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Constraints on the Devonian–Carboniferous closure of the Rheic Ocean from a multi-method geochronology study of the Staré Město Belt in the Sudetes (Poland and the Czech Republic)

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ABSTRACT

This paper attempts to clarify the complex nature of how and when the Rheic Ocean closed in what is now Central Europe and, with respect to the various terranes that were involved, offer a regional chronology for the associated structural, metamorphic and igneous processes that accompanied and followed this closure. The Variscan orogen in Europe originated from the multiple collisions of Gondwana-derived terranes (the Armorican Terrane Assemblage) with Laurussia: however, many important structural details on the timing of these collision-related events remain obscure. In the Sudetes, the Staré Město Belt represents a WNW-dipping part of the Rheic suture that developed from the continental collision of the eastern terranes of the Armorican Terrane Assemblage (now in the Bohemian Massif) with the Brunovistulian Terrane (a part of Laurussia/Old Red Continent). In this study, the results of monazite Th–U–total Pb, garnet Lu–Hf and zircon U–Pb geochronology were integrated into a newly established D1–D3 tectonometamorphic sequence. A Th–U–total Pb age of ~368 Ma from a monazite that grew concurrently with D2 metasedimentary garnet, as well as Lu–Hf ages of ~361 Ma and ~355 Ma obtained from D2 metasedimentary garnets, implies that the regional contractional deformation and progressive metamorphism of D2 took place mainly during the Famennian (Late Devonian) and extended into the Visean (Middle Mississippian of the Early Carboniferous). The ion probe U–Pb zircon ages of ~355 Ma and ~359 Ma obtained from leucocratic neosomes in migmatized amphibolites confirmed a lag in the peak temperature that followed crustal thickening during D1–D2. Metamorphic monazites dated at ~340 Ma provide a time for the subsequent D3 dextral transpressional regime. The closure of the Staré Město Belt segment of the Rheic Ocean probably resulted from a head-on hard collision between the westerly subducting Brunovistulian promontory of Laurussia and the eastern members of the Armorican Terrane Assemblage. Thus, the Rheic Ocean closed during the Late Devonian at ~370–360 Ma and preceded the collision of the Armorican Terrane Assemblage with East Avalonia at the western margin of what is now the Bohemian Massif. Following ocean closure, the Rheic slab may have broken off, resulting in the suture zone becoming dominated by lateral "tectonic escape" movements of the colliding terranes at ~340–330 Ma (Visean). Syntectonic D3 intrusions of granodiorite/tonalite magma acted as a hot lubricant and stitched the suture zone together.

1. Introduction

The Variscan orogenic belt comprises Gondwana-derived terranes that have been variously referred to as the Armorican Terrane Assemblage (see review in Fatka and Mergl, 2009; Keppie et al., 2003; Tait et al., 1997) or as Cadomia (Linnemann et al., 2007; Murphy et al., 2004). These terranes were accreted to Laurussia (the Old Red Continent) during the Carboniferous (Fig. 1a), and it was during this period that the Paleozoic Rheic Ocean between Gondwana and Laurussia finally closed (Linnemann et al., 2007; Nance et al., 2010; Stampfli et al., 2002; von Raumer et al., 2003). In central Europe, the Rheic Ocean suture is taken to be Carboniferous in age and can be traced along the northwestern, northern, and eastern margins of the Bohemian Massif (Finger et al., 1998; Linnemann et al., 2007) (Fig. 1b). However, an evidence from inside the massif shows that even during the late Devonian, the Armorican (Cadomian) terranes had rotated and started to mutually collide (e.g. Franke, 2000; Matte et al., 1990). More recently, Jastrzębski (2012) has suggested that the collision between the Gondwana-derived Bohemian Massif terranes and the Laurussian continent took place along the Brunovistulian segment

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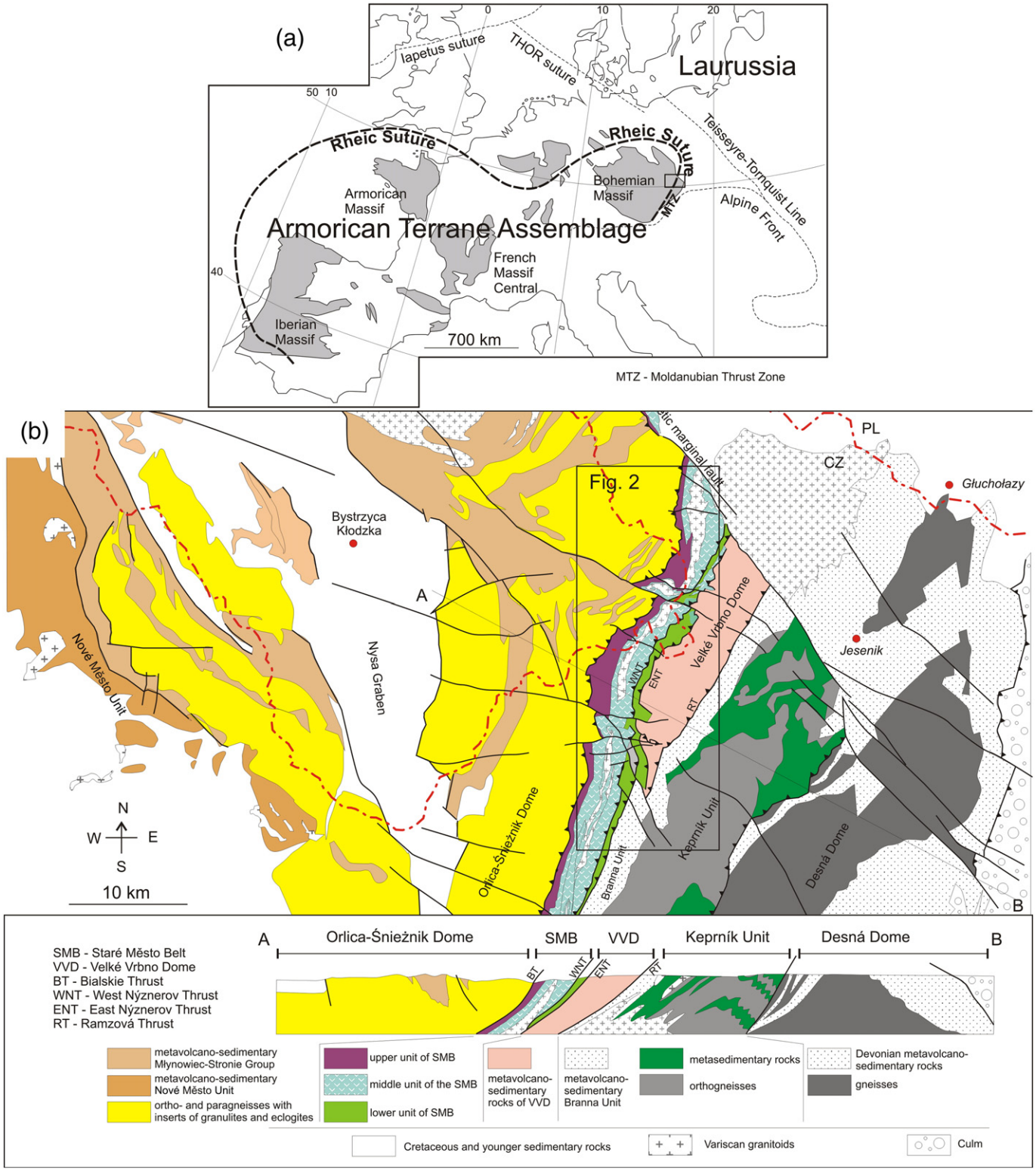

Fig. 1. (a) Location of the Rheic suture and Variscan Massifs in central Europe (modified after Linneman et al., 2007) — rectangular box shows the area discussed in the paper. (b) Location of the Staré Město Belt and geology of the boundary area between the Orlica–Śnieżnik Dome and the Moravo-Silesian domain (after Schulmann and Gayer, 2000; Don et al., 2003).

of the Rheic suture before the end of the Devonian and that it continued into the Carboniferous. This latter interpretation will be geochronologically tested in this paper and the differing models of Variscan closure of the Rheic Ocean will be discussed.

One of the key Cadomian terranes that must be unraveled to give a clearer idea on how exactly the Rheic Ocean closed is the Brunovistulian terrane (also variously known as "Brunovistulicum" or "Brunia"). Previous studies have not always been in agreement as to its status and affinities. Dudek (1980, 1988) considered that it was involved in the Variscan orogen as a type of Cadomian basement to the Moravo-Silesian Zone. But subsequent paleogeographic reconstructions left the ultimate derivation of the Brunovistulian terrane uncertain. For example, provenance studies using acritarch fauna (Moczydłowska, 1997) and single grain U–Pb zircon ages (Finger et al., 2000; Friedl et al., 2000) prompted