

ROBERTS

ON

THE SÃO FRANCISCO RIVER, BRAZIL.

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BY

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THE INSTITUTION OF CIVIL ENGINEERS.

SECT. II.—OTHER SELECTED PAPERS.

(Paper No. 1735.)

“Note on the São Francisco River, Brazil.”

By W. MILNOR ROBERTS,¹ M. Inst. C.E.

THIS river, compared with all others known to the Author, is *sui generis*. Entering from the sea, there is a wide, tidal stream, having a large low-water fluvial discharge of clear water, and an immense volume in the annual flood containing a considerable quantity of alluvial matter in suspension, which has created a delta mouth. The tide only extends about 60 miles; but the navigation of what is called the “lower river,” continues to Piranhas, 147 miles from the ocean. Between Piranhas, on the lower river, and Jatobá, on the “upper river,” 78 miles, the river is obstructed by impassable rapids and the great Falls of Paulo Affonso, which distance the Author considers unimprovable, except by locks and a canal of the same length, at enormous cost—a plan entirely out of the question. The upper and lower rivers are to be united, commercially, by a *mètre-gauge* railway, now under construction by the Government. The upper São Francisco is as distinct from the lower São Francisco as if they were independent rivers; and in all human probability they will for ever remain so.

It is the upper São Francisco, chiefly, that has occupied the attention of engineers and former explorers, and of the special

¹ Mr. Roberts states that his full report, which is rather voluminous, on the São Francisco river has been translated into Portuguese, but he does not know whether it will be printed. The library of the Institution has lately received from Mr. D. S. de Saboia e Silva, Assoc. M. Inst. C.E., two treatises relative to the same river, of which the titles are: “Atlas e relatório concernente a exploração do Rio de S. Francisco, desde a cachoeira da Pirapóra até ao oceano Atlantico, levantado por ordem do Governo de S. M. I. o Senhor D. Pedro II. pelo Engenheiro Civil H. G. F. Halfeld (em 1852, 1853, 1854). Folio, plates. Rio de Janeiro, 1860.” “Explorations scientifiques au Brésil. Hydrographie du Haut San-Francisco et du Rio das Velhas, ou résultats au point de vue hydrographique d’un voyage effectué dans la province de Minas-Geraes, par Emm. Liáis. Publié par ordre du Gouvernement Impérial du Brésil. Folio, plates. Paris and Rio de Janeiro, 1865.”

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commission under the Author's charge. Its main features will be easily understood. First, the lower portion, 263 miles, consisting of rapids and pools, between Jatobá, the terminus of the above-mentioned railway, and the head of Sobradinho rapids, which may be regarded as fairly improvable into a light-draught steamboat navigation at moderate cost. Secondly, its next division, 830 miles of clear river, as it is commonly called, a very remarkable feature. This long stretch is navigable in the lowest stage of the river for "barcas" drawing 3 feet of water, and during more than half the year for "barcas" drawing 4 feet. Only a small expenditure is needed on this division to remove the comparatively unimportant obstructions—rocks, and a few snags—which interfere with its safe navigation. Above this long navigable division occur the Falls of Pirapora (21 feet in a length of $\frac{3}{4}$ mile), and beyond those falls, for a distance of 500 miles to the sources among the mountains, there are rapids and pools, not easily improvable; the improvement of which, to any great extent, belongs to the future more than to the present.

It will be seen from this sketch, that the chief engineering work is the amelioration of the 263 miles, called the rapids portion, between Jatobá and the head of Sobradinho rapids. The primary object of these works, and of the opening of the railway around the Paulo Affonso falls, is to create that which has never existed—a practicable commercial and social communication between the valley of the upper São Francisco and the sea-coast. The upper valley has had a large river-margin population for more than a century; but being isolated, as it were, having only pack-mules for land carriage, and canoes and barcas for local trade (chiefly in food-products) along the river, there has been no proper commercial circulation; so that the people, their primitive mode of tilling the soil on the margin of the stream, their habits, manners, and customs, remain nearly as they were a century back. With an improved navigation, and a convenient connection with the coast by proper light-draught steamboats on over 1,000 miles of the upper river, it is believed that a new era will gradually arise throughout an extensive region which, excepting along the immediate river valley, has been comparatively but little explored.

The great drawback, upon a considerable portion of the immediate river valley, is the dryness of the climate and the irregular and unreliable rainfall, which have compelled nearly all the settlements (or cultivation) to remain close to the river, where the water-supply is inexhaustible, and where the lands are annually irrigated by the floods of the stream; there being, however, an

abundant rainfall toward the upper waters of the river. The upper river is generally from $\frac{1}{3}$ to $\frac{1}{2}$ a mile wide; in some places it is a mile wide. Wherever the stream is concentrated in a single channel of 1,000 feet, or somewhat less occasionally, it is invariably deep; in some places 30, 40, and 50 feet and more. The currents in the clear river vary from $\frac{1}{2}$ a mile to 3 miles an hour, depending on the slopes, width, and depth in ordinary low water. The floods rise from 25 to 40 feet, or somewhat more, varying very much in different years, and considerably in different parts of the stream.

From the head of the Sobradinho rapids down to Jatobá, along the rapids portion to be improved, the minimum flow of water is not less than 35,000 cubic feet per second. The flood discharge is ordinarily at least ten times that quantity; some years it is considerably greater, though occasionally it is somewhat less. This large flow, during the lowest stage of the river, is the key-note to the comparatively easy improvement of the navigation; because one-sixth of the minimum flow concentrated in one channel will, in most cases, make a sufficient navigation for steamboats and barges drawing 4 feet.

The approximate distances from the ocean, and the elevations of the river at a few prominent points, are as follows:—

	Distances from point to point in Miles.	Ascent from point to point in Feet.	Average Ascent per Mile in Feet.	Distance from the Ocean in Miles.	Heights above the Sea in Feet.
Piranhas	147	59	0·40	147	59
Jatobá	78	644	8·25	225	703
Sobradinho	263	322	1·22	488	1,025
Pirapora Falls . . .	830	700	0·84	1,318	1,725

Ivazeiro, in the Province of Bahia, is on the right bank of the river, 469 miles from the sea, where the approximate height of the river is 956 feet above the sea. At the Paulo Affonso falls the river falls 264 feet in about $\frac{3}{4}$ of a mile.

The works deemed necessary for the improvement of the navigation through the rapids are very simple, consisting of undressed timber cribs filled with rough stone, or, in most cases, embankments of rip-rap, rough stone, to be thrown across minor channels, for concentrating the flow of water into the one selected for improvement. These works will generally be quite low, from 3 to 6 feet in height. The abundant supply of water renders it un-

necessary to encounter great expense in making watertight banks. In some cases gravel can be used on the up-stream side of these cribs and embankments. Wherever artificial improvement is needed there are islands, and the river generally occupies several channels. Some of the cribs and embankments will be thrown across outlets to prevent waste of water from the selected channel. In a few instances, at the heads of islands, spur jetties, of similar construction, will be thrown out into the main river to draw an additional supply of water into the selected channel. In several places shoots will be constructed, 30 mètres (say 100 feet) wide, the sides being cribs similar to the other cribs. None of these works are to project above the low-water line—generally they will be submerged. Here and there obstructing rocks must be blown out. The river bottom on the rapids is everywhere rock. The estimated cost of these works, including one small exploring stern-wheel steamer, and one stern-wheel steamboat 120 feet long, is only about £75,000.

The entire river abounds with a variety of fine fish of different species. There are also alligators of moderate size, otters, and river hogs. There are in many places a variety of birds with beautiful plumage, but game is not plentiful. For hundreds of miles along the river on both sides the woods consist of small scattered trees. True woods or forests are not found till the upper part of the clear river is approached. The inadequate and irregular supply of rain along the middle portion of the distance prevents the growth of good forests, such as are found toward the upper part of the navigable river.

The valley of the São Francisco was visited and occupied along its immediate borders more than one hundred and fifty years ago by Jesuits from Portugal, who Christianised the tractable native Indian population, and built numerous churches on the river margins and islands. Settlements, in the usual acceptation of the term, have never been made; but years after the first occupation, planters with their slaves took possession of a number of the most favourable sites along the river, and established plantations, mostly on a small scale, of sugar, mandioca, corn, &c., but no coffee.

There are approximating to five hundred thousand inhabitants who may be considered as appertaining, or as more or less contributing to the river business, many to a limited extent. The great majority of the people are descendants of Indians and negroes, with some admixture. The number of whites is small compared with the whole population. The bulk of the people are very poor. There are some thirty towns along the river, with

populations of a few hundred to four or five thousand. Many of the old churches are now complete ruins, only a few are properly cared for, owing to the general poverty of the people. The reason given for more land not being cultivated is, that the present cost of transportation consumes all the profit, which is true. An improved river, and the railway around the Falls of Paulo Affonso, will change this condition of things. Irrigation may at some future time extend the cultivable area of the immediate river valley, but it will require a different class of population and capital to introduce irrigation to an appreciable extent.