MULTIPLE BANDING OF SEDIMENTS DEPOSITED DURING A SINGLE SEASON.

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ABSTRACT. During the spring flood of 1940, the Arkport Flood Control Reservoir, near Hornell, New York, held water for the first time since its construction. The inflow had three peaks, over a period of two weeks. The sediments deposited by this high water form three pairs of bands, similar to varves in general appearance. Comparison of grain size curves with those of sediments from a proglacial lake in the same general region shows a clear distinction between the two. It is pointed out that several bands of sediments may be deposited in a very short time and may by no means indicate the number of years required for the formation of a given deposit. Such a multiplicity of bands would not necessarily interfere with short-distance correlations.

THE Arkport Flood Control Dam, near Hornell, New York, was constructed under contract for the United States Army Engineers as part of a system of flood protection in the upper Susquehanna watershed. The reservoir has an uncontrolled outlet, so that the drawdown after a period of high water is automatic and depends only on the amount of water in the reservoir and the rate of run-off from the tributary watershed. Construction of the dam began in May 1938, and the dam was completed in November 1939. During the construction period, there were no discharges of such magnitude as to involve ponding in the reservoir. After completion, the initial case of ponding occurred during the spring of 1940, when rain combined with melting snow to give a high run-off. The resulting pool had a maximum depth of about 35 feet, and a length of about half a mile. The reservoir gradually emptied, and after two or three weeks it was dry, and the sediments resulting from the high water could be examined. As the water had been quite muddy, there were very appreciable amounts of these sediments.

An examination of the portions of the reservoir that had been under water showed deposits consisting of sand, fine sand, silt and clay, ranging from a total thickness of an inch or less near the upper end of the inundated area, to a maximum of seven inches in thickness in a temporary diversion channel used during part of the construction period. This channel made an excellent trap for sediments when the reservoir was partly filled. During the same period of high water, small deltas of gravel were built into the flooded area by all the streams entering the reservoir, clearly marking the maximum water level that had any appreciable duration.

The fine sediments, wherever examined, show clear-cut banding, with layers of fine sand overlain by silt, each of the pair being a quarter of an inch to an inch or more in thickness. In many places, however, the sediments unmistakably showed two pairs of strata, and, in the downstream parts of the reservoir, and especially in the former diversion channel where the seven-inch deposit was observed, there were clearly three pairs. In this channel, the deposits consist of ten cm. of fine sand, overlain by one to three cm. of silt and clay, followed by a layer of sand one cm. thick, a layer of silt and clay two cms., a layer of sand one-half cm., and a layer of silt and clay three cms. Three pairs of layers were observed in much of the central area of the reservoir, though the individual bands were much thinner than the figures cited above. These deposits are all unquestionably the result of the one period of high water, since the channel was in use for diversion until after all previous periods of high water, and was filled nearly full with waste rock and spoil during clean-up operations after completion of the construction work. The sediments in question overlie the waste rock fill.

The spring high water of 1940 was caused by high temperatures and a number of light showers over a period of several days, resulting in the melting of the heavy snow cover. Correlated with this, the run-off was characterized by three main peaks, which corresponded to the days when the light showers occurred. The hydrograph (Fig. 1) shows the agreement between the number of run-off peaks and the maximum observed number of bands of sediment.

Each peak in the run-off resulted in bringing a sudden inrush of sediment-laden water into the reservoir, to be followed by a period of lesser inflow. During the periods of high run-off, the velocity of the inflow was naturally higher than at other times, and hence the size of the transported particles was greater. The periods of heightened inflow are believed to have been marked by the deposition of the sand layers, and the quiescent periods by the deposition of silt. It therefore appears that, in some cases at least, as many as three pairs of alternating coarse and fine layers can be formed during a period of only two weeks. It is quite reasonable to

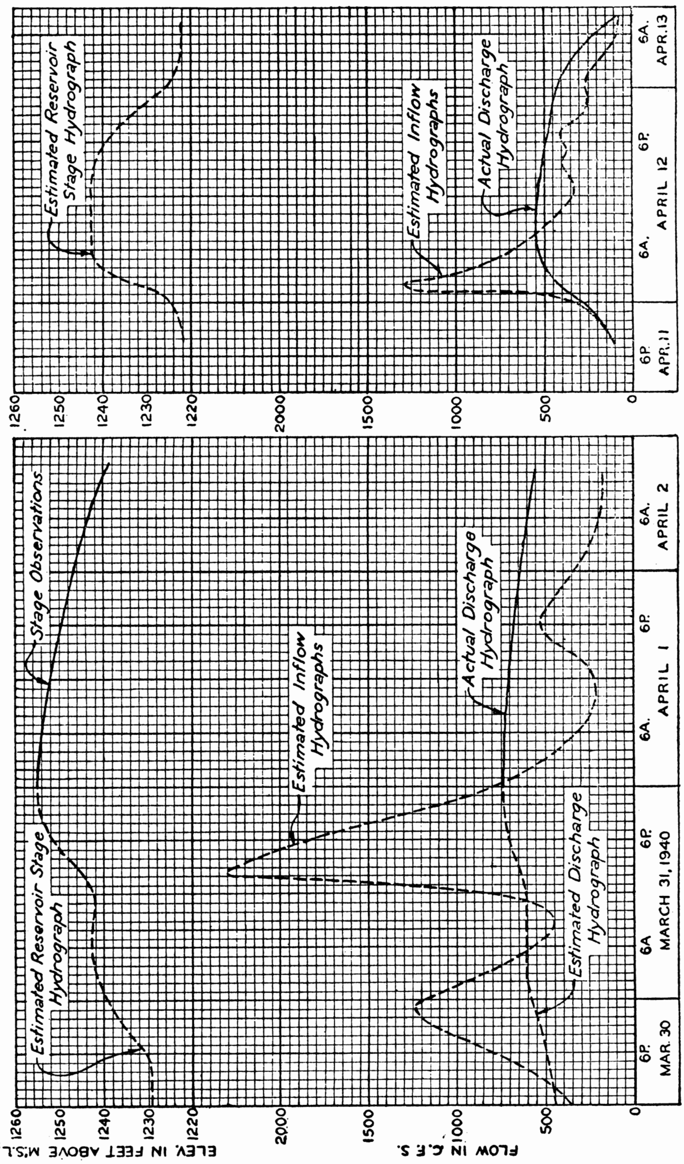

Fig. 1. Reservoir Stage Hydrograph, Inflow Hydrograph and Discharge Hydrograph for Arkport Reservoir, N. Y., March 30-April 2 and April 11-13, 1940, showing peaks of March 30, March 31 and April 12.

assume that inflow into a natural lake would behave in a manner similar to inflow into an artificial reservoir of the same size.

These sediments give a banded appearance resembling various deposits which have been interpreted as of seasonal origin. This raised the question as to whether there is any method of distinguishing such banded sediments of non-seasonal origin from those believed to represent annual layers. Typical glacial varves consist of alternating layers of silt and colloidal clays. However, the glacial and post-glacial deposits of southern New York contain very little clay, being largely derived from the silty strata of the area. The fine material of these glacial deposits is largely silt, much of which is extremely fine grained, being of colloidal size but being rounded particles of silt rather than flat clay flakes. The Arkport sediments were therefore compared with representative samples of varves from a glacial lake (perhaps Lake Binghamton?) at West Oneonta, about 120 miles east of Arkport. The varves were removed from drill holes driven by pressing the casing into the ground, removing continuous undisturbed samples. The sediments appear clearly to have been varves deposited in a proglacial lake filling the valley of Otego Creek.

The grain size curves (prepared by the Soils Laboratory, U. S. Engineer Office, Ithaca, N. Y.) for the Arkport sediments, fall into two distinct categories, one being predominantly coarse silt and the other predominantly medium to fine silt. (Figs. 2-3. Curves numbered 1-3, 6-9, 13, 16, 19, 21 and 23 are of the coarse beds; numbers 4-5, 10-12, 14-15, 17-18, 20 and 22 are of the fine beds.) In the grain size curves from the West Oneonta dam site, the difference between the coarse and fine materials is much more clearly marked, resembling the usual concept of varve deposits (Fig. 4). However, the West Oneonta fine deposits are not true clays, being made up of extremely fine, rounded silt particles rather than of clay minerals. Although it has not been possible to make comparisons with the more usual type of varved deposits, it is believed that the contrast between fine and coarse layers would be greater in such material.

Taking the percent of material finer than 0.01 mm. in diam-

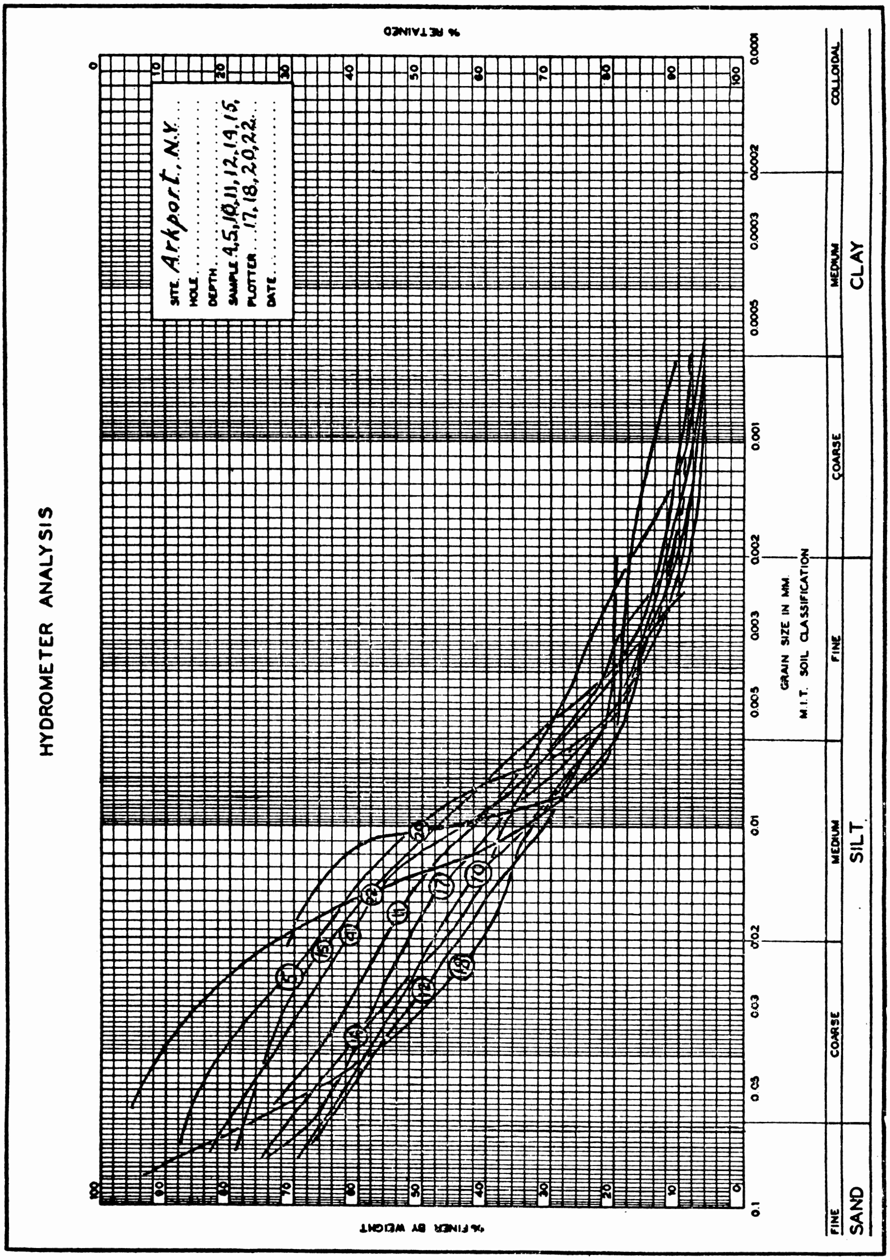

Fig. 2. Grain size curves for samples of fine grained layers, Arkport Reservoir.

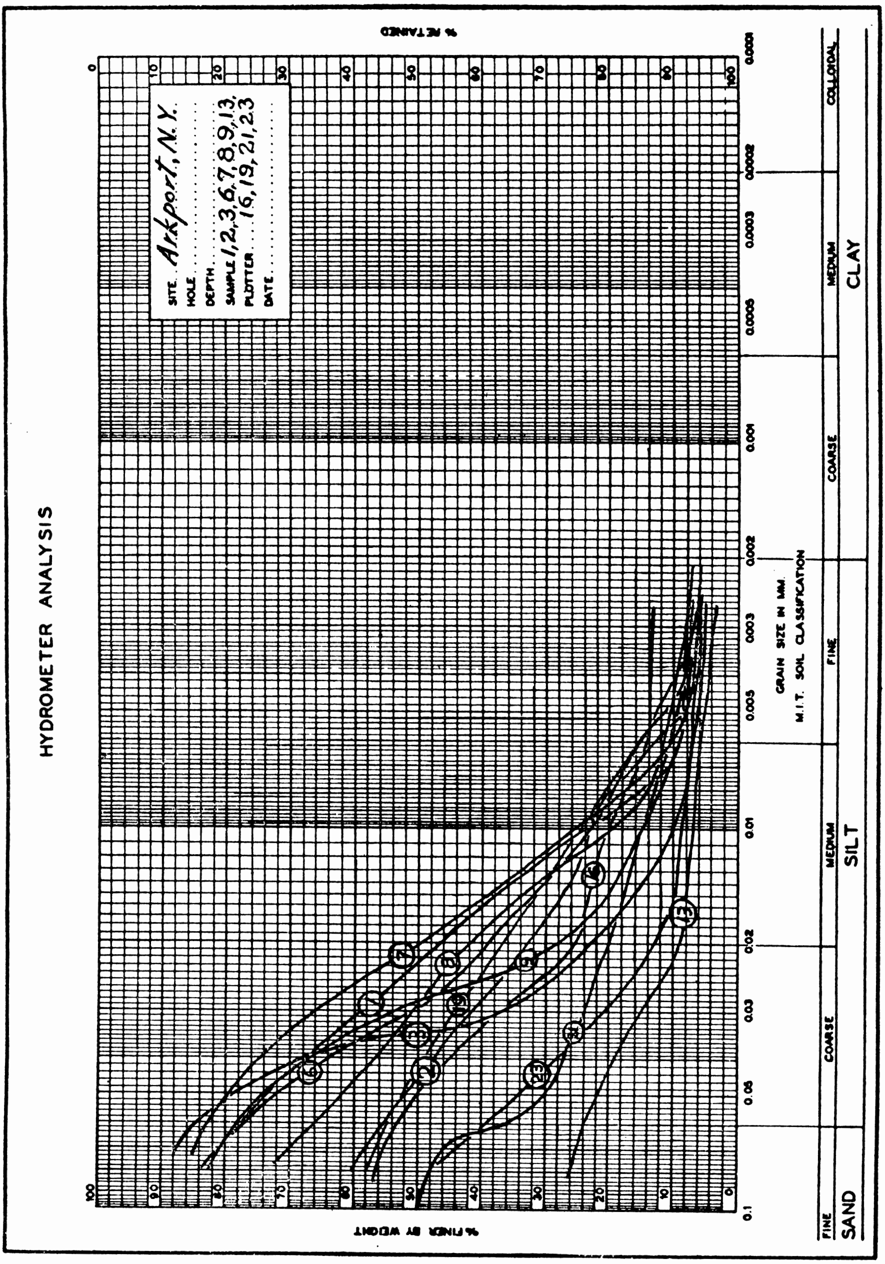

Fig. 3. Grain size curves for samples of coarser grained layers, Arkport Reservoir.

eter as the critical point, the comparison of the two sediments is as follows:

West Oneonta			
Coarse	5 samples	15-35%	finer than 0.01
Fine	8 samples	85-99%	finer than 0.01
Arkport			
Coarse	12 samples	7-25%	finer than 0.01
Fine	11 samples	31-50%	finer than 0.01

The West Oneonta coarse sediments are similar to those from Arkport. The fine material, however, is much finer and much more sharply distinguishable from the coarse. The West Oneonta materials were deposited in a lake of considerably greater area than were the Arkport ones. This raises the possibility that glacial deposits in New York state, formed in small lakes or near-shore phases of those formed in larger lakes, might more closely approximate the Arkport type of banding.

Thus, although the Arkport sediments superficially resemble varved deposits, their distinctness becomes apparent when the grain-size curves are analysed. Hence, although care should be taken in interpreting banded sediments as being indications of seasonal cycles, grain-size analysis will actually show which sediments fall into the varve category.

The three peaks of the 1940 spring run-off resulted from certain meteorological conditions, which, if of common occurrence, could frequently produce banded sediments that would represent a much shorter period than an entire year. Although there is only a limited amount of data available in regard to spring run-off in the upper Susquehanna watershed, what there is suggests that multiple peaks of the sort observed in the spring of 1940 are by no means uncommon. It is entirely possible that similar meteorological conditions have prevailed fairly generally in the past.

The multiplicity of run-off peaks forming banded deposits is likely to be the result of climatic factors affecting a fair-sized area, which might permit the resulting deposits to be correlated with similar deposits from the general vicinity, even when a considerable number of bands were formed in the course of a few days or weeks, rather than over a period of years.

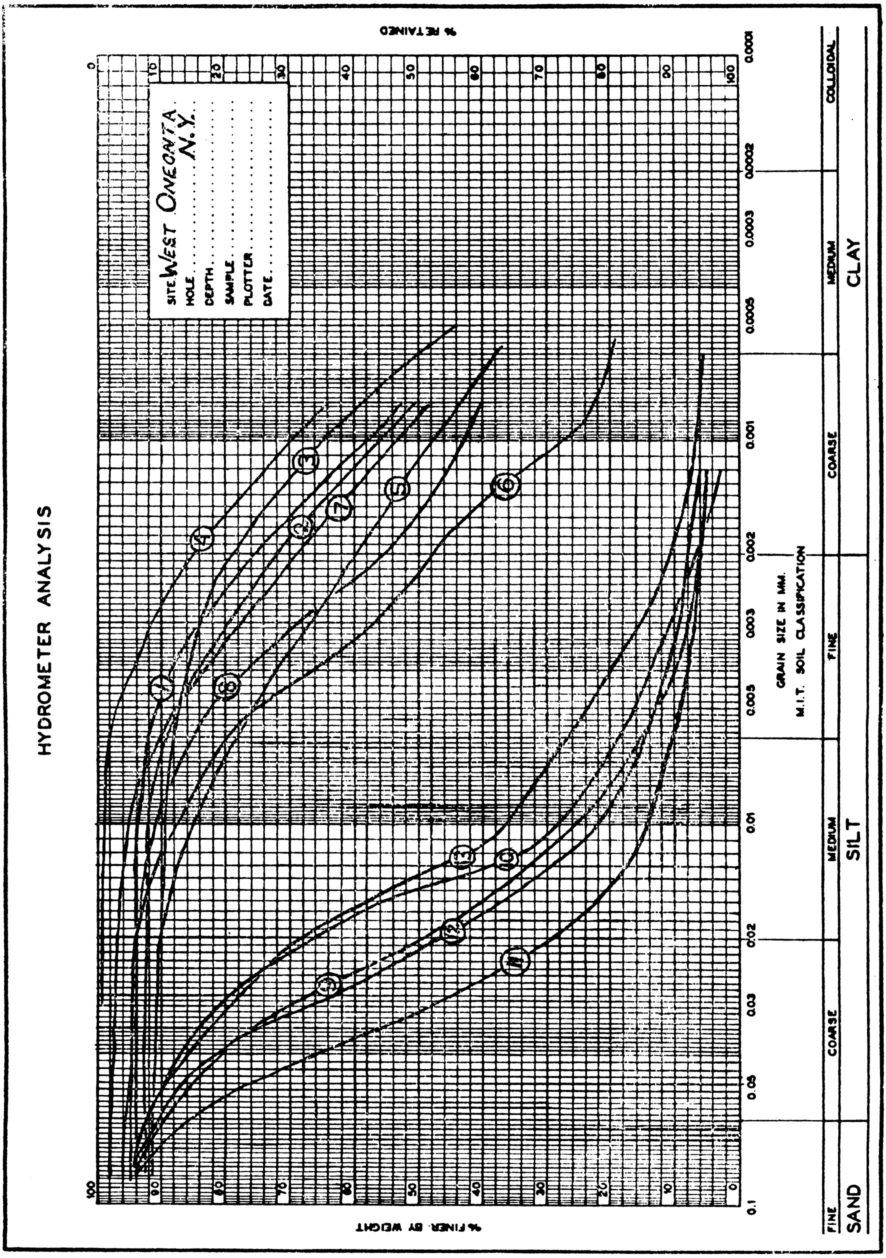

Fig. 4. Grain size curves for fine and coarse grained layers of varves from Drill Holes 12 and 13, West Oneonta Dam Site, Otego Creek, N. Y.

This paper was begun while the author was Geologist for the U. S. Army Engineer Office, Binghamton, New York. Thanks are due to Prof. C. O. Dunbar for critical suggestions.

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