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APPLICATION OF ERTS-1 IMAGERY IN THE FIELDS OF GEOLOGY, AGRICULTURE, FORESTRY, AND HYDROLOGY TO SELECTED TEST SITES IN IRAN

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ABSTRACT

The preliminary study of the ERTS-1 imagery coverage of Iran, commenced on October 26, 1972, upon receipt of the data. All of the images were carefully examined, and a photomosaic covering approximately ninety-five per cent of the country was prepared. A number of images, of selected areas were studied in detail.

In the field of geology, a number of large scale faults were identified, which do not figure on geological maps. Furthermore, a preliminary study was carried out on the recent sediments, their possible sources, and origin. A limited number of geological work maps were prepared as well.

In the fields of agriculture and forestry, studies based on color composite prints of certain areas were undertaken, with a purpose of identifying potential arable areas.

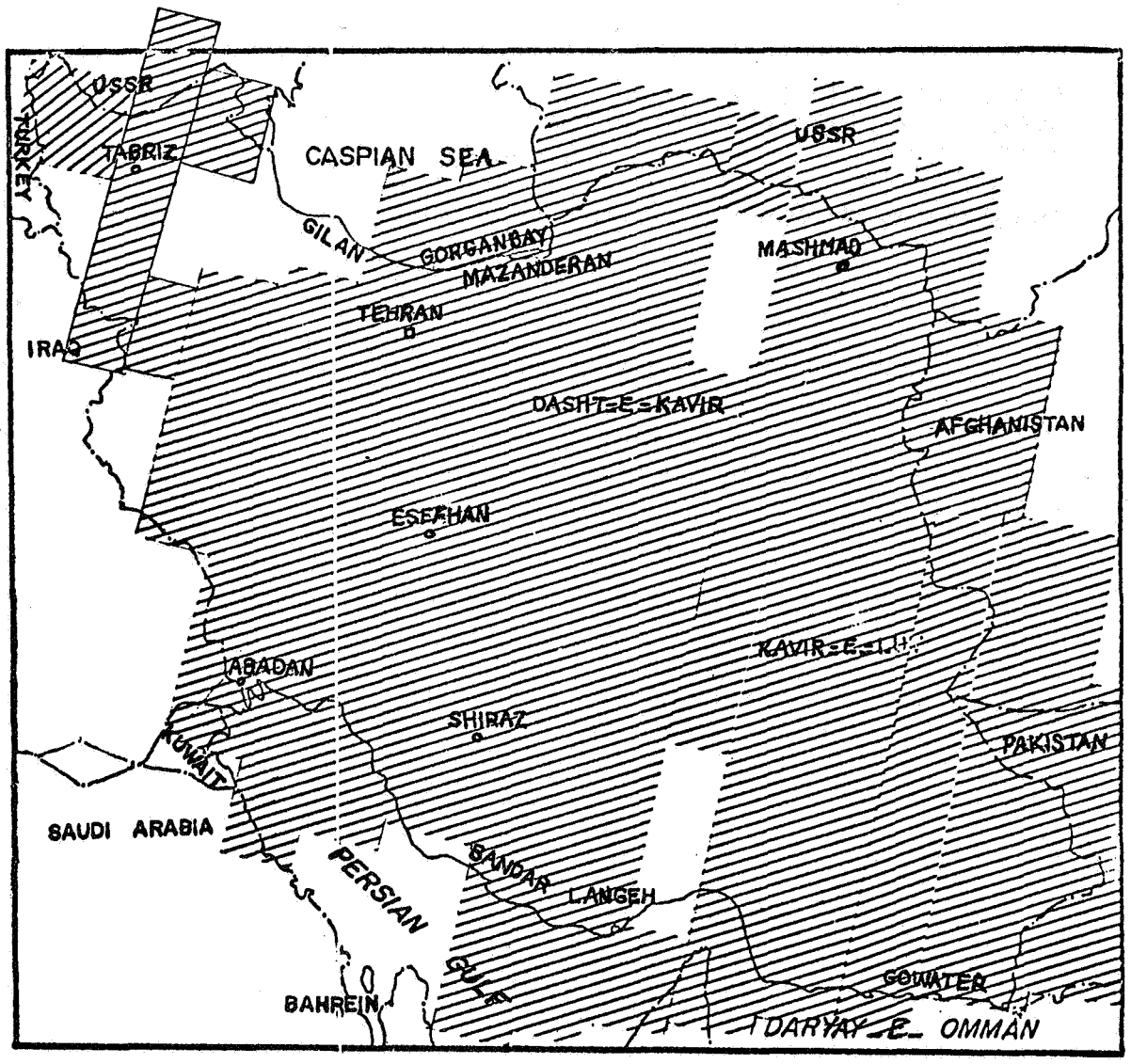
Investigations in the field of water resources resulted in the discovery of a number of small lakes, and streams. Furthermore, fluctuations of the water level in some lakes were observed.

INTRODUCTION

The first series of ERTS-1 imagery coverage of Iran were studied in a number of disciplines, i.e., agriculture, forestry, geology and hydrology. A general preliminary study in the above mentioned fields was undertaken, and particular emphasis was given to certain selected test sites. These results of the investigations and observations were accomplished with conventional photographic interpretation techniques which could be considerably expanded if multispectral imaging equipment permitted additive color techniques to be used.

Notwithstanding these constraints, some interesting observations were made which demonstrate the usefulness of the ERTS-1 data as a means of mapping and defining the natural resources of Iran.

Original photography may be purchased from:
EROS Data Center
10th and Dakota Avenue
Sioux Falls, SD 57198



Areal extent of ERTS-1 imagery coverage of Iran up to this date (coverage shown by shaded areas).

GEOLOGY

All of the ERTS-1 imagery were carefully examined, and a number of them were selected for detailed geological study. These images were compared with the 1:2,500,000 Geological Map of Iran, and the 1:1,000,000 Geological Map of SW Iran, compiled by the Iranian Oil Operating Companies.

Particular emphasis was given to the tectonics, and the lithology of different test sites. A preliminary study was also carried out on the recent sediments, especially in regard to evaporitic deposits in playas.

1. Tectonics

The major physiographic features of Iran are:

- The Alborz range: Located in the northern part of the country, with an E-W trend.

- The Zagros range: Situated in the central part of the country, with a NW-SE trend.

- Dasht-e-Kavir (Kavir desert): An area covered with alluvial and aeolian sediments, in the central part of Iran.

- Dasht-e-Loot (Loot desert): An area in the SE of the country, covered with alluvial and aeolian deposits.

By studying the mosaic of the ERTS-1 imagery, a major fault, several hundred kilometers in length, and more or less parallel to the Zagros Thrust Fault was identified. This fault was not previously recorded, and thus does not appear on geological maps.

Preliminary study of the imagery taken by ERTS-1 of the SE corner of Iran, denotes the presence of a larger number of faults than what appears on our geological maps.

Numerous anticlines, synclines, and salt domes which characterize the SE part of the Zagros range, are clearly visible on the image taken of the Bandar Lengeh area (part of test site A). Thus a regional map of the area was prepared to complement existing large scale maps.

Two fairly large faults with a NW-SE trend were identified on the ERTS-1 images taken of the Isfahan area. These faults do not appear on any of our geological maps.

2. Lithology

A relatively detailed study of the consolidated, as well as the unconsolidated sediments, was carried out on the imagery taken of Isfahan. As a result, different types of recent unconsolidated sediments; i.e., lake evaporitic deposits,

river deposits, and talus, were differentiated using tonal changes. Areas covered by the weathered, and eroded by-products of nearby igneous and metamorphic source rocks (Protores), are visible by dark-grey to black shades. Whereas, by-products of the weathering, and erosion of sedimentary rocks, appear as grey patches. Finally, sediments (mostly evaporites) present in playas, and river channels, are visible as white patches.

On the imagery taken from the extreme SE region of Iran (near the Pakistan border), a number of igneous bodies were identified which are not present on our geological maps. In order to determine their nature, as far as being lava flows, or intrusions, it is planned to study thoroughly this area in the near future.

In general, it can be stated that where geological maps of Iran do not differentiate alluvial deposits, and classify them into different lithological categories, it is possible with a fair degree of certainty, by using tonal changes which different recent sediments exhibit, to further refine their lithological nature, and thus discern differences and subtle facies changes.

Conclusion

It appears that notwithstanding the relatively short time, and the very limited hardware available, some encouraging results were obtained in the application of the ERTS-1 imagery to the field of geology. Hence, it is assumed that by embarking on a detailed field geological investigation program, more fruitful results will be achieved.

AGRICULTURE AND FORESTRY

Investigations in the fields of agriculture and forestry were subject to constraints, for lack of adequate hardware, and especially insufficient repetitive ERTS-1 imagery coverage of Iran. Nevertheless, a few noteworthy observations were made, which demonstrate the usefulness of the satellite imagery for natural resources inventory, and planning in these disciplines.

1. Agricultural and Forestry Survey of the Isfahan Area

Study of the ERTS-1 false color composite prints (MSS bands 4, 5 and 7), of the greater Isfahan area (in central Iran) was undertaken, in order to determine the nature, and distribution pattern of the cultivated fields, as well as the natural vegetation.

As stated above, due to the lack of the required hardware, a definite distinction between different types of cultivated fields and/or crops was not

possible. Nevertheless, cultivated areas were identified, and distinguished from the forested regions. It was possible to delineate cultivated lands around the Zayandeh-Rood river and its tributaries, and also identify potential arable regions.

These regions appear capable of sustaining plant life, and their absence could presumably be due to one, or a combination of the following factors:

- Chemical nature of soil; i.e., too alkaline.
- Physical nature of soil; i.e., texture, permeability, porosity, etc.
- Topography; e.g., steep gorges, or slopes which are being continuously washed by running surface waters.
- Geographical isolation; too distant from the nearest inhabited areas, therefore at the present uneconomical.

Thus, it is planned to start a program of field investigations, with a purpose of collecting adequate ground truth data, in order to identify what is (are) the limiting factor(s), and define possible remedy(ies).

2. Mazandaran-Damavand Region

On the color composite prints (MSS 4, 5 and 7) of the Mazandaran province (including the Damavand volcano), areas covered with vegetation are readily observable. Although at the present with inadequate hardware, and insufficient field data, no attempt was made to distinguish different types of crops or genera of trees, yet different tones of red and pink were believed to be linked to the following phenomena:

- Diversity of tree genera and species.
- Forest distribution and density.
- Presence of areas covered with shrub.
- Deforestation, and timber cutting.
- Possible conversion of forested regions into cultivated or pasture land.

Conclusion

It is firmly believed, that with sufficient ERTS-1 imagery coverage of Iran a resource inventory covering forested regions as well as farmlands can be established. The first order priority will be given to the Mazanderan, Gilan, and Azerbaijan provinces, which are rich in vegetation cover.

WATER RESOURCES

This phase of the investigations consisted of a general study of the ERTS-1 imagery coverage of the Fars province, the SE corner of the Caspian Sea, the Hozsultan salt lake, and the NW region of the Persian Gulf.

The following observations are of significance:

1. Lakes: their location, areal extent, seasonal fluctuations, as well as water quality may be assessed.

2. Rivers: river channel, drainage pattern, and their sources in relation to the snow melt or springs, can be determined.

3. Alluvial Deposits: it is possible to differentiate, and map alluvial deposits, and estimate the areal extent of alluvial plains, and alluvial fans.

4. Marine Phenomena: study of the discharge of stream sediments into the Persian Gulf, the Caspian Sea, and finally the nature and directions of the offshore currents, may be determined.

1. Lakes

The nature, distribution, and location of water bodies, as observed on the photo-mosaic of the ERTS-1 images, were compared with the 1971 Hydrological Map of Iran, with the following results:

a. Three new lakes were identified on the ERTS-1 imagery coverage of the Fars province, which do not appear on hydrological maps of this region. These lakes are:

   - The Dariush Kabir dam and reservoir built on the Kor river in 1972.
   - A small lake, North of the Parishan lake, in the Kazeroon area.
   - A small lake, in the Sivand river basin.

The absence of these lakes on hydrological maps may possibly be explained by the following reasons:

- The Hydrological Map of Iran was published in 1971, and at that time construction of the Dariush Kabir dam, and its associated reservoir was not completed yet.

- The amount of precipitation during the year 1971-1972, exceeded that of the previous years. Hence, topographic depressions were filled with water, and thereby new lakes were formed.

b. Another interesting feature was observed while studying the ERTS-1 images taken of the Fars province. It was noticed that water bodies exhibit tonal differences. This phenomenon presumably is due to one, or a combination of the following factors:

   - Depth of water.
   - Chemical composition of water.
   - Presence of organic material, i.e., algal growth.
   - Industrial pollution of water (although rare).

c. An important observation was recorded, relevant to the fluctuations of the water-level in the Hozsultan salt lake. The image taken by ERTS-1 on September 4, 1972, shows a small body of water, about 18 km^2 in size, present in the western part of this salt lake. But on the following series of images taken 18 days later, the areal extent of this body of water had significantly decreased, to the point of being barely discernible. This phenomenon is probably due to extensive evaporation, and very little surface or subsurface, replenishment.

2. Rivers

River channels, and their drainage pattern, are easily observable on the ERTS-1 imagery. Thus, after ascertaining the area of each watershed, with future repetitive imagery coverage, it may be possible to initiate seasonal yield forecasting for particular streams, taking into account snow coverage, and quality of each particular stream.

An interesting finding was made by studying the imagery taken of the Gowater Bay (near the Pakistan border), in the extreme south-eastern region of Iran. On the image taken of this area, four streams can be readily seen with a N-S direction, terminating into the Gowater Bay, whereas the Hydrological shows only three streams.

3. Alluvial Deposits

The areal extent, and boundary between different types of unconsolidated sediments are easily observable on the ERTS-1 images. Since most wells and Ghanats* in Iran are drilled or dug in alluvial deposits, the distribution and differentiation of the latter is of great significance for hydrogeological investigations, and artificial recharge in a country like Iran, where water is scarce.

4. Marine Phenomena

The following observations were made:

a. Gorgan Bay (Caspian Sea): a comparison between the ERTS-1 imagery taken of this region, with maps based on aerial photographs taken in 1955, indicates that the shape of this bay has significantly changed. It can be seen that the form of the barrier bar has increased eastward towards the mainland. Thus with time the entrance to the bay might eventually become obstructed. This phenomenon is presumably due to the lowering of the sea-level, and also to the accumulation of stream sediments which are being transported, and deposited by offshore currents.

b. On the ERTS-1 images covering the NW portion of the Persian Gulf, extensive delta formation and sedimentary deposition may be observed. In addition to the foregoing, the direction of some of the offshore currents are readily visible. The prevailing direction being from the northwest of the Persian Gulf, southeastward into the Oman Sea.

Conclusion

The preliminary observations, and results obtained, from the ERTS-1 imagery application to the field of hydrology were of significance. Hence, it is firmly believed that by complementing data derived from the interpretation of the satellite imagery, with field observations, a substantial as well as useful volume of data will become available for water resources planning in different regions of the country.

*Ghanat, is a horizontal interceptor to the ground water table, which is linked through a series of interconnected wells. The flow from the intercepted water table is thus directed through the underground channel to the population center.

SUMMARY AND CONCLUSIONS

The preliminary analysis of a number of selected ERTS-1 images was undertaken in the fields of geology, agriculture, forestry, and hydrology, with a purpose of testing its applicability and usefulness for mapping the natural resources of Iran. As a result, a number of phenomena, such as faults, streams, lakes, and potential arable lands were identified.

It must be pointed out, that due to a number of limiting factors, the results of this study is by no means conclusive. Notwithstanding, the relatively short time available, lack of sufficient hardware, and inadequate repetitive imagery coverage, yet, some encouraging results were obtained, which demonstrate the importance of satellite imagery application for multidisciplinary purposes.

FUTURE PLANS

The ERTS-1 program, according to NASA's definition, is a research and development type of project. Thus, rightfully, the Plan Organization of the Imperial Government of Iran approach to this project has been conservative. But in light of the encouraging results obtained thus far, we believe that a more detailed and thorough program of study may now be undertaken. To this effect, the next phase of the investigations will consist of the following:

- Purchase of the necessary color additive and enhancement hardware.
- Ground truth data collection program, in a number of selected test sites throughout the country.
- Formation of a larger multidisciplinary cadre of specialists.

A major project entitled: "Geological Mapping and Mining Exploration in Eastern Iran," will be shortly undertaken. The area is approximately 340,000 km^2, and covers nearly all of the geology test site B. This region will be the subject of detailed field geological investigations, and possibly airborne geophysics in a number of selected areas.

It is also planned to undertake a fixed-wing remote sensing study, as well as, detailed field investigations, in few selected test sites, for multidisciplinary purposes.

It is evident, that the above mentioned activities will be most helpful, and complementary to the volume of information derived from the ERTS-1 imagery interpretation.

B

REFERENCES

Geological Map of Iran, Scale 1:2,500,000. Compiled by the Geological Staff of the Iran Oil Co., 1959.

Geological Map of SW Iran, Scale 1:1,000,000. Compiled by the Geological and Exploration Division, IOOC, 1969.

Hydrological Map of Iran, Scale 1:1,000,000. Compiled by the Ministry of Water and Power, 1971.

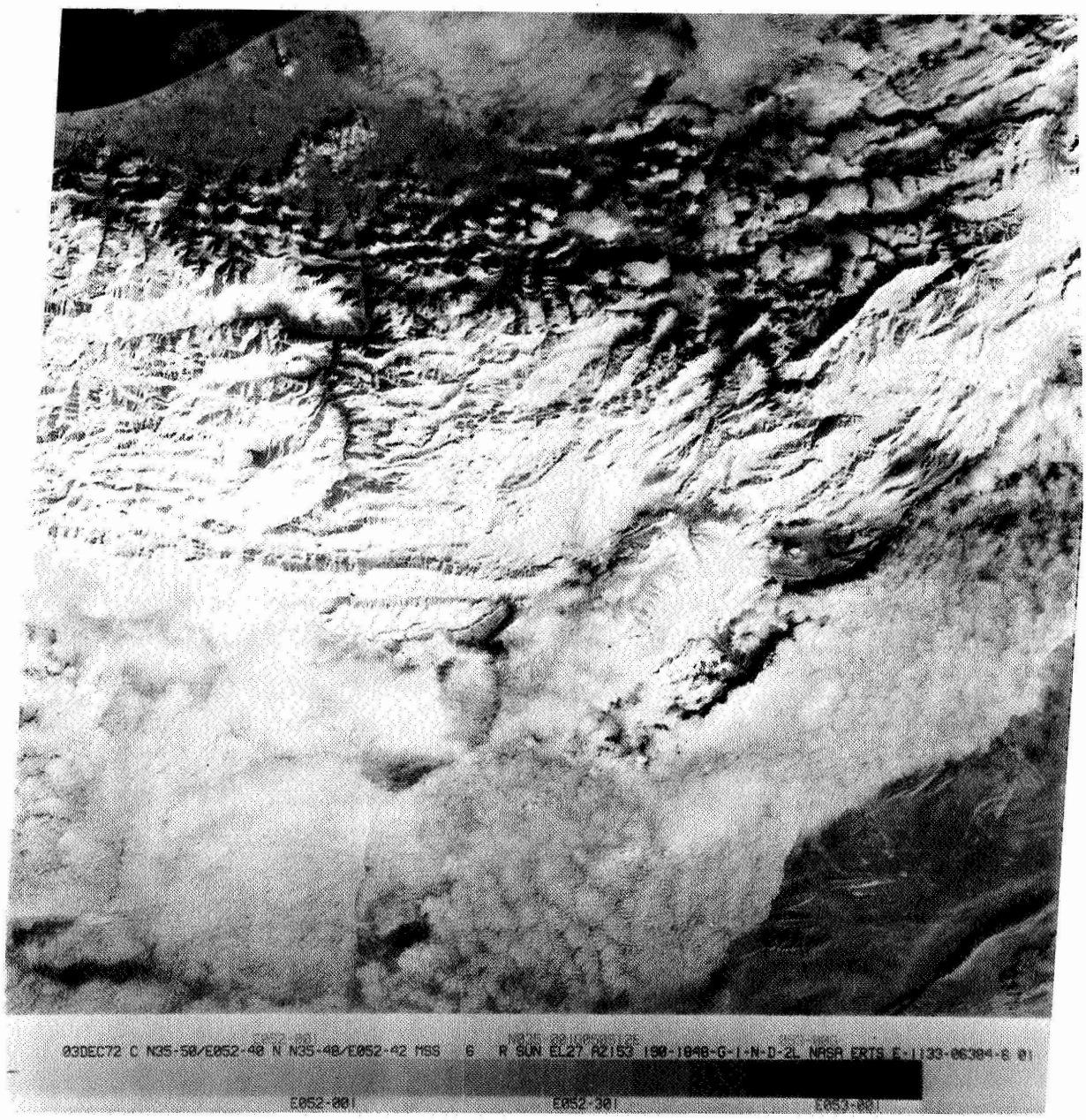


Plate I Damavand Volcano and Alborz Mountains in Mazandaran Province

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Plate II Northeastern Dasht-e-Kavit (Kavir Desert)

Plate III Isfahan, Central Iran

Plate IV Gowater Bay near Pakistan Border

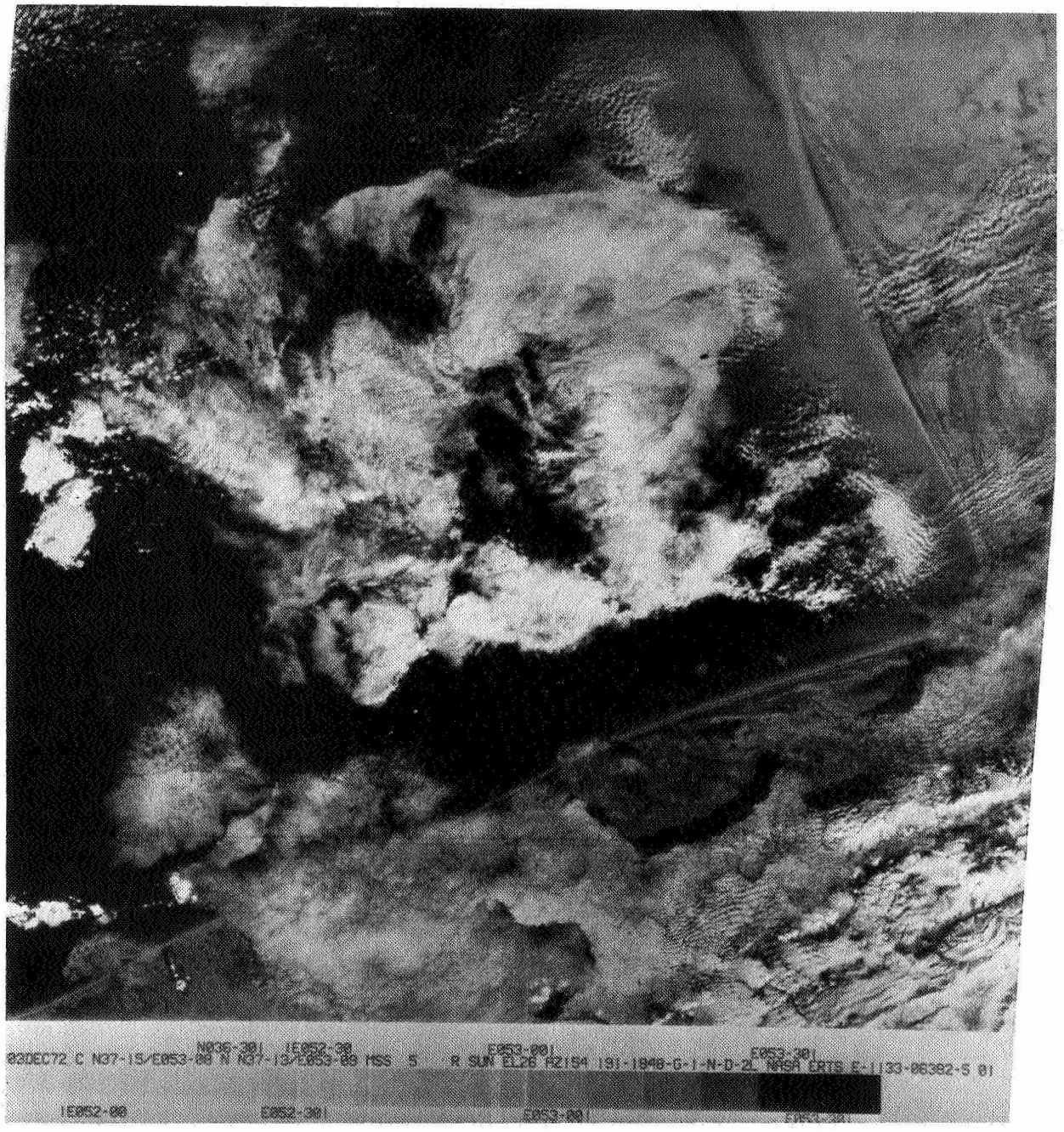

Plate V Gorgan Bay in Southeastern Caspian Sea

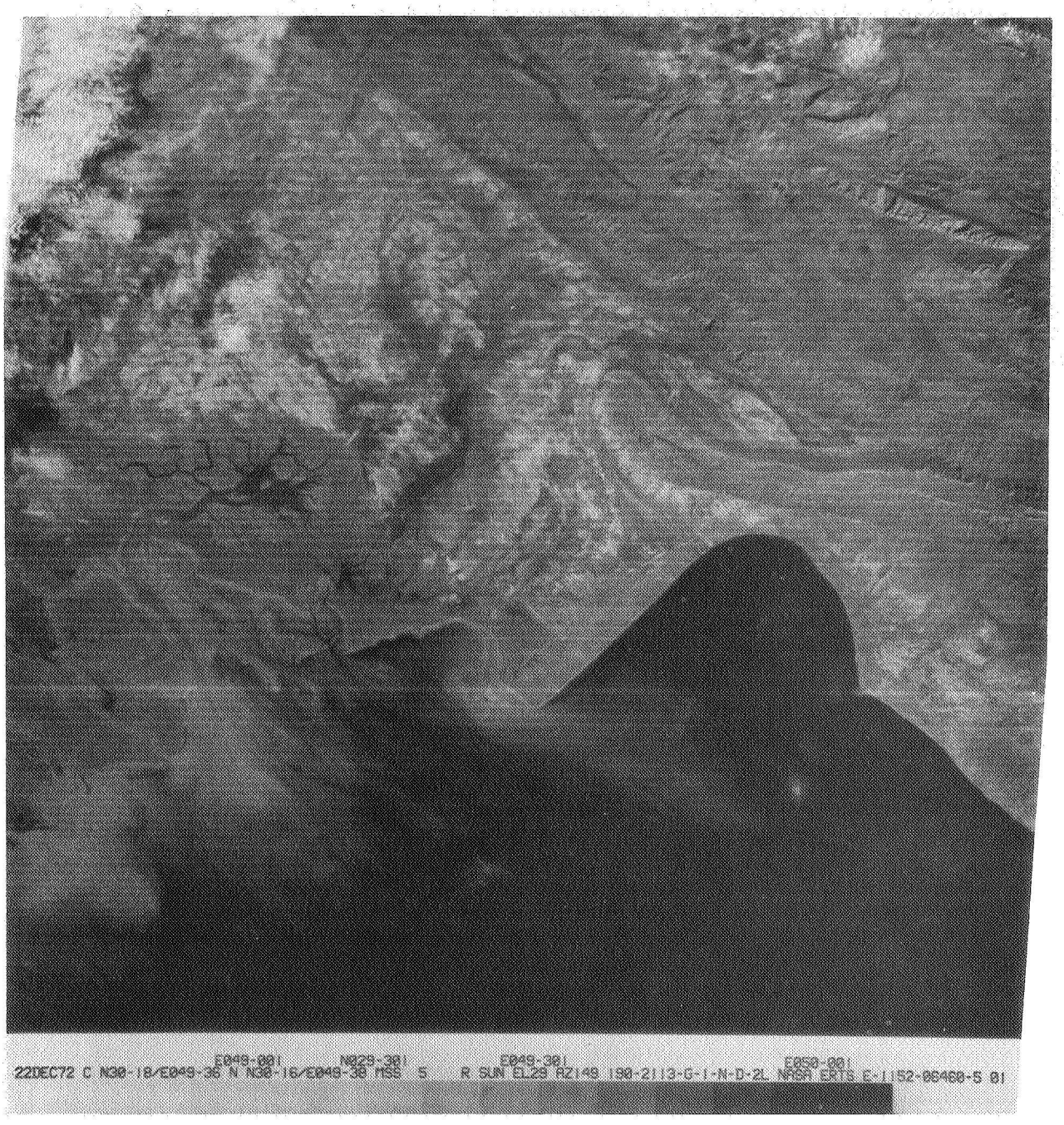

Plate VI Northern Part of Persian Gulf near Tigris/Euphrates Delta