# RECENT MORPHOLOGICAL CHANGES ALONG THE COAST OF WEST PAKISTAN[1]

RODMAN E. SNEAD

*Clark University, Worcester, Massachusetts*

ABSTRACT. The Makran coast of West Pakistan can be divided into three broad geomorphic types: rocky cliffs, wide sandy beaches, and low flat delta plains. Very active tectonic movements are presently taking place and are likely to continue into the future. All large scale epeirogenic movements indicate emergence. Archaeological investigations suggest that coastal extension in places has been on the order of twenty to thirty miles in the last 3,000 to 5,000 years.

THE coastline of West Pakistan stretches from the Iranian border at the mouth of the Dasht River eastward about 616 miles to the Indian border at the eastern edge of the Indus Delta. The total length of shoreline is approximately 1,500 miles. This is necessarily a rough estimate because of the intricate system of tidal channels in the Indus Delta. Geomorphically the coast can be separated into three broad divisions (Figs. 1A and 1B). The first division consists of about 168 miles of steep, rocky cliffs interspersed with small pocket beaches. On the east several mountain spurs come directly to the coast. Farther west uplifted folded and faulted mountain ranges, aligned in an east-west direction parallel to the Arabian Sea, are being slowly denuded. The second major division, making up about 328 miles of coastline, consists of wide, sandy beaches backed by extensive desert alluvial plains. Most of these wide beaches and plains are found around scalloped bays which have formed between the eroded mountain ranges. The third major division is the Indus Delta coastline which is 120 miles long. The small deltas of the Dasht and Hingol Rivers are not included in this breakdown because they lack true delta characteristics. Instead of a network of tidal channels, the finer silts and clays are carried into playa flats and shallow lagoons and the coarser sediments form dunes and sand flats. Outside the large Indus Delta plain there are two very arid plains extending inland from the Makran coast. One of these is the Las Bela Valley, some thirty miles west of Karachi; it is fifty miles wide at the coast and extends eighty miles inland (Fig. 1B). The other plain, near the Iranian border, is the Dasht River plain, which is thirty miles wide at the coast and extends inland over 150 miles (Fig. 1A). The purpose of this paper is to explore briefly the origin and development of the Makran Coast. Some of the conclusions must remain tentative until fuller supporting evidence is gathered from the field. A discussion of the Indus Delta is not included in this report because my research to date has not been extended to this area.

The previous geomorphological literature on the West Pakistan coast is limited to short descriptions by authors who have traveled for short periods in the region.[2] Excellent aerial

*Accepted for publication May 12, 1966.*

[1] Field work for this study was done under a contract of the Coastal Studies Institute, Louisiana State University, with the Geography Branch, Office of Naval Research (Nonr 1575(03) NR 388002). The author is indebted to Professors Richard J. Russell and William G. McIntire, of the Coastal Studies Institute, for their careful and critical supervision of the field work and preparation of this paper.

[2] The following are the significant articles and reports: W. T. Blanford, "Note on Geological Formations Seen Along the Coasts of Baluchistan and Persia from Karachi to the Head of Persian Gulf and Some Gulf Islands," *Records of the Geological Survey of India,* Vol. 5, Pt. 2 (1876); E. W. Vredenburg, "Geological Sketch of the Baluchistan Desert and Part of Eastern Persia," *Memoirs of the Geological Survey of India,* Vol. 21, No. 2 (1901), pp. 198–215, and "Geology of Sarawan, Jhalawan, Mekran and the State of Las Bela," *Records of the Geological Survey of India,* Vol. 38, No. 3 (1909), pp. 189–215; C. F. Minchin, *Las Bela* (Baluchistan District Gazetteer Series, Vol. 8, Allahabad, 1907); M. B. Pithawalla, *The Problem of Baluchistan* (Karachi: Government of Pakistan Press, 1953), pp. 11–41; S. Zoha, "The Physiographical Personality of Baluchistan," *Pakistan Geographical Review,* Vol. 7 (1952), pp. 20–30; M. S. Krishnan, "The Structural and Tectonic History of India," *Memoirs of the Geological Survey of India,*

photographic coverage at a scale of 1:40,000 was made by the Hunting Survey Corporation in 1952–1954 as part of the Colombo Plan Co-operative Project.[3] The field investigation on which this paper is based was carried out during 1959 and 1960. The study involved 1) mapping the surficial deposits, 2) a survey of the modern and Pleistocene coastal landforms, and 3) a review of the sequence of geomorphic events since Mesozoic time.

## REASONS FOR TECTONIC INSTABILITY

Three broad generalizations can be made about the Makran coast. First, the coastal zone is, and has been, tectonically active since most of the Cenozoic Era. Movements are presently taking place and are likely to continue for some time to come. The eastern part of Baluchistan forms a segment of the Alpine-Himalayan geosynclinal belt which accumulated thick marine sediments from Jurassic to Tertiary times. The whole area underwent a great orogeny late in the Tertiary and formed two geanticlinal axial belts: the Central Axis and the Las Bela Axis (Fig. 2). Flanking these axial belts are several anticlinal structures which extend south from the main Himalayan Ranges. On the west side of Sind, the strike of several folded ranges runs generally north-south and can be followed to Cape Monze where the ranges disappear under the sea and appear to become part of the Murray Ridge, which is located in the northern portion of the Arabian Sea (Fig. 2).

In Baluchistan the folds curve westward in a wide arc and become ranges parallel to the coast. On the east side of the Las Bela Axis are found Jurassic, Cretaceous, and Tertiary limestones and sandstones. West of the Las Bela Axis, Tertiary, and Quaternary, arenaceous limestones, conglomerates, and weak mudstones predominate. Some of these rocks, particularly the mudstones, are not resistant to erosion and break down rapidly during heavy rains. Traveling by jeep through the eroded mudstones north of Pasni is like driving through the badlands country of North and South Dakota. The major difference between the two areas would be the color of the rocks; most of the Baluchistan mudstones are a dull gray.

The Makran region of West Pakistan continues to be tectonically active. Active mud volcanoes have developed along several of the weak anticlinal axes.[4] At the crest of the Haro Ranges, on the west side of the Las Bela Valley, individual mud cones have a relief of several hundred feet (Fig. 3). These may well be the largest mud volcanoes found anywhere in the world. Only in an extremely tectonic area, where violent seismic activity is exerting pressures on the gas trapped below, could unheated liquid mud be lifted through a central vent 1,400 feet above sea level to form these mud cones. It was observed that even the slightest earthquake will agitate Chandragup mud volcano which is located close to the Arabian Sea at the south end of the Haro Range.

At least twenty major earthquakes have been recorded in Baluchistan and adjoining areas between 1939 and 1960 (Fig. 2). In recent years there has been a concentration of epicenters off the coast near the fishing village of Pasni. The November 1945 earthquake epicenter (shown as a star on Fig. 2) was one of the most destructive of the twenty recorded earthquakes because a tsunami, estimated to be forty to fifty feet high, moved over the coast.[5] Also, local fishermen assert

Vol. 81 (1953), pp. 62–66; A. Ullah, "Physiography and Structure of the S. W. Makran," *Pakistan Geographical Review,* Vol. 9 (1953), pp. 1–10, and "Geology of S. W. Makran (Baluchistan States Union, Baluchistan)," *Pakistan Journal of Science,* Vol. 6 (1954), pp. 5–21; D. N. Wadia, *Geology of India* (London: Macmillan and Company, Ltd., 1953); O. H. K. Spate, *India and Pakistan: A General and Regional Geography* (London: Methuen and Company, 1954), pp. 423–32, 452–55; M. I. Siddiqi, "The Geology and Physiography of Karachi Coast (West Pakistan)" (Karachi: Department of Geography, University of Karachi: by the author, 1959), pp. 1–7; R. E. Snead, *Physical Geography Reconnaissance: Las Bela Coastal Plain, West Pakistan* (Baton Rouge: Louisiana State University Press, 1966), 118 p.

[3] Interpretation of these aerial photographs was published as a report for the Government of Pakistan by the Government of Canada, titled: *Reconnaissance Geology of Part of West Pakistan: A Colombo Plan Co-operative Project.* (Oshawa, Ontario: Conducted and compiled by Hunting Survey Corporation, Ltd., Maracle Press, Ltd., 1960).

[4] R. E. Snead, "Active Mud Volcanoes of Baluchistan, West Pakistan," *The Geographical Review,* Vol. 54 (1964), pp. 546–60.

[5] V. P. Sondhi, "The Makran Earthquake, 28th November 1945, The Birth of New Islands," *Indian Minerals,* Calcutta, Vol. 1, No. 3 (1947), pp. 147–58; C. G. Pendse, "The Makran Earthquake of the

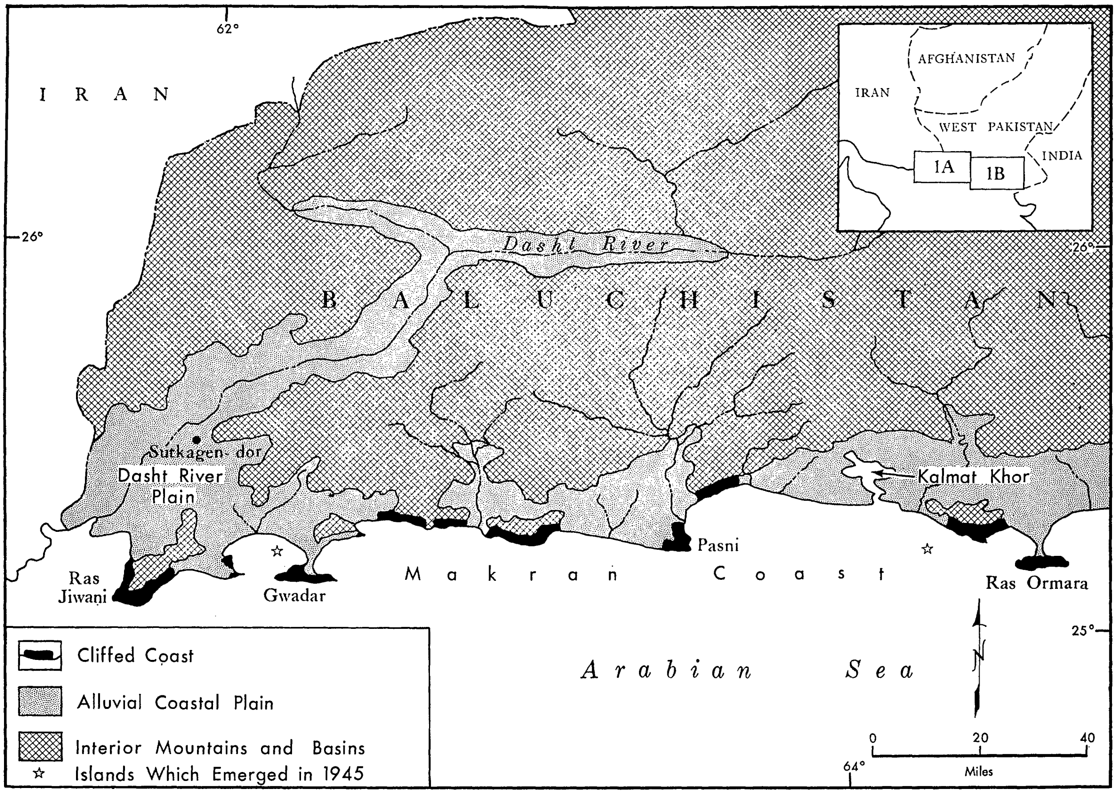


FIG. 1A. Landform divisions: western portion of the West Pakistan coast.

that a section of shore near Pasni was uplifted fifteen feet. It is of interest and perhaps significant that the magnitude of this earthquake, as recorded at the seismological station at Quetta, was under 6.7 on the Richter scale. So active is this whole coastal region, the Hunt Petroleum Oil Company, drilling near the Hingol River in 1956, reported its drill became permanently stuck when an earthquake of slight intensity occurred about 400 miles to the north.[6] Several earthquake epicenters occur along or close to the Las Bela Axial Belt. This axial belt can be followed to the north where it joins with the main Himalayan orogeny, and most likely it has a connection with the structure in the Indian Ocean (Fig. 4).

Discussion with a British oceanographer, on the findings of the International Oceanographic Expedition to the Arabian Sea, suggests that the Owen Fracture Zone can be followed for a distance of 1,800 miles from the coast of West Pakistan south to the east side of the Somali Basin.[7] Movements along this weak structural zone can be tied into the overall instability of the Makran coastal region. An active rift system can be followed, not only directly to the coast but inland through the Las Bela Valley to the spurs of the Himalayan chain.

### DEGREE OF UPLIFT

The second generalization is that all epeirogenic movements appear to be of similar nature, on a large scale, and consistently indicate emergence. Very few areas give evidence of reverse movement and temporary resubmergence. The folding taking place

28th November 1945," *Scientific Notes*, Indian Meteorological Department, Vol. 10, No. 125 (1948), pp. 141–45.

[6] Unpublished report of Hunt Petroleum Oil Company, received June 1959.

[7] A. S. Laughton, personal communication, and B. C. Heezen and M. Tharp, "Descriptive Sheet to Accompany Physiographic Diagram of the Indian Ocean," Geological Society of America, Inc. (1964).

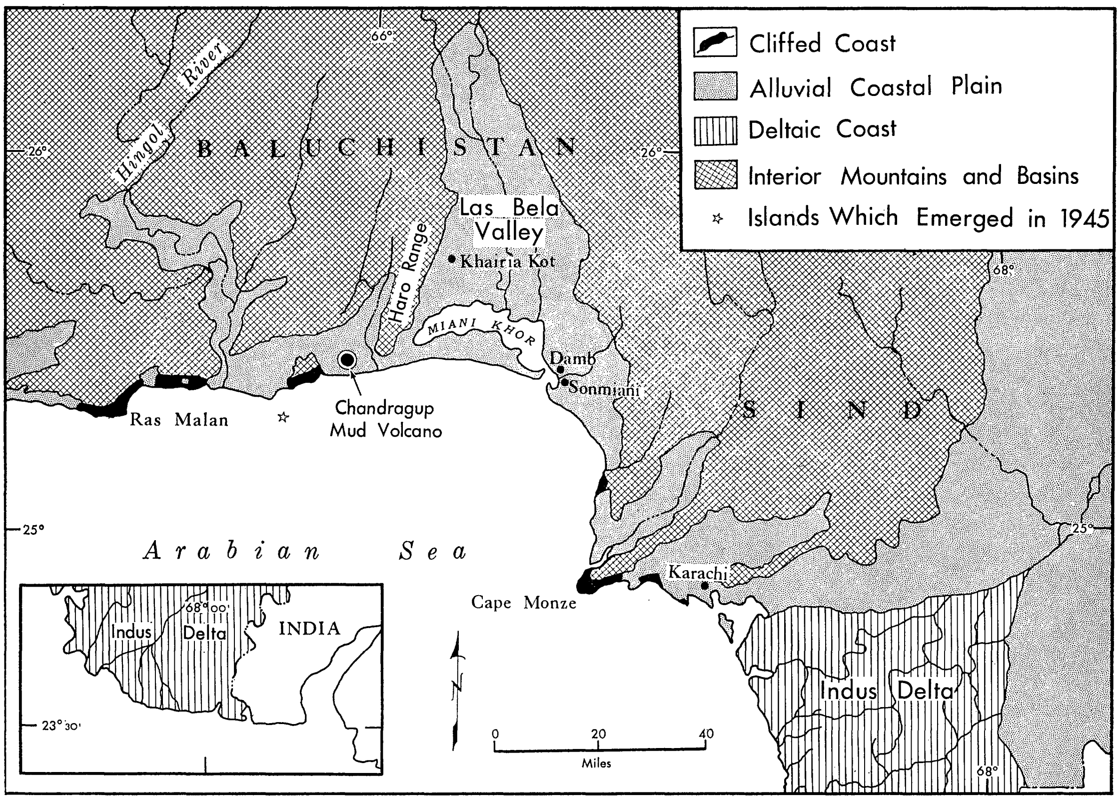


FIG. 1B. Landform divisions: eastern portion of the West Pakistan coast.

along the coast is comparable to the folding of the Appalachian Mountains; that is, regular open folds which have vertical or slightly inclined axial planes[8] (Fig. 5). But the folding is complicated by numerous strike-slip faults and high angle reverse faults which parallel and intersect the fold axes (Fig. 6). Evidence of uplift is most striking in the large individual fault blocks which have risen as islands directly off the coast. Two of these massive blocks have subsequently been connected to the coast by tombolos. A fault block eight miles long and 2.5 miles wide, Ras Ormara, has a fault face which rises 1,000 feet directly from the sea. The ten mile long tombolo which connects this rock mass to the mainland is covered with large shifting dunes and accretion ridges. The fault block called Gwadar, rising to an elevation of 476 feet, is also connected to the mainland by a large tombolo. Two small rocky islands formed off the Makran coast as a result of the November, 1945 earthquake (Figs. 1A and 1B).[9] Their points of emergence most probably indicate crests of hidden anticlines or fault blocks for they are on a general alignment with the headlands of Ras Malan, Ras Ormara, Gwadar, and Ras Jiwani.

Along with anticlinal folding and scattered fault blocks, horizontal rock platforms have been uplifted and in places warped into gently sloping tablelands. Pleistocene shell conglomerates, sandstones, and limestones lie discomformably on the folded Makran Series of Tertiary rocks. Near the Hingol River there is a strand platform, capped by a resistant shell conglomerate that has been uplifted to about eighty-five feet above present sea level (Fig. 7). Upon walking across the surface of this platform numerous shells and barnacles could still be found attached to the outer surface of the rocks. Even slickensides were still

[8] Interpretation of these aerial photographs was published in the report cited in footnote 3; Sheet No. 30A, Correlation Chart.

[9] Sondhi, *op. cit.*, footnote 5.

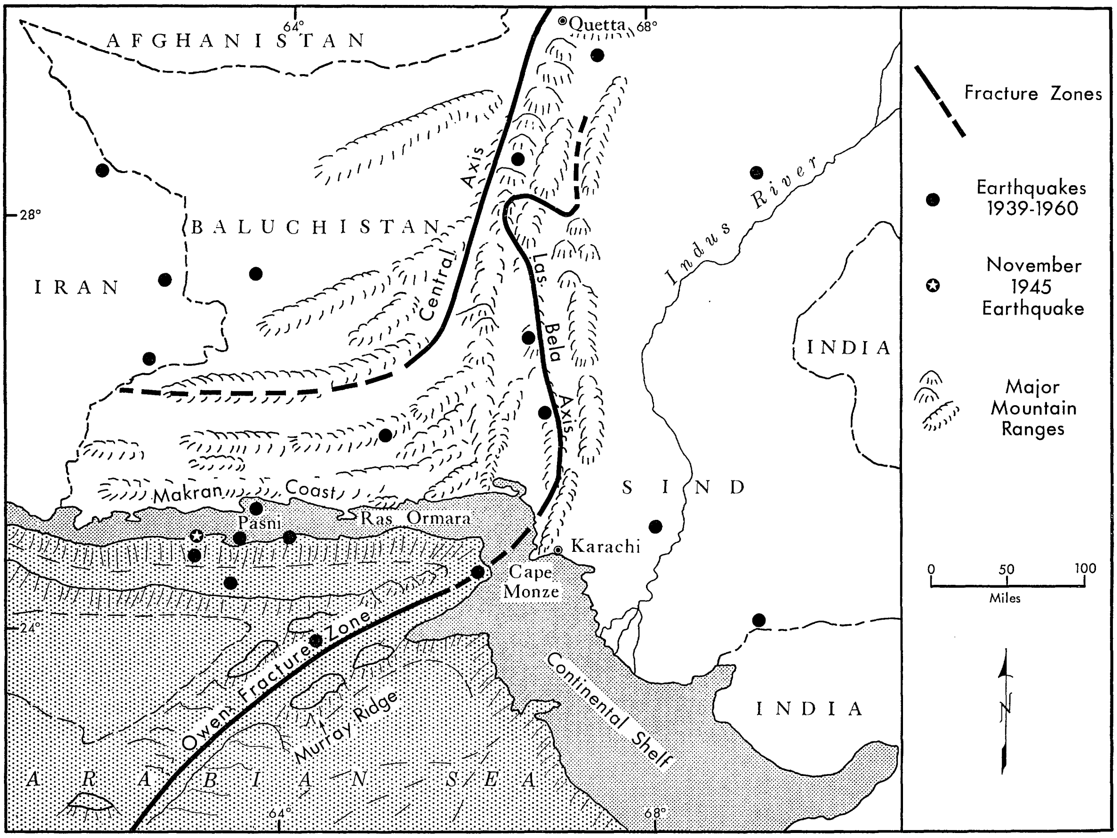


FIG. 2. Tectonic map of West Pakistan, adapted in part from *Reconnaissance Geology of Part of West Pakistan, op. cit.*, footnote 3, Sheet No. 30A.

found on the faceted spur ends of the platform. At Ras Jiwani, near the Iranian border, flat-topped rocky platforms that are now eroded into fantastic shapes have been elevated some 400 to 600 feet. There is a possibility that ancient river and coastal ports are now uplifted several hundred feet above sea level.[10] Buddhist caves, found in the northern part of the Las Bela Valley, are now perched high by faulting in the vertical walls of one of the valleys.[11] The author, visiting the site in 1959, found that rapid downcutting by rivers could not completely account for their elevation.

[10] G. F. Dales, "Harappan Outposts on the Makran Coast,"*Antiquity,* Vol. 36 (1962), pp. 86–92; and "A Research for Ancient Seaports," *Expedition,* Vol. 4, No. 2 (1962), pp. 2–10.

[11] T. H. Holdrich, "Notes on Ancient and Mediaeval Makran," *Geographical Journal,* Vol. 7 (1896), p. 399; and H. S. Scott, personal communication, September, 1961.

There is good field evidence of faulting. Reverse faults on the order of several hundred feet were found by the author along the eastern front of the Haro Range. Near the south end of this range unweathered barnacles and oyster shells were found in places thirty to forty feet above present sea level. Even the present spits, bars, and accretion ridges are being affected. A small graben with two normal faults was found extending from the south end of the Haro Range across a series of thirty beach ridges to within a few hundred feet of the coast. Although this displacement represents a downdropping on the order of only a few feet, moisture collects in the swales and vegetation is more luxuriant. While working along the coast, the author felt two small earthquakes, but they did not appear to be very severe and they were not recorded at the seismological station at Quetta. Yet small earth movements may have taken place.

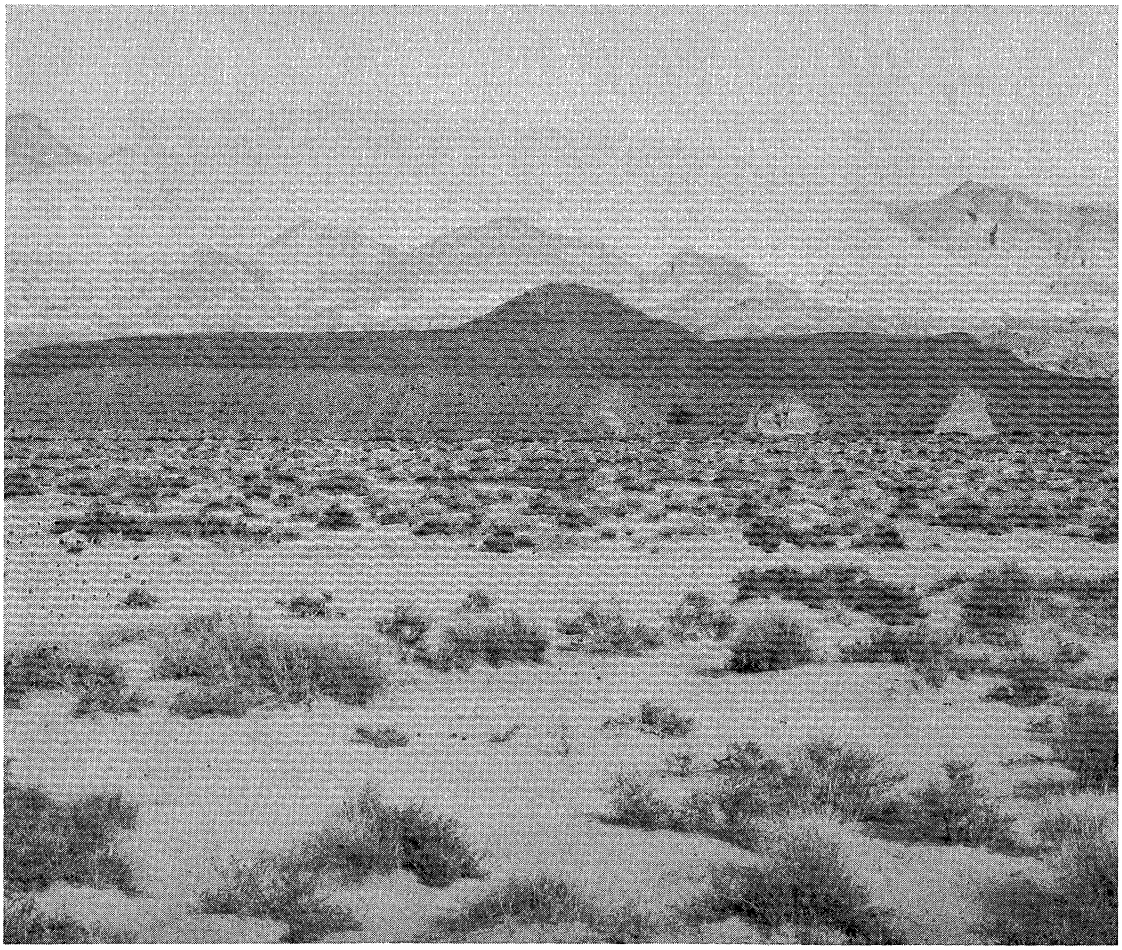

FIG. 3. Along the anticlinal crest of the Haro Range is a group of mud volcanoes which are presently active. Their light gray mud looks almost like snow. These are among the largest mud volcanoes found anywhere in the world. Individual cones have a relief of over 500 feet, and the mud is being emitted over 1,400 feet above sea level indicating tremendous pressure is being exerted on the gases and liquid mud trapped at depth. At the base of the mountains are a series of uplift gravel fans with a nearly straight fault scarp at the outer edge.

### DIFFICULTY IN DATING EPEIROGENIC MOVEMENTS

Close observations of the uplift in the Las Bela Valley clearly show faults which cut tilting beds. Uplift on a small scale in this region is so recent it might be categorized as almost pre-World War II. Tilted and uplifted gravel fans on the flanks of the Haro Range stand out as weathered, isolated remnants. The source for the original gravel fans must have developed when the Haro Mountains rose rapidly in Tertiary Time. The strata composing these mountains are now nearly vertical and rise 1,000 feet or more above their flat outer reaches. Rapid erosion and deposition so complicate the sequence of epeirogenic movements that little or no information as to the exact time of uplift can be derived from studies of Pleistocene and Recent deposits.

Actual dating of marine benches on most of the headlands is very difficult. But it may be that the recent unweathered oyster beds found thirty to forty feet above sea level near the south end of the Haro Ranch can be correlated with similar oyster beds found ten to twelve feet above sea level northeast of Sonmiani, and five to six feet above sea level near Karachi. All three sites may have been uplifted at the same time, possibly in the

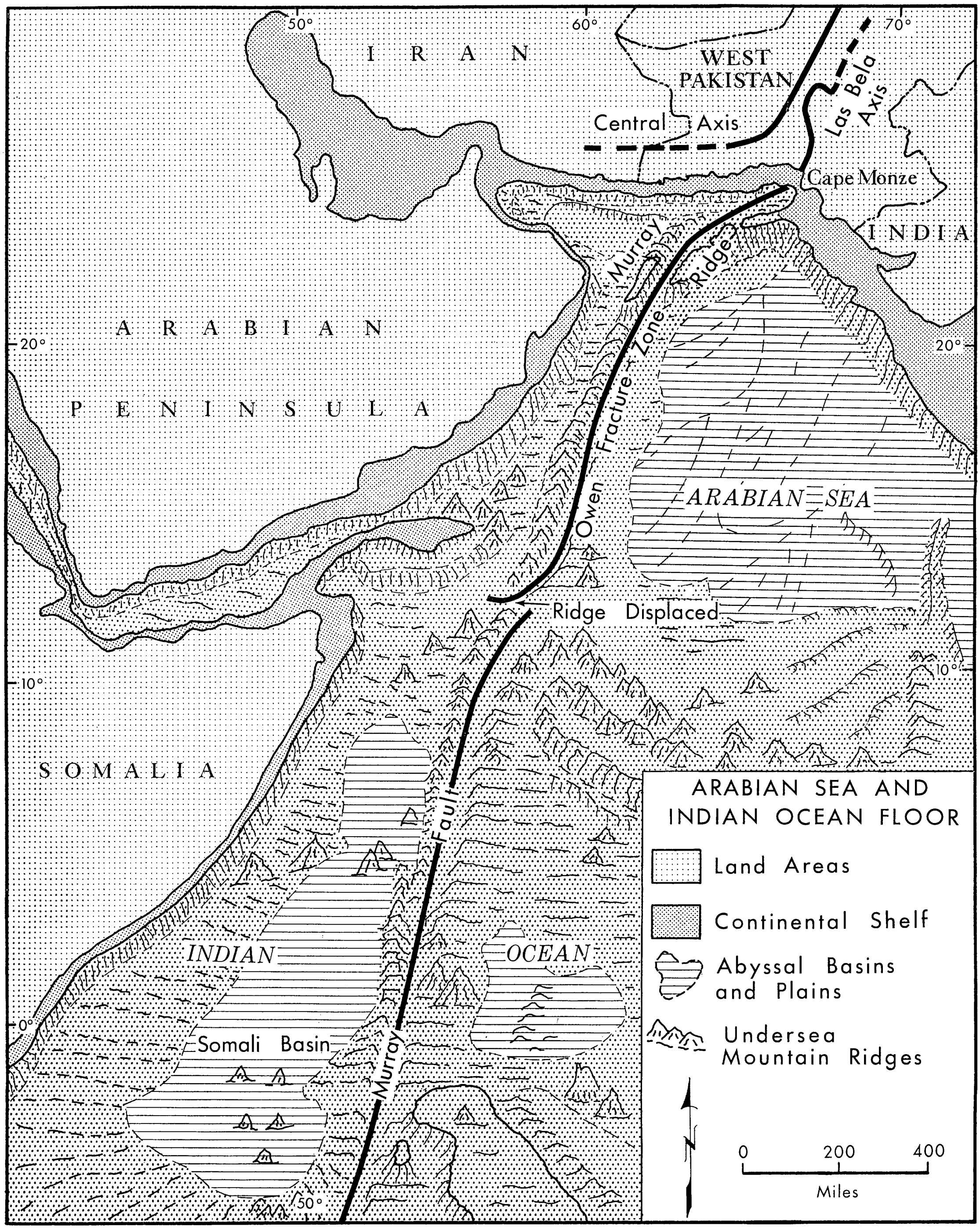


FIG. 4. Physiography of the ocean floor south of the West Pakistan coast. Adapted in part from B. C. Heezen and M. Tharp, *Physiographic Diagram of the Indian Ocean* (New York: Geological Society of America, Inc., 1964).

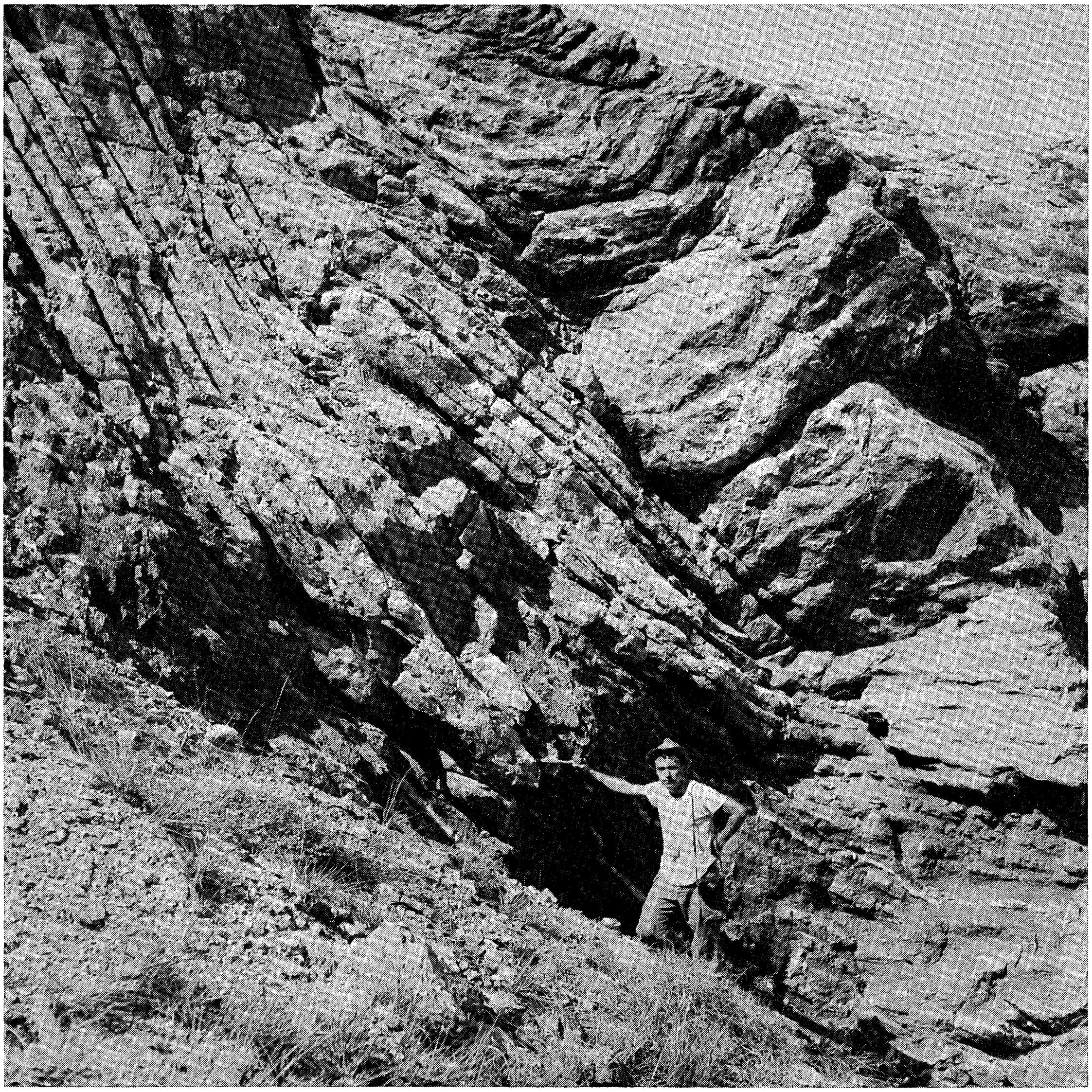

FIG. 5. Folded Cretaceous limestone and sandstone strata exposed near the coast on the east side of the Las Bela Valley.

second millennium B.C., or they may represent three separate isolated periods of uplift. The second millennium B.C. was suggested by Dales as a time when a sudden rise in the Arabian Sea coastline of West Pakistan influenced the Indus Valley civilizations by changing drainage patterns.[12] It appears that the uplift was greatest, about 300 to 400 feet, along the western section of the Makran coast, decreasing to six to eight feet in the Indus Delta region. Local exposures of nonfossilized oyster beds found only a few feet above sea level are both difficult to date, because of their recent formation, and difficult to correlate because of the complex inter-relationship between sea level changes and intermittent uplift. At several locations it appears that sea level changes have had more influence upon the coastline than tectonic movements.

[12] G. F. Dales, "The Mythical Massacre at Mohenjo-Daro," *Expedition,* Vol. 6, No. 3 (1964), p. 43; and R. L. Raikes, "The End of the Ancient Cities of the Indus," *American Anthropologist,* Vol. 66 (1964), pp. 284–99.

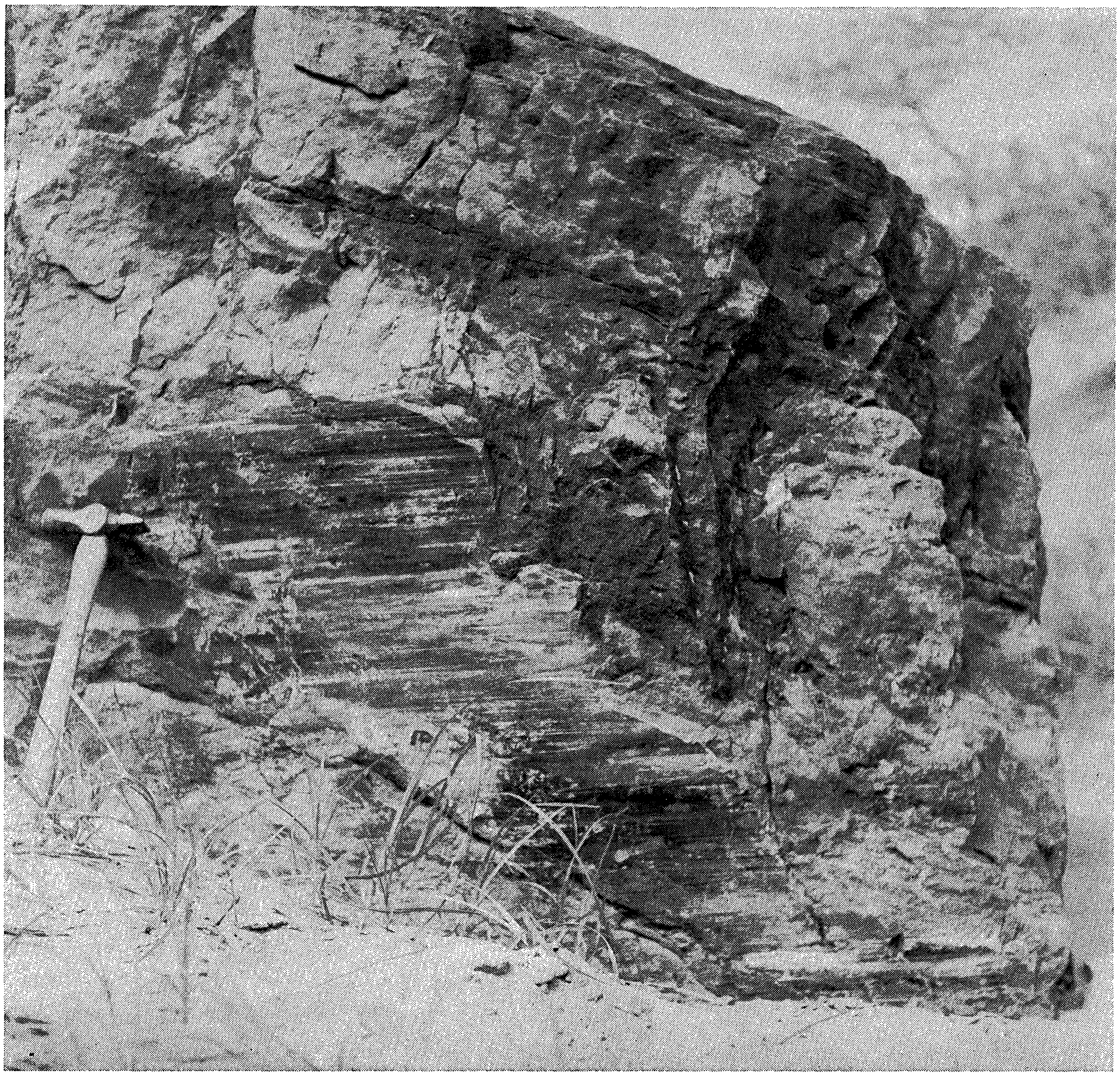

FIG. 6. While traveling in the mountains which border the Las Bela Valley the author found numerous small slickensides along irregular fault faces. This picture was taken at a limestone outcrop on the east side of the valley.

Inland from the coast, evidence of both gradual and sporadic coastal emergence is afforded by the entrenchment of drainage. Approximately ten feet of uplift on the west side of the Las Bela Valley has entrenched a dendritic drainage pattern. Partly as a result of this rapid rejuvenation, scattered areas of older alluvium have been eroded, leaving alluvial remnants which are mapped as Pleistocene deposits.[13] On the east side of the Las Bela Valley there is over seven cubic miles of uniform sand which grades inland into loess. Most of this huge sand complex appears to be Pleistocene in age. Preliminary investigations in the field indicate that most of the sand is eolian. Well preserved sand lenses show cross-bedding with dips twenty-five to thirty degrees. Most of the beds are aligned

[13] The Pakistan Geological Survey calls these deposits "subrecent" because they are alluvial deposits that postdate the Himalayan orogeny, are unfolded, but are in a state of erosional degradation. *Reconnaissance Geology of Part of West Pakistan, op. cit.*, footnote 3, pp. 298–99.

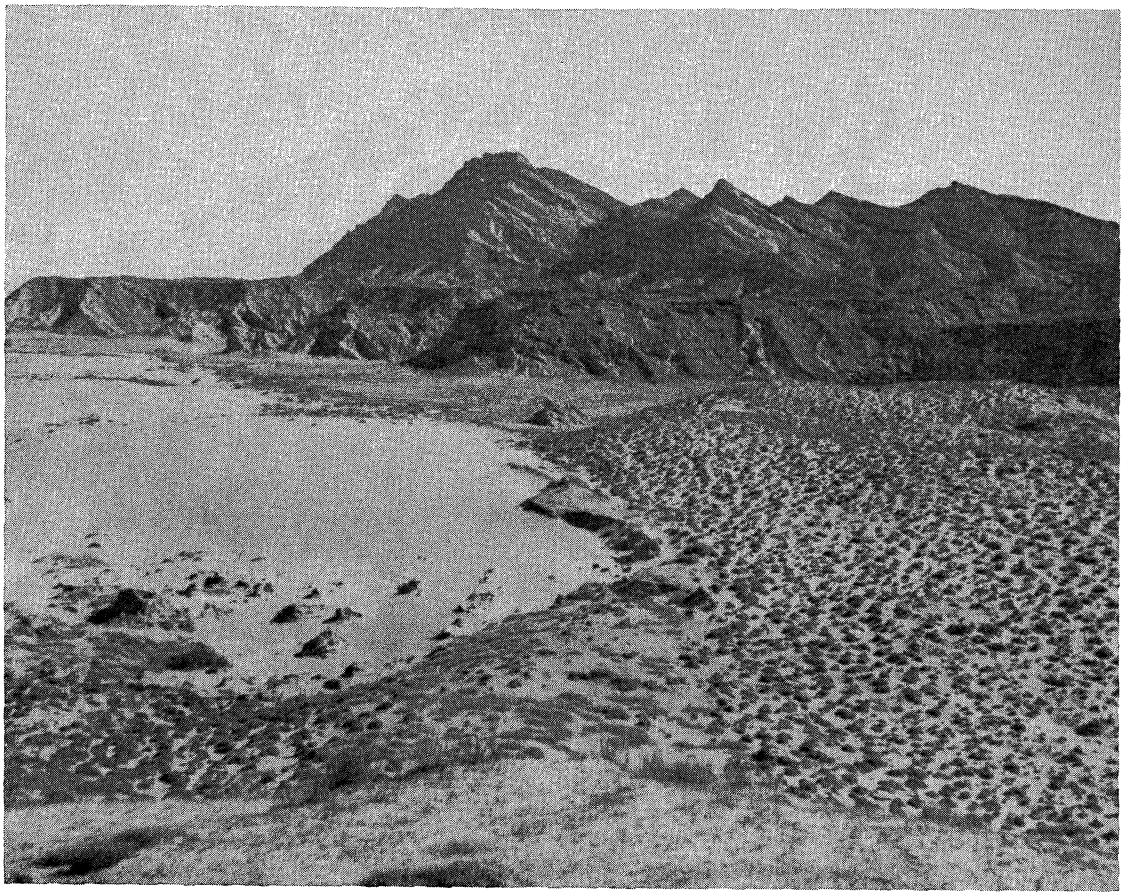

FIG. 7. Near the Hingol River there is an uplifted marine terrace eighty-five feet above present sea level. The front face of this terrace is wave-cut, but alluvial deposits from the Hingol River are presently building a wide sandy beach. Dunes stabilized by vegetation are in the foreground.

northeast-southwest, which is to be expected of deposits formed by strong southwest winds. Except for broken shells and foraminifera, which were probably blown in with the sands, no marine deposits have been found. Stream-carried gravel lenses occur throughout the sand mass and appear to represent small rivers which crossed the region from nearby mountains. Pleistocene sand complexes are found in other localities along the coast. Their presence presents a number of questions which still remain unsolved. There are three main questions: what are the sources of the sands, when did they accumulate, and how can they be tied into the evidence for uplift along the Makran coast? At the present time the Pleistocene sands are being dissected. Evidence for this very recent erosion can be seen in the deep V-shaped canyons which have been formed by rapidly headward cutting streams. While traveling along these canyons, retreating nick-points were found in the unconsolidated sands and gravels. On the seaward side of the Las Bela sand mass there are 100 to 200 foot high cliffs that are being undercut by waves during storm surges.

## DEGREE OF SEDIMENTATION

The problem of deposition leads to the third generalization: the rivers, dry on the surface most of the year, carry in flood enormous amounts of alluvium to the coast in flood stages. The Sutkagen-dor site, a possible Harappan seaport dated in 1961 at 2000 B.C. by Dales is located today thirty-five miles inland from the Arabian Sea coast, at an eleva-

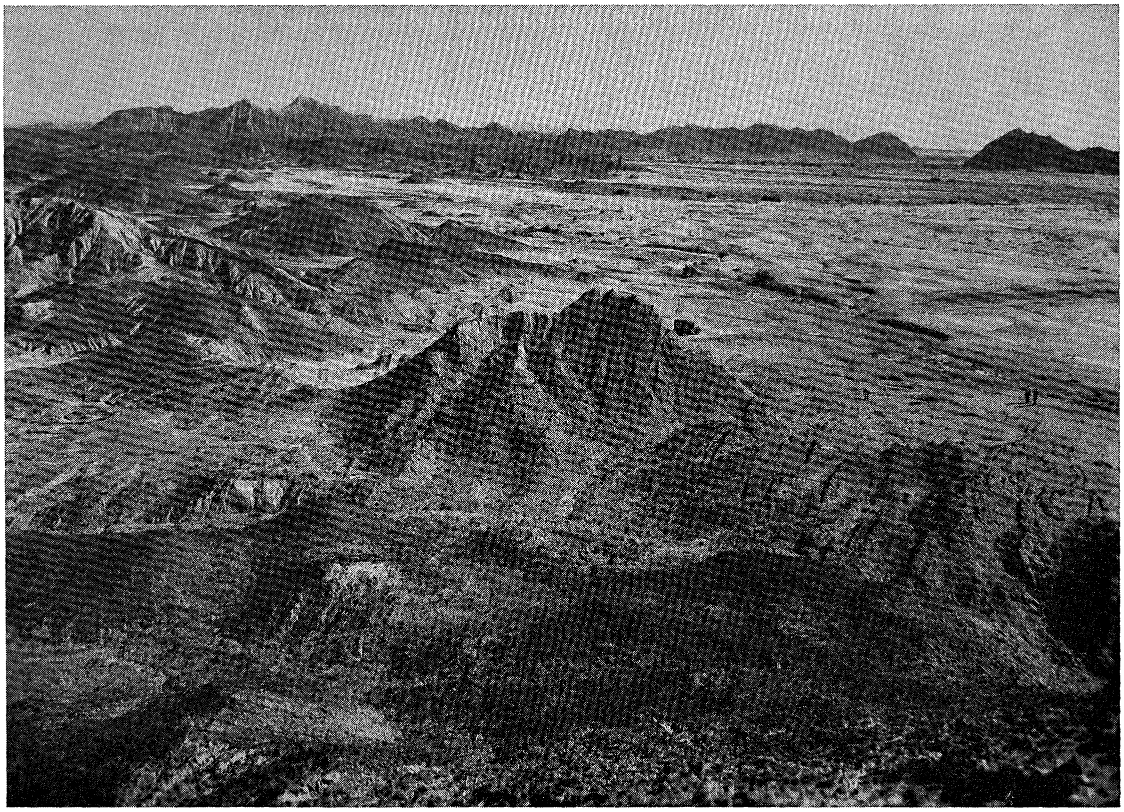

FIG. 8. The 1,000 to 3,000 foot high Makran Coast ranges are steeply folded and faulted. The soft clays, marls, and shales have been eroded into a badland type topography. This picture is north of the fishing village of Pasni.

tion of about 136 feet.[14] This indicates the extent both of silting by the Dasht River and possible uplift during the last 3,000 to 5,000 years. On the west side of the Las Bela Valley another historic site called Khairia Kot was investigated by the author in 1960. This site which is now twenty-five miles from the present coastline may also have been a Harappan port. In an area where the average annual rainfall ranges from nine inches at Karachi and actually decreases to less than seven inches west along the Makran coast, it seems hard to believe that extensive alluvial plains could form so rapidly. However, great erosion from torrential downpours should not be overlooked, for every few years a single storm may bring excessive amounts of precipitation.[15] Deposition has been so great that more than half the coastal zone is made up of unconsolidated river deposited materials (Figs. 1A and 1B).

A major source of material for these large river valleys is the uplifted, only partially indurated, Tertiary mudstones and siltstones of the Makran hills that are eroding at a fantastic rate (Fig. 8). Another source of material for valley filling comes from the rocky headlands, which catch the full force of storm waves. Erosion has been intense, resulting in steep cliffs, stacks, arches, sea caves, and blow holes. A large arch near Karachi, composed of uplifted Miocene sandstone, is under heavy wave attack (Fig. 9).

It appears that there are more sands, silts, and clays on the costal flats than can be accounted for by rivers alone. For example, the extensive sand plains between nearly all the rocky headlands have too few rivers to account for the degree of deposition, although longshore currents may contribute some sedi-

[14] Dales, *op. cit.*, footnote 10.

[15] Between 31 June and 4 July 1959, over twelve inches of rain fell between Karachi and Ormara when an Arabian Sea cyclone joined with a pre-season monsoon depression.

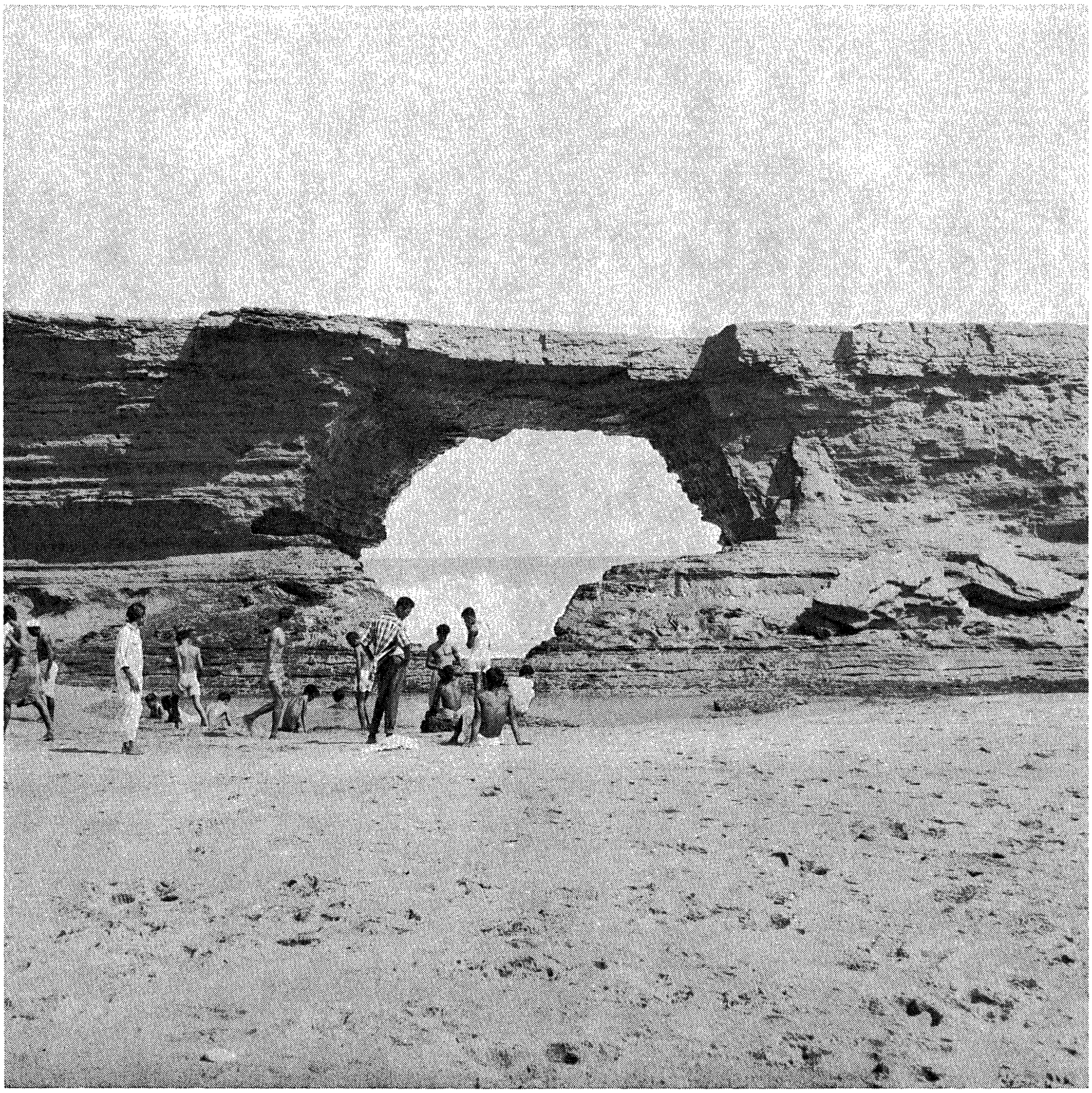

FIG. 9. West of Karachi nearly horizontal Tertiary sandstones have been uplifted fifty to sixty feet above sea level. Where these rocks are under heavy wave attack several large sea arches have been cut.

ment. It may be that slow uplift of the continental shelf, exposing sections of sea floor, is a credible explanation. However, the sequence of events and complexity of the geologic history make it difficult to decipher the changes in detail.

When uplift of a rock mass such as Ras Ormara occurs, the overall changes which take place do become quite clear (Figs. 10 and 11). The inland location of the pre-uplifted coastline can be established by the wave-cut cliffs on the seaward side of the rocky headlands and by the inner coastal dunes which are now stabilized by vegetation (Fig. 10A). An uplifted island, such as the fault block of Ras Ormara, sets the stage for protected pocket bays and lagoons. As material accumulates a series of accretion ridges are formed (Fig. 10B). At several locations along the Makran coast over 100 ridges and swales can be counted. Field investigation of the most seaward of the Las Bela beach ridges found early Arab potsherds indicating these ridges were probably formed after A.D. 711. Sometimes

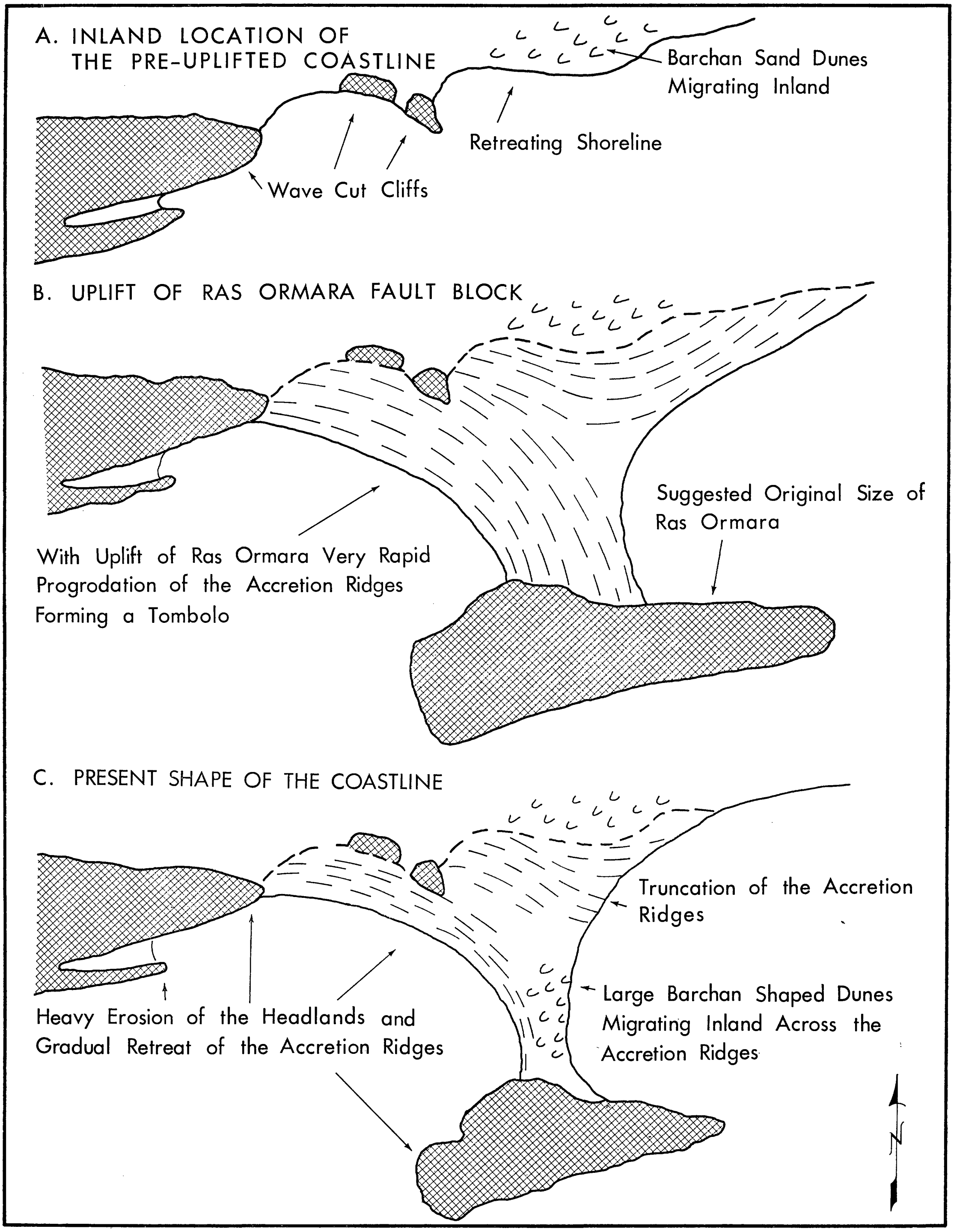


FIG. 10. Coastal changes at Ras Ormara.

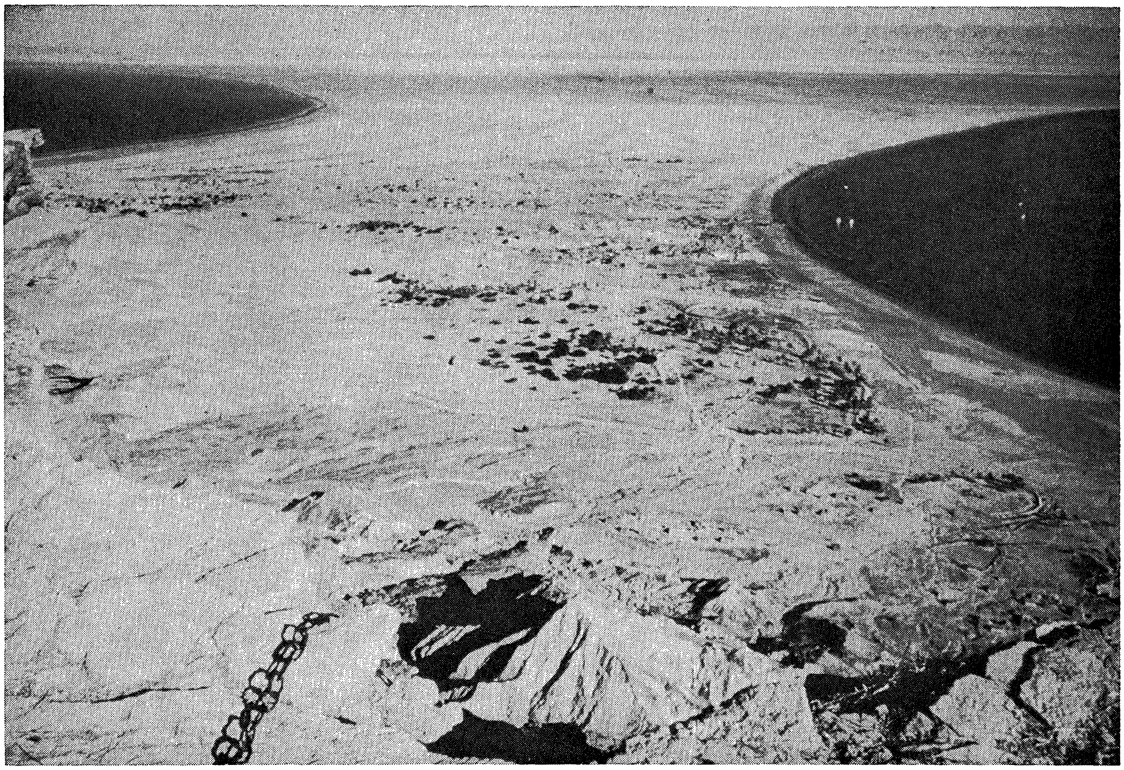

FIG. 11. Looking north across the wide tombolo which connects the headland of Ormara with the mainland. In the left background are accretion ridges which formed the tombolo. In the right background are a series of large crescentic dunes. The fishing village of Ormara is in the right center. Chain was used to climb the 1,000 foot scarp of Ras Ormara.

the growth of accretion ridges will be so rapid that sections of the bay are separated from the ocean and form large shallow lagoons. Miani Khor and Kalmat Khor (Figs. 1A and 1B) are two such lagoons which are slowly being filled with silts and clays. Low mangrove trees, most of which were found to be only three to four feet high, consisting predominantly of *Avicennia* and *Rhizophora* species, grow on the tidal mud flats. These trees are living in a very harsh environment. Not only are they at the northern temperature limit for mangroves, but they face a recurring scarcity of underground fresh water upon which they depend.

Progradation of the coastal plain appears to continue until an equilibrium is reached. This equilibrium consists of rocky control points with wide lunate bays in between. The formation of lunate or scalloped bays depends upon the wave patterns which curve around the bays according to the laws of refraction.[16] In time, as the headlands come under heavy wave attack, especially during the monsoon months of June, July, and August, the entire shoreline retreats in line with the rocky control points. With retreat the shoreline often becomes straightened and this straightening will truncate the former beach ridges. Along with the erosion of the headlands at Ras Ormara there has been a gradual retreat of the accretion ridges on the tombolo (Figs. 10C and 11).

In several locations where coastal retreat is taking place, large, barchan-shaped dunes are migrating inland from the beach. A day was spent by the author on camelback crossing the very large crescentic dunes which are presently migrating across the tombolo which

[16] C. A. Kaye, "Shoreline Features and Quaternary Shoreline Changes, Puerto Rico," United States Geological Survey *Professional Paper*, 317-B (1959), pp. 62–66.

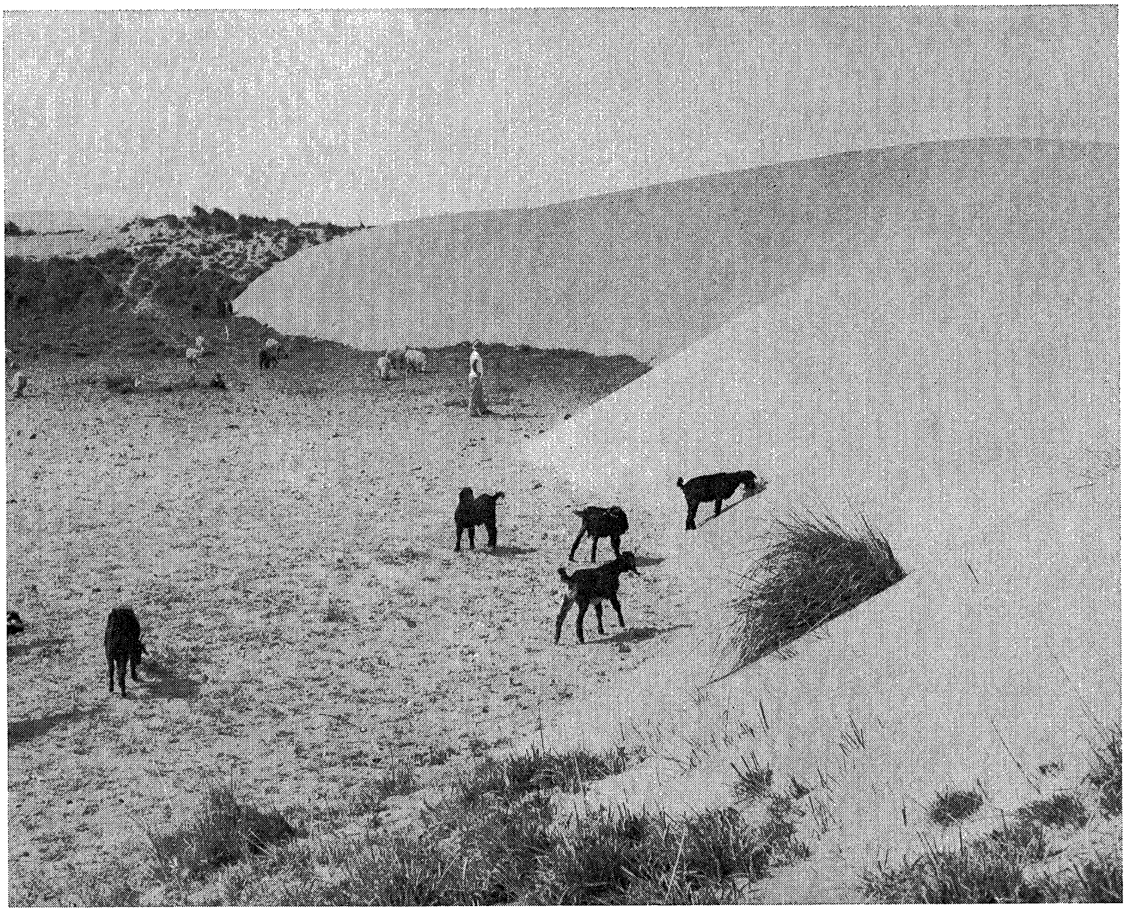

FIG. 12. Large crescentic sand dunes are presently migrating inland from the coast across the accretion ridges. These dunes, averaging twenty to thirty feet high, are extensive along much of the Makran Coast.

connects Ras Ormara with the mainland (Fig. 10C). On the Las Bela coastal plain it was observed that dunes are rapidly covering and destroying the accretion ridges (Fig. 12). More studies need to be made on the rate of movement of these dunes in order to establish a date for the change from deposition and the formation of accretion ridges, to erosion and the development of migrating dune masses. Some of the presently migrating dunes are of exceptional size. Near the fishing village of Damb (Fig. 1B) there is a very large sand mass with a perfect crescentic shape. Its dimensions were measured and found to be over eighty feet in height, 1,500 feet in width, and nearly five-eighths of a mile in length. On top of this single barchan were found a series of smaller barchans which move across the crest and down the lee side.

## SIGNIFICANCE OF THE FINDINGS

The three generalizations presented above are closely related. The Makran coastal region is not only tectonically active, but the movements indicate a continuing uplift. This uplift results in the formation of rocky headlands and exposed portions of the continental shelf. Protected pocket bays and lagoons between the nearly formed headlands are being rapidly filled in by alluvial deposits. Once material is brought to the coast currents and winds take over as the main agents in the formation of the wide, sandy beaches and extensive migrating barchan dune masses.

The Makran coast of West Pakistan is a geomorphologist's paradise because Recent tectonic movements, although complicated, have set the stage for the development of magnificent landforms. Also, the fact that this is a desert coastal region means that the processes of weathering, erosion, and transportation take place without vegetation playing a significant role.

It is hard to believe that so many changes have taken place over such a large area in such a short period of time, generally during the last 3,000 to 5,000 years. It may very well be that George Dales is correct about the 3,000-year-old Harappan coastal ports now found twenty to thirty miles inland. It appears that the changes that took place were more rapid than originally supposed, and the sequence of events may be on the order of hundreds of years, rather than thousands of years.