rent rocks could be shists, gneisses or amphibolites. Chemistry of chromian spinels is characteristic for those deriving form harzburgites, lherzolites and/or cumulates building ophiolite sequences.

The northern source area is commonly connected with the Silesian Ridge. During the Late Cretaceous-Palaeocene the material of the north source area supplied several lithostratigraphic units in the Magura Basin (Książkiewicz (ed), 1962, Oszczypko, 1992): Jaworzynka Beds (biotite-glauconitic beds), Ropianka Beds and Mutne Sandstones (Senonian-Palaeocene) and their equivalents (Solan Fm). The uplift of the Silesian Ridge is probably an effect of the Late Cretaceous-Palaeocene inversion tectonics, which affected the European foreland.

Position of the southern source is still speculative (Oszczypko, 1992). It was uplifted during the Maastrichtian - Palaeocene, being most active during the Eocene. The facies interfingering between the Jarmuta Fm. of the Grajcarek Unit of PKB and Szczawnica Fm. of Krynica Subunit suggest that these deposits were formed in continuous sedimentary area on the basinal slope of the accreted fragments of PKB and Inner Carpathians. The features of heavy minerals and components of sandstones suggest that the great part of clastic material of the formations was reworked many times. The investigations of chemical composition of heavy minerals allow concluding that the southern source area was build of low- to medium grade metamorphic as well as igneous rocks associated with ophiolite sequences. Chemical composition of minerals deriving from NW indicates that they crystallized mainly in medium- to high-grade metamorphic rocks.

The Szczawina sandstones, which contain only traces of chromian spinels and display paleotransport from SE, form different lithosome without any connection with the litofacies of Szczawnica and Jarmuta fms. It suggests that between the Krynica and Bystrica zones could existed an ephemeral uplifted area which supplied the Szczawina submarine fan.

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Evolution of Neogene-Quaternary Magmatism in the Carpathian Arc and Intra-Carpathian Area: Geodynamic Implications

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Neogene to Quaternary volcanism in the Carpathian-Pannonian region was related to the youngest evolutionary stage of the Carpathian arc and the intra-Carpathian basins, with subduction, extension and asthenospheric upwelling as the main driving mechanisms. Volcanism occurred between 20 and 0.1 Ma, and showed a distinct migration in time from west to east (fig. 1). Several groups of calc-alkaline magmatic rock-types (felsic, intermediate and mafic varieties) have been distinguished, and several minor alkalic types also occur, including shoshonitic, K-trachytic, ultrapotassic and alkali basaltic. From their spatial distribution, relationship to tectonic phenomena and their chemical composition, the volcanic formations can be divided into: (1) areally distributed felsic calc-alkaline formations related to the initial stages of back-arc extension, (2) areally distributed intermediate calc-alkaline formations related to advanced stages of back-arc extension, (3) "arc-type" andesite volcanic formations with a complex relationship to subduction processes, and (4) alkali basaltic magmatism related to post-convergence extension. Petrologic and geotectonic models of these magmatic groups place significant constraints on geodynamic models of the youngest stage in evolution of the Carpathian-Pannonian area. Subduction and back-arc extension were not contemporaneous across the whole Carpathian arc and intra-Carpathian area. Instead, three major geographic regions can be defined (Western, Central, Eastern regions) that show progressively younger timing of subduction roll-back and back-arc extension: 20–11 Ma,

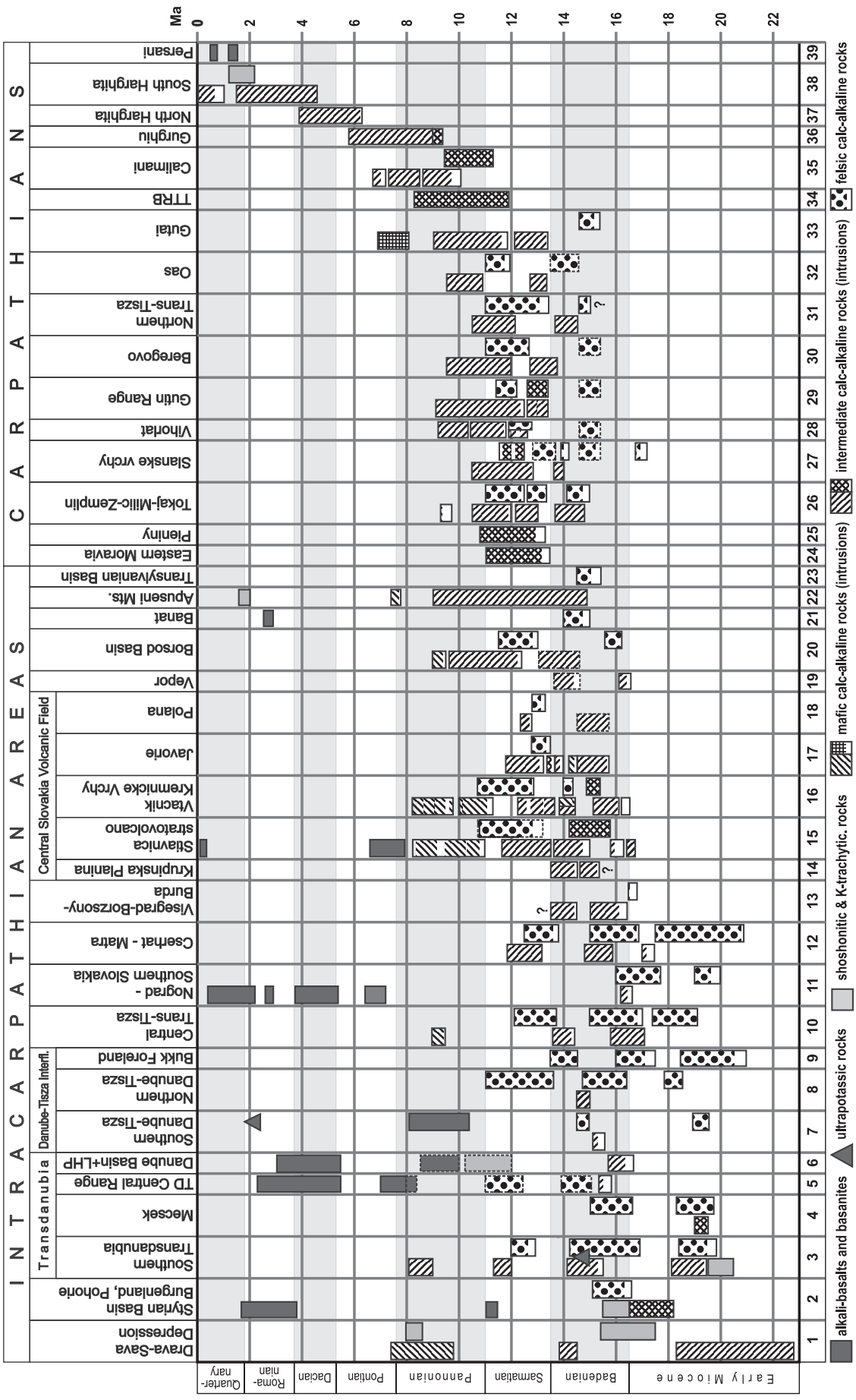

Fig. 1. Timing of Neogene-Quaternary magmatism in the Carpathian arc and intra-Carpathian area.

16–9 Ma, 14–0 Ma, respectively. Short-lived subduction-related volcanic activity can be interpreted either as an indication of a limited width of subducted crust (not greater than 200 km) or as an indication of detachment of the sinking slab. Interpretation of the areally distributed felsic and intermediate calc-alkaline volcanic formations are interpreted as being initiated by back-arc extension induced by diapiric uprise of "fertile" asthenospheric material.

The Structural and Metamorphic Record of the Variscan Orogenesis at the Eastern Margin of the Moldanubian Zone in the Bohemian Massif Associated with the Brunovistulian Foreland Underthrusting

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We investigate an orogenic fabric along the E-W cross-section at the eastern margin of the Moldanubian Zone in order to understand the mechnical behaviour during the formation and exhumation of this part of the orogenic root. The cross section is running from the Raabs lower crustal unit in the west, across the underlying Varied unit and the Podhradska unit to the easterly-situated Moravian Zone. The traditional cross-sections show the eastward thrusting of the Raabs lower crust over the Varied group metasediments, which appear in form of a tectonic window (Fuchs, 1976, Matte, 1990). In this concept the granulite sheet at the eastern border of the Moldanubian zone adjacent to Moravian zone is interpreted as a termination of the antiformal stack of the Moldanubian thrust sheet.

The structural observations show the succession of four fabrics. The relics of the first foliation S1 with unknown original orientation are preserved in form of tight to isoclinal folds within the steeply NW–dipping foliation S2 in the Varied and Podhradská units. The steep NW-dipping S2 fabric is reworked by E-verging F3 folds with westerly dipping axial planes and subhorizontal axes. This late folding results in places to almost complete transposition into a moderately W-dipping S3 foliation, developed with greatest intensity in the Raabs unit. The latest locally developed structure is a flat S4 fabric represented by LT shear zones.

The qualitative PT-paths of the rocks from individual units were deduced from the PT-pseudosections constructed in the NCKFMASH system, using the program THERMOCALC for selected samples representing different units: migmatite from the Raabs unit, metapelite from the Podhradská unit and one sample from the granulitic body on the eastern border of the Podhradská unit. The PT-paths were determined on the basis of the succession of the mineral assemblages and zoning of the minerals.

Both the migmatite from the Raabs unit and the granulite from the bottom of the Podhradska unit contain relics of HP metamorphic stage in form of relics of kyanite and big porphyroblasts of perthitic K-feldspar, plagioclase and quartz. This mineral assemblage is overprinted in LP conditions by the growth of sillimanite and biotite at the expense of garnet. The metapelite from the Podhradska unit shows the evidence of prograde PT path in form of garnet zonation (high Ca-content in cores) and staurolite inclusions enclosed in garnet porphyroblasts. The peak PT conditions are represented by the mineral assemblage ky+grt+kfs+plg+bt+qtz. The following retrogression is displayed by the growth of sillimanite and muscovite on the expense of kyanite and K-feldspar.

To obtain absolute PT conditions we have used the average PT calculations for the observed metamorphic assemblages for a granulite sample from the bottom of the Podhradska unit (grt+kfs+plg+qtz+ky/sil+bt±ms), for a metapelite from the Podhradska unit (grt+kfs+plg+bt+ms+ky/sil+qtz±st), for an eclogite from the bottom of Raabs unit (grt+cpx+plg+amp) and for a migmatite of the Raabs unit (kfs+plg+qtz+grt+ky/sil+bt). The PT conditions of HP metamorphic stage were determined on the basis of the eclogite sample to 881±60 °C and 12.8±1.3 kbar. The PT conditions of retrogression were determined to 744 ± 55 °C and 6.9±1.8 kbar for the migmatite from the Raabs unit and 772 ± 83 °C and 10.1±2.5 kbar for the granulite from the bottom of the Podhradská unit. The retrograde mineral assemblage of the metapelite from the Podhradská unit gives PT conditions of 695±90 °C and 7.1±1.7 kbar

On the basis of the structural observations correlated with the PT estimates we have proposed two major thrust-zones developed in the conditions of the thickened lower crust. The first one is situated at the base of the Raabs unit and is marked by a sheet of amphibolites whith boudins of eclogites. The second thrust is located at the base of the Podhradska unit and is marked by a body of felsic ky-kfs granulite with amphibolite lenses. These thrusts were later reworked in conditions of the middle crust.

The structural observations are consistent with the results of numerical modelling of structural evolution of the continental collision in Central Pyrenees (Beaumont et al., 2000). In agreement with their model P5, we put the first pro-wedge thrust on the bottom of the Raabs unit. This thrusting is connected with extreme deformation of the eastern part of the Varied unit. The second pro-wedge thrust marked by granulites brings the whole sequence over the Brunovistulian foreland.