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FRICTION EXERTED BY THE MOVEMENT OF THE MASSES OF WATER ON THE SUPERFICIAL LAYER OF MARINE SEDIMENTS

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A b s t r a c t

The paper deals with the method of estimation of the friction force, of the turbulent mixture factor, and of the rugosity, and with influence of these parameters on the configuration of the superficial layer of marine sediments.

The movement of the masses of water at the immediate proximity of the sea floor exerts a double influence on the superficial layer of sediments. Such influence is manifesting itself through the apparition of a lateral pressure on the particles, directly proportional to the second power of their diameter, and to the second power of the velocity near bottom, on the one hand, and on the other hand through the creation of a tangential tension or friction force directly proportional to the value of the turbulent mixture factor and to the velocity gradient of the current in the immediate proximitx of the solid boundary (sea floor) (MATEESCU, 1963). In the following, primarily the latter aspect will be discussed.

The analysis of the differential equations of the motion shows the presence of a boundary layer near the bottom of the sea, where the force of the baric gradient, Coriolis's force and the friction force are of the same order of magnitude. However, nearer to the solid boundary, the relation between three forces will change, the friction force becoming preponderent. Thus in the lower part of the boundary layer, a sublayer may be delimited, where the friction force will considerably exceed the force of the baric gradient and Coriolis's force. Although the processes taking place in this lower layer, are connected with the phenomena taking place in the entire boundary layer, and are of sufficient weight to warrant their separate treatment, the establishment of some internal connestions of the movement for the boundary sublayer is sufficient to enable the solution of a series of important practical problems (LAIHTMAN, 1970).

The thickness of the boundary layer may be estimated with the ratio between friction force and Coriolis's force (ROVENTA and SELARIU, 1965). Through experimental determinations and theoretical analyses, based on the theory of similitude, the theory of similitude, the thickness of this sublayer is estimated as being 3 to 5 m (PRANDTL, 1925).

The fact that in the boundary layer the term comprising the friction force is considerably exceeding the terms comprising Coriolis's force and the baric gradient force, enables the simplification of the differential equations of the movement, and equation (1) is thus obtained :

$$\frac{d}{dz}\left[K\,(z)\,\cdot\,\frac{dv(z)}{dz}\right] = 0 \qquad (1)$$

where z = distance in cm from the sea bottom ;

$k(z)$ = turbulent mixture factor, cm^2/sec ;

$v(z)$ = velocity of the current, cm/sec.

From the theory of similitude it results that the value of the turbulent mixture factor - k(z) - is directly proportional to the distance from the solid boundary, and to the square root of the friction force (KARMAN, 1930).

$$K\,(z) = 0,38\ \sqrt{\frac{\tau_o}{\rho}}\,,\ Z \qquad (2)$$

where τ_o = friction force ;

ρ = density of water

By integrating equation (1) we obtain :

$$K(z)\cdot\frac{dv(z)}{dz} = K(z)\cdot\frac{dv(z)}{dz}\Big|_{z=0} \qquad (3)$$

or

$$K(z) \cdot \frac{dv(z)}{dz} = K(z) \cdot \frac{dv(z)}{dz} \Big|_{z=0} = \sqrt{\frac{\tau_0}{\rho}} \qquad (4)$$

If we consider relation (2), then equarion (4) becomes :

$$\frac{dv\ (z)}{dz} = \frac{1}{0,38} \sqrt{\frac{\tau_0}{\rho}} \cdot \frac{1}{z} \qquad (5)$$

from where through integration we finally obtain :

$$v\ (z) = \frac{1}{0,38} \sqrt{\frac{\tau_0}{\rho}} \cdot \ln \left(\frac{z}{z_0}\right) \qquad (6)$$

where ln = tje symbol of the natural logarithm ;

z_0= rugosity parameter, mm.

Relation (6) representing the logarithmic equation of the profile of the velocity of the current in the boundary sublayer, was checked experimentally in various marine conditions (MOSBY, 1947, 1949). Rhe above logarithmic profile depends on two parameters : on the friction force τ_0 and on the rugosity z_0. These parameters may be determined only experimentally through actual measurements of the currents in the immediate proximity of the sea floor.

With the aid of a special installation (LESSR, 1951) several series of such measurements were carried out at 50, 100, 150, 200 and 250 cm above the sea floor, off the southern part of the Romanian shore, near the 40 m depths contour line. The measurements were performed simultaneously on all five levels, at intervals between 10 and 15 minutes for each series of measurements (table 1) The respectiva series were numbered in the increasing order of the velocities.

Table 1

Data on currents in the neighbourhood of the sea floor

Velocity of the current [cm/sec.]

Series / Z [cm]	1	2	3	4	5	6	7
50	7,7	11,4	13,3	15,3	20,0	20,7	23,6
100	8,9	12,0	15,3	17,4	21,9	23,8	26,5
150	9,1	12,6	15,9	18,7	23,9	24,7	28,3
200	9,3	13,7	17,0	19,1	24,3	25,5	28,5
250	9,8	14,2	17,3	20,0	24,7	27,1	29,8

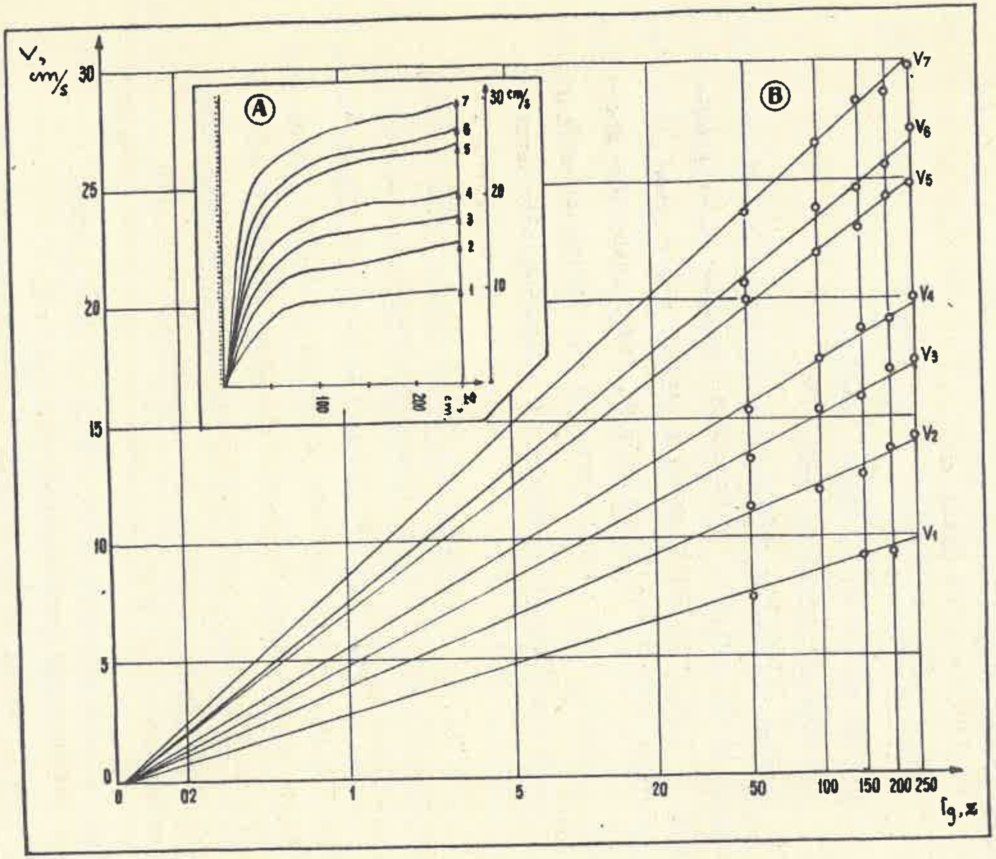

Fig. 1.

Figura 1 - Hodofraph (A) and vertical velocity distribution in semilogarithmic coordinates (B)

By representing the velocities in a graph with semilogarithmic coordinates, a family of straight lines (fig. 1) was obtained, the slope of which is equal to $\frac{1}{0,38}\sqrt{\frac{\tau_0}{\rho}}$, while the point of intersection of these straight lines with the OX axis is equal to the logarithm of the rugosity. Based on this graph, the two parameters of the profile were determined, while with the aid relation (2) the value of the turbulent mixture factor k, was determined at a distance of one metre above the sea floor (table 2).

Table 2

Friction force τ_0 [dyn/cm²] turbulent mixture factor k, [cm²/sec], and rugosity z_0, [mm]

Series	1	2	3	4	5	6	7
τ_0	0,238	0,455	0,778	1,092	1,241	1,570	2,140
k	49,5	67,4	88,2	104,2	111,8	125,8	146,2
z_0	1,4	1,0	1,7	1,9	0,9	1,9	1,2

The values obtained for the friction force and for the turbulent mixture factor, as a whole, are lower than those obtained by other investigators (BOWDEN and FAIRBAIRN, 1952). This is due to the fact taht in the zone investigated, the superficial layer of the sea floor is constituted mainly of sandy silts, with the mean grain size (M_d) being comrised betweer 0, 07 and 0, 03 mm (SELARIU, 1965), implicating a low rugosity. The fact that the rugosity is low, creates the possibility for the existence of relatively higy velocities (5-10 cm/sec) at only a few centrimetres above the bottom, which in turn lead to the apparition of sufficiently higy lateral pressures on certain particles, the size of which is exceeding the mean rugosity. Owing to this fact, the larger particles may be displaced by being rolled-over, until theay reach zones where the rugosity does not any more permit the presence of bottom velocities capable to perform such mechanical work.

The knowledge of the distribution in space, of the friction force, of the turbulent mixture factor and particularly, of the rugosity, corelated with other sedimentologic factors, may give precious information on the mosaic-like aspect of the superficial layer in the southern zone, off the Romanian shore.

At the boundary between two facies, a brusque increase of the value of the turbulent mixture factor takes place as a result of the increase of the friction force ; this is a phenomenon which substantially alters the rate of settling. Owing to these dynamic phenomena the boundaries of the varous facies are well contoured from a granulometric pointof view. The dependence of sedimentation on the turbulent mixture factor, and the dependence of the latter on the rugosity, causes a selection of the particles settling down. Thus, where the rugosity is high, the possibilities for small size particles to settle, are minor and vice versa.

Besides the influence exerted on sedimentation, the role of the friction force becomes preponderant in the processes of particle displacement in the zones of changing slopes, or with high slope angles, as is the case on the outer edge of the continental shelf (SELARIU, 1971). In this case, the impulse created by the friction force may coincide in direction with the component of the gravity force, and as a result of this fact, favourable conditions for the apparition of turbudity currents will arise.

SUMMARY

The experimental data, though not very numerous, enabled nevertheless, the logarithmic profile of the current velocity in the immediate proximity of the sea floor to be checked for the conditions prevailing in the Black Sea.

Based on this logarithmic profile for each series of measurements, the friction force, the turbulent mixture factor and the rugosity were determined.

The fact that value of the rugosity is in agreement with the granulometry of the superficial layer in the zone investigated, enabled a number of conclusions to be drawn regaring the influence of the movement of the masses of water on the processes of sedimentation, which are of

significant importance for the conservation of the mosaicshaped pattern of the superficial layer.

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