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DEEP SUBMARINE EROSION IN TURBIDITE SEQUENCES CENTRAL-CARPATHIAN FLYSCH, LEVOČSKÉ POHORIE Mts.

(Figs. 1—9)

Abstract: The present article gives proofs about the fact, that in certain conditions, turbidity currents cut into formerly deposited beds. The erosive channel was deepened as low as the floor by quick currents in the first phase, and then gradually filled-up.

Turbidity currents filling-up the channel, were not able to erode in depth, they only modified the walls of the channel.

The formation of an erosive channel is connected with a sudden tectonic uplift of the floor and with the changes of palaeoslope in marginal facies of a Flysch basin.

Резюме: В статье приводятся доказательства того, что турбидные течения при определенных условиях врезываются в ранее уложенные слои (турбидитов). Возникающие эррозионные каналы были в первой фазе быстрыми течениями углубленны на дне, а только потом постепенно заполненны. Турбидные течения, которые заполняли канал не были в состоянии производить эрозию вглубь, они только модифицировали боковые стены канала. Возникновение канала зависит от мгновенного тектонического поднятия и связано с изменениями палеосклона в краевых фациях флишевого бассейна.

Introduction

It used to be generally accepted, that turbidity currents only transported sediments over flat submarine fans without being able to cut down into formely deposited beds and to form wide channels there. Numerous channels in turbidity formations contradict the opinion. Although the nature of turbidity currents has not been determined as yet, still it seems that in some conditions quick currents erode as long as to reach the profile of equilibrium. Our research shows that erosive channels — even if they cannot be traced all over the area of their extension — continue as far from the margin of a source zone as to the places with gentle slope of the floor. Channel-cutting was not only related to the nature of turbidity currents but also to synsedimentary movements of the mobile bottom of a Flysch basin, controlling the uplift of an erosion basis.

The Rocks in Which a Channel is Deepened

The erosion channel is exposed in turbidites of the so-called sandstone Flysch in Levočské pohorie Mts., cca 1 km to the E of the town Levoča. Sandstone Flysch represents there an approximate equivalent of the so-called proximal facies. The Flysch is composed of thick beds of graded-bedded coarse-grained and structureless sandstones with a small amount of traction structures in the top. Partings of sandy claystones are thin or eroded down. Due to this amalgamted graded beds occur. In some places claystone fragments may be found with globigerinal and benthonic (dendrophrya)

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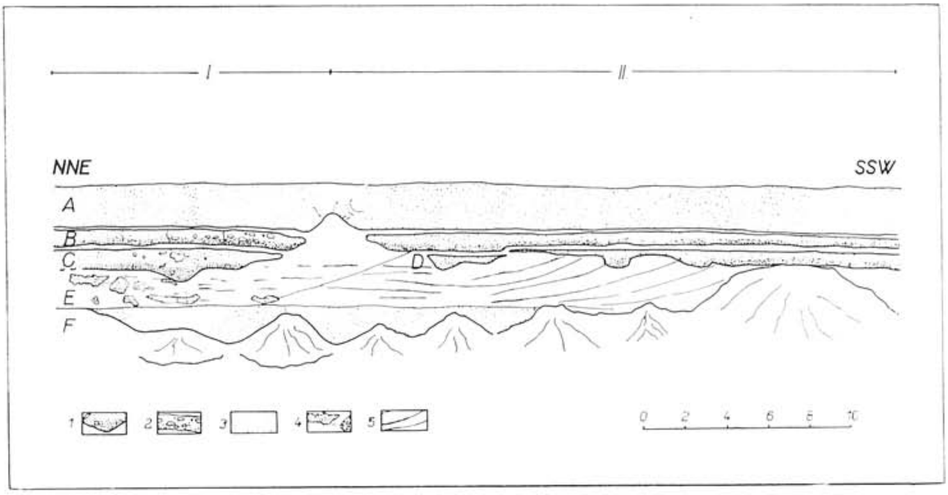

Fig. 1. A. Schematic outline of erosive channel. A channel is 40 m wide, extending to SSN (40 m) divided into two partial downcuts with particular sedimentary filling-up. 1 — graded-bedded coarse-grained sandstones; 2 — angular and rounded claystone fragments; 3 — structureless coarse-grained and medium-grained sandstone; 4 — sandstone blocks deformed in silty-claystone matrix; 5 — a deformed bed of silty claystones as a component part of a coherent submarine slump.

microfauna. According to O. Samuel (1965) the zone of *Globigerina officinalis* Subbotina predominates and belongs to Upper Eocene. Westwards the sandstone Flysch passes facially into turbidite series with greater claystone amount. Palaeogeographic reconstructions of R. Marschalko (1968) proved the transport direction in turbidites of sandstone Flysch from SE to NW and W, in some places from NE to SWW and W. Owing to this, the basin deepens and the slope becomes more gentle in westward direction.

Erosive Channel with Sedimentary Filling

Along the whole quarry wall (Fig. 1, 2) the channel is exposed to the smallest details. It is divided into two not too deep cuts (4 m deep), with their axes perpendicular to the quarry wall. The basis of the cahnnel is irregularly cut in silty claystones (Fig. 1 E), with fractured and deformed sandstone sheets (Fig. 3) displaying directions. In the centre of the quarry (Fig. 1 E — I) silty claystones form a monolitic block displaying deformation along the dip at the higher angle of laminae. On the extreme right side of the quarry the block passes into sedimentary slump deposits with angular fragments of light claystones. Fragments of silty claystones and deformed sandstones represent a component part of a partly coherent slump. The slump movements have not deformed the underlying graded-bedded sandstone including lamination and convolution (Fig. 1-F I), although this could have been expected when supposing a collapse of steep walls upon the graded bed F. We still do know whether (or not), the bed F forms the filling of a wider submarine channel, so we may suppose that the slump deposits (E) form the basis for channel-cutting.

Detaily traced sedimentary channel—filling shows that the beds of the left partial channel cannot be correlated with that of the right one. On the left side the lowest part (the bed I-C) is filled with graded- bedded coarse-grained sandstone with sharpedged fragments (70 cm) of angular claystones predominantly, on the top (Fig. 4). The channel was downcut into the underlying silty claystones (E) with 35—40° angle, extending laterally and forming channel terraces. The lowest part of the downcut (channel axis) had W 290 E striking. On the steps of the cut-walls there were toolmarkings exposed. The beds of sandy claystones (4 cm) and laminated siltstone (6 cm) in the top indicate fading-out current activity. The revival of the activity is proved by a coarse-grained graded bed (Fig. 1 B) with abudant rounded claystone fragments. In the top there are thin traction structures. On the bottom there are groove casts and on the contact with the channel-wall — inconspicuous scour marks.

The right partial channed display a different sedimentary filling (Fig. 5). In the bottom part it consists of graded-bedded, well sorted medium-grained sandstones (Fig. 1 — D II) with groove casts and prod casts. The channel-axis is of W 290 N striking. To the right, on a thin claystone parting, developed gradually a graded bed (II C) with unusually thick groove casts and erosive (?) arcuate cuttings (Fig. 6, 7). On the extreme right side of the quarry, the bed gradually acquires constant thickness and regular striking. On the top there are traction structures composed of a series of silt laminae (3 cm). Although the bed thickness is changed in space, the unusually thick sole markings indicate that the quick current has only left a parts of its load on this place. A short duration of the smaller current activity is indicated by a claystone bed, intensely affected by bioturbation (Fig. 8). Approximately in the same level

Fig. 2. Erosive channel: 2 partial downcuttings and turbidite filling-up. Photo B. M a r s c h a l k o.

Fig. 3. Deformed sheets of sandstone with irregular protrusions on indicating the forming in plastic stage. Photo R. M a r s c h a l k o.

Fig. 4. The left partial channel cutting, in the basal slump. Filled with graded-bedded sanstone. In the middle and on the top remains of claystone framents. Photo R. M a r-s c h a l k o.

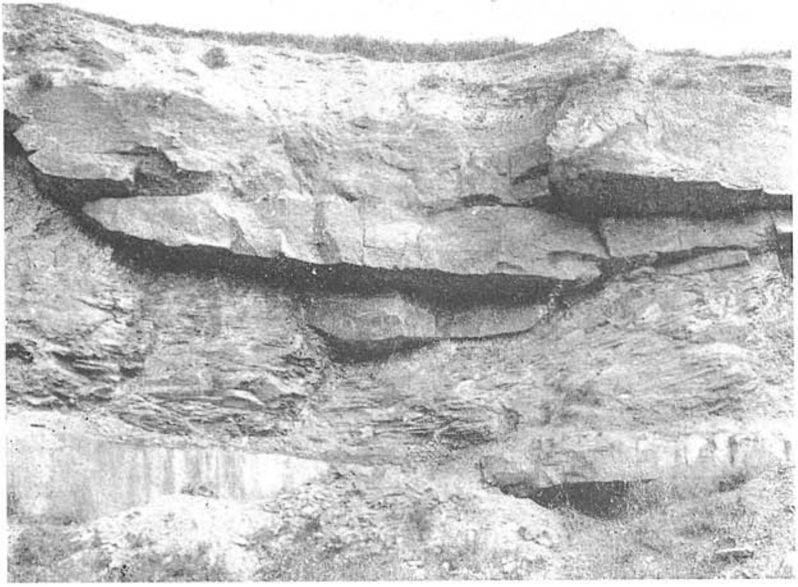

Fig. 5. The right partial channel cut in a block of silty claystone with deformed laminae. The first downcutting current filled the channel only on the basis (bed II D). The next downcutting is represented by a thin bed on he right (II C). Photo R. M a r s c h a l k o

Fig. 6. Cross-section through an extensive groove cast(?). On the basis — conspicuous graded bedding. Photo R. M a r s c h a l k o.

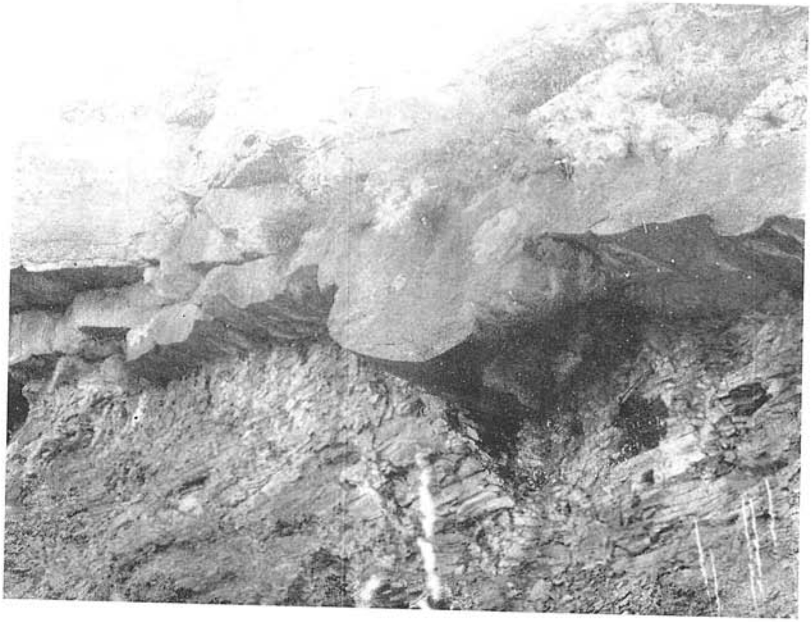

Fig. 7. Giant scour marks(?) of arcuate cross section and smaller groove casts cut in a declined slump sheet. Photo R. M a r s c h a l k o.

Fig. 8. Organic marks on the basis of the bed II B indicating the stage of quiet evolution of the channel. Photo R. M a r s c h a l k o.

as in the left part, there is a graded bed (B — II) with a set of current-ripple lamination. Both partial channels are filled with massive structureless, coarse-grained sandstone with inconspicuous scour marks (Fig. 1, A).

The Process of Cut and Fill of a Channel

The channel-orientations could not be traced, since they were exposed perpendicularly to the direction of filling, keeping the cutting direction only on 1—2 m distance. Still it seems that the orientation of terraced walls and of the axis of basal cutting are widely correlated with sole-markings on the beds of filling. Measurements show that the currents filling a channel are of SE—NW and NWW course (cf. Fig. 9). The analysis of groove and prod casts shows that the currents filling a channel, have only a traction carpet. Erosive scour marks on higher levels of the same beds indicate that in the higher levels of the flow the traction carpet is absent and the flow has a turbulent scouring character. By this fact S. Dżułyński and I. E. Sanders' (1962) scheme of the composition of turbidity currents is supported. In this scheme the overlying turbulent flow of a fluid impels the traction carpet. Still in 1966 R. G. Walker emphasized that fully loaden turbidity current with well-developed traction carpet were not effective in eroding. Then the currents filling a channel may only modify the channel walls into terraced cuttings. They are, naturally, different from those cutting deep and wide channels. The velocity and eroding ability of the latter are partly documented by larg angular blocks of claystones transported not far from the place of erosion and deposited on the channel floor.

Two main erosion phases may be distinguished: in the first phase channels were cut-down to the deepest bottom. In the second phase only the walls of channels were modelled by turbidity currents passing and filling the channel. Velocities of these currents were different. Deep scouring and giant groove casts on the basis of unequally thick graded bed indicated unusually quick turbidity current which deposited a small part of its load on this place. The absence of traction structures means that the top part of turbidity currents with fine-grained material passed downward the channel. Unequal erosion and different filling-up in both channels and the absence of continuous sand

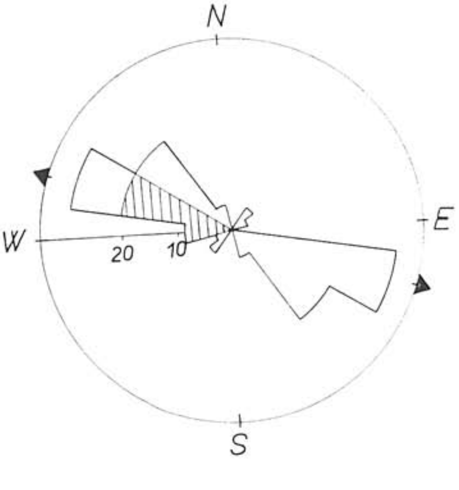

Fig. 9. Current-rose diagram, with marked axes and sole markings on turbidites. Separately marked scour marks, groove casts. Conspicuous correlation of sole markings and of the axes of basal downcutting.

filling up to the top, testify that erosion is not necessarily followed by deposition and that downcutting passed in several phases. We may suppose that cascade channelwalls were repeatedly modified before acquiring their present form filling pattern.

The Origin of a Channel and Its Palaeogeographic Importance

The channel is filled-up with the facies of equal composition as the neighbouring turbidite sequences. This is only possible when erosive ability of downcutting currents is greater than that of the currents depositing the sequences which the channel was cut in. Downcutting takes place in a zone which is in a greater distance from the margin, i. e. approximately in the middle of the distal zone of a submarine fan with formerly predominating deposition and a gentle slope. Now a question may arise: whether downcutting may pass below the erosion level of turbidite currents. The authors suppose that the flows may acquire the velocity inevitable for submarine erosion only after a sudden uplift of erosion level. This may be compared with deep submarine valleys on the western coast of California (F. P. Shepard, E. C. Buffington 1968), representing distal extensions of submarine canyons on submarine fans. In our case the relation of the channel to the submarine valley mapped by R. Marschalko (1964) in marginal facies, was not traced on such a distance (30 km). Still the turbidity currents — as well as in recent cases — were erosively effective only if their current velocity was controlled by slope. One of the most decisive causes is probably in sudden changes due ot tectonic uplift in mobile marginal zones. In SE marginal zone (R. Marschalko 1964) were three important uplifts of the source followed by influx of clastic material forming different gradients and mobilizating anew the erosion levels in connection with displacement and formation of new submarine channels. Turbidity currents flowing down the channels descend to distal zones and create a new profile of equilibrium. This may serve as an explanation of greater thicknesses of the sandstone Flysch in Levočské hory Mts. in comparison with equivalent marginal facies.

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REFERENCES

Dżulyński S., Sanders J. E., 1962: Current marks on firm mud bottoms trans. Conn. Acad. Arts Sci. 42. — Marschalko R., 1964: Sedimentary structures and paleocurrents in the marginal lithofacies of the Central Carpathian flysch. In A. H. Bouma and A. Brouwer (Editors), Turbidites, Elsevier Amsterdam. — Marschalko R., 1968: Facies distribution, paleocurrents and paleotectonics of the Paleogene of Central West-Carpathian flysch. Geol. zbor. Slov. akad. vied, 19, 1, Bratislava. — Samuel O., 1965: Die Zonengliederung des Westkarpatischen Paläogene auf Grund der Planktonischen Foraminiferen. Geol. Práce, Zprávy 37, Bratislava. — Shepard F. P., Buffington E. C., 1968: La Jolla submarine fan-valley. Marine Geology 6. — Walker H. G., 1966: Deep channels in turbidite-bearing formations. Am. Assoc. Petroleum Geolog. Bull. 50, 9.

Review by T. Koráb.