16. *A* DELTA *in* MINIATURE—TWENTY-SEVEN YEARS' WORK. By
    T. MELLARD READE, Esq., C.E., F.G.S. (Read February 6,
    1884.)

*Introductory.*—The rate of sedimentary accumulation has in all
cases that I know of been calculated from the amount of sediment
held in suspension in river-water and the mean annual discharge
of the river.

It is true, history has furnished examples of towns that have
once been sea-ports becoming inland towns through the extension
of river-deltas *; but the information has not been sufficient or
accurate enough to found an estimate of the rate denudation has
proceeded at in the river-basins in question.

*The Rake-Brook Delta.*—In June 1883 Mr. Joseph Parry, C.E.,
who has charge of the Rivington Waterworks supplying Liverpool,
called my attention to the great amount of deposit that had taken
place in the Rake reservoir since 1856, the year it was filled.

On visiting the locality in his company, I found that where the
two forks of the Rake Brook joined the reservoir, a corner of the
reservoir was cut off by the public road from Bolton to Withnell, the
communication being by a culvert, stated to be 8 feet high under
the road, but then nearly silted up with deposit. The following
plan will explain my meaning more fully. The whole corner of
the reservoir on the south side of the road, at A on plan (fig. 1), was

Fig. 1.—*Sketch Plan of Miniature Delta, Rake Reservoir.*



---
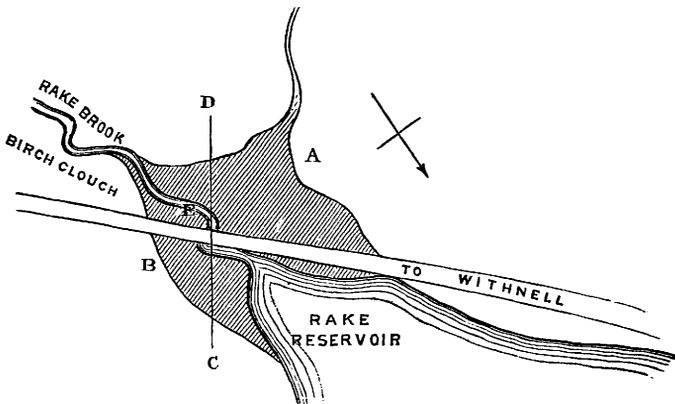
* Adria was a sea-port in the time of Augustus; it is now about 20 Italian
miles inland. Ravenna was also a seaport, and is now about 4 miles from the
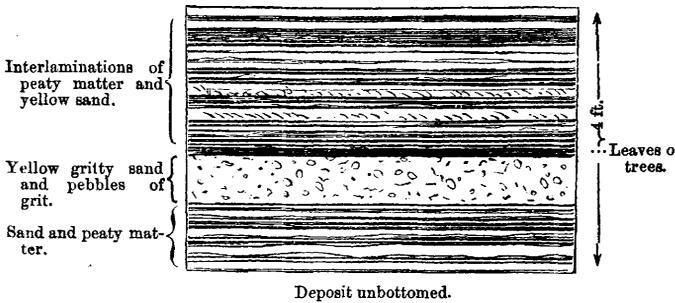main sea. Lyell's ' Principles, vol. i. p. 425 (10th edition).

filled to considerably above the level of the crown of the arch of the culvert (fig. 2) with a beautifully stratified deposit of peaty matter,

Fig. 2.—*Section in line* C–D *of fig.* 1.



A, B. Deltaic deposits.          C. Culvert.
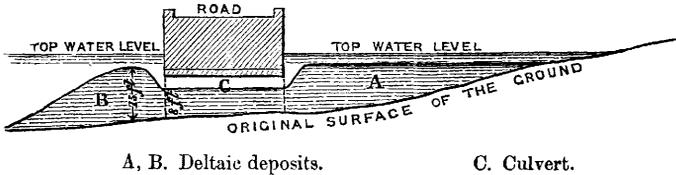
gritty sand, gravel shingle and boulders, as shown in the section below (fig. 3).

Fig. 3.—*Enlarged Section at* E *on Plan, fig.* 1.



Interlaminations of peaty matter and yellow sand.

Yellow gritty sand and pebbles of grit.

Sand and peaty matter.

Leaves o trees.

Deposit unbottomed.

The layers of peaty matter and sand were generally from $\frac{1}{4}$ inch to 1 inch in thickness, one bed of gritty yellow sand being 9 inches thick.

This section was exposed by the excavations then going on to remove the deposit, advantage having been taken of the exceptionally dry weather and the lowness of the water in the reservoir. Part of the sand was being riddled with the object of using it in the filter-beds. About 5 feet thick had been removed off the whole area, there being still 8 feet in thickness at the mouth of the culvert. After consultation with the man in charge, I averaged the thickness over the entire area of 2508 yards at 2 yards. The bed of the Rake Brook had cut a devious course through this delta (for such it was), and its bed was strewn with boulders of Millstone Grit, the largest I measured being 1 foot across. On the north side of the road and in the open reservoir, marked B on plan, was another delta formed by the matter washed through the culvert. Five feet thick of this had been removed from the front of the culvert. It consisted principally of fine sand with a small proportion of peaty matter mixed with it. There was still 10 feet deep of deposit immediately

opposite the culvert. The area of this delta I estimated at 430 yards and the average thickness at 3 yards.

*Rake Brook.*—On walking up one fork of the Rake Brook and coming down the other I found the brook-beds full of large Millstone-grit boulders; in places the rock *in situ* formed the bed of the brook.

The banks, largely cut down vertically, showed a drift composed entirely of the débris of the underlying rocks from large stones through boulders to gravel and sand ; much of it seemed like subaerial detritus. On the top of this was a peaty soil of considerable thickness. In fact all the materials of the delta were there and nothing more. I observed no erratic stones.

*The Drainage-area.*—On walking from one fork to the other I passed over the heath, which was extensively covered with the cotton grass, the beautiful tufts of downy cotton looking at a distance like white flowers. This heath, according to the 6-inch ordnance map, kindly furnished by Mr. Parry, constitutes about $\frac{2}{3}$ of the drainage area; it can hardly be called a " basin " as it occupies the side of the hill. The reservoir is about 550 feet above O.D., and the highest point of the watershed about 1200 feet above O.D. I estimated the drainage-area or "gathering-ground" at 3,643,000 square yards $= 1\cdot176$ square mile. The delta I estimated at 6,306 cubic yards; and as the time of accumulation was 27 years, the rate of removal or denudation over the whole surface was $\frac{1}{432}$ of an inch per annum or 1 foot in 5184 years. The mean rainfall of the Rake-Brook watershed was, during the last 10 years, according to information supplied me by Mr. Parry, 49·57 inches per annum.

*Observations.*—No doubt some of the finer mud has been distributed over the bottom of the reservoir and is not taken into account in my estimate. It is interesting to note that the rate is nearly the same as that of the Mississippi[*]. It is also perhaps more instructive to note what a close agreement there exists between the relative amounts of peaty matter and sand in the deposit and on the surface of the gathering-ground. The example also forcibly impresses on the mind the importance of causes at work, which, but for exceptional circumstances which direct our attention to their accumulated results, would not be noticed. If the reservoir had not been made, the matter would have passed out to sea through the river Douglas without notice; as it was, the matter intercepted seemed so exceptionally great for the time as to attract the attention of the engineer; but, on measurement, we find that the rate of denudation accords well with what has been calculated in other ways. Being in miniature, we are enabled to directly inspect and explore all the processes of nature leading to the result, both on the gathering-ground and in the deposit itself. We also see very beautifully displayed those puzzling alternations of fine laminated beds and coarse sand with boulders resulting from the varying conditions in

[*] See ' Text book of Geology' by Dr. Archibald Geikie: given at 1 foot in 6,000 years. The mean rainfall of the whole Mississippi valley is, according to data given by Humphreys and Abbott, about 30 inches.

fine weather and flood of the same agent, a running stream, modi-
fied, no doubt, by the height to which the reservoir rose at the
time,—conditions often repeated on a larger scale in nature all over
the world.

## DISCUSSION.

Mr. J. EVANS pointed out that the rainfall in the district of the
Rake river was a high one, so that the denudation might thereby
be increased. It would be interesting to have results where the
rainfall was of a more average character. He was disposed to think
that, under similar conditions, the denuding effect of the rainfall
would vary as some higher power than unity with the amount. ;

Prof. JUDD said that Mr. Mellard Reade had found that in higher
regions the harder character of the rock balanced the increased
amount of rainfall.