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Detrital Analysis of the Paleogene flysch deposits of the Levoča Mts.: evidence for sources and paleogeography

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Abstract. Detrital composition of the deep-sea fan deposits of the Levoča Mts. reflects a collision-orogen provenances. In the perisutural part of the basin (Šambron-Kamenica Zone), the flysch formations are significantly enriched with ophiolitic detritus. They even contain sandstones with high proportion of detrital serpentinites, glassy clasts and spinel grains. Petrofacial composition of serpentinic sandstones ($Q_{25}F_8L_{67}$, Lv = 62%) falls to the field of magmatic-arc related arenites (DICKINSON et al., 1983) or oceanic-arc related arenites (VALLONI, 1985). Ultramafic sources are also evidenced by saponitic or corrensitic clay cementation as well as by high Cr and Ni concentrations in mudrocks. Higher up the source lithology of deep-sea fans was significantly changed. Compositional change is recorded by high amount of plutonic, metamorphic and volcanic detritus ($Q_{61}F_{15}L_{24}$), which suggests the recycled-orogen provenance. Temporal evolution of detrital modes from ophiolithic- and carbonate-rich petrofacies to plutoni-metamorphiclastic sandstones reflects progressive exhumation of crystalline basement rocks in the source area of the deep-sea fans.

Key words: Central Carpathian Paleogene, deep-sea fans, sandstone petrofacies, provenance, source lithologies

Introduction

The study of detritus from flysch formations provides important information on the composition and activity of sources and thus on the general paleogeography of basins. For the identification of sources in the Central Carpathian Paleogene of the Levočské vrchy Mts., information has been obtained especially from the analysis of pebble composition of conglomerates, petrofacial analyses of arenites, the composition of heavy mineral associations and the study of alteration of lithic components to clay minerals.

An outline of the paleogeography of the Central Carpathian Paleogene of the Levočské vrchy Mts.

The Levočské vrchy Mts. are a part of the Spiš-Šariš Basin, which does not have a uniform paleogeographic development. The basin shows an asymmetric bottom configuration due to trenchward tilting (Šambron Depression) and oblique antithetic faulting (Poprad Depression). Both depressions are structures of intensive Upper Eocene subsidence, in which the thickness of the sedimentary infill increases up to 3500 m. The Šambron Zone and the Poprad Depression display the Podhale-type of Upper Eocene sedimentation, in the development of Šambron Beds (=Szaflar Beds). The Šambron Beds are formed of dark shaly claystones and thin-rhythmic flysch, with thick intraformational bodies of conglomerates and breccias. The continuity of the Šambron Zone with the Podhale Paleogene is also documented by the polar variation of the paleocurrent directions, the main one from the E and the opposite from the W.

The central part of the Levočské vrchy Mts. and the Hornád Depression was overlapped by transgression probably only in the Lower Oligocene (the nummulite base is missing). Marine transgression progressed here through flat approns of alluvial deposits (Kluknava Beds). Transgressive lithofacies is represented here by the Tomášovce Beds, containing a fauna of gastropods, bivalvians (Gryphaea) and foraminifers (*Heterostegina*-type forms). The transgressive formations are covered by a claystone lithofacies, which equalised the sedimentation in the whole basin. The sedimentation of claystones, laminated mudstones and muddy turbidites led to the undersaturation of the basin (underfilled basin - PITMAN and ANDREW, 1985). The claystone lithofacies represents actually the Lower Oligocene sub-flysch, which is the presage of a powerful onset of deep-sea fan sedimentation.

The Upper Oligocene cycle of the development of the Spiš-Šariš Basin is characterized by sedimentation in the deep-sea fan environment (MARSCHALKO, 1981). In this time, the basin had a transparent paleocurrent system coming from the east of the Šarišská vrchovina Hills (the entrance of a submarine valley) to the west and northwest (MARSCHALKO, 1966). The deposition system of the basin had developed all parts of the deep-sea fan zones, according to the model of MUTTI and RICCI-LUCCHI (1972). The slope of the deep-sea fan occupies the area of the Šarišská vrchovina Hills and the eastern margin of the

Levočské vrchy Mts. The slope and channel facies are formed of thick conglomerates and chaotic slump bodies (associations F and A), surrounded by levee sandstone facies. Towards the Levočské vrchy Mts., the cone passes into a system of depositional lobes. The covering of the claystone lithofacies by prograding lobes is gradual. Transitional formations above the sub-flysch have the character of medium-rhythmical flysch sequences and they contain already Egerian nanoplankton communities. The structure of the lobes is characterised by upward-thickening flysch sequences, beginning with claystones and thin-rhythmical flysch sediments (associations E and D) and ending with turbidite sandstones (association C) and channelized sandstones (association B). However, accumulation of sand in the depositional lobes became gradually uncompensated with rate of subsidence. Therefore, the lobe systems were growing up into an elevated ramp with a convex-upward relief, which alleviated the dip slope of cone. Due to this cone geometry, the dense cohesive currents were not able to pass into turbulence. From these non-turbulent currents, the top sandstone lithosomes of the Levočské vrchy Mts. were deposited, representing the final stage of the development of deep-sea cone, referred to as "suprafan" (NORMARK, 1970).

The lower part of the deep-sea fan occures in the Poprad Depression and the near-klippen area. The Upper Oligocene flysch has distal character in these areas, documented by the non-cyclic structure of fringe lobes (Ke¾marok Beds), thin-rhythmical to laminated development of turbidites and basinal facies of claystone lithology. With progressive progradation of cone in the stage of "suprafan" development these distal zones were in some places also overlapped by active fronts of sandstone lobes.

Sources of flysch detritus

The sources of flysch detritus in the Paleogene of the Spiš-Šarišarea exhibit different activity and composition. In the Eocene, the most active sources worked during the accumulation of conglomerates and breccias in the thick intraformational bodies of the Šambron Beds. Their material is composed predominantly of Mesozoic carbonates of Central Carpathian units, differently in the Plavnica area (predominant dolomites) and Lipany area (prevalence of Upper Jurassic - Lower Cretaceous pelagic limestones). In the arenite component of breccias, there are however abundant fragments of basic volcanites (the borehole Šambron PU -1) and in the Lipany area also ultramafics (Lipany-6). The presence of volcanoclastic material in the breccias is reflected also in the specific character of their matrix. The breccias are characterised by greenish colour, caused by the presence of smectite (saponite) and mixed-layer chlorite/smectite (corrensite). These minerals appear as fibrous aggregates, formed by diagenetic alteration and recrystallization of protomatrix. Chloritization of smectite took place in environments with high Mg (and/or Fe) concentrations. In the case of Šambron Bed breccias, the source of Mg may be inferred from the abundance of mafic detrital material. The greenish breccias with smectite and corrensite occur in the borehole Šambron PU-1 (1480 - 2000 m) and in the Lipany area especially in the borehole Lipany-6 (2328 - 2430 m). It is however noteworthy that identical breccias were found also in the Poprad Depression near Toporec (samples from hydrogeological boreholes). We stress the presence of smectite and corrensite also in view of their importance for the determination of the fluid and pressure regime in the intraformational bodies. The intraformational breccias occur in claystone formations with high degree of postsedimentary alteration (ordered R3 mixed-layer illite/smectite, estimated temperature about 170°C; POLLASTRO, 1993). However, in the intraformational breccias persistence of highly expandable clay minerals indicates a considerably lower temperatures of post-sedimentary alteration (T<100°C). The slowing-down of diagenetic processes is characteristic of a rock environment with fluid overpressure (JABOYEDOFF and JEANBOURQUIN, 1995). From this viewpoint, the diagenetic system in the intraformational breccia bodies, which are the best colector rocks in the Central Carpathian Paleogene of Levočské vrchy Mts. (RUDINEC, 1992), was originally overpressured.

In the surface structure of the Šambron Zone, the composition of conglomerates is partly different. Besides carbonates of the Central Carpathian units, the pebble material also contains substantional amounts of granitoids and crystalline rocks (gneisses, micaschists, amphibolites, quartzites, etc.). However, specific components of the conglomerates are folded dark phyllites, calcareous phyllites and marbles, reminding of rocks from the Iňačovce-Kričevo Unit. The presence of breccias and conglomerates in intraformational bodies of the Šambron Zone indicates that besides axial currents (E-W) there existed also a lateral input of coarse-grained detritus. The source of detritus is inferred in fault-bound and seismotectonically strongly active slopes of basin. The accumulated scarp sediments slipped into the basin and, propelled by gravitation, entered the calm environment of pelitic and turbiditic sedimentation of the Šambron Beds (gravity mass movement). It is probable that the source of this detritus were the slopes of the active Central Carpathian plate, however, it is not clear, whether they were downfaulted outwards (southern slopes of the basin) or inwards (structural high of the northern collisional edge). This source probably had also a littoral Paleogene cover, as it contributed a large amount of shallow-water biodetritus (nummulites, coralline algae, bryozoans etc.) and pebbles into the basinal facies of the Šambron Beds.

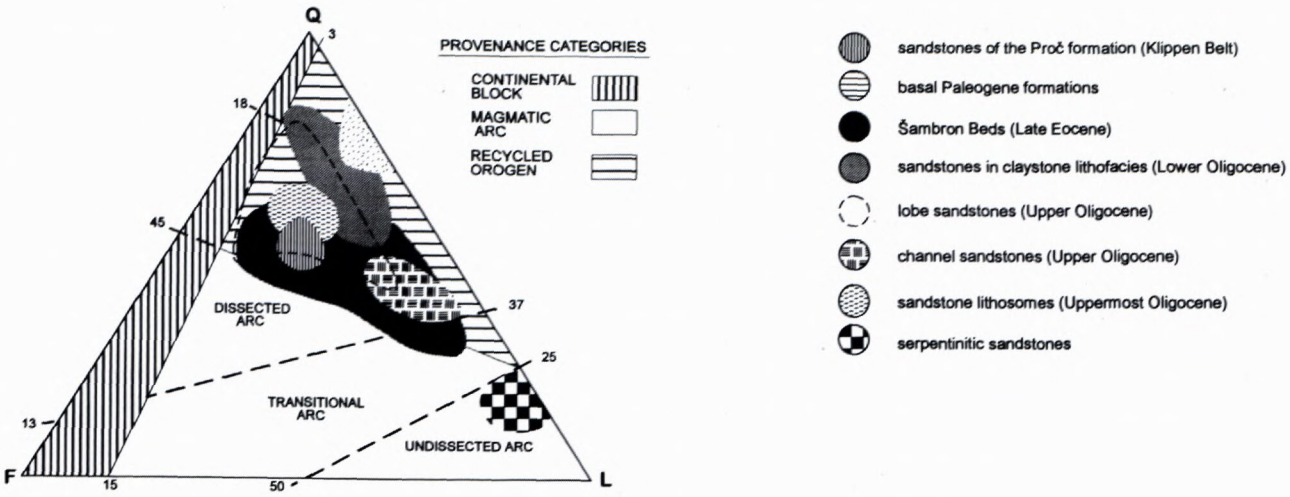

Fig. 1 Q-F-L plot of sandstones from the deep-sea fan deposits of the Levoča Mts.

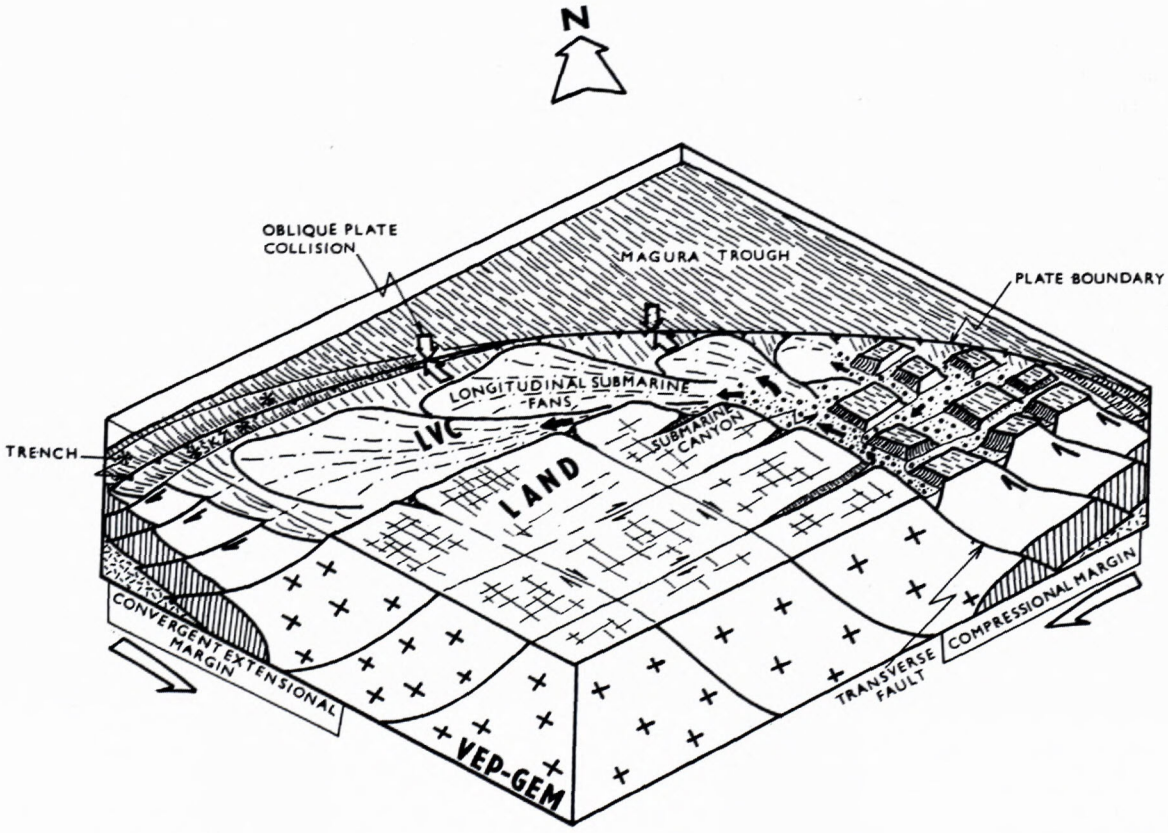

Fig. 2 Blockdiagram demonstrating the evolution of the East Slovakian collisional zone in the Late Oligocene. Oblique plate interaction caused both compression and extension in the hangingwall of a subduction zone. Compressional margin above the Iňačovce-Krichevo zone, in which the Middle Eocene sediments were also underplated, had been strongly emerged and tectonically eroded. The convergent extensional margin of the Centrocarpathian plate was occupied by fore-arc basin (Central Carpathian Paleogene), which was supplied by the longitudinal submarine fans. From the North the fore-arc basin was formed at distance of active subduction (perisutural basin). The plate margin had been pushed gradually foreward and produced compressional structures at the front. Abbrevations: LVC - Levoča basin,ŠKZ - Šambron-Kamenica Zone, Gem - Gemericum, VEP- Veporicum.

Sandstones of the Šambron Beds contain approximately a balanced share of siliciclastic and lithic components (Q/L) at a low proportion of feldspar (F/L). These parameters are plotted in the diagram for geotectonic provenances of sandstones on the boundary of recycled orogeny and magmatic arc fields (Fig. 1). In sandstones of younger, Upper Oligocene formations of the Šambron Zone, oceanic sources play a greater role in the detrital composition of sandstones. In the most distal facies of flysch, occurring on the contact of the Šambron Zone with the Klippen Belt, there were recorded also occurrences of serpentinitic sandstones (SOTÁK & BEBEJ, 1995, 1996). They are flysch deposits with a high concentration of serpentinite detritus, clasts of devitrified and pelagonized glass and a specific type of diagenetic minerals (saponite, corrensite, opal-CT etc.). The dominance of serpentinite grains results here in the increased portion of unstable lithic components (Lv), which shift the sandstones into the area of the magmatic arc and subduction complexes provenance. The origin of the detritus of the serpentinitic sandstones may be thus derived from oceanic crust sheets dragged out on the collisional edge of the Central Carpathian plate in the subduction trench zone (Fig. 2). The sediments of the Šambron Zone are generally very rich in spinel detritus (up to 80% of the heavy fraction of sandstones at localities near Plavnica and Kamenica), having apparently the same origin.

The study of conglomerates in the central and southern parts of the Levočské vrchy Mts. showed a change in the composition of carbonate detritus (predominance of Upper Jurassic - Lower Cretaceous limestones - e.g. pelagic calpionella limestones with pyroclastic admixture, Jurassic spotted limestones, Malmian microoncolithic limestones, shallow-water Neocomian limestones, Urgonian-type limestones, etc.) and higher-up also in diminishing of carbonates and increasing of plutonic and crystalline rocks. However, volcanites display a relatively homogeneous distribution both in conglomerates and flysch sandstones of the Levočské vrchy Mts. They are represented by various types of basalt, felsitic volcanites, porphyries, volcanoclastics, andesites, etc. In the east of the Šarišská vrchovina Hills we recorded in sandstones the presence of unaltered volcanic clasts, which are probably neovolcanic in origin. In view of the fact that the first phases of volcanism in Eastern Slovakia occurred evidently only in the Eggenburgian, the presence of neovolcanic clasts in the detritus of flysch sandstones is an important stratigraphic indicator (it confirms some biostratigraphic determinations of Lower Miocene sediments in the eastern part of Šarišská vrchovina Hills - MOLNÁR et al. 1992).

Similarly as in the composition of conglomerates, sandstone petrofacies of the Levočské vrchy Mts. display a trend of gradual decrease of carbonate detritus and increase in the amount of detritus from the crystalline basements. With younger age, the sandstones are shifted in the discrimination diagram from the recycled orogeny field (sandstones of the claystone lithofacies) to the proximity of the continental block provenance (sandstones of progradational loges and of the suprafan). A similar trend is reflected also in the heavy mineral composition, the spinel associations of the Šambron Beds being represented in younger formations by transitional garnet-chromium spinelid associations, which is in the progradational lobe and lithosome zone replaced by garnet-tourmaline associations. The determined inverse trend of detritus distribution is explained in literature by the exposure of lower crustal levels in exhumed structures of orogenes (CRITELLI and LE PERA 1994). This interpretation may be accepted, as the sources of Upper Oligocene deposits of the Levočské vrchy Mts. and Šarišská vrchovina Hills were exposed in the east, where exhumation of the Iňačovce-Kričevo unit took place in this time (Fig. 2)

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