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Late Paleozoic – Early Mesozoic Tectonic Activity within the Donbass (Russian Platform)

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Abstract: The Donbass is a large structural domain in the south of the Russian Platform, whose origin and tectonic evolution is still debated. Our new model suggests the Late Paleozoic and Early Mesozoic tectonic activity within the Donbass was controlled by the dynamics of the Northern Palaeotethyan Shear Zone. The Late Paleozoic dextral movements along the latter led to the detachment of the Ukrainian Massif and extension of the Donbass. The change to sinistral strike-slip in the Late Triassic resulted in regional contraction and folding.

Key words: Shear zone. Strike-slip. Contraction. Paleozoic. Mesozoic. Palaeotethys. Donbass.

Resumen: El Donbass es un gran dominio estructural de la Plataforma Rusa cuyo origen y evolución tectónica es objeto de debate. Se propone un nuevo modelo según el cual la actividad tectónica durante el Paleozoico tardío y el Mesozoico temprano fue controlada por la dinámica de la Zona de Cizalla Septentrional del Paleotetis. Los movimientos dextrales de esta Zona en el Paleozoico tardío condujeron al despegue del Macizo Ucraniano y a una extensión en el Donbass. El cambio a un movimiento en dirección sinistral durante el Triásico tardío dio lugar a una contracción y plegamiento.

Key words: Zona de cizalla. Strike-slip. Contracción. Paleozoico. Mesozoico. Paleotetis. Donbass.

Recent advances in global palaeotectonic reconstructions (e.g., Stampfli and Borel, 2002; Scotese, 2004; Torsvik and Cocks, 2004) ask for reconsideration of the traditional models of the tectonic evolution of particular regions. The Donbass (alternatively named Donets Basin or Donbass Fold Belt) is a large structural domain in the southern part of the Russian Platform (Fig. 1). It is located between two stable Precambrian blocks: the Ukrainian and Voronezh massifs, and their marginal structures. The Donbass is the eastern and the most "mature" domain of the elongated structure, which also includes the Dniepr-Donets Basin and the Pripyat Trough.The Donbass contains Carboniferous and Permian coal-bearing deposits several kilometres thick, which are strongly folded and disrupted by numerous faults. Overviews of the tectonic activity of the Donbass are presented by Laz'ko (1975), Stephenson et al., (1996), Maystrenko et al., (2003), Saintot et al., (2003), Stovba et al., (2003), Vai (2003), and Kostjutchenko et al., (2004).

Two significant questions arise about the Donbass: (1) why did intracratonic rifting occur in the Late Devonian-Carboniferous, and (2) what forces led to end-Triassic contraction? We present a new model to answer them.

Northern Palaeotethyan Shear Zone

A major shear zone was active on the northern margin of the Palaeotethys in the Late Paleozoic and Early

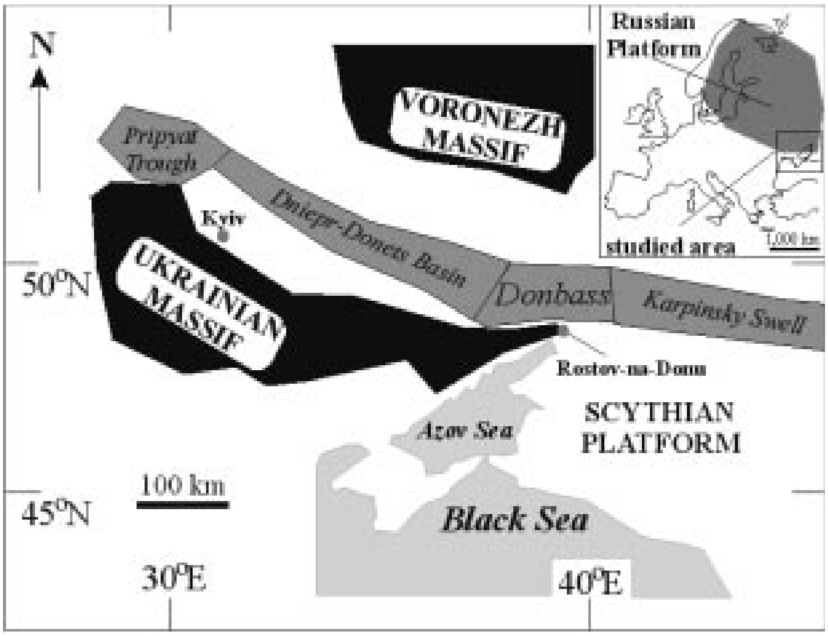

Figure 1. Main tectonic structures in the SW of the Russian Platform (simplified from Maystrenko et al., 2003). Areas of the Precambrian rock exposure are highlighted as black. The Late Paleozoic basins are highlighted as grey. Other areas (white) are covered by the Mesozoic-Quaternary deposits.

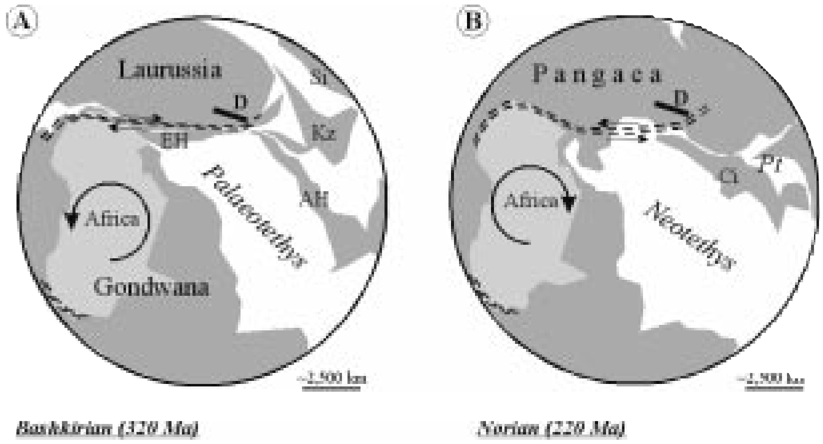

Figure 2. Global palaeotectonic reconstructions for the Bashkirian (Pennsylvanian) (A) and the Norian (Late Triassic) (B); base palaeotectonic maps are strongly simplified from Stampfli and Borel (2002). Double dashed lines trace the shear zones related to the Africa rotation. Abbreviations: D – Donbass, Dniepr-Donets Basin and Pripyat Trough, EH – European Hunic Terranes, AH – Asiatic Hunic Terranes, Kz – Kazakhstan, Si – Siberia, Ci – Cimmerian Terranes, Pt – Palaeotethys.

Mesozoic (Arthaud and Matte, 1977; Swanson, 1982; Rapalini and Vizán, 1993; Lawver et al., 2002; Stampfli and Borel, 2002; Vai 2003; Garfunkel, 2004). Strike-slip movements along this zone were dextral since the Devonian until the Late Triassic (Fig. 2A), and since then it became sinistral (Fig. 2B) (Swanson, 1982; Rapalini and Vizán, 1993; Vai, 2003). These movements stopped in the Middle Jurassic (Rapalini and Vizán, 1993). These displacements were caused by the rotation of Africa (Rapalini and Vizán, 1993). The latter may be explained with the 'global wrench tectonics' (Storetvedt, 2003).

An intriguing question for further studies is connected with the hypothetical relation of motions along the Northern Palaeotethyan Shear Zone in the Late Paleozoic to the strike-slip deformations along the other major shear zone, which was located between the Laurentia and Baltica in the Middle Paleozoic (Lawver et al., 2002).

The global-scale dynamics of the Northern Palaeotethyan Shear Zone could enforce the tectonic evolution of the Donbass.

A tectonic model

Dextral strike-slip movements along the Northern Palaeotethyan Shear Zone occurred since at least the Visean (Lawver et al., 2002; Stampfli and Borel, 2002), but probably began a little earlier, in the Late Devonian,

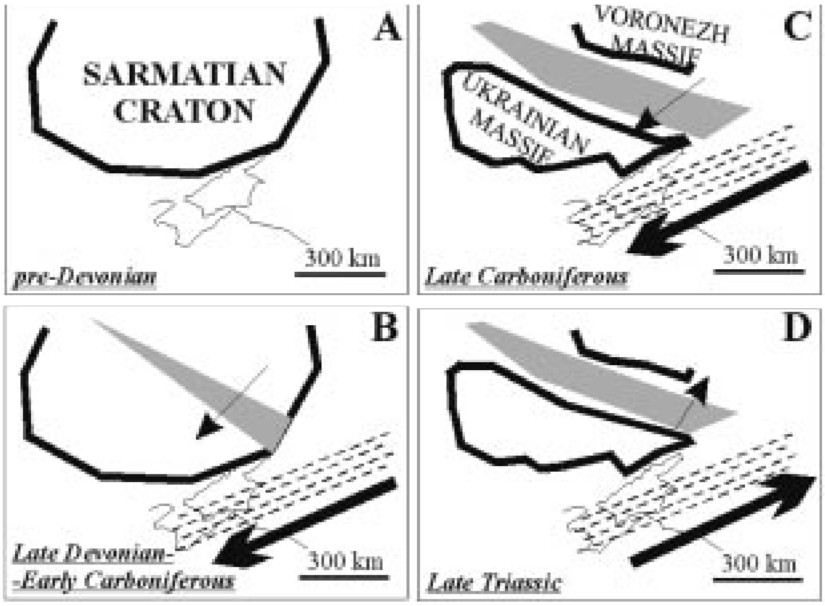

Figure 3. A model of the development of the Donbass from the pre-Devonian (A) to the Late Triassic (D). Dashed lines mark the shear zone. Thick arrows indicate the movements of the land masses in relation to the Russian Platform. Thin arrows indicate direction of the Ukrainian Massif movement. The Pripyat Trough, the Dniepr-Donets Basin and the Donbass are highlighted as grey.

when the European Hunic Terranes just docked to the Laurussia after the partial closure of the Rhenohercynian Ocean (Stampfli and Borel, 2002). These movements influenced intense fault activation and reactivation in European structures (Arthaud and Matte, 1977; Vai, 2003). It seems that dextral strike-slip movements were able to break up the previously stable Sarmatian Craton (Fig. 3A), detaching the Ukrainian Massif (Fig. 3B). This break-up occurred along the tectonically weak zone, which crossed the Sarmatian craton since the Precambrian (Stephenson et al., 1996). Kostjutchenko et al. (2004) estimated that the southeastern part of the Ukraininan Massif was transported 100-150 km off the craton margin. A number of basins (i.e., Pripyat Trough, Dniepr-Donets Basin and Donbass) were formed in this way (Fig. 3C). The regional extension, i.e. between the Ukrainian and Voronezh massifs, in the Carboniferous due to the continued detachment of the Ukrainian Massif seems to be a factor that controlled the deepening of the Donbass and, therefore, provoked deposition of thick sedimentary complexes. The rates of this regional extension, which was also marked by the magmatic activity, are discussed in Stephenson et al., (1996).

The change of movement direction along the shear zone in the Late Triassic caused contraction and folding within the Donbass. Sinistral strike-slip caused the Ukrainian Massif to move back towards the northeast, i.e. towards the Voronezh Massif. Such change of the motion of the Ukrainian Massif in the Triassic was also hypothesized by Kostjutchenko et al., (2004). As the ‘mature’ structure of the Donbass existed between the massifs, it was contracted (Fig. 3D), with folding of the sedimentary complexes. The main phase of shortening occurred in the Late Triassic (Maystrenko et al., 2003; Saintot et al., 2003; Stovba et al., 2003; Vai, 2003).

Thus, the Donbass evolution was influenced by the African geodynamics because the Northern Palaeotethyan Shear Zone evolution was controlled by the rotations of this continent (Rapalini and Vizán, 1993).

Our model explains the differences between the Pripyat Trough, the Dniepr-Donets Basin and the Donbass. The first is a relatively ‘shallow’ structure, while the second is deeper, but neither is as deep or deformed as the Donbass (Maystrenko et al., 2003). According to the model presented here, extension at the margin of the Sarmatian Craton increased towards the southeast, i.e., towards the most peripheral part of craton. The latter was especially strongly affected by the strike-slip movements, because shear zone was located along it.

The Donbass tectonic developments has analogues. Similar strike-slip movement along another great shear zone were documented in East Asia during the Mesozoic, particulary in Japan and Korea (Otoh and Yamakita, 1995; Otoh and Yanai, 1996; Yamakita and Otoh, 2000; Sasaki, 2001). The initial dextral movement changed to sinistral in the Early Cretaceous, which influenced the evolution of nearby regions.

Conclusion

Dextral strike-slip movements along the Northern Palaeotethyan Shear Zone detached the Ukrainian Massif from the previousely existed Sarmatian Craton, and the thick Late Paleozoic sedimentary complex was accumulated in the opened basin, i.e. in the Donbass. When these strike-slip movements became sinistral since the Late Triassic, the compression of the Donbass occurred, which was resulted into the strong deformation of the mentionned sedimentary complex.

It is important to note, that the Late Devonian-Triassic movements along the Northern Palaeotethyan Shear Zone also controlled the development of many basins in the North and South America, and Africa (Rapalini and Vizán, 1993).

Further studies are necessary to test deeply the model proposed in this paper.

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