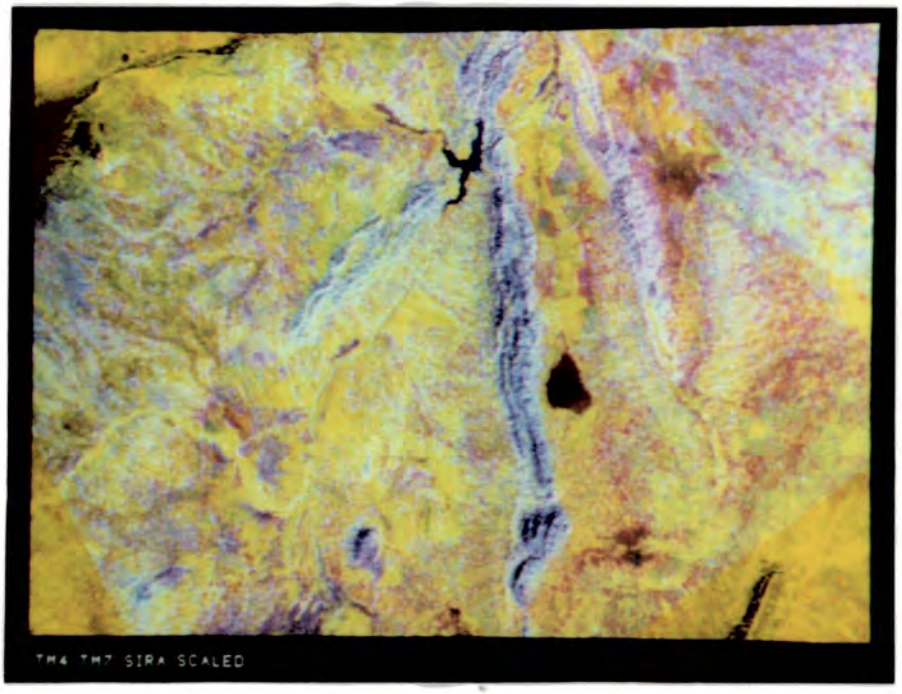


Plate 5.21 False colour image produced from TM bands 4 and 7 and the co-registered SIR-A scene. The image is useful for the discrimination of vegetation and soil and for the identification of water bodies.

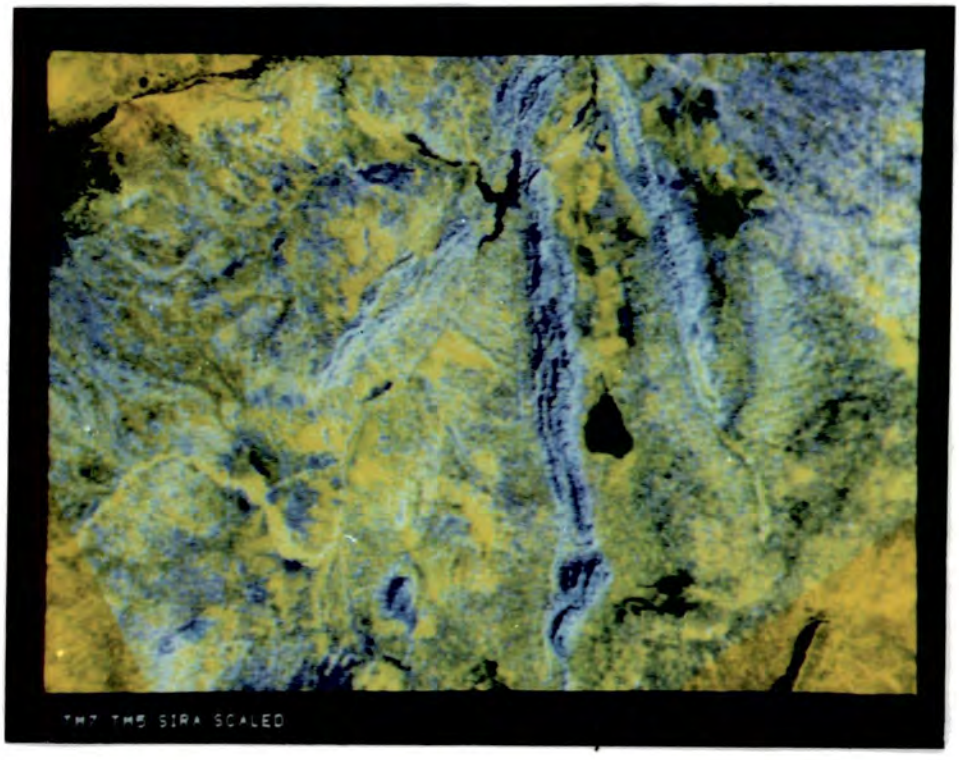


Plate 5.22 False colour image produced from TM bands 7 and 5 and the co-registered SIR-A scene. The image gives a good impression of relief, but tends to confuse rough soil and vegetated areas.

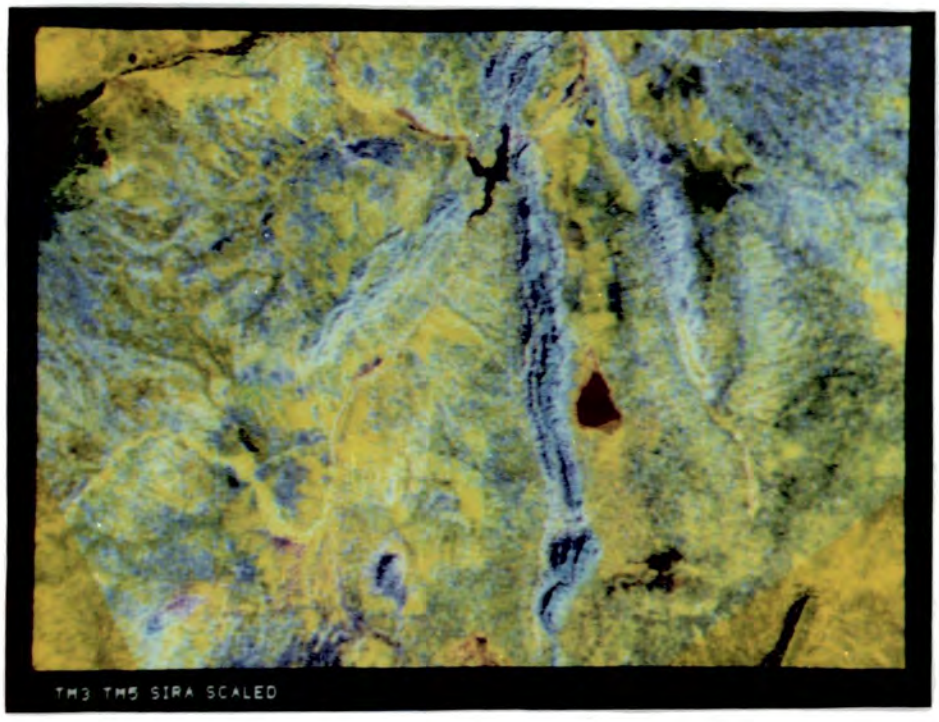


Plate 5.23 False colour image produced from TM bands 3 and 5 and the co-registered SIR-A scene. The image is particularly valuable for detecting areas of moist soil and hydrological features.

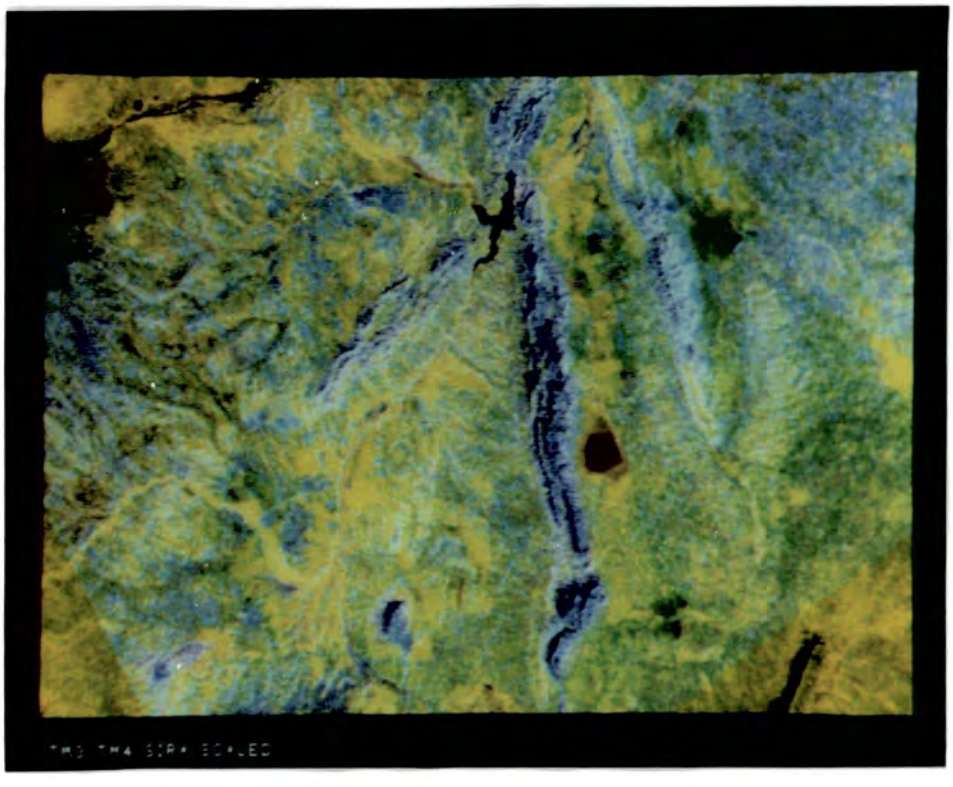
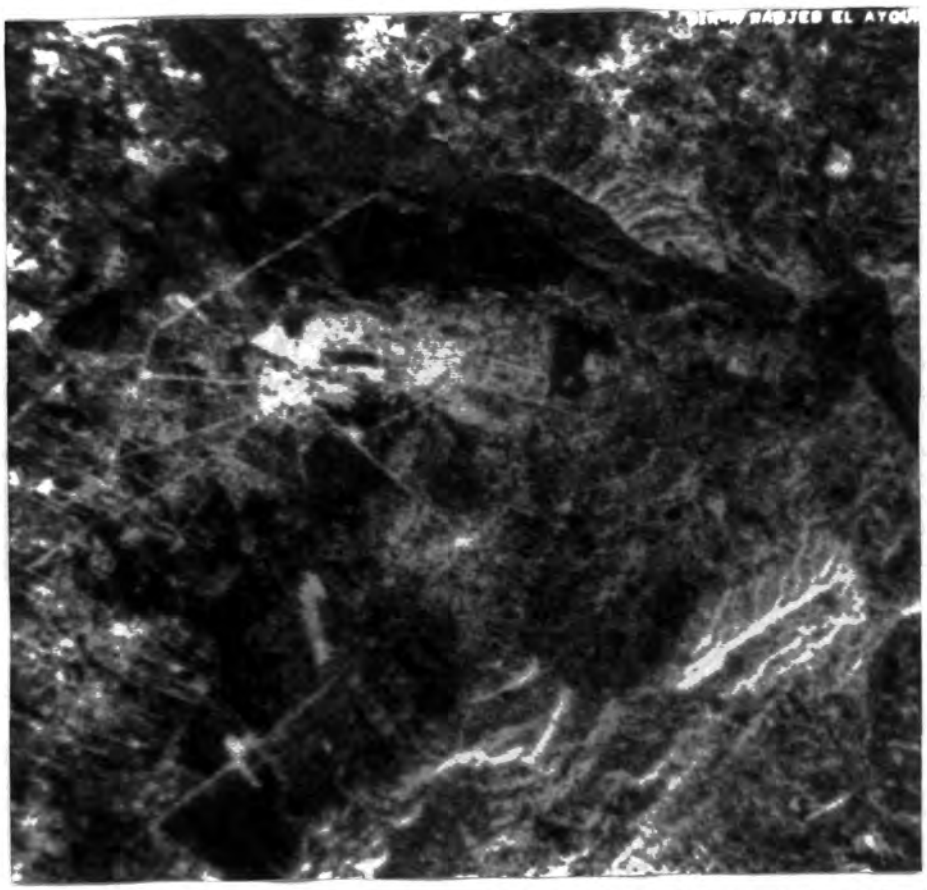


Plate 5.24 False colour image produced from TM bands 3 and 4 and the co-registered SIR-A scene. The image is useful for the discrimination of vegetation and soil conditions and hydrological features.



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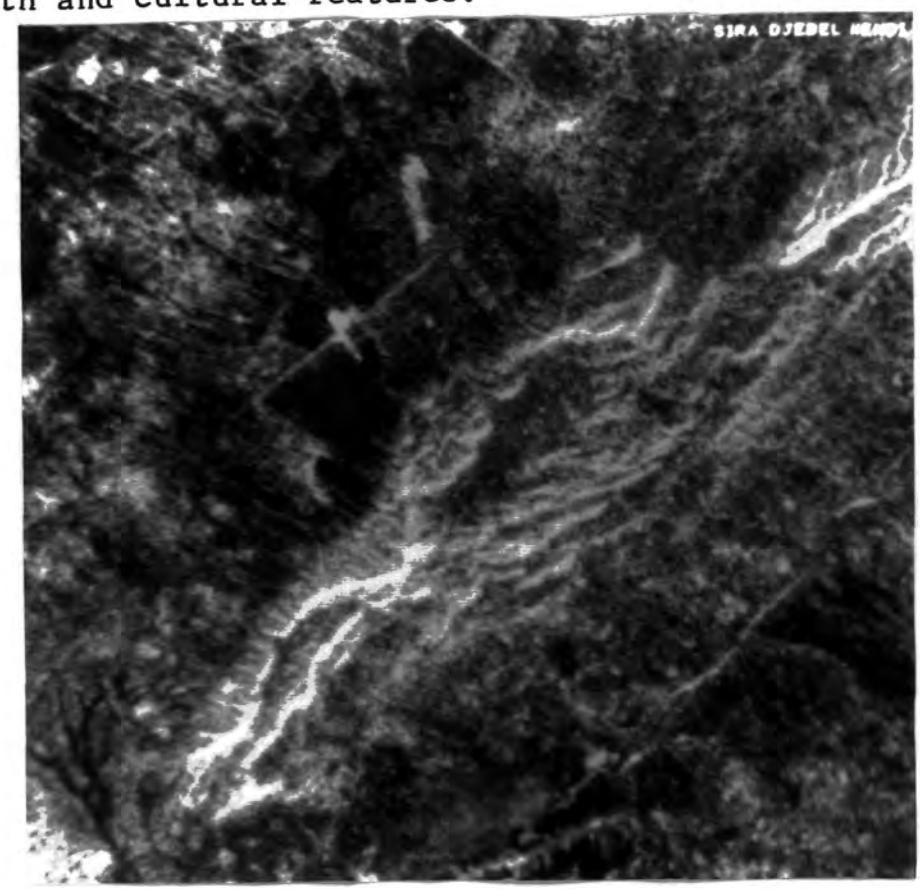

Plate 5.26 SIR-A subscene of Djebel Henndi. The high backscatter from the djebel dominates this image. The dissected area of calcrete (bottom left) is clearly visible.

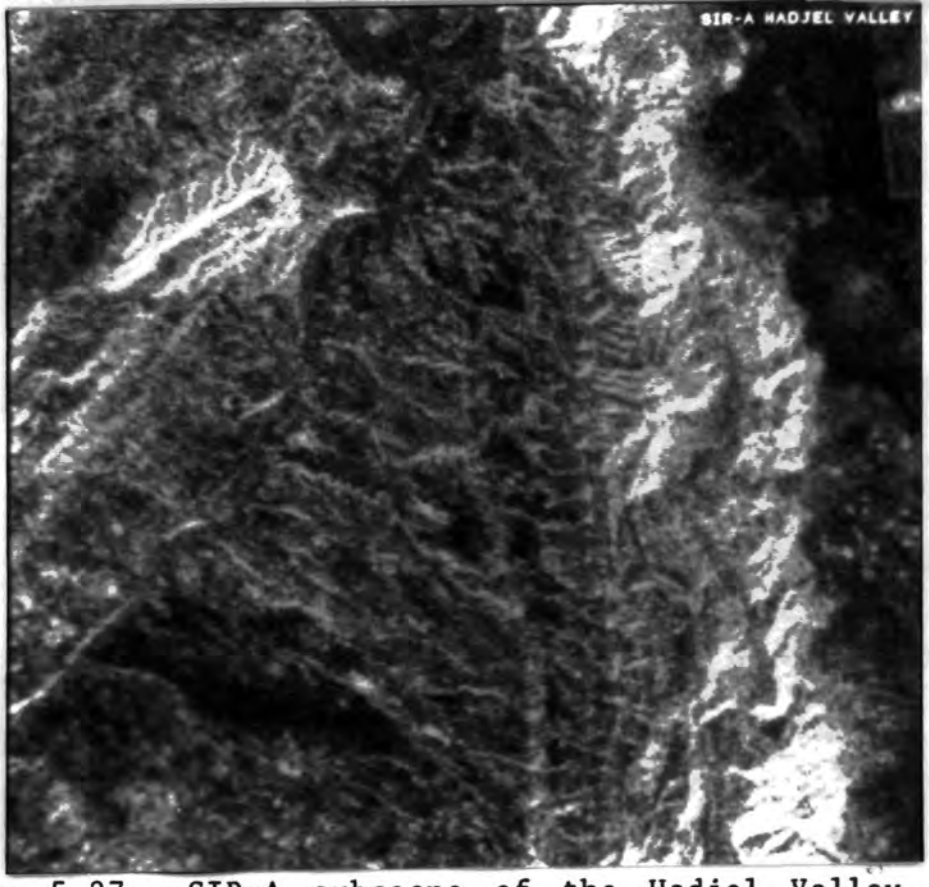

Plate 5.27 SIR-A subscene of the Hadjel Valley and Djebel Nara. The gullies of the Hadjel Valley can be discriminated by their high backscatter values, as can the steeper slopes of the djebel.

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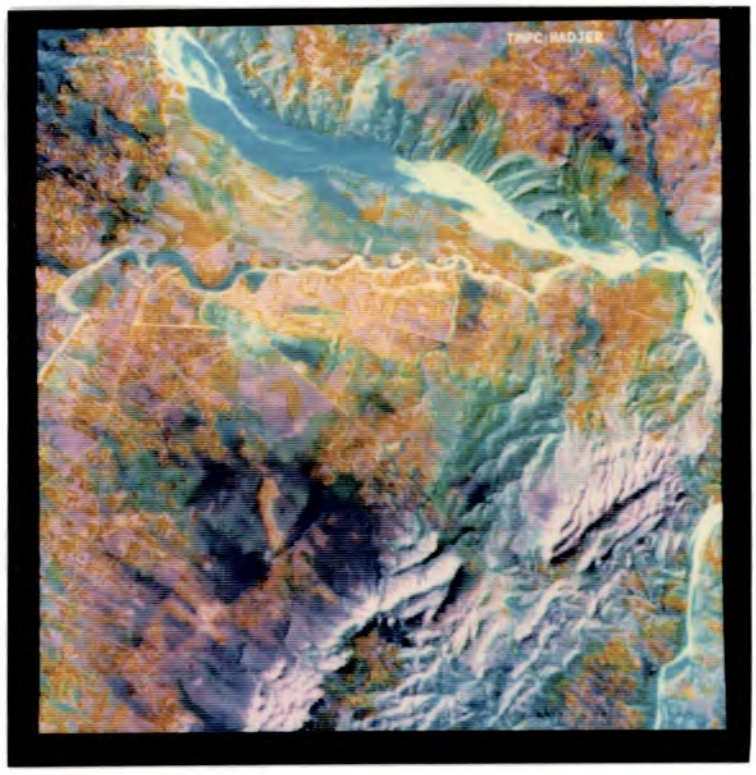

Plate 5.29 Image derived from TM Principal Components 1, 2 and 3 for the Hadjel el Ayoun subscene. Vegetated areas are shown by blue, purple and pink, white areas of bare ground are represented by green and orange hues.

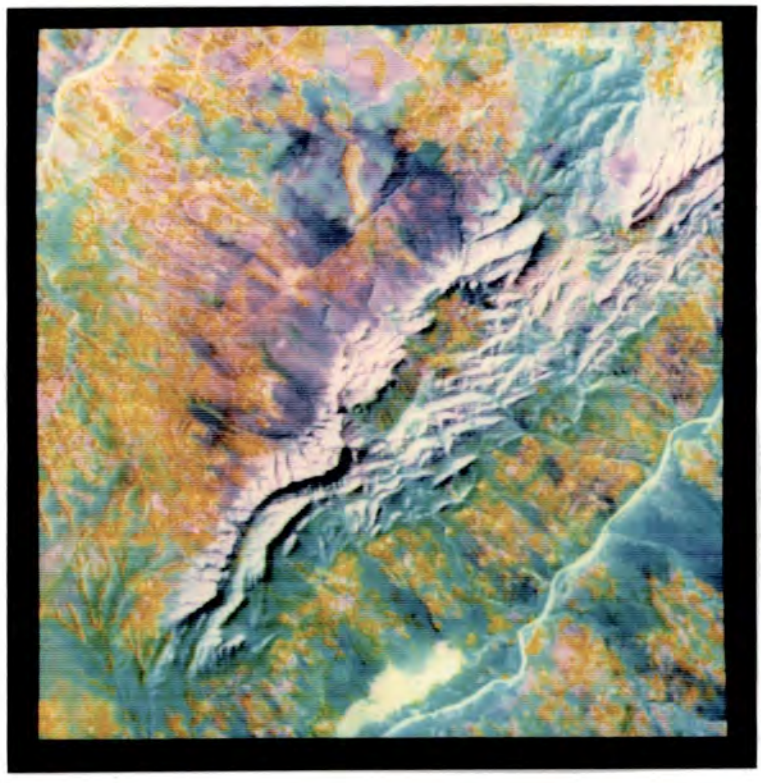

Plate 5.30 Image derived from TM Principal Components 1, 2, and 3 for the Djebel Henndi subscene.

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Plate 5.32 Image derived from TM Principal Componnts 1, 2 and 3 for Djebel Cherahil. Variations in vegetation and soil are shown by clear changes in hue.

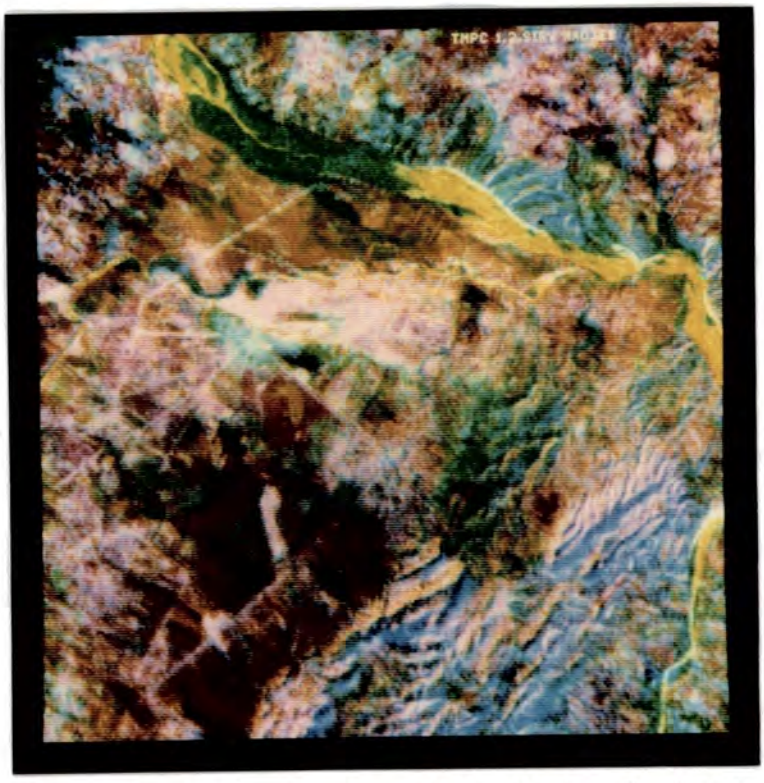

Plate 5.33 Subscene image of Hadjeb el Ayoun derived from TM Principal Components 1 and 2 and the SIR-A image. Vegetated areas are characterized by red and orange hues, while the great input from SIR-A in the mountain regions produces mainly blue tones in these areas.

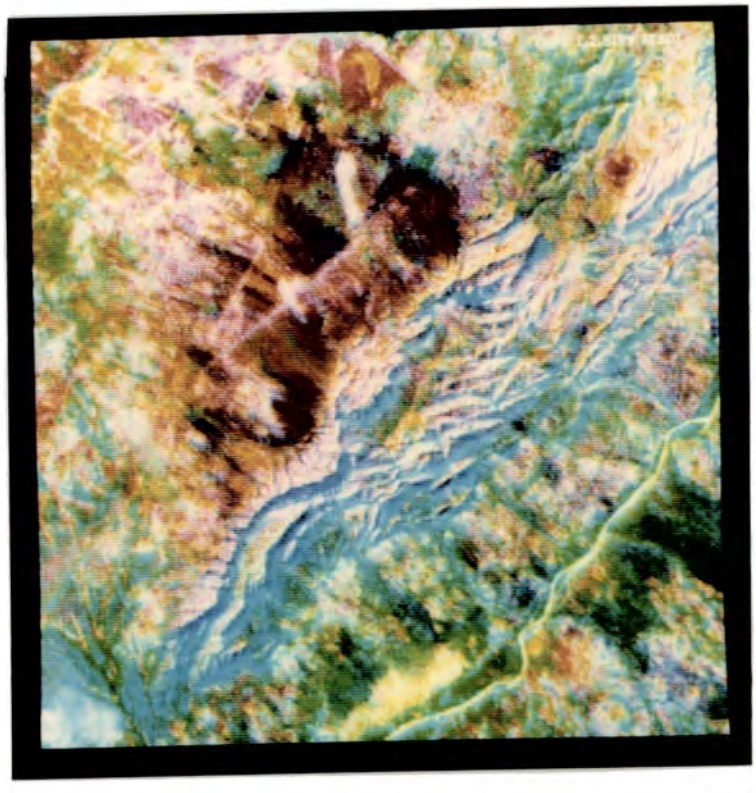

Plate 5.34 Subscene image of Djebel Henndi derived from TM Principal Components 1 and 2 and the SIR-A image. The inclusion of TM reveals some lithological information in mountain areas.

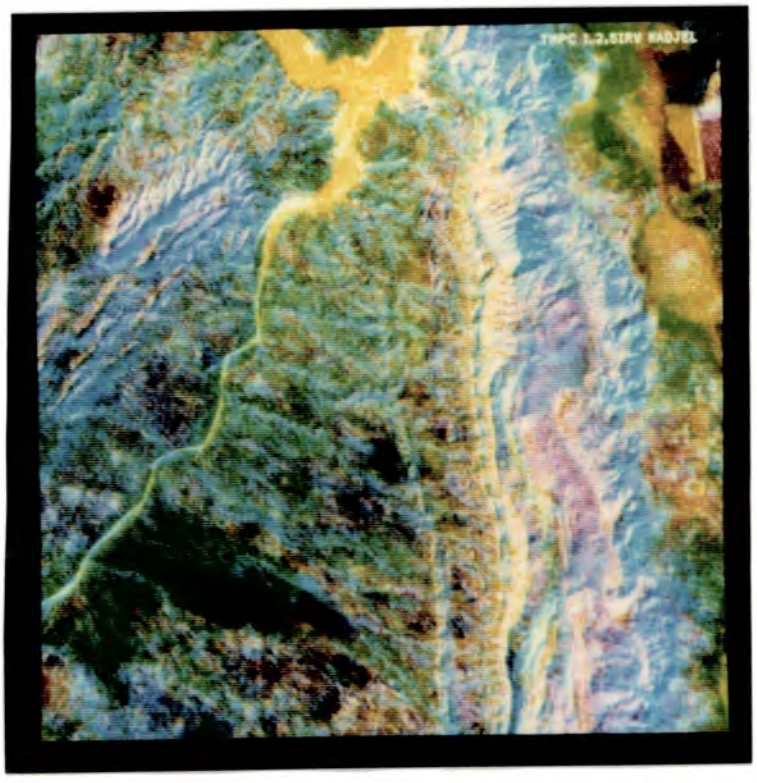

Plate 5.35 Subscene image of The Hadjel Valley and Djebel Nara produced from TM Principal Components 1 and 2 and the SIR-A image.

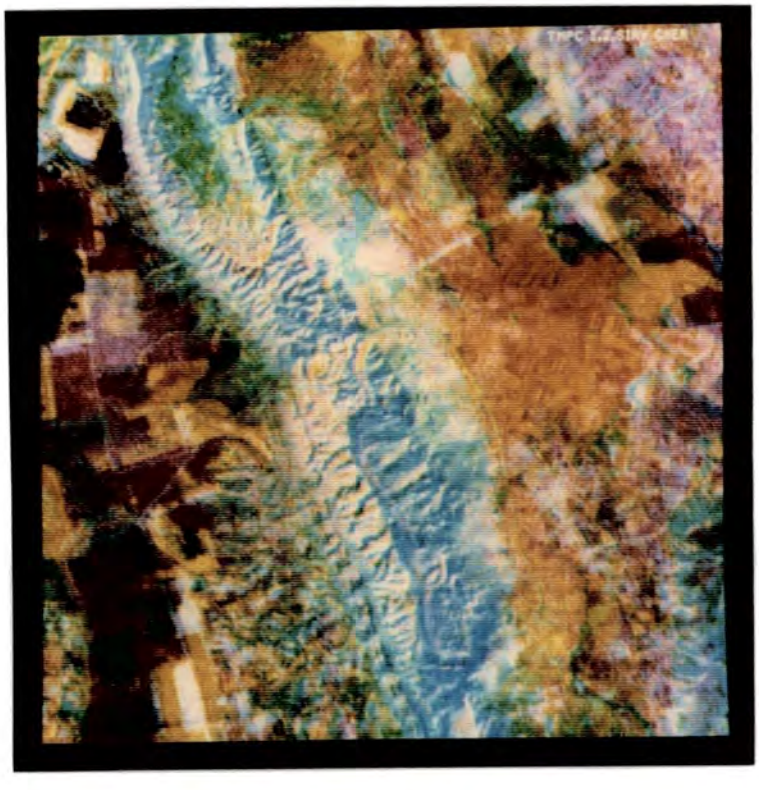

Plate 5.36 Subscene image of Djebel Cherahil produced from TM Principal Components 1 and 2 and the SIR-A image. The red and orange tones of the agricultural plains are mainly produced from TM information, while the blue tones of the djebel owe their existence to the high SIR-A backscatter from mountain slopes.

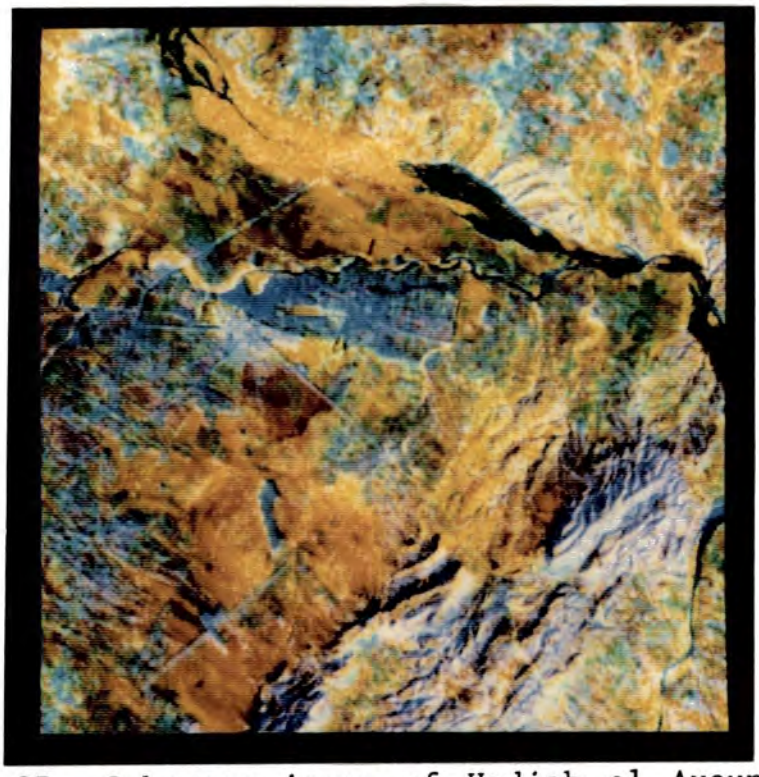

Plate 5.37 Subscene image of Hadjeb el Ayoun derived from Principal Component Analysis of TM bands 4 and 7 and SIR-A. This image provides a particularly good representation of relief, with mountainous areas standing out clearly from the surrounding areas of bare soil and vegetation.

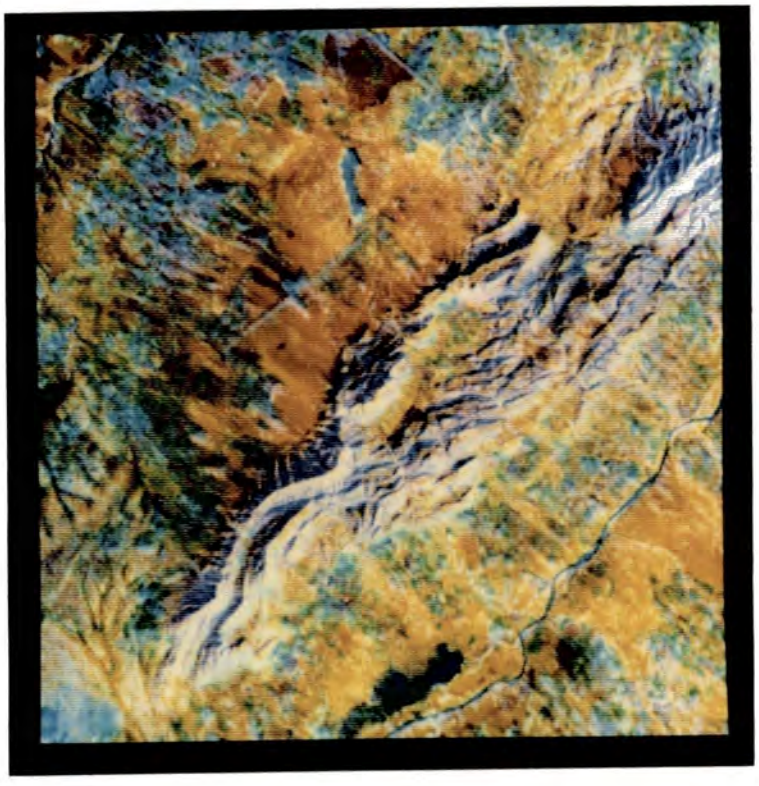

Plate 5.38 Subscene image of Djebel Henndi produced from Principal Components Analysis of TM bands 4 and 7 and SIR-A.

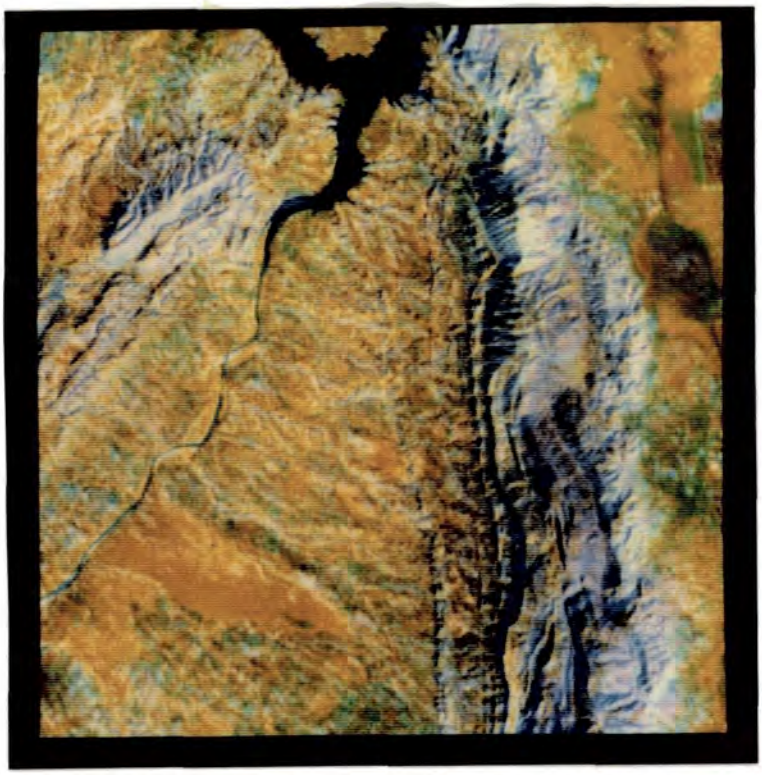

Plate 5.39 Subscene image of the Hadjel Valley and Djebel Nara derived from Principal Components Analysis of TM bands 4 and 7 and SIR-A. The inclusion of TM band 7 in the analysis allows variations in lithology within Djebel Nara to be shown on the resultant image.

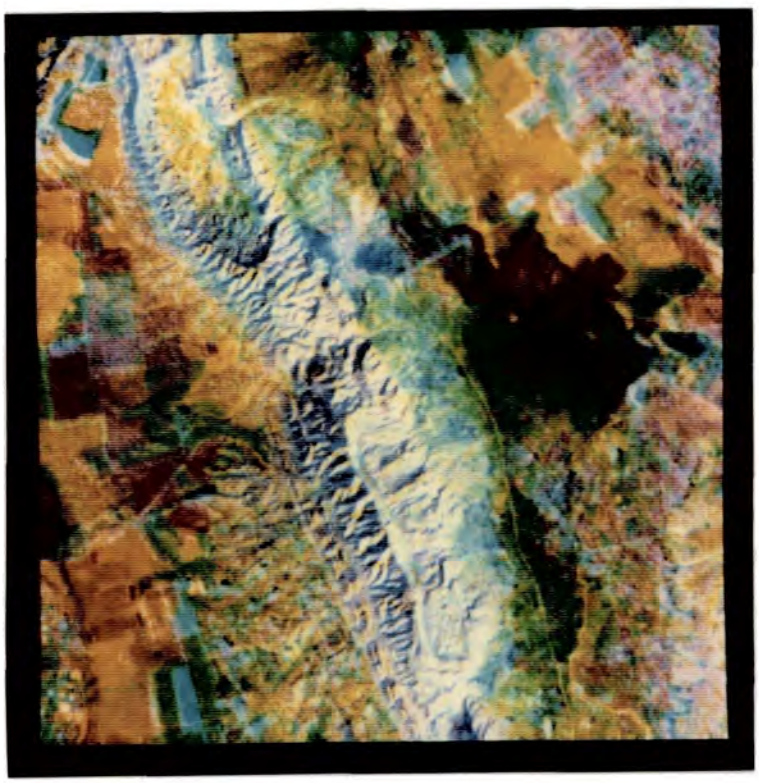

Plate 5.40 Subscene image of Djebel Cherahil derived from Principal Components Analysis of TM bands 4 and 7 and SIR-A. The image is particularly useful for the discrimination of mountain slopes and vegetated areas.

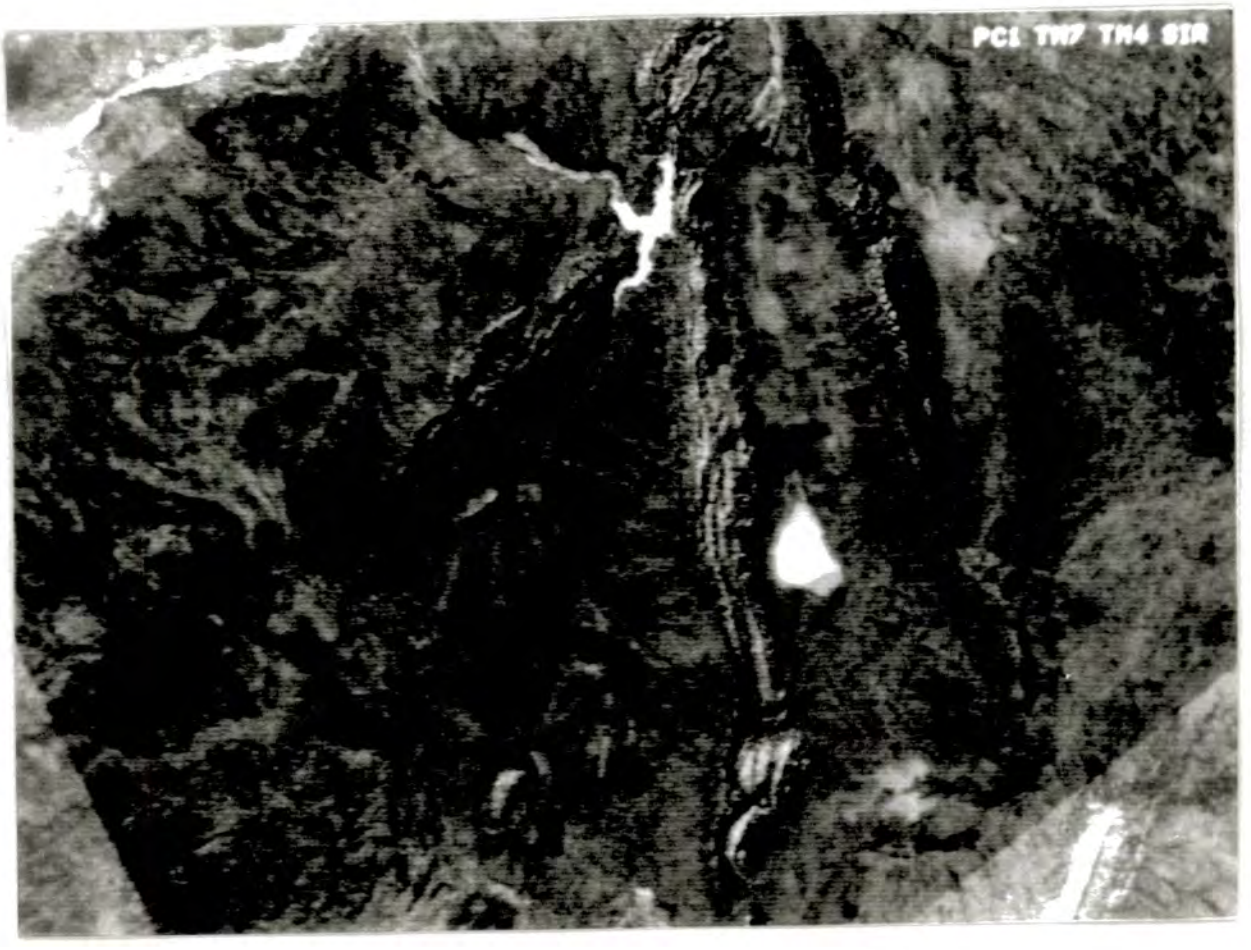

Plate 5.41 First Principal Component of combined TM bands 7 and 4 - SIR-A image. The image is dominated by relief and hydrological information.

Plate 5.42 Second Principal Component of the combined TM bands 7 and 4 - SIR-A image. The component contains information relating to soil and vegetation conditions. (Note: the photographic process has reduced the clarity of the screen image).

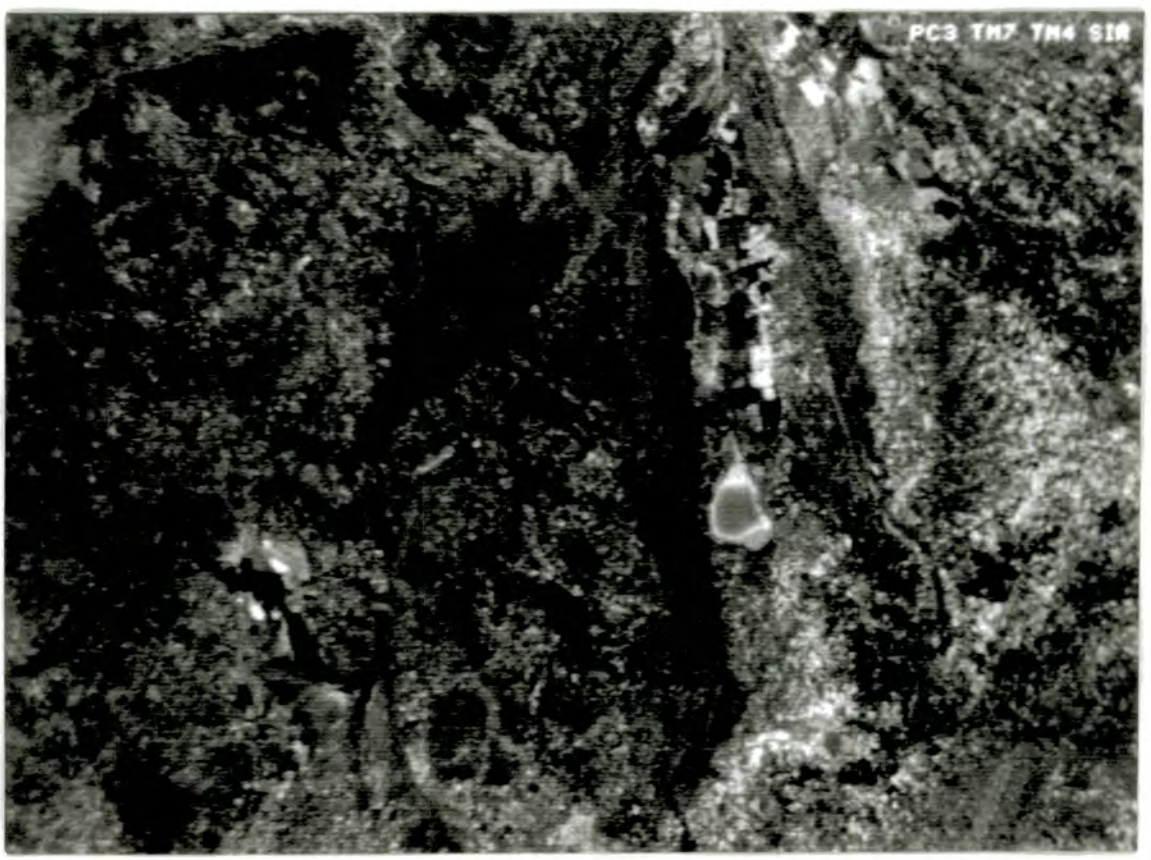

Plate 5.43 Third Principal Component of the combined TM bands 7 and 4 - SIR-A image. The image includes information on soil moisture and vegetation.

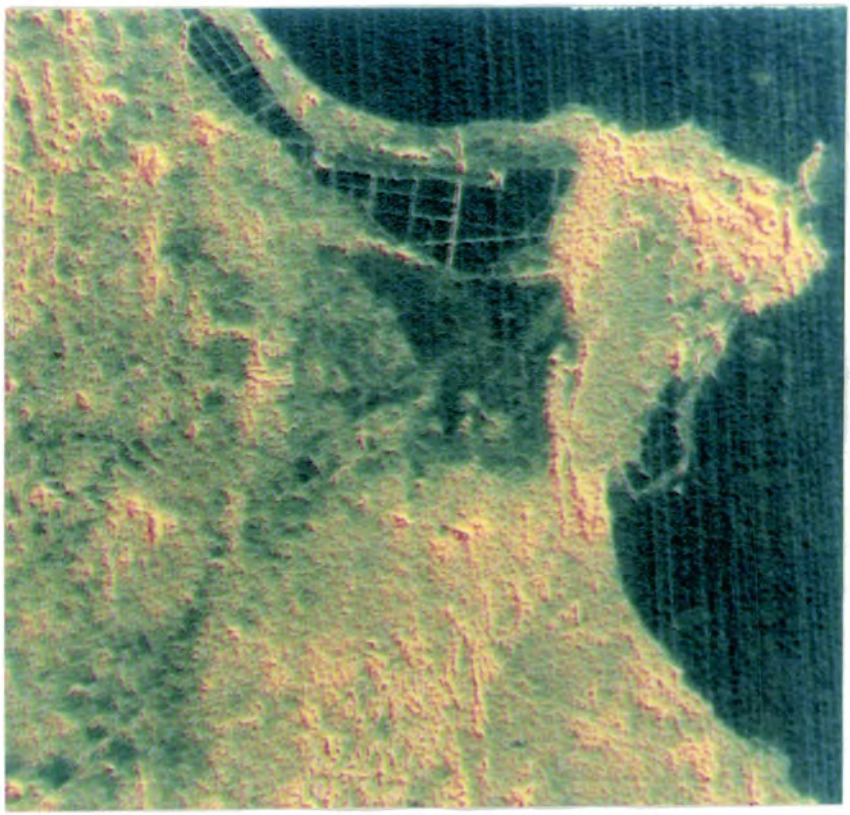

Plate 5.44 Filtered subscene Seasat image of Monastir. Relief information dominates this image, with north-south features preferentially enhanced.

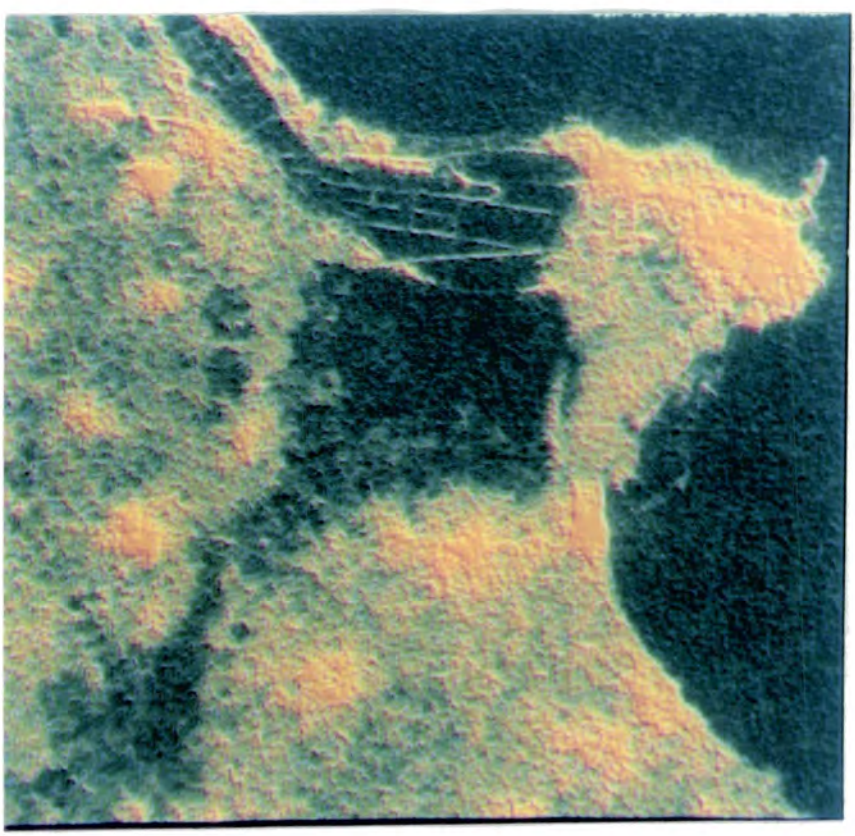

Plate 5.45 Filtered subscene SIR-A image of Monastir. Cultural and textual information dominates this image. East-West linear features have been preferentially enhanced by the SIR-A look direction.

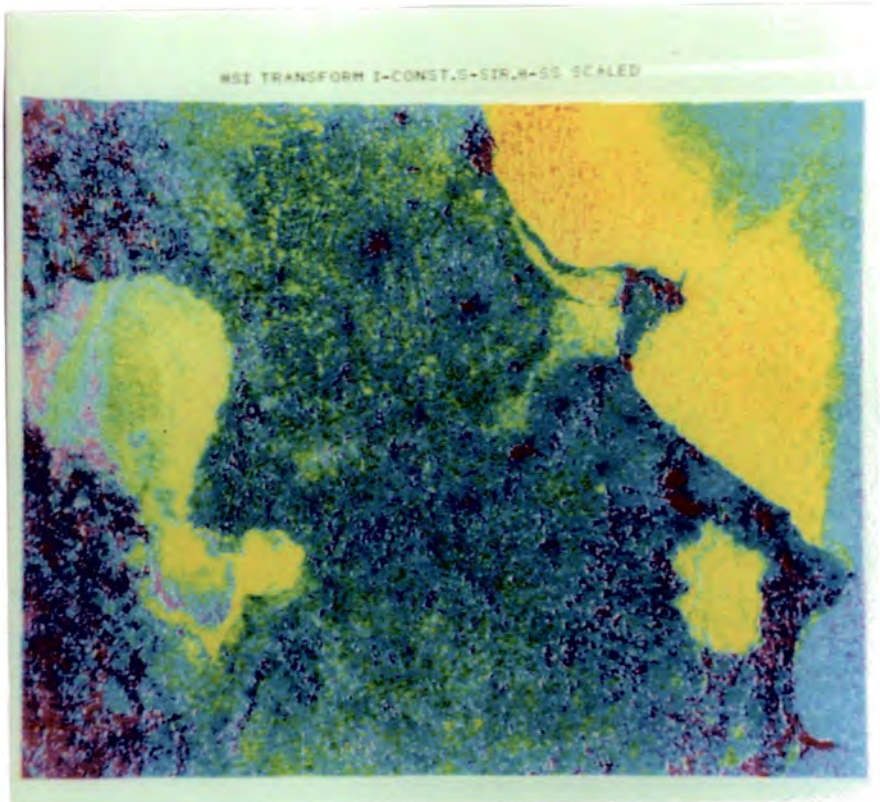

Plate 5.46 HSI transform image, with intensity held constant, saturation determined by SIR-A and hue determined by Seasat. The image is particularly useful for discriminating areas of low radar backscatter within hydrological features.

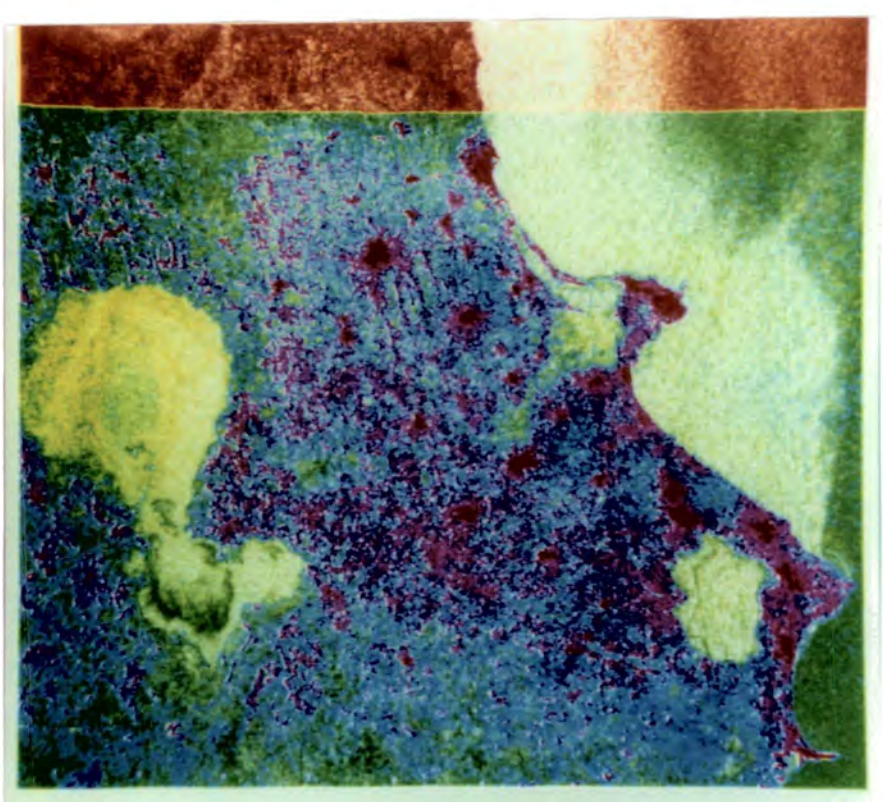

Plate 5.47 HSI transform image with intensity held constant, saturation determined by Seasat and hue determined by SIR-A. The image is particularly useful for the discrimination of cultural features and surface roughness information.

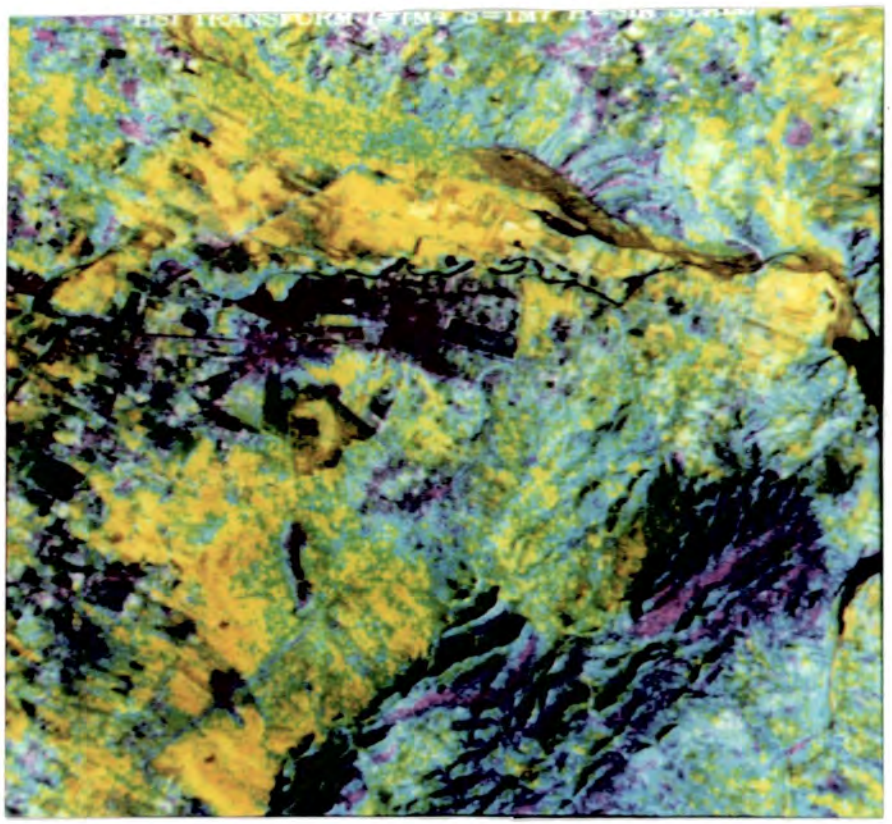

Plate 5.48 HSI transform image of Hadjeb el Ayoun, with intensity determined by TM band 4, saturation by TM band 7 and hue by SIR-A. In this, and the following three subscenes, the transformation produces a dramatic representation of relief, which stands out clearly from the surrounding areas.

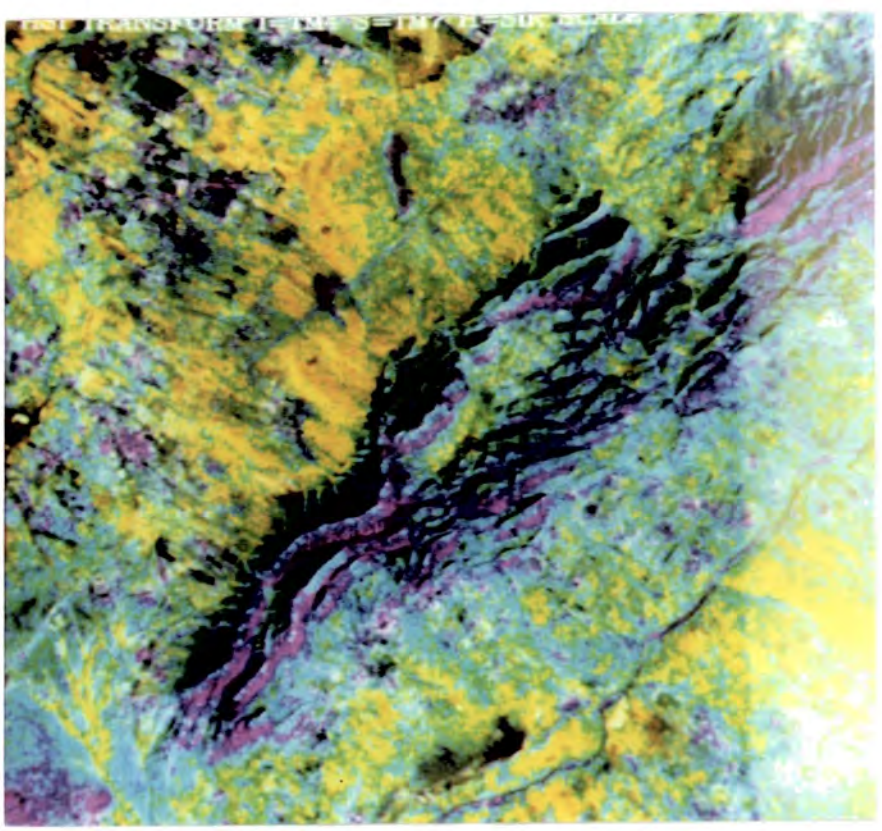

Plate 5.49 HSI transform image of Djebel Henndi, with intensity determined by TM band 4, saturation by TM band 7 and hue by SIR-A.

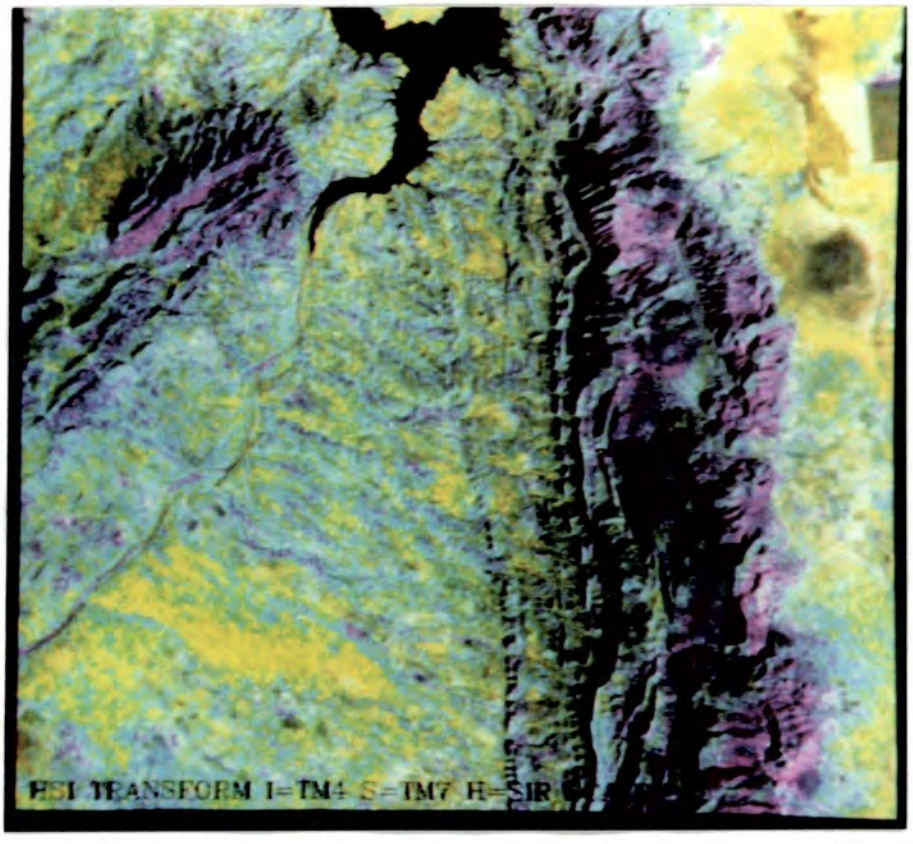

Plate 5.50 HSI transform image of the Hadjel Valley and Djebel Nara, with intensity determined by TM band 4, saturation by TM band 7 and hue be SIR-A. The bare soils of the Hadjel Valley are easily distinguished from the surrounding vegetated or eroded areas by their yellow colouration.

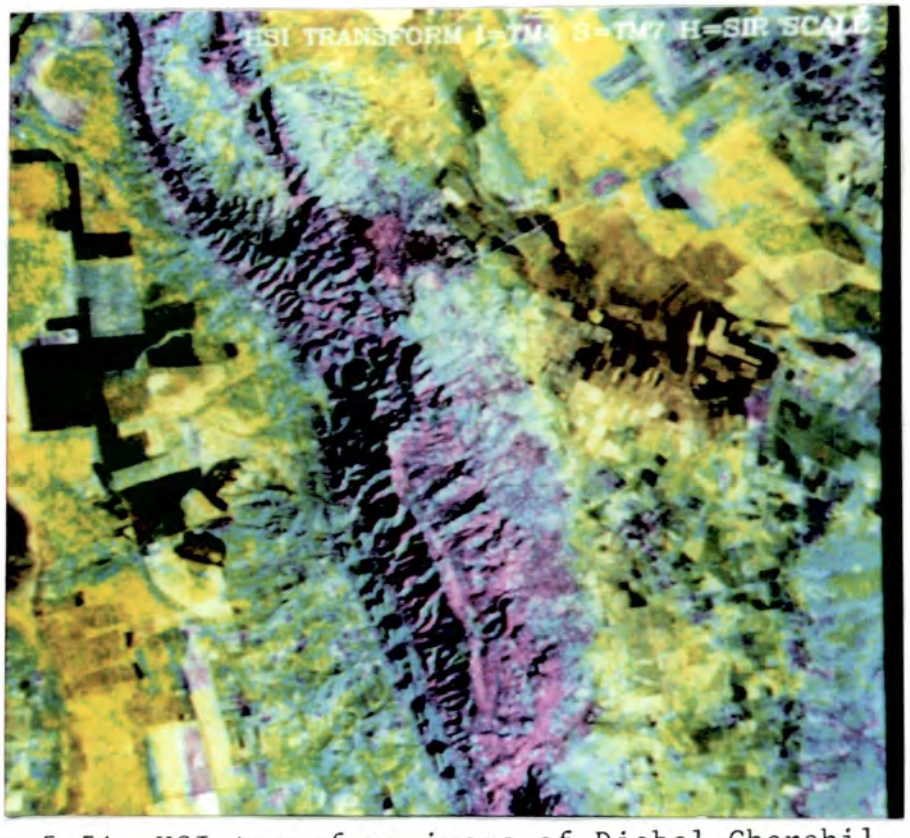

Plate 5.51 HSI transform image of Djebel Cherahil, with intensity determined by TM band 4, saturation by TM band 7 and hue by SIR-A. The intensity of colouration in the lowlands surrounding the djebel are determined by variation in soil, moisture and vegetation.

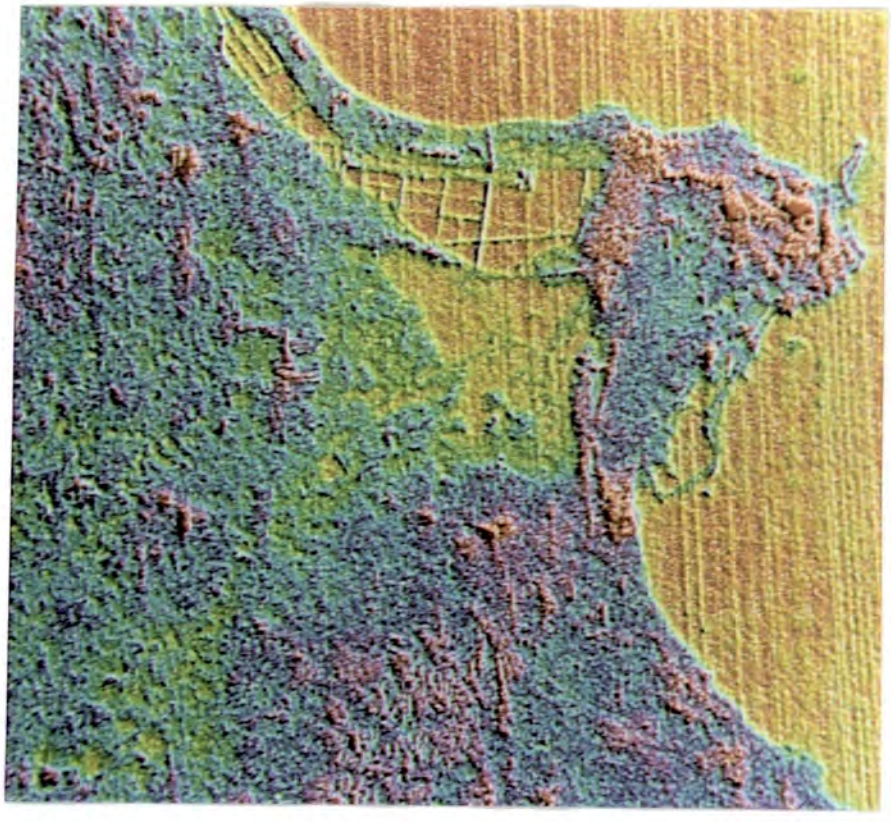

Plate 5.52 HSI transform of the Seasat image of Monastir, with hue determined by the low-pass filter, saturation by the high-pass filter and intensity by the directional filter. Relief information has much greater clarity than on the simple filtered combination (see Plate 5.44).

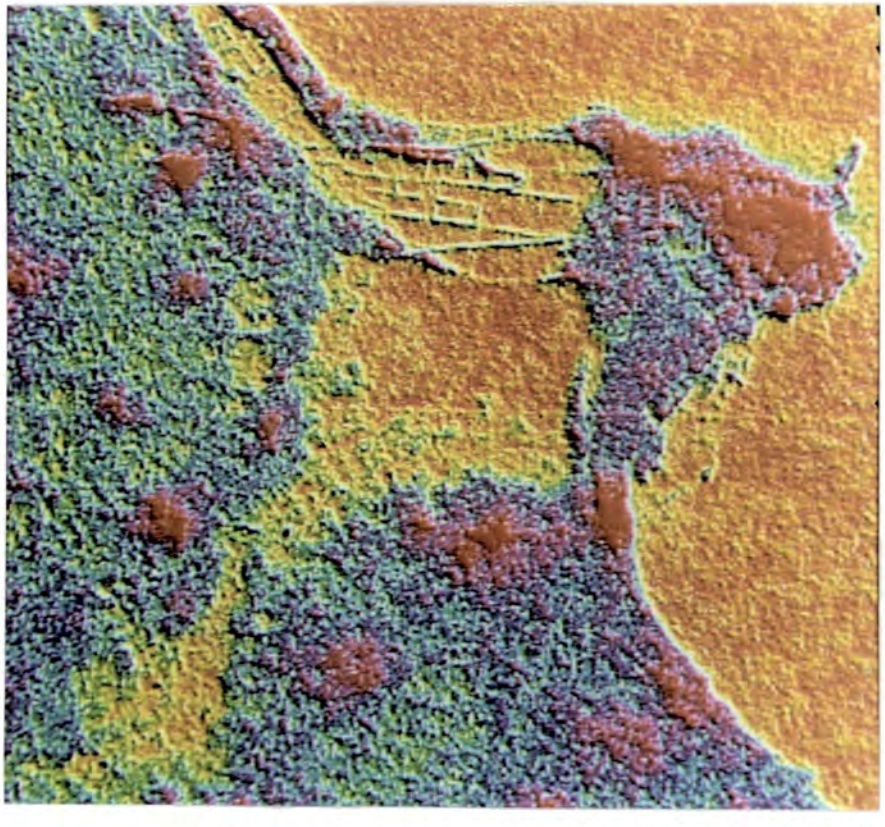

Plate 5.53 HSI transform of the SIR-A image of Monastir, with hue determined by the low-pass filter saturation by the high-pass filter and intensity by the directional filter. The appearance of textural information and cultural features is much improved over the simple filtered product (see Plate 5.45).

Plate 5.54 HSI transform of filtered SIR-A image of Djebel Henndi. Hue is determined by the low-pass filter, saturation by the high pass filter and intensity by the directional filter. The image is particularly useful for the identification of linear features and relief form.

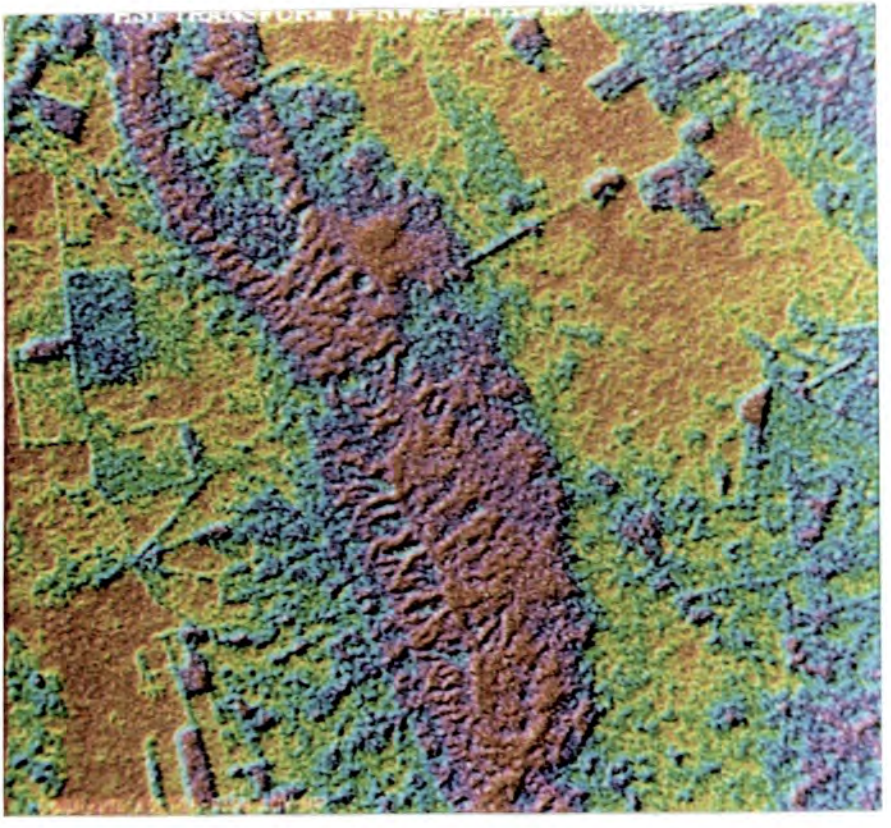

Plate 5.55 HSI transform of the filtered SIR-A image of Djebel Cherahil. Hue is determined by the low-pass filter, saturation by the high-pass filter and intensity by the directional filter. The image is valuable for revealing textural information and linear features.

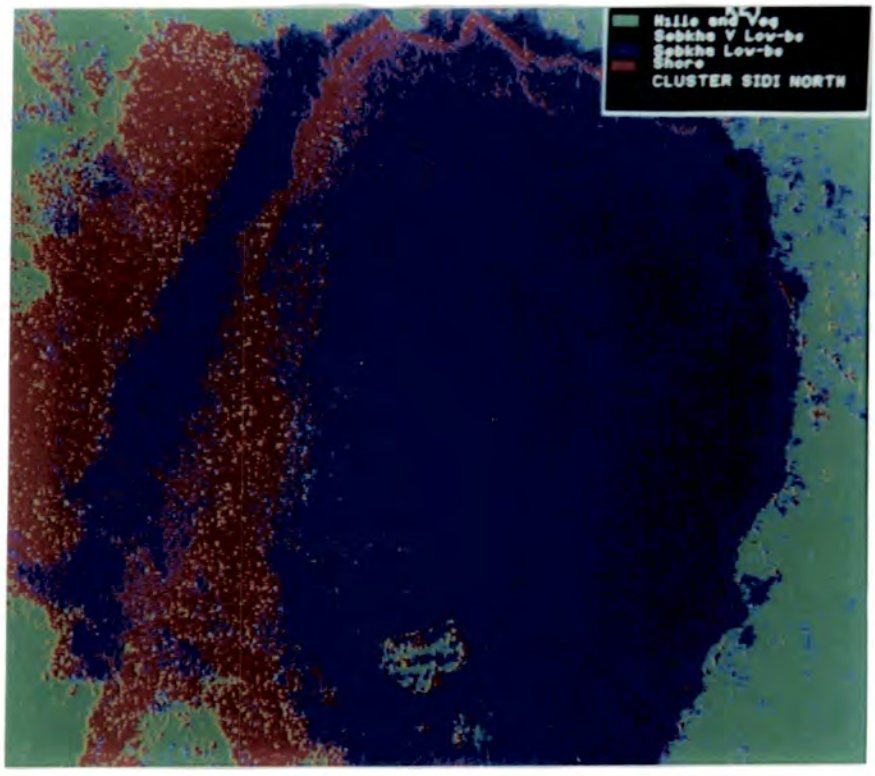

Plate 5.56 Cluster Analysis of northern part of Sebkha Sidi el Hani. The classification procedure produces a clear separation between the sebkha and the surrounding area.

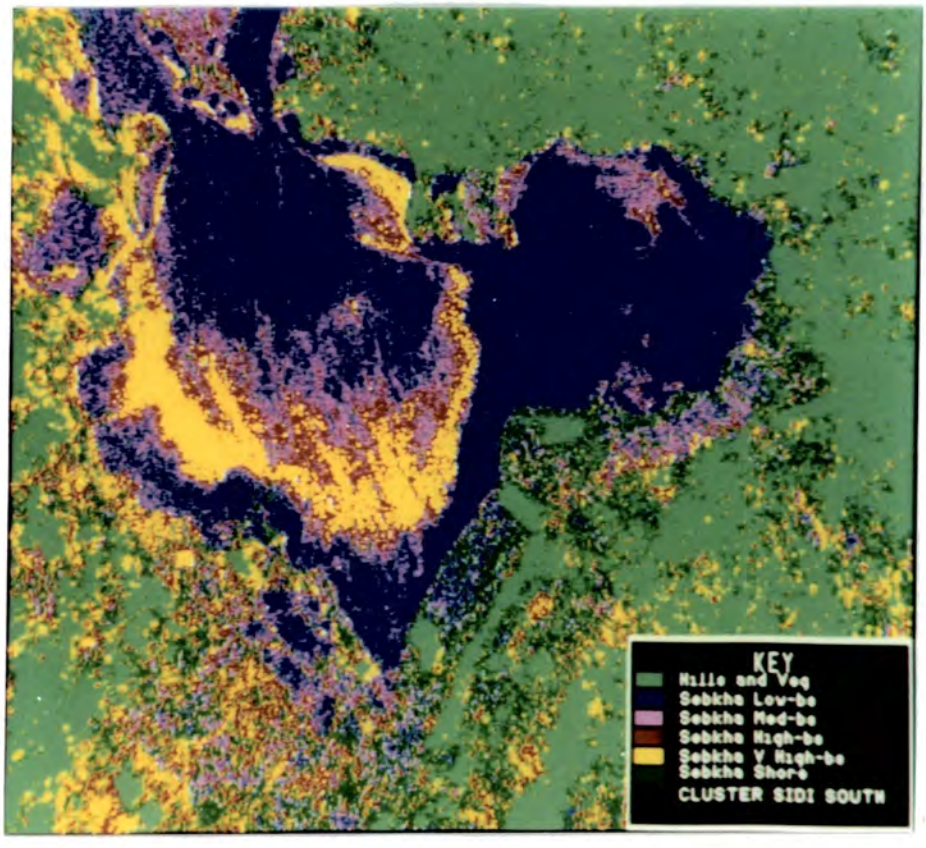

Plate 5.57 Cluster Analysis of southern part of sebkha Sidi el Hani. The analysis has differentiated between areas with different radar backscatter roughness characteristics.

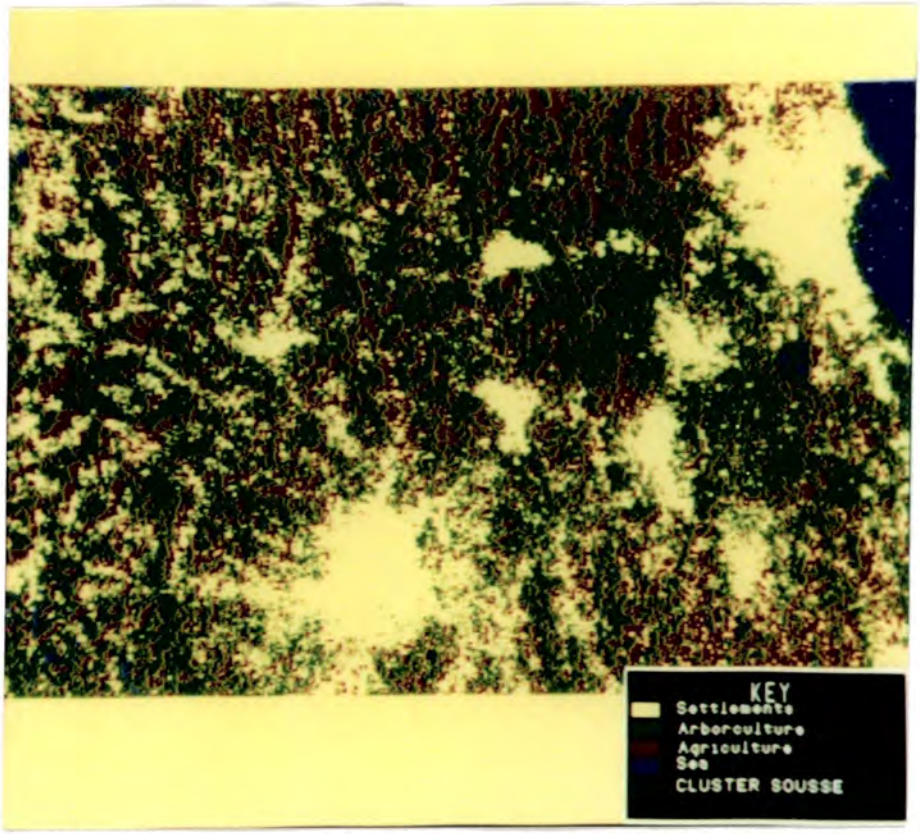

Plate 5.58 Cluster Analysis of the environs of Sousse. The analysis reveals a certain amount of confusion between settlements, hill country and vegetated areas.

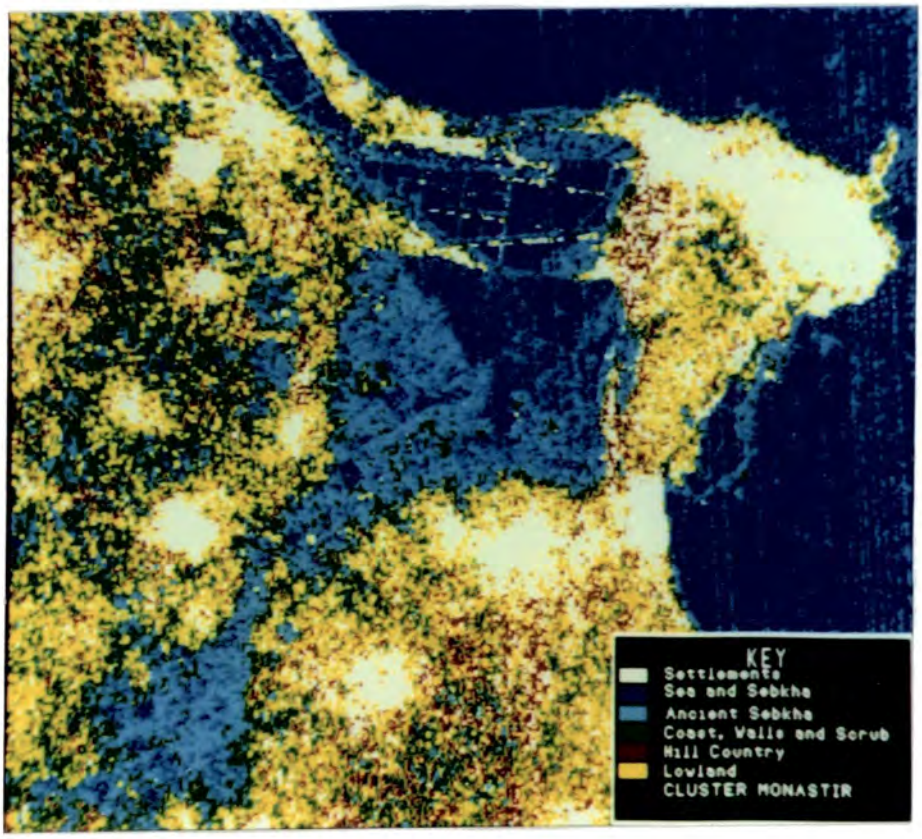

Plate 5.59 Cluster Analysis of the ancient sebkha at Monastir. Roughness and cultural information are classified most clearly.

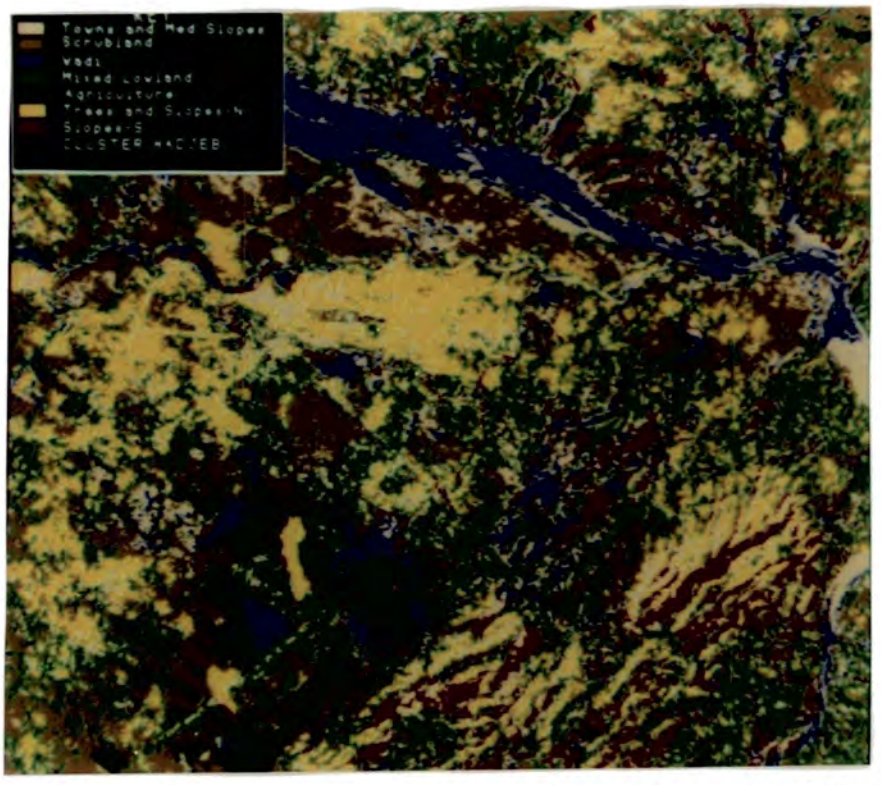

Plate 5.60 Cluster Analysis of combined TM/SIR-A product of Hadjeb el Ayoun. Hydrological and cultural features are particularly well-classified.

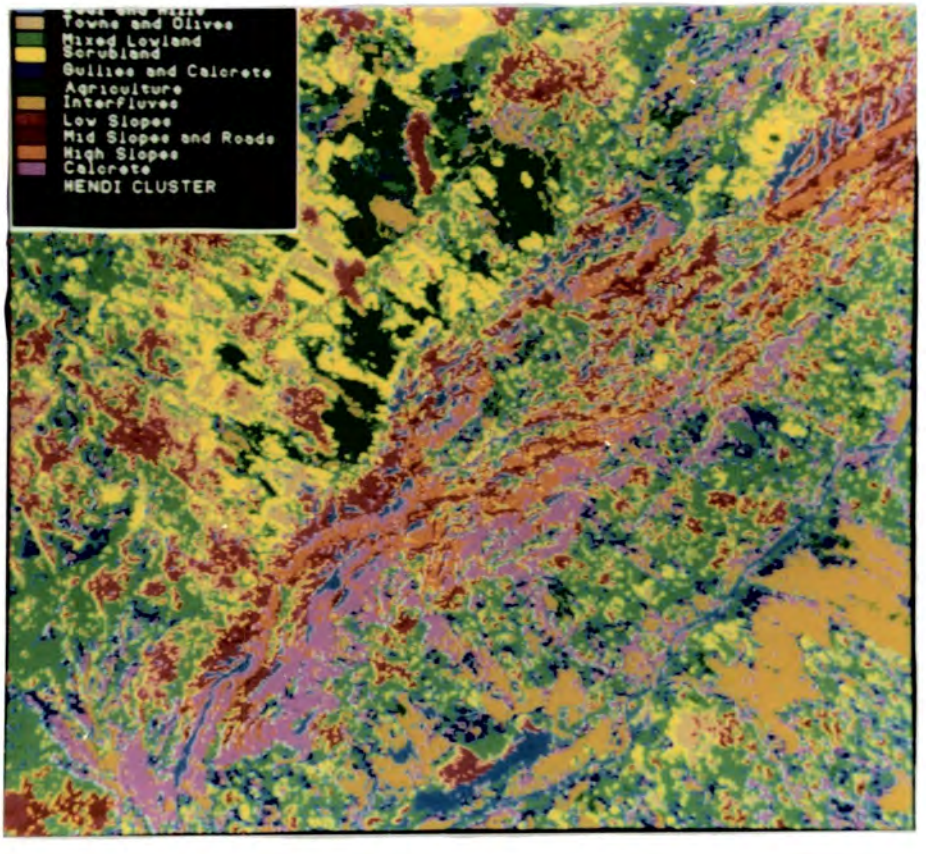

Plate 5.61 Cluster Analysis of combined TM/SIR-A product of Djebel Henndi. Variations in slope angle and areas of exposed sand on gully interfluves are well-classified.

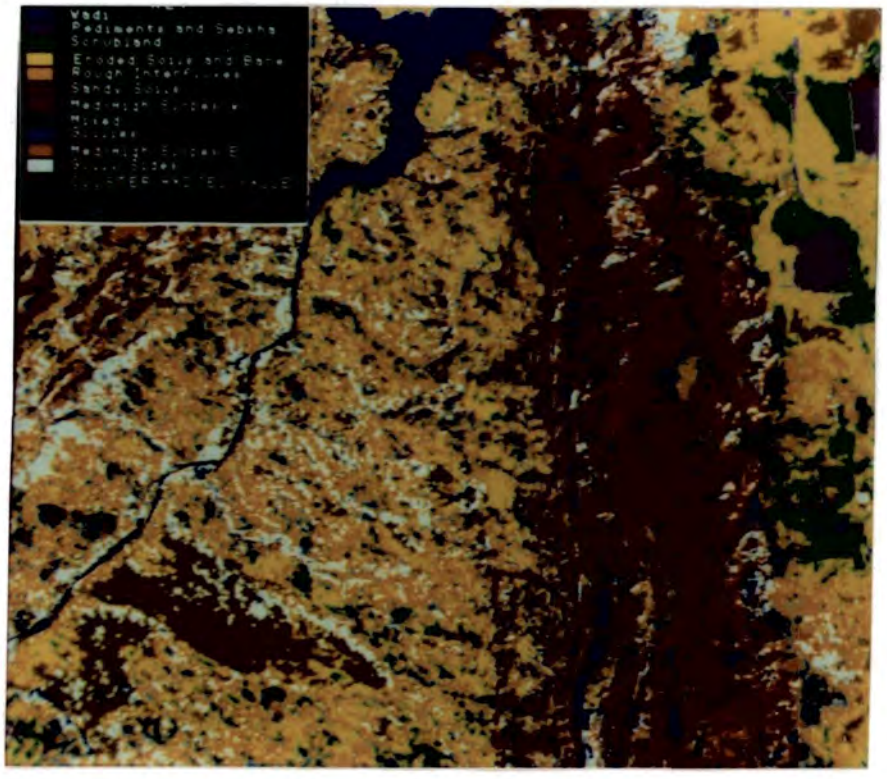

Plate 5.62 Cluster Analysis of combined TM/SIR-A product of the Hadjeb Valley and Djebel Nara. Wadi and gully features in the valley have been correctly classified.

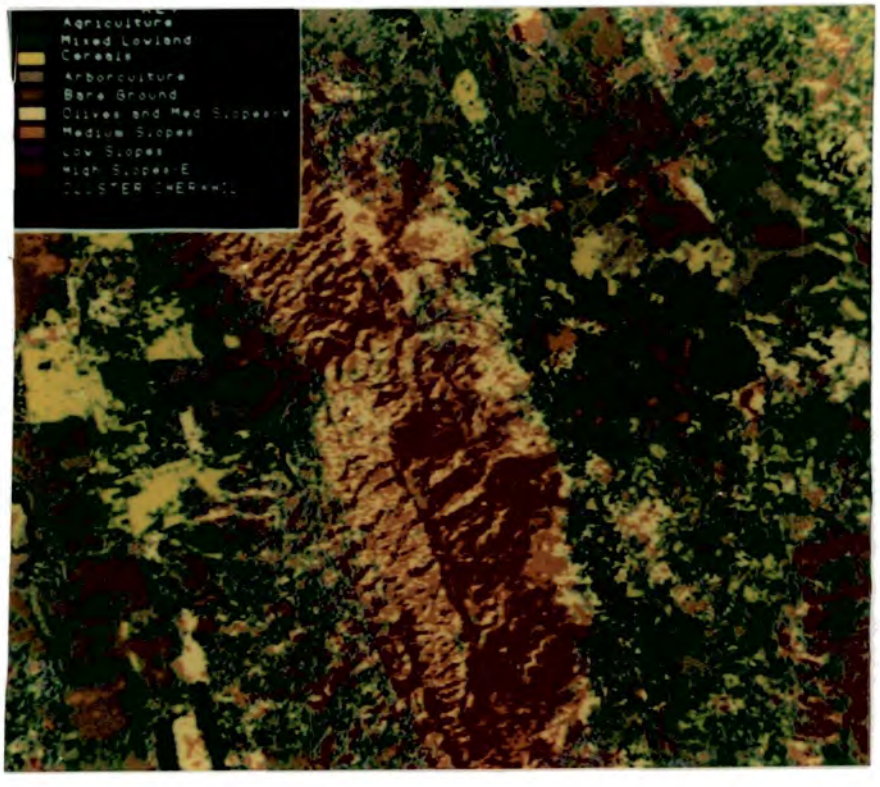

Plate 5.63 Cluster Analysis of combined TM/SIR-A product of Djebel Cherahil. The classification has produced a useful separation of relief and agricultural information.

Plate 6.1 Surface conditions of Sebkha Sidi el Hani towards the end of the southern transect. Underneath the surface layer of salt crystalization there is evidence of gleying in the soil. At this point, the water table was just beneath the sebkha surface.

Plate 6.2 The southern shore of Sebkha Sidi el Hani. Halophytic vegetation grades into Eucalyptus woodland beyond the sebkha margin. The raised ground of the lunette dune can just be seen in the distance.

Plate 6.3 View across part of the surface of the ancient sebkha at Monastir, showing the clumps of halophytic vegetation and the streams.

Plate 6.4 Measurement of vegetation size and spacing in the field.

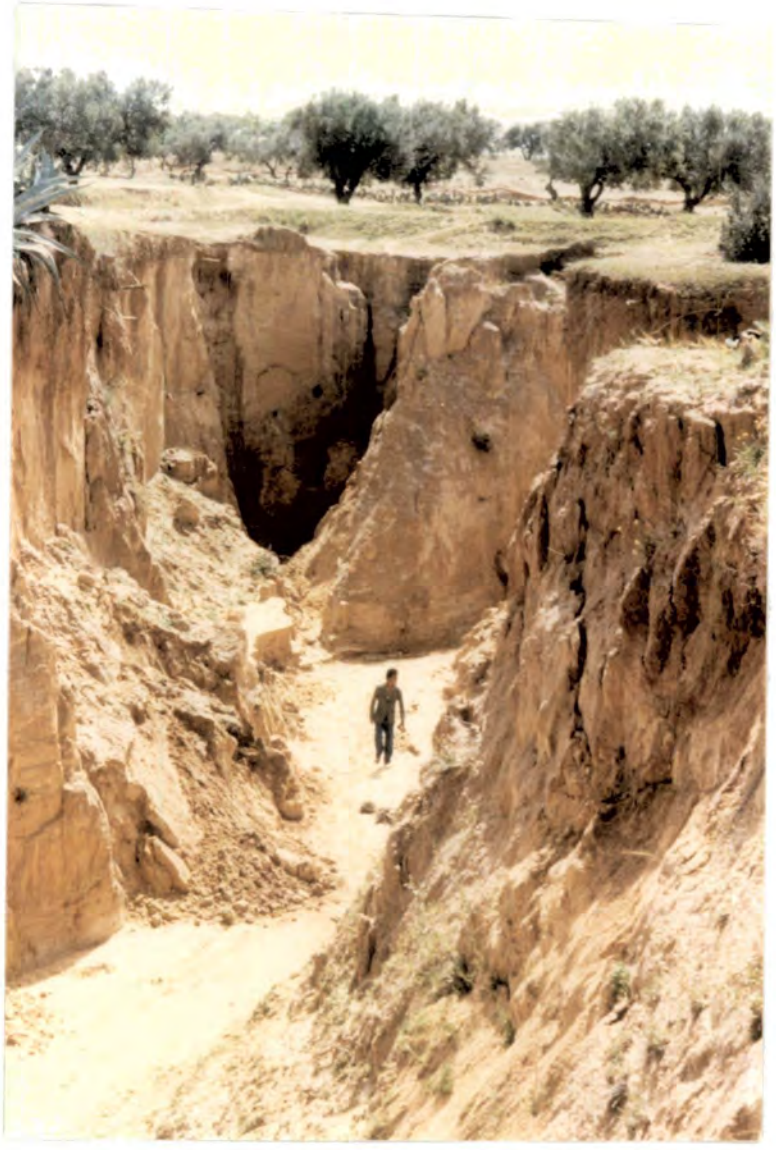

Plate 6.5 Headwall of gully located in hill country to the south of Sebkha Sidi el Hani.

Plate 6.6 Measurement of gully width in the field.

Plate 6.7 Gully selected for detailed study in the Hadjel Valley. This gully is typical of many of the tributaries of L'Oued et Hadjel.

Plate 6.8 Typical form of wadi in southern part of the Hadjel Valley.

Plate 6.9 View north-east along L'Oued el Hadjel from the point at which the road from Hadjeb el Ayoun crosses the feature.

Plate 6.10 View eastwards across Oued Zeroud along the line of the main road to Kairouan.

Plate 6.11 Conductivity meter used for the measurement of specific conductivity of samples collected in the field.

Plate 6.12 Particle Size Analysis of soil samples collected in the field.

Plate 6.13 High salt content of sample 22.

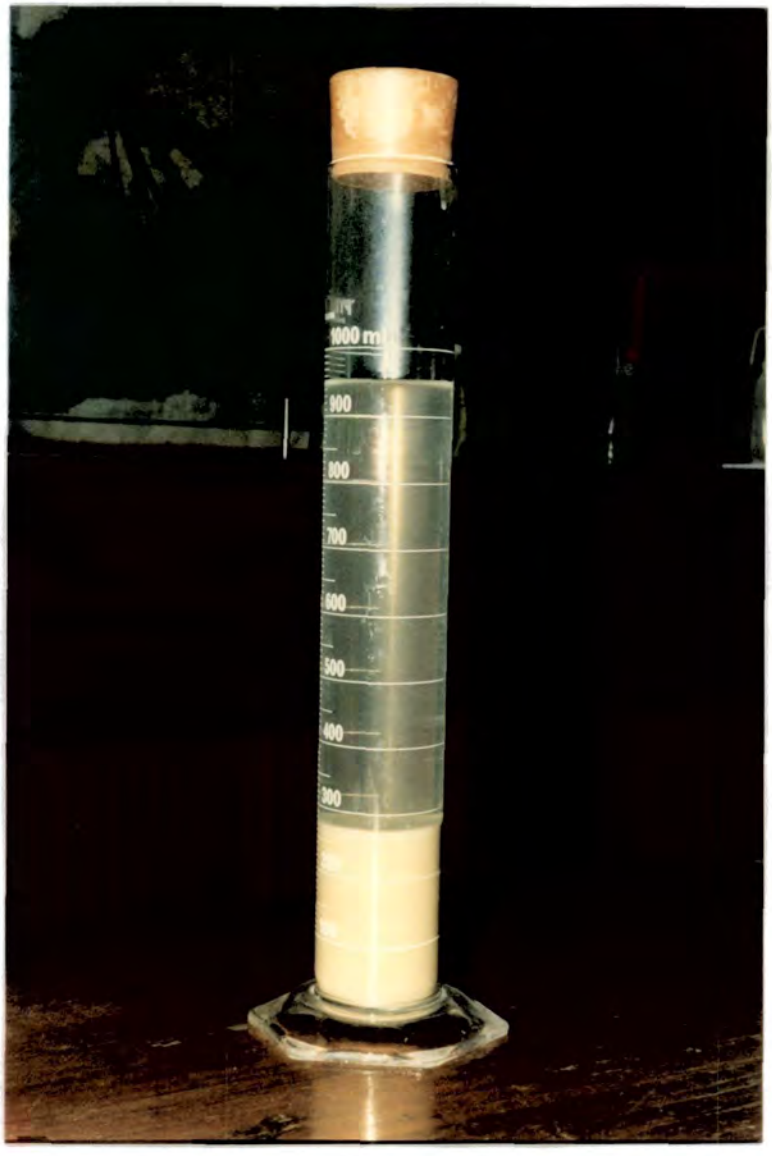

Plate 6.14 The high salt content and flocculation of particles in sample 22 prevented the measurement of soil particle size by the hydrometer method.

Plate 6.15 Microscale variations in surface roughness superimposed upon the macroscale relief profile of Djebel Henndi. Loose boulders, bushes and clumps of alfa grass will lead to a considerable increase in radar backscatter from these slopes.

Plate 7.1 Eastern facing steep slopes act as corner reflectors, sending most of the incoming SIR-A signal directly back to the sensor.

Plate 7.2 The southerly slopes of Djebel Henndi. The high and medium slope angles generate high levels of radar backscatter due to local incidence angle considerations.

Appendix 1. Field and Image Data For 44 Cases in The Eastern Study Area.

Each case is represented by four lines of data listed in the following form:

Line 1. Soil sample number or position code; Seasat DN; SIR-A DN; Slope angle (degrees); Aspect (degrees); Roughness (mean height in cm); Roughness category;

Line 2. Conductivity; % sand; % silt; % clay; Texture category; % oven-dried moisture content; % organic matter;

Line 3. Tree spacing (m); Tree height (m); Tree canopy diameter (m); Low-level vegetation spacing (m); Low-level vegetation height (m); Low-level vegetation canopy diameter (m); Vegetation category;

Line 4. Vegetation orientation (degrees); Apparent SIR-A local incidence angle (degrees); Apparent Seasat local incidence angle (degrees); Apparent SIR-A/ vegetation orientation (degrees); Apparent Seasat/vegetation orientation (degrees).

-1. = Missing data or data not appropriate for inclusion in statistical analysis.

01 1	12	167	172	03.50	270	36.00	5.0
01 2	00285.0	77.53	10.12	12.35	4	01.20	00.07
01 3	00.00	00.00	00.00	00.00	00.00	00.00	0
01 4	000	041.62	070.25	-1.	-1.		
02 1	27	081	113	00.00	000	18.00	4.0
02 2	06250.0	78.54	04.25	17.21	4	01.21	01.11
02 3	00.00	00.00	00.00	03.00	00.30	-1.	2
02 4	-1.	043.00	067.00	-1.	-1.		
03 1	28	064	173	00.00	000	18.00	4.0
03 2	34500.0	93.49	01.62	04.88	6	01.63	01.32
03 3	00.00	00.00	00.00	00.00	00.00	00.00	0
03 4	000	043.00	067.00	-1.	-1.		
04 1	29	055	128	00.00	000	00.50	2.0
04 2	41000.0	93.08	01.63	05.28	6	01.63	01.22
04 3	00.00	00.00	00.00	00.00	00.00	00.00	0
04 4	000	043.00	067.00	-1.	-1.		
05 1	30	046	109	00.00	000	00.50	2.0
05 2	44500.0	69.30	10.23	20.47	4	03.09	02.68
05 3	00.00	00.00	00.00	00.00	00.00	00.00	0
05 4	000	043.00	067.00	-1.	-1.		
06 1	31	043	108	00.00	000	00.50	2.0
06 2	47000.0	68.80	20.50	10.69	4	02.56	02.05
06 3	00.00	00.00	00.00	00.00	00.00	00.00	0
06 4	000	043.00	067.00	-1.	-1.		
07 1	32	048	100	00.00	000	00.50	2.0
07 2	64000.0	68.34	05.64	26.02	3	07.76	04.73
07 3	00.00	00.00	00.00	00.00	00.00	00.00	0
07 4	000	043.00	067.00	-1.	-1.		
08 1	33	046	097	00.00	000	00.50	2.0
08 2	66000.0	18.66	12.57	68.76	1	08.69	04.89
08 3	00.00	00.00	00.00	00.00	00.00	00.00	0
08 4	000	043.00	067.00	-1.	-1.		
09 1	34	037	095	00.00	000	00.00	1.0
09 2	63200.0	21.81	06.59	71.60	1	07.53	06.95
09 3	00.00	00.00	00.00	00.00	00.00	00.00	0
09 4	000	043.00	067.00	-1.	-1.		
10 1	35	032	098	00.00	000	00.00	1.0
10 2	76250.0	83.72	06.70	09.58	5	08.23	05.27
10 3	00.00	00.00	00.00	00.00	00.00	00.00	0
10 4	000	043.00	067.00	-1.	-1.		

11 1	36	028	106	00.00	000	00.00	1.0
11 2	76250.0	13.80	13.19	73.01	1	07.53	04.82
11 3	00.00	00.00	00.00	00.00	00.00	00.00	0
11 4	000	043.00	067.00	-1.	-1.		
12 1	13	062	105	00.00	000	03.60	3.0
12 2	00452.0	30.62	24.51	44.87	1	03.73	03.32
12 3	00.00	00.00	00.00	00.00	00.00	00.00	0
12 4	000	043.00	067.00	-1.	-1.		
13 1	14	070	142	00.00	000	30.00	5.0
13 2	04200.0	67.57	16.33	26.10	3	01.94	01.22
13 3	00.00	00.00	00.00	00.00	00.00	00.00	0
13 4	000	043.00	067.00	-1.	-1.		
14 1	15	061	077	00.00	000	05.50	3.0
14 2	51000.0	60.59	13.96	25.45	3	02.57	02.26
14 3	00.00	00.00	00.00	00.00	00.00	00.00	0
14 4	000	043.00	067.00	-1.	-1.		
15 1	16	059	074	00.00	000	00.60	2.0
15 2	58200.0	75.49	21.50	03.01	5	00.42	02.29
15 3	00.00	00.00	00.00	00.00	00.00	00.00	0
15 4	000	043.00	067.00	-1.	-1.		
16 1	17	054	072	00.00	000	00.00	1.0
16 2	58500.0	42.74	25.30	31.96	2	04.93	02.41
16 3	00.00	00.00	00.00	00.00	00.00	00.00	0
16 4	000	043.00	067.00	-1.	-1.		
17 1	18	055	083	00.00	000	00.00	1.0
17 2	65500.0	28.64	16.68	54.68	1	06.84	03.52
17 3	00.00	00.00	00.00	00.00	00.00	00.00	0
17 4	000	043.00	067.00	-1.	-1.		
18 1	19	058	121	00.00	000	01.40	3.0
18 2	40000.0	27.68	14.07	58.24	1	07.41	03.01
18 3	00.00	00.00	00.00	00.00	00.00	00.00	0
18 4	000	043.00	067.00	-1.	-1.		
19 1	20	060	158	00.00	000	02.00	3.0
19 2	91000.0	24.71	13.73	61.55	1	07.76	03.34
19 3	00.00	00.00	00.00	00.00	00.00	00.00	0
19 4	000	043.00	067.00	-1.	-1.		
20 1	21	065	107	00.00	000	01.20	2.5
20 2	23675.0	-1.	-1.	-1.	0	06.30	00.02
20 3	00.00	00.00	00.00	00.00	00.00	00.00	0
20 4	000	043.00	067.00	-1	-1		

21 1	06	068	111	00.00	000	00.50	2.0
21 2	00740.0	64.45	16.55	18.99	4	02.10	00.08
21 3	00.00	00.00	00.00	00.00	00.60	00.00	1
21 4	-1.	043.00	067.00	-1.	-1.		
22 1	07	058	083	00.00	000	03.50	3.0
22 2	03625.0	51.30	24.56	24.14	3	03.90	00.06
22 3	00.00	00.00	00.00	02.00	00.20	00.70	2
22 4	-1.	043.00	067.00	-1.	-1.		
23 1	08	066	128	00.00	000	03.50	3.0
23 2	02760.0	18.07	25.91	56.02	1	05.04	00.13
23 3	00.00	00.00	00.00	00.00	00.00	00.00	0
23 4	000	043.00	067.00	-1.	-1.		
24 1	09	072	131	02.00	135	05.60	3.0
24 2	27750.0	52.45	28.95	18.60	4	03.52	00.15
24 3	12.90	03.40	03.96	00.00	00.00	00.00	5
24 4	090	044.88	066.23	065	060		
25 1	10	060	083	00.00	000	03.50	3.0
25 2	02875.0	19.87	30.88	49.25	1	04.17	00.17
25 3	00.00	00.00	00.00	-1.	-1.	-1.	2
25 4	-1.	043.00	067.00	-1.	-1.		
26 1	23	133	200	50.00	335	07.00	3.5
26 2	01150.0	91.19	01.43	07.38	6	02.40	00.03
26 3	-1.	-1.	-1.	00.00	00.00	00.00	5
26 4	-1.	006.99	077.63	-1.	-1.		
27 1	24	156	176	02.00	335	18.00	4.0
27 2	00900.0	83.51	03.05	13.44	5	01.80	00.01
27 3	08.70	04.00	05.83	00.00	00.00	00.00	5
27 4	-1.	040.99	067.12	-1.	-1.		
28 1	25	164	196	58.00	330	18.00	4.0
28 2	00755.0	90.62	00.00	09.38	5	01.90	00.03
28 3	05.00	04.00	03.50	00.00	00.00	00.00	5
28 4	-1.	015.48	084.35	-1.	-1.		
29 1	26	131	183	52.00	330	18.00	4.0
29 2	00550.0	96.76	00.59	02.65	6	01.30	00.00
29 3	00.00	00.00	00.00	00.00	00.00	00.00	0
29 4	-1.	009.72	081.97	-1.	-1.		
30 1	FIELD23	093	126	00.00	000	20.00	4.0
30 2	-1.	-1.	-1.	-1.	0	-1.	-1.
30 3	07.88	03.00	02.50	00.00	00.00	00.00	5
30 4	-1.	043.00	067.00	-1.	-1.		

31 1	LIN1	154	161	03.00	270	18.00	4.0
31 2	-1.	-1.	-1.	-1.	0	-1.	-1.
31 3	06.55	03.00	04.50	00.00	00.00	00.00	5
31 4	-1.	041.80	069.78	-1.	-1.		
32 1	22	146	191	03.00	090	18.00	4.0
32 2	01445.0	-1.	-1.	-1.	0	10.30	00.12
32 3	08.60	03.00	02.78	00.00	00.00	00.00	4
32 4	-1.	044.33	064.22	-1.	-1.		
33 1	LUN3	170	195	03.00	270	32.00	5.0
33 2	-1.	-1.	-1.	-1.	0	-1.	-1.
33 3	09.88	03.00	04.60	00.00	00.00	00.00	4
33 4	-1.	041.80	069.78	-1	-1.		
34 1	LUN4	166	183	03.00	270	07.00	3.5
34 2	-1.	-1.	-1.	-1.	0	-1.	-1.
34 3	11.88	03.00	05.30	03.18	00.50	-1.	3
34 4	-1.	041.80	069.78	-1.	-1.		
35 1	EUCAL	117	131	04.00	280	30.00	5.0
35 2	-1.	-1.	-1.	-1.	0	-1.	-1.
35 3	02.00	08.00	04.50	00.00	00.00	00.00	6
35 4	090	040.81	070.41	065	060		
36 1	SEBDEK	133	131	00.00	000	09.00	4.0
36 2	-1.	-1.	-1.	-1.	0	-1.	-1.
36 3	11.58	03.50	04.50	00.00	00.00	00.00	5
36 4	110	043.00	067.00	045	040		
37 1	NWKERK	124	124	00.00	000	15.00	4.0
37 2	-1.	-1.	-1.	-1.	0	-1.	-1.
37 3	13.61	03.50	03.23	00.00	00.00	00.00	5
37 4	170	043.00	067.00	015	005		
38 1	11	109	121	02.00	090	07.00	3.5
38 2	00240.0	81.58	07.08	11.34	5	01.20	00.10
38 3	21.05	04.00	04.24	00.00	00.00	00.00	5
38 4	045	043.87	065.15	110	105		
39 1	EKERK	111	116	00.00	000	03.50	3.0
39 2	-1.	-1.	-1.	-1.	0	-1.	-1.
39 3	10.00	04.00	05.00	-1.	00.60	-1.	3
39 4	090	043.00	067.00	065	060		
40 1	NBOUMERD	119	119	02.00	090	03.50	3.0
40 2	-1.	-1.	-1.	-1	0	-1.	-1.
40 3	20.00	03.50	03.50	00.00	00.00	00.00	5
40 4	110	043.87	065.15	045	040		

41 1	NEBOUMERD	107	126	-1.	-1.	03.50	3.0
41 2	-1.	-1.	-1.	-1.	0	-1.	-1.
41 3	07.05	03.00	05.50	00.00	00.00	00.00	5
41 4	290	-1.	-1.	045	040		
42 1	WOUERD	145	140	02.00	-1.	08.00	4.0
42 2	-1.	-1.	-1.	-1.	0	-1.	-1.
42 3	10.98	03.50	04.01	00.00	00.00	00.00	5
42 4	135	-1.	-1.	020	015		
43 1	EJEMMEL	127	152	-1.	-1.	07.00	3.5
43 2	-1.	-1.	-1.	-1.	0	-1.	-1.
43 3	08.88	04.50	04.15	00.00	00.00	00.00	5
43 4	135	-1.	-1.	020	015		
44 1	SIDI	097	133	00.00	000	08.00	4.0
44 2	-1.	-1.	-1.	-1.	0	-1.	-1.
44 3	12.00	03.00	03.50	00.00	00.00	00.00	5
44 4	135	043.00	067.00	020	015		

Appendix 2. Field and Image Data for 60 Cases in the Western Study Area.

Each case is represented by five lines of data listed in the following form:

Line 1. Soil sample number or position code; SIR-A DN; TM-1 DN; TM-2 DN; TM-3 DN; TM-4 DN; TM-5 DN;

Line 2. TM-6 DN; TM-7 DN; Slope angle (degrees); Aspect (degrees); Roughness (mean height in cm); Roughness category;

Line 3. Conductivity; % sand; % silt; % clay; Texture category; % oven-dried moisture content; % organic matter;

Line 4. Vegetation spacing (m); Vegetation height (m); Vegetation canopy diameter (m); Vegetation category; Vegetation row orientation (degrees); Wadi orientation (degrees); Wadi width (m);

Line 5. Wadi height (m); Wadi northern-most slope angle (degrees); Wadi southern-most slope angle (degrees); Slope form category; Apparent SIR-A local incidence angle (degrees); Apparent SIR-A/ wadi orientation(degrees); Apparent SIR-A/ vegetation orientation (degrees).

-1. = Missing data or data not appropriate for inclusion in statistical analysis.

01 1	01	077	087	045	058	059	091
01 2	114	045	00.00	000	06.50	3.5	0
01 3	00140.0	58.30	26.51	15.19	4	01.21	01.47
01 4	03.00	00.25	00.80	2	000	-1.	-1.
01 5	-1.	-1.	-1.	0	043.00	-1.	-1.
02 1	NE01	000	088	048	067	075	127
02 2	109	074	00.00	000	00.80	2.0	0
02 3	-1.	-1.	-1.	-1.	0	-1.	-1.
02 4	00.00	00.00	00.00	1	000	-1.	-1.
02 5	-1.	-1.	-1.	0	043.00	-1.	-1.
03 1	02	033	077	038	052	059	098
03 2	114	058	00.00	000	00.30	1.0	0
03 3	00265.0	91.16	01.01	07.83	6	00.50	00.00
03 4	00.00	00.00	00.00	0	000	-1.	-1.
03 5	-1.	-1.	-1.	0	043.00	-1.	-1.
04 1	CSEBS	048	078	039	041	019	011
04 2	091	005	00.00	000	06.50	3.5	0
04 3	-1.	-1.	-1.	-1.	0	-1.	-1.
04 4	00.00	00.00	00.00	0	000	-1.	-1.
04 5	-1.	-1.	-1.	0	043.00	-1.	-1.
05 1	NSEBS	012	082	043	054	051	024
05 2	102	007	00.00	000	00.50	2.0	0
05 3	-1.	-1.	-1.	-1.	0	-1.	-1.
05 4	00.00	00.00	00.00	0	000	-1.	-1.
05 5	-1.	-1.	-1.	0	043.00	-1.	-1.
06 1	FAN	120	082	045	062	069	120
06 2	113	068	04.00	180	18.00	4.0	0
06 3	-1.	-1.	-1.	-1.	0	-1.	-1.
06 4	00.00	00.00	00.00	0	000	-1.	-1.
06 5	-1.	-1.	-1.	2	046.60	-1.	-1.
07 1	03	230	095	053	074	078	139
07 2	105	082	03.00	180	00.50	2.0	1
07 3	-1.	97.19	01.61	01.20	6	00.20	00.00
07 4	00.00	00.00	00.00	0	000	090	170.00
07 5	15.00	50.00	80.00	0	045.76	065	-1.
08 1	04	246	085	046	063	061	073
08 2	102	035	00.00	000	00.50	2.0	1
08 3	-1.	98.20	00.60	01.20	6	00.10	00.00
08 4	00.00	00.00	00.00	0	000	090	170.00
08 5	15.00	50.00	80.00	0	043.00	065	-1.
09 1	05	255	093	051	074	083	140
09 2	108	087	50.00	180	18.00	4.0	2
09 3	-1.	92.78	00.00	07.22	6	00.30	00.00
09 4	00.00	00.00	00.00	0	000	090	170.00
09 5	15.00	50.00	80.00	2	090.00	065	-1.

10 1	1MAINGUL	218	104	062	088	087	148
10 2	102	094	00.00	000	25.00	4.0	2
10 3	-1.	-1.	-1.	-1.	0	-1.	-1.
10 4	04.00	00.30	00.50	2	000	135	050.00
10 5	10.00	65.00	65.00	0	043.00	020	-1.
11 1	NEAROUED	187	098	052	069	073	118
11 2	100	072	00.00	000	35.00	5.0	2
11 3	-1.	-1.	-1.	-1.	0	-1.	-1.
11 4	00.00	00.00	00.00	0	000	125	006.00
11 5	06.00	75.00	75.00	0	043.00	030	-1.
12 1	2MAINGUL	194	104	060	087	089	147
12 2	104	089	00.00	000	18.00	4.0	2
12 3	-1.	-1.	-1.	-1.	0	-1.	-1.
12 4	00.00	00.00	00.00	0	000	150	030.00
12 5	10.00	60.00	60.00	0	043.00	005	-1.
13 1	3MAINGUL	198	106	063	088	089	152
13 2	102	092	00.00	000	10.00	4.0	2
13 3	-1.	-1.	-1.	-1.	0	-1.	-1.
13 4	00.00	00.00	00.00	0	000	130	050.00
13 5	12.00	55.00	55.00	0	043.00	025	-1.
14 1	LGEBLOBL	237	077	037	043	064	083
14 2	106	043	00.00	000	40.00	5.0	2
14 3	-1.	-1.	-1.	-1.	0	-1.	-1.
14 4	00.00	00.00	00.00	0	000	150	400.00
14 5	10.00	55.00	55.00	0	043.00	005	-1.
15 1	4MAINGUL	194	098	056	075	081	131
15 2	106	079	00.00	000	32.00	5.0	2
15 3	-1.	-1.	-1.	-1.	0	-1.	-1.
15 4	00.00	00.00	00.00	0	000	155	040.00
15 5	20.00	60.00	60.00	0	043.00	000	-1.
16 1	5MAINGUL	170	098	055	075	082	137
16 2	103	077	00.00	000	03.50	3.0	2
16 3	-1.	-1.	-1.	-1.	0	-1.	-1.
16 4	00.00	00.00	00.00	0	000	160	020.00
16 5	08.00	45.00	45.00	0	043.00	005	-1.
17 1	BLOBNRCLF	174	095	052	069	079	121
17 2	102	074	00.00	000	35.00	5.0	2
17 3	-1.	-1.	-1.	-1.	0	-1.	-1.
17 4	02.00	00.00	01.00	2	000	155	025.00
17 5	10.00	55.00	30.00	0	043.00	000	-1.
18 1	SMGULN	178	098	053	074	076	130
18 2	104	079	00.00	000	03.50	3.0	2
18 3	-1.	-1.	-1.	-1.	0	-1.	-1.
18 4	00.00	00.00	00.00	0	000	115	060.00
18 5	10.00	40.00	40.00	0	043.00	040	-1.

19 1	ZERCHAN	013	106	060	082	081	149
19 2	107	095	00.00	000	00.50	2.0	1
19 3	-1.	-1.	-1.	-1.	0	-1.	-1.
19 4	00.00	00.00	00.00	0	000	115	804.00
19 5	10.00	75.00	75.00	0	043.00	040	-1.
20 1	ZERVEG	059	108	060	080	076	138
20 2	108	091	00.00	000	18.00	4.0	1
20 3	-1.	-1.	-1.	-1.	0	-1.	-1.
20 4	02.00	00.15	00.20	2	000	115	804.00
20 5	10.00	75.00	75.00	0	043.00	040	-1.
21 1	HATABCHAN	007	107	059	076	078	140
21 2	110	086	00.00	000	00.50	2.0	1
21 3	-1.	-1.	-1.	-1.	0	-1.	-1.
21 4	00.00	00.00	00.00	0	000	135	536.00
21 5	08.00	50.00	50.00	0	043.00	020	-1.
22 1	HATABVEG	061	103	059	079	075	136
22 2	110	086	00.00	000	40.00	5.0	1
22 3	-1.	-1.	-1.	-1.	0	-1.	-1.
22 4	01.00	00.10	00.15	2	000	135	536.00
22 5	08.00	50.00	50.00	0	043.00	020	-1.
23 1	SMGULHADS	130	098	057	074	075	131
23 2	106	080	00.00	000	10.00	4.0	2
23 3	-1.	-1.	-1.	-1.	0	-1.	-1.
23 4	00.00	00.00	00.00	0	000	160	020.00
23 5	03.50	30.00	30.00	0	043.00	005	-1.
24 1	CALCRCHAN	035	078	040	050	080	088
24 2	106	045	01.50	190	00.50	2.0	4
24 3	-1.	-1.	-1.	-1.	0	-1.	-1.
24 4	00.00	00.00	00.00	1	000	-1.	-1.
24 5	-1.	-1.	-1.	0	044.33	-1.	-1.
25 1	CALCRBANK	140	095	049	066	070	114
25 2	104	066	10.00	315	06.50	3.5	4
25 3	-1.	-1.	-1.	-1.	0	-1.	-1.
25 4	00.00	00.00	00.00	0	000	-1.	-1.
25 5	-1.	-1.	-1.	2	043.00	-1.	-1.
26 1	HENDIFLP	170	092	049	070	076	139
26 2	106	076	70.00	335	18.00	4.0	6
26 3	-1.	-1.	-1.	-1.	0	-1.	-1.
26 4	00.00	00.00	00.00	0	000	-1.	-1
26 5	-1.	-1.	-1.	1	027.00	-1.	-1.
27 1	HENDIFLPN	136	075	037	047	051	084
27 2	098	048	25.00	335	20.00	4.0	6
27 3	-1.	-1.	-1.	-1.	0	-1.	-1.
27 4	00.00	00.00	00.00	0	000	-1.	-1.
27 5	-1.	-1.	-1.	2	018.52	-1.	-1.

28	1	HENDICS	107	091	051	070	076	140
28	2	109	082	12.00	180	25.00	4.0	6
28	3	-1.	-1.	-1.	-1.	0	-1.	-1.
28	4	10.00	00.50	01.00	2	000	-1.	-1.
28	5	-1.	-1.	-1.	1	054.09	-1.	-1.
29	1	HENDICN	118	086	046	066	074	129
29	2	104	073	25.00	335	20.00	4.0	6
29	3	-1.	-1.	-1.	-1.	0	-1.	-1.
29	4	10.00	00.50	01.00	2	000	-1.	-1.
29	5	-1.	-1.	-1.	1	018.52	-1.	-1.
30	1	HENDIDN	152	083	043	061	067	121
30	2	109	066	30.00	335	25.00	4.0	6
30	3	-1.	-1.	-1.	-1.	0	-1.	-1.
30	4	10.00	00.50	01.00	2	000	-1.	-1.
30	5	-1.	-1.	-1.	1	014.00	-1.	-1.
31	1	HENDNWDIP	194	074	036	045	047	085
31	2	098	046	75.00	190	15.00	4.0	6
31	3	-1.	-1.	-1.	-1.	0	-1.	-1.
31	4	00.00	00.00	00.00	0	000	-1.	-1.
31	5	-1.	-1.	-1.	1	110.50	-1.	-1.
32	1	HENDSEROD	126	097	054	071	080	146
32	2	111	083	03.00	180	03.50	3.0	6
32	3	-1.	-1.	-1.	-1.	0	-1.	-1.
32	4	-1.	-1.	-1.	4	045	-1.	-1.
32	5	-1.	-1.	-1.	1	045.76	-1.	110
33	1	HENDNDIP	147	082	043	058	065	113
33	2	110	069	30.00	335	05.00	4.0	3
33	3	-1.	-1.	-1.	-1.	0	-1.	-1.
33	4	00.00	00.00	00.00	0	000	-1.	-1.
33	5	-1.	-1.	-1.	1	014.00	-1.	-1.
34	1	HENDCHOL	080	090	048	071	072	124
34	2	113	074	03.00	335	03.50	3.0	3
34	3	-1.	-1.	-1.	-1.	0	-1.	-1.
34	4	00.00	00.00	00.00	1	000	-1.	-1.
34	5	-1.	-1.	-1.	1	040.00	-1.	-1.
35	1	HENDBSSL	150	077	038	052	054	091
35	2	098	053	20.00	170	18.00	4.0	6
35	3	-1.	-1.	-1.	-1.	0	-1.	-1.
35	4	10.00	00.50	01.00	2	000	-1.	-1.
35	5	-1.	-1.	-1.	1	062.00	-1.	-1.
36	1	KEFNARWN	154	081	042	056	071	135
36	2	107	075	30.00	315	35.00	5.0	6
36	3	-1.	-1.	-1.	-1.	0	-1.	-1.
36	4	10.00	01.00	01.00	2	000	-1.	-1.
36	5	-1.	-1.	-1.	2	017.00	-1.	-1.

37	1	KEFNARWS	176	065	027	031	030	041
37	2	104	020	30.00	135	35.00	5.0	6
37	3	-1.	-1	-1.	-1.	0	-1.	-1.
37	4	10.00	01.00	01.00	2	000	-1.	-1.
37	5	-1.	-1.	-1.	2	072.00	-1.	-1.
38	1	KEFNAREN	145	087	046	061	072	149
38	2	101	081	25.00	315	35.00	5.0	6
38	3	-1.	-1.	-1.	-1.	0	-1.	-1.
38	4	10.00	01.00	01.00	2	000	-1.	-1.
38	5	-1.	-1.	-1.	2	021.00	-1.	-1.
39	1	KEFNARES	169	070	031	037	038	047
39	2	096	021	30.00	135	35.00	5.0	6
39	3	-1.	-1.	-1.	-1.	0	-1.	-1.
39	4	10.00	01.00	01.00	2	000	-1.	-1.
39	5	-1.	-1.	-1.	2	072.00	-1.	-1.
40	1	DNARNWRI	134	089	049	067	079	121
40	2	100	063	30.00	300	20.00	4.0	5
40	3	-1.	-1.	-1.	-1.	0	-1.	-1.
40	4	02.00	00.50	00.40	2	000	-1.	-1.
40	5	-1.	-1.	-1.	2	024.00	-1.	-1.
41	1	DNARNPARG	147	097	054	071	083	116
41	2	105	061	35.00	300	20.00	4.0	7
41	3	-1.	-1.	-1.	-1.	0	-1.	-1.
41	4	02.00	00.50	00.40	2	000	-1.	-1.
41	5	-1.	-1.	-1.	1	023.00	-1.	-1.
42	1	DNARNAPEX	194	083	044	061	069	123
42	2	107	066	60.00	135	20.00	4.0	5
42	3	-1.	-1.	-1.	-1.	0	-1.	-1.
42	4	02.00	00.50	00.40	2	000	-1.	-1.
42	5	-1.	-1.	-1.	2	100.90	-1.	-1.
43	1	DNARSPARG	158	083	043	057	060	102
43	2	103	056	30.00	300	25.00	4.0	7
43	3	-1.	-1.	-1.	-1.	0	-1.	-1.
43	4	02.00	00.50	00.40	2	000	-1.	-1.
43	5	-1.	-1.	-1.	1	024.00	-1.	-1.
44	1	DNARSPARG	130	102	058	078	085	129
44	2	104	071	25.00	300	25.00	4.0	7
44	3	-1.	-1.	-1.	-1.	0	-1.	-1.
44	4	02.00	00.50	00.40	2	000	-1.	-1.
44	5	-1.	-1.	-1.	1	025.98	-1.	-1.
45	1	DNARSWSL	141	102	054	067	071	123
45	2	100	069	40.00	300	25.00	4.0	5
45	3	-1.	-1.	-1.	-1.	0	-1.	-1.
45	4	02.00	00.50	00.50	2	000	-1.	-1.
45	5	-1.	-1.	-1.	1	023.16	-1.	-1.

46 1	DNARSTOPW	107	090	045	060	060	103
46 2	104	055	80.00	320	25.00	4.0	5
46 3	-1.	-1.	-1.	-1.	0	-1.	-1.
46 4	02.00	00.50	00.50	2	000	-1.	-1.
46 5	-1.	-1.	-1.	1	039.12	-1.	-1.
47 1	DNARSTOPE	190	067	027	033	036	050
47 2	104	023	80.00	090	25.00	4.0	5
47 3	-1.	-1.	-1.	-1.	0	-1.	-1.
47 4	02.00	00.50	00.50	2	000	-1.	-1.
47 5	-1.	-1.	-1.	1	099.00	-1.	-1.
48 1	DNARASCOL	081	080	042	052	064	118
48 2	110	067	25.00	100	00.50	2.0	3
48 3	-1.	-1.	-1.	-1.	0	-1.	-1.
48 4	00.00	00.00	00.00	0	000	-1.	-1.
48 5	-1.	-1.	-1.	2	060.16	-1.	-1.
49 1	CHERFOOT	114	077	038	049	066	098
49 2	110	054	20.00	270	18.00	4.0	0
49 3	-1.	-1.	-1.	-1.	0	-1.	-1.
49 4	00.00	00.00	00.00	0	000	-1.	-1.
49 5	-1.	-1.	-1.	1	038.20	-1.	-1.
50 1	CHERDIN	166	088	045	061	086	127
50 2	105	070	80.00	090	40.00	5.0	0
50 3	-1.	-1.	-1.	-1.	0	-1.	-1.
50 4	00.00	00.00	00.00	0	000	-1.	-1.
50 5	-1.	-1.	-1.	1	066.00	-1.	-1.
51 1	CHERWSL	135	087	044	057	074	120
51 2	110	060	40.00	270	35.00	5.0	0
51 3	-1.	-1.	-1.	-1.	0	-1.	-1.
51 4	00.00	00.00	00.00	0	000	-1.	-1.
51 5	-1.	-1.	-1.	1	041.79	-1.	-1.
52 1	CHERESL	172	088	046	058	080	127
52 2	112	066	35.00	090	18.00	4.0	0
52 3	-1.	-1.	-1.	-1.	0	-1.	-1.
52 4	00.00	00.00	00.00	0	000	-1.	-1.
52 5	-1.	-1.	-1.	1	064.29	-1.	-1.
53 1	CHERDIPN	082	107	059	079	098	124
53 2	112	065	05.00	090	25.00	4.0	0
53 3	-1.	-1.	-1.	-1.	0	-1.	-1.
53 4	00.00	00.00	00.00	0	000	-1.	-1.
53 5	-1.	-1.	-1.	1	045.29	-1.	-1.
54 1	CHERDIPS	141	109	061	080	097	141
54 2	109	078	10.00	090	90.00	5.0	0
54 3	-1.	-1.	-1.	-1.	0	-1.	-1.
54 4	00.00	00.00	00.00	0	000	-1.	-1.
54 5	-1.	-1.	-1.	1	047.92	-1.	-1.

55 1	CHERVALOL	140	071	036	047	056	095
55 2	122	057	00.00	000	03.50	3.0	0
55 3	-1.	-1.	-1.	-1.	0	-1.	-1.
55 4	16.00	03.50	04.00	5	090	-1.	-1.
55 5	-1.	-1.	-1.	0	043.00	-1.	-1.
56 1	CHERVALNW	011	088	049	065	076	118
56 2	110	069	00.00	000	03.50	3.0	0
56 3	-1.	-1.	-1.	-1.	0	-1.	-1.
56 4	00.00	00.00	00.00	1	000	-1.	-1.
56 5	-1.	-1.	-1.	0	043.00	-1.	-1.
57 1	OLINRD	196	074	037	048	065	091
57 2	106	052	05.00	270	18.00	4.0	0
57 3	-1.	-1.	-1.	-1.	0	-1.	-1.
57 4	-1.	-1.	-1.	5	-1.	-1.	-1.
57 5	-1.	-1.	-1.	1	041.08	-1.	-1.
58 1	GRAINSN	023	070	035	041	067	087
58 2	108	045	00.00	000	01.50	3.0	0
58 3	-1.	-1.	-1.	-1.	0	-1.	-1.
58 4	00.00	00.00	00.00	1	000	-1.	-1.
58 5	-1.	-1.	-1.	0	043.00	-1.	-1.
59 1	MHRLCALRG	194	085	051	074	078	138
59 2	110	095	03.00	280	20.00	4.0	4
59 3	-1.	-1.	-1.	-1.	0	-1.	-1.
59 4	00.00	00.00	00.00	0	000	-1.	-1.
59 5	-1.	-1.	-1.	2	041.33	-1.	-1.
60 1	HENDCALRG	181	076	038	052	068	096
60 2	106	052	25.00	270	20.00	4.0	4
60 3	-1.	-1.	-1.	-1.	0	-1.	-1.
60 4	02.00	00.50	00.50	2	000	-1.	-1.
60 5	-1.	-1.	-1.	0	038.31	-1.	-1.