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# TECTONIC STYLES, OPHIOLITES AND PALEOALPINE SUBDUCTION: IMPLICATIONS FOR PALINSPASTIC RECONSTRUCTIONS OF THE WEST CARPATHIANS

JOSEF JAROŠ*

*(Fig. 1)*

Abstract: The analysis of subduction zones of the Central West Carpathians from the viewpoint of tectonic styles and character of ophiolite associations leads to the idea that development of the West Carpathian geosyncline was obviously taking place on continental crust only. In palinspastic reconstruction of development of the geosyncline, zones with different grade of preceding Variscan consolidation, with various intensity of tension, magmatism and serpentite protrusions in the initial stage and with various intensity of intra-crustal subductions in the orogenic stage of Paleoalpine development may be distinguished.

Резюме: Анализ зон субдукции центральных Западных Карпат с точки зрения тектонических стильев и характера офиолитовых ассоциаций ведет к представлению, что развитие западнокарпатской геосинклинали протекало вероятно только на континентальной коре. В палинспастической реконструкции развития геосинклинали возможно выделить зоны с низкой степенью предыдущей варийской консолидации с разной интенсивностью расширения, магматизма и серпентинитовых протрузий в первичной стадии и разной интенсивностью внутрикоровых субдукций в орогенной стадии палеоальпийского развития.

## *Subductions and palinspastic reconshtructions*

The classical palinspastic reconstructions of geosynclines from orogens are based upon unfolding of folded and nappe structure to original width of the sedimentation area. The width of infractructure zones, consumed in the root areas of nappes, i.e. in zones of intra-crustal subduction in the sense of Amstutz, it is possible at least approximately to infer from the amplitude of nappe overthrusts and their inner deformations in the suprastructure of mountain ranges.

The geodynamic model of tectonics of lithospheric plates introduced a new element into palinspastic reconstruction by the process of lithospheric (Wadati—Benioff's) subduction. The complete geotectonic (Wilson's) cycle of geosynclinal-orogenic development includes opening and repeated closing of oceanic basins. The cycle begins with continental taphrogenesis and continues with oceanic taphrogenesis (spreading); a turn is commenced with subduction orogeny and the cycle terminates with collisional orogeny (suturation). During subduction of oceanic lithosphere this is, besides exceptions, consumed to depth. It is mentioned that only about 1 % of oceanic crust is getting to the margins of continents or occurs in intercontinental sutures under specific conditions. Direct material and structural evidence of oceanic lithosphere subduction is thus very little; the extent of ophiolite nappes is not in direct relation to the width of original oceanic basin. In palinspastic

* Doc. RNDr. Josef Jaroš, CSc., Faculty of Natural Sciences, Charles University, Albertov 6, 128 43 Praha 2.

reconstructions therefore particularly the results of paleomagnetic measurements play an important role. The existence and character of subduction zones can be, however, also controlled by geological criterii (lithofacial, biofacial and structural relations, tectonic styles, ophiolites etc.).

The structure and development of the West Carpathians were largely discussed by Czechoslovak and foreign geologists from the viewpoint of new geodynamic model of lithospheric plate tectonics in the last decade. Of essential importance for palinspastic reconstruction of the geosynclinal development of the West Carpathian segment of the Alpides are the existence character and extent of subductions, particularly in the Klippen Belt, root zones of superficial nappes and considered subduction in the southern belt of the West Carpathians. To this problem I mention some remarks from the viewpoint of tectonic styles and occurrence of ophiolite association rocks.

*Position, character and importance of root zones of Paleoalpine superficial nappes in the West Carpathians, particularly of the Krížna nappe*

In some palinspastic reconstructions (e.g. F. Horvath et al. 1977, J. E. T. Channell et al. 1979 and others) the Mesozoic of the Krížna nappe (Fatric) is assigned facially to the Austroalpine development of South Tethyan affinity and its root zone is situated as far as south of the Veporic, to the root zone of the Choč nappe (Hronic) (compare also A. Abonyi, 1974, B. Lešku, 1978 a.o.).

Such interpretations are not suported by field data. Lithofacially the Mesozoic series of the Krížna nappe belongs to the N part of the Central Carpathian region, i.e. the Tatraveporide region (M. Maheľ, 1961 a.o.). The homeland of the Krížna nappe was located by J. Jaroš (1965, 1966, 1967, 1971, in M. Maheľ, 1974) between the regions of Tatric envelope groups in the N and Veporid mantle groups in the south (A. Biely, 1961).

The northern boundary of the root zone of the Krížna superficial nappe is quite clear: it is where at the S margin of the Tatric the already tectonically detached Krížna Mesozoic sequence is found (Donovaly line in the sense of J. Jaroš, 1971). The southern boundary of the root zone cannot be already defined so precisely and therefore it is discussed more often (M. Maheľ, 1975, 1977 a.o.; a detailed analysis of new statements see in A. Biely, 1978; V. Zoubek, 1979 a.o.). O. Fusán — A. Biely (1967) locate the root zone of the Krížna nappe directly into the Čertovica line. This line appears actually as the most distinct structure at the S margin of the nappe root zone (J. Jaroš, 1971; O. Fusán, 1975 a.o.). N of it in the area of Banská Bystrica gradual detachment of the Mesozoic at the level of the Lower-Middle Triassic boundary may be observed: the crystalline of the Ľubietová zone, Staré Hory inlier and obviously also a part of the crystalline at the S foothills of the Ďumbier core, together with the Permian in Verrucano facies and Lower Triassic clastics remain in the homeland of the nappe, whereas the majority of predominantly carbonate Mesozoic was pushed out as superficial nappe. The process of gradual detachment is also shown in distribution of tectonic styles, in the fundament and its tegument, as well as in detachment of cover sequence (J. Jaroš, 1966, 1967, 1971 a.o.). This implies that the Krížna nappe

as one whole is not a rootless nappe but has its roots, at least in the area of Banská Bystrica, distinctly preserved owing to incomplete tectonic reduction of the homeland. Near the Čertovica line transition of the Krížna unit Mesozoic to the mostly undetached, episonally metamorphosed Veľký Bok group may be observed. This transition is not running parallely with the Čertovica line but to the NE to the area between Ľubietová and Mýto p. Ďumbierom it takes its course to the Ľubietová zone. The N part of the Veporic is of complicated structure (A. Klinec, 1971, 1976), in which local detachment also of the Veľký Bok group may occur (particularly N slopes of the Low Tatra), making interpretation very difficult. In every case, the development and position of the envelope groups on the southern Veporic zones do not permit to locate the southern boundary of the Krížna nappe root area in them (A. Biely — O. Fusán in P. D. Gamkrelidze et al. 1978, J. Vozár, 1979). The more, when the nappe structure of the Veporic is obviously also Variscan (J. Vozár, 1979). The root zone of the Krížna nappe (Fatric including the Vysoká nappe and ? Manín unit M. Maheľ, 1978c) is so the most important intra-crustal subduction zone inside the N, i.e. Tatraveporide part of the West Carpathians.

The Choč nappe or the whole newly divided Hronic (D. Andrusov, et al., 1973; M. Maheľ, 1979) is of Mesozoic lithofacial development largely different from the Krížna nappe (Fatric). It is in agreement with interpretations of the Krížna nappe as Ultratatride and of the Choč nappe as Ultraveporide and rooting of the latter into the Margecany—Lubeník line (A. Biely — O. Fusán, 1967). The Choč nappe is considered as rootless. Besides the so far known only lenticle of mylonites discovered by D. Andrusov, A. Vozárová — J. Vozár (1979) found further occurrences of mylonitized granitoids at its base. The character of these fragments and correlation of the Choč Permo-Carboniferous with the Veporide and Gemeride one testify (together with development of the Mesozoic) to the position of the Choč nappe homeland S of the Veporic.

The Lubeník—Margecany suture appears as the most important intra-crustal subduction suture in the structure of the Central West Carpathians. Besides the north-vergent Hronic also the primarily south-vergent Silicic is rooted in it (H. Kozúr — R. Mock, 1973a, b, 1977; J. Mello — R. Mock, 1977; R. Mock, 1978 a.o.). Lithofacial relationship between the Choč nappe and higher north-vergent nappes (Vernár strip, M. Maheľ, 1957) and the Silica nappe point to the existence of a sedimentation area of Upper Austroalpine affinity in the middle part of the Central Carpathian region. With complete reduction of this area with bilateral intra-crustal subduction the originally more distinct fan-like structure formed along the Margecany—Lubeník suture (D. Andrusov, 1975).

### *Ophiolites and reconstruction of the southern parts of the Central Carpathians*

The pre-orogenic (pre-overthrust, „initial") volcanism of the individual West Carpathian paleogeographical zones may be ranged to several magmatic-volcanic associations. From them only volcanics of spilite-keratophyre association S of the Lubeník—Margecany line, occurring together with serpentinites,

pelagic sediments (and in places also glaucophanic rocks) may be designated as incomplete ophiolite association (D. Hovorka, 1976, 1979). The occurrence of „ophiolites" in the S part of the Carpathians, particularly along the Rožňava line and Dárno line in N Hungary stimulated considerations about subduction of the oceanic lithosphere, consequently considerations about sutures representing Paleoalpine zones of lithospheric subduction (I. Varga,

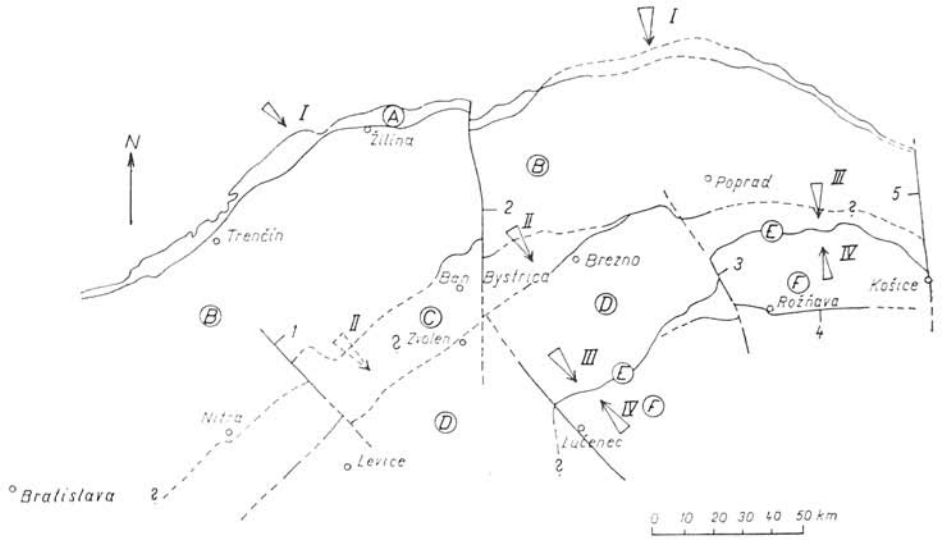


Fig. 1. Indicative scheme of main Paleoalpine intra-crustal subductions of the West Carpathians in present-day coordinates of mountain ranges. Orogenic zones: A — Pieninic Klippen Belt, B — Tatride zone, C — root zone of nappes of the Fatric, D — Veporide zone, E — Lubeník — Margecany suture, into which nappes of the Hronic and Silicic are rooted, F — „Gemeride" zone. Faults: 1 — Skýcov, 2 — Revúca, 3 — Štítnik, 4 — Rožňava, 5 — Hornád faults. Paleoalpine subducttons are designated with arrows: I — in the Klippen Belt, II — in the root zone of Fatric nappes, III — IV — in the root zone of Hronic and Silicic nappes.

1976, 1978; F. Horvath et al., 1976; J. E. T. Channell et al., 1979 a.o.). The extension, character and structural position of ophiolite association rocks, however, need not be in accordance with reconstructions of this type.

The most occurrences of ophiolite association rocks are obviously linked with the Meliata group, designated as group of ophiolite type by M. Mahel' (1975). The regional setting of the Meliata group extended with gradual revaluation of profiles from the „South Gemeride" region and Rudabánya mountains (H. Kozur — R. Mock, 1973a, b; J. Mello — R. Mock, 1977; J. Mello, 1978; J. Mello — P. Reichwalder, 1979) to the Bükk-Igal zone (H. Kozur — R. Mock, 1977) and through Radzim (R. Mock, 1978) to the „North Gemeride" region (R. Mock in J. Jaroš, et al., in press, compare L. Rozložník, 1978). It turns out that the Meliata group originally covered continuously the Gemeride Paleozoic and its absence in the central elevation of Volovec is result of erosion. Its relation to the substratum is

solved in different ways: according to R. Mock (1978/a.o.) it is the mantle group of the Gemeric, according to other authors it is thrust over the Paleozoic from S. Local or frequent secondary tectonization of the base of a relatively plastic Meliata group, lying between rigid complexes of the underlying metamorphosed Paleozoic and thick carbonates of the overlying Silica nappe, need not be in contradiction with the primary envelope position of the group. Lithofacial linking of the „North Gemeride" Permian and Lower Triassic near Margecany (M. Maheľ, 1957; Š. Bajaník — A. Vozárová, 1979) is not necessarily contradictory to the presence of the Meliata group below the Silica nappe, the base of which can lie even at the level of the tectonized base of the thick sequence of Middle Triassic limestones. The extension of the facially variable Meliata group and particularly the character of its contact with the substratum has not been solved completely so far. This is the essential question, the answer to which is significantly influencing the model of structure and development of the southern part of the Central Carpathians. The following model sets out from the idea that the Meliata group is the original mantle group of the Gemeride and North Hungarian Paleozoic (R. Mock, 1978 a.o.) and serpentinites and volcanics of the „North Gemeric" (Galmus—Stratená) zone are lying in the Meliata group (R. Mock in J. Jaroš et al., in press).

The ophiolite association of rocks is incomplete alrready in representation of rock types (D. Hovorka, 1976, 1979; D. Hovorka — J. Zlocha, 1974 a.d.), the sheeted dike complex, mostly also gabbros are missing. Besides that the structural analysis of relations of rocks to the surroundings and analysis of inner structure, particularly of serpentinite bodies (J. Jaroš et al., in press) has shown that:

a) Serpentinite bodies and bodies of spilite-keratophyre volcanism, although often occurring together, show different relations to surrounding rocks and different character of emplacement to present-day position. The intrusive contacts of volcanics testify to magmatic emplacement, whereas tectonic contacts of serpentinites to protrusive emplacement. The formerly described thermal contacts of serpentinites are their secondary reaction borders with surrounding rocks and are often of rodingite character (D. Hovorka); the only so far well-known contacts of volcanics with serpentinites (Švablica in Jaklovce, D. Hovorka, 1977) testifies to penetration of volcanics into serpentinites. The volcanics are connected also through tuffs with sediments of Ladinian and Carnian age Jurassic volcanism is not proved (R. Mock).

b) Larger serpentinite bodies or clusters of bodies obviously represent original protrusions, which penetrated into the Late Paleozoic and mainly the Lower Triassic of the Meliata group below the base of thick Middle Triassic limestones, into the zone of abundant interformation slips. In this zone they are further divided tectonically into partial bodies of lenticular shape. The bodies of lower stratigraphic levels (Kalinovo — Breznička are therefore jointed, cleaved and sliced but otherwise compact; on the contrary, bodies of higher stratigraphic levels are brecciated, with „pseudopebbles" to blocks of compact serpentinite in mylonitized serpentinized matrix.

The structural analysis of position and inner structure of bodies of ophiolite association shows that the ophiolite association of the S part of the West Carpathians is already primarily incomplete and cannot be compared, as it

is possible in case of complete ophiolite massifs of Trodos, Vourinos type a.o., with the complete profile of oceanic lithosphere. They also cannot be an argument for the existence of a Paleoalpine oceanic region of any type („of small ocean" of rift type, of marginal sea etc.), regardless of the position of the Meliata group on the substratum. Its envelope („autochthonous") position on the uderlying Paleozoic, so far as it will be confirmed, would underline this conclusion only. It seems that „oceanization" of crust of the S part of the West Carpathians is only partial and took place in a tensional regime by protrusive penetrations of serpentinites and dike intrusions and effusions of magmatites of spilite-keratophyre formation. The differences in development of the N and S part of the Central Carpathians were most likely caused by a various degree of Variscan consolidation of the geosyncline fundament (various degree of deformations, metamorphism and granitoid penetrations), as argumented by M. Maheľ (1975, 1976, 1978 a,b). The occurrences of glaucophanic rocks, particularly along the Rožňava line (P. Reichwalder, 1971, 1973; J. Mello, 1978) could be part of bodies protrusively emplaced from corresponding depths into the „Gemeric" suprastructure. „Oceanization" of crust was taking place only in the initial stage during the Triassic. It was connected with opening of the Tethys (Tethys de reconquète, sensu Aubouin) and did not reach further stages of the origin of small basins with oceanic lithosphere as elsewhere in the Mediterranean region in the Jurassic.

*Ophiolite detritus and subduction in the Klippen Belt region.*

The second zone of possible occurrence of rocks of ophiolite sequence, in this case drawn into deeper levels of structure, is the source area of sediments of the Pieninic Klippen Belt, designated as „Pieninic cordiller". Their presence is indicated by clastic chrome spinelids in pebbles of Urgonian limestones in conglomerates and also in sandstones of Middle to Upper Cretaceous age, pebbles of melaphyres and quartz porphyries, also glaucophanic rocks in the Upohlava conglomerates of the klippen mantle (M. Mišík, 1976).

Very often it is supposed that the ophiolite detritus can be derived only from obducted fragments of the oceanic lithosphere. On the basis of experience with the ophiolite association from the S part of the West Carpathians, however, also in case of the Klippen Belt, besides the model of oceanic or quasioceanic crust (Z. Roth, 1974; compare also N. Herz—H. Savu, 1974; P. Grecula—Z. Roth, 1978; M. Mišík, 1976, 1978), the model of only partial „oceanization" of continental crust by magmatic penetrations and diapir protrusions of ultrabasics may be considered.

In the East Carpathian Marmaroš Klippen Belt and its neighbourhood it is shown that basalts and serpentinites occurring at the surface and connected into ophiolite association are together linked secondarily (M. G. Lomize, 1975, 1976). The Upper Jurassic to Lower—Cretaceous basalt volcanism is primarily linked with preflysch development of the Rachlov—Severin trough. Serpentinites in the Albian—Cenomanian wild-flysch of the Sojmul suite are in secondary position. It may be infered from the situation in the Persani mountains that they are a primary part of Transylvanian nappes of the Inner East Carpathians, overthrust from far away W.

*Conclusion*

The analysis of subduction zones of the Central West Carpathians from viewpoint of tectonic styles and occurrence of ophiolites leads to the idea that the Paleoalpine development of the West Carpathians could have taken place only on a crust of continental type of various degree of Variscan consolidation (compare M. Maheľ, 1975, 1976, 1978a, b). The character of primarily incomplete ophiolite association of rocks does not testify to the existence of zones with oceanic lithosphere and thus also of lithospheric subductions. In palinspastic reconstruction of the West Carpathian geosyncline three zones may be distinguished S of the Pieninic belt: northern Tatraveporide zone, shortened mainly by intra-crustal subduction in the root zone of the Fatric, the central zone of the Hronic and Silicic, reduced by bilateral intra-crustal subduction to the Lubeník—Margecany cicatrix and the southern zone og the „Gemeric" (continuing to N Hungary). The intra-crustal subductions of the fundament were connected with formation of competent superficial nappes.

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