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A. L. Lugn
State University of Iowa

SOME OBSERVATIONS ON UNDERTOW

A. L. Lugn

Undertow has been the subject of considerable discussion among geologists and has received some attention in the press. Some hold that it is a continuous return flow of water along the bottom from a shoreline and others contend that it is a pulsatory return of water alternating with its piling up due to the shoreward movement of waves of translation.

Many natural phenomena associated with shorelines may be observed as well or even to better advantage along the shores and beaches of small lakes or along the banks of large rivers than along the shores of large bodies of water or even of the ocean itself. It is apparent that on small bodies of water the waves are of small amplitude and the resulting shore forms such as terraces, bars, cliffs, caves, etc., are formed on a proportionately smaller scale. For example, when small waves are cutting cliffs out of fairly resistant and compact mud or clay the whole phenomenon can be observed conveniently within a limited and easily accessible area.

The observations described below were made on some shoreline processes along the banks of Mississippi river and the shores of artificial lake Cooper north of Keokuk, Iowa, while making a sedimentation study of the river, during the summer of 1925. The amplitude of the waves was usually small, from about six inches to two or three feet. The processes and resulting features are apparently identical with those seen along the shores of large bodies of water or the ocean, where indurated rock is being sculptured and disrupted by large waves. Undertow is just as accessible for convenient study on this small scale as are other shoreline phenomena.

The purpose of this report is to state very briefly some observations made on undertow along the banks of the Mississippi river, where the current was negligible and the waves active. Some of the best observations were gotten along the east bank of Glaucus island, north of Hannibal, Missouri.

Where waves are normal and regular in their periods and uniform in amplitude the shoreward movement of water is in uniform

pulsations. The normal condition prevails when waves of translation bring shoreward equal quantities of water at equal time intervals. Under these normal conditions, when the water is moving shoreward as a wave, there seems to be no undertow moving outward from the bank along the bottom. The water thus periodically piled up on the beach flows back at equally regular intervals of time, which alternate with the shoreward pulsations. Thus at any instant the water is either all moving shoreward or all moving outward from the bank. This is the pulsatory return flow or undertow that some hold to be the only mode of "seaward" return of the water prevailing most of the time. In general this seems to be the dominant mode of behavior.

However, at longer or shorter intervals, a somewhat larger wave of translation, which moves shoreward faster than the smaller waves, over-rides at times the return flow of the preceding pulsation. This over-riding is due to the shortening of the time interval required for the return flow of the normal quantity of water from the preceding smaller wave. Thus a larger wave disturbs the equilibrium which was established under the immediately preceding prevailing uniform conditions. The quantity of water brought in toward the bank by the larger wave of translation, being greater than normal, requires in turn a longer interval of time for its return or outward flow than had been necessary under the conditions of equilibrium for the smaller and slower translatory pulsations. This may cause the next incoming wave also to over-ride the outflowing sheet of water. Thus there are times when there may be a sheet of water moving outward from the bank along the bottom, while an incoming wave of translation is moving water shoreward at the surface. Such a condition does not seem to be at all constant nor continuous for any great length of time.

At times when the continuous undertow is active very appreciable quantities of sediment are moved away from the banks. This seems to be a very effective factor in the removal of débris from the beach where it has been ground and broken by wave action. This mode of removal of beach débris is probably not as important in a quantitative way as shore currents but infrequent as it is, even if it were the only mode of seaward transportation of shore sediment there would be a net loss of beach material.

The continuous undertow, which occurs at irregular intervals, is most active at times when conditions of wave equilibrium are most frequently disturbed. This commonly happens with the passing of storms over bodies of water. As a storm increases in

intensity the waves of translation increase in size. This condition rather continuously disturbs the tendency of the waves to come to equilibrium. With the dying down of the storm the waves of translation continuously decrease in size and so reach a condition of equilibrium only after the water has quieted down to such an extent that the waves again become regular in their periods and uniform in amplitude.

Summary. Under condtions of wave equilibrium, there is no continuous return flow or undertow from shore but the movement of water is pulsatory and sediment is dragged alternately shoreward and riverward or seaward, with only a slight predominance of the outward drift of débris due to the pull of gravity down the slope. Under disturbed conditions, as with the passing of a storm or even a large steamboat in a river, the condition of wave equilibrium is destroyed, and an undertow may be set up more or less continuously for longer or shorter intervals of time and quantities of transportable sediment may be moved from the shore or bank into deeper water.

STATE UNIVERSITY OF IOWA,
IOWA CITY, IOWA.