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MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

The Gulf of Suez: A Brief Review of Stratigraphy and Structure [and Discussion]

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The Gulf of Suez: a brief review of stratigraphy and structure

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This paper gives a brief review of the main elements of the complex stratigraphy and structure of the Gulf of Suez, with an attempt to interpret or rather speculate on the role of lateral movements in its development.

The stratigraphic record shows that the Gulf existed as a shallow embayment of the Tethys since at least the Carboniferous, and that a landmass lay at its southern end until upper Cretaceous. Predominantly clastic sediments characterizing its early history changed to calcareous marine since the Cenomanian. Intensive faulting and subsidence, associated with volcanic and intrusive activity was evident since Upper Cretaceous, reached a maximum towards the end of Oligocene, continued through the Miocene and into the Pleistocene; hot springs are still active at present. Structurally the Gulf was divided by van der Ploeg into four provinces delineated by NNE–SSW trending 'cross disturbances'. The four provinces appear to have formed two deep basins separated by two structural highs. It is speculated that the cross disturbances may represent transform faults between *en échelon* tension fissures (basins), produced as a result of a limited movement of Sinai towards the NNE relative to Africa, perhaps at a slower rate than the movement of Arabia.

1. Introduction

The Gulf of Suez is essentially a continuation of the northwest trend of the Red Sea; in its present form it extends from the southern tip of Sinai some 300 km ending near the city of Suez. The widest part of the Gulf does not exceed 50 km and unlike the Gulf of Aqaba the water is not more than 100 m deep. The present Gulf, however, occupies only the central part of a much larger depression which attained maximum development in the Miocene when the waters of the Gulf inundated the entire width of the basin between the cliffs of western Sinai and those of the Red Sea range to the west. Throughout most of its geological history the Gulf was essentially an elongated embayment of the old Tethys seaway. The latter was essentially destroyed during the Pliocene phase of the Alpine orogeny and in the Pleistocene taphrogenic movements resulted in the present day Mediterranean.

The structure of the Gulf of Suez is extremely complicated and poses puzzling questions concerning its relation to the Red Sea. The age of the Red Sea may date back to the Cretaceous (Swartz & Arden 1960) and the rift has presumably started to open from south to north. On the other hand, the Gulf of Suez is known to have been in existence in one form or another since at least the Carboniferous. Another puzzling question is whether the Gulf of Suez may have been affected by translational movements, like those suggested for the Red Sea, and the Gulfs of Aqaba and Aden, or is it simply a graben dominated by normal faults.

These questions will not be fully answered until more information becomes available on many critical aspects of its subsurface structure. This paper is a summary of the broad stratigraphic and structural elements of the Gulf of Suez, with some tentative speculations concerning its development.

2. Summary of stratigraphic history

Figure 1, plate 5, shows the northern part of the Red Sea cutting across the African–Arabian shield and bifurcating into the Gulfs of Suez and Aqaba, which border the triangular block of Sinai. The stratigraphic succession in the Gulf of Suez area is generally represented by the section overlapping the Precambrian (PC) basement in Sinai. The succession starts with marine Paleozoic (Carboniferous sandstone and dolomite) (P), overlain by Upper Mesozoic (Lower Cretaceous Nubian Sandstone and Upper Cretaceous calcareous section) (M) and Eocene limestone (E). In northern Sinai Lower Mesozoic marine sediments and Paleozoic strata occur in depth and crop out locally on the surface. Within the Gulf of Suez depression a sequence starting from Paleozoic to Quaternary, with a well-developed marine Miocene section is found. The stratigraphy of the Gulf of Aqaba, on the other hand, is quite different since it appears to lack the sedimentary rocks older than Pliocene, and is essentially bordered by shield rocks. Said (1962) gave a good description of the stratigraphy of the Gulf of Suez, from which we can distinguish several stages in its development.

The Gulf of Suez dates back at least to the Carboniferous, at which time the Gulf extended as an arm of the old Tethys seaway as far south as Hurgada (Schürmann 1966, p. 281). The water of the Gulf, however, was rather shallow and remained as an elongated submerged basin receiving predominantly clastic sediments until the end of Lower Cretaceous (Nubian Sandstone). The Cenomanian marked the first drastic change from clastic to calcareous sedimentation and the beginning of significant subsidence. The main axis of the Gulf lay near the Sinai coastal strip and it was essentially a submarine trench bordered by shallow banks. Its southern end extended no farther than Gebel Zeit, since Cenomanian strata thin considerably in that area and disappear altogether farther south. Most geologists have long agreed that the southern tip of the Cenomanian shoreline overlapped a land mass or promontory situated near the southern end of the present-day Gulf (point A, figure 1). In view of the evidence that the Red Sea may have developed and widened as a result of the lateral movements of Arabia and Africa, it is reasonable to assume that this land mass was part of the undifferentiated African–Arabian shield. Abdel-Gawad (1969*b*) pointed out that the anomalous occurrence of Miocene sedimentary rocks at the southeastern side of the Gulf of Aqaba (Maqna block) suggests that the block lay, before its movement to its present position, at the southern end of the Gulf of Suez (arrow Z, figure 1) and may be regarded as a detached part of the old Gulf. There is evidence also that the elongated blocks of Gebel Araba on the Sinai west coast and Gebel Zeit on the southwestern bank of the Gulf existed as islands or submerged highs in the middle of the Cretaceous Gulf (Said 1962).

Whether these two blocks, which have similar Precambrian foundations and stratigraphic succession until Upper Cretaceous, were perhaps connected in some way and have since separated by a transcurrent fault is a speculation which deserves further consideration.

During Upper Cretaceous considerable faulting within the Gulf and in the entire region took place. This resulted in irregularities in the sedimentation pattern as indicated by evidence that many blocks started to show markedly different stratigraphic character from adjacent ones. Perhaps the most significant events of the Upper Cretaceous is the development of a system of NE–SW deep faults in the basement extending from northern Egypt and Sinai towards Syria, which resulted in considerable flexuring of the overlying strata known as the Syrian Arc 'folds'. A good example of this system is the faulted Wadi Araba anticline which is intersected by the NW–SE faults of the Gulf (figure 1). It must be recalled that the Upper Cretaceous activity in the Gulf of Suez area coincides with uplifts and faulting in Arabia, and with the early phases of the Tauros–Zagros mountain orogeny. The Upper Cretaceous tectonic activity was also associated with considerable volcanicity and intrusion in the neighbourhood, as

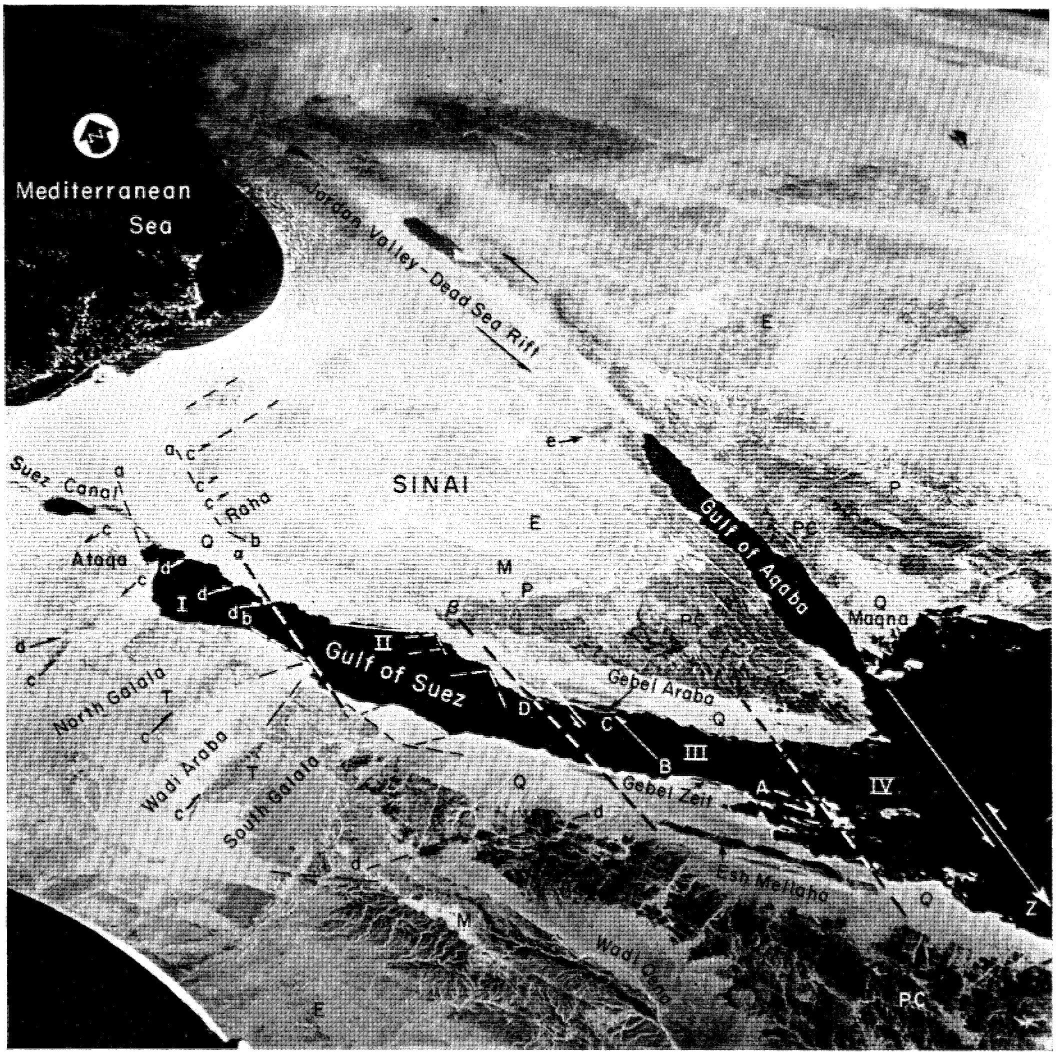

FIGURE 1. Gemini XI photograph of Sinai, Gulfs of Suez and Aqaba. The Precambrian basement (PC) is overlain by Paleozoic (P), Mesozoic (M), and Eocene (E) strata. Bordering the Gulf of Suez, Miocene and younger sediments (Q) are underlain in depth by older strata which outcrop in the elongated fault blocks of Gebel Araba, Gebel Zeit, and Esh Mellaha. The Gulf of Suez and Sinai are profoundly affected by several sets of faults: *a* (NNE–SSW), *b* (NW–SE), *c* (NE–SW), *d* (WNW–ESE), *e* (E–W). Evidence along Red Sea indicates that the Maqna block (SE side of Gulf of Aqaba) may have been part of Gulf of Suez province (arrow Z) before its displacement. Tectonic lines (α, β, γ) trending N–S divide the Gulf of Suez into four structural provinces (I, II, III, IV). It is postulated that the N–S lines may be major transform faults which may have resulted in a limited movement of Sinai towards the NNE and the gradual opening of the Gulf. Block and normal faulting may have acted to impart a superimposed graben structure. (Photo S-66-54893. Courtesy of Nasa.)

(*Facing p.* 42)

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evidenced by lavas and tuffs of Upper Cretaceous age in the Nile Valley, acidic alkaline intrusives in many places of the Eastern Desert (Barthoux 1922; Higazy & El Ramly 1960) and gabbroid basalt intruded in fossiliferous Cretaceous strata in deep wells in the Gulf of Suez (Schürmann 1966).

The Middle Eocene marked a period of widespread submergence and calcareous sedimentation associated with faulting and deepening of the Gulf, followed in Upper Eocene and Oligocene by a general uplift associated with doming (Tromp 1950) which culminated in the drastic tectonic events of the Miocene. In late Oligocene intensive faulting associated with widespread basic volcanicity was followed in the Miocene by the greatest taphrogeny in the history of the Gulf. In the Miocene the 'graben' attained its maximum width where the fringe areas between the present shore lines and the Precambrian cliffs on both sides were almost totally submerged and the Gulf gained unhindered access to the Red Sea. The bottom of the Miocene depression was extremely uneven and rugged. In the basins within the Gulf marls with deep water microfauna were deposited, while the shallow water, structurally high areas received conglomerate and pebble deposits. This period was followed by the deposition of a thick section of evaporites (Said 1961, 1962).

Further subsidence took place in Middle Pliocene and this was associated with marine invasion from the south as evidenced by the mixing of Mediterranean and Indo-Pacific fauna in the Gulf area, an event which probably marks the final opening of the Strait of Bab El Mandeb at the southern end of the Red Sea. It may be noted that during the Pliocene the final and most intensive phase of Tauros–Zagros folded mountain orgeny took place, and was associated with a general uplift in the Mediterranean area and the final destruction of the Tethys Sea and its shrinkage into isolated land-locked freshwater lakes (Picard 1939). The Pleistocene was a period of renewed faulting in the Gulf of Suez. Towards the north faulting of large crustal blocks along E–W, N–S, and NW–SE lines created the Mediterranean basin. The Isthmus of Suez was submerged until late Pleistocene when the connexion between the Gulf of Suez and the Mediterranean emerged above the sea level, leaving a few isolated 'Bitter Lakes' north of Suez, now connected by the Suez Canal.

3. Fracture pattern

Before describing the structure of the Gulf itself, it may be appropriate to examine the surrounding land areas particularly the fracture pattern which seems to greatly influence the shape of the depression (figure 1). It is often impossible to distinguish in aerial or orbital photographs between fractures and eroded dykes which are essentially fractures filled with magmatic matter. Nor is it always possible to determine the relative ages of these linear structures. Whether most of these faults are of Precambrian age and therefore are old features which happen to control the shape of the 'graben' as Schürmann (1966) argues, or may have developed as a result of a regular stress pattern sustained for a long period which eventually resulted in the creation of the depression as advocated by Youssef (1968), the fact remains that a highly regular fracture pattern is a predominant feature in the area. In Sinai and west of the Gulf there are essentially five systems of fractures: an Aqaba trend striking NNE–SSW, a Gulf of Suez or Erythrean NW–SE trend and a more subtle yet significant system trending WNW–ESE; the three exercise a most profound influence on the outline of the depression at large and on the coast lines. There are in addition, two important systems trending NE–SW (Syrian) and

E–W (Tethyian) systems. The influence of these systems on the Red Sea rift in general has been discussed recently by Abdel-Gawad (1969*a*, *b*), Youssef (1968) and others.

There is evidence that many of the faults belonging to these systems show a significant lateral component of movement. The Aqaba–Jordan valley sinistral shear and the small displacement in Gebel Araba–Durba block in western Sinai are examples of the NNE–SSE system. Examples of strike-slip displacement along NE–SW, E–W, and WNW–ESE faults are known in northern Sinai (see, for example, Vroman 1961, Fig. 7). Sinistral displacements of 7 km along NE–SW faults in Gebel Um Disi area (SW of the Gulf of Suez) were suggested by Abdel-Gawad (this volume, preceding paper). It is worthwhile to mention that rejuvenated movements along all these fault systems seems to have been the rule. For example, the Erythrean NW–SE faults which are mostly characterized by large normal throws since the Miocene cut the NE–SW faults of the Cretaceous 'Syrian Arc' system such as Wadi Araba Anticline (figure 1). Yet the NW–SE system must have existed much earlier as indicated by its influence on the trend of the Carboniferous Gulf and the elongated ridges of Gebel Araba, Gebel Zeit, and Esh Mellaha since the Cenomanian.

4. Structural provinces

Geophysical surveys and deep drilling indicate that the depth of the 'basement' reaches close to 5 km in large stretches within the central depression. The basement shows evidence of block faulting which is often expressed as flexures in the overlying sediments. According to Schürmann (1966) the surface of the basement shows pronounced differences in its general tilt. In the northern part of the Gulf of Suez the basement is tilted towards the east, while in the southern part the tilt is completely opposite or towards the west, which indicates a major disturbance or rotational fault between the two parts. The occurrence of such a major line of disturbance is not unique. From surface and subsurface structures van der Ploeg (1953) divided the Gulf of Suez into four structural provinces delimited by three tectonic lines (α, β, γ, figure 1), all trending NNE–SSW, or parallel to the trend of the Gulf of Aqaba. The significance of these divisions may have important bearing on the structural history of the Gulf. For example line γ lies approximately where the basement shows the drastic change in the direction of tilt.

Line γ coincides with trends in bathymetric contours at the entrance of the Gulf. There, Said (1962, p. 33) infers a N–S fault which 'seems to cut across the Gulf of Suez and produces the outcropping of basement rocks at Gebel Araba in Sinai, and Gebel Zeit and Esh Mellaha ranges in the Eastern Desert. The extension of this fault inland to Abu Shaar Plateau (near Hurgada) may be inferred from the presence of tilted coral reefs and from the continuation of the fringe of limestone at the base of the Red Sea Hills to the south of the Abu Shaar Plateau'.

According to van der Ploeg the northern tectonic province (I) to the north of line α is characterized by two parallel fault lines delimiting the depression on its eastern and western sides (Raha and Ataqa blocks, figure 1). The second province (II) lacks the simple marginal faults and is rather characterized by a very complex fault pattern, produced by the intersection of several fault systems, particularly NNE–SSW (Aqaba); NW–SE (Suez), WNW–ESE. Said (1962) mentions the presence of many strike faults of several directions within this province in western Sinai. The third province (III) is characterized by three elongated fault blocks: Gebel Araba in Sinai and Gebel Zeit and Esh Mellaha on the western side. The structure of Gebel Araba consists of a Precambrian basement block faulted along and parallel to the coast and tilted towards the east and is faulted in depth against the basement horst of Sinai. The eastern flank of the block is overlapped by a succession of Mesozoic and Tertiary sediments. Gebel Zeit block, on the western side of the Gulf, is essentially a mirror image of the Gebel Araba structure and is tilted towards the west.

The basement rocks are similar in both blocks (Lower Gattarian granites and Hammamat series intruded by Upper Gattarian Red Granite (Schürmann 1966, plates I and II). The stratigraphic succession from the basal Nubian Sandstone (L. Cret.) and the Cenomanian are also strikingly similar. According to Said (1962) the two blocks were probably alined in the middle of the Cretaceous Gulf as islands or submerged highs. Esh Mellaha block is also tilted towards the west and between its steeply faulted eastern margin and Gebel Zeit block, there is a deep structural depression which is now filled with sediments. The fourth province (IV) is more similar to province (II) in the complexity of its faulting pattern which according to van der Ploeg represents the interaction of the Aqaba and Suez fault zones.

The structural provinces of the Gulf of Suez appear also to have distinct sedimentary facies characteristics. Paleontologic evidence (Said 1961) indicates that province (I) formed a persistent structural high (Ayun Musa Promontory) throughout a long period of the Gulf's history. Even during the great Miocene transgression this province was characterized by shallow water Miocene facies. The second province (II) coincides with a deep basin 'Abu Zeneima Basin' which received a great thickness of sediments particularly during Upper Cretaceous, Middle Eocene, Lower and Middle Miocene. During the Miocene the basin had a rough bottom topography and was characterized by deep water facies. Province (III) formed also a persistent structural high, particularly towards its southern end as indicated by the absence of Middle and Upper Cretaceous, Eocene and Oligocene sediments. At the southern end of this province the Miocene unconformably overlies the thin Nubian Sandstone which rests on the basement. In the fourth province (IV) which constitutes the southernmost part of the Gulf we find that the Upper Cretaceous Section is missing; Eocene sediments and a record thickness of Miocene evaporites are well developed.

The four provinces appear to have formed two highs (Ayun Musa and Araba-Zeit blocks) alternating with two deeps (Abu Zeneima and Hurgada basins) separated by NNE–SSW lines of 'cross disturbance' which may be major faults. In view of the increasing worldwide evidence that horizontal movements play a major role in crustal tectonics, these structural elements and their bearing on the history of the Gulf of Suez need to be re-examined. Before speculating on their significance a brief review of previous interpretations is in order.

5. Vertical and lateral movements

Most workers have interpreted the structure of the Gulf in terms of purely vertical movements (e.g. Shata 1959; Said 1962; Schürmann 1966) and some place emphasis on downwarping as a predominant feature (Whiteman 1968). Certainly, the role of normal faults in shaping the depression is so overwhelming that it need not be emphasized. The nagging question, however, is whether there is any justification for considering a role of translational movements in the geological history of the Gulf. We must consider as significant the widespread evidence of strike-slip faults with horizontal displacements often exceeding the maximum vertical throws of normal faults in the area. Knetsch (1954) drew attention to many examples of this class of faults, and indeed strike-slip displacements characterize most major faults in northern Sinai

(Vroman 1961). Tromp (1950) reasoned that the main cause of the formation of the Gulf of Suez depression may have been a combination of shearing faults and stretch faulting.

Swartz & Arden (1960) postulated that at the end of Lower Eocene the Sinai block moved towards the southeast along NW–SE faults. They reason, however, that both compressional and tensional forces were active in the Gulf of Suez and that the initial movement was not simply a matter of gradual separation but of opening and closing which haphazardly elevated and depressed the slump blocks.

Youssef (1968) suggested that the Gulfs of Aqaba and Suez form two complementary sets of shear fractures produced by a simple stress parallel with the bisector (N 10° W). Accordingly the Gulf of Suez would be essentially a wrench fault of right-lateral displacement. Geological evidence for this movement which involved more than 60 km off-set is still ridden with problems (Youssef 1968).

It is difficult to relate a right-lateral movement along the Gulf of Suez with van der Ploeg's tectonic provinces and cross disturbances. The orientation of the latter are more consistent with the assumption that the dominant movement of Sinai relative to Africa was towards the north-northeast. Although largely speculative, the idea is consistent with the following structural features:

(i) The outline of the greater depression which includes the fringing coastal strips as well as the present shore lines show zigzag patterns, not unlike that of the Red Sea at large, and dominated by similar structural elements: namely NNE–SSW, WNW–ESE and NW–SE trends.

(ii) The cross-disturbances delineating the tectonic provinces in the Gulf of Suez have a NNE–SSW trend, and this system provides good examples of lateral movements.

(iii) van der Ploeg's divisions are not perpendicular to the Gulf which implies that opposite points across the Gulf are dissimilar. The orientation of cross-disturbance is rather consistent with the northward displacement of the Sinai side.

(iv) The four provinces, as mentioned earlier, appear to correspond to two basins separated by structural highs.

If we assume that the Sinai block has moved relative to Africa in the same direction as Arabia and perhaps as a part of it towards the NNE but at a slower rate, the movement will be consistent with the left-lateral shear along the Aqaba–Jordan Valley structure and will produce a limited extension across the Gulf of Suez.

A plausible model for the development of the Gulf of Suez consistent with these features is based on the assumption that a system of tension fissures may have developed *en échelon* fashion in the middle of the depression with orientation trending NW–SE (or WNW–ESE) and these lines of tension were separated by a series of transform faults of NNE–SSW (Aqaba) trend. The tension fissures would be analogous to mid-oceanic 'ridges' and presumably would form basins filled with volcanic rocks mixed with abundant sediments derived from the bordering highlands. The Abu Zeneima and Hurgada basins described by Said (1962) may be examples of these high tension zones.

The transform faults between the basins may presumably have been left-lateral and their extensions on both sides would be lines of transcurrent faults with sinistral or dextral displacements depending on the difference in the rate of movement of adjacent blocks. The NNE–SSW left-lateral fault cutting across Gebel Araba block in western Sinai may be an example. It is suggested that the structure of the Gulf of Suez may represent sea floor spreading arrested in an early stage. If only a limited and unequal lateral motion has taken place, the blocks which border the rift could still be in contact with one another at the transform fault zones and thus form structural highs or promontories such as those reported at Ayun Musa, Ras Gharib and Little Zeit. The cross-disturbances of van der Ploeg may conceivably be zones of transform faults where the vertical rotation suggested by Schürmann (1966) is likely to accompany lateral motion and extensive normal and block faulting. If the movement of Sinai towards the NNW relative to Africa is valid, then the most likely shear zone of left-lateral motion between the two blocks is a NNW–SSE line in northwestern Sinai. It may approximately be the extension of the cross-disturbance line α running along the western cliffs of the Raha Plateau (figure 1). Marked differences in terrain and geology are observed east and west of that line. Although contour lines in the Bouguer Gravity Map of northern Egypt Amin (1959) could be interpreted variously, many features are not inconsistent with the occurrence of a tectonic break along that zone. Deep drilling within the Gulf may reveal the occurrence of normal continental basement in many places which may not be representative of the entire Gulf. According to Schürmann (1966) many wells in the Gulf of Suez penetrated a great thickness of sediments without reaching the 'basement'. In order to understand the very complex and often puzzling structure of the Gulf of Suez, one has to be cautious of serious pitfalls, but I venture to say that if a deep well is to be drilled (or the records of such a well be made known) in the deep basin areas within the Gulf the foundation may reveal the occurrence of deep seated volcanics masked by a thick overburden of light sediments. The existence of volcanics within the central trough is yet to be confirmed. Yet it is hard to believe that the entire foundation of the Gulf is all continental in composition while the evidence of basic volcanics in the surrounding land areas less affected by faulting is rather extensive.

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Discussion

D. A. Robson (*University of Newcastle upon Tyne*). (Dr Robson was invited to comment on this written contribution because he has spent six years in the field in the Gulf of Suez rift area. He believes that the points made below would be supported by C. E. Thiébaud & F. Heybroek who have an aggregate of nine years field work in the area. Another comment of relevance by Drs Robson and Thiébaud will be found in the general discussion section, p. 413.)

§ 1. The age of the Gulf of Suez block-faulting and rifting does not pre-date the Oligocene.

§ 2. The Gulf of Suez Carboniferous to Eocene rock sequence can be matched on the same latitudes both within and outside the rift. Faulting occurred in Cretaceous times along the Egyptian Syrian arc but no rift movements occurred before the Oligocene.

§ 3. There is no surface evidence of volcanicity before or after the Oligocene in the Gulf of Suez rift, nor was it 'very widespread'. Field evidence is lacking for shearing movements in the Araba–Durba block and indeed along any part of the Gulf of Suez except of the most minor kind. Field evidence is also lacking for a 'Carboniferous gulf' and for the existance of the Gebel Araba, Gebel Zeit and Esh Mellaha uplifts in the Cenomanian.

§ 4. Van de Ploeg's major disturbances do not appear to be based on field mapping which is sometimes in direct conflict with them.

§ 5. North Sinai is not in my opinion the place to seek evidence for rift type faulting. The Raha Plateau lies east of a perfectly normal faulted block.

M. Abdel-Gawad (written reply). After the deposition basal Eocene the distribution and thickness of lower Lutetian rocks indicate that the Sinai side of the Gulf, which up until then represented the deeper part of the Gulf, became largely above the sea level and the deep part o the Gulf appears to have shifted to the western side. This drastic change and the erratic distribution and thickness of the Upper Cretaceous chalk indicate to me that the faulting within the Gulf was probably active before the Oligocene.

The thickness of the Cenomanian decreases regularly from north to south in Araba and Zeit blocks, becoming nil at little Zeit (Said 1962, pp. 167–168). When compared with the more homogeneous thickness of the underlying Nubian Sandstone, this suggests not only that these blocks were more uplifted towards their southern ends but also that tectonic movements were active in the Cenomanian.

The extent of basic volcanicity in northern Egypt has in my opinion been much more widespread than apparent from the surface exposures. During my six years of work on the staff of the U.A.R. Atomic Energy Establishment, shallow drilling revealed that the basalt layer exposed at Abu Zaabal extends over a large area east of the Nile Delta under some 12 or 15 m of cover. During my work with Sahara Petroleum Co. we penetrated basalt in Wadi El Natrun well No. 1 at a depth of 300 m or so. The distribution of the basalt, which is found from the edge of the Faiyum depression north to Wadi El Natrun and east of the Delta, along the Cairo–Suez area, on the limestone plateau between the Nile and the Gulf, not mentioning the swarms of dikes in the Gulf of Suez itself and in Sinai and dolerite flows near Quseir, is widespread indeed. Many geologists (e.g. Schürmann) consider the evidence for the existence of a Carboniferous Gulf is strong on the basis of the drilling record. I also wonder why should 5 or 7 km of lateral displacement on shear faults outside of the main rift be considered minor while the maximum vertical throw in the Gulf hardly exceeds that amount, and if lateral displacements of that magnitude occur in the marginal blocks why shouldn't one expect larger displacements within the rift?

Figure 1. Gemini XI photograph of Sinai, Gulfs of Suez and Aqaba. The Precambrian basement (PC) is overlain by Paleozoic (P), Mesozoic (M), and Eocene (E) strata. Bordering the Gulf of Suez, Miocene and younger sediments (Q) are underlain in depth by older strata which outcrop in the elongated fault blocks of Gebel Araba, Gebel Zeit, and Esh Mellaha. The Gulf of Suez and Sinai are profoundly affected by several sets of faults: *a* (NNE–SSW), *b* (NW–SE), *c* (NE–SW), *d* (WNW–ESE), *e* (E–W). Evidence along Red Sea indicates that the Maqna block (SE side of Gulf of Aqaba) may have been part of Gulf of Suez province (arrow Z) before its displacement. Tectonic lines (α, β, γ) trending N–S divide the Gulf of Suez into four structural provinces (I, II, III, IV). It is postulated that the N–S lines may be major transform faults which may have resulted in a limited movement of Sinai towards the NNE and the gradual opening of the Gulf. Block and normal faulting may have acted to impart a superimposed graben structure. (Photo S-66-54893. Courtesy of Nasa.)

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