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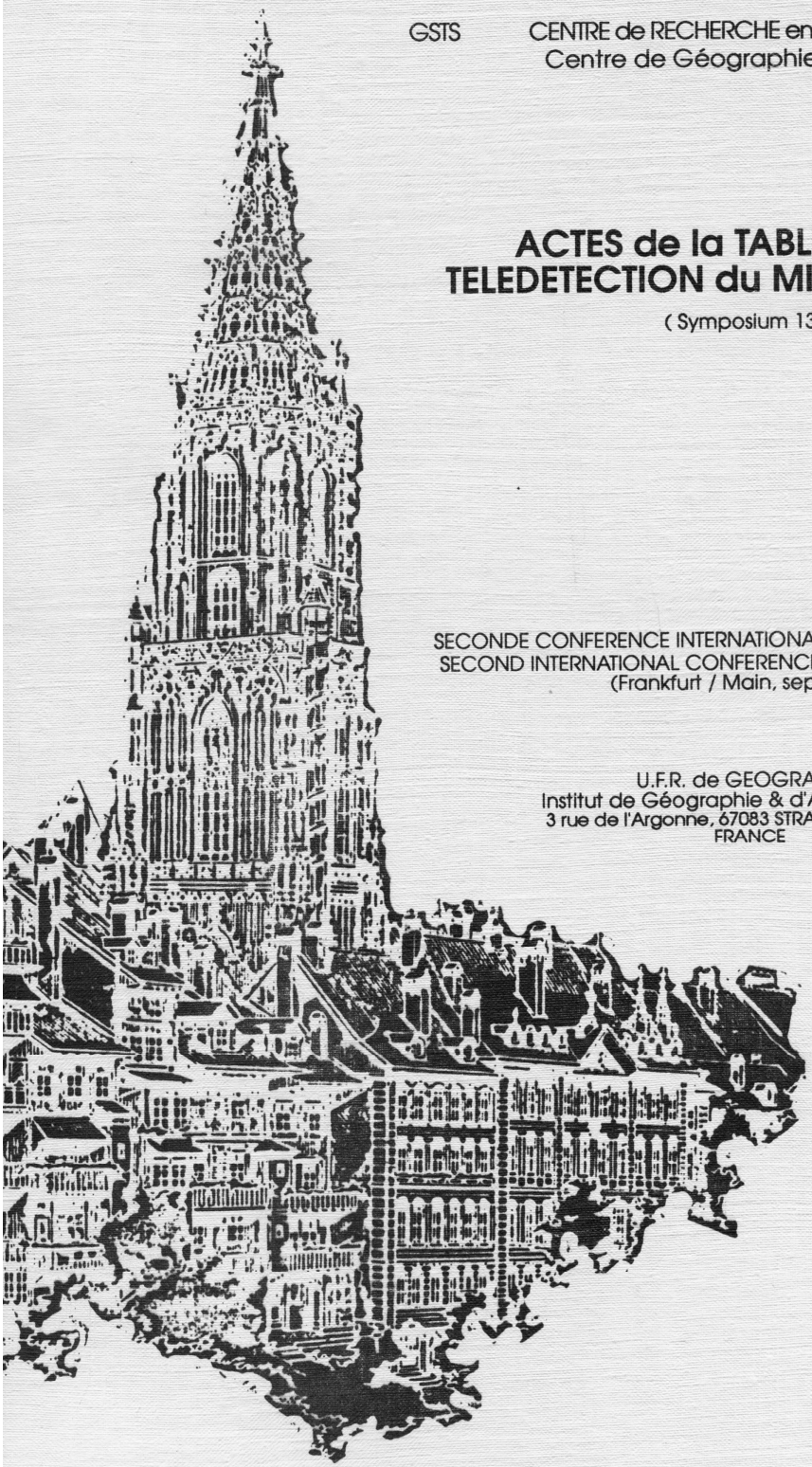

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FRANCE

REMOTE SENSING DIACHRONIC STUDY OF THE DRAINAGE PATTERN OF TUNIS REGION

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SYNOPSIS

Cette communication présente une étude diachronique de l'hydrographie de la région de Tunis à partir de deux images Landsat. Deux approches de traitement numériques sont utilisées : l'une se basant sur des classifications d'images (supervisées ou par nuées dynamiques) et l'autre sur des filtrages numériques dans le domaine fréquentiel.

Sur les images d'hiver, les Sebkhets es Sedjoumi et er Riana, ainsi que le "lac" de Tunis sont pleines d'eau. L'embouchure de la Medjerda se signale par un panache important décalé par la dérive littorale de Sud-Est.

Sur les images d'été, les sebkhas s'individualisent par une série d'auréoles concentriques de sols humides nus plus ou moins salés. La partie centrale de la Sebkhet er Riana serait une mince pellicule d'eau sur une croûte de sel, alors que la Sebkhet es Sedjoumi conserve, au Sud-Sud-Est d'un croissant d'algues, une flaque d'eau turbide assez im-

portante, représentée de la même couleur que le panache, le pourtour intérieur du "lac", la bordure Sud du golfe de Tunis et du lac de barrage (vers le Sud-Ouest) et le bassin d'épuration de l'ONAS. La dérive littorale vient alors du Nord-Ouest.

INTRODUCTION

The area surveyed covers part of NE Tunisia at latitude a little less than 37° North and 10° longitude East. It includes the capital city Tunis and extends northward to the Medjerda delta and southward beyond jebel Bou Kornine on the western coast of the Gulf of Tunis which opens widely northward in the Mediterranean Sea (fig. 1).

The most part is constituted of hills (which reach a height of 328 m at the jebel El Ahmar) separated with plains and depressions. However, in the SE, the Tunisian Ridge ends with the vigorous summit of the jebel Bou Kornine (576 m).

The main originality of this area is the particularly complex drainage pattern. The two main permanent rivers in Tunisia, the Miliane and especially the Medjerda, flow into the Mediterranean Sea. The mouth of the Miliane, in the South, seems to have little influence on the dynamic of the Gulf of Tunis. On the other hand, the Medjerda (about 480 km long with a drainage area of 22 000 km²) deposits large amounts of sediments redistributed in the Gulf, on an average of about 9,5 x 10⁶ t/year (according to R. PASKOFF, 1981) or 16 x 10⁶ t/year (according to R. CO-

QUE and A. JAUZEIN, 1967). Despite the proximity of the coast and fairly abundant rainfall (annual mean rainfall in Tunis : 444 mm), two sebkhas subsist and form the northernmost tunisian sebkhas. The Sebkhet es Sedjoumi with an altitude of less than 10 m is at the downstream end of the endoreic plain of the Manouba, at the feet of the hills of Tunis and its southern suburbs (maximum altitude : 92 m). On the other hand, the Sebkhet er Riana takes up the northern part of the depression between the N-S hills of the jebels Nahali-Sidi Amor (about 200 m) and those of Gamarth-Sidi bou Saïd (129 m), with an altitude of 4 to 7 m and separated from the Gulf of Tunis by a slender line of coastal dunes with an altitude of less than 14 m. In the southern part of this depression, "lake" of Tunis is the last hydrological originality. It is really a shallow lagoon (averaging less than 2 m deep) which is connected with the Mediterranean Sea through the La Goulette offshore bar.

The complexity of this area becomes clearer in respect with its recent geological history. According to J. PIMIENTA (1959), the origin of the depressions of La Manouba-es Sedjoumi, on one hand, and the "lake" of Tunis, on the other hand, is an ancient course of the Medjerda which has laid large amounts of coarse alluviums. After diverting of the river towards the North, the quaternary subsidence has permitted the genesis of the Sebkhet es Sedjoumi. Its persistence is explained at once with the lack of clastic sedimentation and with the important exportation of fine materials by eolian deflation (30 000 t/year ac-

cording to E.J. WEDMAN (1964). The Sebkhet er Riana is younger, even historical (A. JAUZEIN in R. MANSOURI-MENAOUAR, 1979) since it seems that it was connected with the sea until the 7th century, being the last remain of the chain of lagoons closed with the sediments brought by the Medjerda before the Utique transgression (J. PIMIENTA, 1959). Those sediments brought by the Medejerda also explain the formation of the Tunis lagoon from an ancient gulf the exact age of which, certainly historic, is discussed (J. PIMIENTA, 1959, J. ZAOUALI, 1983).

Finally, the Medjerda river course was recently changed many times. The last one was at the time of the important flood of 1973, shifting the delta to the South of the current position (R. PASKOFF, 1978).

ANALYSIS AND RESULTS

The images used were extracted from the LANDSAT II scenes 206-34, one taken in the winter (26-01-77) and the other in the summer (19-07-81).

In the winter image, the "lake" of Tunis and the two sebkhas are full of water. However, the Sebkhet er Riana stands out clearly because it is filled with turbid water. The supervised classification (23 classes) brings out three organized concentric rings as if water was being added from the South. The sheet of water does not entirely fill the bottom of the depression, leaving wide outcrops of bare ground on three sides. On the other hand, in Sebkhet es Sedjoumi, the generally non turbid sheet of water dee -

pens towards the Southeast. The main offshore visible dynamic is due to the continental supplies. The suspended sediments from the Medjerda form a large complex plume in which four density levels can be distinguished. Sebkhet er Riana contributes to its formation through an artificial channel. In a general way, this plume is offset toward the NW from the river mouths, which indicates a SE coastal drift which is rare in winter (Y. NOURI, R. PASKOFF, 1980, T. BOUHAFA, 1985). However, near the shore, the plume is oriented toward the SE. The plume from the Miliane is much more modest, but it shows the same presence of two drift directions.. The main westward drift pushes most of the plume against the Radès offshore bar (and makes it penetrate part way in the "lake" ?). The secondary eastward drift displaces turbid water similar to that in Sebkhet er Riana toward the Est of the mouth.

In the summer image, the offshore dynamic is more simple, but the sebkhas become more complex. The typical essential feature of the coast is the presence of the plume from the Medjerda. Pushed by the NW drift, it goes beyond Cap Gammarth. It is less voluminous than in winter. However, the supervised classification (23 classes) has also permitted to distinguished four shades the outside part of which, higly diffuse, is accumulating at the end of the gulf. The coastal drift is loaded with sand, as shown by the large offshore bar separating Sebkhet er Riana from the sea (T. BOUHAFA, 1985), and with clay and silt (R. PASKOFF, 1981). During the dry season, Sebkhet er Riana is subdivised into rings of varying width, corresponding to damp or

more or less salty soils. A dissymetric halo surrounds these rings and corresponds to salty bare ground, distinct from the eastern non-salty bare ground observed in the winter image. A previous study (R. MANSOURI-MENAOUAR, 1979) also distinguished four concentric rings. From the outside edge inward, there were halophile plants, narrower than or equal to 1 m in width (non detectable on Landsat MSS), hard yellow ochre clay with dessication cracks during the summer (probably corresponding to the salty bare ground halo), very soft black mud covered by a thin saline film during summer (corresponding to the three rings) and a salt crust several centimeters thick made of polygonal slabs underneath a thin sheet of water (about 10 cm). This crust lies on top of the same black mud (probably corresponding to ring 4). In the eastern part, zoning is less obvious because of considerable sand influxes during major storms.

Concerning Sebkhet es Sedjoumi, from the outside edge inward, there are an irregular halo of salty bare ground, that is scattered toward the exterior with damp soils, a crescent of vegetation, green on the image (algae ?), surrounding a fairly large area of turbid water with a clear-cut outline. Within this turbid water, a supervised classification shows a crescent of identical reflectance as the polluted fringe of the "lake" of Tunis, and the purification basins of ONAS, and the central part with a turbidity comparable to the offshore water. All the islands are linked to the terra firma, as the case of Sebkhet er Riana.

CONCLUSION

This diachronic survey can be used to assess the contribution of Landsat imagery in the analysis of coastal environments and the sebkhas. As well as an increased accuracy, for Sebkhet er Riana, in comparison with standard investigation methods, new data are provided for Sebkhet es Sedjoumi, the Medjerda and Miliane plumes, the pollution of the "lake" of Tunis. This survey will be used as a reference for further and more recent researches, and with different sensors, so as to see how the area evolves over some ten years.

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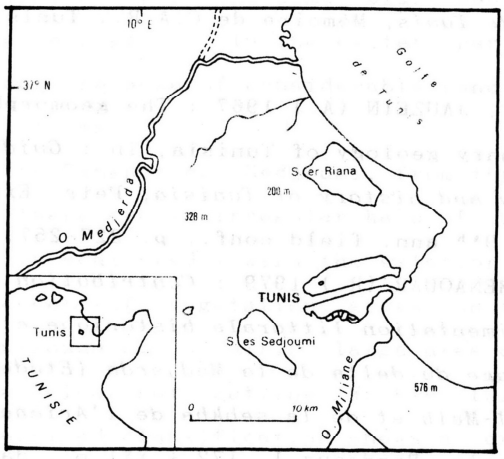


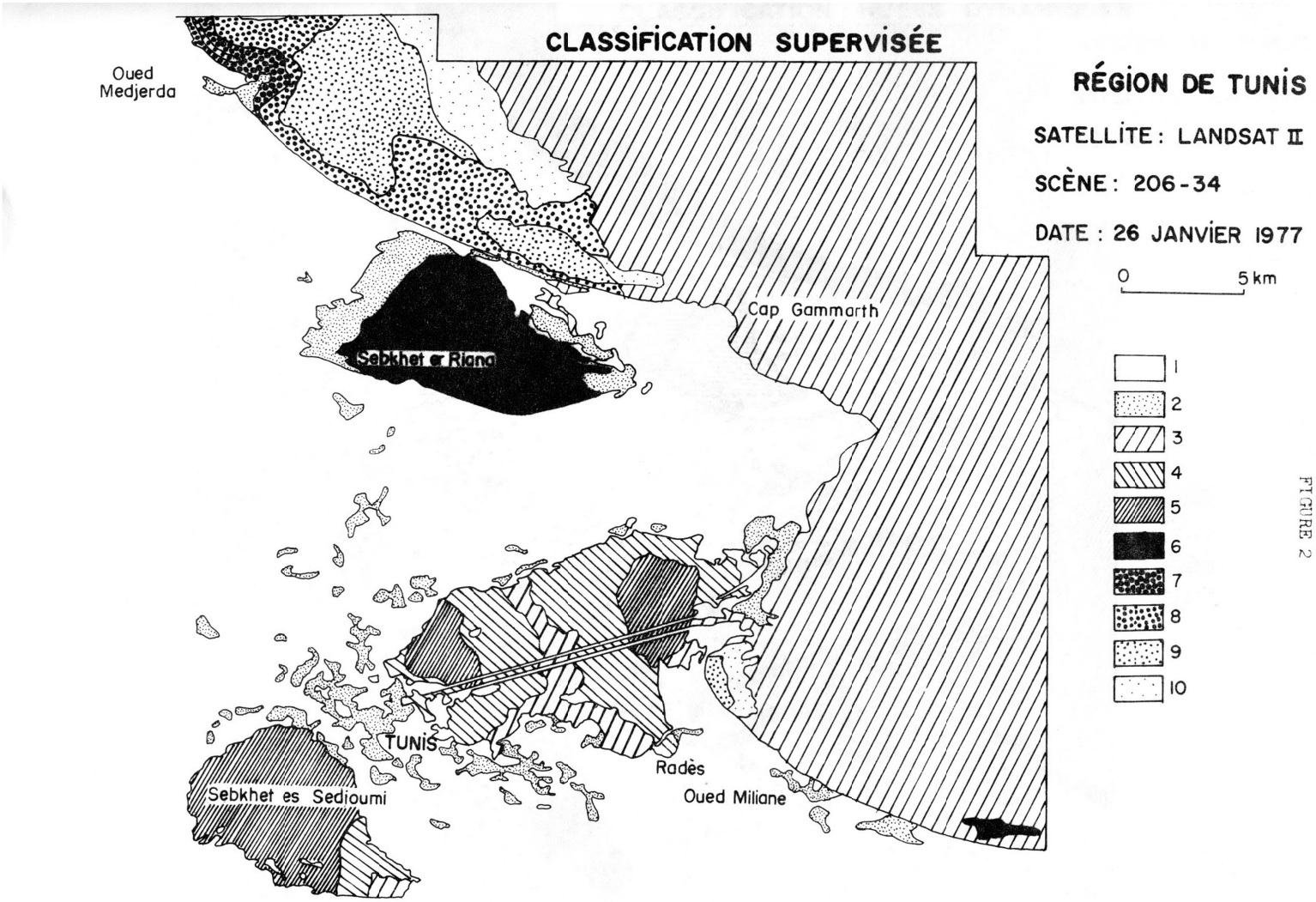
LEGENDE DES FIGURES

Fig. 1 : Location map. *Carte de localisation.*

Fig. 2 : 1. Not interpreted. *Non interprété*, 2. Bare ground or constructed area. *Sols nus ou bâtis*, 3. Sea water or deep water. *Eau de mer ou profonde*, 4. Shallow water. *Eau peu profonde*, 5. Pellicular water. *Eau pelliculaire*, 6. Turbid water. *Eau turbide*, 7. Very dense plume. *Panache très dense*, 8. Dense plume. *Panache dense*, 9. Diffuse plume. *Panache diffus*, 10. Very diffuse plume. *Panache très diffus.*

Fig. 3 : 1. Not interpreted. *Non interprété*, 2. Bare ground. *Sols nus*, 3. Vegetation. *Végétation*, 4. Water. *Eau*, 5. Turbid or polluted water. *Eaux turbides ou polluées*, 6. Rings 1 and 3. *Anneaux 1 et 3*, 7. Ring 2. *Anneau 2*, 8. Ring 4. *Anneau 4*.

FIGURE 2


CLASSIFICATION SUPERVISÉE
RÉGION DE TUNIS
SATELLITE : LANDSAT II
SCÈNE : 206-34
DATE : 26 JANVIER 1977
0
5 km
1
2
3
4
5
6
7
8
9
10
Oued Medjerda
Cap Gammarth
Sebkhet el Riana
TUNIS
Radès
Oued Miliane
Sebkhet es Sedioumi

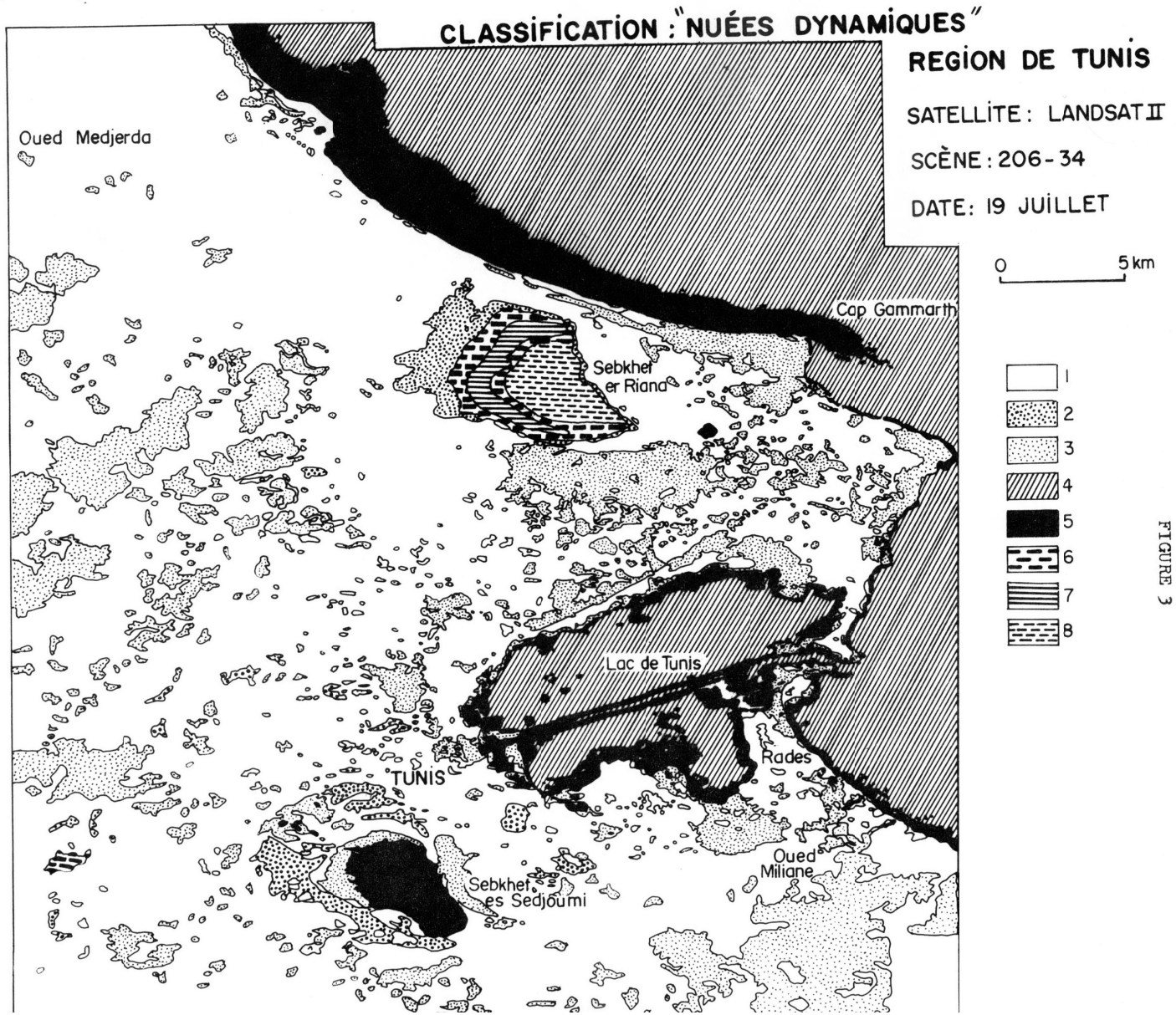

CLASSIFICATION : "NUÉES DYNAMIQUES"
REGION DE TUNIS
SATELLITE : LANDSAT II
SCÈNE : 206-34
DATE : 19 JUILLET
0
5 km
1
2
3
4
5
6
7
8
Oued Medjerda
Cap Gammarth
Sebkhet er Riana
Lac de Tunis
Rades
TUNIS
Oued Miliane
Sebkhet es Sedjoumi

FIGURE 3