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III. *Sketch of a Geological Delineation of South America.*
By F. A. VON HUMBOLDT.

[Continued from our last volume, p. 357.]

THE cordillera of Parima never reaches to the same height as the Sierra Nevada in the province of Caraccas, which is 2350 toises. Their highest summit seems to be the Cerro de la Esmeralda, or the mountain Duida, which, by trigonometrical measurement, I found to be 1323 toises above the surface of the sea, which is the height also of the Canigou. This mountain is situated in a delightful plain covered with ananas and palms: the monstrous mass which it exhibits towards the Mission and the rivers Canu-canuma and Tamatama, and the flames it vomits up towards the end of the rainy season, give it a romantic and majestic appearance. No Indian is able to clamber up to the top of this mountain and the rocks of its summit without a week's labour, because the luxuriance of vegetation in this climate impedes the progress of travelling. Next to the Duida, the Maraguaca, more towards the east of the river Simirimóni, and the high cordillera of Cunarami and Calitamini, which at Maypuré and St. Barbara is known under the false name of Sipapo, are the highest summits of the chain; they are from 1000 to 1100 toises in height. The common height of the cordillera, however, does not exceed 600 toises, and sometimes it is less, as the part situated between the left bank of the Cassiguiaré, an arm of the Orinoco which connects together the Rio Negro and the river Amazon, and the sources of the cataracts and Piramena between Carichana and Morocoté, is destroyed, and still exhibits insulated rocks rising from the ground. The cause of this destruction seems to have been an eruption of water from the basin of the Amazon river towards the basin of Calabozo and Baxo-orinoco, which differ in height about 160 toises.

The geological chart of this district which I have constructed represents an immense valley which unites the Llanos of the Rio Negro, Cassiguiaré, and Amazon, with those of the province of Caraccas, Barcelona, and Cumana; a valley which sinks down towards the north, and is intersected by a large series of single rocks which show the direction of the old cordillera on the banks of the Guaviare and Nuta in the province of Cassemora. The eastern extremity of this valley is the lowest part of it, and therefore the remains of the water of the Orinoco cut out for itself a
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bed in this place. This cordillera has two remarkable properties. In the first place, as has been remarked in other ridges, the southern declivity is much steeper than the northern: the high summits of Caravani, Jao, of the volcano of Duida, Maraguaca, &c., all lie towards the south, and are there cut into perpendicular precipices. In the second place, this cordillera does not seem to contain a single rock of alluvial mountains, and consequently has borrowed nothing from the organized kingdom. On our passage over this ridge we observed nothing but granite, gneiss, micaceous schist, and hornblend schist; nowhere a covering of sand-stone or alluvial chalk, which on the cordillera of Venezuela on the coast rises to the height of 976 toises above the level of the sea. Had the proximity of the equator and the rotation of the earth any influence on this phenomenon?

The third chain of original mountains, the cordillera of Chiquitos, is known only from the accounts of some persons who have resided at Buenos-Ayres and travelled through the Pampas. It unites the Andes of Peru and Chili with the ridges of Brasil and Paraguay as it stretches from La Paz, Potosi, and Tucuman, through the provinces of Maxos, Chiquitos, and Chaco, towards the government of the Mines and of St. Paul in Brasil. Their highest summits seem to be situated between the latitude of 15° and 20° south, as the streams between the rivers Amazon and La Plata divide themselves at that height.

Between the three cordilleras, the direction of which we have hitherto followed, lie three broad and deep valleys. 1st, The valley between the south side of the cordillera of Venezuela, on the coast, and the cordillera of the Cataracts, or the valley of Orinoco and Apuré, between latitude 8° and 10° . 2d, The valley of the rivers Negro and Amazon, bordered by the Parima ridge and the cordillera of Chiquitos, between latitude 3° north and 10° south. 3d, The valley of Pampas of Buenos-Ayres, which extends from Saint Cruz of Sierra to Cape Virgin, between 19° and 52° south latitude. The first and second valley are in some measure united by the destruction of a part of the Parima cordillera. I do not know whether this be the case also with the Pampas and valley of the Amazon; it, however, appears that it is not, though the Llanos of Monso form a sort of canal which descends from north-west to south-east. All these immense valleys or plains are entirely open towards the east, as they run out into a low sandy coast: towards the west they are shut by the chain of the high Andes. There are some creeks
(*anses*)

(*anses*) which proceed from east to west in the direction of the tropical current, and on that account extend further into the land the broader the continent is. The valleys of Apuré and Orinoco are closed by the ridge which extends from Pampelona to Merida in longitude 73° , and the valley of Pampas in longitude 70° : they both fall together a little towards the east, and seem to be covered by one and the same formation of alluvial strata.

Tralles says, that in Switzerland there is more reason to wonder at the depth of the lakes than at the height of the mountains: I will venture to make a similar observation in regard to the *Llanos* or plains of South America. How astonishing it is to see a continent which in its interior parts several hundred miles from the coast, and in the neighbourhood of mountains 3000 toises in height, is elevated scarcely fifty toises above the surface of the sea! If the flux in these places should rise to as great a height as at St. Malo and Bristol, and if more motion should be communicated to the ocean by earthquakes, the greater part of these valleys would be laid under water. The highest Llano which I have measured is that between the rivers Ymirida, Temi, Pimichia, Cassiguarié, and Guainia (Rio Negro); it is 180 toises in height; but it sinks down towards Atures in the north, as towards the river Amazon in the south. The valley of Orinoco and Apuré is still much lower than that of Cassiguarié and Calabozo in the middle of the Llano where I made observations, in latitude $8^{\circ} 56' 56''$ and longitude $70^{\circ} 9'$ west from Paris. At Angostura, the capital of Guyana, latitude $8^{\circ} 8' 24''$, longitude 66° , it is only 33 toises, and eighty miles from the coast scarcely eight toises above the level of the sea. The plains of Lombardy, in Europe, have the greatest resemblance to the Llanos on account of their small elevation. Pavia is only 34, and Cremona 24 toises in height; the other plains of Europe have a much greater elevation. In Saxony and Lower Silesia the plains are only from 87 to 120 toises in height; those of Bavaria and Swabia are from 230 to 250. The declivity of the Llanos of America is so gentle, their inequalities are so imperceptible, that no large river flows to either side. The Orinoco appears in the longitude of about 70° , as if about to discharge itself in the sea towards Portobello; but at Cabrouta it turns to the east without the least obstacle being discovered either there or at St. Fernando de Atabapo, in latitude $7^{\circ} 55' 8''$, to oppose its course. In the large valley of Rio Negro, and of the Amazon river, is a tract of land, in 2° or 3° north latitude, of not less than

1600 square miles, which is bordered by the large rivers Atabasso, Cassiguarié, Guainia, and Orinoco, and represents a parallelogram, in which the water flows on the four opposite sides in opposite directions. In regard to the Orinoco, I found a fall of 151 toises in the distance of 70 miles from the mouth of Guaviare to the Apuré; but from the capital to the sea not more than eight toises. La Condamine observed the same thing in regard to the river Amazon, from the narrow pass of Paucis to Para, where it runs through a district of 240 miles, but falls not more than 14 toises. It is not improbable that there might have been on the north side of the cordillera of the coast of Venezuela a plain as much lower than the plain of Orinoco as the plain of Rio Negro is higher than that of Orinoco, and on this account the former plain was covered by the water of the bay.

The two Llanos or plains which lie at the opposite extremities of America exhibit a striking difference from that which lies between them, namely, the vale of the river Amazon. The latter is covered by so impenetrable forests that rivers alone can force a passage through them, and that scarcely any other animals but such as frequent trees can live in that district; so much is vegetation favoured by the continual rains under the equator. The case is quite different with the plains of Orinoco and Pampas; they are level valleys covered with herbs, and savannahs which contain only a few scattered palm-trees. The same heat, the same want of water, and the same phenomena of refraction, that is to say, the inverted image of objects seen floating in the atmosphere, are observed here as in the deserts of Africa and Arabia. But plains so perfect are nowhere else to be found; for the Mesa de Pavone and the Mesa de Guanipa in 800 square miles contain no eminence of eight or ten inches in height. The plains of Lower Hungary, on the west of Presburgh, have the greatest resemblance to them; for the flat land of La Mancha, Champagne, Westphalia, Brandenburg, and Poland, is hilly when compared with the Llanos of South America. Nothing but a long stagnation of water could have produced so horizontal a bottom. Traces of old cities are found here, but seldom are any seen which rise like castles (La Piedra Guanán, longitude $69^{\circ} 3'$, latitude $1^{\circ} 59' 48''$) in the Llano of Cassiguarié and of Rio Negro. But from St. Borja to the mouth of the Black river Condamine observed no eminence; and the Llano of Orinoco is also without islands. As the Morros of San Juan belong to the southern declivity of the cordillera of Venezuela,

zuola, an impetuous current of water must have swept every thing along with it; and the present sea presents large spaces without islands: instead of islands there are in the Llanos whole uninterrupted portions of from 200 to 300 square miles of surface which rise from two to five feet above the plain, and which are called *mesas* or *bancos*; which is as much as to say, that they were shoals or sand-banks in the antient sea. I must here observe, that the middle of the plain of Orinoco is the most beautiful and levellest part of it. The bottom of this immense bason rises up and becomes unequal at the edge; the plains therefore which one traverses between Guyana and Barcelona are less perfect and level than those of Calabozo and Uritucu.

This remarkable difference which we found between the cordillera of Venezuela and that of the Cataracts, which is that the latter consist of alluvial mountains entirely bare, is observed between the northern Llano of the Orinoco and that of the Rio Negro and river Amazon. In the former, the original mountains are every where covered with compact limestone, gypsum, and sandstone: in the latter the granite every where appears. The more one approaches the equator the thinner is the stratum of sand which covers the crust of earth on the original mountains: in a land where vegetation is so luxuriant, there is seen in the middle of forests spaces of 40,000 square toises scarcely covered with a few lichens, and which do not rise two inches above the rest of the surface. Will the same be discovered in Africa? for it is only in America and Africa that there is land under the equator.

Having taken a view of the direction of the mountains and valleys, or the form of the inequalities of the earth, let us now turn our attention to objects of more importance which have been less examined, namely, the rising and falling of the strata of the original mountains which form this part of the earth I have traversed. I have been convinced since 1792 that the rising of the original mountains follows a general law, and that, making allowance for those inequalities which may have been produced by trifling local causes, and particularly veins and strata in mines, or by very old valleys, the stratified coarse-grained granite, the foliated granite, and particularly the micaceous schist and argillaceous schist, rise in the league $3\frac{1}{2}$ by the miner's compass, as they form with the meridian of the place an angle of $52\frac{1}{2}^{\circ}$. The falling of the strata is towards the northwest; that is to say, they fall parallel with a body that might be thrown in the same direction, or the aperture of the

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the angle of inclination (less than 90°) which it makes with the earth's axis stands towards the north-east. The rising is more constant than the falling, especially in the simple mountains (argillaceous schist, hornblend schist), or in the compound mountains with fewer crystallized grains, such as the micaceous schist. In granite (it is, however, found very regularly stratified rising in the league 3 — 4, and falling towards the north on the Schneekopfe, the Ochsenkopfe, the Siebengebirge, and the Pyrenees,) and in the gneiss the attraction of the crystallized mixed parts to each other seems to have prevented the regular stratification; therefore more coincidence is found among the micaceous and argillaceous schist, and these first led me to the idea of the law of rising during my tour to the Fichtelberg and the Thuringian forest. Since that time I have examined with great care the angle of the strata of other original mountains in other parts of Germany, in Switzerland, Italy, the southern parts of France, and the Pyrenees, and lately in Galicia. Mr. Freiesleben, whose labours have been of so much service to geology, assisted me in this examination; and we were astonished at the uniformity in the rising and falling of the mountains which we found at each step on one of the highest cordilleras of the earth, the Alps of Savoy, the Valais, and the Milanese.

An examination of this phenomenon, and of the identity of the strata, was one of the principal objects when I undertook a voyage to America. A measurement of the angles which I have hitherto made on the cordillera of Venezuela and Parima gave again the result of my observations in Europe in the chain of the micaceous schist mountains of Cavaralleda as far as Rio Mamon; on the Silla de Caracas at the height of 1000 toises; of the Rincon del Diablo, on mount Guigue; in the islands in the beautiful lake of Valencia, which has almost the same elevation as the lake of Geneva, at the boundaries of the isthmus of Maniguaré and Chupariparu; on the hornblend schist which appears uncovered in the streets of the capital of Guyana, and also in the Cataracts, and on the stratified granite at the foot of the Duida. Every where the strata form an angle of 50° with the meridian (in the league 3 — 4 by the Saxon compass) as they rise from the north-east to south-west, and fall about from 60 to 80 towards the north-west.

This great coincidence in the old and new world must excite serious considerations. It exhibits a very important geological fact. After so many observations which I have made in places so far distant from each other, it can no longer

longer be believed that the rising of the strata follows the direction of the cordillera, and that the falling follows the declivity of the mountains. The profile of many of the mountains, particularly a section of the mountains, such as that of Genoa through the Bochetta, and of St. Gothard as far as Franconia in Germany, which I intend to publish at a proper time, proves exactly the contrary. The rising and declivity of the cordillera, the form of the small inequalities of the earth, seem to be newer phenomena. A stream might scoop out a valley in this or in that direction; might tear asunder a part of the cordillera, and give it apparently one direction or another. The strata of the original mountains appear, amidst all these angles of rising and falling observed at present, to have existed before these changes at the surface of the earth. They are the same at the summit of the Alps, and in the mines into which we descend. When one travels for 15 miles over strata of argillaceous schist, which are inclined parallel to each other, at an angle of 70° towards the north-west, one can no longer believe that they are deranged strata, which once stood horizontal. We must suppose mountains that were once 15 miles in height, and that the whole mass had an uniform fall, and then reflect on the space which such a mass would occupy: and one must remember the strata on the heights of Genoa, or on the heights of Bochetta, or on St. Maurice, which are exactly parallel; and on the strata of the Fichtelberg of Galicia, the Silla de Caracas of Robolo on the isthmus of Araya of Cassiguare, in the neighbourhood of the equator. One must allow that this coincidence gives evidence of a cause which has acted at a very early period, and in a general manner; a cause which must have arisen from the first attraction by which matter was forced together to form a spherical planet.

This grand cause does not exclude local causes, by which individual smaller parts of matter were determined to arrange themselves in this or in that manner, according to the laws of crystallization. Delametherie has made an ingenious remark on this subject: he shows the influence of a large mountain (as a small nucleus) on the neighbouring small mountains. One must not forget that, besides the general attraction towards the centre, all matters exercise a mutual attraction on each other.

The crust of the earth, for I will venture to speak only of this part, must be the result of an immense action of powers of attraction of affinities, which determined, put in equilibrium, and modified each other. M. Klugel
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thought he found, by calculation, that the great flattening of the earth must be on the west side of the north pole. Has the axis of rotation been changed? What will be the inclination of the strata in the southern hemisphere? We are not acquainted with the cause; let us rather continue to examine the phænomena.

This falling of the strata of the original mountains in the cordillera of Venezuela has a great and melancholy influence on the fertility of the provinces of Caracas, Cumana, and Barcelona; the water which filters through at the summit of the mountain flows down according to the direction of the strata, and for this reason there is great want of water in the whole large district which lies on the south side of the cordillera, and therefore so many springs and small streams burst forth on the northern declivity, which, by this great quantity of moisture, and the superabundance of wood, which shelters it almost the whole day from the sun's rays, is rendered as unhealthful as it is fruitful.

The alluvial mountains which I have hitherto observed are almost under the same circumstances as in Europe. The oldest seem to have experienced the action of the same causes which determined the strata of the original mountains, as they rise in the league 3—4, or as the seamen express it, N. 50 E. They often fall towards the south-east, as in the Alps of Bern, the Valais, Tyrol, and Steyermark; but the greater part of them, and particularly the newest, which where I have been are the most numerous, follow no certain law; their strata often lie horizontally, or rise towards the edge of the large dried-up basons, which in America are called Llanos, and in Africa Deserts.

La Condamine says that in Peru and Quito he observed no petrifications. The cordillera of Quito, however, is not like that of Parima, naked granite, for at Cuenca, and on the south side, there is gypsum and alluvial chalk. Buffon dwells much, in his *Epoques de la Nature*, on the question whether South America contains petrifications? I have found an immense quantity of them in calcareous alluvial sandstone which covers the northern and southern declivity of the coast of Venezuela, from the summit of St. Bernardin, and the Altos de Conoma, to the Cerro de Meapiré, or the headland of Puria and Trinidad. The same stratum is found also in Tobago, Guadeloupe, and St. Domingo. An immense quantity of sea and land shells, which in Europe are seldom found mixed together, cellularia, madreporas, corallines, and astroites, are found in-

terspersed in this sandstone. The shells themselves are half broken : whole rocks consist merely of such remains reduced to powder. My fellow-traveller, Bonpland, discovered in them shells of the genus *Pinna*, *Venus*, and *Ostrea*, of which living specimens are still met with on that coast ; an observation of great importance to geology. Every thing shows that this stratum, which I have seen only at the distance of nine or ten miles from the present coast, is of very modern origin, and that the fluid in which it was produced had been in a state of violent motion. The petrified shells in a much older stratum of compact limestone are scarcer and much differently stratified : they are anomia, *tercebratulites*, &c. placed together in families, and in such a manner that it is seen that they have lived (as those of Mount Salve, the Heineberg near Göttingen, of Jena, and Geneva) on the spot where they are now found petrified. They are not interspersed throughout the whole mass of the limestone ; they are only peculiar to certain strata. Many rocks may be examined without finding any of these petrifications ; but where found they are in great quantity, and present themselves chiefly on great heights ; peculiarities which they have in common with the shells found in the limestone of the high Alps of Switzerland and Salzburg, which is identic with the hardened marl of Thuringia, a limestone which lies above the very old sandstone.

I must observe also, that, besides the new sandstone stratum with a calcareous base, of which I have already spoken, the petrifications do not often occur ; and I was particularly astonished to find no single belemnites or ammonites which are so common in all the mountains of Europe. The Llano of Orinoco, and that even of Rio Negro, are covered with a coarse grained breccia (*magel-fluke*) which contains no petrified shells, and perhaps covers the other alluvial strata with petrifications. But this breccia contains on the other hand petrified trunks of trees, which are sometimes found of the length of a toise, and of the diameter of two feet. They seem to belong to a kind of *Melophigia*.

The sandstone which contains all kinds of marine animals (the quarry of Punta del Barrigon near Araya is of this sort) never exceeds the height of from 30 to 40 toises. In several places it forms the bottom of the Gulph of Mexico (Cabo Blanco, Punta Araya). In the compact limestone I never saw petrified shells above the height of 800 toises ; but other very new testimonies prove the residence of the water at much greater heights. Slate found on the Silla de Caracas,

Caracas, at the height of 1130 toises, proves that the water once, as on the Bonhomme in Savoy, formed this aperture between the two peaks or pyramids of the Avila, an aperture which is much older than the five counted in the cordillera of the coast, namely, those of Rio Neveri, Unare, Tuy, Mamon, and Guyaca. Among the mountains of the province of Cumana, there are very singular valleys of a perfect circular form, which seem to be dried up lakes. Of this kind are the valleys of Cumanacoa and St. Augustine, 507 toises in depth, which are celebrated for the refreshing coolness which travellers experience in them.

When the modern action of water is considered, two opposite effects are observed: one recollects a very distant epoch, when the irruption of the sea formed the Gulph of Cariaco and the Golfo Triste; separated Trinidad and Margaretha from the main land, and convulsed the coast of Mochima and Santa Fé, where the islands of la Boracha, Picua, and Caracas, form a heap of ruins. The sea then attacked the land; but the contest did not long continue: the ocean again begins to draw back. The islands Coche and Cuagua are shoals which emerged from the water; the large plain of Salado, lying in Cumana, belongs to the Bay of Cariaco, and is only $5\frac{1}{2}$ toises above the level of the sea. The hill on which the castle of St. Antonio is situated was an island in this gulph, as an arm of the sea passed to the north of Tatoraqal through the Charas towards Punta Delgada, as is proved by a multitude of unaltered shells. It is observed here and at Barcelona that the sea is daily retiring: in the harbour of Barcelona it has lost in 20 years above 900 toises. Is this decrease of the sea in the Gulph of Mexico general, or is it the case here, as in the Mediterranean Sea, that it gains in one point and loses in another? This retreat of the sea must not be confounded with another real phænomenon easy to be explained, namely, the decrease of fresh water, of rain, and of the rivers in this continent. The Orinoco, as we see it at present, is no longer the shadow of what it was 1000 years ago, according to the evidence of the traces which the water has left on both banks at the height of 70 or 80 toises. These traces have long attracted the notice of learned Europeans who have seen the Barraguan, the Cueva de Atarnipe (the burying place of the Atures Indians, who formed a kind of mummies), the Cerro Cuma, the Daminari, the Keri, Oco, and Ouivitari, the bottom of which at present is scarcely covered by the foam of the Cataracts of Maypuré. These traces remind the Indians of a great inundation, during

which many persons saved themselves on rafts of Agave, and afterwards cut out inscriptions and hieroglyphics, with which the granite of Urnana, of Incaramada, and the banks of Cassiquiare, are seen covered, but of which no one at present has the key. This tradition, common among the Indians of Erovato and of Parima, shows great analogy with the mythology of the antients. People think they read the history of Deucalion, and Pauw would find the remembrance of this flood not uninteresting.

[To be concluded in our next.]

IV. *Natural History and Anatomical Description of a new Genus of Fish named Polyptera, found in the Nile.* By G. GEOFFROY*.

IT is in general among fish with fixed branchiæ and a cartilaginous skeleton that the most varied and most curious forms are found: it is there that the important modifications of some of the organs which constitute life necessarily determine the major differences in the rest of the organization. But among the abdominal fishes, where these beings have so great relation to each other, there is one species almost entirely different from those analagous to it, and, as we may say, foreign in the midst of its family. This no doubt is a new object of consideration for natural history, and worthy the attention of physiologists.

This species, known in Egypt under the name of *bichir*, is indeed so anomalous in regard to abdominal fishes, that it may be said to have no other relation to them than in the respective position of the pectoral and ventral fins; and that in other respects it is entirely different.

I. *Physiognomy of the Bichir.* The appearance of this fish might cause it to be considered as a serpent, and on this account, indeed, it has been distinguished among the Egyptians by the name of *bichir* or *aboubchir*: its head is defended by broad osseous pieces, and its body is clothed with large scales. It is in some measure cased in armour. It is particularly remarkable by the extent of its abdomen, the length of which is equal to four-sixths of its whole body.

II. *Organs of Motion.*—The *bichir* seems to be deprived of that organ which acts the principal part in natation; for its tail is exceedingly short, being equal at most to no more

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