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# THE EAST EUROPEAN CRATON: SOME ASPECTS OF THE PROTEROZOIC EVOLUTION IN ITS SOUTH-WEST

**Abstract:** The East European Craton (EEC) was created ca. 1.8-1.7 Ga ago by the successive collision of three previously autonomous crustal segments known as Fennoscandia, Sarmatia and Volgo-Uralia. The part of the EEC in NE Poland was formed by several accretionary orogenic events in the Palaeoproterozoic and was subsequently strongly reworked at ca. 1.5 Ga during the Danopolonian orogeny. Some outboard terranes along the Trans-European Suture Zone in Poland and Romania derived from the EEC.

**Keywords:** East European Craton, Proterozoic crust, intracratonic deformation, magmatism, NE Poland

## SEGMENTS OF THE EAST EUROPEAN CRATON

The East European Craton (EEC) is the core of the Baltica proto-plate (Fig. 1, inset) and simultaneously the oldest part of Europe. It originated from the collision of the three once independent crustal segments Fennoscandia, Sarmatia and Volgo-Uralia ca. 1.8-1.7 Ga ago. Very distinctly, these crustal segments had totally different pre-collisional Archaean and early Palaeoproterozoic histories of development (Gorbatschev, Bogdanova 1993b; Bogdanova 1993; Bogdanova *et al.* 2005b).

In **Fennoscandia**, the Archaean crust is made up of several crustal domains and terranes with ages not exceeding 3.5 Ga. Major stages of accretion and gradual growth of the continental crust occurred between 3.1 and 2.65 Ga ago (Glebovitsky 2005). From 2.5 to 2.0 Ga, the crust of Archaean Fennoscandia was affected by mantle-plume events that led to its rifting and fragmentation, and the opening of minor “intra-continental” oceans. However, between 1.9 and 1.8 Ga these were closed again during several accretionary (subductional-collisional) orogenic episodes collectively reckoned as parts of the Svecofennian orogeny. Later orogeny took part mostly along the south-western margin of Fennoscandia at ca. 1.81-1.78 and 1.77-1.75 Ga, and after the creation of the EEC at ca. 1.70-1.65, 1.60-1.55 and 1.50-1.45 Ga as well as during the Sveconorwegian orogeny between ca. 1.2 and 0.95 Ga. All these processes were semi-simultaneous with crust-forming events in the North American Craton (Hoffman 1988, 1989; Åhäll, Gower 1997; Karlstrom 2001).

As different from Fennoscandia, **Sarmatia** is built up of several once independent Archaean domains developed at 3.7-2.9, 3.2-3.0 and ca. 2.7(?) Ga. Approximately 2.3-2.1 Ga old orogenic belts separate these domains from each other (Kalyaev *et al.* 1984; Shchipansky, Bogdanova 1996; Claesson *et al.* 2000; Glevassky, Kalyaev 2000; Shcherbak *et al.* 2003). Along the north-western edge of Sarmatia, an extensive ca. 2.0-1.95 Ga old continental-margin magmatic arc (the Osnitsk-Mikashevichi Igneous Belt, cf. (Bogdanova *et al.* 2001; Aksamentova 2002) marks a major accretionary orogenic event that took place ca. 200 Ma before Sarmatia began colliding with Fennoscandia. During the late stages of that

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collision and somewhat later, large1.80-1.74 Ga old gabbro-anorthosite-rapakivi intrusions such as the Korosten pluton were formed in western Sarmatia. This appears to have been the last major Proterozoic crust-forming event in that crustal segment.

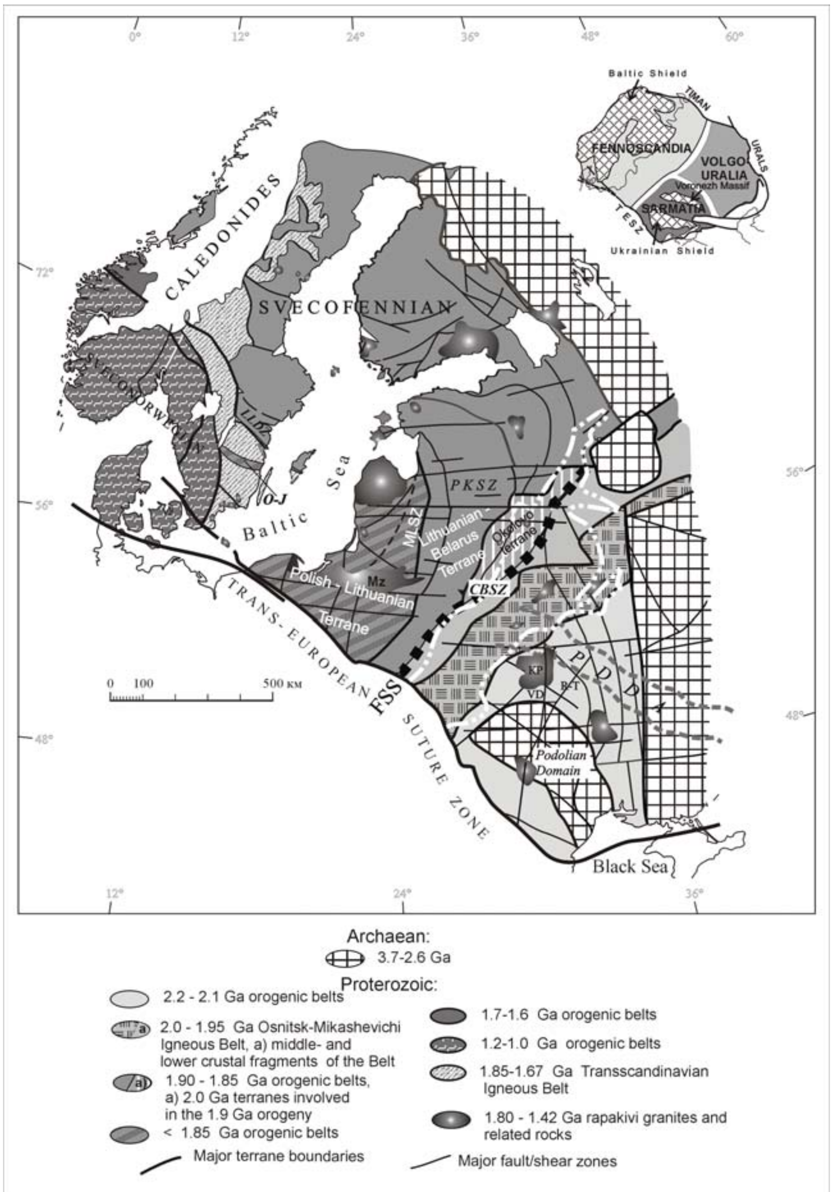


Fig.1. Major tectonic subdivisions of the crust in the western part of the East European Craton (©S. Bogdanova). The letter symbols are: CBSZ – Central Belarus Suture Zone , KP – Korosten' pluton, LLDZ – Loftahammar-Linköping Deformation Zone, MLSZ – Mid-Lithuanian Suture Zone, Mz – Mazury plutonic rocks, O-J – Oskarshamn-Jönköping Belt, PDDA – Pripyat-Dniepr-Donets Aulacogen, PKSZ – Polotsk-Kurzeme Shear Zone, RP – Riga pluton,. The dashed white line delimits the Volyn-Orsha Aulacogen. The inset shows the three-segment structure of the East European Craton (Bogdanova 1993).

**Volgo-Uralia** is a coherent Meso- to Neoarchaean high-grade domain buried virtually completely beneath a Proterozoic to Phanerozoic sedimentary cover (Bogdanova 1986; Bogdanova *et al.* 2005). In the Palaeoproterozoic, it was affected by crustal doming at some time between 2.6 and 2.1 Ga.

At ca. 2.1-2.0 Ga, Volgo-Uralia collided with Sarmatia to form the larger proto-craton of Volgo-Sarmatia and thereafter evolved within that crustal unit.

## INTERSEGMENT SUTURE ZONES

The collisional suture zones between Fennoscandia, Sarmatia, and Volgo-Uralia comprise remnants of Palaeoproterozoic oceanic island arcs, back-arcs, and active as well as passive continental margins. As can be seen from recent geophysical surveys, intense collisional and post-collisional tectonics, and magmatism characterized these zones. Subsequently, Meso- to Neoproterozoic trans-cratonic rifting followed the Palaeoproterozoic sutures (Bogdanova *et al.* 1996). Thus the Late Proterozoic Volyn-Orsha - Central Russian rift system follows the 1.8-1.7 Ga old collisional boundary between Volgo-Sarmatia and Fennoscandia. Later, the westernmost part of the EEC developed largely within active-margin tectonic settings, which regimes lasted until theformation of the Rodinia supercontinent ca. 1.2 to 1.0 Ga ago. In the east, in contrast, rifting and the formation of a passive margin occurred at ca. 1.6-1.5 Ga and later (Puchkov 2000; Maslov 2004).

## INFERENCES FOR THE SOUTHWESTERN MARGIN OF THE EEC IN POLAND

**2.0-1.8 Ga terranes.** Geophysical data and drillcore materials indicate that the crystalline basement in NE Poland and adjoining parts of the region between the EUROBRIDGE study area and the Trans-European Suture Zone (TESZ), comprises several lithotectonic units (Kubicki, Ryka 1982; Cymerman, Wiszniewska 1999; Wybraniec 1999; Cymerman 2004a). Evidently, the Osnitsk-Mikashevichi Igneous Belt of NW Sarmatia, the Central Belarus Suture Zone separating Fennoscandia from Sarmatia, the Belarus-Podlasie Granulite Belt with the East Lithuanian Belt, and the West Lithuanian Domain all continue through NE Poland all the way to the TESZ (Fig. 1). The evolutionary histories of these belts allow to group them into three different terranes/subterranes with crustal ages of 2.0-1.9, 1.90-1.85, and <1.85 Ga, respectively. However, the precise correlation of these units with the lithotectonic complexes in Poland still meets many problems mostly due to the lack of precise age determinations of the Precambrian crystalline rocks and reconstructions of their tectonic settings.

Previous Sm-Nd reconnaissance studies (Claesson, Ryka 1999) across the major subdivisions of the crystalline basement in Poland have not shown significant differences of the isotopic characteristics and model ages of the rocks in that region. All the latter vary between ca. 2.25 and 2.0 Ga, and are thus similar to those in the adjacent EUROBRIDGE area and in SE Sweden, distinctly indicating a juvenile Palaeoproterozoic origin of the crystalline basement in NE Poland (Claesson *et al.* 2001).

One of the most important questions is whether the Precambrian crust in Poland is essentially younger than that in the Svecofennian orogen proper in the Baltic Shield, *i.e.* younger than ca. 1.85 Ga.

Here, it is tempting to suggest that the rocks of the Mazowsze, Ciechanów, Dobrzyn ect. domains should be combined with those of the West Lithuanian Granulite Belt into one single terrane with ages less than 1.85 Ga. Zircon U-Pb ages between 1.84 and 1.81 Ga of the volcanic rocks, magmatism and metamorphism in the West Lithuanian Belt and the

Mid-Lithuanian Suture Zone (Skridlaite *et al.* 2003a; Motuza 2004) appear to support such correlation as well as correlation with the rocks in SE Sweden (Mansfeld *et al.* 2005). In addition, Cymerman (2004) recently found that the Mazowsze Massif is separated from the rock belts farther east by a wide mylonite zone which may be the southern continuation of the Mid-Lithuanian Suture Zone.

Another important point is that the bulk of the crystalline basement in Poland, particularly in the massifs consists of granitoids with associated mafic igneous and various volcanic-sedimentary rocks in the same manner as in the Transscandinavian Igneous Belt in Sweden (Högdahl *et al.* 2004). The large magnetic anomaly corresponding to this Belt turns from NS- to SE- trend indicating its continuation across the Baltic Sea (Gorbatschev, Bogdanova 1993a; Sundblad *et al.* 1998). The 1.8 Ga ages of a granodiorite in the southern part of the Mazovsze Massif (Valverde-Vaquero *et al.* 2000) and of ortoamphibolites in its central part (Krzemińska *et al.* 2005) support this idea.

Subsequent Palaeoproterozoic orogenic events around 1.77-1.75 Ga, which are known well from south-easternmost Sweden (Johansson, Larsen 1989)l. and the Danish island of Bornholm, have hitherto not been recognized in NE Poland, but their influence upon the tectonothermal evolution of the crust may not be excluded.

**The ca. 1.5 Ga Danopolonian orogeny: intracratonic deformation and AMCG magmatism.** Between 1.50 and 1.45 Ga, the crust along the south-western margin of the EEC, particularly that in Poland and Lithuania, underwent deep deformation, attendant melting, AMCG magmatism (Wiszniewska *et al.* 2002; Skridlaite *et al.* 2003b) and strong reworking all the way down to the upper mantle (Środa *et al.* 1999; Czuba *et al.* 2002). In Poland there are numerous ductile shear zones (Cymerman 2004a), while the most pronounced extensional deformation was related to the Mazury complex. All these events were probably linked to the Danopolonian orogeny, which was proposed by Bogdanova (2001) to explain ca. 1.5- 1.45-Ga penetrative compressional deformation and A-type magmatism in SE Sweden (Čečys 2004) and on Bornholm island (Bogdanova 2001; Cymerman 2004b). That orogeny appears to have affected the EEC crust also much farther to the north, where 1.5-1.45 Ga AMCG magmatism and mafic dyking have been recognised in many places (Söderlund *et al.* 2005).

The Danopolonian orogeny can have been caused by accretionary and collisional processes involving the Amazonia, Baltica and Laurentia cratons in the course of the assembly of the Rodinia supercontinent that culminated ca.1.2 to 1.0 Ga ago. In this context, it is important to note that zircons of 1.45 Ga age have been found also among the xenocrysts of the Volyn basalts, indicating the presence of such crust also farther to the south, in the Ukraine.

## RODINIAN ASPECTS

Current Rodinia reconstructions have confirmed previous ideas that Laurentia, Greenland, Baltica (*i.e.* the EEC) and Amazonia were in close positios in the Rodinia configuration (Pisarevsky *et al.* 2003). Recently, Oaxaquia in southern Mexico has been recognized as a new member in the realm of continental blocks that composed south-eastern Rodinia ca. 1.0 Ga ago. That unit was situated between Amazonia and Baltica.

In the EEC, direct evidence of a Rodinia-related collisional event at that time is found in the Sveconorwegian orogen in south-western Fennoscandia (Fig. 1). Also the Volyn-Orsha Aulacogen and the Central Russian rift system appear to have been formed in connection with the final assembly and break-up of Rodinia between ca. 1.0 and 0.75 Ga.

Discussing the occurrence of possible evidence of Rodinia-related processes along the TESZ, Żelaźniewicz (1998). He has noted the presence of many crustal blocks in SE

Poland and beneath the Carpathians Mountains that could be outboard fragments of the EEC detached during the break-up of Rodinia in the Neoproterozoic. Studies of the provenance of detrital zircons in Middle Cambrian platform-type sediments in the Holy Cross Mountains (Valverde-Vaquero *et al.* 2000) have also suggested that some relic fragments of Baltica may still exist along its boundary with the Phanerozoic orogenic belts of Western Europe.

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