The Drainage Pattern and Denudation Chronology of the Mahaveli Ganga (Ceylon)

THE rivers of Ceylon are remarkable more for their number than for their size. Most of them are simple water-courses for the discharge of the surplus rainfall into the sea. The Mahaveli Ganga is a significant exception. It is the longest river ; it is longer than any other two rivers of the Island put together. It is 206 miles long. The next, Aruvi Aru (Malwatu Oya) is only 104 miles long. The lengths of the next dozen rivers in order of size, range from 97 miles (Kelani Ganga) to 70 miles (Kumbukkan Oya). All others are shorter.

The Mahaveli Ganga, as would be clear from the accompanying map, is a most peculiar and marvellous river, or rather a highly anomalous drainage system. An attempt is made here to explain and interpret the river in terms of its drainage pattern, natural history and denudation chronology, in the light of modern geomorphological knowledge.

For this, in the first instance, we should try to find out the environmental milieu in which the river system has developed. This consists of:—

1. The geological structure of the region drained by the river. By structure are implied both the nature of the rock outcrops and their disposition. The region drained by the river consists mostly of rocks belonging to the Khondalite System. It comprises a wide variety of gneisses, granulites, crystalline limestones, quartzites, etc. These have been intruded by various granites, especially in the form of sills. Thus the surface is not homogeneous. This heterogeneity implies differences in the rates of erosion according to the relative resistivity of the rocks in which valleys are carved, viz: differential erosion. With regard to the disposition of the rocks, they are arranged in the form of a synclinorium. The keel of the downfold may be taken as including the high plains, running from the Horton Plains N.N.W. towards Hantane. This is an excellent example of *inversion of relief*, the fold axis of the syncline becoming eventually the crest line of a ridge. Further, it has to be noted that the synclinorium pitches N.W., i.e. the fold axis shows a N.W. plunge.

2. Jointing in the rocks. This is well developed in many of the rocks of the System, especially in the case of the intrusives, the migmatites or composites resulting from intrusion, etc.

3. Shatter-belts and fault-zones caused by earth movements.

4. Variations in the regional distribution and seasonal incidence of rainfall.

For an Island with its general relief pattern resembling a topographical dome in the centre, the normal drainage pattern would be radial and centrifugal like the spokes of a wheel. The Central Highlands of Ceylon are not in the form of a simple dome, however. They assume the shape of an anchor, with the bow running somewhat east to west in the south and the shank pointing towards the N.N.W. Drainage direction should therefore be to the N.W. and W. on the western flank of the shank, and N.E. and E. on the eastern flank. With regard to the south, the drainage is directed southwards down the Southern Mountain Wall aligned on the bow of the anchor. This indeed appears to have been the case in the early or initial stages of drainage evolution in the Island. Since then, pronounced changes have taken place, with considerable *adaptation to structure*, under the influence of the factors enumerated above.

A landscape has a definite life history, whereby the initial forms pass through a series of sequential forms before an ultimate form is attained. Generally, however, this cycle of attainment of an ultimate form from an initial form is interrupted, and fresh cycles and sub-cycles are introduced. Hence the statement that peneplanation is only a theoretical abstraction never attained in practice. Most landforms are thus palimpsests containing in their composition the elements and evidences of former cycles. Hence they are said to be polygenetic or multicyclic. The drainage pattern is the result of the interplay of sculpture and structure. In regions of homogeneous and/or horizontal strata, the normal pattern of drainage is dendritic, determined only by slope and precipitation. In regions of inclined or heterogeneous and jointed strata, as in the Central Highlands of Ceylon, the pattern of drainage tends to be trellised or rhomboidal, particularly when the strata have also been riddled with fault zones.

On the initial slopes, consequent streams develop, flowing down the slope. Then tributaries come into being to drain the interfluves; they are named as subsequents. These discover and explore belts of structural weakness due to less resistant strata, fault or joint planes or shatter zones.

This marks the beginning of adjustment to structure. A process of divide migration then ensues owing to the fact that neighbouring streams are corroding at different rates. By this means the large number of consequent streams is reduced. Those possessing some initial advantage, structural or climatic, widen their valleys at the expense of those of their neighbours, collecting them as sub-parallel tributaries. This process is called stream abstraction. It is a kind of natural selection. One river takes the other on the flank. Drainage piracy by beheading, leaving wind gaps and creating elbows of capture is a normal incident in a veritable struggle for survival between rivers. The Mahaveli Ganga system illustrates these phenomena abundantly.

As it is today, the Mahaveli Ganga is not just one river, but a composite and polygenetic drainage system. It has grown as a parasite, at the expense of other rivers, by beheading, capturing and sapping them and diverting to itself the rainfall discharge of a large area. The drainage of the region on the western side of the central backbone no longer reaches the Arabian Sea. The Mahaveli has misappropriated it to augment its discharge into the Bay of Bengal. This would explain the disproportionate length of the Mahaveli Ganga, in relation to the size of the Island and in comparison to the other rivers of the Island.

The composite character of the Mahaveli is shown not merely by its well-defined elbows; it is also demonstrated by the nature of the various reaches of the river. The natural thing for any river which has followed the normal course of development is to show youthful features in its upper course, mature features in its middle course and senile features in its lower course. But in the case of the Mahaveli Ganga, there is a confusion of these, showing that some portions belong actually to other rivers. The uppermost reaches of the river in the Horton Plains are already late-mature, reflecting the uncertain shuffle of old age, like what is found in the flood plain above the mouth. The impetuosity of youth and the swinging vigour of manhood are seen in portions not normal to them. So, heterogeneous limbs of various rivers are found linked together, as a result of the structure and tectonic history of the region, into this abnormal drainage system called the Mahaveli Ganga. The Mahaveli Ganga with its heterogeneous parts presenting many anomalies holds the key to the evolution of the morphology of the Central Highlands, and to a considerable degree, of the whole Island.

THE DRAINAGE PATTERN

The normal drainage pattern has been very much modified by structure, differential erosion and jointing; "above all the ancient river systems have suffered some sudden disruption in recent geological times by earth movements, which have rejuvenated erosion and interrupted the previous cycle ".

The Mahaveli Ganga rises in the heart of the mountainous south-centre of the Island, a region of 125-200 inches of rainfall per year. Its headstream, the Hatton river, after flowing some distance on the Hatton plateau, along a strike valley determined by the underlying geological structure of the Island turns north-east on descending the plateau and then the river flows in the direction across the strike as far as Kandy. The Kotmale Oya tributary also follows the strike and cuts across it in different portions, utilising joint and other planes of weakness in the rocks.

North of Kandy, at Katugastota, is an elbow bend caused by the beheading of the headwaters of the Amban Ganga. Here the Mahaweli turns south-east, flowing in the opposite direction of plunge (which is N.N.W.) of the Dumbara syncline. Thus it flows "up the syncline" as far as Hanguranketa and then due east for about 20 miles in a narrow transverse underfit valley down to Minipe. Here it receives its tributaries from the Uva Basin such as Belihul Oya, Kurundu Oya, Uma Oya and Badulu Oya. Then it turns to flow due north for about 50 miles along a longitudinal valley, following the foliation strike of the rocks (and the topographic grain of the country) and accompanying a long outcrop of crystalline limestone and finally enters a low flood plain, after crossing a ridge along a joint plane at Dastota. Here, it sweeps gently northeast when it is joined on its left bank by the Amban Ganga, and later splits itself into a number of distributary channels.

With the exception of the short streams hurling themselves down the Southern Mountain Wall to join the south-flowing Walawe Gange, Kirindi Oya, etc., and the Kehelgamu and Maskeli tributaries of the Kelani Ganga, the entire drainage of the Central Highlands is accomplished by one river system, viz: the Mahaweli Ganga and its tributaries. This drainage system above Alutnuwara may be considered under the following heads :

1. The Hatton and Kotmale system or the upper Mahaveli Ganga from its source to Katugastota.

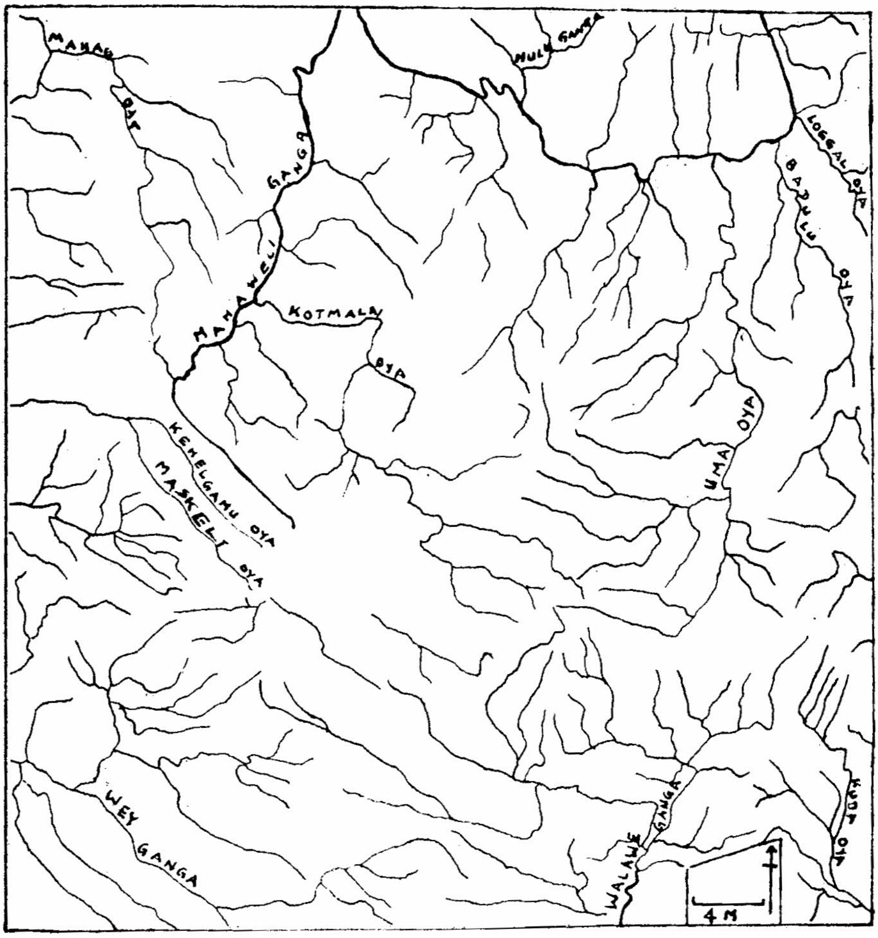
2. The Uva system which drains the eastern amphitheatre of the Central Highlands, and

3. The middle Mahaveli Ganga, comprising the Dumbara syncline and the transverse valley as far as about Minipe.

I. The Hatton—Kotmale Drainage

The Kotmale Oya

This river starts as the Agra Oya in the Horton Plains and follows the structural grain of the country as far as Glen Lyon (in Agrapatana), flowing W.N.W. Here it takes advantage of some parallel divisional planes in the rocks and cuts across the grain at an elevation of about 4,500 feet for about three miles. At Caledonia, it receives the Dambagastalawa Oya which has been following a course parallel to that of the upper Agra Oya, i.e. along the geological strike. From Caledonia, as far as Tillicoultry, it continues along the same strike. From Tillicoultry to Lindula, the direction becomes at right angles to the strike, only to change to the more convenient strike direction thereafter as far as Talawakelle. Above Talawakelle, it receives the Nanu Oya which comes from the Nuwara Eliya plains in a course aligned on the strike and along the foot of the Great Western ridge. The junction is achieved only after taking a rectangular bend S.W. near the Great Western factory. Up to a little beyond Dimbula this strike direction is maintained in the Talawakelle syncline. Thereafter, joints developed in the rocks at right angles attract the river and it turns N.N.E. to flow in this direction for about eight miles as far as Otalawa village. In doing so, it cuts the Great Western anticline and the Pundul Oya syncline in a deep, though rather broad, gorge, with walls nearly 2,000 ft. high. It receives the Pundul Oya tributary at Maldeniya and the Puna Oya at Otalawa. The confluences of tributary streams are made at the intersections of the strike and joint lines. It will be noted that the upper Agra Oya, the Dambagastalawa Oya, the Nanu Oya, the Pundul Oya and the Puna Oya all flow in parallel valleys following the N.N.W./S.S.E grain of the country. This same direction is adopted by the Kotmale Oya too from Otalawa village to its confluence with the Mahaveli Ganga a few miles below Nawalapitiya. The minor zig-zags in the course of the river on this stretch are adjusted in obedience to the rectangular lines present in the structural predisposition of the country, which running water has tended to discover and exploit, namely, the fold strike of the synclinorium and the divisional planes at right angles to it. Thus there are strike limbs and joint limbs with elbow bends at the intersections of these.



UPPER MAHAWELI DRAINAGE AREA

It is apparently baffling why the Kotmale Oya should leave the well-developed Talawakelle syncline below Dimbula (near Bogahawatte Power Station) and turn N.N.E. to cut across two anticlines and a syncline. This is probably due to the dominance of fault or joint-control over the strike, assisted by some tectonic tilting of the surface. Just above this bend is a deep gorge left behind by the recession of the waterfalls of St. Clair. Similarly, but higher up, on the Dambagastalawa Oya are the Elgin Falls, which have also left behind a gorge in their headward march. Above the Bogahawatte bend, the river flows in the Talawakelle syncline from Elgin downwards. There is no observable lithological difference in the resistance of the rocks above or below the Falls, as the same rocks continue along the syncline. These dislocations of the long profile therefore indicate either faulting or the advanced positions of knick-points arrested by resistant outcrops in a composite valley. When we examine the cross-profile of the river we see terraces on both sides of the river from its bed right up to the ridge-crests. These terraces are obviously not structural rock-benches; this is certain because the rock strata are inclined and they are truncated by the terrace planes. Therefore they are paired river-terraces which prove the "valley in valley" feature. The tributary streams are also discordant; they hang and hurl themselves over the ledges in falls, e.g. Devon Falls below Dimbula. The incised valleys with ingrown and intrenched meanders, all point to rejuvenation, e.g. the Kotmale Oya near Talawakelle, the Nanu Oya, the Hatton river and the Hambantota Oya near Bogawantalawa. Similar examples of rejuvenation such as paired river-terraces with steep sides, are seen in the tributary streams just beyond Watawala and Galboda. Uniclinal shifting of valley near Nawalapitiya with rapids and falls, the incised meanders of Talawakelle, etc., all point to the same phenomenon of revived regressive erosion.

The Hatton River

This is the main head-stream of the Mahaveli Ganga. It flows from its source in the Elbedde ridge for about fifteen miles, as far as Ginigathena in the Hatton syncline. Below Ginigathena, it makes a rectangular bend N.N.E. wards (in the same manner as the Kotmale Oya does below Bogahawatte) and flows in that direction as far as Katugastota. It receives a small tributary, the Halgran Oya, above Nawalapitiya, which too displays the same rectangular drainage pattern.

The Atabage Oya and Nilamba Oya and their tributaries which join the Mahaveli Ganga above and below Gampola respectively conform to the same pattern. The same holds good also for the Kehelgamu Oya and Maskeli Oya tributaries of the Kelani Ganga, though in a subordinate way. They both descend to the uplands by waterfalls, (Aberdeen and Laxapana falls). The Hatton river has no falls but descends to the lower level by a series of cascades. The above two rivers which flow in strike directions parallel with the Hatton river appear to have been captured and directed into its drainage system by the Kelani Ganga at the Ginigathena gap. But for this, they would have gone to augment the discharge of the Mahaveli and thus relieved Colombo of its frequent devastating floods. Ginigathena area is a region of heavy precipitation with vigorous headward erosion of streams. Thus the headstreams of the Kelani Ganga have been able to rob the Mahaveli of these two rivers, viz: Kehelgamu and Maskeli Oyas.

The streams and rivers of the area under review show a fair amount of development of rectangular or "trellis" drainage pattern. It comprises sets of lines nearly at right angles to each other. One set, perhaps the dominant, runs almost N.W./S.W. The dominant direction is that of the grain of the country, the axes of the anticlines and synclines. The secondary direction is that of the divisional planes, local and regional tensional effects such as joints, fissures, sheer and fracture planes. The orientation of these structure and joint patterns shows a consistency throughout wide areas. It is amply demonstrated by the Gin Ganga (also) which is developed on the South-West scarplands whose topographic pattern is simulated in the Central Highlands west of the main backbone, the difference being only in the degree of adjustment to structure. For the most part, "trellis" is an incipient stage in the Hatton plateau. The Gin Gange type of drainage pattern is beautifully displayed on the One inch topographical maps of Rakwana, Ambalangoda and Alutgama, among others. It is typically of the Appalachian type. It perhaps forms a part of a world wide pattern.

"This impression is strengthened by the evidence of morphological features of the earth's surface which to a large extent seem to depend on the structural pattern of the underlying formations. Frequently, the relief plan of a landscape shows significant lines be it in its drainage system or shore-lines, escarpments or arrangements of volcanic vents, or some other physiographic features. However expressed, these approximately right lines in the plan of the earth's surface have been designated LINEAMENTS, significant lines in the earth's surface."*

*UMBGROVE, J. H. F., *The Pulse of the Earth*, The Hague, 1947, p. 295.

In the Hatton Plateau area which we have considered above and the others mentioned, the existence of one set of rectangular lineaments, N.E./S.W. and N.W./S.E. is very patent. The surface has suffered cycles of erosion and the lineaments also have undergone revival along with the physiographical features. "A high degree of adjustment, combined with relatively youthful landforms thus becomes a criterion of the second cycle condition."**

The Hatton river syncline is continued further north-westwards beyond Ambagamuwa by the overfit valley of the Coolbawn stream and across a low col into the Modera Ela, tributary of the We Ganga. The Hatton river and the Coolbawn stream are not aligned on the same straight line, however. The same slight lateral displacement of alignment is manifest in the case of other synclinal and anticlinal axes disposed on either side of the Ginigathena-Gampola section of the Mahaveli Ganga. The logical inference is that the Ginigathena-Gampola section of the Mahaveli Ganga is carved along a fault or release plane and that the fractured blocks on both sides are differentially tilted in relation to each other. This would explain adequately the peculiar features of the Kotmale Oya, especially the departure of the river from the Talawakelle syncline (in which the Goorook Oya flows) at Bogahawatte to flow N.N.E. to Otalawa, taking advantage of the joints there. The Goorook Oya itself appears to have originally continued its flow further N.W. along the syncline into the Maha Oya of Aranayake, but later diverted into the Ginigathena-Gampola section of the Mahaveli Ganga after the formation of the latter.

The same phenomenon of fault tilting will seem to have been a strong contributory circumstance for assisting the reversal of drainage along the Dumbara syncline so that at Katugastota, the Mahaveli turns south-east abandoning its previous course into the Matale Valley. The former drainage down the Dumbara syncline towards Katugastota is now reversed "up the syncline".

Map studies would suggest the same explanations for the following features of a similar nature in the course of this anomalous river:

1. The diversion N.E. at the N.E. extremity of the Botanical Gardens hump, of the Mahaveli from its N.W. course past the Kobbekaduwa valley (an overfit valley) into the Rambukkan Oya.

**WOOLRIDGE, S. W. and MORGAN, R. S., *The Physical Basis of Geography*, Longmans, London, 1939, p. 41.

2. Diversion of the headwaters of the Deduru Oya tributaries N.E. of Galagedara and Ankumbura into the Mahaveli in the proximity of Katugastota.

3. Diversion of the headwaters of the Hingulu Oya, Kuda Oya and other tributaries of the Maha Oya near Gampola into the Ginigathena-Gampola limb of the Mahaveli Ganga.

The Knuckles Drainage

The Heen Ganga and the Hassalaka Oya flow east into the longitudinal (meridianal) valley of the Mahaveli Ganga. The Galmal Oya, a tributary of the Hulu Ganga flows south into the middle or transverse reach of the Mahaveli Ganga, past Teldeniya to join the main river above Victoria Falls. Between the 18th and 19th mileposts on the road from Teldeniya to Madugoda, the Galmal Oya shows some excellent intrenched meanders, as in the courses of the Heen and Hassalaka Oyas, and providing cumulative evidence in support of revived erosion cycles brought about by changes of base-level through probable uplift.

The Middle Mahaveli Ganga

At Katugastota, the Mahaveli develops a sharp elbow bend. For many reasons, this is a curious phenomenon. It is this bend which mainly led to the choice of Kandy as the one time capital of the kingdom of Ceylon because of the natural protection offered by the river against invasion from the north. Instead of continuing northward, along a broad valley, now an overfit valley for the present Ravana Oya which occupies it, the Mahaveli flows south-east in a direction parallel to, but opposite to that of the N.W. flowing headwaters and tributaries like the Hatton river, Kotmale Oya, etc. The broad valleys of Ravana Oya and its northern continuation—the Sudu Ganga—show that they carried a larger volume in the past and that the present streams which flow in them are under-fits. Probably, the valleys must have been carved by the Mahaveli Ganga with its large drainage collected from the wet Hatton plateau. It must have flowed north instead of taking a south-east turn below Katugastota. Actually, the water-parting between the Mahaveli and the Ravana Oya at Katugastota is only about thirty feet high.

Between Katugastota and Hanguranketa, the Mahaveli occupies a strike valley conforming to the grain of the country. This valley is called the Dumbara Valley. It is quite broad and old and occupies a structural syncline. But between Hanguranketa and Minipe, the valley cuts the grain of the rocks perpendicularly and becomes a veritable transverse valley. From this, it might be permitted to infer that the portion of the Mahaveli between Katugastota and Hanguranketa was a tributary river which flowed N.W. down the Dumbara syncline (i.e. in a direction opposite to its present direction of flow), like the Kotmale Oya and joined the river coming from the Hatton plateau at Katugastota. This combined river flowed north, into the Matale valley. In other words, the drainage of the Hatton plateau and a part of that of the Uva plateau west of the Uma Oya was collected into two main streams which converged towards Kandy and made their confluence near Katugastota to form one river flowing north through the valleys of the Ravana Ela and Sudu Ganga, past Matale.

That portion of the middle Mahaveli Ganga between Hanguranketa and Minipe always flowed east as it does now, but it is quite young. It probably started its career as a left-bank tributary of the longitudinal portion of the Mahaveli Ganga or of the northward continuation of the Loggal Oya discharge. It flows east like the Heen Ganga and Hassalaka Oyas of the Knuckles, which are joint-guided streams, with no doubt, certain strike—guided reaches following less resistant rocks in the N/S direction, and the joint-guided W/E direction at right-angles to it. One or other of these dominates in the drainage pattern, ceteris paribus. By vigorous headward erosion as is today performed on the Knuckles by the Heen Ganga, this east flowing tributary of the Mahaveli (of the Hanguranketa-Minipe transverse valley) also succeeded in capturing and diverting the then N.W. flowing Dumbara river. Thus we see the coming into being of the phenomenon of the drainage turning southeast below Katugastota. The capture has probably been aided by recent dislocation and tilting of the blocks. Practically the whole drainage of the Hatton plateau is thus conveyed into the transverse valley to be in turn conducted into the longitudinal valley of the Mahaveli on the east flank of the Knuckles, instead of the original course from Katugastota through the Sudu Ganga on the west flank of the same upland region. The water makes a long detour to finally reach the sea ultimately through the same outlet, namely the present Mahaveli mouths. The transverse valley between Hanguranketa and Minipe is narrow and is underfit for the present body of water which is conducted through it. It shows all the features of youth at Minipe where it flows through a narrow gorge at Rantembe. There are also many rapids. In places the gorge is about 2,000 ft. deep.

Below Minipe, the northward flowing meridianal Mahaveli appears to flow along a fault zone as has been suggested by the studies of its Hassalaka and Heen Ganga tributaries. The fault zone is developed along a line of weakness, namely the axis of a fold as demonstrated by the strike direction here, which is N/S. Added to this is the presence of the elongated outcrop of jointed crystalline limestone, to help further in aligning the valley.

We see thus that in the drainage pattern and denudation chronology of the Central Highlands of Ceylon, diverse factors have contributed their significant share, one or the other, or a combination of more than one factor, playing the dominant role in any area, according to the circumstances.

1. Fold axes, synclines and anticlines,
2. Joints and other divisional planes in the rocks, the master joints being strongly developed and remarkably presistent,
3. Faulting, and
4. Headward erosion.

Rejuvenation under the control of the above, and following differential uplifts of portions of the Central Highlands region is noticeable everywhere, but it is most conspicuous near the edges of the plateaus and elevated plains.

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