AN ASSUMED INCONSTANCY IN THE LEVEL OF LAKE NICARAGUA; A QUESTION OF PERMANENCY OF THE NICARAGUA CANAL.

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A source of doubt which attaches to the Nicaragua Canal and involves the question of permanency is furnished by the level of Lake Nicaragua—the fountain-head of the San Juan River, and the summit and feeder of the proposed canal. The regulation of its level is necessarily a matter of absolute or vital importance to the canal. The very elaborate measurements of American engineers that have been made during the last fifteen years indicate for the surface of the lake an average elevation at this time of approximately 105 feet above tide.* The earlier determinations of Lieut. Baily, made from 351 levels, and with what had generally been assumed to be sufficient accuracy, placed the surface in 1838 at 128 feet 3 inches above low water at San Juan del Sur, on the Pacific side; while in 1781 the Spanish engineer Galisteo made the altitude still 5 feet higher (or, more exactly, at 133·11 feet).† It is difficult to understand these discrepancies in values or to assume that competent engineers should have erred over such short distances of measurement to the extent of twenty per cent of their results; yet the concurrence of the newer results of measurement leaves no room for doubt that either Baily's and Galisteo's determinations were faulty or there has actually been an abasement of the lake level since these measurements were made. The measurements of Lieut. Baily have been particularly commended in the earlier discussions of the canal problem, and in the historical summary of the canal project published by the Nicaragua Canal Construction Company in 1891, it is stated that "he was thoroughly competent and well equipped for the undertaking [the survey of the canal route]." He himself states that his levels were run with great care and attention by a good theodolite during a period of four months.‡

It is a little surprising that in their discussions of the possibility of maintaining a general level for the lake, neither the Nicaragua Canal Board nor the Nicaragua Canal Commission of 1897-99 makes particular reference to this earlier determination of altitude; nor does the survey of Chief Engineer Menocal take count of it. Manifestly its wide divergence from the results obtained by the newer surveys has given to it the stamp of inaccuracy, but this has perhaps not yet been proved to be the case, and it is by no means certain that the differences in values between the higher and lower elevations that have been found in recent years, with a tendency toward the lower plane, may not in part be the expression of an actual abasement of the surface, and not merely a fluctuation dependent upon the hygrometric condition of the atmosphere.§ Some evidence for considering an actual lowering of the level of Lake Nicaragua is found in the condition of its northwestern termination—the so-called Estero Panaloya. At the time of the Baily survey, and eleven years later (in 1849), when Squier passed over the region and drew his plan of the Managua-Nicaragua Canal, the Estero was open to free navigation (with water of 5 to 15 feet depth) and to the extent that Squier represented the two lakes as being separated by only four miles. Colonel Ludlow in his report states that the course of the Tipitapa (Panaloya) River between the two lakes is 23 (?) miles, and that in the dry season, at least, the channel of the river is also dry, whatever water finds its way into it from the smaller lake disappearing through fissures in the bed.

The extent of the recent fluctuations of the lake-level is, indeed, such as to have caused some of the well authenticated data that have been obtained by the different commissions to be accepted by them with both surprise and incredulity. Colonel Childs assumed the absolute fluctuation of level to be measured by not more than 5 feet, or little less than what was subsequently reported by Chief Engineer Menocal. The researches of the Nicaragua Canal Board of 1895 extended the range of variation to about 14 feet—from 96·6 to 110 to 111 feet. In the report of the Nicaragua Canal Commission reference is made to a reported variation between 97 feet and 112 feet, but the "reports of traditions" of such variation are said to be uncertain. It is admitted, however, to be "reasonably certain that it fluctuates between 100 and 110 feet above sea level, at not distant intervals."

* See the reports of Chief Engineer Menocal, of the Maritime Canal Company, and of the Nicaragua Canal Board. Col. Childs, in 1851, determined the ordinary high water to be 102 feet 10 inches above Pacific high tide and 111 feet 5 inches above low tide.

† Galisteo's measurement was obtained from 347 levels, of about a hundred yards distance, starting from the Gulf of Papagayo, on the Pacific Coast. The Spanish MS. referring to this determination was formerly deposited with the archives of Guatemala, and was copied by Mr. Thompson before 1825.

‡ Fitz-Roy corrects Baily's measurement to 125 feet 6 inches—"mean elevation of the lake above mean height of Pacific Ocean."

§ Col Ludlow, in his testimony given before the House Committee of Interstate and Foreign Commerce, gives a lowest stage of the water of 96·6 feet. At other times it has stood at 98·6, and May 2, 1872, 100·97 feet In 1873, as determined by Commander Lull, the surface-level was 102·28 feet. The extreme range within a few years has therefore been 14 feet. There is seemingly a tendency to hold to the lower levels.

Chief Engineer Menocal discredits the report, furnished by the Nicaragua Canal Board, of the lake ever having fallen to 96·6 feet, as "such low-lake would practically cut off the flow of the San Juan below Toro Rapids, an event not recorded in the history of the country."*

Such an extreme low stage of the river, however, appears actually to have existed at the time that it was surveyed by the English engineer Collinson, who, in his report to the Royal Geographical Society (1867), states that the water was so low that small stern-wheelers, drawing when laden only 10 inches of water, could hardly grope their way from rapid to rapid, and were finally stalled by the swift, bowlder-charged current. And yet this was the stream that Squier in 1850 compared with the Hudson and the Connecticut, and which he said was for "far the greater part of its length capable of being navigated by our largest river steamers."

It has been customary to regard the surface fluctuations of the lake as being periodic or recurrent, depending upon the seasonal changes of one or more years. But might it not equally well be assumed that, apart from the minor periodic fluctuations, there is a distinct oscillation of level, tending to a possible permanent lowering of the surface, which is dependent upon conditions largely distinct from those which are associated with the seasonal rainfall? And is it not after all likely that the high levels given by Galisteo and Baily were correct for their times? In his communication to the Royal Geographical Society already referred to, Engineer Collinson gives emphatic testimony to the lowering of the level of the lake, and suggests—what is not unlikely to prove the true explanation of the phenomenon—that it may be due to increased potentiality of the outgoing or draining waters incident to a differential rise of the land surface. He says: "Every year it becomes more evident to all living on its banks or using its stream that the flow of water is becoming less in the San Juan; and even the least observant native, dwelling on the lake, will tell how its banks are rising year by year visibly before his eyes, how the River Panaloya connecting the two great lakes is becoming drier every season, so much so that at times lately no water connection has existed between them. Noting the fact that these lakes are in the middle of the great volcanic range bisecting the Isthmus, which dies out to nothing before reaching the low alluvial shores of the Atlantic, may it not be conjectured that the gradual upheaval of the center, while the coast has remained almost unmoved, should year by year increase the gradients of the river, and by creating a more rapid flow of water cause the perceptible drainage of the lakes and lower the level of their waters? Also, will not this help to account for the formation of the deltas and silting up of the estuary of the San Juan?" At this time it would appear by no means unlikely that a pronounced shrinkage of the lake, brought about in the manner indicated by Collinson, did in fact take place, and it would hardly be surprising if it should be determined that a considerable dropping of the surface was effected in the period of a very few years. Indeed, the Childs survey, if we assume correctness in his and Lieutenant Baily's measurements, makes it almost indisputable that this must have been the case, for in 1850 the level of the lake had already been found reduced to 103·07 (low stage) feet.† The Baily survey was made in the interval of time between the catastrophic eruption of Coseguina (1835) on the northwest and the very violent one of Irazú (1841) on the southeast, and it was also about this period of special excitability of the crust that, as Squier reports, Nicaragua suffered most from earthquake visitations. It was in May, 1844, when the city of Nicaragua itself suffered much, that the waters of the lake "were observed to rise and fall with the throes of the earth." Naturally, it is to a period of this kind that one would look for most rapid or permanent terraine displacements.

The subject of the oscillation of lake-levels has only during the last 20 or 25 years attracted the serious attention of geographers, and only in the case of a very few lakes is the information pertaining to them of such a precise nature as to permit of definite conclusions being drawn regarding their condition. This much is known, however, that a number of lakes have undergone marked changes in volume, whether toward an increase or a decrease, in comparatively short periods of time; others have gained or lost through slow but steady accretions or diminutions extending through a considerable number of years. In some instances the oscillations can be referred to well-known causes; for others an acceptable explanation is still to be found and given. A few instances of marked oscillation, which may have a bearing upon the condition and question of permanency of Lake Nicaragua, are here given.

* Testimony before the Committee of Interstate and Foreign Commerce, Senate Document 315, 1896, p. 69. Mr. Menocal, in his various reports, does not appear to have confined himself to a strict unit of measurement for the surface of the lake. In his report addressed to the Directors of the Nicaragua Canal Construction Company, January 31, 1889, it is stated that the elevation of the lake at the time the surveys were made was 102·5 feet; elsewhere its "elevation above mean sea level is taken at its mean as 110 feet."

† On September 19, 1850, it was 105·62 feet.

LAKE GENEVA.—The height of this lake above the level of the Atlantic is according to the more recent measurements 1,218·8 feet. On the old Carte Fédérale Suisse it appears with 375·03 meters or 1,229 feet, an excess of 10 2 feet over the newer determinations. During the past century, according to the researches of Prof. F. A. Forel, the surface oscillation between the highest (July 16, 1817) and lowest (Feb. 4, 1830) levels was 8·7 feet.

GREAT SALT LAKE. —The noted fluctuation of this lake is compassed within 11 to 13 feet. On Stanbury's map of 1850 it is represented as covering an area of 1,750 square miles and having a maximum depth of 36 feet. The newer survey (1869) of Clarence King placed the area covered by it at 2,170 square miles, and its maximum depth at 49 feet.

NEUSIEDLER SEE (or Fertö-Tava) of Hungary.—According to the investigations of Béla Széchényi, this lake began slowly to empty itself in 1854, and became quite dry in 1868. In 1869 the waters again began to accumulate, and by 1879 had once more reached full high water mark. A protracted period of increase was noted in the years 1744-55.

LAKE TANGANYIKA (East-Central Africa).—The marked increase in the volume of this lake was noted by both Thompson and Stanley. The latter asserts, from soundings made by himself and the testimony of reliable natives, that within a period of some thirty years preceding 1876 the surface of the lake had risen fully 18 to 20 feet.

LAKE ILOPANGO, in Salvador, Central America.—The most remarkable changes of level recorded in the case of any lake are those which were made known by Profs. Ortega and Rockstroh, representing an official Guatemalan Commission, in the course of their investigations into the eruption of the volcano of Lake Ilopango in 1879-80. It was then observed that between December 31 and January 11 the surface of the lake had risen just four feet. Through the increase in volume of 66,000,000 cubic meters the lake changed its moderate drain into a broad and tumultuous torrent, which in a short time so rapidly degraded its channel as to cause a sudden subsidence of the lake. A lowering of the surface began on January 12, and within three hours the waters had subsided 8·3 feet. On February 11 the surface had been reduced to 30 feet below the highest stage, and on March 6 it was still further lowered by 3·5 feet. In a period of less than two months, therefore, the surface had fallen 33·5 feet, and the lake lost in volume, as estimated, 635,000,000 cubic meters. This extraordinary lake measures approximately 5·5 miles in length and 4·3 miles in width.

It will thus be observed that the fall of Ilopango considerably exceeds that which is indicated for Lake Nicaragua in the difference between the measurements of Baily and Childs (or Menocal), and this fact becomes of special interest when it is recalled that both lakes are hardly less than close neighbors of one another, and that their phenomena are largely associated with the phenomena of volcanism of one and the same region. Unfortunately we possess no extended history of Lake Nicaragua, and seemingly the only precise geographical data that are extant regarding it, and which antedate the Childs survey, are just those that are contained in the reports of the authorities whose measurements differ so largely from the ones of more recent date. Hence, they can give evidence neither for nor against accuracy.

This lack of comparative knowledge of the physics of the lake and river region of Nicaragua in its bearing upon the construction of a canal has been properly emphasized by the Nicaragua Canal Board in their report of 1895, and its existence is also fully appreciated by Mr. Menocal. In a review of the engineers' report he significantly says: "In a country like Central America, where the range of rainfall in the same locality varies as much as 100 inches from one year to another,* and 200 inches or more in the same year between points less than 100 miles apart, theories based upon observations extending over twenty years may be entirely upset the twenty-first." Hence, in conclusion, it may not be safe to assume that the earlier measurements of the lake were erroneous, and rather would one believe that:

1. The level of Lake Nicaragua is inconstant.
2. The surface had dropped 15 to 20 feet in the period of little more than half a century.

* In the record of rainfall at Rivas kept by Dr. Flint for the years 1880-1894 a maximum and minimum of 105 and 32 inches, respectively, were found. A precipitation of 108 inches was determined to add 154 inches (12·8 feet) of water to the lake. At Greytown a rainfall of 296 inches has been recorded.

THE death of a noted evangelist brings to mind the fact that he and his collaborator exerted the most beneficial influence upon the organ trade for many years. When they were at the height of their success, people all wished to be able to sing their hymns at home, and an organ seemed to produce the best effect, so that their tour was always sure to be followed by substantial orders for small organs suitable for the household.