by the sound arising from shaking rods within it, Mr. Andrew Haddow, the engineer, lowered four eight-inch bar-magnets (placed end to end, with the south pole down) into the bore. The north pole of a compass-needle in the mine moved first to the west, and then to the east, of magnetic north, as the magnets were lowered, indicating that the magnets were to the westward of the compass. While the heading was being enlarged in this direction, Mr. Haddow experimented by passing a magnet around the compass, and drawing a series of curves for positions of the magnet, which produced different angular deflections of the needle. The compass was then placed successively at two different points in the heading, and the deflections caused by the magnets in the bore-hole were noted, — at one point $3\frac{7}{8}°$, at the other $6\frac{1}{2}°$. The two points were then marked on the plan of the mine, a tracing of the magnetic curves just referred to was placed over each point, and the intersection of the curves corresponding to these deflections was noted. Upon excavating to the point thus indicated, the bore was found, being about eight feet from the true vertical.

In a second case, in Australia, the diamond drill, in going down three hundred and seventy feet, had deviated beyond sensible magnetic influence, and the search by underground mining was continued for nearly twelve months without success. Mr. E. F. Macgeorge then employed glass phials partly filled with melted gelatine, and having a compass-needle in a lower connected bulb of the phial. When these were carefully lowered in the bore to different depths, and the gelatine congealed, the needle would become fixed in the magnetic north, and the surface of the gelatine would be horizontal. These two indications, when the phial was withdrawn, showed the inclination and magnetic bearing of the bore-hole at that point; and a sufficient number of observations at convenient depths permitted the erratic bore-hole to be completely mapped from top to bottom. This map showed a deviation of nearly forty feet at three hundred and seventy feet down (the point so long searched for), and of between seventy and eighty feet at the full depth of five hundred feet. A drift straight for the indicated spot found the lost bore thirty-seven feet and a half away from its proper place, and the bottom was found seventy-five feet astray. This device has since been perfected and patented.

FISHING-INTERESTS IN HUDSON BAY.

The chief commercial value of this district undoubtedly lies in its immense fishing-interests, if we include in that term whaling and sealing.

American whaling-vessels have for more than a quarter of a century been conducting a very profitable fishery in Roe's Welcome, a large basin in the north-western portion of Hudson Bay. The vessels usually leave New England in July, and reach Marble Island in September, where they winter, one or two every season, and occasionally more. Sawing out of the ice in the following June, and pressing northward as fast as the ice will permit, they fish until about the first of September, unless sooner loaded, and then sail for home. During the eleven years preceding 1874, about fifty voyages are known to have been made; and the returns give an average of $27,420 per voyage, which shows a large margin of profit to the small sailing-vessels usually engaged in the trade. It is estimated that the aggregate value of oil and whalebone already obtained is about two and a quarter million dollars, and every thing points to a large extension of the industry.

The porpoise-fishery is extensively carried on by the Hudson-Bay company; the fish, as they are popularly called, being held in check by means of trap-nets on flats in coves where the tide rises ten or fifteen feet, and left high and dry when the water recedes. Last year the company secured nearly two hundred in one tide at Churchill, and a much larger number at Ungava Bay. The blubber weighs from two hundred and fifty to four hundred pounds, and is very rich in the finest of oil. Formerly the blubber was exported; but the company has established extensive refineries at several of its northern stations, and now ships the oil in casks.

The company also carries on a walrus-hunt, sending two sloops annually from Churchill to two very productive walrus-grounds north of Marble Island, where they have never failed to obtain full cargoes of blubber, ivory, and hides in a few weeks, besides carrying on a valuable trade in oil, ivory, musk-ox, and other skins, with the northern Eskimo.

During the exploring-steamer Neptune's visit to Stupart's Bay, the Eskimo were living on the harp-seal (Phoca groenlandica Linné), and had in their possession skins of a good many harbor and square-flipper seals (Phoca vitulina Linné, and Erignathus barbatus Fabricius), seals of all kinds being abundant.

The Hudson-Bay company has a steamer, the Diana, plying between London and Ungava Bay direct, fitted up with refrigerating apparatus, and engaged solely in conveying salmon fresh to the London market. Last year's cargo is reported to have realized eighteen thousand dollars. Nearly every stream contains both salmon and trout in vast quantities, chiefly where the salt and fresh waters mingle.

Cod abound in the vicinity of Chudleigh, though not up to the present time found in Hudson Bay. Newfoundland schooners even now work as far north as Nachvak, and seem to be going farther each year. The cod, though good, are not equal to those of the Banks. While the Neptune was at Port Burwell, both in going and on returning, the anchorage teemed with cod, which were taken in great numbers by jigging from the ship's deck.

THE DRAINAGE SYSTEM OF BRAZIL.[1]

The hydrographic features of Brazil are to a certain extent determined by the orographic system, and by the distribution of mountains and plains described

[1] From the Rio *News*.

in *Science*, No. 112. 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.[1] 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 plateaus 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 plateaus, 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 plateaus 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 plateaus; 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 drains 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 watershed 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 watershed 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 stated in a previous article, very imperfectly known.

The secondary watershed, 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 south-west to north-east; but farther 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 tableland, 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 tableland, rise the Rio Alegre — one of the head waters 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 streams 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 levelling 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 pre-eminently rivers of the depressions (the first descends to a level of less than 10) metres very near to the foot of the Andes, and the

[1] See the map on p. 274.

latter flows at an elevation of only 123 metres at Cuyabá near its source), afford uninterrupted 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 plateaus. Of the rivers that flow directly to the Atlantic, those of the province of Maranhão and the Parnahyba, in Piauhy, 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. These canals are particularly notable in the case of the Amazonas, where they are called *paranamirins*, or *furos*;[1] 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 five hundred 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 much more water than the Tocantins to the so-called Pará River, which is only the southern branch of the great Amazonian estuary.

[1] The former are canals that return to the same river from which they parted; the latter, those that unite two distinct rivers.

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 flow 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 north-westerly direction, as if they were seeking the source, rather than the mouth, of the main river. This indicates a general north-westerly slope in this part of the plateau.

A few peculiarities in the principal rivers of the direct Atlantic drainage system, which indicate interesting points in the topographical structure of the country, may 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 a U-curve in the upper part of its course, and, after a course of about two hundred 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.

O. A. DERBY.

IRVING ON THE COPPER-BEARING ROCKS OF LAKE SUPERIOR.

IN his opening chapter, Professor Irving gives a succinct history of the earlier investigations of the copper-bearing rocks of Lake Superior, a clear exposition of the views that have been held respecting them, and a full bibliography of his subject. The discussion proper is introduced by a sketch of the extent and leading characters of the formation, illustrated by an excellent map. This is the first really synoptical view of the series, in any thing like its regional entirety, that has been presented.

Instead of a mere local phase of some well-known geological horizon, it is described as a unique formation of consistent characters and enormous thickness, stretching out to an ascertained length of five hundred miles, with a width of a hundred miles, and an area, excluding the Nipigon extension in Canada, of forty-one thousand square miles, — nearly two-thirds the size of New England. "Throughout this wide extent, though local peculiarities are to be noted, the general characteristics of the group are wonderfully constant." It consists of an enormous series of eruptive sheets, — lava overflows in the main, — among which are intercalated beds of sandstones and conglomerates, and over which lies a great thickness (fifteen thousand feet) of detrital material, making a total pile of forty thousand feet.

A careful description of these rocks next follows, illustrated by very fine microscopic sections, and conveniently summarized in tables. The studies of Professor Irving do not add greatly to the kinds of basic rock previously described by Professor Pumpelly in the reports of Michigan and Wisconsin; viz., diabases, malaphyrs, and gabbros. He has, however, amplified the varieties and the geographical distribution of these, and added an interesting anorthite rock. To the acid eruptives he has made a more notable contribution in determining not only the presence, which was partially known before, but the important development of quartzless porphyries, quartziferous porphyries, felsites, augite syenites, granitells, and granites. He shows that these are, at the same time, members of the original eruptives, and chief contributors to the detrital beds, especially the conglomerates. But more completely new and theoretically important is the recognition of a class of intermediate rocks (silica from fifty-two to sixty per cent) which constitute phases of the orthoclase, uralitic, and hornblende gabbros, and of the diabases, diabase porphyries, and their amygdaloidal forms. The detrital rocks are conglomerates and sandstones, with shaly phases. They are chiefly derived from the acid eruptives, though where closely associated with basic rocks, a large element is derived from these. In some parts a notable contribution has been made by the older crystalline rocks.

The lithological discussions are critical, and evince a familiarity with the latest phases of this rapidly developing branch of study. They embrace a hundred and eighteen pages.

Following this are nearly two hundred pages devoted to the stratigraphy of the series. The author maintains with justness, that the igneous beds, being overflow sheets, are fully amenable to the common laws of stratigraphy; and his discussion is notably free from the license of eruptive geology. He brings together for the first time, from his own and others' observations, specific descriptions of the formation from all sides of the Lake-Superior basin. It is to be hoped that in this he inaugurates a new era in the discussion of Lake-Superior geology, in which the study of its problems shall be cosmopolitan, in distinction from that narrow provincialism or that distant unfamiliarity which has so largely vexed their past history. Professor Irving's descriptions necessarily fall much short of full completeness; but they constitute a great advance in the endeavor to give, by precise descriptions, maps, and sections, an approximately accurate conception of the entire formation, so far as displayed in the Superior region. Completeness will only be approached when it is possible to extend over the whole region such excellent detail work as that of Pumpelly and Marvine in Michigan, and the author himself in Wisconsin.

The eighth chapter of the monograph is devoted to the relations of the Keweenaw series to the associated formations, and traverses the ground which has been most contested in Lake-

Monographs of the U.S. geological survey. Vol. v. The copper-bearing rocks of Lake Superior. By ROLAND DUER IRVING. Washington, *Government*, 1883. 16+464 p., 29 pl., 37 figs. 4°.