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INTERPRETATION OF MULTISPECTRAL AND INFRARED THERMAL SURVEYS OF THE SUEZ CANAL ZONE, EGYPT

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SUMMARY

Remote sensing airborne surveys have been conducted, as part of the plan of rehabilitation, of the Suez Canal Zone using I^2S multispectral camera and Bendix LN-3 infrared passive scanner. The multispectral camera gives four separate photographs for the same scene in the blue, green, red and near infrared bands. The scanner has been operated in the microwave bands of 8 to 14 microns and the thermal surveying has been carried out both at night and in the day time.

The surveys, coupled with intensive ground investigations, have been utilized in the construction of new geological, structural lineation and drainage maps for the Suez Canal Zone on a scale of approximately 1:20,000, which are superior to the maps made by normal aerial photography. A considerable number of anomalies belonging to various types have been revealed through the interpretation of the executed multispectral and infrared thermal surveys. These anomalous features are related to faults and fractures, salt crusts and salinization, buried channels, surface and subsurface drainage lines, wetness, cultivated lands, sediments submerged under water, suspended sediments, and water bodies. The defined features have been of particular importance in the designing of engineering projects, and in studying the natural resources and environment of the Suez Canal Zone.

A buried channel which is almost completely buried under accumulating wind blown dune sands has been delineated by the multispectral photography and the infrared thermal imagery. The dune sands are also covering the surrounding terrain. The distinction between the dune sands filling the channel and those covering its surroundings is mainly due to the wetness of the sands in the former case while they are dry in the latter.

The distinction of salt crust and other exhibitions of salinization are very important criteria of land management in the Suez Canal Zone, as well as in arid regions at large especially those endangered by saline water intrusion. The Suez Canal Zone is subjected to the invasion of saline water from the Red Sea, Mediterranean Sea and other saline lakes covering large surfaces in the Zone and its environs. Infrared thermal imagery and multispectral photography have proved to be excellent tools in studying the various manifestations of salinization in comparison to normal aerial photography.

INFRARED THERMAL AND MULTISPECTRAL SURVEYS

The Suez Canal Zone in Egypt (Figure 1) has been surveyed in the night time and day time by the Bendix thermal mapper LN-3 and in the day time by the I^2S multispectral aerial camera Mark-I. Both are mounted on a twin-engine aircraft AN-2 operating at a speed of 180 km/h. LN-3 is an airborne infrared passive scanner which has been operated during the survey in the microwave bands of 8 to 14 microns, and the thermal anomalies are recorded in a visual fashion on photographic films. On the other hand, the multispectral camera gives for the same scene four photographs simultaneously in four bands of the electromagnetic spectrum, namely the blue (band 1), green (band 2), red (band 3) and near infrared (band 4).

The surveys of the Suez Canal Zone have been conducted in parallel flight lines in an approximate NE-SW direction across the Suez Canal, and the resulting photographs and images are on a scale of about 1:20,000. New maps for the geological and environmental units, structural and other lineaments, and drainage on a scale of 1:25,000 have been prepared for the Suez Canal Zone based on the previously mentioned surveys, as well as on the normal black and white aerial photographs (El Shazly, et al., 1975). Mosaics have been prepared from the photographs of band 4 of the multispectral camera and from the night time infrared thermal images of the thermal mapper to help in the construction of the maps in question, while other images and photographs have been utilized in the mapping separately.

In the present work examples are given illustrating the advantages of using the multispectral photography and infrared thermal imagery in an environment such as that prevailing in the Suez Canal Zone, which is covered by an arid desert with cultivated lands irrigated by fresh Nile water introduced into the Zone through artificially dug canals. Notable features in the Zone are manifested by salinization and salt water intrusion from the Mediterranean Sea, Red Sea and various saline water bodies including Lake Manzala, Lake Timsah and the Bitter Lakes (Figure 1). The examples are classified into those illustrating lithology and environment, structural lineaments, and drainage (wetness) features. The classification of the thermal anomalies is in agreement with that proposed by El Shazly, Abdel Hady and Morsy (1974).

DRAINAGE FEATURES AND BURIED CHANNEL

The drainage systems are very important features in the Suez Canal Zone as in most deserts of the world where they act as channels for rainfall and thus they play a significant role in groundwater accumulation and distribution. The multispectral and infrared thermal surveys have been found to be of particular use in delineating the drainage systems of the Suez Canal Zone especially where the land surface is dominated by featureless plains. The utilization of airborne infrared techniques in elucidating surface and subsurface drainage lines have been demonstrated by Abdel Hady, Abdel Hafez and Karbas (1970); El Shazly, Abdel Hady and Morsy (1974); etc. In multispectral photography not all the bands are equally good for this purpose. It has been demonstrated in this respect that the drainage lines are most clear in the photographs of band 1 (Figure 2), less clear in those of bands 2 and 4, and least defined in those of band 3 (Figure 3).

In El Devreswar west locality, an artificial channel has been discovered by the night time infrared thermal and multispectral aerial techniques. This channel was almost completely buried under dune sands and the same materials cover the surrounding terrain. The sands filling parts of the buried channel are wet, while they are dry in the surrounding sand dunes. In the multispectral aerial photograph of band 2, the wet parts in that buried channel show dark tone in contrast to the lighter tone of the surrounding sand dunes, while the dry parts show light grey tone with a notable trace following the trend of the buried channel (Figure 4). In the infrared thermal image the wet parts of the buried channel show dissected patches in white tone arranged in a nearly straight line, while the dry parts show dark tone indicating colder temperature at about 2 a. m. which is the time of the night time thermal imagery. The direction of the buried channel is shown by an arrow in the image (Figure 5). The estimated width of the buried channel is about 10 to 12 m, its trend is NW-SE and it is located 7 km to the north west of the Serabeum Station. The other white patches appearing in the same figure are wet land sometimes covered by a thin layer of water and vegetation, a broad light tone patch appearing in the image corresponds to cultivated land.

STRUCTURAL FEATURES

Although the night time is sometimes superior for conducting infrared thermal imagery because it produces an end product free of extraneous solar interferences and has proved to be suitable for detecting anomalies related to geological structures, the day time, especially the late afternoon imagery, however, may display good enhancement of topography and linear elements such as faults which often show in clear manner at that time. An example of day time imagery of linear features is the delineation of two faults of NW-SE trend which attain lengths of 2 and 2.5 km respectively on the infrared thermal image of a locality lying on the eastern side of the Little Bitter Lake (Figure 7). On the other hand, these faults are hardly recognizable on the normal aerial photograph of the same locality (Figure 6). In the day time infrared thermal images, the topographic features are notable and the land-water interface is also clearer as the water appears black or with darker tone while the land shows lighter tone.

LITHOLOGIC AND ENVIRONMENTAL FEATURES

There are many examples to illustrate such features in the Suez Canal Zone. One of these is demonstrated by comparing a night time as well as a day time infrared thermal image with a normal aerial photograph at El Ballah Island where a layer of rock salt and wet salty mud are present in association with other sediments and water bodies to the west of El Ballah Island in the Suez Canal Zone. In the normal aerial photograph (Figure 8), the rock salt layer which is some 10 to 20 cm thick is hardly seen and it is also difficult to distinguish between wet salty mud and the surrounding sediments and water bodies. In the day time infrared thermal image of the same locality (Figure 9), the rock salt layer and wet salty mud are clearly visible from the other surrounding sediments or water bodies. The salty layer and wet salty mud show with lighter tone in contrast to the darker tone of the water and other wet sediments because of their thermal anomalies. On the other hand, the night time infrared thermal image of the same locality (Figure 10) clearly shows the difference between the rock salt layer and the wet salty mud. In the latter image, the rock salt layer appears white due to its higher temperature, while the wet salty mud shows with light grey tone in contrast to the bright white tone of the water bodies.

The applicability of day time and night time infrared thermal imagery in studying the small water bodies in the Suez Canal Zone is demonstrated also by examining the previously mentioned images of El Ballah Island. The configuration of the boundary of the water body including its very shallow marginal parts is well defined in the night time image (Figure 10), while only the relatively deep part is shown in the day time image (Figure 9).

The multispectral photographs, especially of bands 2 and 1, proved to be of particular use in revealing submerged sediments under the water surface to various depths and suspended sediments in the water, while certain depth of the water bodies and shorelines are clearly recognized. These features are important for studying recent sedimentation in the lakes in the Suez Canal Zone, and they are illustrated by comparing a multispectral aerial photograph of band 2 of the western shore of the Little Bitter Lake (Figure 12) with a normal black and white photograph of the same locality (Figure 11).

Another interesting example of the application of multispectral photography in revealing lithologic and environmental units is the recognition of white limestone outcrops in low relief hills belonging to the Middle Miocene El Shatt Formation in the multispectral photograph of band 2 eastwards of Lake Timsah (Figure 14), while they can be hardly recognized in the normal aerial photograph (Figure 13). Further important uses of multispectral photography especially in band 4 incorporate the distinction between already cultivated lands which appear in white to light grey tones and those being prepared for cultivation which appear divided in divisions of dark gray or grey tones depending on the availability of water in each division.

REFERENCES

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EL SHAZLY, E. M., <u>et al</u>. (1975). Geological and geophysical investigations of the Suez Canal Zone. Remote Sensing Research Project, Academy of Scientific Research and Technology, Cairo, Egypt.

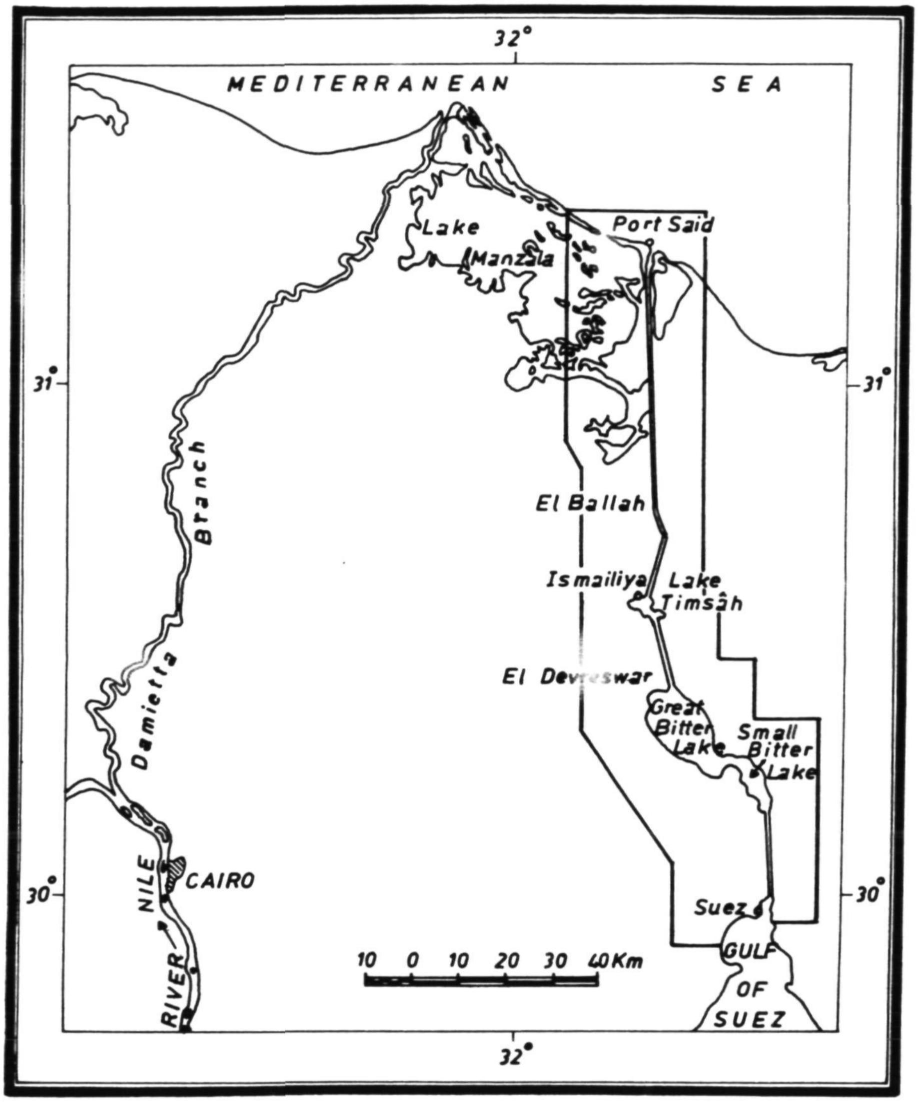

FIGURE 1. LOCATION MAP OF THE SUEZ CANAL ZONE, EGYPT.

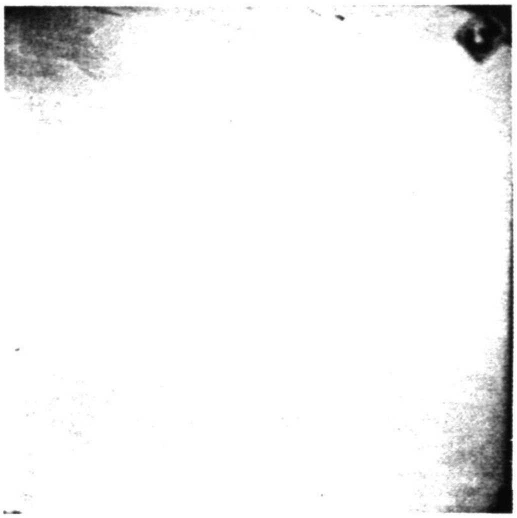

FIGURE 2. MULTISPECTRAL AERIAL PHOTOGRAPH, BAND 3 (1974) WHERE THE DRAINAGE LINES ARE NOT WELL DEFINED. WESTWARD OF SUEZ. APPROXIMATE SCALE 1:20,000.

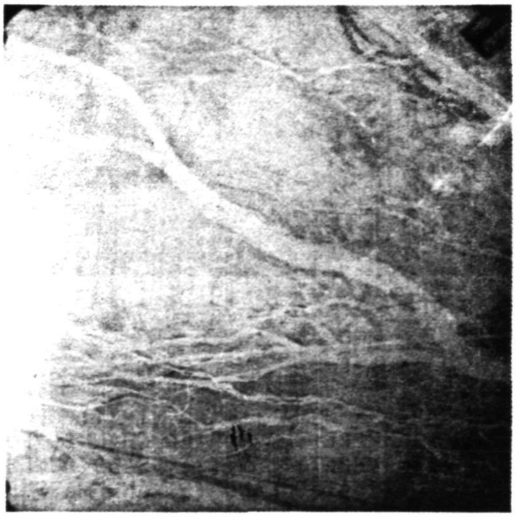

FIGURE 3. MULTISPECTRAL AERIAL PHOTOGRAPH, BAND 1 (1974) OF THE SAME LOCALITY SHOWN IN FIGURE 2 WITH THE DRAINAGE LINES SHARPLY DEFINED.

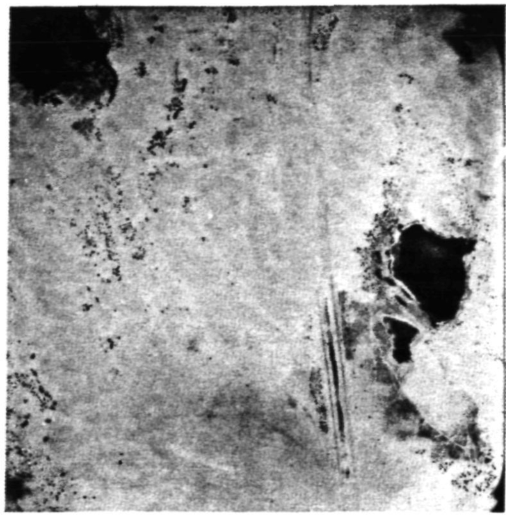

FIGURE 4. MULTISPECTRAL AERIAL PHOTOGRAPH, BAND 2 (1974) WHERE THE BURIED CHANNEL IS CLEARLY DEFINED. EL DEVRESWAR WEST LOCALITY. APPROXIMATE SCALE 1:20,000.

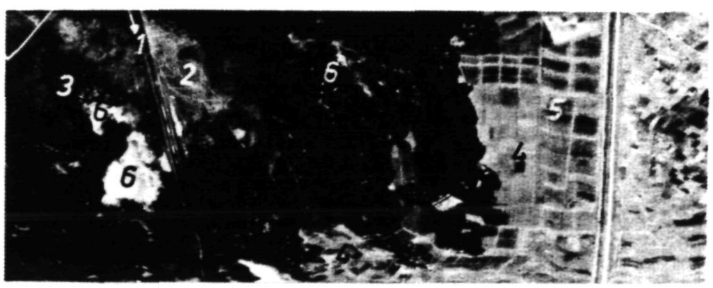

FIGURE 5. NIGHT TIME INFRARED THERMAL IMAGE (1974) FOR THE SAME LOCALITY SHOWN IN FIGURE 4 WHERE THE BURIED CHANNEL POINTED TO BY AN ARROW (1), WET LAND WITH VEGETATION (2), SAND DUNES (3), CULTIVATED LAND (4), DIVIDED UNCULTIVATED LAND (5) AND MARSHES ARE EASY TO DIFFERENTIATE.

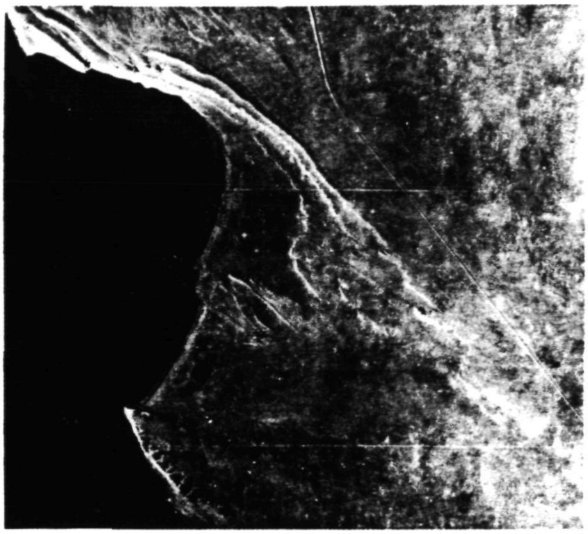

FIGURE 6. NORMAL AERIAL PHOTOGRAPH (1956) WHERE FAULTS ARE NOT CLEARLY OBSERVED. EASTERN SIDE OF LITTLE BITTER LAKE. APPROXIMATE SCALE 1:20,000.

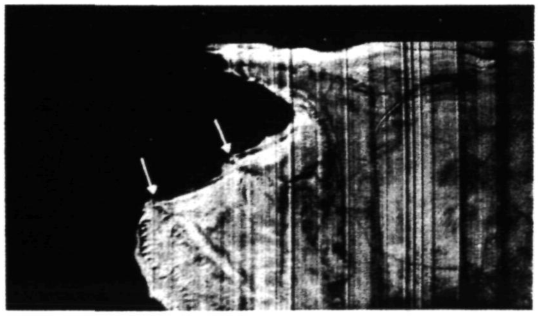

FIGURE 7. DAY TIME INFRARED THERMAL IMAGE (1974) OF THE SAME LOCALITY SHOWN IN FIGURE 6 WHERE FAULTS POINTED TO BY ARROWS ARE EASY TO DISTINGUISH.

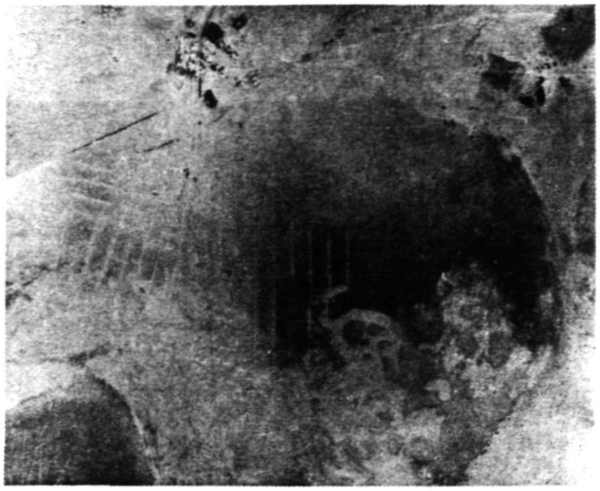

FIGURE 8. NORMAL AERIAL PHOTOGRAPH (1956) WHERE THE ROCK SALT LAYER IS NOT CLEARLY DELINEATED. WEST EL BALLAH ISLAND. APPROXIMATE SCALE 1:20,000.

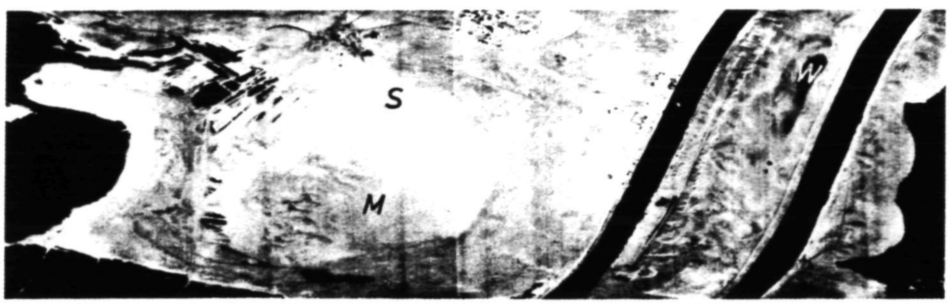

FIGURE 9. DAY TIME INFRARED THERMAL IMAGE (1974) WHERE THE ROCK SALT LAYER (S) AND THE WET SALTY MUD (M) ARE NOTED BUT NOT POSSESSING SHARP CONTACTS. THE RELATIVELY DEEP PART OF THE WATER BODY (W) IS ONLY SHOWING. WEST EL BALLAH ISLAND.

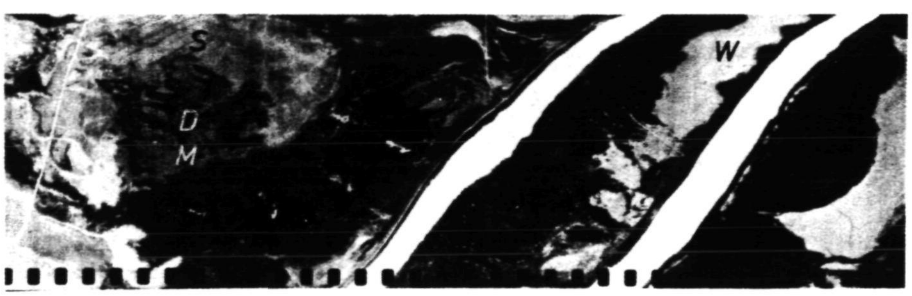

FIGURE 10. NIGHT TIME INFRARED THERMAL IMAGE (1974) WHERE THE ROCK SALT LAYER (S), THE WET SALTY MUD (M) AND THE WATER BODY (W) ARE IDENTIFIABLE WITH SHARP BOUNDARIES. SAND DUNES (D) AND WET DRAINAGE LINES POINTED TO BY ARROWS ARE CLEARLY DIFFERENTIATED. WEST EL BALLAH ISLAND.

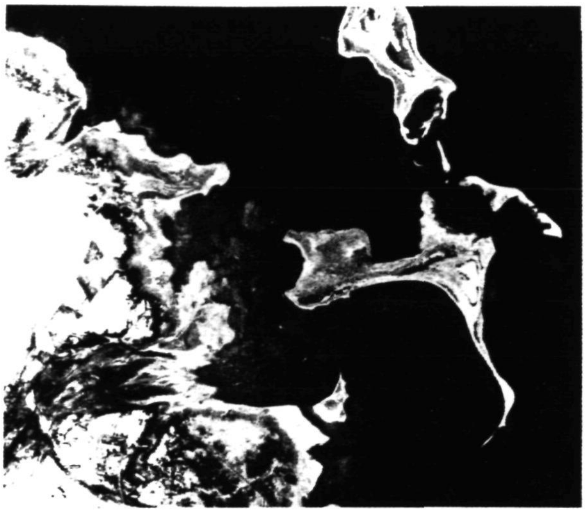

FIGURE 11. NORMAL AERIAL PHOTOGRAPH (1956) FOR THE WESTERN SHORE OF LITTLE BITTER LAKE. APPROXIMATE SCALE 1:20,000.

FIGURE 12. MULTISPECTRAL AERIAL PHOTOGRAPH, BAND 2(1974) SHOWING NOTABLE SUSPENDED SEDIMENTS NEAR THE WESTERN SHORE OF LITTLE BITTER LAKE. THE CONFIGURATION OF THE ISLAND IN THE LAKE IS DIFFERENT IN 1974 AS COMPARED TO 1956 DUE TO THE EROSION AND SEDIMENTATION PHENOMENA. APPROXIMATE SCALE 1:20,000.

FIGURE 13. WHITE LIMESTONE OUTCROPS OF LOW RELIEF APPEARING HAZY IN NORMAL AERIAL PHOTOGRAPH. EASTWARD OF LAKE TIMSAH. APPROXIMATE SCALE 1:20,000.

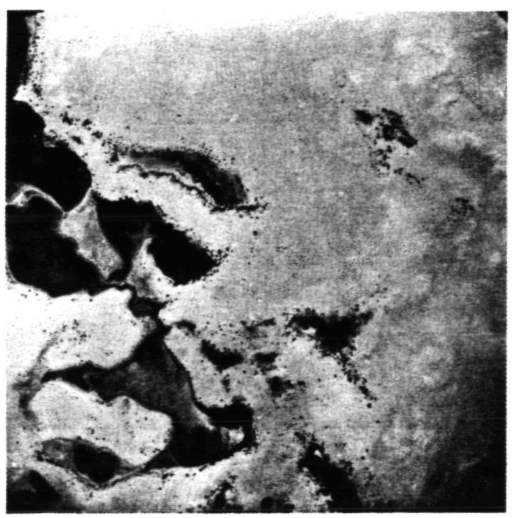

FIGURE 14. THE SAME WHITE LIMESTONE OUTCROPS IN FIGURE 13 ARE CLEARLY OBSERVED IN MULTISPECTRAL AERIAL PHOTOGRAPH, BAND 2. APPROXIMATE SCALE 1:20,000.