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SHORE MORPHODYNAMICS OF THE IZVORU MUNTELUI RESERVOIR (EASTERN CARPATHIANS)

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La morphodynamique des rivages du lac de barrage Izvoru Muntelui (Carpates Orientales). L'étude de la dynamique des rivages du lac de barrage Izvoru Muntelui (31 km^2) met en évidence l'action de l'abrasion sur 64% de la longueur des rivages. Le rythme moyen de la retraite des rivages est de 0,17m/m.l. rivage/année, avec un maximum de 2,51 m/m.l. rivage/année dans les conditions de la présence des dépôts alluviaux-proluviaux.

MORPHODYNAMIC CONDITIONS

The Izvoru Muntelui Reservoir [1] is situated in the flysch of the Eastern Carpathians on the middle course of the Bistrița River. The valley is characterized in this area by an alternation of large depression-like sections with narrow, strait-like ones. The slopes have a diclivity of more than 10 – 15° and are intensely dissected ; due to this fact, the shores have a sinuosity coefficient of up to 1.77, without taking into account the modulations imposed by confluences.

In relation to the geological conditions, the shores were found to evolve on flysch structures (along 65% of the total length of the perimeter of the reservoir) and on alluvial and proluvial deposits.

Some 10 to 15 m thick (and even more) deluvial deposits have formed on the flysch structures, diminishing the role of bedrocks in the shore dynamics (Fig. 1 *A*).

Several climatic and hydrological factors are playing a conspicuous part in the shore dynamics. From the first category, the temperature, the rainfalls and the winds will be dealt upon ; the water-stage variations, the wave and the longshore currents, as well as the frost phenomena, belonging to the second category of factors, will also be analysed.

The following characteristics of the air thermal regime are mentioned : average date of first recorded temperature below 0°C (December 5) ; average date of first recorded temperature above 0°C (March, 8) ; mean number of days favourable to frost (about 82 days per year), mean monthly temperature of the coldest month (– 4°C... – 5°C) (Fl. M i h ă i l e s c u, 1975).

These characteristics have determined, in some years, the formation of an ice cover on the whole surface of the reservoir. During this season, the reservoir is in the minimum level phase and consequently the shore belt in emersion is subjected to freeze-thaw phenomena.

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[1] Total approximate surface : 31 sq. km ; maximum depth : 88.25 m ; average depth : 37.1 m ; shore length : 106 km ; commissioned in 1960.

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As regards rainfalls, the pluviometric gauges of Ruginești and Izvoru Alb have recorded, over the 1961 – 1973 period, about 330 rainfalls with morphogenetic effect (in this area, rainfalls over 10 mm/24 h), of which 45% occurred when the shore-belt was in emersion, with a water-stage variation of more than 10 m (I. Ichim et al., 1975).

Winds with velocities higher than 6 – 8 m/s are considered to be favourable to wave formation (O. J. Norrman), 1964; I. J. Tsvetkova, 1966, etc.) Analyzing, from this point of view, the winds recorded at the Tunnel-Entrance meteorological station[2] over the 1965–1975 period, at 1.00, 7.00, 13.00 and 19.00 hours, out of the total of 14,600 observations there could be noted in the reservoir area 943 cases (6.4%) of winds favourable to wave formation, of which 14.75% with velocities higher than 10 m/s. The fact should also be mentioned that out of the same number of cases, about 73.70% of the winds favourable to wave formation occurred when the water in the reservoir was not frozen (Fig. 1 *C*).

Over the last 16 years since the reservoir was commissioned, the water-stage variations recorded a maximum amplitude of over 30 m, a value also recorded within one year (i.e. 1976).

In this period, the level motion velocity was on average of 22.26 cm/day in the phase of level rising (motion velocities of over 80 cm/ day were also recorded) and of 11.20 cm/day in the phase of level lowering (I. Ichim et al., 1977).

The marked water-stage variations have determined the waves and the surface currents to the shore to develop on an inclined plane in the direction of the level motion. In the phase of level lowering, the value of the angle at which the waves are breaking against the shore is increased, whereas in the phase of level rising, the angle is smaller and the morphogenetic effect is diminished (Fig. 1 *F*).

With regard to waves, as no direct observations were available we estimated some characteristics based on correlations between the fetch length, the wind velocity and the wave height. In the present case, we made use of the curves established by the Beach Erosion Board (1961, 1962) for the inland reservoirs in the United States; for certain comparisons, A. P. Braslavski's curves (1952, according to V. Chiriac et al., 1976) have been used. The highest fetch value for the Izvoru Muntelui Reservoir was of 8 km in the Chirițeni – Izvoru Alb area. Therefore, at the maximum wind velocities recorded in the reservoir, waves of 1.5 m height could result. The correlations established in some places of the shore are given in figure 1 *E*. Moreover, as the reservoir waters are deep, the high waves are moving very fast, being "instable", broken sharp by the wind; the water-surface is getting rough shortly after the waves have started. The wave length is relatively short, at most 10 m (if the ratio of 1/7 between the wave length and the wave height established by Stokes – according to J. O. Norrman, 1964 – is taken into account). On 60% of the shore length, the waves are breaking by spreading.

Besides the wind-induced waves, there are also waves due to navigation. They, however, do not last for a long time and their effect on the shore morphogenesis is of little importance.

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[2] The data were put at our disposal by the Laboratory of Climatology of the Research Station "Stejaru", Pîngărați.

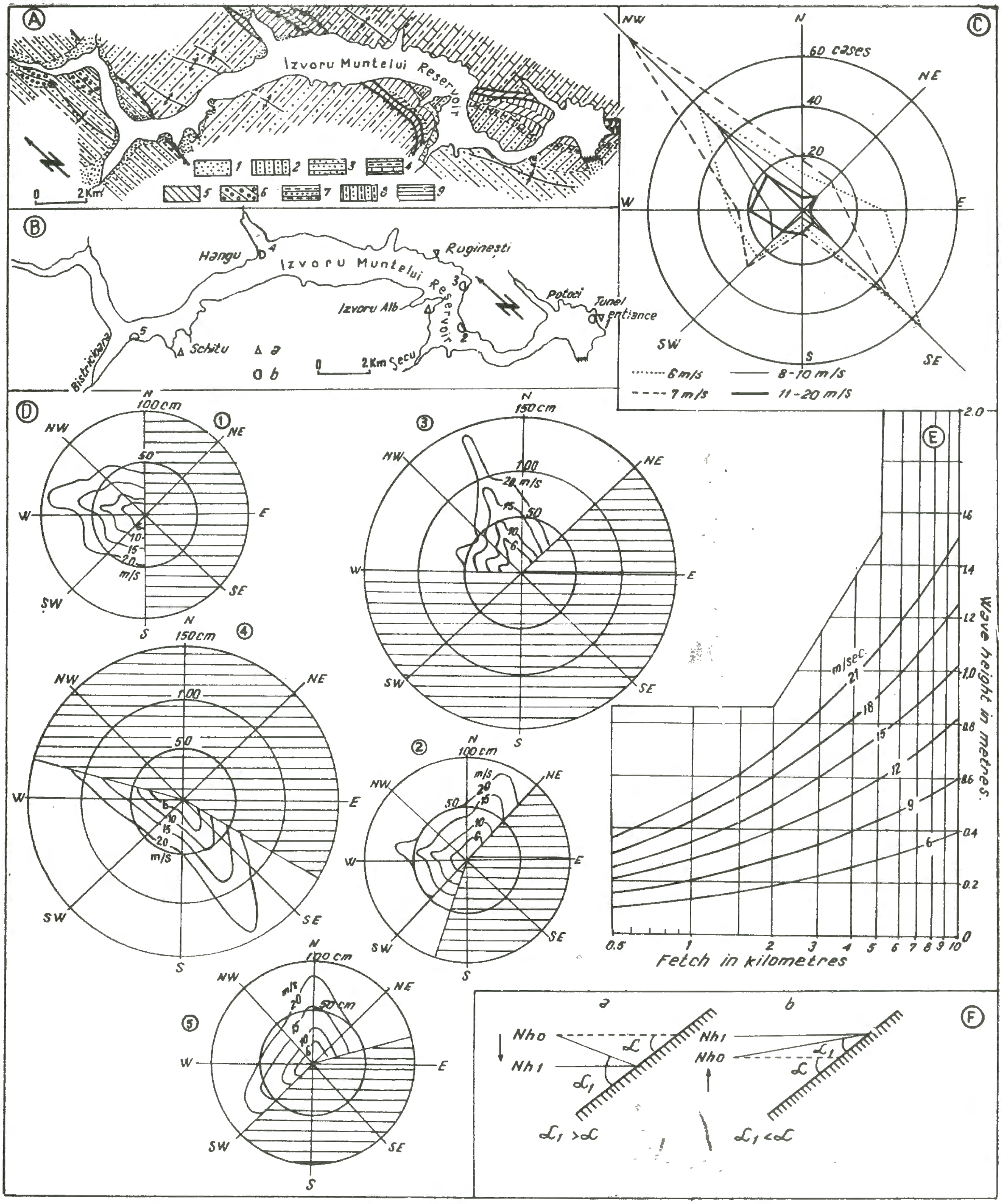


Fig. 1. — Characteristics of morphodynamic factors in the area of the Izvoru Muntelui Reservoir (I. Ichim, Maria Rădoane).

A. *Geological structure* (according to Romania's geological map, Piatra Neamț and Toplița) : *1*, alluvial deposits; *2*, schistose-sandstone flysch ; *3*, sandstone flysch ; *4*, calcareous-schistose flysch ; *5*, red and green clays; *6*, conglomerates and sandstone flysch ; *7*, schistose-sandstone flysch with massive sandstone ; *8*, schistose-sandstone flysch (Bistra strata) ; *9*, black schists.

B. *Meteorological stations* (*a*) *for which diagrams D were drawn* (*b*).

C. *Wind frequency distribution at the Tunnel-Entrance station.*

D. *Wave heights for minimum duration corresponding to effective fetches at the following stations* : *1*, Tunnel-Entrance ; *2*, Secu ; *3*, Ruginești ; *4*, Hangu ; *5*, Bistricioara.

E. *Wave heights for wind velocities between 6 and 21 m/sec and fetches between 0.5 and 10 km* (according to Beach Erosion Board, 1961, 1962).

F. *Deviation of the operation direction of waves and longshore currents, under the conditions of the water-stage variations* : in the phase of level lowering (*a*), in the phase of level rising (*b*).

During some years, the whole surface of the reservoir is ice-covered and in the upstream area of Hangu, this is a usual phenomenon every year. The phenomenon has two consequences : on the one hand, it cancels the effect of wind in the wave formation ; on the other hand, as the ice cover is formed in the phase of level lowering, the ice crust breaks into big plates with a diameter of several metres. In the thaw phase, the plates are gliding on the surface of the shores with a declivity of more than 10°, transporting in their frontal part small amounts of sediments (Fig. 3 *D*).

MORPHODYNAMIC PROCESSES

We have studied over 100 shore profiles according to the analysis model presented in figure 2. It enables us to find causal relationships between the evolution factors and to classify them into dynamic factors (climatic and hydrological) and passive factors (lithologic and morphologic).

The graphs of the relationships between processes, slopes, lithologic structure and width of shore belt allowed a delimitation of the operation field of different processes (Fig. 3 *B*). Thus, the slope inclined at 45° constitutes the inferior declivity limit of profiles where abrasion is exclusively acting ; the slopes at 30 to 45° are the limits of the subaquatic talus-creep ; the slopes at 9 — 30° are profiles where abrasion-accumulation terracettes are formed and on slopes at lower angles than 9° beaches and bars are formed.

Abrasion. This term has lately acquired different meanings than those generally acknowledged in the field of littoral geomorphology, so that certain specifications are required : we used the term in J. Geikie's sense (1898) (according to J. O. Norrman, 1964), who introduced it in the field literature, giving the following definition : abrasion is "...the operation of wearing of the shores by erosion waves, currents and mobile ice". According to C. A. M. King (1959) abrasion implies four modelling processes of the shores : corrosion, corrasion, atrition, hydraulic action. Eventually G. A. Safianov (1973) mentioned three types of abrasion : mechanical, chemical and thermal, ascribing to the notion a broader meaning ; it is not related to the totality of processes, but to the notion of shore.

According to this approach, in case of reservoir, at least in the stage of development of a morphodynamic equilibrium, such processes as landslides and landfalls in the shore area could be ranked among the abrasion processes.

In case of the Izvoru Muntelui Reservoir, there are some studies on abrasion by I. Bojoi (1964, 1968), who analysed 6 shore profiles. Recently, Maria Rădoane (1976) has especially studied the problem of the formation of abrasional niches and kettle holes.

A general view on the intensity of abrasion is given by the shore retreat rate over the 1960 — 1975 period (Fig. 4 *A*). The analysis points to the fact that the left shore of the reservoir has a higher retreat rate than the right shore. This is mainly due to the lithologic structure : on the left shore, between the Chiriţeni and Hangu localities, abrasion operates on clay sand and gravel deposits; between Hangu and Ruginești it operates on very thick deluvial deposits with a prevailingly sandy-clay matrix, which was formed in the *Inoceramus* strata; the right shore has a lithologic structure made up of rocks more resistant to the modelling action.

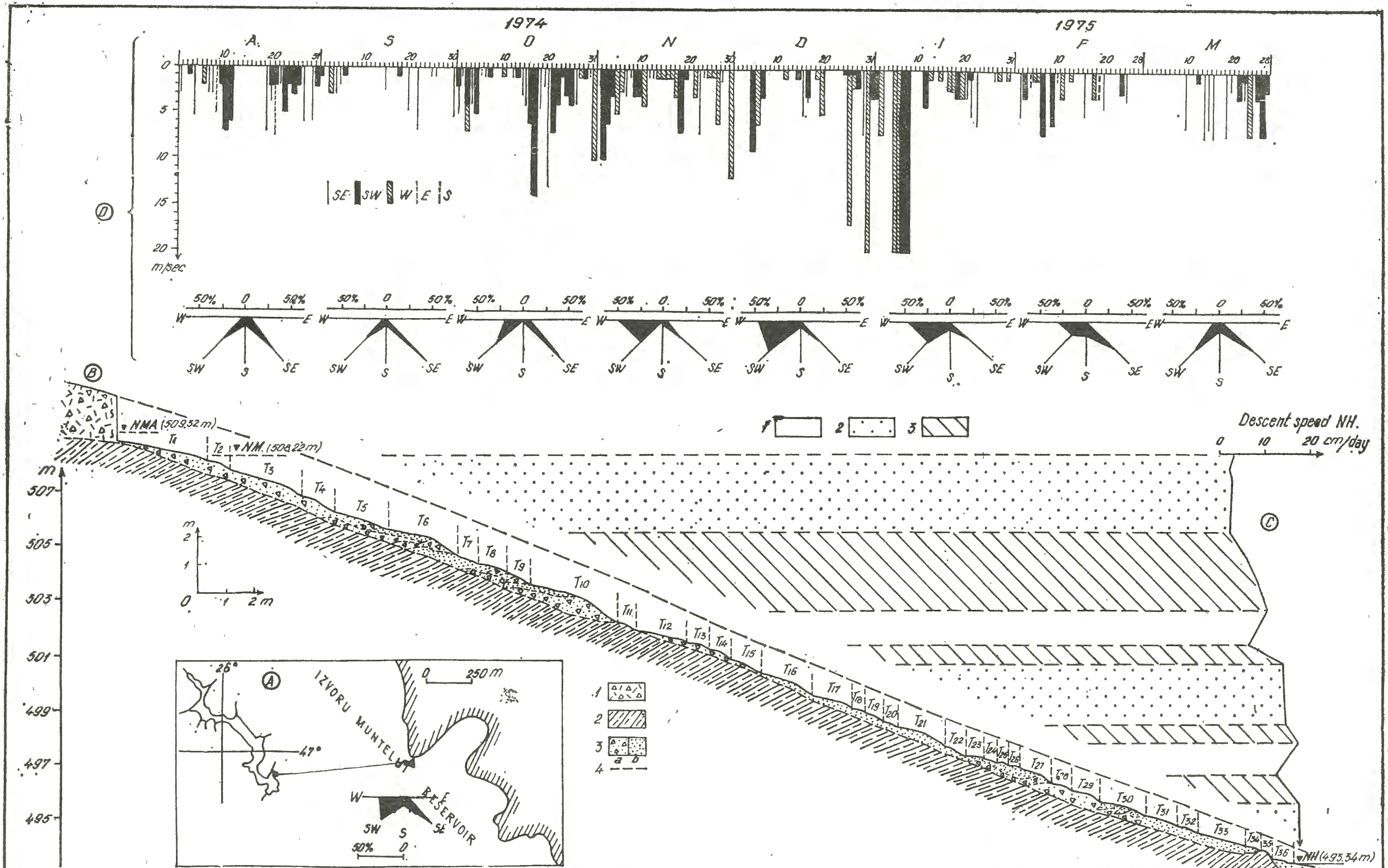
With regard to this differentiation, the variation of the dynamic factors should also be taken into account (about 75% of the winds favourable to wave formation blew in the NW, W and SW direction and in 40 of the 50 cases of winds with velocities higher than 20 m/s they blew in the direction of the right shore).

Fifteen years after the formation of the reservoir, the mean value of the retreat of shores subject to abrasion (about 64 km long) was 2.5 m. This points to an abrasional yearly rate of 17 cm. Along the shore there is, however, a strong differentiation determined especially by the lithology. A mean yearly rate of 1 m was recorded for the shores made up of alluvial deposits. In comparison with other reservoirs the retreat rate is low, due especially to the fact that the reservoir reaches the maximum level for a short time (6%).

In the morphology of abrasional shores, cliffs constitute the main element. They have different sizes, in relation to the shore lithologic structure and to the fetch of the wind. They are generally 3 m high. The highest cliffs are those situated at: the confluence with the Pîrîu Mare brook (14 m high, initially a scarp of selective modelling); Chiriţeni (8 m high, in sandy silts); Călugăreni (5.80 m high, in proluvial deposits); at the confluence with the Pîrîu Rotarului brook (5.30 m high, in deluvial deposits and silt); at Hangu (5.10 m high, in gravels), etc.

In the shore evolution and retreat process, the formation of niches and kettle holes is a very frequent phenomenon, contributing in some cases to the triggering of mass movement processes on the slopes in close vicinity of the shore (Maria Rădoane, 1976). Abrasional niches are generally formed in unconsolidated deposits (Fig. 3 *C 81*), seldom on bedrocks (only when the structures is favourable) and are opened at an angle of 37—78°, with a height varying between 0.40 and 2.50 m and a depth reaching 1.50 m and even more; their formation cycle is relatively short and corresponds to the maximum level period. Abrasional kettle holes were signalized on the cliff at the confluence with the Pîrîu Mare brook. The cliff is carved in a friable microconglomerate sandstone with thin inserted layers of schistous marl-clays, which brought about an abrasional action differentiated by stratum surface. The differentiated evolution of these microforms is also illustrated by other examples (Fig. 4, II, III).

Subaquatic talus-creep. Mass movement processes of the talus-creep type occur, under subaquatic conditions, on the shores sloped at angles of 30 to 40°. These processes are characteristic of shores evolving on slopes with rock debris (such as the right slope of the reservoir between Secu and the dam, or the left slope between the Buba and Rotaru brooks, etc.). In these cases, abrasion has removed the fine material; a disequilibrium in the debris mass is induced, flowed by its shifting to the foot of the slope, below the variation limit of the reservoir water level. When the bedrock is altered or less consolidated, the material displaced from



Nr.t	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18
L (m)	2.80 / 0.32	0.80 / 0.42	1.90 / 0.80	0.80 / 0.75	1.50 / 0.54	1.50 / 1.0	0.45 / 0.32	0.82 / 0.92	0.33 / 0.67	1.00 / 2.30	0.30 / 0.40	1.60 / 0.40	0.55 / 0.35	0.55 / 0.45	0.50 / 0.80	1.20 / 0.65	1.00	0.60
∠ degrees	10 / 36	11 / 32	16 / 34	6 / 34	14 / 28	12 / 34	14 / 28	10 / 27	18 / 30	11 / 26	12 / 33	10 / 27	11 / 32	10 / 34	14 / 30	18 / 56	13	14
ϕ particoles (cm)	10-15	10	5-10	5-10	5 / 10	<2 / <4	<2	1.5 / 4	5-8	<1 / 1-3	R	1.5 ÷ 15	5 ÷ 15		5 ÷ 15	2-3 ÷ 10	3-4	3

Nr.t	T19	T20	T21	T22	T23	T24	25	26	T27	T28	T29	T30	T31	T32	T33	T34	35	T36
L (m)	0.35 / 0.50	0.35 / 0.25	1.45	0.40 / 0.55					0.75 / 0.50	0.40	0.70	1.20 / 0.55	0.90		1.50			
∠ degrees	18 / 56	14 / 31	13	14 / 32					18 / 56	12	12	10 / 26	12		6			
ϕ particoles (cm)	4	1-2	2-3	1-2	<2	<1	2	<1	3 ÷ 10	10	1-2 ÷ 10	3-4 / 10	2 ÷ 4	3-5	1-2 ÷ 4	<1	R	<2

Fig. 2. — Analysis model of a shore profile (I. Ichim, Maria Rădoane).

A. *Location.*
B. *Geomorphological profile of the shore:* 1, rough deluvial deposits (over 10 cm ∅ 2, black schists; 3, deposits displaced by wave action and water-stage variations: *a*, gravel of 5—10 cm ∅; *b*, sand and gravel; 4, "initial" profile contour.
C. *Level lowering rate over the period August 1, 1974—March 25, 1975:* 1, phases of decreased rate; 2, phases of relatively constant rates; 3, phases of increased rates.
D. *Distribution of mean daily wind velocities and frequencies at the Tunnel-Entrance meteorological station.*

the cliffs by abrasion is "feeding" the talus-creep (Fig. 3 *C 106*, *C 85*). The evolution stages of this process may be reconstituted taking into account the gravels wearing and the deposits sorting. These stages are more conspicuously pointed out by the talus-creep formed in gravel and proluvial deposits (Fig. 3 *C 81* and 3 *D*).

According to the granulometry of deposits, formation stages of terracettes may alternate with formation stages of talus-creep on shores with a declivity of 28 to 30° (Fig. 3 *C 68*). Such a phenomenon is frequently occurring in front of the terraces of the Bistriţa River between the Schitu and Bistricioara localities as well as in the area of the Hangu gulf. Details of the evolution of this process are given in figure 3*D*. The slow movement of blocks (up to several cubic metres) is also ranked among the creep forms.

Abrasion-accumulation terracettes. A terracette microrelief is found within the water-stage variation limits, on slopes at angles of 10 — 30°. Their number and morphometrical characteristics (length, height, top declivity) vary within very wide limits in relation to slope, granulometry of deposits (shores made of deluvial and gravel deposits with a diameter larger than 10 — 15 cm are not favorable to the formation of these terracettes), wave height, etc.

These microforms are ephemeral stages of the transport of deposits displaced by abrasion and are giving an idea of the general retreat rate of the shore belt subject to the abrassion process. It is a type of discontinuous transport, generally called "transport in succession".

The following conclusions could be drawn after studying the terracettes :

— variations of the reservoir water level, waves, slopes with a declivity of 10 — 30° and granulometry of deposits of less than 10 — 15 cm are favourable to terracette formation ;

— the existence of one or two of the mentioned factors is not enough for the terracette formation ; this is proved by the fact that on the same slopes but under different lithologic conditions, their number and characteristics vary widely ;

— the different levels of terracettes have no continuity along the shore (even under conditions of similar slopes and lithology) they are converging or diverging, as an effect of seiches ;

— the average length of the top of terracettes varies between 0.65 and 3.1. m on the analysed profiles, but may reach at the most 7 m ;

— the top inclination varies, on average, between 10 and 15° and has extreme values of 8 — 30° ;

— height varies, on average, between 0.40 and 1.90 m, reaching 5 m at the most (terracettes formed in gravels) ;

— the mean volume of deposits accumulated at each terracette level (per one metre of shore) is of about 0.90 m^3, which is evincive of an important transfer of deposits to the foot of the slope ;

— an alternation of rougher and finer deposits was noted in the terracette structure ; sometimes, along the same shore profile, terracettes of fine deposits alternated with terracettes of rougher structure (Fig. 2) ;

this phenomenon points to the existence of a "transport in succession", due to the waves action and to the general level lowering in the reservoir;

— a cross-bedding of deposits was noted in terracettes of fine deposits (Fig. 3 *C 66*), emphasizing the fact that part of the deposits are accumulated in the phase of level lowering when the detachment of terracettes also occurs whereas the other part of the deposits are accumulated in the phase of level rising.

The dynamic state of these forms is their main characteristic and is expressed both in the structure of deposits (especially those reaching the foot of slopes (Fig. 3 *C 99*)) and in the change of morphometric traits. In this respect, the aspect of a profile gradually arisen in 1975 and 1976 (Fig. 3 *C 66*) is illustrative.

Beaches and bars. As the Izvoru Muntelui Reservoir has deep waters and very slanted slopes, the processes of beach and bar formation play a relatively insignificant role in the shore morphology. They however develop on slopes slanted at angles lower that 10°, in the area of former colluvio-proluvial glacises. Deposits accumulated in the beach are not very thick (less than 20 cm). On most beaches, bars long of up to 120 — 150 m may be found, with an asymmetric profile (Fig. 3 *C 99*), a maximum width of 1.5—3 m and heights of up to 0.60 m. The length of bars increases to the foot of the shore-belt which is subject to water-stage variations.

Other shore processes. Within the limits of the shore belt temporarily in emersion sheet erosion and accumulation of deposits due to rain-wash occur. The process is amplified on shores made up of fine deposits and we found that during one emersion phase, erosion has removed to the reservoir up to 0.250 — 0.300 m^3/m^2 of deposits. A significant share is held by landslides; over the past years, an increase in these processes was noted, especially on the left shore.

Under the conditions of thick deluvial deposits, the water-stage variations and the very existence of the reservoir have determined major changes in the equilibrium of slopes. The action of the slope processes, also generated by other factors, extended to the reservoir area and determined a specific micromorphology (Fig. 3 *C 68*). An important mass transfer occurs from the slope to the reservoir. The Huiduman — Hangu area is typical from this point of view.

The problem of small valleys in the area temporarily flooded by the reservoir waters. The shore belt alternatively in submersion or emersion is sometimes larger than 100 m. Within this framework the evolution of many smaller valleys is integrated in the general processes of shore morphogenesis. A differentiation may be done between:

a) the evolution of torrential valleys with a general trend of bottom rising, due both to deposits displaced by abrasion and to deposits carried by longitudinal transport (Fig. 3 *E*);

b) the evolution of slope valleys, with a general trend of slopes retreat and of interfluve destruction due exclusively to abrasion (Fig. 3 *G*);

c) the formation of vallons of selective abrasion under the conditions of shores modelled on vertically disposed strata (Fig. 3 *F*) and even the formation of small valleys; the latter's evolution is characterized by several elements worth mentioning. In the abrasion process, there is a quicker shore retreat on the intercalations of soft rocks; the wide amplitude of the water-stage variations in the reservoir leads to the extension of shore irregularities along the whole level difference of the shore belt; an uneven level perpendicular to the shore is formed with all the elements of a slope valley; in a further phase of the abrasion action the cliff in soft rocks is undermined, landslides occur and the valley is partly filled with slide deluvial deposits (Fig. 3 *F*).

The shore evolution rate. On the basis of measurements made on 135 shore profiles under quite distinct evolution conditions, we were able to calculate the main dynamic elements of the shore indicated in figure 4 (the volume of displaced deposits per metre of shore and the shore retreat, in metres). The volume of deposits was estimated for the maximum level phase. The dislocated deposits inferior to the maximum level, although reaching an average thickness of 0.90 m for the whole width of the shore belt, are considered a mass transfer within the framework of the same morphogenetic environment (subaquatic environment). Abrasion at maximum levels influences to a considerable extent the transformation of the shore, also manifesting itself in the change of the general surface of the reservoir. In this respect, it is estimated that up to now, over 200,000 m^3 of deposits have entered the reservoir, increasing its surface by 17 – 18 ha. The most important shore modification was recorded at Chirițeni – Hangu (about 160 m^3/m of shore), where the cliff evolves on sandy silts deposits. It may be concluded that the evolution of the reservoir shores has not reached yet a morphodynamic equilibrium; the remarkable reactivation of the mass movement processes on the slope implies that even more spectacular processes are likely to occur.

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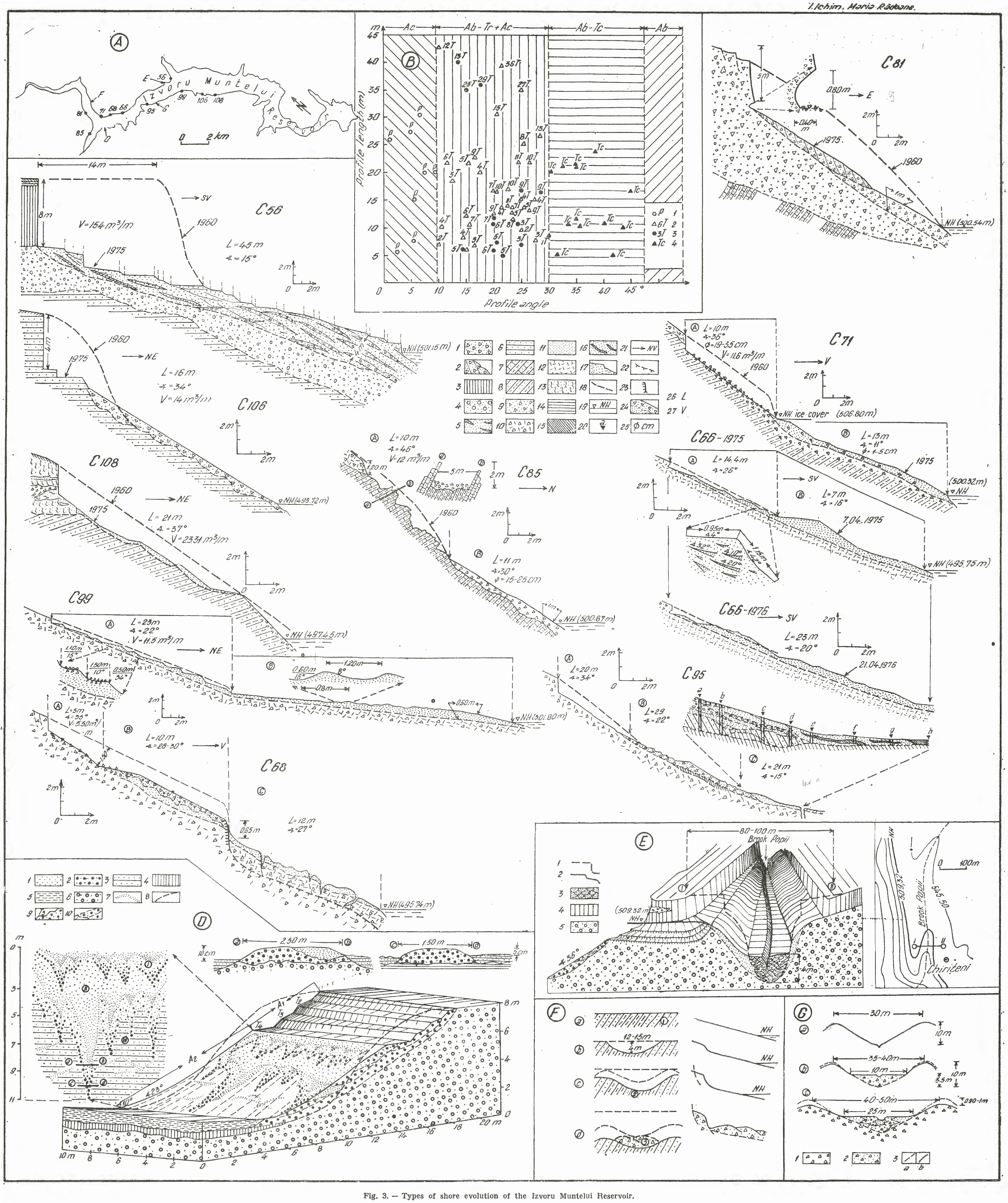

Fig. 3. — Types of shore evolution of the Izvoru Muntelui Reservoir.

A. *Location of exemplified profiles.*

B. *Relationships between shore processes, declivity, length and lithology structure of shores:* Ab, abrasion; Ab—Tc, abrasion and talus-creep; Ab—Tr—Ac, abrasion, "transport in succession" (terracettes) and accumulation; Ac, accumulation; *1*, beach; *2*, number of terracettes and profiles made up of alluvial deposits; *3*, talus-creep profile.

C. *Types of shores: C 56*, cliff in sandy silts and abrasion-accumulation terracettes; *C 81*, cliff in proluvial deposits and talus-creep lobes; *C 106*, cliff in bedrocks and structural terracettes; *C 108*, cliff in unconsolidated deposits and structural terracettes; C 71, cliff, talus-creep (A) and terracettes attenuated by sliding of floating ice (B); *C 85*, mixed cliff, selective abrasion vallons (A, a—b) and talus-creep (B); *C 99*, abrasion-accumulation terracettes (A) and bars (B); *C 68*, talus-creep (A), terracettes "buried" by talus-creep (B) and terracettes deformed by landslides (C); *C 66*, modifications in the morphology of a shore profile during a yearly cycle of water-stage variations; *C 95*, detail in the accumulation structure at the foot of a profile with terracettes: talus-creep (A), abrasion-accumulation terracettes (B), bars (C): *1*, proluvial deposits; *2*, talus-creep lobes; *3*, sandy silts; *4*, gravels; *5*, stratified sands; *6*, sandstones; *7—8*, alternation of calcareous sandstone and schistose marls; *9*, sandy deluvial deposits with angular fragments; *10*, rough deluvial deposits; *11*, sands; *12*, sandy deluvial deposits; *13*, clay slope deluvial deposits; *14*, sandy clay; *15*, soil; *16*, intercalations of sand and clay; *17*, abrasion-accumulation terracettes; *18*, "initial" contour of the shore profile; *19*, water level in the reservoir; *20*, drilling points; *21* profile exposition; *22*, sliding plane; *23*, sliding cornice; *24*, evolution phase of terracettes expressed by the deposit structure: *a*, terracette phase; *b*, talus-creep phase; *25*, granulometry of deposits; *26*, profile length (m); *27*, volume of deposits displaced from the shore (m³/m of shore).

D. *Shore with abrasion-accumulation terracettes* (A_1) *and talus-creep* (A_2): *1*, fine sands; *2*, gravels stratified by the talus-creep action; *3*, sediments of sand in the shore area; *4*, soil; *5*, sandy clay; *6*, alluvial deposits (gravels); *7*, "wave" of sediments accumulated by sliding of floating ice; *8*, "initial" profile contour; *9*, abrasion-accumulation terracettes; *10* talus-creep (lobes); *I—III*, generations of talus-creep.

E. *Evolution of an elementary valley in the area of water-stage variations*: *1*, "initial" profile; *2*, present profile; *3*, sandy deposits with cross-bedding; *4*, sandy silts; *5*, gravels.

F. *Formation and evolution of selective abrasion vallons*: *a*, "initial" surface of the slope; *b—c*, formation and deepening of an elemtary valley by selective abrasion; *d*, sliding triggered in the superior part of the shore belt and "burial" of the elementary valley with deluvial deposits; *1*, sandstone; *2*, marl-clay; *3*, deluvial deposits.

G. *Evolution of an elementary valley in the area with waterstage variations.* Under the conditions of a relatively homogeneous lithology, there is a trend of "destroying" elementary slope valley subject to abrasion: on the one hand, there is a gradual reduction of interfluve (by abrasion) and on the other hand, a rising of their bottom by accumulation (*a*, *b*, *c*): *1*, deluvial deposits in which the elementary valley is carved; *2*, deposits accumulated in the abrasional process and in the littoral transport; *3*, *a*, "initial" profile; *b*, profile formed by abrasion.

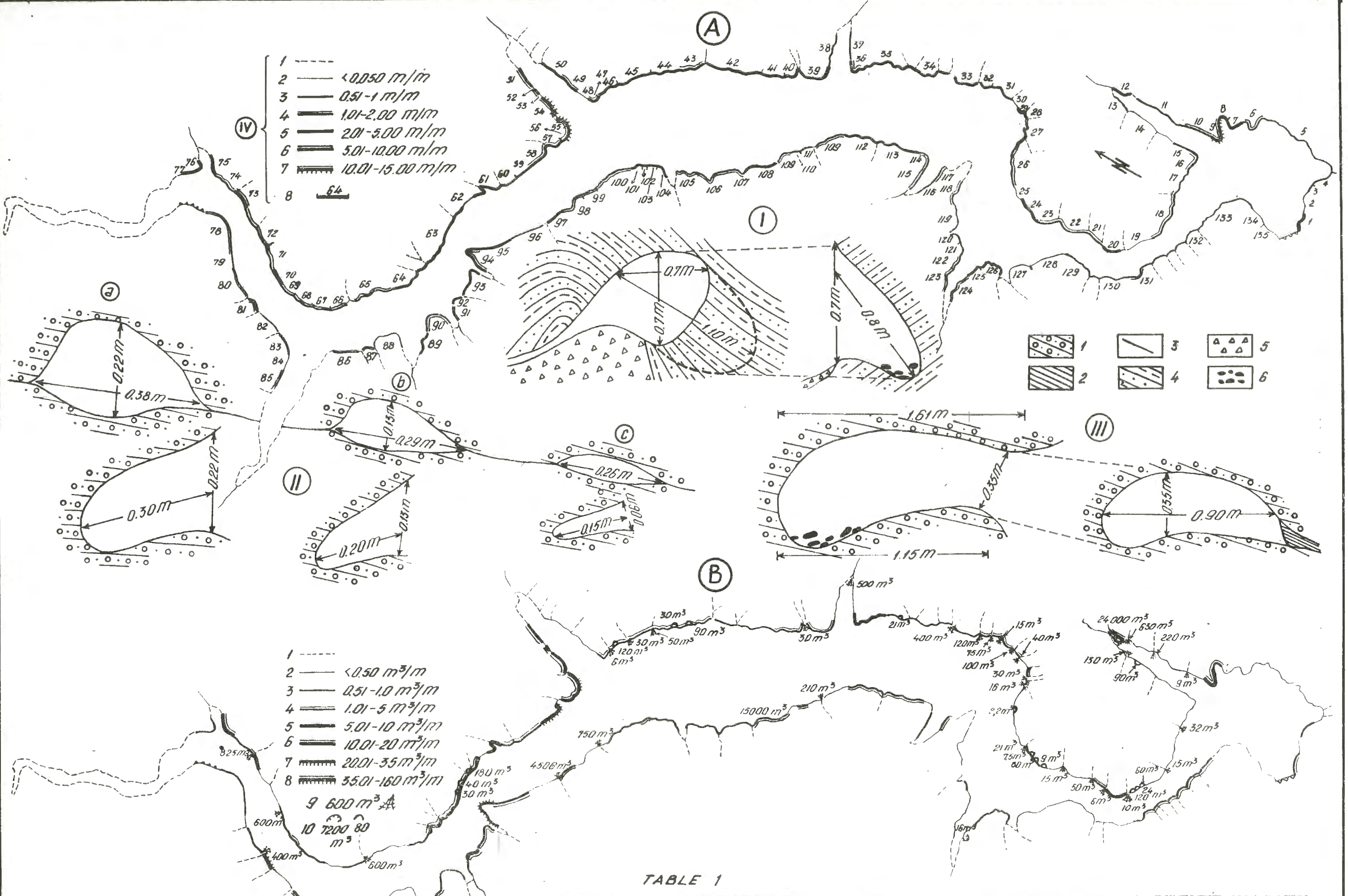

TABLE 1

1	No. of section	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
2	V. (m³/m)	2.079	0.015	0.69	0.75	0.169	0.297	0.42	1.26	16.26	0.25	0.10	20.0	0.08	0.07	0.08	0.15	0.24	0.462	0.30	8.44	1.18	0.166	0.27	0.83	0.02	0.35	2.57	0.41
3	L. (m/m)	2.31	0.30	1.83	0.60	0.97	1.70	2.10	3.60	10.1	1.01	0.99	4.0	0.54	0.47	0.54	1.1	0.98	1.85	0.30	2.41	1.89	1.11	0.90	2.20	0.34	1.48	3.68	1.73

1	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
2	1.665	0.112	1.21	2.06	0.913	0.969	8.325	9.5	0.117	0.114	2.36	4.05	2.551	0.877	2.91	1.45	1.2	1.88	4.66	0.07	0.27	0.14	16.2	0.13	0.06	11.27	13.0	159.5	12.43	33.94	4.02	2.74	7.03	0.112	12.07	0.84	0.32
3	3.51	0.90	2.58	3.30	2.15	2.73	7.40	9.5	0.86	0.67	4.06	4.36	3.29	2.81	6.70	3.34	4.00	3.40	6.66	0.69	1.37	0.70	6.20	0.65	0.49	11.5	4.0	14.5	6.72	3.75	3.35	3.45	5.10	0.75	5.75	2.10	1.30

1	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113
2	0.62	0.497	0.68	0.58	1.26	0.87	0.36	2.14	0.54	13.65	0.56	0.74	0.88	0.20	0.76	24.2	0.107	1.595	0.063	0.72	4.94	0.66	0.22	1.89	0.90	0.90	17.6	1.68	24.0	1.26	0.075	2.43	0.48	0.30	0.95	1.68	0.945	102.0	0.55	0.95	0.55	0.716	4.60	0.32	1.37	0.27	1.20	2.28
3	1.56	1.42	1.70	1.45	3.40	1.50	1.80	5.62	1.80	3.50	1.40	2.00	1.60	1.00	1.70	4.40	0.75	2.90	0.42	1.20	4.30	1.90	0.90	2.70	2.00	2.00	2.20	4.20	6.00	2.10	0.50	2.80	1.60	1.20	1.90	4.20	2.10	1.70	2.20	1.90	1.50	1.70	4.60	1.60	2.50	1.00	3.0	3.8

1	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	9'	55'	56'	59'	70'	78'	86'
2	0.375	0.579	0.170	1.071	0.17	0.041	0.55	0.11	0.45	0.375	0.438	0.61	0.65	0.075	0.018	0.041	0.06	0.80	0.06	0.167	0.008	0.018	8.05	12.0	16.43	0.90	0.80	16.5	3.64
3	1.50	1.93	0.89	1.53	1.11	0.55	0.88	0.88	1.80	1.40	1.46	2.04	2.20	0.50	0.25	0.55	0.53	1.60	0.54	0.92	0.17	0.37	4.60	6.86	3.10	2.0	1.6	11.0	1.3

Fig. 4. — The Izvoru Muntelui Reservoir. Shore transformation over the 1960 — 1975 period.

A. *Value of shore retreat (in m/m. of shore)*: *I—III*, sections in abrasional kettle holes (*II — a, b, c*, abrasional structural kettle holes, according to Maria Rădoane, 1976); *1*, microconglomerate sandstone; *2*, clay schists; *3*, diaclases; *4*, marl-limestone; *5*, deluvial deposits; *6*, gravels from abrasion of kettle holes walls; *IV. 1*, accumulation shore; *2, 3, 4, 5, 6, 7*, mean values of shore retreat; *8*, location of analysed profiles, corresponding to those in table 1 of this figure (table: *1*, number of analysed profile; *2*, volume of displaced deposits, m³/m. of shore; *3*, shore retreat length, m/m of shore).

B. *Average volume of deposits displaced from the shore* (m³/m) and entered in the reservoir in the phases of maximum level: *1*, accumulation shore; *2, 3, 4, 5, 6, 7, 8*, mean volume values of displaced deposits (numbers of profiles correspond to those in table 1); *9*, alluvial fans accumulated over the period 1974—1975; *10*, lanslides.