2. The geographical outline

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1. Introduction

Four major geographical zones can be distinguished in Suriname: the Interior (Precambrian Shield or Basement), the Savanna Belt (Zanderij Belt or Cover Landscape) and the Old and Young Coastal Plains. Each zone has its own typical combination of landscapes, soils and hydrological conditions, which will be discussed below (Fig. 1).

2. Geology

2.1. The Interior (Precambrian Shield or Basement)

The oldest part of Suriname is formed by Precambrian rocks, often indicated as the "Basement". These rocks are a part of the Guiana Shield, from which Suriname covers about 10%. The Guiana Shield forms a smaller counterpart of the Brazilian Shield, from which it is separated by the Amazonian geosyncline. Locally, this part of Suriname is often referred to as the "Residual Uplands", or the "Interior" (this term will be used here). It occupies about 80% of Suriname.

The shield gently slopes towards the north where it extends under the younger sediments and the continental shelf (Fig. 2). The boundary between Suriname and Brazil forms the watershed between the catchment of the Amazon and those of the Guianan rivers.

The shield is composed chiefly of a complex of granitoid rocks, gneisses, metasediments and metavolcanics, mostly dating from the Lower Proterozoic and older (mostly about 1900 million years BP). Very locally the basement is covered with sandstones and conglomerates which were formed during the middle Proterozoic, of which the Tafelberg is the principal representative. Dolerite dikes were formed during two periods, namely the Middle Proterozoic (NW-SE trending) and the Permo-Triassic (N-S striking). For more detailed information on the geology of the Precambrian Shield see De Vletter (1984) and Bosma *et al.* (1984).

Paul E. Ouboter (ed.), Freshwater Ecosystems of Suriname, 13–28.

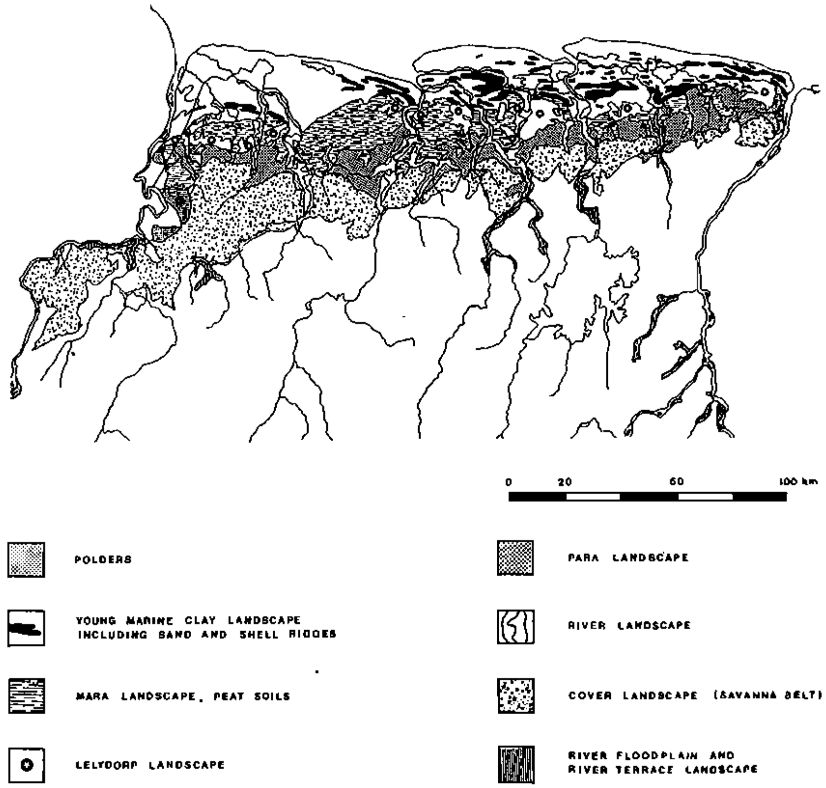

Figure 1. Geomorphological map of Northern Suriname (by S. Sahdew and P. Ouboter after SPS and OAS 1988, Suriname Planatlas).

No major geological changes have occurred during the Middle Proterozoic up to the Late Jurassic, when the Guiana sedimentary basin was formed and sedimentation started. The basin contains Upper Cretaceous, Tertiary and Quaternary sediments on top of the Precambrian basement, which dip gently and thicken towards the coast. They are thickest near the Corantijn rivermouth (1800 m), where the basin extends about 150 km inland. A detailed review of the stratigraphy and sedimentary history is presented by Wong (1984).

2.2. *The Savanna Belt*

The oldest sediments that appear at the surface are those of the Upper Coesewijne Formation. They were deposited under semi-arid conditions in the Pliocene, when braided rivers from the Interior deposited large amounts of

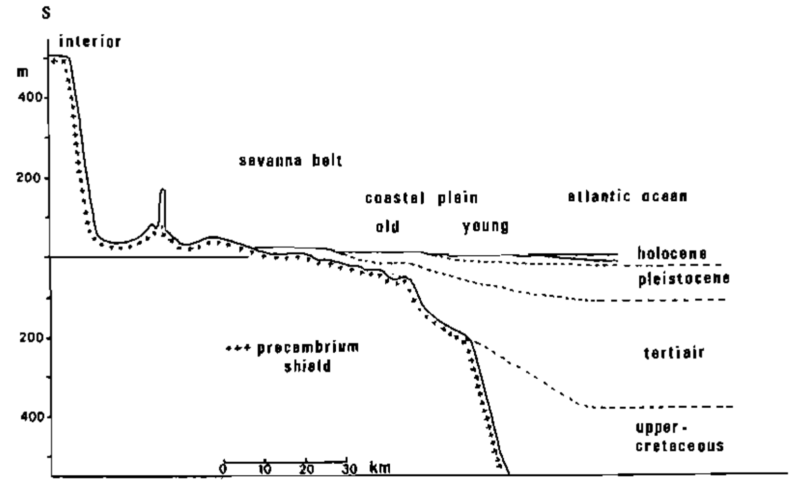

Figure 2. Simplified North-South section of the coastal area near Paramaribo (by J.H. Mol after Krook 1984).

predominantly sandy sediments to form a belt of alluvial fans along the northern edge of the basement. This belt, known as the Savanna or Zanderij Belt (Fig. 2), continues northward beneath the Pleistocene Coropina Formation. At the base of the upper Coesewijne Formation a clayey facies is found. The medium and coarse sandy layers of the Coesewijne Formation are important aquifers.

2.3. *The Old Coastal Plain*

During the Pleistocene, the Old Coastal Plain was deposited during two interglacial transgressions (Fig. 2). Clays where deposited as tidal flats and coastal swamps and sands as (semi-)parallel beachbars and offshore bars during transgressions. The deposits, known as the Coropina Formation, were strongly eroded during the regressive phases. A reconstruction of the geo- and pedogenesis has been presented by Veen (1970).

2.4. *The Young Coastal Plain*

The major part of the Holocene deposits forming the Young Coastal Plain consists of Amazon-derived clays (Fig. 2). Besides these, sands and shells have been deposited as (semi)parallel beach ridges. The deposits are known as the Demerara Formation. The oldest part was deposited during the post-glacial sea level rise (10,000–6,000 years BP) when clays were sedimented in a coastal mangrove swamp to tidal flat environment. The conditions of this environment were favourable for the formation of peat and pyrite. At the same time the erosion gullies in the Old Coastal Plain were filled with the same type of sediment. These elays were named Mara deposits by Brinkman and Pons (1968) in their pedo-geomorphological classification of the Coastal Plain of the Guianas. The deposits form a low-lying, discontinuous belt in the southern part of the Young Coastal Plain.

When the sea level rise came to a standstill, another type of sedimentation started, resulting in a rapid lateral accretion of the coast by sedimentation of clayey materials as mud banks alternated by phases with coastal erosion and the deposition of beach ridges (sands and shells). The coastal processes have been described by Augustinus (1978). These sediments deposited under more or less constant sea level conditions were named the Coronie deposits by Brinkman and Pons (1968). On morphological and pedological grounds these authors distinguish three phases of deposition, separated by periods of regression or erosion. The sedimentation phases are the Wanica (6,000–3,000 years BP), the Moleson (2,500–1,300 years BP) and the Comowine phase (1,000 years BP–present).

At some places deep water conditions and a stagnated drainage have resulted in the formation of thick peat layers.

2.5. *Flood Plains and Riverbound Terraces*

Besides the sediments of the Guiana basin also alluvial deposits have been formed along the rivers during the Quaternary Period. The Pleistocene deposits are found in terraces and vary in consistency from sand to clay, locally underlain by gravel layers. The terraces are mostly less than 2 km wide and they are found at several parts along the major rivers and creeks in the Interior. Two levels can be distinguished: a 15 m and a 30 m level.

The Holocene fluvial sediments have been, and still are deposited as levees and backswamps. They usually consist of silty clays at the levees and heavy clays in the backswamps. Along the Corantijn river, however, also sandy clays, clayey sands and sands can be found. Going inland the fluvial deposits become less extensive and discontinuous. They form isolated patches here. For an extensive description on the Quaternary geogenesis of the river valleys one is referred to de Boer (1972).

Except for the estuarine part where the bottom is usually formed by clay, the bottom of the rivers is covered with coarse sands while in the upper courses fine gravel may occur. Little sand is transported by the rivers in recent times.

3. Geomorphological Development and Geography

3.1. *The Precambrian Shield*

The Precambrian Shield is characterized by a series of step-like planation surfaces that can be followed over large distances. The older of these surfaces are thought to have developed under the influence of intermittent upwarping of the Interior, which gave rise to strong denudation, finally resulting in a more or less flat sloping surface toward the coast. In the next cycle of upwarping the same occurred but now at a lower level. These older surfaces, which date from the Tertiary Period, are now represented by their remnants: flat-topped, bauxite- or laterite-capped surfaces which escaped erosion because of their protective duricrust. They are separated from each other by a pronounced scarp. Isolated remnants of these older surfaces are found in the interior of Suriname, e.g. the Tafelberg, Brownsberg, Nassaugebergte and Bakhuysgebergte. Information on these so-called denudation surfaces in the Guianas is given by (e.g.) King *et al.* (1964). During the Quaternary the Late Tertiary surface was repeatedly attacked during alternating cycles of planation and linear erosion, occurring in respectively dry and humid periods. For the formation of the step-like build-up a very slow constant epeirogenic upward movement has been assumed. The resulting planation surfaccs can be reconstructed by drawing planes through hill tops (hill top envelopes). Contrary to the Tertiary surfaces, which slope towards the sea, the Quaternary planation surfaces are clearly river bound. The proccss mechanism of the development of these lowcr planation surfaces has been described by Kips and Snel (1979). The Quaternary planation surfaces occupy large parts of the basement, which can be characterized as a multi-convex relief of low hills. The 30, 15 and 5 m planation surfaces can be considered as strath terraces, as fluvial deposits have been found on the hilltops.

The remaining landscape is predominantly low-lying with only a few mountain groups rising above the 250 meter contour, with summits exeeeding 1000 meters. The border zone towards Brazil is somewhat higher, with altitudes generally between 250 and 500 meters above sea level, again with mountain groups with a height of approximately 1000 meters. This can be explained as the planation surfaces are bound towards the local erosion level, which increases going upstream.

Rock outcrops are only incidentally found, mostly in sula complexes, and scattered as inselbergs. Bornhardts (locally known as tebu), ruwares (rock plateaus) and boulder inselbergs are found. The latter two are usually hidden by the dense rain forest.

O'Herne (1969) made a study of the landscapes of Suriname using aerial photographs. He defines a landscape as "..an area, which as a result of its specific geological origin, morphologically forms a unit, characterized by a special rock formation and a variation typical of this area". He also states that "In a strongly weathered and densely forested country like Suriname, a landscape is characterized mainly by its relief and occasionally by its particular vegetation." For each of his landscapes O'Herne presents data on form and size of the hills, degree of dissection, altitude and the rock type on which it has developed.

Another approach to describe the landform of the Interior is that of Balsem *et al.* (no date) on their map of central Suriname. They emphasize the geomorphogenesis of the area presenting the various planation surfaces. These surfaces may comprise several landscapes as they have been described by O'Herne, while also one single landscape may be found on two or more planation surfaces.

The landform of the Precambrian Shield can shortly be described as follows. The flood plain and the 5 meter terrace are (almost) flat. The flood plain is periodically inundated at high river levels. The 15 meter terrace up to the 30 and 50 meter planation surfaces can be characterized as undulating to moderately steep, with increasing relief (15, 25 and 40 m respectively) and maximum slope (8, 18 and 30% respectively). The 100 meter planation and the older surfaces consist of steep hills, flat to rolling, steep sided plateaus and steeply dissected mountains, and locally elongated steep hills of the dolerite dikes.

3.2. The Savanna Belt Landscape

The Savanna Belt Landscape went through the same alternation of dry and humid conditions. The original depositional surface was flat and gently dipping to the north. Erosion has resulted in a strong dissection and locally proceeded so far that almost no Coesewijne material has been left. The present Cover ("Dek") Landscape is flat to gently undulating, with broad plateaus alternated by creeks and rivers. The river valleys are deep and here as well erosion terraces at different levels have been reported (Krook and Mulders 1971). In the western part of the country the Savanna Belt is found at a higher altitude and dissection is deeper. Steep to very steep slopes are reported with active erosion (Pleysier 1973). This is attributed to a recent lowering of the erosion basis.

Savannas on bleached, white sands form marked features within the landscape (hence, the name Savanna Belt) although they cover only 7%, the remaining part being mostly savanna forests.

3.3. The Old Coastal Plain

The Old Coastal Plain consists of a discontinuous belt of a large number of disconnected large and small surfaces. Two very large coherent parts are found within Suriname, one south of Paramaribo and one in the Wane Creek area. The original surface, comparable with the Young Coastal Plain, has been strongly attacked by erosion during the last glacial period, when large parts were completely eroded away, while in other parts deep erosion gullies have formed. Surface wash processes leveled the ridge landscape. The original tidal clay flats are now known as the Schollen (Islands), or Para landscape, while the part with the old sandbars is indicated as the Old Ridges, or Old Offshore Bar Lelydorp Landscape. The landscapcs arc low-lying and nearly flat with depressions.

3.4. The Young Coastal Plain

The Young Coastal Plain consists of extensive swamps and marshes, locally interrupted by roughly east-west striking ridges. The southern edge towards the Old Coastal Plain is often formed by very low lying deep swamps with a thick peat layer developed on Mara deposits. The same environment is found in the filled-up erosion gullies of the Old Coastal Plain.

The northern deposits have a slightly higher elevation, and less deep swamps and marshes are found. From the north to the south the originally saline deposits under a mangrove vegetation are gradually desalinized and a sequence of brackish to fresh environments can be distinguished. The peat layer gradually thickens, but usually very thick layers do not occur.

Ridges of variable width (25–400 m) rise 1–3 m above the neighbouring clay flats; they occur as elongated, usually narrow bodies, either individually or in bundles. Bundles are particularly abundant west of the major rivers. The most extensive ridge complexes were formed during the deposition of the Wanica phase. In the western part of the country only few ridges are found.

4. Soil Formation

4.1. The Precambrian Shield

A discussion on the pedogenetic processes and the polycyclic development of the soils of the Precambrian basement is presented by de Boer (1972); this largely also applies to the Tertiary and Pleistocene sediments.

The first cycle is represented by the often reworked sesquioxide nodules (laterite gravel, iron peas etc) from the various planation surfaces. They are the result of plinthitization, followed by hardening of the mottles. In the following period gleyzation of flat surfaces occurred, finally resulting in plinthite. These surfaces presently have a deep ground water table.

This period was followed by a period with illuviation of clay (lessivage), which occurred probably under drier conditions during the last glacial. The resulting orientated clay has been found preserved in nodules. Argillic horizons from that period were only found in soils with a low faunal activity, e.g. hydromorphic soils (de Boer 1972). Most of the remnants are, however, destroyed by the more recent soil formation and bioturbation.

Under the present humid conditions bioturbation and ferralitization are common processes on well drained soils. Another process considered active now on these soils is "appauvrisement" resulting in an increase in clay content from topsoil to subsoil. The hypothesis is that fine particles are brought to the surface by biological activity from where they are removed by surface wash processes. No-clayskins result from it, as the fine particles do not migrate downwards into the profile. Under hydromorphic conditions plinthitization occurs in older soils, while on the younger river deposits gleying can be observed.

Processes of local importance are podzolisation and the formation of Terra Preta. Podzolisation occurs on very poor, acid sandy soils under hydromorphic conditions. Terra Preta are found as patches, characterized by a deep black humic top layer. They have developed at the dwelling sites of pre-Columbian Indians. They are usually found near navigable waterways.

4.2. The Savanna Belt

The soils of the Savanna Belt as well have been subjected to clay illuviation in drier periods (Krook and Mulders 1971; Bennema 1982) and relics of clayskins have been found (De Fretes 1984). In the preceding, more humid climate podzolisation under hydromorphic conditions will have been active resulting in hardpans. These hardpans are found at a depth of 2 to 4 meters in the wet savannas and are considered fossilized features by Krook and Mulders (1971). Podzolisation is considered a presently ongoing process. Hardpans now develop only at the water courses at the foot of slopes with impeded drainage.

According to a theory developed by Lucas *et al.* (1982), podzolisation starts at the center of the plateaus and at the lower foot slopes, under the influence of impeded drainage triggering destruction and removal of clay followed by podzolisation. The areas with podzols will very gradually increase as a result of the worsening of the drainage conditions through the above process. In the final stage the whole plateau will be turned into podzols.

No extensive areas with signs of plinthitization of the plateaus in earlier humid periods have been found. Ferralitization and bioturbation are the common present-day processes on well drained sites with (sandy) loamy to clayey soils.

According to Poels (1987), a podzolisation process is active in the topsoil of all soils, made possible by the sandy textures, the poor nutrient status and their acidity. Organic matter is transported downslope by lateral flow or groundwater; it accumulates at the lower footslope, or is carried to the creeks. Hardly any iron or aluminium is, however, transported.

4.3. The Old Coastal Plain

Almost the same polycyclic development as described above for the Precambrian Shield has been presented for the Old Coastal Plain by Veen (1970), with the exception of the first cycle.

4.4. The Young Coastal Plain

The soil formation of the clay soils of the Young Coastal Plain has been described by Pons (1966) and Brinkman and Pons (1968). After a mudflat has been silted up high enough, the process of initial soil formation starts. This comprises desalinization, oxidation, mottling and water loss. These processes are summarized under the term "ripening". Through ripening, the initially soft and saline mud is gradually turned into a firm, non-saline acid clay soil with gley mottles, provided drainage is adequate. Generally the older claysoils will have the highest degree of ripening.

An exception has to be made for the oldest deposits of the Young Coastal Plain, the Mara deposits which, due to their low elevation at or below present sea level, never have been drained properly. They are largely still very soft, grey without mottles, and reduced.

Another exception is formed by the claysoils along the rivers, which have known different conditions during both geo- and pedogenesis e.g. the less saline environment and the stronger leaching as a result of a better drainage.

Finally, differences in parent material may have influenced soil formation. This is particularly the case when pyrite or potential acid sulphate soils (PoASS) are involved, which may turn into cat clays or acid sulphate soils. Outside the area with Mara deposits these PoASS are only found patchlike, usually correlated with estuarine deposits.

Peat accumulation is found on submerged terrains. Under the prevailing anaerobic conditions the mineralization of organic matter is slowed down considerably which results in an accumulation in the form of peat. Accumulation is more pronounced under conditions of low nutrient availability in soil and/or water, and under acid conditions. Little organic matter accumulates in an aquatic alkaline environment in contact with shell bodies. Besides water quality, also the vegetation type and the depth and frequency of inundation are important characteristics determining peat accumulation. Large areas of eustatic peat of varying thickness are found in the Coastal Plains of Suriname. Besides these, there are some vast areas in which peat grows above sea level. The best known is the Coronie swamp, where peat layers of over 4 meters have been reported. These domed low mounds of ombrogenous peat are the result of an impeded drainage, combined with a poor nutrient supply and a low pH (also see Teunissen, Chapter 5).

Also in the ridges, a progressive soil formation going from young to old can be observed. The originally pale sandy soils turn yellowish to reddish brown as a result of weathering and dispersion of iron oxides. Also, the formation of an accumulation horizon of organic matter starts as soon as vegetation has settled itself. On less well drained parts of sandy ridges gleying can be observed. Impeded drainage leads to ground water podzolisation, in particular on the older sandy ridges. However, podzolisation has been observed already at the slopes of a relatively recent ridge of the Comowine phase (Westerink 1989), probably under the influence of acid water from the neighbouring swamp, combined with the poor nutrient status of the medium sandy parent material.

A different soil formation occurs on the shell ridges where thick humic topsoils may form because of the presence of calcium carbonate.

5. Soil Conditions

5.1. The Precambrian Shield

The regolith, in which the soils of the Precambrian basement have developed, usually shows a deep and intensive weathering. Weathering depths for various rock types are presented by O'Herne (1965). For granites and granodiorites, the most common rock types, depths between 0–16 m are indicated, with maxima up to 28 meters. Basic rock types generally have developed a thicker regolith.

The major part of the basement is covered with (moderately) well drained brown to red ferralitic soils, usually with a loamy to clayey texture and a lighter textured topsoil. Often iron and/or quartz gravel is found, in particular on hill tops. The higher plateaus generally have a laterite or bauxite duricrust. Stripping in the recent dry period has locally produced shallow soils and bare rock land. Part of the (lower) rock inselbergs also date from these periods, but the majority is much older. Shallow, gravelly soils and bare parts are also found on steep slopes.

The lower footslopes and the creekvalleys are imperfectly to poorly drained. Grey to mottled sandy to loamy alluvial and colluvial materials, which are often stratified, are found here.

On the almost flat 5-meter terrace, less well-drained, mottled loamy to clayey soils are found.

Bleached soils have developed locally on poor sandy parent material, e.g. on coarse Pleistocene fluvial deposits and on some sandstones.

The flood plains along the rivers generally have poorly drained, very fine sandy to silty clay soils in the backswamps and better drained loamy to silty clayey soils on the levees. Loeally, sandy to loamy soils can be found.

5.2. The Savanna Belt

The soils within this belt are often divided into the bleached white sands and the non-bleached, yellowish brown sands, loams and clays.

The white sands are internationally known as "Giant Podzols". They consist of several meters of white, medium to coarse quartz sand with a topsoil with varying amounts of highly mobile humus. The latter depends on the vegetation type (Heyligers 1963). A hardpan may be found, containing organic carbon and alumina.

The non-bleached soils have textures ranging from sand to clay. An increase in clay content is found mostly from topsoil to subsoil. The soils are very poor and very acid, and have moderate to good physical properties.

5.3. The Old Coastal Plain

In the southern part of the Old Coastal Plain, where the Old Para sea clay Landscape is found, the soils consists of stiff, compact, strongly mottled clays with an often slightly podzolized silty (clay) loam topsoil. The soils exhibit water stagnation on the stiff topsoil. Fertility is moderate and the soils are very acid.

In the Old Offshore Bar (Lelydorp) Landscape a rather complex soil pattern is found, ranging from well-drained, reddish brown, very fine sands or loams on the better drained ridges, to poorly drained (clay)loam over clay profiles or podzolized white fine sands at the plateaus. Fertility ranges from moderate to poor, and the physical properties vary from good in the sandy soils to poor in the clayloam and clay soils.

Throughout the Old Coastal Plain, erosion gullies can be found. They are filled up with the Holocene Mara deposits. The clays are soft and grey, and will turn extremely acid upon drainage (potential acid sulphate clays).

5.4. The Young Coastal Plain

As may be deduced from the description of the soil formation in the Young Coastal Plain, a wide variety of clay, peat, sand and shell soils occurs here. In general, it may be stated that the clay soils are very rich, with a variable pH and salinity. The physical properties of these soils, which have been described by Kamerling (1974), are usually moderate to bad.

On the ridges a toposequence of well to poorly drained soils is usually found, going from ridge top to footslope. The wider ridges may exhibit an impeded drainage at the central part, which can result in podzolization. At the footslopes, groundwater podzols may develop.

6. Hydrological Aspect of Land and Soil

The drainage of a piece of land is chiefly controlled by the climate, vegetation cover, lithology and relief. The relief, however, is the result of the actions which form the drainage pattern of a certain landscape. In general, these actions are in turn controlled by the characteristics of the regolith (lithology). Below, attention will be given to the lithology, in particular soil characteristics, as far as it influences the hydrology..

6.1. The Precambrian Shield

The hydrological faetors in an area are, besides precipitation and evapotranspiration, run-off, percolation, ground water flow, lateral flow, deep flow and creek drainage. Run-off will only be an important factor in areas with bare rocks or shallow soils. Such areas cover minor parts of the Interior. For most soils under rain forest the infiltration capacity will be sufficiently high to prevent large-scale surface run-off, although some run-off may occur, in particular during rain storms and on steep slopes.

Percolation into the groundwater will in some soils be hampered, due to a clayey subsoil with a relatively low permeability. In this case lateral flow may occur. Other soil characteristics favouring lateral flow are the presence of sandy topsoils overlying loamy to clayey subsoils, and the presence of stonelines parallel to the surface. In many sloping soils, lateral flow will play an important part. In some soils percolation is so slow that some water stagnation occurs in the topsoil, resulting in epiaquic soil charaeteristics.

In sufficiently permeable soils, infiltrating water will effect a rise of the groundwater table, followed by a slow discharge into the creeks. It is assumed that groundwater flow indeed plays an more or less important part in most soils. Haug (1966) mentions that the forest creeks in his study area (Palumeu) carried water in the dry season as they are fed by springlets. Anonymous (1984) recorded a very low, but measurable flow in the Marechalls Creek during the long dry season of 1983. This creek discharges a small, predominantly schist area. Observations in the rainy season report on the other hand, a rapid increase of river and creek levels in the Interior after rainfall, indicating diseharge through surface run-off and/or lateral flow. Anonymous (1984) mentions a time-to-peak period of about 13 to 28 hours and a concentration time of 51 to 72 hours, indicating a predominanee of lateral flow processes over surface run-off.

As the discharge through run-off and lateral flow is much faster than by way of groundwater flow, and deep flow is usually not encountered, it may be expected that a higher drainage capacity (density) will be found in sloping areas with a slow percolation. So in an area with schists, a high drainage density may be found with small, round, low hills with colluvial footslopes without marshy bottomlands. On the other hand, granites produce a regolith which favors percolation and a slow release of water, which may result in a less dense drainage pattern, with rounded or elongated hills, and marshy bottomlands often without a clear colluvial footslope. At many places this generalized pattern is however not found because of the formation of planation surfaces, followed by linear erosion.

The drainage pattern is described as basically fine to coarse dendritie, with oecasionally a rectangular pattern as controlled by diaclases and faults. Wensink (1968) mentions a reetangular drainage pattern with a definite SSW-NNE direction that can be followed over 18 km and eomprises a number of ereeks.

Haug (1966) describes a barbed wire pattern at a loeation where recent stream capture has oecurred. The same author shows that the direetion of faults

and joints is refleeted by the direction of the creeks and rivers in the area studied by him. The same holds for the whole Precambrian basement.

No figures on drainage density on various rock types are known to me.

Unlike rivers in the temperate zone, whose longitudal profiles can be characterized as a smooth curve with rapidly increasing steepness toward the headwaters, the thalweg of the rivers of Suriname, outside the estuarine area sector, shows a more or less straight profile with steps. In the headwater section a steep increase may be observed. The profile of the middle section, which comprises the bulk of the river stretches, is formed by numerous rapids (local name "sula") of some meters high and by somewhat higher falls that alternate with quiet reaches with only a very low gradient. Discussions on the origin and development of this river type are presented by, among others, de Boer (1972), Krook (1979), Kips and Snel (1979). A elassification of rapids has been made by Zonnevcld (1952).

According to Haug (1966), the watersheds may be very indistinct with swamps in the upstream parts.

River capture is reported for several parts of Suriname. An example is given by Haug (1966) who describes the capture of the upper part of the Jai Creek by the Tapanahoni River. This is related to planation during glacial periods.

6.2. The Savanna Belt

In his study of a small catchment in the Savanna Belt, Poels (1987) found that groundwater flow was the main contributor to discharge. Surfacc run-off and lateral flow were important in the valley bottom and on footslopes. There is, however, a decrease in permeability going from topsoil to subsoil, giving rise to some lateral flow. In other areas surface flow has been observed at places with a clayey subsoil, or at places where the kaolinitic substratum is close to the surface (Duynisveld and Van der Weert 1974). It was estimated by these authors that about 15% of the rainfall is drained into the rivers as direct flow.

Compared to the figures of the schist catchment (Anonymous 1984), the period of time-to-peak in the area studied by Duynisveld *et al.* is much quicker (6.5–15 hours). The systems react more quickly to rainfall.

On the other hand, the length of the dry period with no or very little discharge varies between 0 and 8 months, indicating a relatively rapid depletion of the water, or a deep flow. It has indeed been indieated that the Savanna Belt is an important source of recharge of an aquifer. According to Sevenhuysen (1977), the amount of water drained in this way can, however, be neglected.

The Savanna Belt has a relatively wide, dendritie drainage pattern. The ereek valleys are usually wide and flat. The upper stretches may consist of shallow gullies, without a clear creek, carrying water during rainy periods.

Originally, drainage took place by consequent rivers but as a result of river capture the picture has been changed in the southern part of the belt, where subsequent rivers are now found, draining east to west. The northern part still has a more or less south-north drainage. Part of the water from the northern part is drained into the swamps north of the Savanna Belt.

6.3. *The Old Coastal Plain*

The stiff silty clays of the "schollen" in the Old Para (sea clay) Landscape exhibit a very low infiltration and percolation. Most of the rainfall is drained direetly into the nearby depressions and swamps giving rise to an increase in waterlevel. Through these swamps, the water is very slowly drained into the rivers to which the swamps are connected by short creeks. Some swamps drain through more pronounced creeks (e.g. the Nani Creek).

More or less the same holds for the loamy to clayey plateaus of the Old Offshore Bar landscape, whieh also show predominantly a drainage by surface run-off. In areas with a sandy topsoil, lateral flow may be important, while the sandy and loamy soils of ridges may have a considerable groundwater flow.

Most of the water in these areas is drained toward depressions or swamps. Here as well, few distinetive creeks can be observed.

It has been mentioned that the sandy soils in some areas recharge the Zanderij aquifer, so some deep flow may occur as well.

6.4. *The Young Coastal Plain*

The vast swamps with clay and peat soils found here have hardly any percolation and surfaee drainage is also very slow. Some drainage into the few creeks or nearby rivers occurs. Most water is, however, removed by evapotranspiration.

For the Coronie Swamp a radial drainage pattern is indicated by Brinkman and Pons (1968), which is considered the result of the dome formed peat mound that is found here.

On the sand and shell ridges, groundwater flow is usually the most important componcnt, although usually surface and lateral flow also oecur in small quantities. The water is drained into the neighbouring lowlands (swamps). Drainage channels, if any, usually have an east-west direction.

7. A Few Remarks on Waterquality in Relation to Soil Conditions

7.1. *The Precambrian Shield*

The water draining from the shield will usually contain very few nutrients as the soils in these areas are very intensively weathered with a deep regolith. Areas with rock outcrops may influence the local water quality, but these areas are of limited extent.

The load of suspended matter is mostly vcry low as hardly any erosion takes place under natural eonditions. At present it is sometimes slightly incrcased owing to human influenees (villages, roads).

7.2. *The Savanna Belt*

A detailed study of the nutrient balance of the Savanna Belt has been executed by Poels (1987). He concludes that podzolisation strongly influences the water quality. The famous black water is the result of groundwater flow from podzol areas or lateral flow trough sandy topsoils, by which dissolved complexes of organic matter are drained into the creeks. Little or no iron or alumina is involved.

In areas with loamy to clayey soils the water is slightly brown.

The black water is very acid and very poor in nutrients. It has been observed that water from the Savanna Belt strongly influences the vegetation of the northern swamps into which it drains directly (Sevenhuysen 1977). A very poor vegetation type has developed here.

7.3. *The Coastal Plains*

In these areas with their moderate to high nutrient supply (Old and Young Coastal Plain resp.) a luxury vegetation has developed in marshes and swamps. Organic acids are produced by the destruction of organic matter in these environments, resulting in acid water. Most swamps produce brownish water.

In deep swamps where the vegetation is not rooted into the underlying soil, the vegetation may be poor as only rain water is involved.

Shell bodies will locally influence the water quality of nearby swamps by an increase of pH; the same is true for sandy ridges although the effect is much less pronounced.

A special case is formed by the potentially acid clays which are found in the Mara swamps and occur patch-like in the other part of the Young Coastal Plain. In the dry season the swamps may be drained sufficiently to oxidate the topsoil, thus producing strong acidity. Thesc acid components will dilute into the water after recharge of the swamps in the rainy season, thus producing very to extremely acid eonditions. Part of this water will be drained into creeks and rivers.

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