ON THE PLEISTOCENE SHORE LINES OF ARABS' GULF, EGYPT[1]

KARL W. BUTZER[2]

ABSTRACT

The accepted sequence of Pleistocene shore lines southwest of Alexandria, outlined by F. E. Zeuner and Shukri, Philip, and Said, is questioned and considered as misleading on the grounds of insufficient field evidence. Profiles drawn on the basis of the topographic maps employed by these authors show the impossibility of assigning reliable altimetric values to most of the former sea levels responsible for the offshore bar and lagoon topography. That which is actually known about the sequence of sea levels is discussed, the accepted warping or folding of the area is negated, and the occurrence of NW.–SE. fracture zones in the Maryut is proposed. Although there are several submerged shore lines, no evidence points toward a so-called "Epi-Monastirian" level of ±0 m.

INTRODUCTION

For almost seventy years the Pleistocene deposits of the northern Egyptian littoral have been subject to investigation by numerous authors, an array including such names as R. Fourtau, M. Blanckenhorn, W. F. Hume, K. S. Sandford and W. J. Arkell. After Fourtau (1893) had recognized the marine nature of the deposits, which Blanckenhorn (1901) very succinctly describes as consolidated offshore bars and intervening lagoons, the sediments were later generally considered as fossil coastal dunes. It is to the credit of F. E. Zeuner (1950) and also Shukri, Philip, and Said (1956) that the marine origin was finally clearly recognized and accepted; more precisely, that the distinctive morphology of the Arabs' Gulf area represents a succession of fossil offshore bars and lagoons. Zeuner indicated that a sequence of similar ridges and depressions occupied the coasts to some 40 km. inland.

However, Zeuner went further to set up a sequence of bars and lagoons corresponding to some ten stages of the Pleistocene Mediterranean: "Good topographic maps exist, and the following sequence of bars was identified. In this work Mr. Roger Summers contributed his intimate personal acquaintance with the area" (Zeuner, 1950, p. 233). Apparently, at any rate, no field-mapping of any kind was carried out. In this connection the recent study of Shukri, Philip, and Said (1956) brings a welcome selection of new facts and valuable evidence, particularly new observations on the foraminifera and microfacies. As valuable as their field evidence is, new difficulties become apparent regarding current views on the altimetric sequence. It is indeed disturbing that Shukri, Philip, and Said also employ the available cartographic material to set up an equally logical and detailed sequence of precise sea levels as does Zeuner, but with considerable differences on matters of bar identification and, above all, on the associated sea levels. In the meantime, however, the very specific values of the almost classical Arabs' Gulf chronology, particularly those proposed by Zeuner (1950), have attained an important position of respect and reliability in the current literature. It is the purpose of this paper to examine the acceptability of the existing sequences and to emphasize some of the serious difficulties inherent in them. A purpose will be served if the criticism leveled at the existing work in the Arabs' Gulf area leads to a more qualified use of dubious data felt to be particularly striking at this locality. With the great mass of field results, good or bad, building up information on the Pleistocene, it will become increasingly necessary to pause and reflect on the validity of evidence presented. Uncritical employment of data would eventually be disastrous for a coherent understanding of the recent geological past.

[1] Manuscript received March 14, 1960.

[2] Department of Geography, University of Wisconsin, Madison 6, Wis.

QUESTIONABILITY OF THE PRE-MONASTIRIAN ALTIMETRIC SEQUENCE OF SEA-LEVEL DETERMINATIONS

The two successions of supposed Mediterranean sea level corresponding to the twelve odd barrier bars in question are listed in the accompanying tabulation.

Zeuner (1950)	Shukri, Philip, and Said (1956)
Harbour Island Bar 0 m.	Harbour Island Bar 0 m.
Not recognized	Coastal Bar 10 m.
Abusir Bar 5–10 m.	Abusir Bar 25 m.
Gebel Maryut Bar 15–20 m.	Gebel Maryut Bar 35 m.
Sanakra-Habbub Bar 35 m.	Not recognized
Ruweisat Bar 58 m.	Khashm el Eish Bar 60 m.
Gebel Bein Gabir Bar 80 m.	Alam el Khadim Bar 80 m.
Alam el Halfa Bar 80–100 m.	El Mikheirta Bar 85 m.
El Mikheirta Bar 85 m.	Raqabit el Halif Bar 90 m.
Raqabit el Halif Bar 90 m.	Alam Shaltut Bar 110 m.
Alam Shaltut Bar 103 m.	

The approximate location of the various bars and the corresponding lagoons is given in figure 1. The topography can generally be easily followed on the 1:100,000 series of the "Survey of Egypt" (see maps listed in "References Cited").

The reasons for discrepancies involving the recognition of bars are obscure but seem to be that the Coastal Bar is not clear on the maps and requires field familiarity. On the other hand, some concurrent bars require closer field investigation before their mutual relationships can be clarified. Some difficulties also seem to exist in correlative tables attempted by Shukri, Philip, and Said.

The strongly divergent sea levels ascribed to identical bars are slightly easier to account for. Zeuner (1950, 1952) accepts the altitudes of the flat parts of the lagoon floor as an index of corresponding high sea level. This principle alone can be somewhat misleading. The level of a lagoon floor can only be considered as a criterion of former sea level when the transition from the aquatic-lagoonal facies to a terrestrial one can be demonstrated in the field (cf. Zeuner, 1959). With a maximum local tidal amplitude of 30 cm. (between mean spring high water and neap low water) and a mean maximum storm level, the writer assesses at less than 200 cm. Zeuner's distinction between high and mean sea level does not alter the uncertain nature of his altimetric sequence in Arabs' Gulf. Similarly, the basis of the altimetric assessment employed by Shukri, Philip, and Said (1956), again approximate, is not necessarily accurate. These authors consider the "dominant level" of the offshore bar as indicative of former mean sea level (m.s.l.). However, offshore bars can be encountered anywhere from several meters below sea level to many meters above. Only occasionally does the surface of an offshore bar coincide with the m.s.l.

In order to obtain a visual impression of each of these features and particularly of the difficulties involved, the writer has constructed due west-east vertical profiles from the topographic maps (fig. 2) (cf. maps listed in "References Cited"). The descriptions of the younger bars in the literature (Blanckenhorn, 1901; Hume and Hughes, 1921; Sandford and Arkell, 1939; Shukri, Philip, and Said, 1956; Butzer, 1957) have been regarded while interpreting topographic detail in the process of the map study involved. The demarcation of the older bars above the 60-m. contour is made solely according to the map topography, with the assistance of descriptions and rough sketches by the Egyptian authors. The terminations in the west are consequently somewhat arbitrary.

It becomes obvious that the bars 1–4 have *relatively* uniform lagoon floors whose irregularities can be adequately explained by consequent stream erosion, as Professor Zeuner informed the writer in a personal

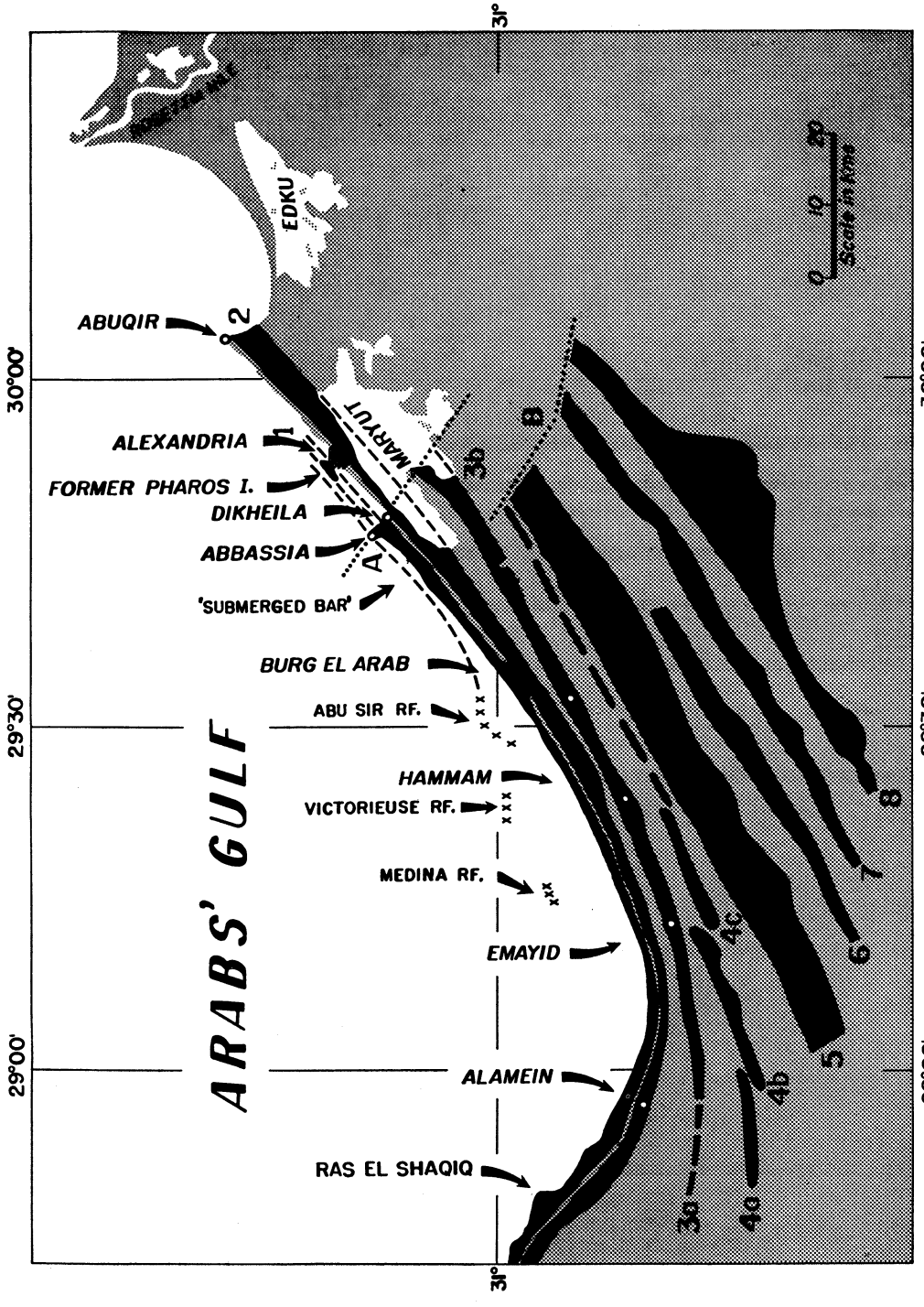

FIG. 1.—Outline map of the Pleistocene bars and lagoons of Arabs' Gulf. The seaward margin of the solid dark banks represents the crest line of the offshore bar, the landward margin, the axis of the respective lagoon floor. *1*, Coastal Bar; *2*, Abusir Bar; *3a*, Gebel Maryut Bar; *3b*, Sanakra & Habbub Bar; *4a*, Ruweisat Bar *4b*, Gebel Bein Gabir Bar; *4c*, Khashm el Eish Bar; *5*, Alam el Halfa Bar; *6*, El Mikheirta Bar; *7*, Raqabit el Halif Bar; *8*, Alam Shaltut Bar. The dotted lines *A* and *B* indicate probable fault lines in the Maryut area.

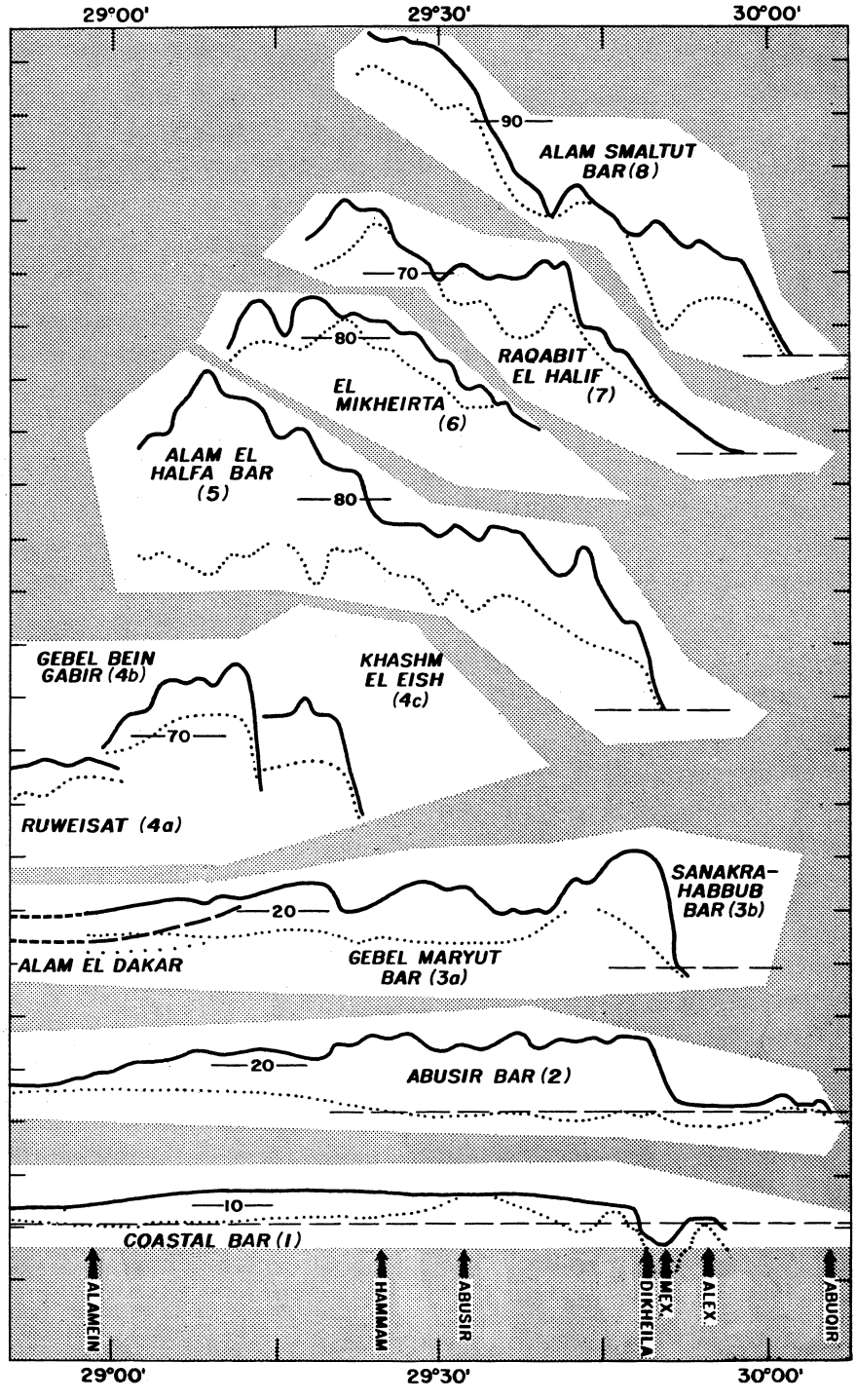

FIG. 2.—Vertical profiles of the Pleistocene bars and lagoons of Arabs' Gulf. Vertical interval indicated is 20 m., vertical exaggeration 400:1, vertical elevations (datum) relative. *Heavy full lines:* crest lines of offshore bars; *dotted lines:* axes of lagoon floors; *thin dashed lines:* sea level, where pertinent.

discussion. Such a stream flowed northeastward behind the Abusir Bar, for example.

Neither consequent nor antecedent stream erosion can explain all the irregularities of the bars, however. A good deal can be attributed to lithologic differences, selective weathering, and differences in original sedimentation. But an added complication is undoubtedly that fossil dunes cap many of the marine features, as in the case on the Coastal Bar. Bars 5–8 have never been examined in the field prior to the study by Shukri, Philip, and Said, who necessarily studied selected samples from a scatter of localities, and bars 3 and 4 are little better known. Without accurate, large-scale mapping of the surficial deposits much of our understanding of the variable constituents and of the present-day morphology of the older bars remains speculative.

The comparison of Shukri, Philip, and Said's and Zeuner's sequences with figure 2 underlines the differences of bar classification. The crest line of the Gebel Maryut and Sanakra-Habbub bars is definitely continuous, yet the lagoon floors are disrupted. Whether the apparent discontinuity of the latter is real or whether it is due to very obvious faults of the two adjacent map sheets is uncertain at this point. The analysis of the geomorphology and microfacies by Shukri, Philip, and Said indicates no noticeable contrasts between bars 3a and 3b. Whether or not the two represent different stages, as Zeuner would apparently have them, can be concluded only in the field.

The bars listed as 4a, 4b, and 4c present a similar problem. Zeuner considers them as two; Shukri, Philip, and Said, as one. All three are morphologically distinct on the map, suggesting successive formation during a period of fluctuating higher sea level. The ridge—without apparent lagoon—lying back a further step and extending east of bar 4c may represent another such stage eroded by later marine action. The matter can again be decided only in the field.

The same applies to the shallower Alam el Dakar ridge, which coalesces, with bar 3a between El Alamein and El Hammam.

With all these problems of local identification and of highly irregular and anything but uniform flat-lying surfaces, it remains inconceivable how "precise" estimates of associated sea level could have been forwarded by the respective authors. A comparison of the profiles shows that Zeuner usually seems to have employed the highest lying flat lagoon surface as relevant level; Shukri, Philip, and Said seem to have taken some median value of the highest parts of the bar crest lines. Neither paper is very specific about the methods used. Neither set of values is accurate other than on a ± 20-m. level.

How, for example, does the jagged crest line of bars 5–8 mean anything in terms of respective sea level? How does the highest (preserved) flat lagoon floor indicate corresponding m.s.l. without knowledge of the facies involved? A few examples should demonstrate the latter. At El Alamein the writer found marine shells in abundance on the lower parts of the Abusir lagoonal surface; elsewhere it was covered with later alluvial deposits to unknown depths. Farther east near Abusir town, Fourtau (1893) and Blanckenhorn (1901) describe widespread gypsum deposits alternating with bands of clayey marl. At El Hammam, Said, Philip, and Shukri (1956) describe some eight alternating layers of lagoonal and terrestrial facies in a 5-m. section in the lagoonal deposits behind bar 3. For some 30 km. south of the Alam el Halfa Bar, Blanckenhorn (1901) found widespread surfaces of terrestrial *Helix* limestones. In other words, field investigations are invariably necessary to understand the vital transition of brackish to terrestrial sediments in the former lagoons. As it is, the respective sea levels can only be grossly approximated, those of bars 4–8 lying somewhere between 50 and 120 m.

Altimetrically, bars 4–8 seem to lie in the range of the Lower Pleistocene eustatic levels. The fauna and foraminifera support

this suggestion strongly. Blanckenhorn (1901) described the mentioned *Helix* limestones as Lower Pleistocene on account of the curious extinct fossil *H. quadridentata* Blanck. Blanckenhorn also mentions *Strombus coronatus* from bar 4c, a distinctly Senegalese form. The examination of the foraminifera (Shukri, Philip, and Said, 1956), which contain Indo-Pacific elements, such as *Operculinoides venosa* and many extinct forms, bears out this Lower Pleistocene date. The Milazzian position suggested by Shukri, Philip, and Said for bar 5 and the Sicilian for bars 6–8—on the basis of considerable faunal evidence—at least seems reasonable. One should hesitate to offer any opinion at all on the Gebel Maryut bar(s) other than to mention that some Atlantic as well as Indo-Pacific foraminifera occur (Shukri, Philip, and Said, 1956), whereas Blanckenhorn (1901) reported only modern mollusca, such as *Glycimeris* and *Cardium edule*. The alternating facies behind the bar in the quarry at El Hammam (Said, Philip, and Shukri, 1956) indicate one period of sea level fluctuating between about +3.5 and +8.5 m., considering that the top of the local quarry is at about 9 m. above m.s.l. However, major sea level responsible for this development must have been appreciably higher.

SOME REMARKS ON ABUSIR AND COASTAL BARS

On the basis of intensive geomorphological field work carried out by the writer between El Alamein and Ras el Shaqiq in March, 1956, it seems locally possible to assess the highest m.s.l. responsible for the older of the two youngest bars at +10 m. (cf. Butzer, 1959). The railroad from Alexandria to Mersa Matruh runs on the Abusir lagoon surface (bar 2) at 8–11 m. between a point 7 km. NW. and 2 km. SE. of El Alamein station. A little seaward lies the corresponding bar at 10–14 m. The lagoon surface is littered with marine shells of *Arca*, *Lucina*, *Donax trunculus*, etc., which are sharply limited to below the 9 m. or 10 m. contours. They do not occur at higher levels, suggesting an upper limit of the marine facies at about this level. Higher up, silts, clay, and marls with *Helix* occur. The foraminifera examined from the same bar farther east (Blanckenhorn, 1901; Shukri, Philip, and Said, 1956) are largely extinct species of Mediterranean character. Blanckenhorn (1921, p. 150) also lists *Strombus bubonius*. This would suggest a Tyrrhenian age on the basis of the fauna, more specifically an early Monastirian on altimetric grounds.[3] The writer makes no attempt to explain the lower, smoother level of the bar west of El Hammam or the higher, rougher crest line to the east.

On the same 18-km. stretch from Alamein to Ras el Shaqiq, the altitude of the crest of the Coastal Bar, of white oölitic limestone, fluctuates between 2 and 9 m., the landward lagoon between sea level and 4 m. The bar contains the same foraminifera as the Abusir (Shukri, Philip, and Said, 1956), but it was not possible to obtain a closer estimate of corresponding m.s.l. as the lagoon has been reflooded and re-formed morphologically at the height of the post-Monastirian, i.e., Flandrian, transgression. For details of this the reader is referred to Butzer (1957, 1958, p. 37–38). A notch was cut into the seward flank of bar 1 at 4 m. m.s.l., and corresponding tidal inlets and landward terraces in the reflooded lagoon testify to the renewed transgression. The surface shells of this lagoon floor include numerous *Glycimeris* (*Petunculus*) as well as *Arca noae*, *Cypraea*, *Lucina leucoma*, and *Conus* (fragmentary). Among these were found two pieces of *Strombus bubonius*, one of which was strongly rolled. This extinct species of the characteristic Tyrrhenian fauna may be derived from the Early Monastirian bar slope, at the foot of which it was found, or more unlikely, it may belong to the earlier deposits of the Late Monastirian lagoon. It may even belong to

[3] Although the term "Monastirian" was abolished by resolution of the INQUA Congress, Madrid, 1957, it is used here for want of something better.

the warmest phase of the Postglacial transgression of the Mediterranean.

Following the 4-m. Flandrian maximum, a drop of sea level by two meters led to the formation of a second notch at 1.8 m. with corresponding tidal inlets and lagoon floor, with a 1–2-m. landward terrace rising to the 4-m. stage lagoon surface (Butzer, 1957, 1958). Strong alluviation has covered the marine fauna of this youngest stage, and only *Helix* can be found in the colluvial red earth accumulated.

Brief reconnaissance work in 1956 indicated that farther east the Coastal Bar is disconformably covered by eolian, calcareous sand, achieving a maximum elevation of some 13 m. A part of this sand is consolidated and seems to be fossil, possibly dating from the post–Late Monastirian regression. Another part is recent, for example, the dunes immediately west of El Dikheila. About Abusir town the lagoon floor disappears entirely, the surface of the Coastal and Abusir bars being almost even, due to the later deposition of eolian sand.

THE SO-CALLED "HARBOUR ISLAND BAR" AND SUBMERGED RIDGES

Both Zeuner (1950) and Shukri, Philip, and Said (1956) recognized a last bar separated from the present shore line by a "phase of low sea level," occurring as a "shore platform" in Alexandria and westward. It can only be guessed whether all authors refer to the same features and to what features they actually refer. The current maps of Alexandria Harbour do not show a "Harbour Island," so that one is inclined to suspect an identification with the peninsula between Ras el Tin and Qaitbai Fort, once forming the Island of Pharos in classical times. This island was joined to the mainland by a causeway, which has subsequently developed into a peninsula through silting, similar to that at Tyre in Lebanon. On the other hand, the reference may also be to the chain of reefs lying several hundred meters seaward of the former Island of Pharos. Without more precise identification the "Harbour Island Bar" cannot be located.

In point of fact, there are several fossil bars in the Alexandria area. First and foremost is the continuation of the Coastal Bar from behind Dikheila airport to the former Pharos Island, which forms an integral part of it (see figs. 2 and 3). It is readily possible to follow the crest line of the Coastal Bar from the land through the bay to Ras el Tin by means of the Admiralty maps. There is a sinuous ridge at a depth of 5–10 m. running parallel to the shore at a distance of 1.5 km., eventually merging with the outer breakwater near the silt banks known as "Harbour Bank." They are separated from the shore by a deep basin at 12–18 m. following an axis of quite uniform depth, apparently a continuation of the lagoon surface from west of Dikheila. The reason for this apparent discontinuity in elevation is irrelevant to the argument that Pharos Island formed an outlier of the Coastal Bar, although this problem will be further considered below. This same discontinuity in elevation is repeated by the other bars farther south at a similar longitude and is either a tectonic or a gradational feature.

A second bar-and-lagoon sequence is indicated by the chain of reefs and islands extending from offshore of Pharos Island across the ruins of Fort Abbassia to at least the longitude of El Hammam. An almost unbroken chain of near-surface reefs or rocks extends for some 4 km. between about Qaitbai and Ras el Tin, separated from the shore by El Anfushi Bay, and then continues over the rock El Aramil as a chain of shoals and reefs at 2–6 m. below m.s.l. These include El Ikhwan, El Hut, El Kelb, El Kot, El Fara, North Shoal, Hydrographer Shoal, El Medjul, Homney Shoal, Etram Reef, Mazula Reef, and the islands El Akarish and El Agami. From the headland of Fort Abbassia the chain continues over El Kunaisiya Island, Long Rock, the Salama Reef, etc., at depths of 0–7 m. at a distance of about 1 km. from the shore to 29°38′ E. In this whole zone from Aramil southwest-

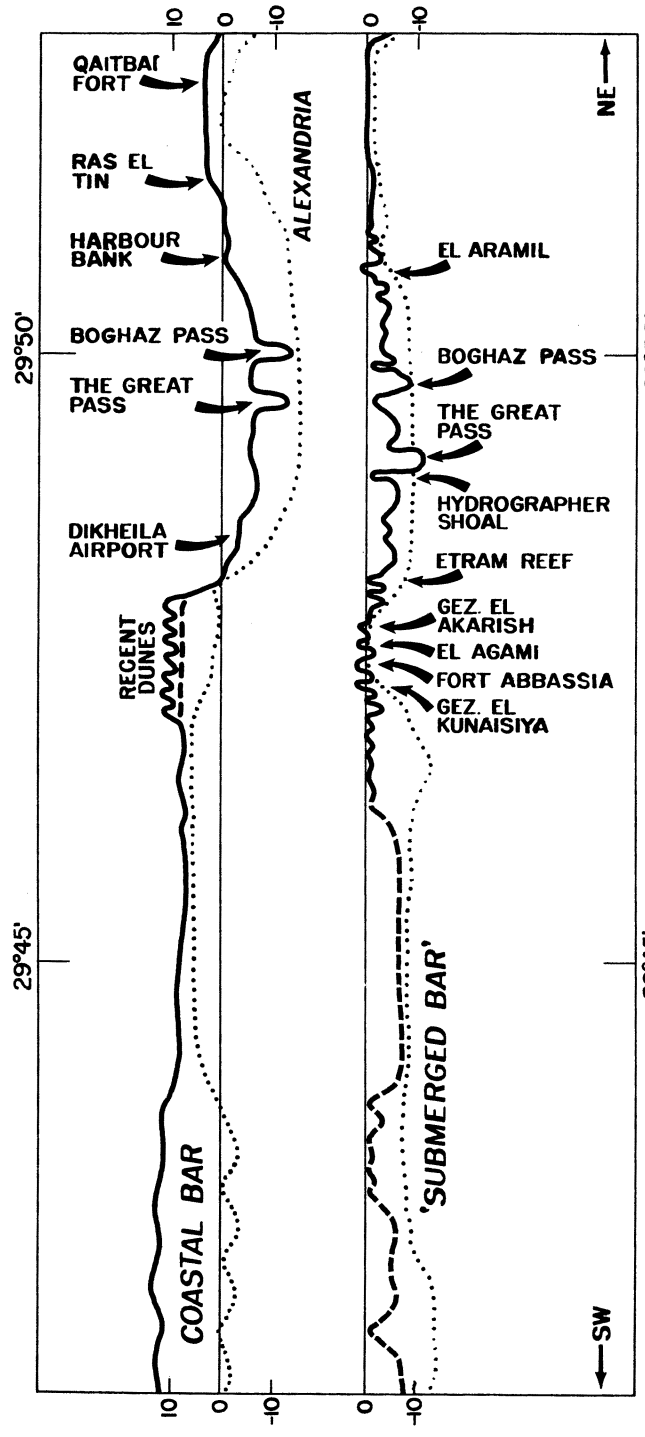

FIG. 3.—Vertical profiles of the coastal bar and "submerged bar" near Alexandria. Vertical exaggeration 65:1. Legend same as for fig. 2

ward the basin separating this submerged ridge from the Coastal Bar lies at some −10 m., except where Fort Abbassia is now joined to the mainland. West of 29°38′ E. the "Submerged Bar," as we may call it (fig. 3), continues farther out at sea as the Abu Sir, Victorieuse, and Medina reefs, possibly subdividing into two submarine ridges. The age of this Surmerged Bar is fully uncertain, but it presumably represents a stage of sea level at least several meters below that of the present, postdating the Late Monastirian.

Other submarine features most likely representing former offshore bars and lagoons can be suspected from the Admiralty maps. Examples are the parallel, uniform ridge at 11 m. below m.s.l. with a basin at from −13 to −14 m. lying 1 km. off former Pharos Island; and again ridges at −40 m. with basins at −45 m., some 6 km. offshore, extending along the coast between about El Hammam and Alexandria (cf. also Pfannenstiel, 1951, for the delta area).

If the Harbour Island Bar of Zeuner (1950) is that indicated by former Pharos Island, then it is Late Monastirian. If it should form part of what has been outlined here as the "Submerged Bar," one can only insist that it again does not represent a former ±0-m. sea level and that the somewhat connotative term "Epi-Monastirian" should not be applied to it. In either eventuality there is no evidence in favor of an Upper Pleistocene ±0-m. level of the Mediterranean Sea at Arabs' Gulf, and speculations regarding an equally speculative intra-Würm marine transgression of from 0 to +2 m. m.s.l. should be avoided as far as the Alexandria area is concerned.

PROBLEM OF SUBSIDENCE AND FRACTURE ZONES IN THE MARYUT AREA

Since Flinders Petrie drew attention to the submergence of Greco-Roman ruins in the Abuqir area, geologists have spoken of continued subsidence in the delta area due to compaction of the looser delta sediments —long after the delta collapse in Miocene times. During the last several years, however, evidence has come together to support a temporary marine regression of the Mediterranean of from −2 to −4 m. in classical times, followed by a new rise to the present level (McBurney and Hey, 1955, p. 98–99; Shukri, Philip, and Said, 1956, p. 404; Butzer, 1958, p. 39; R. W. Fairbridge, 1959; D. Hafemann, 1959). Hellenistic quays and other constructions are partially submerged on the coasts of Cyrenaica, in the Maryut and Nile delta areas, and along the littoral of Palestine and Lebanon—not to mention other parts of the Mediterranean Basin. Some of these coasts, such as the shores of Cyrenaica (McBurney and Hey, 1955), have been shown free of any notable warping since the Lower Pleistocene. Repeated violent earthquakes in the delta and around Alexandria during the last two millennia certainly indicate recent earth movements. But the eustatic evidence indicates that *two* factors are involved, and this evidence appears good enough to merit major responsibility for the differential movement of land and sea in historical times.

Is the curious Maryut depression, then, a symptom of earth movements on the basis of the local geological evidence?

As far as the available borings show, the Maryut is not underlain by loose, uncompacted fluviatile sediments but by the so-called "Mex limestone," i.e., Pleistocene marine oölitic limestone. The underlying bedrock is apparently Neogene limestone like that which forms the rest of the Marmarican Plateau; at least nothing to the contrary is recorded so far. Farther west the Arabs' Gulf littoral deposits certainly overlie the Miocene.

No sound evidence of tectonic lines in the Maryut area has yet been presented. Today it seems a historical curiosity that Hume and Hughes (1921) considered the parallel lagoon floors formed between the offshore bars as depressions due to subsidence. This was a big step backward, considering that 20 years earlier Blanckenhorn had recognized the bars and lagoons and had understood them as raised shore lines due to differential movements of land and sea. In

their study of structures in the Nile Valley, Yallouze and Knetsch (1954) drew several folding axes parallel to the lagoonal depressions in the area under question, on grounds unknown to the writer. In view of the genesis of the bars and lagoons there seems to be no necessity for an assumption of E.NE.–W.SW. folding axes here.

If there has actually been subsidence in the Maryut area, the bars and lagoon floors would necessarily be inclined from SW. to NE. (cf. Sandford and Arkell, 1939, p. 77–82). A glance at figure 2 shows that the crest line of the Coastal, Abusir, and Gebel Maryut bars runs at an equal elevation, in part even rising a little from SW. to NE., up to the longitude of El Dikheila. The same applies to lagoons 1 and 3. Both crests and lagoons of bars 4a, 4b, and 4c are absolutely horizontal. Even the summit lines of many of the obviously strongly eroded older features, presumably of Villafranchian age, show long stretches of absolutely horizontal profile, as, for example, the Alam el Halfa Bar, on 20 km. between 29°23′ and 29°38′ E., or the Raqabit el Halif Bar, between 29°30′ and 29°43′ E. These characteristics, as well as the fact that the five highest bars all decline in altitude in two directions from a zone of maximum elevation (*not*, however, constituting an anticlinal axis between the various bars), make it unlikely that the older bars and lagoons are warped either. It appears certain that there has not been any warping or bending of the beaches since at least Lower Pleistocene times.

The origin of the sharp discontinuity in elevation of each of the bars at the longitude of Dikheila or farther east is another matter. The Abusir Bar continues northeastward at a lower but horizontal level (locally there are recent dunes on top) up to Abuqir; the Coastal Bar, to eastern Alexandria Harbour. The remaining bars are cut off at the edge of the Nile floodplain[4] and do not reappear at the surface—although they have been tapped in borings. In figure 1 these major discontinuities in level have been indicated as two almost straight lines affecting bars 1–3 and 5, 7–8, respectively. These zones may represent fault lines. The question is acute in view of the identical NW.–SE. fracture zones known from the southwestern periphery of the delta (see Yallouze and Knetsch, 1954). One could postulate a differential movement amounting to 10 m. since the deposition of bar 1; 25 m. since that of 2; and over 30 m. since that of 3. The older bars could be fractured along an older line, which, however, has curiously not had any effect on the younger bars to the seaward. The "Submerged Bar" would not seem to have been affected by either fault line. If it is pre-Holocene in date, which seems likely, the phenomena in question ceased before the close of the Pleistocene.

On the other hand, a plausible gradational agent responsible for these discontinuities in level has always been present in the form of the Nile. Possibly the greater part of the Maryut was excavated to below modern m.s.l. by a branch of the Nile during one or more regressional phases prior to the deposition of the Abusir Bar. In this way the Nile would have undercut the older offshore bars, while pluvial erosion of the local, consequent tributaries could have deepened the lagoonal depressions. Then in early post-Monastir or final pre-Würm time, when the Mediterranean was still a little higher than now, another branch of the Nile could theoretically have planed the surface of the two youngest bars east of El Dikheila to ±0 m., to +1 m., and +2–3 m., respectively. Another possibility would be that the presence of the Nile prevented sedimentation west of about these lines during the genesis of the various bars. From the evidence presented thus far the gradational agents would appear as plausible as the more speculative inferences of faulting in the Maryut area.

However, one feature cannot be explained as gradation; namely, that the difference in elevation between the crest line and the lagoonal axis of the Coastal Bar

[4] The El Mikheirta Bar seems to have been destroyed east of 29°40′ E. during the creation of the Alam el Halfa Bar.

remains nearly constant at about 7 m. both NE. and SW. of the discontinuity near Dikheila airport. If planation by the Nile had removed the Coastal Bar between Dikheila and Alexandria, this difference in elevation would have been either reduced or eliminated altogether. This same point can be raised on the basis of the limestone ridges struck by borings to below m.s.l. in the general Maryut depression. As it is, gradation cannot explain such a characteristic, so that major credit must be given to faulting along the fracture zone extending NW.–SE. along the western margins of the delta.

CONCLUSIONS AND SUMMARY

In conclusion, then, the following suggestions are offered:

a) The sequence of shore lines of Arabs' Gulf, representing offshore bars and lagoons, provides evidence in favor of at least eight transgressions above modern m.s.l. in the course of the Pleistocene. The altimetric values provided so far are insufficient, because of use of inaccurate criteria. Only when the levels of transition from lagoonal to terrestrial facies in the various lagoonal deposits have been accurately determined in the field can satisfactory and reliable values of former m.s.l. be ascertained. This has not yet been done for any but the two youngest bars.

b) On the basis of the fauna and foraminifera (particularly due to Shukri, Philip, and Said, 1956) the five oldest, major transgressions, achieving altitudes in the very approximate range of 50–120 m., can reasonably be considered as Lower Pleistocene.

c) A local m.s.l. of 10 m. has been determined at El Alamein (Abusir Bar), with a corresponding Tyrrhenian fauna both here and nearer to Alexandria. This transgression can be safely designated as Early Monastirian.

d) A Late Monastirian transgression of presumably 3–4 m. is also recorded (Coastal Bar), although it is no longer possible to determine the related sea level accurately.

e) The Coastal Bar and the related former lagoonal surface continue NE., with a sharp drop in elevation near El Dikheila, as a submerged ridge and trough, re-emerging as the former Pharos Island, now part of the peninsula of metropolitan Alexandria. A little seaward lies a chain of reefs and islands extending from Alexandria to the center of Arabs' Gulf. This represents another fossil bar ("Submerged Bar"), indicating a post–Late Monastirian sea level several meters below that of the present. Which of the two is supposed to represent the "Harbour Island Bar" is uncertain. Neither, however, is evidence in favor of an "Epi-Monastirian" sea level of ± 0 m. In either case the designation "Harbour Island Bar" should be abandoned.

f) The origin of the bar-lagoon topography south of Arabs' Gulf has not been associated with any local folding. Similarly, there has not been any warping or synclinal subsidence around Arabs' Gulf or in the Maryut area since at least the close of the Lower Pleistocene.

g) There is a marked discontinuity in level of the various bars in the Maryut area. Two possible explanations are considered: (i) Pleistocene fracture lines running NW.–SE. in the zone of the Miocene Delta collapse and (ii) subsequent gradation and also excavation by a branch of the Nile, coupled with stream erosion along consequent drainage lines between the parallel ridges.

Although only the former hypothesis is capable of providing satisfactory explanations of all the various features evident in the area, the coagency of erosional forces cannot be fully excluded. In either event the undeformed character of the "Submerged Bar" may indicate a pre-Holocene date.

ACKNOWLEDGMENT.—The fauna was in large part kindly identified by Professor K. H. Erben, of Bonn and Dr. A. Zilch, of Frankfurt a.M. Professor E. H. Hammond, of Madison, Wisconsin, kindly read the manuscript.

REFERENCES CITED

BLACKENHORN, M., 1901, Neues zur Geologie und Paläontologie aegyptens. IV. Das Pliocan- und Quartärzeitalter: Zeitschr. deut. geol. Gesell. Berlin, v. 53, p. 307–502.

——— 1921, Ägypten. Handbuch der regionalen Geologie: Heidelberg, C. Winters Verlag, 244 p.

BUTZER, K. W., 1957, The 2-m. raised beach at el Alamein, Egypt: Madrid-Barcelona, Actos V. Cong. INQUA (in print).

——— 1958, Quaternary stratigraphy and climate in the Near East: Bonner Geogr., Abh. 24: Bonn, F. Dümmlers Verlag, 157 p.

——— 1959, Contributions to the Pleistocene geology of the Nile Valley: Erdkunde, v. 13, p. 46–67.

FAIRBRIDGE, R. W., 1959, *in* Physics and chemistry of the earth: London, Pergamon Press (in press). See also: Dating the latest movements of the Quaternary sea level: N.Y. Acad. Sci. Trans., ser. II, v. 20, p. 471–482 (1958).

FOURTAU, R., 1893, La région de Mariout: étude géologique: Bull. Inst. d'Égypte, v. 3, p. 141–163.

HAFEMANN, D., 1959, Die Frage des eustatischen Meeresspiegel anstieges in historischer: Zeitschr. deut. Geographentag Berlin (in print).

HUME, W. F., and HUGHES, F., 1921, The soils and water supply of the Maryut district, west of Alexandria: Surv. Dept. Pub. 37, Cairo.

MCBURNEY, C. B. M., and HEY, R. W., 1955, Prehistory and Pleistocene geology in Cyrenaican Libya: Cambridge, Cambridge University Press, 315 p.

PFANNENSTIEL, M., 1951, Quartäre Spiegelschwankungen des Mittelmeers und des Schwarzen Meers: Vierteljhrsschr. Naturforsch. Gesell. Zürich, v. 96, p. 81–102.

SAID, RUSHDI, PHILIP, G., and SHUKRI, N. M., 1956, Post Tyrrhenian climatic fluctuations in northern Egypt: Quaternaria, 3, p. 167–172.

SANDFORD, K. S., and ARKELL, W. J., 1939, Paleolithic man and the Nile Valley in lower Egypt: Chicago, Univ. Chicago Orient. Inst. Pub. 46, 105 p.

SHUKRI, N. M., PHILIP, G., and SAID, RUSHDI, 1956, The geology of the Mediterranean coast between Rosetta and Bardia. II. Pleistocene sediments: geomorphology and microfacies: Bull. Inst. d'Égypte, v. 37, p. 395–427.

YALLOUZE, MEYER, and KNETSCH, G., 1954, Linear structures in and around the Nile Basin: Bull. Soc. géog. d'Égypte, v. 27, 1953, p. 168–207.

ZEUNER, F. E., 1950, Dating the past: rev. ed., London, Methuen & Co. (4th ed., 1958), 516 p.

——— 1952, Pleistocene shore-lines. Geol. Rundschau, v. 40, p. 39–50.

——— 1959, Criteria for the determination of mean sea-level for Pleistocene shore-line features: Mimeographed notes for the INQUA Subcommission on Mediterranean shore lines.

MAPS

The following maps were used by the author in preparation of this paper:

1:100,000 Topographic Series of the Survey of Egypt and Department of Surveys and Mines, Cairo; reprinted by the Army Map Service, Washington, D.C. Sheets: 92/48 Alexandria, 1939 (1942); 88/48 El Ghayata (rev. ed., 1927) (1943); 88/42 El Hammam (rev. ed., 1938) (1941); 88/36 El Alamein, 1926 (1942); 84/48 Wadi el Natrun, 1932 (1942); 84/42 Qaret Somara, (rev. ed. 1938) (1942).

U.S. Hydrographic Office publications:

1:250,680 Mediterranean Sea: Matruh to Alexandria, H.O. 3977, 1942 (1951).

1:20,000 and 1:10,000 Alexandria Harbour. H.O. 2553, 1955 (1957).