# River Piracy and Diversion in Karachi Basin

**Karachi Basin**

Karachi drainage basin is a well defined physiographic unit, demarcated by the high outfacing scarps of the Gaj formation on the east and north west. On the south, the coast line forms the base of this triangular basin, while the apex is formed by the northern extremity of the Mol plateau, the point on which the two scarps converge. In the north these scarps rise abruptly and steeply about a thousand feet above the surrounding plain of the Upper Nari formations. These scarps have been developed due to the presence of resistant limestone beds in the Gaj formations, dipping inwards at a low angle. Their thickness has been estimated about 500 feet at the Khar Nai Gorge by Blanford. Southwards, the scarps lose in height as the Basin gradually plunges in this direction. Below Lang Loharani, due to the increased dips, lesser thickness of limestones and alternation of beds of varying resistance to erosion, the vertical scarps split into parallel quests and hogback ridges. On the east, the height of the scarp is less but it is continuous and well marked upto Karachi-Sehwan Road. Below this point for some miles there are only low isolated hills of Gaj rocks and the water-divide shifts to the crest of the Kara Range. But after a few miles the scarp again becomes prominent and continues upto Dhabeji area.

Structurally, the Karachi Basin is a synclinal basin with exposures of the Uppermost Tertiary rocks namely, the Gaj and the Manchhar formations, ranging from Miocene to Pliocene in age. The Basin comprises the drainage areas of the Malir and the Lyari rivers, and and two re-entrant plains, one around Mauripur to the west and the other east of Landhi. The so-called rivers of this area remain

dry for most of the year, flowing only after rains for a few days or hours. At such times they carry large volume of water, muddy with heavy charge of silt, to the sea. Some of them have perennial surface flow in certain reaches. Most of them carry underground flow, fluctuating with the season. The Karachi drainage area is hemmed in between two more powerful drainage systems, the Hab Drainage on the north and west and the drainage of the Indus tributary, the Baran river on the east.

**Rock Formations in the Area**

The newest rocks exposed in the Basin area are the Manchhar rocks, Upper Miocene to Pliocene in age. They are seen along the coast from a few miles east of Cape Monze to Dhabeji area. They are interrupted in the middle, where they are covered by recent alluvia of the Layari and the Malir rivers. In the Layari valley, they extend far inland into the Gadap plain. A narrow outlier of these rocks is situated in the upper Mol valley, extending north and south of Thana Shah Beg. The Manchhar rocks consist of pale brown purplish clays, soft grey or brown sandstones and conglomerates, containing pebbles of similar sandstone and clay nodules. These rocks contain marine beds at different horizons, and in this they differ from the Manchhars of the other parts of Sind which are considered to be fluviatile deposits. For this reason Vredenlurg renamed them Hinglaj formations and grouped them with the similar marine formations found along the Makran coast and considered them older than the Manchhars. But in his last publication of 1925,[1] he discarded this name and adopted the name "Makran group" for the whole formation, restricting its age to Post Gaj period or Pontian to Pliocene. In Karachi area mammalian bones and a complete skull was found near Rehri. Lignite seams are also seen in this area. Bone fragments have been found in other parts also. Therefore, this formation even in this area is not wholly marine. This formation is capped unconformably by a thick and coarse conglomerate, considered by Blanford to be Post-Tertiary or Sub-Recent.[2]

The Manchhar group is underlain by the Gaj formation of Miocene age. They occupy the greater part of the basin. They

consist of coarse sandstones near the base and above them pale brown or white limestones sometimes rubbly. The uppermost beds consist of more sandstones and clays. The total thickness of the group was estimated by Mr. Fedden at about 800 feet near Sawaji.[3] At the Khar Nai Gorge its total thickness of 500 feet consists of limestones.[4] Towards Karachi, limestone becomes subordinate to other rocks, being prominent only due to its greater resistance to erosion and therefore, forming ridges. The next older group underlying the Gaj formation is the Nari group of Oligocene age. Nari formations surround the Basin all along the Gaj scarps. A narrow inlier of this formation, about 23 miles from north to south and 4 miles across where broadest, lies between upper Khadeji and the Mol rivers. The Upper Naris consist of thick bedded usually soft grey sandstones with subordinate bands of clays, shales, ironstone and conglomerate. In Sind areas, they are unffossiliferous and partly fluviatile. But near Karachi, in the Hab valley, they contain bands of fossiliferous limestones at different horizons. The Lower Naris are the Nummulitic limestones, with lower beds often white and massive and the upper beds brown or yellow, interbedded with shales and layers of sandstones.

The entire lower Hab valley consists of Upper Nari formations. In the section between Band Murad Khan and Lang Loharani, on the eastern side of the river, sandstones are dominant, with a few intercallations of limestones in the upper part and of clays and soft sandy shales in the lower. Sandstones are generally fine-grained and soft. Some of the beds are ripple-marked. On the western side the outcrops consist mostly of sandy shales, pale coloured and thinly bedded. They break into minute fragments where exposed on the surface. They are interbedded with fine-grained thinly-bedded sandstones often ripple-marked. These shaly beds extend right upto the foot of the Pab Range, and apparently resemble the Flysch of Western Baluchistan. Nari Group has great thickness. Blanford estimated it at over 5000 feet west of Bailithap.[5] In the lower Hab valley they may have still greater thickness. The Upper Nari rocks with their great thickness and very low resistance to erosion are very important element in the evolution of landscape in this area.

Further outward to the east, the anticlines rising above the Nari Plains are composed of the Kirthar group, the next older formations of Middle Eocene age. They consist of white or grey massive Nummulitic limestones of great thickness and high resistance to erosion. The Kara and Laki Ranges and a few more anticlinal folds east of the Kara consist of Laki group, also with Nummulitic limestones but older than the Kirthar formation. In the faulted core of the Laki Range, Rani Kot of Palaeocene and some Upper Cretaceous rocks outcrop. To the north west, the Hamlig, the Lakhan and the Kara ranges are composed of Kirthar formations, while the Pab Range to the west shows outcrops ranging from Lower Nari to the Lower Cretaceous rocks. Most of the Tertiary formations in this area are unconformable to their underlying and overlying formations.

**Folding and Faulting in the Area**

The most pronounced orogenic movements in Baluchistan occurred in Upper Eocene, Middle Miocene and Pliocene periods. But in Sind the mountains are entirely due to the last movements. Areas to the west and particularly along the Hab valley appear to have been affected by the earlier movements also. A well marked disconformity is noticeable in the Miocene Gaj formations at Cape Monze and also towards the east in the ridge running along the coast. Conditions during the deposition of the Manchars were not stable. Presence of pebbles derived from the Gaj and even lower Manchhar sandstones in the Manchhar conglomerates, indicates that certain areas had been arched up and emerged above the sea. These emerged areas were undergoing dissection, while deposition of the upper Manchhars was still going on in the troughs. North of Karachi, irregularities of stratification in the Manchhars indicate the fluctuating conditions in the area, "at one time subjected to river action, at another to marine". Force acted mainly from the west to east. But in the vicinity of Karachi the forces, as stated by Dr. Crookshank, acted from south east and west south west, the former becoming more important westward into Baluchistan.

Structurally, the Karachi Basin differs markedly from the region lying to the east and also from that on the west. The easter tract

is occupied by Jura type of folds. These folds are asymmetrical, anticlines being gentler on the west and very steep on the east. Apart from the Laki and Kirthar Ranges, all the folds are short, with their pitching ends interlooking and arrouate in plan with their convex sides to the east. Their axes are not even but show sags and rises. There are three long, continuous and broad synclines, running from north to south all through the tract. They are separated by belts occupied by small pitching anticlines, running obliquely and arranged rather echilon. This tract has attained greater amplitude of tectonic relief and has been arched as a whole. The Kirthar and Laki limestone formations have been raised in the anticlinal axes upto 2000 to over 3000 feet above sea level in the north, but they markedly fall in level to the south. Normal strike faulting is a common feature of this area. East of Bhedur Range a thrust fault has been mentioned by Blanford where Kirthar formations have been thrust over the Nari rocks to the east, both the formations showing dips to the west. This fault continues southwards upto the Nari inlier previously mentioned. Here this same disturbance has produced double fold in the Nari inlier and some slipping on their east, close to Rahuja gorge.

The Karachi Basin is structurally a down folded basin. It is enclosed on the east by an interrupted arc of Nummulitic limestones constituting the anticlinal folds of the Bhedur, Dumbar, Hundi and Kara Ranges; while the Kirthar formations of Hamlig, Lakhan and the Pab Ranges demarcate this tectonic basin on the west. The floor of the Basin has been mildly folded. More important folds strike obliquely through the middle of the Basin. Synclines are long, broad and shallow. Anticlines are rather long and narrow, and pitching towards ends. They are again steeper on their eastern flanks. They appear to be the south-westerly continuation, into the newer rocks, of the folds structures of the Benir, the Kirthar and the Dambar Ranges, The middle portion of the Basin rises up like a low undulating plateau. Most of these folds die out as they reach the alluvial plains of Gadap and Malir, and give place to two broad synclines occupied by the Lyari and the Malir rivers, separated in their lower reaches by the Drigh Road Dome.

Mangho Pir fold is a breached anticlinal spur, plunging in a south westerly direction. It appears to be a shallow fold, restricted only to the upper half of the Upper Nari formations. Strata on the right bank of the Hab at Band Murad Khan show no effect of this fold and have regular strikes parallel with the Pab Range and dipping with them to the south-east, at an angle of about 35°.

Hamlig, Lakhan and the Pab are rather complex anticlinal folds much disturbed by a faulting. The Pab Range represents only the eastern limb of the great original fold, the core area has been reduced to valleys and plains. Western Gaj scarp and the area to the west is all shattered by faults. The whole area is literally a mosaic of fault blocks. Three distinct sets of faults can be recognised in this area. Firstly, the strike faults are in evidence along the eastern foot of the Pab Range. Similar faults are present in Lakhan, Karo and Hamlig Ranges. Within the Hab valley there is much disturbance along the right bank of the river, where the reversal of dip and much shattering is visible near Hasan Pir North of Band Murad Khan. West of this line, many low engled minor thrust faults, hading south east, can be seen in stream banks. Drag folds and contortions, with over folding to the north west, are well seen in some of the incompetent shaly beds in this area. This line of disturbance has been actually seen upto Kuraro Nallah. But it appears to be extending north east all along the valley in the direction of Hinidan gap between Hamlig and Mehar plateau. Sections of some stream channels appear to be aligned along this fault zone.

The second set of faults has a general direction of the fault lines from north west to south east. These faults are most numerous in the ridges running through Mangho Pir area. They show in many cases considerable horizontal offset. Some of them are reverse faults. These faults have affected the Pab and the Hamlig Ranges also. Two such parallel faults separate the Hamlig Range from the northern ranges and provide a gap through which the Hab river passes from one syncline to the other on the west. Faults of the third set run from north east to south west. All these faults have topographic expressions and are important in providing gaps in the limestone ridges through which the streams pass, and also in exposing the weaker strata to erosion where they underly resistant beds.

**Adjustment of Drainage to Structures**

The basin area with broad and shallow synclines, low anticlinal folds, thick and resistant Gaj limestone formation and gently plunging towards the sea, possesses great structural stability. The original consequent streams still find their way to the sea through the synclinal valleys. They cross the anticlines only occasionally where aided by a fault or some other structural weakness.

Over the eastern tract, with the advantage of greater altitude, tension cracks and jointing better developed over the crests of the anticlines, steeper slopes and more numerous transverse streams passing through the gaps between pitching anticlines, the resistant covering of Gaj limestone was more easily breached. Subsequent streams established themselves into the Nari formations. The Gaj scarps were formed and started receding outward from the anticlines and the Nari beds were gradually penetrated, until the next resistant formation of Nummulitic limestone was reached. This limestone being very resistant, thick and massive, erosion over it was very slow and the entire cover of the weak Nari rocks along with the Gaj capping was completely stripped off from anticlines. The subsequent streams shifted towards the synclines, thereby undercutting and reducing the Gaj formations even in the synclines. In this way the anticlinal domes of Nummulitic limestones have been exhumed and some sort of annular drainage has been developed round them in the Nari beds. Main streams still flow in the synclines but drainage is, in a way, resequent. The main Gaj area has been shifting westward and now forms the steep scarps forming the eastern margin of the Karachi drainage Basin. It is constantly retreating under atmospheric attack and against the head ward erosion by steep graded obsequent streams, working back in the weak underlying rocks. Lithological conditions are similar in the western area also. A great thickness of weak Nari sandstones and shales lies between the Gaj and the Kirthar formations. Moreover, the whole belt has been shattered by faulting. The lower Hab valley which is a strike valley owes its existence as much to faulting as to the degradational processes. From both sides the Gaj scarps are under attack and gradually retreating inwards. The area of Karachi

drainage basing is slowly shrinking and yielding ground to the flanking drainage areas of the Hab and the Baran rivers.

**Process of Stream Capture**

Apart from this gradual shrinkage of the basin, some more spectacular changes have occurred in the form of stream capture. On the eastern side headstreams of Gangiaro, a tributary of the Baran, have been extending their valleys to the west by headward erosion into Gaj scarp. One of them, the Isar Nadi working into Nari rocks south of the Benir fold, has penetrated upto the Nari inlier and reached within 2 miles of the Mol river. In doing so, it has captured the northern streams Rahuja and others, which flowing through synclines joined the Khadeji rivers. The second stream, the Ular through an obsequent tributary has captured a stream Gorand originally entering the Khadeji valley. This stream descends from the Gaj area to the Nari plain over 2 falls, one of them 100 feet and the other 50 feet high.

Further north, the upper part of the Hikabro Dhora now flowing due north appears to be a reversed stream as indicated by its hooked tributaries. This reversal has occurred along the south ward continuation of the thrust fault east of Bhedur. The consequent drainage from the flanking anticlinal folds into the Basin has been intercepted by the development of subsequent valleys on their western sides. In case of Kara Range to the south, this process is not yet complete and a few streams still join the Khadeji river. But they form an insignificant part. Greater part has already been diverted away from the Karachi Basin, through the Trak N. towards Kalri Lake and through Bade N. and Ran Pethani into the Gharo creek.

On the west similar changes have occurred. The original drainage through the synclines occupied by the Lyari and Wattenwari in its lower part has been dismembered through the process of stream capture. The Kand Nadi, a tributary of the Hab river and occupying an antinclinal valley, has captured the drainage of its northern section. The Sham Nadi, forming the middle part of the drainage has been turned to the west to join the Hab river through the Khar

Nadi. At its sharp turn to the west, it descends 70 to 80 feet in 3 steps into the gorge of Khar Nadi. The presence of terraces to the east of the Sham Nadi indicates that the channel had been gradually shifting to the west and sinking down into Gaj beds before the capture took place. Further south, obsequent tributaries of the Hab river, working back along the fault lines have captured some smaller tributaries of the Lyari. Some smaller diversions of the drainage have occurred due to normal recession of the scarps. The Mol valley being situated in the middle has remained intact and projects far to the north.

The process of river capture has been accelerated in the area due to the intermittent vertical uplifts during recent times. Abandoned sea cliffs, raised beaches, permanently exposed wave-cut benches and shell banks along the coast and "valley-in-valley" condition in the river channels and the presence upheaval. This uplift is not a local phenomenon, but has been observed and noted by different geologists all along the coast from Karachi area right upto the head of the Persian Gulf and even along the western coast of Indian Peninsula. It has rejuvenated the rivers and streams of this area again and again and given added advantage to the streams flowing through the subsequent valleys, flanking the Karachi Basin.

**Changes during Pleistocene Period**

Apart from the slow and gradual changes occurring during geologically recent times, some more important and drastic changes took place during earlier times. Thick formations of conglomerates in the Karachi area have already been mentioned. They rest horizontally on the truncated strata of the Manchar group, often dipping steeply. They sometimes cover the Gaj formations also. They show slight tilting where they lie close to some fault line, along which movement has occurred after their deposition. All the high grounds along the coast from Mauripur area upto Clifton and even parts of Ghizri are composed of these conglomerates. Many exposures are seen within the limits of the city and in Lyari valley they extend upto the Gadap plain and cover large areas. They are considered Post-Tertiary or Sub-recent by Blanford. They are very coarse and composed mostly of river-worn ellipsoidal or spheroidal pebbles of

Nummulitic limestones, deposited by rapid currents. They are coarsest at Manora, Mauripur Road and in the Lyari valley. Towards Ghizri they become finer and across the Ghizri creek on Ibrahim Haidari ridge they are still finer composed mostly of gravels and sands with some pebbles generally flattish and probably wave-worn. Also the pebbles of the Nummulitic limestones are scarce in this area. Deposition of these coarse conglomerates by a river is also clear from the oblique bedding of deltaic structure, with foreset beds dipping to the west, observed in them occasionally in Karachi area. Occasional association of oyster shells with these conglomerates noted by Blanford, indicates that they were deposited under deltaic conditions in shallow water.

At present there is no stream in Karachi drainage area, capable of depositing such extensive and coarse conglomerates. Moreover, Nummulitic limestones are nowhere exposed in the present catchment areas. The pebbles are sometimes very large; their longer axes measuring 10 to 11 inches and their rounding is so perfect that they require a powerful river to transport them for very long distances. Hab river is the only river which could have flowed through this area. The structural control oven the initial drainage appears such that the passing of the Hab river through this area seems to be inevitable, because the formation of the lower Hab valley is a later development.

North of Dureji, the Hab river occupies a long syncline which continues directly southwards and is occupied in the lower section by the Mol, the longer tributary of the Malir river. Conglomerates are developed in the Malir valley also. The Dumlottee Gorge has been out in thick conglomerates. These conglomerates extend northwards as well as southwards for many miles, now forming flat topped hills. But these conglomerates differ markedly from those of the Lyari valley. Firstly they are much finer, mostly consolidated gravels and sands. Large pebbles are seen only in one band exposed at the base of cliffs at Dumlottee Gorge. They are not well rounded but rather subangular. More significantly the whole mass is composed of pebbles and gravels derived from the Gaj limestones. No pebbles of Nummulitic limestone could be traced in these deposits. The source of the materials forming these conglomerates could not be

very distant, and it is apparent that the Hab river never flowed through this valley.

Hab river in the very early stages was forced to the west at Pureji through a gap caused by the sinking of the block between two parallel faults. Then it turned again sharply to the south into another synclinal valley between Hamlig and Karo Ranges. From this it entered the syncline occupied by the upper Kand and the Sham Nadi and flowed directly into the Lyari-Wattenwari valley.

**Two Wind Gaps at the head of Lyari-Wattenwari Valleys**

At the head of the Lyari-Wattenwari valley, there are two broad wind gaps, separated by a narrow ridge of Gaj limestone. Both of them are about three quarter of a mile broad, their cliffs, particularly the western ones, being smooth and water worn. These gaps are deeply filled with alluvium, without any rocky outcrop on the floor and no talus accumulations under the cliffs. Permanent water table in the gaps is not very deep and they are covered by dense growth of Babul trees and bushes. After rains they support considerable growth of creepers and grasses providing fodder for the camels and cattle of the Gadap plain. They could not be the channels successively occupied by the river. The form of the intervening narrow ridge, with its flat and broad end to the north and tapering off to the south, suggests that the gaps mark the channels of two rivers near their confluence. The old Hab river flowed through the valleys of upper Kand and the Sham Nadi and through the eastern gap entered the Gadap plain.

The western gap is a remnant of a channel of another river which entered from the north west to join the old Hab further down. Probably the Wira Hab flowing upto the present position of its junction with the Hab continued flowing in the same direction, the lower Hab valley being non-existent at that time, and flowing through the gorge of the Khar Nadi, which is now more than 600 feet deep, entered the western gap and joined the old Hab river. Later on when the Wira Hab drainage was intercepted by the development of the lower Hab valley, its lower course was reversed to form the present Khar Nadi.

**Ultimate Diversion of the Hab**

Below the Wira Hab, the transverse consequents from the Pab Range came down directly to the Lyari valley and the re-entrant valley of Mauripur area. Due to the shattering of the harder strata by faults they rapidly sunk down and subsequent valleys were formed and aided by strike faults extended rapidly in either direction. Considerable area towards the Hab mouth is a plain of marine erosion. A broad belt along the coast north of Cape Monze still preserves large patches of old plain of marine abrasion capped by conglomerates and uniformly rising above 50 feet contour. Recent marine shells are noticeable further inland at still higher levels, proving encroachment of the sea upto these areas. In this way by the development of subsequent drainage in the broad Nari belt, helped by strike faults, and the marine attack from the west a broad valley was formed, directly communicating with the sea to the west. Crumbling under atmospheric attack and retreat of the Gaj scarp, headward erosion by the small subsequents and obsequents in the weak Nari beds and probably further subsidence between the old strike faults in this area brought about the final diversion of the Hab river into this valley. Farther history of this valley is the history of the Hab river itself. Coarse river conglomerates have been developed in the valley, but they appear to be confined within a narrow belt on either side of the river. West of this belt the broad slopes appear to be continuous upto the feet of the Pab Range. A few points visited in this area did not show any conglomerate capping, but a covering of normal talus and drift material of angular and sub-angular fragments.

In the present state of knowledge it is not possible to work out an ordered chronology of the events in this area. Several marine terraces reaching upto 150 feet contour have been noticed. Some of the wave out benches have covering of beach gravels full of marine shells. Similarly in the valleys, three or four river terraces are developed. But no palaeontological or archaeological investigations in these newer deposits have been made so far and correlation is not possible. Under these conditions only some tentative suggestions can be made at this stage.

In the Hab valley within the narrow belt of the conglomerates 3 or 4 terraces are seen. The alluvium below Band Murad Khan is

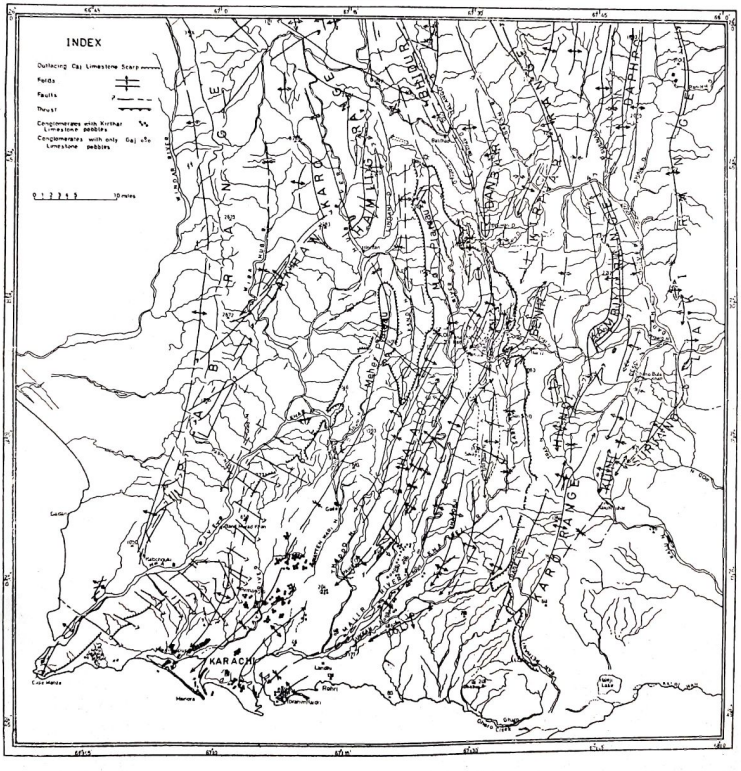
# KARACHI DRAINAGE BASIN

AND

ADJOINING AREAS

SHOWING

DRAINAGE IN RELATION TO STRUCTURES



not merely a thin veneer over the valley slopes. It is fairly deep and is underlain by a thick basal conglomerate. This conglomerate is met with in all the irrigation wells below Band Murad Khan and forms the aquifer in this area. From this we may conclude that a graded stream cut a broad valley floor by lateral planation and later during a phase of transgression it aggraded the whole valley, spreading coarse gravel and pebble beds all over the floor, and built up the alluvial plain. Now due to recent uplift it has again degraded its channel, removed the entire cover of finer alluvium from the channel and is now cutting into the lower conglomerates and minor rapids and irregularities in the stream profile can be seen below Hab Chouki. Dissection of the upper terraces has also much advanced. All this requires considerable time.

Similar conditions also prevail in the deeply filled channel of the Malir river. Further upstream, the Khadeji falls about 20 feet high are formed in a new consolidated gravel derived from the Gaj limestones, and showing excellent crossbedding. At this point this consolidated gravel rests on the floor of the gorge previously cut in the limestone. Further downstream it rests upon another gravel bed not so strongly consolidated and partly eroded. At this place two previous phases of degradation two phases of aggradation are recorded. After the recent uplift the entire filling is being removed in the present phase of degradation. Now, if these aggradational phases in the Khadeji Gorge and Hab valley could be proved on other grounds also to be due to the eustatic changes of sea level during the later half of the Pleistocene period, the conglomerates of the Lyari and the Malir valleys which are certainly older than those of the Hab valley and the gravels of the Khadeji gorge, must have been formed during early Pleistocene period. And therefore, the diversion of the Hab river may have occurred sometime in the middle of the Pleistocene period.

**Acknowledgments**

I have to thank officers of the Survey Department, Geological Survey of Pakistan and Canadian Photographic Survey Corporation for their permission to examine the serial photographs of the area and also for help in the study of these photographs. I also acknow-

ledge with thanks the help received from some oil geologists working in this area.

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