Paper G 25

GEOLOGIC INTERPRETATION OF ERTS-1 SATELLITE IMAGES FOR WEST ASWAN AREA, EGYPT

E. M. El Shazly, M. A. Abdel-Hady, M. A. El Ghawaby and I. A. El Kassas

ERTS-1 images of West Aswan area are interpreted in terms of geology, drainage and structure, and this interpretation is compared with previous investigations on this area. The drainage pattern of the Nile is mainly controlled by structural elements of N-S, NNW-SSE, NNE-SSW trends and the slope towards the Mediterranean, while the wadis are usually taking the ENE-WSW, E-W fractures and directed by the slope towards the Nile in the eastern part of the area and by the slope towards the depressions in the Western Desert in the western part. The branches of Lake Nasser (Aswan Dam Reservoir) in its northern part are occupying the wadis and the fracture systems.

The structure of the area is dominated by the ENE-WSW folding of the open type occurring on a regional and minor scale, while the fractures and faults belong to several trends and are either extending for long distances or they may be short and grouped together in parallel arrangement echoing the major fractures.

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Apart from cultivation and vegetation, twenty two geological units are distinguished on ERTS-1 images in West Aswan area covering geological formations and erosional levels within some formations ranging from the Precambrian to the Quaternary. Apart from the distinction of Aswan monumental granite, which is characteristic of Aswan, the investigated area shows very interesting exposures of sedimentary rocks ranging from the Cretaceous to the Quaternary. Of special interest from the economic geology point of view is the delineation on ERTS-1 images of the iron-ore member of the Nubian Sandstone and the phosphate-bearing formation. From the scientific point of view the tracing of the geological formations from south to north and the distinction of the varied geological units within the Pliocene and Quaternary, and the discussion on the origin of tufa are of particular significance.

Also, the tracing on these images of major fractures and faults intercepting Aswan Dam Reservoir and their significance on the seepage and possible future development of diversion channels from reservoir is emphasized.

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BY

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INTRODUCTION

This report complements a previous one published in July 1973 by the Academy of Scientific Research and Technology (Egypt) on the "Geologic Interpretation of ERTS-1 Satellite Images of East Aswan Area, Egypt". The report is considered a part of the continued effort initiated by the Remote Sensing Research Project, presently conducted by the Egyptian Academy of Scientific Research and Technology in cooperation with the U.S. National Science Foundation, Oklahoma State University, and the Remote Sensing Institute at South Dakota, to evaluate the significance of ERTS-1 satellite images in regional geologic and natural resources survey and mapping.

The clear weather all year around over Egypt permits excellent and clear satellite images which allows excellent exposure of geologic and other surface features. Undoubtedly a survey from such images can assist in revising and complementing present geologic maps compiled by limited ground survey techniques. Information

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provided by these iamges would yield significant information necessary for the regional development of agriculture, mineral exploitation, and transport in such arid areas as Egypt. It is also hoped that results obtained and experience gained from this investigation can assist in interpretation of satellite images over similar arid regions in the world.

The present report deals with the drainage, structure and geology of a large area in the southern part of Egypt namely West Aswan area, as interpreted from ERTS-1 satellite images. The area under study covers some 34000 km^2, and is limited by the following points of coordinate intersections : lat. 25°15'00" N, long. 31° 25'40" E, and lat. 24°57'30" N, long. 33°15'10" E from the north, and lat. 23°22'30" N, long. 32°50'30" E, and lat. 23°37'30" N, long. 31°04'30" E from the south.

The River Nile passes from south to north in the eastern side of the area which overlaps with the western side of the previously investigated East Aswan area (El Shazly, Abdel-Hady, El Ghawaby and El Kassas, 1973). In contrast to the previously examined area the great part of the present area lies in the Western Desert of Egypt to the west of Aswan town (Fig. 1).

The area covered in these images is significant in the fact that it shows the pattern of filling of the Aswan Dam Reservoir and some of the significant geologic features in the surrounding region, e.g. some of the faults intercepting the reservoir did not appear in other available geologic maps for this area. Such features warrant very careful detailed investigation to study their effects on the seepage from the reservoir and their impact on the future development of the Aswan Dam region.

To demonstrate the value of information provided by ERTS-1 satellite images, geologic and structural maps compiled from these images for this area are shown in comparison to the geologic map for the same area compiled from various sources by the Geological Survey and Mineral Projects Authority published in 1971.

DRAINAGE ANALYSIS

West Aswan area is essentially covered by Foreland sediments ranging from Cretaceous to Quaternary with the exception of the igneous-metamorphic basement exposures of limited distribution in the vicinity of Aswan town and to its south.

The eastern part of the drainage map (Fig. 2) is dominated by the Nile drainage, including that of the present Nile and the plains surrounding it especially on the west side. The present Nile is controlled by the N-S, NNW-SSE, NNE-SSW fractures as already mentioned by the same authors in their interpretation of ERTS-1 images of East Aswan area. In this report more observations are available on the northern part of Lake Nasser (Aswan Dam Reservoir) extending from south of Aswan town to Kalabsha.

It is evident that branches of the Lake penetrating in the desert are formed by water back filling the wadis (valleys) draining the desert to the east and west of the River Nile. At Kalabsha the branches of the Lake are particularly well developed and they are controlled by the NNW-SSE, ENE-WSW, and E-W faults.

This phenomenon should be carefully evaluated in relationship to the possible future development of other significant branches

from the Lake along major faults traced on the satellite images. Detailed investigation should be carried out to show the nature of these faults (e.g. activity, openness, filling material, etc). This will help to predict whether in the future erosion along these faults would allow branches from the reservoir to grow rapidly causing significant seepage and water diversion problems.

On the west side of the present Nile the area is geomorphologically distinguished into two major units, namely the wide plain adjacent to the Nile and the plateau with its escarp towards the west. The plain - which normally ranges in the width from 20 to 30 km - has been the scene of activity of the older Nile in the Quaternary and Tertiary (Butzer and Hansen, 1968). It is sometimes called Kalabsha plain to the south where the bed rock is mainly Nubian Sandstone and Darb El Gallaba plain to the north where the most important bed rock is Darb El Gallaba gravel produced by the Nile drainage in the Pleistocene. The plateau - Sinn El Kaddab and its continuation - starts from the plain and extends westwards to the Kharga Oasis depression and southwards and northwards outside the boundary of the present map.

The wadis running from the plateau towards the Nile are mainly controlled by the ENE-WSW and E-W fractures although their tributaries are controlled to a considerable extent by the other fractures and rock texture. In the north the wadis including W. Rimidin and W. El Magal are interrupted by the plain. In the south, however, the wadis run directly from the plateau to the Nile, these include W. El Kobbaniya, W. Kurkur and W. Kalabsha.

In the western part of the map the wadis are better developed southwards in comparison to the north where they drain westwards into the depression of Kharga Oasis being controlled largely by the ENE-WSW and E-W fractures. Southwards, the drainage is complicated, however, by the presence of various fracture systems and the gentler slope towards the west and south. Accordingly, W. Abu Silla, W. Mareef and other wadis draining the southwestern part of the plateau are essentially running in southwestern and southern directions.

STRUCTURE

The linear structural elements delineated by the examination of ERTS-1 satellite images are given in (Fig. 3) and they are represented essentially by folds and fractures.

Folds

The presence of sinuous trace extending NNW-SSE along Sinn El Kaddab escarp at the centre of the images and of more or less parallel crenulated lineations or traces in many parts of the investigated area reveals a major dominant folding system of ENE-WSW trend. These traces indicate that the folding which is of a regional nature is of the open type and slightly plunging WSW. Minor crenulations of the same type and trend are noted, thus proving the presence of smaller folds within the regional ones.

The folding influences the Cretaceous and early Tertiary sedimentary rocks in the area west of Aswan. Accordingly it is believed to have been caused essentially by the Upper Cretaceous-Tertiary diastrophism. It is noted that the trend of folding in

the presently investigated West Aswan area is ENE-WSW which is in agreement with the dominant younger fold trend in East Aswan area as given in Interim Report No. 4 of this series.

Fractures (Including Faults)

There are two major fault trends delineated in the images of West Aswan area, namely the NW-SE faults making notable horizontal separation and the NNW-SSE faults showing horizontal separation and indicated vertical separation along geological and relief boundaries. Furthermore, the NNE-SSW fault west Kurkur Oasis shows marked horizontal left-lateral separation of the Lower Esna Formation, Gebel Garra Formation and Upper Esna Formation.

Furthermore, two major fracture trends are widely distributed in the area namely the NE-SW and the ENE-WSW, E-W groups. The NE-SW fractures do not show separation, and they may be major tension fractures perpendicular to the principal force creating the previously mentioned two major fault trends. The ENE-WSW, E-W fractures seem to represent tension zones along the hinges of major folds which may have been faulted along the same zones.

Other shorter lineations are found in closely spaced patterns which are usually related to major fractures and faults. The NW-SE lineaments are observed to the west of Idfu and Kom Ombo towns, and near the northern part of the escarp. The NNW-SSE lineaments are noted to the west of Aswan town, and near the middle and southern parts of the escarp. Near Kalabsha on the western side of Lake Nasser lineaments are abundant in a N 35° W - S 35° E direction. Furthermore, crenulated lineaments of a N-S trend have been also recorded near the escarp. At the western side of the plateau notable widely separated lineaments are noted trending N-S to N 10°E-S 10° W.

As it was mentioned earlier in this report, some of the fractures and faults, particularly the NNW-SSE and ENE-WSW, E-W trends intercepting Lake Nasser (Aswan Dam Reservoir) should be given careful detailed investigation. This is essential to determine their significance on the seepage and possible future development of diversion channels from the Lake.

Comparing the present investigations with previous studies related to the structure of West Aswan area (Issawi, 1968; Barakat and Ashri, in press) it may be noted that major folds and faults reveal in general greater continuity in the present work, and the groupings of short lineaments echoing large fractures and faults are better delineated. However, the small structural basins and domes associated with faults which have been mapped by the previous authors have not been noted in the present work.

GEOLOGY

The geology of West Aswan area is dominated by a sedimentary succession ranging from Cretaceous to Quaternary. The igneous-metamorphic rocks are represented by the exposures of Aswan monumental granite and associated rocks in the vicinity of Aswan town on the east side of the Nile, as well as, by small outcrops on the west bank of the river, apart from small parts of outcrops of gneisses and pink granite. The igneous-metamorphic rocks are of Precambrian age passing into early Paleozoic and their characteristics in ERTS-1 images have been given already in Interim Report No. 4 of the present series (El Shazly, Abdel-Hady, El Ghawaby and El Kassas, 1973).

The most important point revealed by ERTS-1 images in this respect is the distinction of Aswan monumental granite by its medium grey tone and medium texture from the pink granite with its light tone and fine texture. This distinction is of particular importance in the geology of Egypt and the evolution of granites in relation to major tectonics (El Shazly, 1970).

The sedimentary column in West Aswan area starts by the Cretaceous Nubian Sandstone which covers the southern part of the plain on the west side of the Nile termed Kalabsha plain, as well as, large exposures north of Aswan town. In the studied area the Nubian Sandstone is distinguished on the ERTS-1 images into four units each possessing characteristic tone and texture. The basal unit is of coarse texture and of darker grey colour. The iron-ore member is the darkest in colour among the Nubian Sandstone exposures and has a medium texture. The undifferentiated unit is of grey tone and with a medium to fine texture, while the Nubian Sandstone with wind-blown sand is light grey to yellowish in tone with medium texture and lineated with sand of greyish tone.

The Fourth Calcareous Sediments cover the greatest part of West Aswan area especially on the Western side of the Nile. They range in age from Upper Cretaceous to Lower Eocene being represented by seven geological formations, the youngest one of them namely Gebel Serai Formation has been distinguished into two units of variable tone and texture. The Upper Cretaceous formations namely Wadi Abbad Formation, Gebel Duwi Phosphate Formation, and Lower Esna Formation have been described in Interim Report No. 4 of the present series. Of economic importance, however, is the distinction on the satellite images of G. Duwi Phosphate Formation - which incorporates the phosphorite beds - by its very coarse texture and medium grey tone.

The escarp on the western side of the Nile starts at the base with the Lower Esna Formation, followed upwards by the essentially Paleocene Gebel Garra Formation and the Lower Eocene Upper Esna Formation and Gebel Serai Formation. Gebel Garra Formation is made up of chalk and limestone with subsidiary marl and shale (Issawi, 1968), and it is well developed in the investigated area although it tapers off northwards. This formation possesses a fine to medium granular texture, a medium grey tone and is lineated parallel to the escarp.

The plateau covering the central and western parts of the images is capped by: the Upper Esna Formation - especially towards the south and exposed in the wadis, and Gebel Serai Formation - which is distinguished into a basal unit covering in particular the higher elevations in the southern part of the plateau and the proper well developed formation in the northern part of the plateau with its typical limestone lineated in the images with widely spaced fractures. The geology of the southern part of the plateau and plain are in general agreement with the investigations of Issawi (1968) on Kurkur-Dungul stretch. Kurkur Formation has been, however, distinguished in the images only in Gebel Marawa.

The Fifth Detrital-Calcareous-Evaporite Sediments are of particular interest in the investigated West Aswan area and they show great variation. Tufa and calcite are delineated towards the eastern and western side of the plateau. According to Butzer and Hansen (1968) tufa is of Pliocene age passing into Quaternary being related in origin to paleoclimatic conditions. The delineation of the tufa northwards of Kurkur Oasis has been established in the geological map of West Aswan area interpreted from ERTS-1 images, as well as, the possible relation between the tufa and the fracture systems observed in the area especially in their intersections. The authors of the present work are accordingly advancing the theory that the

tufa and calcite are originally related to the hydrothermal activities of the tectonic movements of the late Pliocene-early Quaternary, which have been partly mobilized and redeposited by the climatic conditions prevailing in the later Quaternary.

The Quaternary deposits in West Aswan area have been distinguished into Darb El Gallaba gravel, conglomerate, playa, alluvium-eluvium and surficial deposits which are mainly alluvium, each of these is characterized by its particular texture and tone. Darb El Gallaba gravel covers the northern part of the plain west of the Nile, the gravel is accumulated by a Pleistocene Nile running at this locality to the west of the present Nile (Butzer and Hansen, 1968). Conglomerate accumulated on the southern part of the escarp slope, while playas are superimposed on the Nubian Sandstone plain not far from Kalabsha. One of the points of interest provided by studying ERTS-1 images is the distinction between the alluvial-eluvial deposits which have not been transported for long distance from their source rocks and the alluvial deposits which have been moved for longer distance from their source - in West Aswan area the former have been found to be relatively coarse in texture than the latter.

The compiled geological map of West Aswan area has been reproduced in (Fig. 6) (after the geological map of Egypt - published by the Geological Survey and Mineral Projects Authority in 1971) for the purpose of comparing it with the present geological map of West Aswan area interpreted from ERTS-1 satellite images (Fig. 4). The number of the geological units distinguished on our satellite images interpreted map are 22, while the number of geological units separated in the compiled map are only 7. Of particular importance is establishing the continuity of the geological units in the northern part of the area in (Fig. 4) as well as the continuity of the structural elements in the presently constructed structural lineament map in (Fig. 3) as compared to the compiled map in (Fig. 6).

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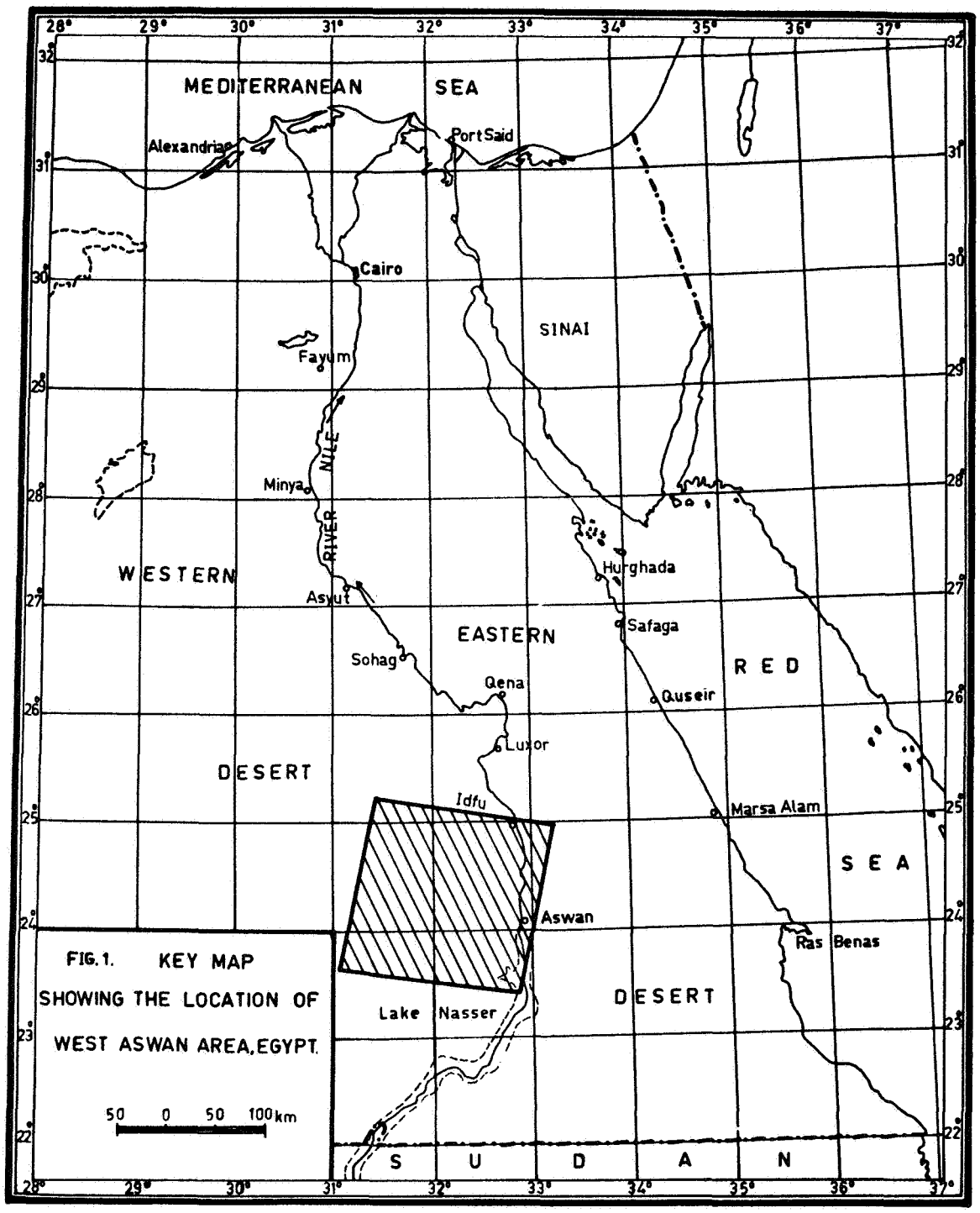


FIG. 1. KEY MAP SHOWING THE LOCATION OF WEST ASWAN AREA, EGYPT.

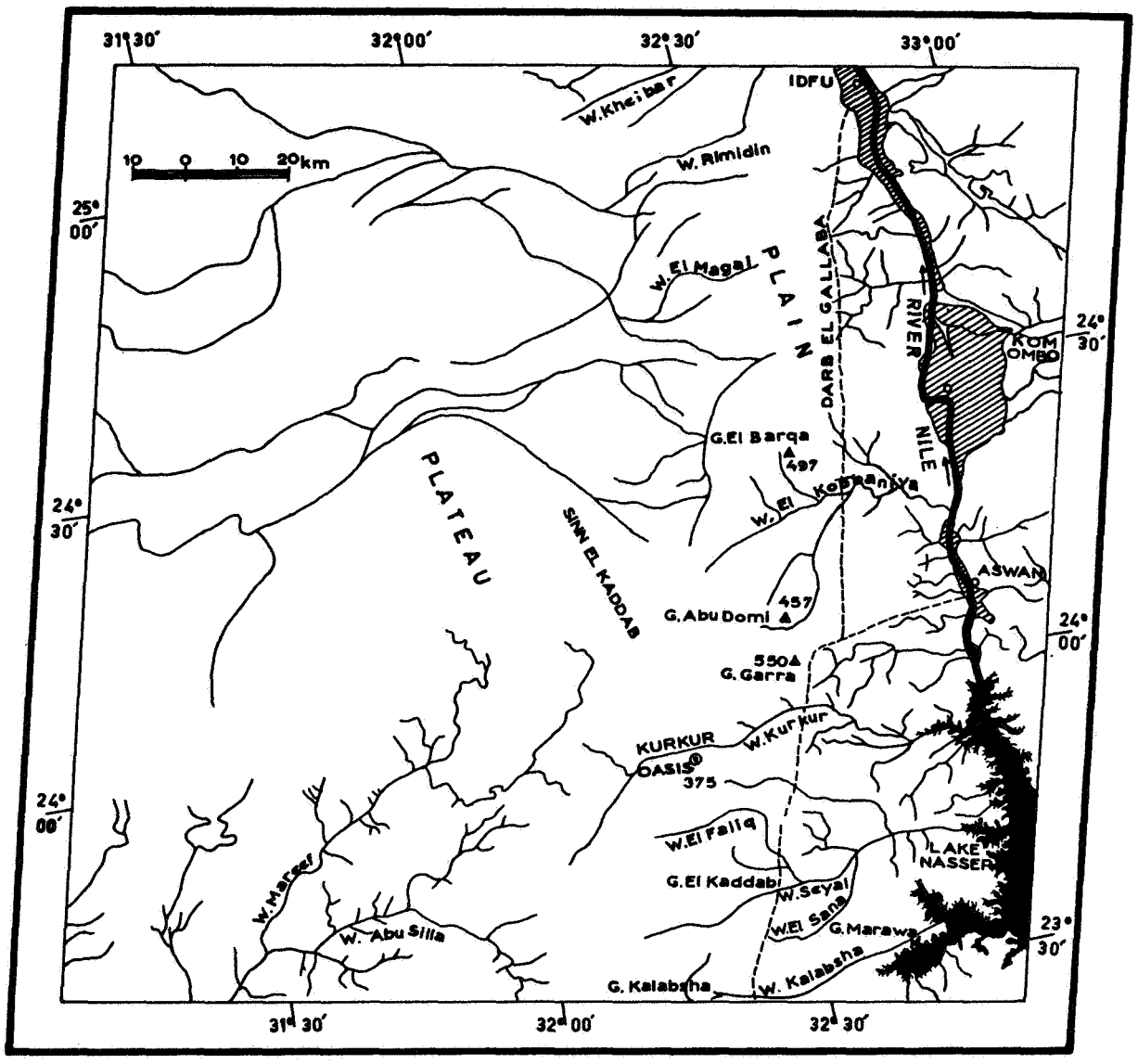


FIG.2. **GENERAL DRAINAGE MAP OF WEST ASWAN AREA**

(FROM ERTS -1 SATELLITE IMAGE)

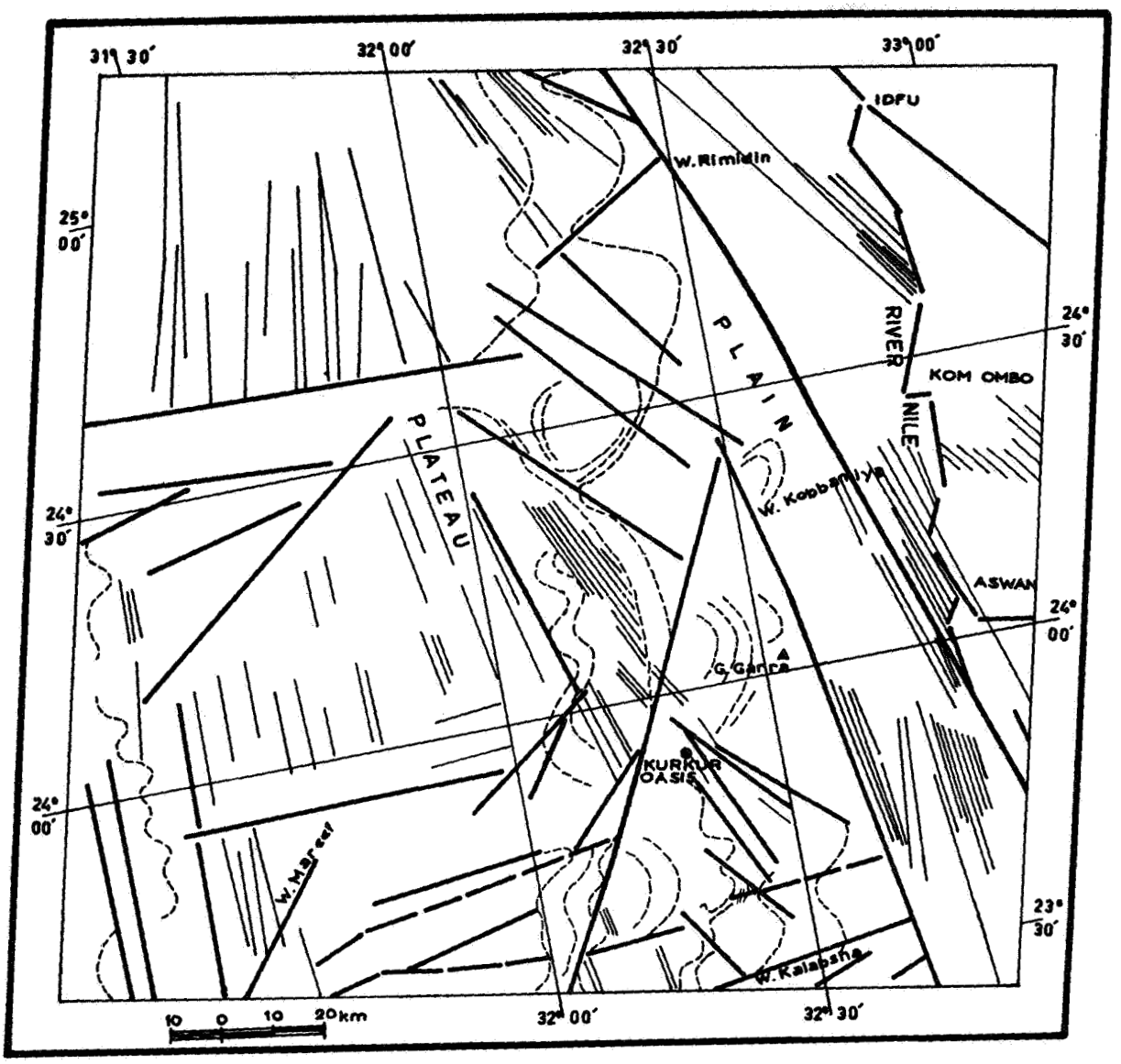
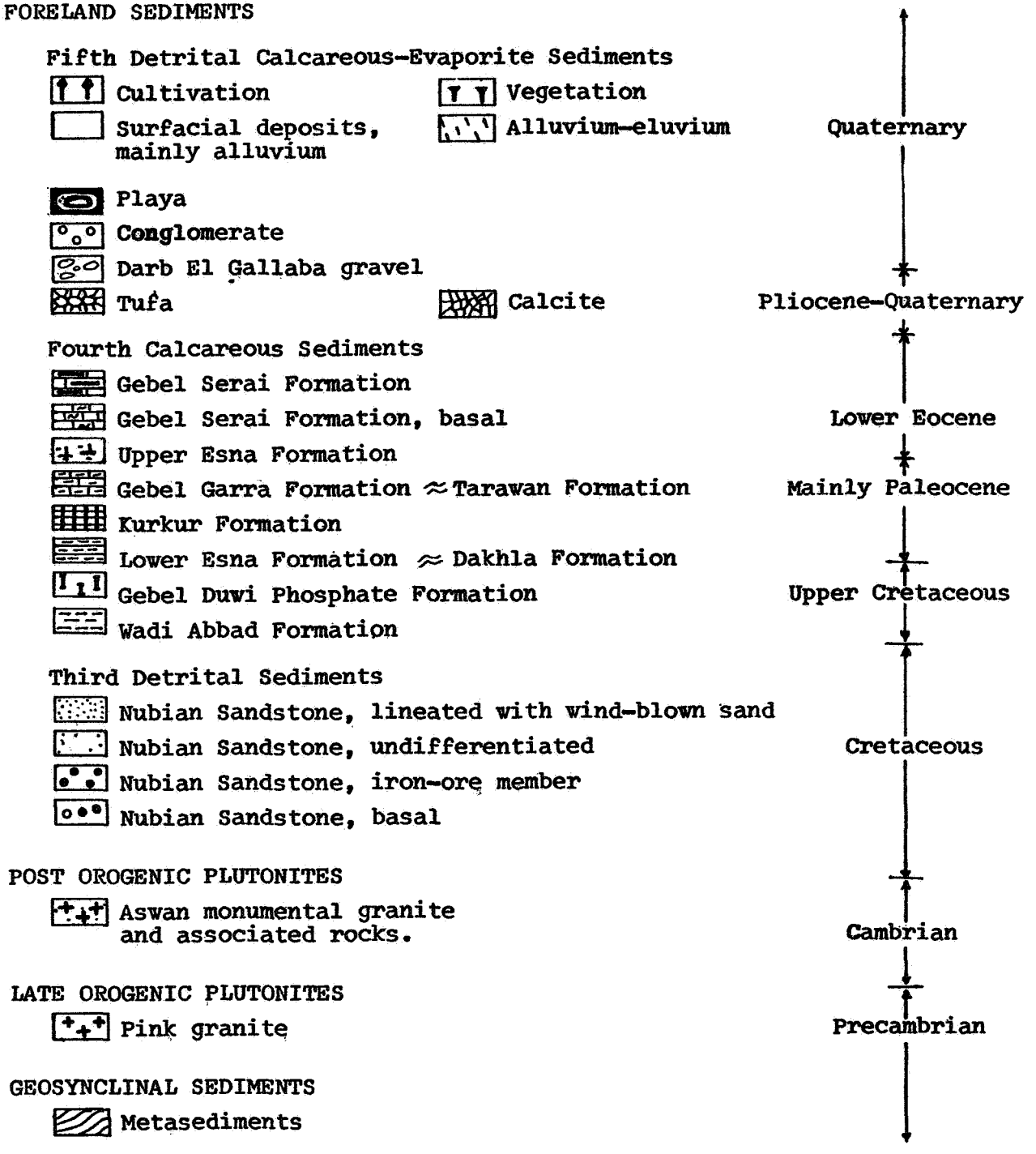


FIG.3. STRUCTURAL LINEATION MAP OF WEST ASWAN AREA

(FROM ERTS-1 SATELLITE IMAGES)

FOLDS — FRACTURES INCLUDING FAULTS — OTHER LINEAMENTS

LEGEND OF FIG. 4



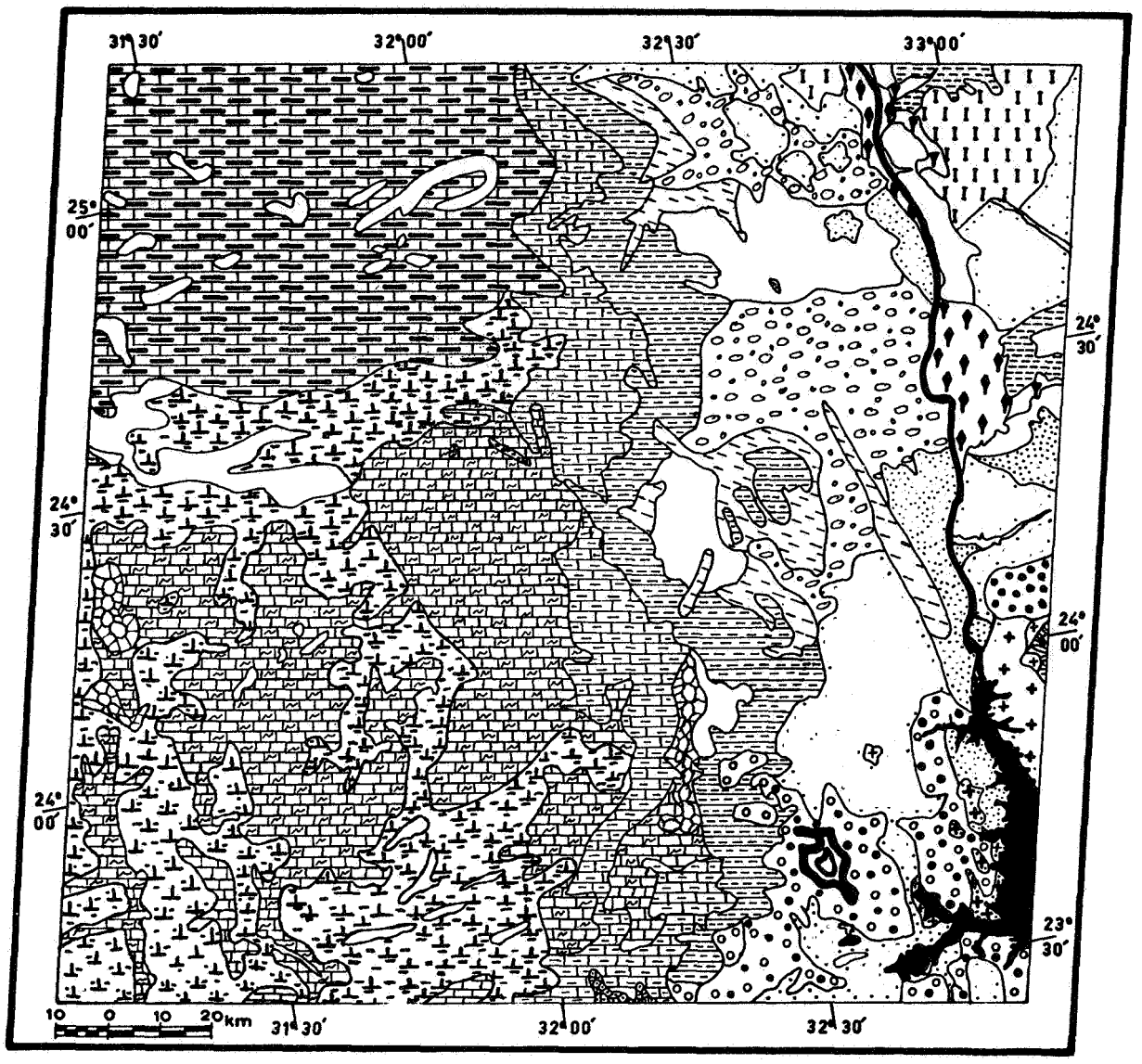


FIG 4. GEOLOGICAL MAP OF WEST ASWAN AREA

(FROM ERTS-1 SATELLITE IMAGES)

FIG. 5. INFRARED IMAGE OF WEST ASWAN AREA

(ERTS-1 SATELLITE, NOV. 1972)

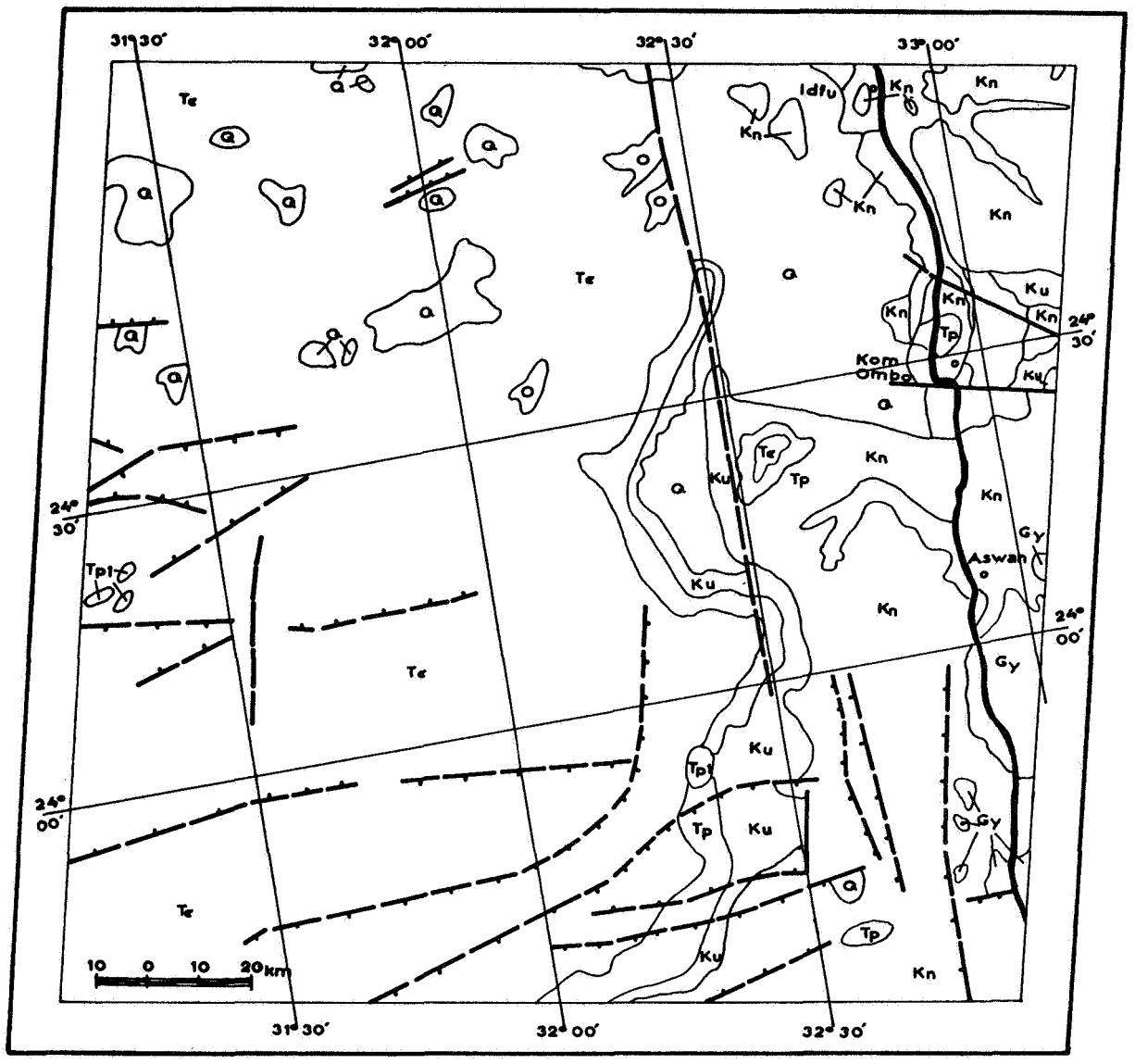


FIG. 6. **COMPILED GEOLOGICAL MAP OF WEST ASWAN AREA**

(AFTER GEOLOGICAL MAP OF EGYPT, 1:2 000 000, 1972)

ويسيطر على تركيب منطقة غرب اسوان الطيات المفتوحه والمتجهه شرق شمال شرق — غرب جنوب غرب ، ويظهر هذا النوع من الطى اقليميا وعلى المستوى الصغير كذلك • وتتبع الكسورات والفوالق عدة اتجاهات وقد تمتد لمسافات طويلة اوقد تظهر كمجموعات قصيرة موازية للكسورات الكبرى •

وقد أمكن فى هذه الدراسة من صور سفينة الفضاء سفتط — ١ (ERTS-1) حصر ٢٢ وحدة جيولوجيه وضعت على الخريطة الجيولوجية لمنطقة غرب اسوان ، بينما اظهرت الخريطة الجيولوجية السابقة المجمعة من مصادر مختلفة والمنشوره فى عام ١٩٧١ سبع وحدات جيولوجية فقط بنفس المنطقة • وتتراوح هذه الوحدات من حقب ما قبل الكمبرى المتوغل فى القديم الى الحقب الرباعى الذى يستمر حتى عصرنا هذا • وقد امكن فى هذه الدراسة تمييز جرانيت اسوان من الانواع الاخرى من الجرانيت ، وكذلك الحجر الرملى النوبى الحامل لخامات الحديد ، والتكوين الجيولوجى الذى تتخلله طبقات الفوسفات ، مما يدعم الاهمية الاقتصادية للدراسة الحالية • وقد تم التوصل من الناحية العلمية الى استنتاجات هامة تختص بامتدادات التكاوين الجيولوجية من الجنوب الى الشمال ، والتفريق بين الانواع المختلفة من الرواسب الحديثة نسبيا ، ومناقشة نشأة التوفا وطريقة تكوينها •

وقد تعرضت الدراسة الحالية لمسألة الكسورات والفوالق التى تعترض بحيرة ناصر وأوصت بالقيام بدراسات تفصيلية لمعرفة خصائصها من ناحية نشاطها وانفتاحها ومادتها المالئة حتى يتسنى تقييم احتمالات تأثيرها على المياه المخزونه فى البحيرة ، وهى دراسات اساسية ولها اهميتها الكبيرة من الناحية الهندسية — الجيولوجية ولتلافى اى تأثيرات ضارة مستقبلا تنشأ عن تأثير بعض هذه العوامل الجيولوجية على الجوانب الهندسية لمثل هذا المشروع الحيوى الهام •

ويعطى هذا التقرير أمثلة واضحه للفوائد الكثيرة التى يمكن استنتاجها من دراسة الصور المأخوذه عن طريق سفن الفضاء الخارجى لاغراض مسح واستكشاف الثروات والموارد الطبيعية للارض ، والكشف عن بعض الظواهر والعوامل الجيولوجية التى تؤثر على المشروعات الهندسية والقومية الهامة •

الدارسة الجيولوجية للصور الالكترونية
المجمعة بواسطة سفينة الفضاء سفتا ـ ١
لمنطقة غرب اسوان ، جمهورية مصر العربية

اعداد

الشاذلى محمد الشاذلى[١] محمد احمد عبد الهادى[٢] محمد عبد الرازق الغوابى[٣] ابراهيم القصاص[٤]

الملخص

درست الصور الالكترونية المجمعة بواسطة سفينة الفضاء سفتا ـ ١ (ERTS-1) والمأخوذه فى اربعة مجالات ضوئية مختلفة لمنطقة غرب اسوان ، من الناحية الجيولوجية والتركيبية وخطوط الصرف ، ثم قورنت هذه الدراسة بالابحاث السابقة عن نفس المنطقة فى المجالات سالفة الذكر . ويعتمد صرف النيل فى المنطقة المدروسة أساسا على العناصر التركيبية ذات الاتجاهات شمال ـ جنوب ، شمال شمال غرب ـ جنوب جنوب شرق ، شمال شمال شرق ـ جنوب جنوب غرب وكذلك على الانحدار ناحية البحر الابيض المتوسط . وتتخذ الوديان وهى مجارى السيول عامة اتجاه الكسورات شرق شمال شرق ـ غرب جنوب غرب ، شرق ـ غرب وتتجه مع الانحدار الى النيل فى الجزء الشرقى من المنطقة ومع الانحدار ناحية المنخفضات بالصحراء الغربية فى الجزء الغربى منها . وتشغل تفرعات بحيرة ناصر من ناحيتها الشمالية (التى تظهر فى الصورة) الوديان والكسورات الارضية . وهذه ظاهرة لها أهميتها القصوى من الناحية الهندسية ـ الجيولوجية لما قد يترتب عليها مستقبلا من فاقد بالتسرب مع خلق تفرعات رئيسية من البحيرة قد تساعد فى تكوينها عوامل النحر من تسرب المياه من البحيرة خلال الشقوق والفوالق المفتوحة او الممتلئة بمواد غير صلبة .

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١) نائب مدير هيئة الطاقة الذرية ، ورئيس المجموعة الجيولوجية بمشروع الاستشعار من البعد اكاديمية البحث العلمى والتكنولوجيا ـ القاهرة .

٢) أستاذ الهندسة المدنية بجامعة ولاية اوكلاهوما بالولايات المتحدة الامريكية ، ومدير مشروع الاستشعار من البعد ـ باكاديمية البحث العلمى والتكنولوجيا ، القاهرة .

٣ ، ٤) جيولوجيان بهيئة الطاقة الذرية بالقاهرة .

جمهورية مصـــر العربيـــة

أكاديمية البحـــث العلمـــى والتكنولوجيـــا

الدراسة الجيولوجية للصور الالكترونية
المجمعة بواســطة سفينة الفضاء سـفتمـا ــ ١ (ERTS-1)
لمنطقـــة غرب اســـوان
جمهورية مصـــــــر العربيـــة

تقرير مبدئى رقـــــم ٥

مشـــروع الاستشـــعار من البعـــــد

بالتعـــاون مـع

ــ مؤسسة العلوم القومية ، واشنطون ، الولايات المتحدة الامريكيـــة

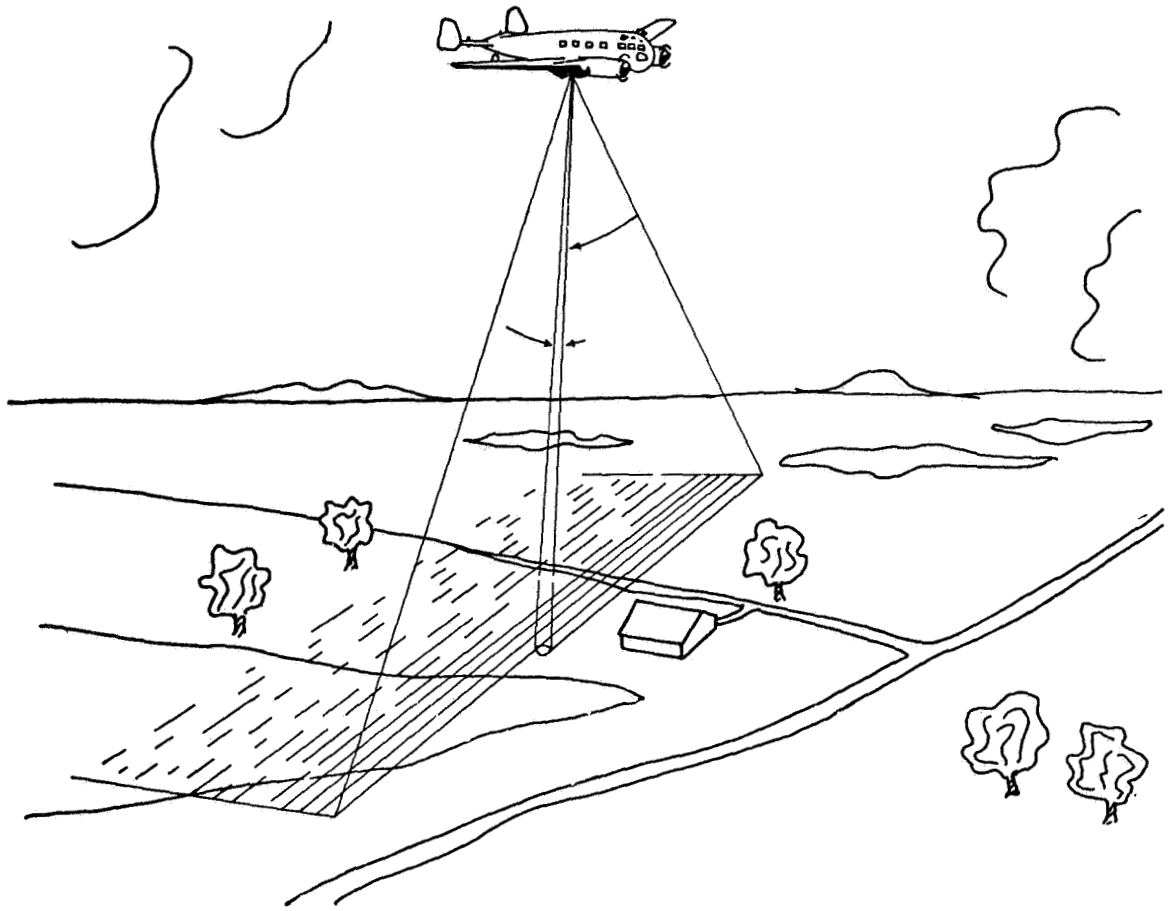
ــ جامعة أوكلاهومـا ، ستيلووتـر ، أوكلاهوما ، الولايات المتحدة الامريكية

الناشـــــر

أكاديميـــة البحث العلمى والتكنولوجيـــــا

القاهـــــرة ــ ج . م . ع .

(اكتوبـــــر ١٩٧٣)



ACADEMY OF SCIENTIFIC RESEARCH AND TECHNOLOGY

REMOTE SENSING RESEARCH PROJECT