

Sir J. W. Dawson
with the Compliments of
Orville A. Derby

Physical Geography and Geology of Brazil.

PHYSICAL GEOGRAPHY AND GEOLOGY OF BRAZIL,

(Contributed to Vol. I (*A GEOGRAPHIA PHYSICA DO BRAZIL*) of *BRAZIL GEOGRAPHICO E HISTORICO*
by Abreu and Cabral.)

BY

ORVILLE A. DERBY.

REPUBLISHED FROM THE RIO NEWS.

Physical Geography and Geology of Brazil.

Translated from *A Geographia Physica do Brazil*, and reprinted
from "The Rio News" of December 5th,
15th and 24th 1884.

The following sketch of the physical features and geological structure of Brazil with the accompanying maps was prepared at the request of the editors of a general geographical treatise on the empire, which is for the most part a translation of the part relating to Brazil of the well-known *Handbuch der Geographie und Statistik* of J. G. Wappæus. Having been invited to revise and annotate, so as to bring up to date, the part relating to the subjects of which I have made a special study, I found it more advisable to rewrite, on a somewhat different plan from the original, the chapters relating to the physical features, geology and hydrography. The original chapters as they stand in Wappæus' work, give an excellent summary of what was known on these subjects previous to the Agassiz expedition to this country in 1864, from which the last phase of geological study in this country dates. As is well known, Prof. Agassiz was accompanied by two or three geological assistants, one of whom, the late Prof. Charles Frederic Hartt, devoted himself to the study of the country with a zeal and dedication that finally cost him his life. The fruitful results of his fourteen years labor, first in expeditions organized by himself with the assistance of friends interested in science, and afterwards in an official capacity as chief of a geological commission, have very materially advanced our knowledge of the structure of the country and profoundly modified the views previously held. Unfortunately, however, they have never been fully published. So far as the limits and scope of this article and my knowledge of them through his scattered publications and through personal relations with my lamented master and friend, would admit, they have been incorporated here. The new phase of geological study so auspiciously begun by Prof. Hartt has been continued on a very modest scale by myself, and, under more favorable circumstances, by Prof. Henri Gorceix and the young Brazilian scientists he has trained in the Escola de Minas de Ouro Preto, and thus a considerable number of interesting facts, for the most part unpublished as yet, has been accumulated, upon which I have freely drawn. Imperfect as this sketch is, it is hoped that it may prove of some interest and value as presenting a resumé of what is positively known, up to the present time, of the physical and geological structure of the country and as showing how much still remains to be done in this fruitful field of research.

ORVILLE A. DERBY.

Physical Aspect: Mountains and Plains.

The greater part of the empire consists of an elevated plateau having the mean elevation of 300 to 1,000 metres, limited on the north and west by the great continental depressions of the Amazonas and Paraguay basins which are almost united through the valley of the Madeira and its tributary, the Guaporé. A portion of the elevated plateau of Guiana, nearly the whole of the great Amazonian depression, and the upper part of that of the Paraguay are also included in the empire. In addition to these four grand natural physical divisions there is also an Atlantic border region forming a narrow strip between the ocean and the eastern margin of the great continental plateau.

Although generally represented as wholly mountainous, the Brazilian plateau consists in great part of table-lands which, from the deep excavation of the innumerable river valleys, have become very much accidented so as to present a mountainous aspect. The true mountains (restricting the term to the elevations formed by upheaved strata) are mainly in the eastern and central portions and may be considered as constituting two groups, nearly separated by the elevated table-lands of the Paraná and São Francisco basins.

The eastern or maritime group accompanies the coast of the Atlantic at a short distance from the sea, from near the north-east shoulder of the continent at Cape São Roque to, or near, the southern limits of the empire. The central, or Goyaz, group occupies a part of the southern portion of the province of Goyaz and of the part of the province of Minas Geraes to the west of the São Francisco, and is joined to the eastern group by a transverse ridge extending in the direction east-west across the

southern portion of the province of Minas Geraes. This transverse ridge with the mountains of Goyaz forms part of the great east and west water-shed of the continent, which is generally known as the Serra das Vertentes, an improper designation since a considerable portion of the water-shed is not, properly speaking, mountainous.

The mountains of the eastern group form a long and comparatively narrow zone of about sixty miles in maximum width in the provinces south of Rio de Janeiro, which widens to four or five times that width in the southern part of the province of Minas Geraes, but becomes reduced to a width of 150 to 200 miles in the region to the east of the São Francisco. In the provinces of Paraná, São Paulo, Rio de Janeiro, Espírito-Santo and the south-eastern part of the province of Minas Geraes, where this group attains its greatest development, there are two well defined parallel ranges, the Serra do Mar and the Serra da Mantiqueira, which extend from south-west to north-east. The culminating points are the peaks of the Organ Mountains in the Serra do Mar, at the head of Rio bay, 2,232 metres high, and Itatiaia in the Serra da Mantiqueira at the angle of the three provinces of Rio de Janeiro, São Paulo and Minas Geraes, with 2,712 metres of elevation above the level of the sea, this last being the highest point of the empire. Somewhat to the north of Rio de Janeiro the culminating line of the group passes from the Serra da Mantiqueira, which continues in a north-easterly direction, to a branch which, under the name of Serra do Espinhaço, extends north, or a little east of north, along the eastern margin of the São Francisco basin. The highest points of this range are the peaks of Itacolumi (1,752 metres) and Caraça (1,955



metres) near Ouro Preto, the peak of Piedade near Sabará (1,783 metres) and Itambé, near Diamantina (1,823 metres). The mountains of this group become lower in the provinces north and south of those above indicated and to the northward of the São Francisco are represented by short detached ranges and isolated peaks.

The western mountain group consists of at least two distinct ranges: that of the Serra da Canastra, or Matta da Corda, extending in a general northerly direction from the headwaters of the São Francisco to the southern rim of the basin of its great western tributary, the Paracatú, and the mountains of southern Goyaz extending in a north-easterly direction between the heads of the Tocantins—Araguaya and Paraná basins. The first is an offset from a broad expansion of the Mantiqueira range, which in southern Minas Geraes and northern São Paulo extends westward to, and somewhat beyond, the head of the São Francisco. Its culminating point is the Serra da Canastra at the source of the São Francisco, which rises 1,282 metres above the sea. The limits and extension of the Goyaz chain can not be definitely traced, as the accounts of the geology of the region are too meagre to enable one to discriminate between the true mountains of upheaval and the ridges produced by denudation from horizontal strata. It is thus impossible at present to state how great a part of the various water-sheds radiating from the Goyaz mountains as a centre should be classed with them, or whether any of these ridges constitute, or not, a distinct system. The culminating point of the system is the Montes Pyreneos near the city of Goyaz, whose height is variously estimated at 2,310 and 2,932 metres, the former being probably nearest the truth.

The great table-lands (composed of horizontal, or nearly horizontal, strata) of the

Brazilian plateau are those of the Paraná, Amazonas, São Francisco and Parnahyba basins. That of the Paraná basin, which may be considered as including the Uruguay, includes a large portion of the provinces of Rio Grande do Sul, Santa Catharina, Paraná and São Paulo, a small part of south-western Minas Geraes and southern Goyaz, and the elevated portion of the province of Matto Grosso and of the republic of Paraguay, lying between the Paraná and Paraguay. The maximum elevation along the eastern border in the provinces of Paraná and São Paulo is approximately 1,000 metres, the general level becoming a few hundred metres lower to the southward and westward as the result not only of denudation but also of a general lowering of the surface.

The Amazonian table-land includes the greater part of the provinces of Matto Grosso and Goyaz, a large part of southern Pará and relatively small portions of south-eastern Amazonas and western Maranhão. It is drained by the Tocantins-Araguaya, Xingú, Tapajós and lower Madeira with its tributary, the Guaporé, all of which descend from the table-land in a series of rapids at a distance of 100—200 miles from the Amazonas. The southern margin of this great table-land, an escarpment rising to between 800 and 1,000 metres above the level of the sea and facing the depression of the Paraguay and Guaporé, has received the name of Serra dos Parecis.

The São Francisco table-land lies mainly to the west of that river in the western part of the provinces of Minas Geraes and Bahia and rise to the height of about 800 meters. It is doubtful as to whether, or not, it extends over the water-shed so as to be continuous with those of the Tocantins and Parnahyba valleys. The latter occupies all, or nearly all, of the province of Piauhy and a portion of southern Maranhão and western Ceará and is perhaps continuous with the Am-

azonian table-land along the Tocantins divide.

All of these table-lands are deeply cut by numerous river valleys so as to present almost everywhere a mountainous aspect and the ridges formed by denudation are generally spoken of as mountains and are represented as such on all maps of the empire.

The Brazilian portion of the Guiana plateau is very imperfectly known. Along the water-shed between the Amazonas and the rivers flowing to the Carribean sea there are mountains whose culminating points are said to rise to the elevation of 2,000 metres, or more, and spurs of high lands extend to within a few miles of the Amazonas at several points between the mouth of the Rio Negro and the sea. This region is drained by the Rio Negro, with its tributary the Rio Branco, and a number of smaller rivers, among which the Jamundá, Trombetas, Parú, Jary, and Araguay are the most important.

The great Amazonian depression is relatively narrow along the lower river, below the mouth of the Rio Negro, the average width being probably between 100 and 200 miles. Above the Rio Negro and Madeira, in the province of Amazonas, it widens considerably so that it presents a bottle or flask shape. The river is generally bordered by low alluvial plains, often of considerable width, which are subject to overflow and

are full of lakes and anastomosing side channels of the great river, or of the lower courses of its tributaries. The higher lands are either table-lands less than 300 metres in height formed by deposits peculiar to the depression, or denuded outliers of the margins of the great continental plateaux on either side or of the Andean plateau at the head of the basin.

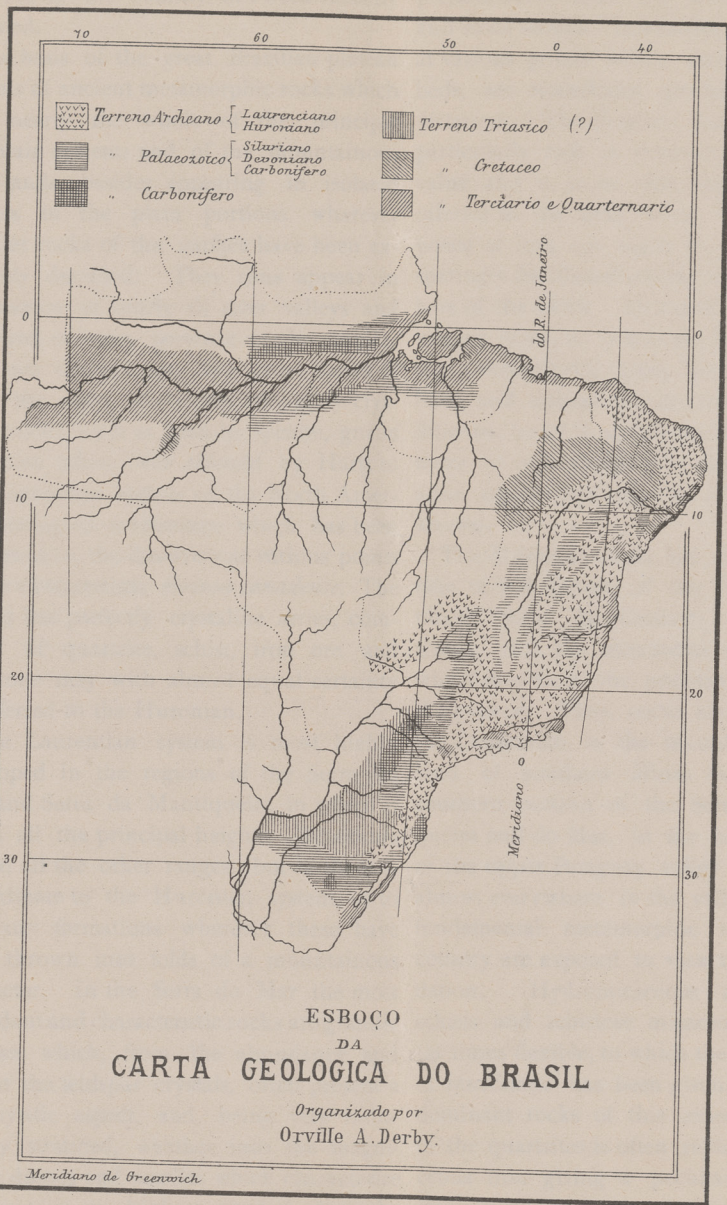
The Brazilian part of the Paraguay depression is the upper portion of the immense plains of the basin of that river which form a large part of the Argentine Republic, Paraguay and eastern Bolivia. These plains lie several hundred metres lower than the lands of the plateau that encircle them, and of its numerous spurs and outliers that rise above their level. They are for the most part but slightly elevated above the level of the rivers (the upper Paraguay and its tributaries) that traverse them, and during the wet season become transformed into immense lakes and marshes.

The Atlantic border region consists of a zone, generally only a few miles in width, lying between the coast and the margin of the continental plateau. South of Rio de Janeiro it is constituted by low sand plains, full of lagoons, and by denuded spurs and outliers of the plateau. North of Rio de Janeiro there are in many places, in addition to these, hills and table-lands of formations peculiar to this coast belt which rise to a height of from 100 to 200 metres.

Geological Structure and Minerals.

Relatively little is known of the geology of the vast area of the Brazilian empire. The early investigations of Eschwege, Sellew, Martius, Pissis, d'Orbigny, Lund and others, were entirely geognostical and mineralogical, and, being unaided by palæontology, their identifications and clas-

sifications of the various formations that go to make up the empire, require to be considerably modified. The basis of a true palæontological division of the Brazilian formations was laid by the investigations of Hartt and his assistants. Although only a beginning has been made,



Lith. Paulo Robin & C^o

the richest of the world in iron ores. The weathering of these rocks along their outcrops gives rise to a crust of conglomerate of more recent formation, consisting of masses of iron ore cemented by limonite, which is known as *tapanhoacanga* and which covers large areas, often miles in extent. Extensive beds of marble also occur as members of this series. The almost universal schistose character of the Huronian beds which are everywhere tilted up at a high angle, gives a peculiarly jagged saw tooth-like character to the mountains in which they form the principal elevations, in marked contrast with the domes and needles of the Laurentian mountains.

This series is the great mineral repository of Brazil, but only those that have been actually utilized can be mentioned in the limits of this article. The extraordinary abundance of iron ores of the best quality has already been noted. These furnish material to over a hundred small forges that work on an exceedingly limited scale by the direct process. Nearly all the gold extracted in Brazil in the various provinces of Minas Geraes, S. Paulo, Paraná, Goyaz, Matto Grosso and Bahia, has been taken from mines in this series, or, principally, from alluviums derived from it. The *tapanhoacanga* has been extensively worked, since the itabirite from which it is derived is often extraordinarily rich in gold, which occurs in irregular lines of a peculiar mixture of iron and manganese oxides, called *jacutinga* by the miners, and which appears to be peculiar to Brazil. In the other rocks of the series the gold occurs in veins of quartz accompanied by the sulphurets of iron, arsenic and, rarely, of copper, bismuth, lead and antimony. Some of the pyritiferous veins are of extraordinary size and constancy. The topaz mines near Ouro Preto are in veins of lithomarge and quartz traversing the schists of this series.

A connection has long been suspected between the Huronian rocks and the diamond-bearing alluviums of Minas, Goyaz, Matto Grosso and Bahia, and the recent researches of Derby and Gorceix have definitely proved that near Diamantina the diamonds occur in veins very similar to those bearing topazes near Ouro Preto and, like them, associated with Huronian schists. It is therefore probable that everywhere in Brazil they have had the same origin and that the gravels, from which, with the exception of a single mine, they have been exclusively taken, have been derived either directly from these rocks or from other later formations constituted by their debris.

The Serra do Espinhaço throughout a part of its length in northern Minas and central Bahia is capped by a great sheet of sandstone, passing at times to conglomerate, and presenting in its finer portions a strong resemblance to the itacolumite of the Huronian series with which it has generally been confounded. It is bent into broad simple folds and lies unconformably on the upturned edges of the Huronian and Laurentian beds. As it has afforded no fossils, its geological position is doubtful, but it may with tolerable certainty be referred to the Silurian age. Very probably a part of the sandstones of the S. Francisco—Tocantins divide and possibly some of those of the Amazonas—Paraguay water-shed, should also be referred to this series. The southern end of the Serra da Mantiqueira in southern São Paulo and Paraná, and the mountains of the margin of the continental plateau to the east of the Serra do Espinhaço in northern Bahia and Sergipe, present still another formation, or formations, consisting of sandstones, shales and limestones, which are apparently newer than the Huronian, and if so are probably Silurian.

The table-lands of the Paraná basin are composed for the most part of horizontal,

or nearly horizontal, strata of sandstone and shale with some limestone, which belong in great part, if not wholly, to the Devonian and Carboniferous ages. The distribution and limits of these two formations have not as yet been definitely determined. The Devonian is known by its fossils to occupy an extensive area in the Campos Geraes of Paraná, while the Carboniferous covers a large region farther to the westward in the same province and in southern and western São Paulo, in Santa Catharina and Rio Grande do Sul. Both formations probably occur in western Minas Geraes and in Matto Grosso. Coal has been found in various points of all the first group of provinces, and in Santa Catharina and Rio Grande workable beds have been discovered, one of which in the latter province is being worked. The beds of these two formations are traversed by numerous immense dykes and intrusive masses of diorite which on decomposition afford a dark red soil known as *terra roxa*, famed for its fertility.* A very extensive area in the central portion of the Paraná basin is covered by a great sheet of sandstone associated with dykes and eruptive sheets of amygdaloid trap very similar in aspect and mineral contents to the Triassic traps of Europe and North America. This rock in Santa Catharina caps the eastern margin of the plateau and forms extensive ridges in the provinces of Rio Grande do Sul, Paraná and São Paulo. It furnishes almost everywhere fine amethysts and agates which are exported in considerable quantities from Rio Grande do Sul and the republic of Uruguay.

The Amazonian table-lands of the plateau are, like those of the Paraná basin, composed for the most part of sandstones and shales

resting on metamorphic rocks which are exposed in the river valleys. The geological age of these strata is unknown as no fossils have ever been found in this region. D'Orbigny referred to the Carboniferous Age the beds about the mouth of the Guaporé, apparently on account of their similarity to the fossiliferous Carboniferous beds of Bolivia. Both the Carboniferous and Devonian are represented along the Amazonian margin of the plateau and it is quite possible that these strata extend up on to the plateau and form the table-lands in question. The apparent similarity of the Amazonian and Paraná table-lands favor this view. On the other hand it is possible that the secondary strata of the Parnahyba and São Francisco basins extend over the Tocantins divide and form part of the Amazonian table-lands.

In the São Francisco basin two, or perhaps three, distinct formations have been recognized, aside from those already mentioned as characterizing the mountain regions on either side. The first and oldest consists of hard, bluish sandstones, shales, (in part altered to slates), and limestones, which according to the indications of the few and unsatisfactory fossils found, belong to the Silurian or Devonian age. These beds are disturbed and present simple folds which, by bringing the limestones several times to the surface, have given rise to the idea that these are the predominant rocks, whereas in fact they constitute, as far as thickness is concerned, the least important member of the series. These strata form high ridges extending parallel with the watersheds, on both sides of the valley but do not, so far as known, rise into the culminating ridges. Similar formations occur in the valley of the Tocantins and in central Bahia, east of the Serra do Espinhaço, which may perhaps be identical with that of the São Francisco. Saltpetre caves abound in the

* All rocks of a certain character have hitherto been referred indiscriminately to diorite. A recent examination however shows that a considerable portion of them are pyroxenic rather than amphibolic and indicates that perhaps the larger number should rather be called diabase.

limestone which furnished to Lund an important series of quarternary mammals. Veins of argentiferous galena occur at various points. The second formation consists of horizontal strata of sandstones and shales which form extensive table-lands in the upper portion of the valley in western Minas and Bahia. These beds have afforded no reliable fossil evidence as to their geological age but have been referred by most writers to the secondary age and by some even to the tertiary. It is however equally probable that they correspond to the Devonian or Carboniferous strata of the Paraná basin. In the lower portion of the valley in the province of Pernambuco, Alagoas and northern Bahia, sandstones and shales of a somewhat different aspect occur, which have afforded cretaceous fossils and correspond with the strata of the Parnahyba basin. These are apparently distinct from the somewhat similar strata of the upper portion of the basin. The soil throughout this region is quite generally impregnated with salt and it is probable that saliferous beds occur in this formation.

The Parnahyba basin is almost exclusively occupied by a great sandstone formation affording calcareous nodules containing beautifully preserved fossil fishes of the cretaceous age. The same formation appears also in the province of Ceará somewhat outside of the limits of the basin.

The tertiary formation is represented at various points on the plateau, as in the upper Parahyba and upper Tieté valleys in São Paulo and at several places among the mountains of Minas Geraes, by small local basins of fresh-water deposits which often contain lignite. The quarternary is represented by fluvial and lacustrine deposits and by a soil cap covering a great part of the highlands as the result of subaerial denudation. True glacial drift is not positively known to occur within the limits of the

empire, though there are many problematic deposits which have been referred to it by some geologists.

From the little that is known of the Brazilian portion of the Guiana plateau it is probable that it does not differ materially in geological structure from the Brazilian. The fundamental rocks are Laurentian and Huronian and the highest mountains are covered by a great sheet of sandstone of unknown age which may perhaps be compared to that of the Serra do Espinhaço. Along the southern margin of the plateau the beds of the Amazonian depression abut against the crystalline rocks, but it is not known to what extent they enter into the structure of the higher portions of the plateau.

In the Amazonian depression the upper Silurian, Devonian and Carboniferous, each with its characteristic fossils (exceedingly numerous and varied in the case of the last two) are known to occur in the narrow portion of the valley below the mouth of the Rio Negro. They consist of sandstones, shales and, in the case of the carboniferous, of limestones also, and occur in long and comparatively narrow strips parallel to the river on both sides, abutting against the highlands of the plateaux and perhaps extending up on to them. Part of the Silurian shales are alum bearing. Diorite dykes are numerous. The beds of these formations are somewhat disturbed and present in general a slight inclination from each side towards the central line of the valley, and, near Monte Alegre they are thrown into an anticlinal fold, the disturbance having included also some beds of sandstone with fossil leaves which are presumably cretaceous. Overlying these older formations there are, in the same region, horizontal beds of soft particolored sandstones and clays forming table-topped hills up to 300 metres in height which are apparently of tertiary age. In the upper Amazonian region cretaceous

beds with characteristic reptilian remains are known to occur on the Purús, and tertiary deposits with lignites and an abundance of fossil mollusks of brackish water types, occupy a considerable area along the Amazonas on both sides of the Peruvian boundary. The lowlands of the Amazonian depression are formed by deposits of late tertiary and quarternary age which rise a few metres only above the level of the river.

The Paraguay depression is occupied by denuded outliers of the different formations of the plateau and by the extensive pampas formation celebrated for its gigantic fossil mammals. This formation is of tertiary and quarternary age, but it is probable that older formations may be found near the limits of the basin.

The geological features of the Atlantic border region, aside from the denuded outliers of the plateau formations and the recent sand plains, marshes and lagoons, are a series of cretaceous rocks occurring in isolated basins in the provinces of Bahia, Sergipe, Alagôas, Pernambuco, Parahyba and Pará, and a tertiary series which appears along nearly the whole of the coast from Rio de Janeiro to the mouth of the Ama-

zonas. The cretaceous strata of the islands and margins of the Bahia de Todos os Santos consist of sandstones and shales of fresh water origin containing abundant reptilian and fish remains. The beds are slightly disturbed and rise in hills from 30 to 40 metres above the level of the sea. The same formation in the other provinces mentioned is of marine origin, lies at the same low level and is also slightly disturbed.

The beds consist principally of arenaceous limestones and sandstones containing an abundant and varied fauna, principally molluscan. The tertiary formation lies horizontally and forms table-lands rising to a height of about 100 metres. The margins of these table-lands present to the sea long lines of cliffs of brilliantly colored sands and clays which constitute a very characteristic feature of the northern coast of the empire.

No volcanoes exist in Brazil and no evidence of extinct volcanoes is known on the main land, the small mountainous island of Fernando de Noronha off the coast of Pernambuco being the only known point of Brazilian territory of volcanic origin.

General Characteristics of the Water-sheds and Hydrographic Basins.

The hydrographic features of Brazil are to a certain extent determined by the orographic system and by the distribution of mountains and plains already described. They are, however, still more dependent on the general structure of South America since almost all of the great Brazilian rivers belong to hydrographic systems which interest other parts of the continent outside of the Brazilian plateau.

South America is made up of three great masses of highlands, in great part mountainous, more or less completely separated by depressed areas in which flow the great rivers Amazonas, Orinoco and Paraguay, the latter, rather than the Paraná, being taken as the dominant feature of the La Plata system. These masses of highlands are: the long and narrow Andean plateau, the Brazilian plateau, and the plateau of

Guiana. The Andean plateau being very near the Pacific coast throws nearly all the drainage of the continent eastwards to the Atlantic, while the plateaux of Brazil and Guiana force the waters to flow northward to the Caribbean sea, southward to the South Atlantic, or eastward through the central basin or great Amazonian depression which separates them. Thus the Paraguay has a southerly course in the centre of the great depression between the Andean highlands and those of Brazil, receiving a considerable part of the drainage of both; the Orinoco bears the same relation to the highlands of the Andes and of Guiana, which give a northerly course to the drainage, while the vaster Amazonas has relations with all three of the continental plateaux, rising in the Andes and flowing between the highlands of Brazil and of Guiana receiving tribute from both of them, while, by means of its great tributaries the Madeira, Rio Negro and others above them, it includes in its basin a considerable portion of the great depression between the Andes and the two detached eastern plateaux of the continent.

With few exceptions all the great rivers of South America belong to one or the other of these basins, which may be called continental because they pertain to more than one of the great component parts of the continent. The other rivers belong to one or another of the three plateaux and of these, those of Brazil are the largest and most important, because the Brazilian plateau is larger than that of Guiana and better watered than the part of the Andes that drain into the central depressions. Considering the Uruguay as belonging to the La Plata system, the exclusively Brazilian rivers (in a geographical sense) are those that flow from the eastern water-shed of the plateau directly to the Atlantic. If, however, not only those that have their course in the country but also those that

commence or terminate in it are considered as Brazilian, the rivers group themselves naturally into three great divisions, viz, those that flow directly to the Atlantic and those that form part of the Amazonian and Platine systems.

The great water-shed of the empire, that which separates the indirect from the direct Atlantic drainage, is determined by the orographic features already described. It does not, however, follow continuously the culminating orographic lines but rather passes from one to another of these lines by means of the transverse ridges which unite them. Thus in the south the Atlantic-Paraná divide is formed by the culminating ridges of the southern part of the Serra do Mar; in the central portion the Paraná-São Francisco divide is formed by the Serra da Canastra, or Matta da Corda, in Western Minas, and by the transverse ridges which unite this chain with the Mantiqueira branch of the Serra do Mar and with the mountains of Goyaz; in the northern portion of the great watershed the divide is formed by the extensive ridge which, branching off from the Goyaz mountains; accompanies all the course of the Tocantins, a ridge whose true orographic character is, as already stated, very imperfectly known.

The secondary water-shed which divides the waters of the Amazonas from those of the La Plata system, is well defined and regular in the part between the Araguaya-Tocantins and the Paraná, being formed by the mountains of southern Goyaz which extend from S. W. to N. E.; but further west between the Paraguay on the one side and the Xingú, Tapajós and Guaporé of the Amazonian system on the other the divide is near the irregular jagged margin of the Amazonian table-land and is not marked by any notable elevation of the surface, and the passage from one system to the other is comparatively easy. Thus in the detached

Serra do Aguapehy, which seems to be an outlier of the southern margin of the table-land, rise the Rio Alegre one of the headwaters of the Guaporé and the Aguapehy which through the Jaurú discharges into the Paraguay. In the lower lands at the base of the serra, and after both these stream have become navigable for small craft, they flow for a certain distance near together and the intervening land affords two practicable portages of the extension of 8,640 metres and 11,708 metres respectively, over which boats have been passed from the waters of the Paraguay to those of the Amazonas, or vice-versa. In 1773 an attempt was made to open a canal across the shortest of these portages which, like the Cassiquiari, should serve to unite two great basins and afford uninterrupted fluvial communication from the mouth of the La Plata to that of the Orinoco. The attempt was however abandoned and accurate leveling will probably show that the project is impracticable. There are also two practicable portages between the affluents of the upper Tapajós and the Cuyabá, a tributary of the Paraguay. One of these is only 1,285 metres wide and canoes with cargoes of Amazonian products have frequently been transported to the waters of the Paraguay. As in this region the Tapajós flows at a much higher level than the Cuyabá (at least in its navigable portion) the difference of level to be overcome is probably much greater than in the case of the Alegre and Aguapehy.

In consequence of the disposition of the highlands and lowlands above indicated, there is a great difference between the rivers of these two divisions, which is of capital importance with reference to the internal communications of the empire. The Amazonas and Paraguay being preeminently rivers of the depressions (the first descends to a level of less than 100 metres very near

to the foot of the Andes and the latter flows at an elevation of only 123 metres at Cuyabá near its source) afford interrupted navigation for almost their entire course. The tributaries of these two rivers and the other Brazilian rivers in general are however plateau streams and have two navigable portions, one on the upper stream on the plateau and the other in the depression or coast border region. The difference of level between these two portions is one, or more, hundred metres and the descent has to be accomplished by a series of cataracts situated at a relatively short distance above the mouth of the river. Of these the most notable are the Paulo Affonso cataract on the São Francisco, and the Sete Quedas (Seven Falls) on the Paraná. The upper tributaries of the Amazonas, between the foot of the Andes and the Rio Negro on the north and the Madeira on the south, are exceptions to this rule since they descend from the plateau on which they rise in their upper courses and afford long lines of navigation. They thus reveal the interesting fact that a vast area of the almost unknown upper Amazonian region is at a much lower level than the adjacent plateaux. Of the rivers that flow directly to the Atlantic those of the province of Maranhão and the Parnahyba in Piahy offer the greatest facilities for navigation because they rise at a lower level than the rivers to the southward and effect their descent to the sea level by a gradual slope distributed along the whole course instead of being concentrated in one or more grand series of rapids.

The Amazonas and Paraguay present peculiar features in the very extensive alluvial plains that border the main river and the lower courses of their tributaries, and in the great number of anastomosing lateral channels that cut these plains and put the main river in communication with the tributaries, often at long distances above the

junction, and these last with each other. There canals are particularly notable in the case of the Amazonas where they are called *Paranamirins*, or *Furos* * and it is said that a boat may traverse almost the entire length of the Amazonas valley without entering the main stream. The formation of these canals is to be attributed in part to the formation of alluvial islands that are constantly being created by the sediment-loaded waters of the great river. The number and character of many of them, and especially of the *Furos*, seem however to indicate a more general cause and suggest the idea that since a relatively slight depression of the surface would transform the river valley into an estuary, it may reasonably be supposed that at some time a correspondingly slight elevation has transformed an estuary into a river valley. The long distance to which the influence of the tide (it is sensible at Obydos 500 miles above the mouth of the Amazonas) is felt gives an air of probability to this hypothesis. In this case the present tributaries would have been independent rivers and would naturally have had deltas, the canals of which would in part become closed and in part be transformed into *Furos* when the estuary was changed into a river. The *Paranamirins* would in this hypothesis represent the marine channels of the muddy bottom of the estuary. It is certain that the lower portion of the Amazonas valley still presents so much of the character of an estuary that a question has arisen among geographers as to whether the Tocantins should be considered as a tributary or an independent river. The fact that it receives a considerable quantity of water from the Amazonas through various *Furos* decides the question of its being a tributary, since the Amazonas contributes

* The first are canals that return to the same river from which they parted; the last those that unite two distinct rivers.

much more water than the Tocantins to the so-called Pará river, which is only the southern branch of the great Amazonian estuary.

Attention has often been called to the curious fact that, unlike most large sediment-loaded rivers, the Amazonas has no delta. The reason appears to be that its lower course is still in a transition state between the estuary and fluvial conditions and the delta is not to be looked for at what is generally considered as the mouth of the river, but higher up at the head of the estuary. In this case the network of canals between the mouth of the Xingú and the western end of the island of Marajó may be considered as the true delta.

In a certain sense the La Plata basin is a triple one since a slight change of level, which should take the head of the estuary to the mouth of the Paraná would effect the separation of the Paraguay, Paraná and Uruguay as three distinct basins. Although smaller than the Paraná, the Paraguay should be considered as the main stream on account of its relations with the elevated portions of the continent to the east and west. The Paraná, as already stated, is essentially a highland river. Its tributaries empty into it before it enters the depression by the great cataract of Sete Quedas. The only exception is the Iguassú which has its great cataract of Santa Maria close to the junction. A peculiarity of the Paraná is that the eastern margin of its basin is so close to the Atlantic that one of its tributaries, the Tieté, may be said to rise in sight of the sea. Another peculiar feature is the tendency of its eastern tributaries, especially marked in the case of the Tieté, to flow in a northwesterly direction as if they were seeking the source rather than the mouth of the main river. This indicates a general northwesterly slope in this part of the plateau.

As the principal rivers of the direct Atlantic drainage system are to be minutely described farther on, only such peculiarities as indicate interesting points in the topographical structure of the country will be mentioned here. Such a point is the general parallelism of the São Francisco to the coast line in the greater part of its course due to the river being confined behind the Serra do Espinhaço which, terminating to the northward, finally permits the river to escape and direct its course toward the sea making a right angle to its former course. The same phenomenon is presented in a still more interesting manner by the Parahyba which exhibits a double parallelism, the river making an U-curve in the upper part of its course and after a course of about 200 miles passing close by its source. This is due to a subordinate member of the Serra do Mar system, (the Serra da Bocaina, or Quebra Cangalha) which, being intercalated between the maritime range and the Serra da Mantiqueira, impels the river to the south until, escaping around the end of this barrier, it encounters another in the Mantiqueira which forces it northward until it finds a passage across the Serra do Mar and escapes to the sea. The Iguape, or Ribeira, in southern São Paulo, with its northern tributary, the Juquiá, reveals the same fact of the splitting up of the maritime range into distinct ridges.
