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MINERAL EXPLORATION FROM HIGH-ALTITUDE IMAGERY

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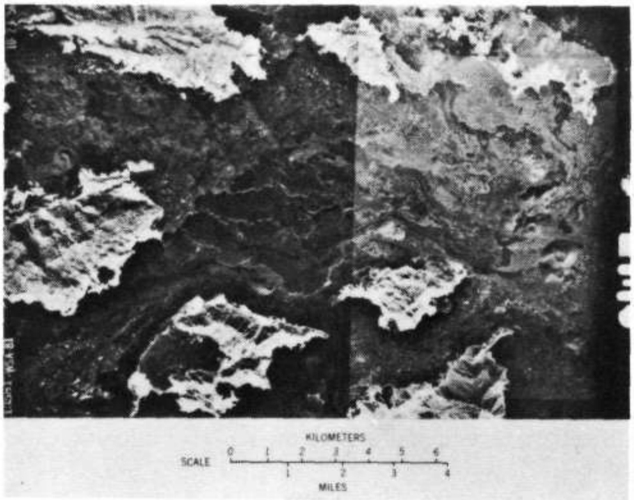
There is still considerable debate within the geologic community as to what types of remote sensing can best be done from spacecraft and what types can best be done from aircraft. To help resolve this problem, we selected five geologically distinctive areas in northwestern Saudi Arabia for detailed study. The areas were mapped as thoroughly as possible on each of several different types of imagery. The final objective was to identify those classes of geologic problems that can best be resolved using satellite data and then to identify areas where orbital imagery might profitably be used to extend existing knowledge, with emphasis placed on mineral exploration.

I have selected the Harrat volcanic area to illustrate some of the imagery used in this study and will point out a few of the advantages and shortcomings of each type. (See Figure 1.)

Standard aircraft photographs yield by far the greatest detail. At 1:60 000 scale, resolution of 6 m (20 ft) is adequate to define features as small as cooling fractures and collapse depressions on individual lava flows. The small area covered by individual photographs, however, makes it impossible to recognize the significance of the area in the regional context.

Photomosaics are constructed by reducing overlapping aircraft photographs to a convenient scale. We can readily see that they have an inherent patchwork pattern that results from the different photometric density of adjacent photographs; this can mask important but subtle linear and tonal features. At the 1:250 000 scale of this mosaic, resolution is reduced to 34.5 m (115 ft), but the subject area appears in context as part of a total volcanic field.

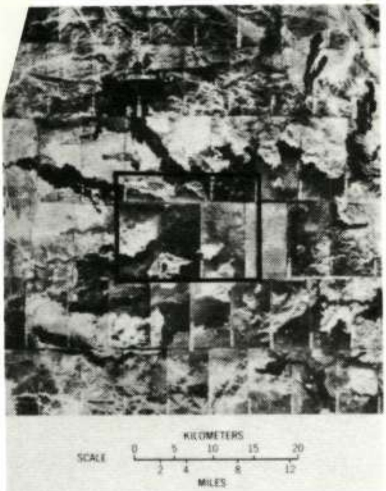
Resolution of the Gemini 11 photograph (Figure 1) is approximately 195 m (650 ft) in the area covered by the mosaic. This compares with 90 m (300 ft) expected of ERTS. Toward the horizon, however, the resolution degrades to more than 900 m (3000 ft) because of photographic obliquity. Although the resolution is low, the scene provides a useful overview for the study of regional tectonics and generalized lithology distribution. The subparallelism of the coasts is easily recognized and we can see finer structural detail, such as fracture patterns on both sides of the Red Sea. Based on textural and tonal differences, we can identify at least four generalized rock types on this picture; but even this gross classification can be subject to local interpretive error if not validated by field checking.



(*a*) Aircraft photograph, altitude 9.1 km (30 000 ft).

(*b*) Aircraft photomosaic.

Figure 1–Earth observations from spacecraft and aircraft.



(*c*) Gemini 11 photograph, altitude 410 km (220 n. m.).

(*d*) Nimbus 3 high-resolution infrared radiometer photograph, orbit 711, altitude 1110 km (600 n. m.).

Figure 1 (Cont.)–Earth observations from spacecraft and aircraft.

Nimbus imagery has about 8-km (5-mile) resolution. We find that this is too low for most geologic research, but it does provide a framework for interrelating major structural units within systems of intercontinental magnitude.

It is obvious, even from this comparative glimpse, that the synoptic view (such as the Gemini 11 photograph), despite its low resolution, is the best type of imagery for regional investigations. We determined that the mapping of the distribution and alinement of major structural fracture systems can be done particularly well from synoptic imagery, and such studies may yield important information for extending known mineral provinces.

After considering the geologic history of the Red Sea and noting the similar structural and stratigraphic relationships between a described mineral deposit in Saudi Arabia and mineral occurrences near the coast of Egypt, we have concluded that northwestern Saudi Arabia is particularly well suited for synoptic mapping designed to locate prospective areas for the occurrence of ore deposits.

The rationale for this conclusion is that, geologically, western Arabia was part of the Egyptian shield until it was separated by rifting of the Red Sea during Miocene time. The nature of the rifting mechanism is still conjectural; but, with the recent developments of Plate Tectonics concepts, the Red Sea is now generally considered to be an area of incipient continental drift. This means that, as indicated on the schematic, in Figure 2, the present coastlines were once contiguous, and of course implies that the pre-Miocene rock types near the present coasts should be very similar.

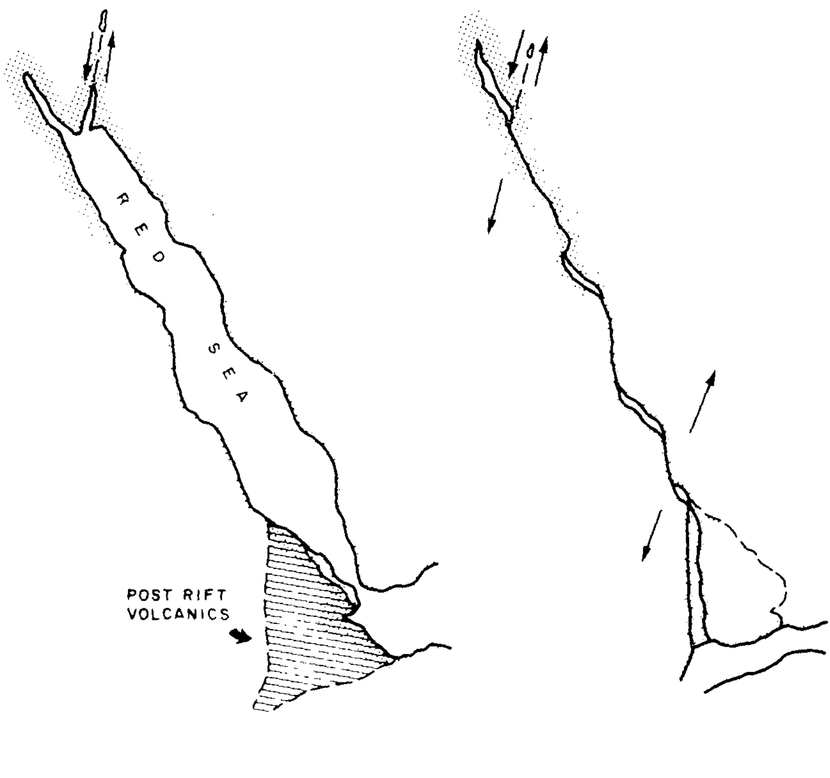


Figure 2–Schematic drawing of the Red Sea, present position (left) and reconstructed pre-Miocene position (right).

The map in Figure 3 shows locations of Miocene and older mineral deposits worked in historic time. Most of these are controlled by geologic structures such as fault zones. In contrast to Egypt, practically no mining has been done in the corresponding part of Saudi Arabia. Thus, locating ore deposits in Saudi Arabia might be possible if geologic structures there could be correlated with the Egyptian mineral-bearing structures; synoptic imagery with its uniform photometric geometry can provide the means for such regional correlation.

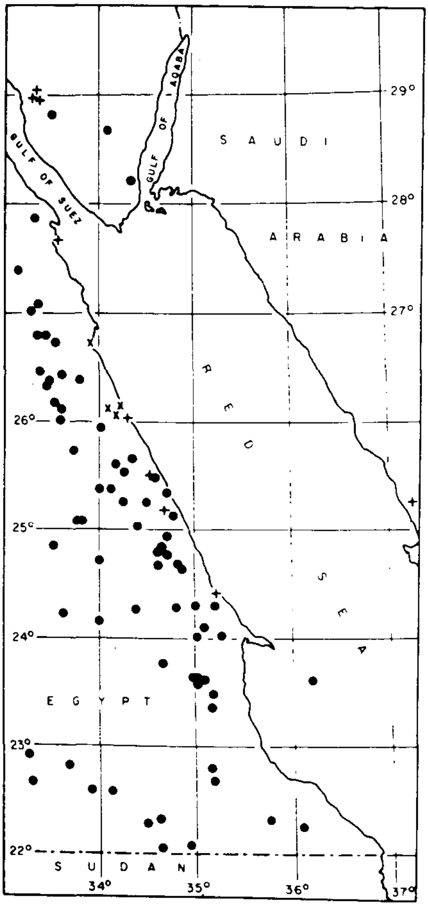


Figure 3–Map of Egypt showing locations of economic mineral deposits (from Ref. 1). •: pre-Cambrian mineral deposits; x: Cretaceous mineral deposits; +: Miocene mineral deposits.

Present investigations are restricted by limited coverage and the obliquity of available orbital photography. The availability of overlapping, vertical, high-resolution imagery from ERTS should permit systematic mapping of major structural trends on both sides of the Red Sea. Correlation of these trends then should provide the means of isolating the more prospective mineral-bearing fractures from the total structural system of western Arabia.

REFERENCE

1. Said, Rushdi: The Geology of Egypt, Delsevier Pub. Co. (Amsterdam-New York), 1962.