Northern (Slovak) part of the Danube Basin: tectonics, crustal and lithospheric dynamics

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Pre-Tertiary basement in the central part of the Danube basin in Slovakia is broken by a system of major faults into seven large upper-crustal blocks. Besides that , in the western part of the basin, the Tatric crystalline rocks are formed (after reflection seismic data) into one to three each over other superposed tectonic scales. Eastwards, these scales gradually crop out beneath the basin fill on the pre-Tertiary surface. The lowest tectonic scale of them continues as far as the Ripňany-Galanta fault system where it submerges beneath the thick pile of rocks in the Tríbeč block (Hrušecký, 1997, 1999).

The N-S (with slight deviations in both directions) and the NE-SW directions predominate in the basin fault tectonics. There are also important transversal W-E and WSW-ENE striking faults. The recently realized reflection seismic profiles (1992) have not confirmed any important faults of the Sudetic (NW-SE) direction which were in the past considered to have played an important role in the forming of the pre-Tertiary and Tertiary structure of the basin (the Ölved-Dobrá Voda fault named also Ludince fault; Pezinok and Danube faults). All these facts are confirmed also by the map of Bouguer anomalies.

Most major faults defined by reflection seismic profiles are broader weakened tectonic zones (boundaries of major upper crustal blocks) during the basin evolution periodically re-activated and producing several generations of the faults (at least 3-4 generations) in these zones. The most important tectonic lines (e.g. the Čertovica-Mojmírovce fault system, the Hurbanovo line) are re-activated in places of older pre-Tertiary basement lines. Some of the major faults in the basin may have been produced during the basin evolution (e.g. the Cífer transversal fault, the Medveďov fault, the Kolárovo fault). Besides that, for the important tectonic lines in the basin (e.g. the Čertovica-Mojmírovce fault system, the Ripňany-Galanta fault system) the following profile characteristics can be stated:

- complex geometry of the fault zone composed of geometries changing in space and time during the basin evolution;
- different senses of movements within the fault zone in dependence on the position of the main stress in the different periods of basin evolution;
- different areal (fragmental) activity and vertical reach of the faults.

Due to the long-term directional predispositions of old basement tectonic lines in the broader region of the Slovak part of the Danube basin and their considerable directional dispersion (from E-W to NNE-SSW i.e.70-80°) the Slovak part of the Danube basin was forced, from beginning of its evolution, to develop not in a purely orthogonal extension regime, but in a transtension-extension regime. The tectonic evolution of the Slovak part of the Danube basin has been controlled by two subsequent tectonic phases:

1. Crustal extension phase - (Paleogene? – Ottnangian?), Karpatian to Lowest Pannonian (17.5-11.0 MA);
2. Thermal collapse phase - later Lower Pannonian to Quaternary (11.0-0.0 MA).

Although the early evolution stage of the Slovak part of the Danube basin (Paleogene? to Ottnangian?, Karpatian, Lower Badenian) with rapid transtension-extension spreading of the crust played an important role in the further evolution of the basin, the dominant evolution element, from viewpoint of the evolution of the Slovak part of the Danube basin and also its broader surroundings, appears to be the Úľany ridge. In the derived model of lithospheric extension (Hrušecký, 1997,1999) the ridge connects into one dynamic context the Slovak part of the Danube basin and the Vienna basin. Until the end of the crustal extension phase (Lowest Pannonian), the ridge behaved as an interbasinal ridge (in the sense of Rosendahl et al., 1986 and Allen & Allen, 1995). The recent structural inexpressiveness of the Úľany ridge is due to its tectonic unroofing in the crustal extension phase, erosion and later (upper Lower Pannonian to Recent) thermal collapse.

An analysis of the tectonic evolution of the Slovak part of the Danube basin and the derived lithospheric model suggest that the genesis of the Slovak part of the

Danube basin and also the Vienna basin commenced by the passive rifting phase (in the sense of Allen & Allen, 1995) when transtension pull-apart basins (the Vienna basin, the Györ-Meder pull-apart basin, the Blatné depression) were produced. This crustal extension protostage presumably facilitated the further evolution of the basins as at this stage the uplift of the Úľany interbasinal upwelling ridge started. This ridge controlled active rifting with production of the first generations of large Neogene detachments and subvertical normal faults in both directions (towards NW to W and SE to E) from the NNE-SSW axis of the ridge uplift. The bivergent gravitational spreading controlled by simple-shear mechanisms on both sides of the uplifting ridge started to predominate. With progressing extension the crust thinning was taking place, heavy masses were uplifted to the pre-Tertiary surface of the basin, and volcanic activity intensified.

Tectonic transport of upper crustal blocks from the uplifting Úľany ridge towards NW to W, realizing on the originally Paleoalpine or Mesoalpine thrust planes of Alpine-Carpathian units, with high probability contributed to the uplift of the Malé Karpaty Mts., and in such a way also to the gradual separation of the Blatné depression from the Vienna basin as early as in the Upper Karpatian and Lower Badenian. This process of uplifting of the Malé Karpaty Mts. and separating of the Blatné depression from the Vienna basin culminated in the Middle and Upper Badenian. At the same period gravitational spreading of upper crustal blocks towards SE to E from the Úľany upwelling ridge produced extensive halfgrabens in the central part of the basin. At the end of the Upper Badenian the stormy crustal extension gradually ceased. The presumably big loss of thermal energy and material in the upper mantle and crust resulted in cessation of volcanic activity in the centre of the Slovak part of the Danube basin before the end of the Upper Badenian, and the basin gradually passed into the thermal-collapse phase starting in the Pannonian, and in the central part of the basin lasting until the Recent.

According to main features of geological structure, tectonic development and lithospheric model of the basin, Slovak part of the Danube basin was classified by Hrušecký (1997) among polyhistory, composite basins (after global classification of basins from Shannon & Naylor, 1989). Reason for this consists in a fact that this basin includes in its "basinal curve", according to which it is developing in time, at least two of pure basin types (pull-apart and rift basins) and final stage of the basin development is associated with thermal collapse.

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