The Neoproterozoic Timanide Orogen of eastern Baltic: introduction

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This volume was conceived during EUROPROBE’s investigations into the dynamic evolution of the Palaeozoic Uralide Orogen and relationships northwards into the Eurasian high Arctic. During these European Science Foundation studies, the preservation of Neoproterozoic deformation over large regions of northern Europe became increasingly apparent. This mainly Vendian tectonic event is referred to as the Timanian Orogeny and became the focus of many recent and on-going investigations. Much progress has been made in understanding Timanian Orogeny and a Memoir synthesizing our current knowledge is not only timely, but also relevant to Neoproterozoic global tectonic reconstructions.

The type area for the Timanide Orogen is located in the Timan Range of northwestern Russia, which separates the East European Craton from the Pechora Basin and Polar Urals. The orogen extends over a distance of at least 3000 km, from the southern Ural Mountains of Kazakhstan to the Varanger Peninsula of northernmost Norway, flanking the eastern margin of the older craton (Fig. 1). From the Timan Range, it reaches northeastwards below the thick Phanerozoic successions of the Pechora Basin and Barents Shelf (O’Leary et al. 2004), and reappears in the Polar Ural Mountains and northwards through Pai Khoi to Novaya Zemlya. Timanian orogeny thus influenced a vast region of northwestern Russia. The Phanerozoic cover, Arctic shelf areas and, further east, Uralian deformation, obscure the importance of this orogenic event for the geodynamic evolution of Europe.

The Timanide Orogen has been referred to by various other names, most frequently as the ‘Baikalian’. The term ‘Baikalian Orogeny’, with a type area along the southern margin of the Siberian Craton, was introduced by Edelstein (1923) and promoted by Shatsky (1963), and suggested a tectonic event that started in the Late Precambrian and finished in the Early Palaeozoic. Other authors prefer to restrict ‘Baikalian’ events to those that took place in the Neoproterozoic time interval of 850–650 Ma (e.g. Khomentovsky 2002). The term ‘Baikalian’ has also been used to designate a late Precambrian stratigraphic system in Siberia, corresponding to the Cryogenian of the IUGS International Stratigraphic Chart (2000). To avoid ambiguity, we advocate the use of the term ‘Timanian’ Orogeny to describe the late Neoproterozoic tectonic events documented along the eastern margin of the East European Craton, best exemplified in the Timan–Pechora region, and restrict the use of the term Baikalian to tectonic events associated with Siberia.

For much of the last century, the domino hypothesis for the evolution of northwestern Europe has explained Timanian tectono-thermal activity in terms of rift basin (aulacogen) inversion. Thick Neoproterozoic and partly Mesoproterozoic sedimentary successions were described and interpreted to separate blocks of older Precambrian crust that previously had been a part of the Archaean and Palaeoproterozoic core of Europe. Thus, Stille (1958) inferred that the Timanides were a result of deformation between the Fennoscandian Craton and an outboard continent, which he called Barentsia. Subsequent geophysical studies, particularly potential field, but also seismic, suggested a more complex crustal evolution. Deep drilling (up to c. 5 km) of the Pechora Basin provided convincing evidence (Belyakova & Stepanenko 1991) that a broad belt of calc-alkaline igneous rocks flanked terrigenous slope-to-basin deposits of the Timan Range. Late Neoproterozoic granites carry Grenville-age zircon xenocrysts and complexes of this age were shown to exist further towards the hinterland within the Palaeozoic allochthons of the Subarctic Urals. Late Neoproterozoic ophiolites, albeit fragmented, were described from the Polar Urals (Dushin 1997). Thus, despite powerful resistance (e.g. Ivanov & Rusin 2000), an alternative hypothesis has emerged that favours the existence of a Timanian accretionary orogen, on the eroded roots of which were deposited the early to mid-Palaeozoic rifted and passive margin successions which flanked the Uralian ocean. Continent–ocean collision played an important role in the orogenic process and some authors (e.g. Sengor et al. 1993) have speculated on the possible continuity between the ‘Timanian’ and Uralian oceans; however, the question remains unresolved.

The studies of the Timanides included in this Memoir are structured to provide a comprehensive overview of the orogen. The first three contributions treat the pre-Timanian rifted margin of the East European Craton. Roberts et al. describe the Neoproterozoic passive margin sedimentary successions of the Kanin Peninsula, and northern and central parts of the Timan Range. Maslov provides comprehensive descriptions of the Mesoproterozoic and Neoproterozoic (Riphean–Vendian) stratigraphy preserved within the Uralian foreland and western flank of the Ural Mountains, making regional correlations to the Timan–Pechora area. Grazhdankin follows with an overview of the late Neoproterozoic differential subsidence patterns of the East European Craton in the Mezin Basin SW of the Timan Range, significantly relating this to development of a Timanian foreland basin in the late Vendian. The magmatic, metamorphic and structural evolution of the Timanide Orogen is described regionally, divided into the Timan Range, the Pechora Basin, and Ural Mountains. Roberts & Olovyanishnikov present the structural and tectonic development of the Timanide Orogen in the Timan region. Larionov et al. present U–Pb ages on an alkaline igneous suite in northern Timan which provides constraints on the beginning of Timanian orogeny. Using Neoproterozoic high-grade metamorphic rocks from the Kanin Peninsula, Lorenz et al. document P/T conditions associated with Timanian orogenesis.

In the Pechora Basin region, drillcore samples of pre-Palaeozoic basement provide the foundations for our understanding of the pre-Palaeozoic events. Belyakova & Stepanenko’s paper (1991) documenting the different structural and metamorphic zones within the basement to the Pechora Basin, is particularly important. New geochemical evidence from Dovzhikova et al. (2004) suggests that the Precambrian mafic complexes in the Pechora zone represent Neoproterozoic oceanic crust, probably accreted during Timanian orogenesis. Pease et al. provide geochemical evidence for the calc-alkaline affinity of Vendian granitoid rocks which are interpreted to indicate late-orogenic westward subduction beneath north-eastern Baltic at about 560 Ma.
Fig. 1. Geological map of the eastern margin of Baltica, showing the extent of the Timanides from the southern Urals to Novaya Zemlya and the Varanger Peninsula (VP).
Within the Ural Mountains, the evidence for Timanian orogeny is fragmentary and the contributions are geographically restricted to the Polar and Northern Urals. Glodny et al. report Timanian protolith ages within the eclogitized Marun-Keu complex and to the Polar and Northern Urals. Glodny regional Early Palaeozoic unconformity across the Timanides is fragmentary and the contributions are geographically restricted interpreting the timing of orogeny and the post-Timanian tectonic framework. Beckholmen & Glodny follow with a description of, and age constraints for, blueschist metamorphism in the pre-Ordovician basement to the Kvarkush anticline, also interpreted within a Timanian tectonic framework.

The sections on Timanian Orogeny are followed by descriptions of post-Timian platform successions, which are important for interpreting the timing of orogeny and the post-Timanian return to a passive margin setting. These include assessment of the regional Early Palaeozoic unconformity across the Timanides (Bogolepova & Gee), as well as Late Cambrian age constraints from acritarchs of Kolguev Island on post-Timanian deposition (Moczydłowska et al.). Finally, regional correlations are explored in which it is concluded that Timanian Orogeny does not extend to Svalbard (Gee & Tehenkov; Johansson et al.), but is present on Novaya Zemlya (Korago et al.). Work in progress also suggests it influences Franz Josef land basement (Pease et al. 2001). Comparison is made between the Neo- and Neoproterozoic passive margin of western Baltic, in the Scandinavian Caledonides, and contemporaneous orogeny in the Timanides (Siedlecka et al.). Similarities in the Neoproterozoic tectonic evolution of Baltic and Siberia are also explored (Vernikovsky et al.).

Syntheses of Timanian orogenic evolution have been provided by several authors (e.g. Sengör et al. 1993; Roberts & Siedlecka 2002; Dovzhikova et al. 2004; Gee 2004). The contributions presented in this Memoir will promote further elaboration. In pursuing research on the Timanides, critical aspects related to this orogeny have been identified for future work. The nature of the hinterland beneath the Pechora Basin and as it is exposed in the Ural Mountains needs more investigation. Determining the role and extent of subduction along the orogen and characterization of the arc-related magmatic rocks remain a critical point. Future collaborative studies with Russian partners which seek to understand Timanian orogenesis better will undoubtedly contrib-

ute significantly to a clearer understanding of its role in the tectonic evolution of Baltic.

Several different geological timescales are in routine use within the scientific community at present. Though the use of the IUGS International Stratigraphic Chart (2000) has been encouraged, the older International Stratigraphic Chart of Plumb (1991), as well as the Russian timescale (Keller & Chumakov 1983) in which Riphean and Vendian are used to subdivide parts of the Precambrian, have also been used. For the convenience of the reader, we provide a cross-reference for these three timescales (Fig. 2). Additionally, the International Commission of Stratigraphy has recently revised the Precambrian timescale (Gradstein et al. 2004), but it has not yet received wide usage. Regarding nomenclature and especially the translation of Russian stratigraphic terms, a few more years are needed to achieve consensus on these matters.

References


