Geol. Mag. **149** (*3*), *2012, pp. 443–458.* © *Cambridge University Press 2011*
doi:10.1017/S0016756811000744

Detrital zircon populations in quartzites of the Krkonoše–Jizera Massif: implications for pre-collisional history of the Saxothuringian Domain in the Bohemian Massif

ELIŠKA ŽÁČKOVÁ*‡†, JIŘÍ KONOPÁSEK*, JAN KOŠLER*§ & PETR JEŘÁBEK*‡

*Czech Geological Survey, Klárov 3, 118 21 Prague, Czech Republic
‡Institute of Petrology and Structural Geology, Charles University, Albertov 6, 128 43 Prague, Czech Republic
§Centre for Geobiology and Department of Earth Science, University of Bergen, Allegaten 41, N-5007 Bergen, Norway

(*Received* 12 August 2010; *accepted* 21 March 2011; *first published online* 13 September 2011)

Abstract – Age spectra of detrital zircons from metamorphosed quartzites of the Krkonoše–Jizera Massif in the northeastern part of the Saxothuringian Domain were obtained by U–Pb laser ablation inductively coupled plasma mass spectrometry dating. The zircon ages cluster in the intervals of 450–530 Ma and 550–670 Ma, and show individual data between 1.6 and 3.1 Ga. Zircons in the analysed samples are predominantly of Cambrian–Ordovician and Neoproterozoic age, and the marked peak at *c*. 525–500 Ma suggests a late Cambrian maximum age for the sedimentary protolith. Detritus of the quartzites probably originated from the erosion of Cambrian–Ordovician granitoids and their Neoproterozoic (meta)sedimentary or magmatic country rocks. The lack of Neoproterozoic (meta)sedimentary rocks in the central and eastern part of the Krkonoše–Jizera Massif suggests that the country rocks to voluminous Cambrian–Ordovician magmatic bodies were largely eroded during the formation of early Palaeozoic rift basins along the southeast passive margin of the Saxothuringian Domain. The detrital zircon age spectra confirm the previous interpretation that the exposed basement, dominated by Neoproterozoic to Cambrian–Ordovician granitoids, was overthrust during Devonian–Carboniferous subduction–collision processes by nappes composed of metamorphosed equivalents of the uppermost Cambrian–Devonian passive margin sedimentary formations. Only a negligible number of Mesoproterozoic ages, typically from the Grenvillian event, supports the interpretation that the Saxothuringian Neoproterozoic basement has an affinity to the West African Craton of the northwestern margin of Gondwana.

Keywords: detrital zircon, laser ablation ICP-MS, Saxothuringian Domain, Bohemian Massif.

1. Introduction

The Saxothuringian Domain (Saxothuringian Zone, *sensu* Kossmatt, 1927) represents a block of Neoproterozoic–early Palaeozoic continental crust that collided during the Variscan orogeny with the core of the Bohemin Massif (Franke, 1989, 2000; Matte *et al*. 1990; Schulmann *et al*. 2009). The early Palaeozoic evolution of the Saxothuringian crust has been associated with its rifting from the northern Gondwana margin during late Cambrian time (e.g. Furnes *et al*. 1994; Kachlík & Patočka, 1998; Linnemann *et al*. 2000; Franke, 2000; Mazur & Aleksandrowski, 2001; Schulmann *et al*. 2009), although the measure of separation of the Saxothuringian Domain from the Gondwana mainland is a matter of debate (cf. e.g. Franke, 2000 and Linnemann *et al*. 2004). Apart from sedimentation of Cambrian and thick Ordovician sequences (Linnemann *et al*. 2000), the rifting process was accompanied by pronounced igneous activity resulting in synsedimentary volcanism and intrusion of numerous Cambrian–Ordovician plutons into the Neoproterozoic basement (Kröner *et al*. 2001; Tichomirowa *et al*. 2001; Mingram *et al*. 2004; Košler *et al*. 2004; Pin *et al*. 2007).

The interpretation of the pre-Variscan Palaeozoic evolution of the entire Saxothuringian Domain is more straightforward along its northwestern flank owing to the absence of intense tectonometamorphic overprint during Devonian and early Carboniferous times. There, the Saxothuringian Domain is represented by unmetamorphosed Neoproterozoic sedimentary rocks and locally exposed granitoids, which are unconformably overlain by a pile of Palaeozoic sedimentary and synsedimentary volcanic rocks (see e.g. Falk, Franke & Kurze, 1995; Franke, 2000; Linnemann *et al*. 2000). The southeastern flank of the Saxothuringian Domain is represented by medium- to high-grade metamorphic rocks that were thrust over the Neoproterozoic–early Palaeozoic basement during the Carboniferous collision with the easterly exposed rocks of the Teplá-Barrandian Domain (e.g. Franke, 1989, 2000; Matte *et al*. 1990; Mazur, 1995; Mazur & Kryza, 1996; Seston *et al*. 2000; Mazur & Aleksandrowski, 2001; Konopásek & Schulmann, 2005; Mazur *et al*. 2006; Schulmann *et al*. 2009; Žáčková *et al*. 2010; Mlčoch & Konopásek, 2010). This general scheme is valid for the central and southwestern part (southwest of the Elbe Zone) of the Saxothuringian Domain, as well as for its

†Author for correspondence: eliska.zackova@geology.cz

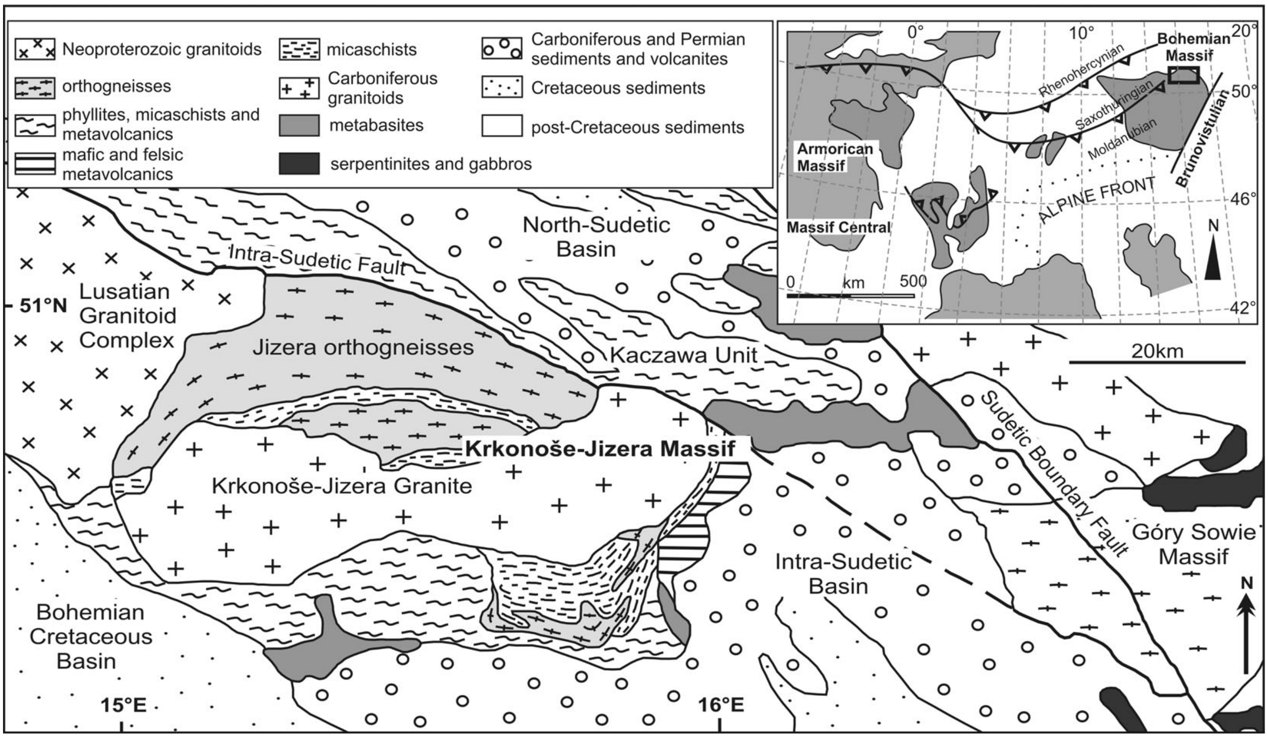

Figure 1. Simplified geological map of the West Sudetes (modified after Aleksandrowski *et al.* 1997) with its location within the European Variscides (in right upper corner).

northeastern part represented by the Lusatian Complex and the West Sudetes (Fig. 1).

The protolith age and depositional setting of the intensely deformed, low- to medium-grade pre-Variscan sedimentary rocks in the West Sudetes has been a widely discussed topic (Chaloupský *et al.* 1989; Chlupáč, 1993, 1997; Winchester *et al.* 1995, 2003; Kryza *et al.* 2007; Kryza, Mazur & Pin, 1995; Kachlík & Patočka, 1998; Patočka, Fajst & Kachlík, 2000; Mazur & Aleksandrowski, 2001; Hladil *et al.* 2003; Kryza & Zalasiewicz, 2008; Oberc-Dziedzic *et al.* 2010). In this work we contribute to this discussion and present new results from the dating of detrital zircon populations in metaquartzite samples from the southern part of the Krkonoše–Jizera Massif (Fig. 1). The resulting age spectra, interpreted as reflecting maximum sedimentary ages of the studied rocks, are compared with the protolith, xenocryst and detrital zircon ages from neighbouring rock complexes of the Saxothuringian basement. Finally, we discuss the existing interpretations of the palaeogeographic affinity of the Saxothuringian continental crustal block prior to its rifting from the Gondwana supercontinent during early Palaeozoic time.

2. Geological setting

The Krkonoše–Jizera Massif belongs to the group of several lithotectonic units defined in the West Sudetes in the north of the Bohemian Massif (Fig. 1). These units are inferred to be a collage of terranes amalgamated during the Variscan orogeny (Narębski, 1994) within the NW-verging orogenic wedge (Kachlík & Patočka, 1998; Mazur & Aleksandrowski, 2001; Mazur *et al.* 2006 and references therein). The works of Mazur (1995), Seston *et al.* (2000), Mazur & Aleksandrowski (2001) and Žáčková *et al.* (2010) suggested that the Krkonoše–Jizera Massif of the West Sudetes can be subdivided into four major tectonic units. The parautochthonous unit consists of Jizera orthogneisses (Fig. 1). The lowermost thrust sheet is exposed structurally above the Jizera orthogneiss in the southeastern part of the Krkonoše–Jizera Massif (Fig. 2). It consists mostly of micaschists with or without garnet with subordinate bodies of orthogneisses, quartzites, calcsilicates and marbles. A recent petrological study of garnet-bearing samples suggested blueschist-facies metamorphism in the range of 18–19 kbar and 460–520 °C (Žáčková *et al.* 2010). The middle thrust sheet (Fig. 2) consists of garnet-free micaschists, phyllites and marbles with a high proportion of metavolcanic rocks that show blueschist-facies metamorphism reaching conditions of 300–530 °C and 6.5–12 kbar (Cháb & Vrána, 1979; Guiraud & Burg, 1984; Kryza, Muszynski & Vielzeuf, 1990; Smulikowski, 1995; Patočka, Pivec & Oliveriová, 1996). A thick orthogneiss slab is apparently present at the contact of these two thrust sheets (Fig. 2). The uppermost thrust sheet (Fig. 2) is dominated by mafic and felsic meta-igneous rocks (the Lesczcyniec Complex) with a low intensity of deformation (Mazur, 1995; Kryza & Mazur, 1995; Seston *et al.* 2000).

The schists and gneisses of the thrust sheets were interpreted as metamorphosed magmato-sedimentary sequences deposited during intracontinental rifting of the Cadomian basement and subsequent development

https://doi.org/10.1017/S0016756811000744 Published online by Cambridge University Press

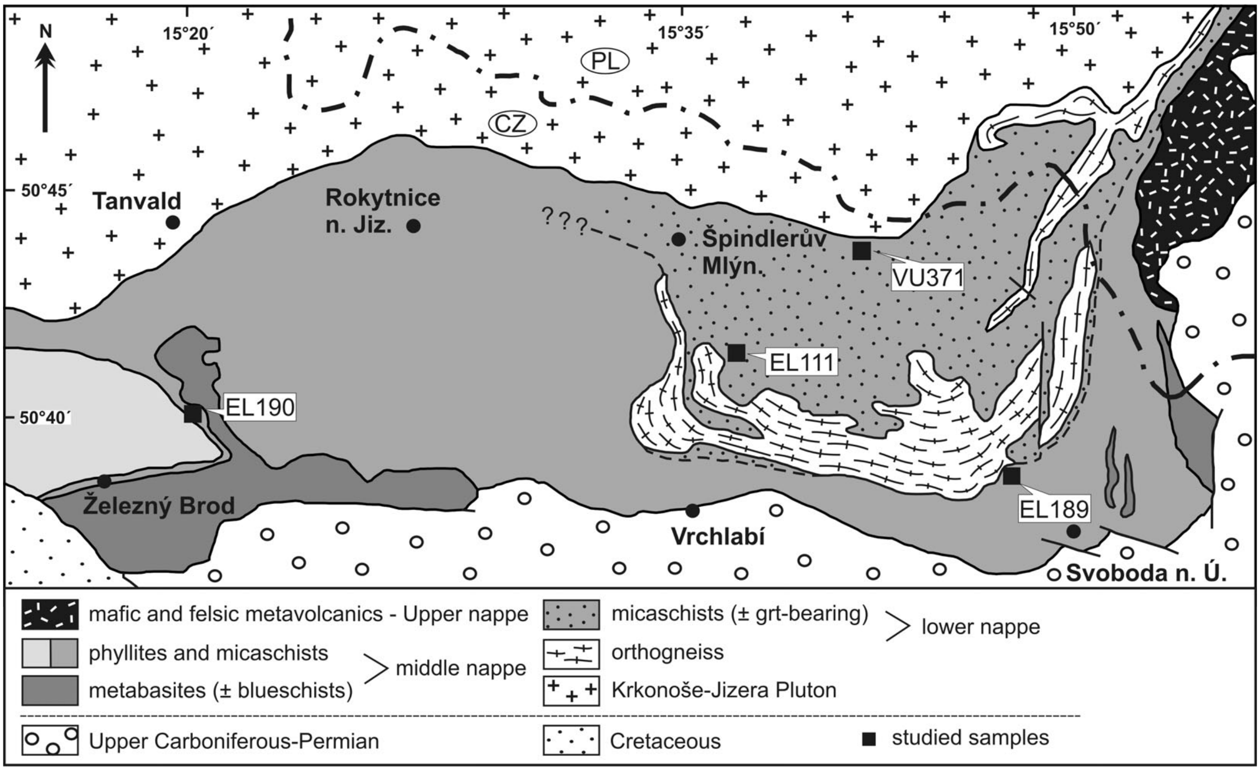

Figure 2. Simplified geological map of the studied part of the Krkonoše–Jizera Complex (modified after Kachlík & Kozdroj 2001) with location of analysed samples (solid squares) EL190 (50° 40.784′ N, 15° 17.814 E; WGS84), EL111 (50° 40.989′ N, 15° 37.175′ E; WGS84), VU371 (50° 44.005′ N, 15° 39.758′ E; WGS84) and EL189 (50° 38.436′ N, 15° 46.604′ E; WGS84).

of an oceanic basin (Kryza, Mazur & Pin, 1995; Kryza *et al*. 2007; Winchester *et al*. 1995; Kachlík & Patočka, 1998; Patočka, Fajst & Kachlík, 2000; Dostál, Patočka & Pin, 2001; Kryza & Pin, 2010). The rifting phase is strongly suggested by the presence of large volumes of meta-igneous rocks, including basic lavas and volcaniclastic rocks partly with MORB affinities, and felsic rocks of within-plate signature (Winchester *et al*. 1995; Patočka & Pin, 2005; Dostál, Patočka & Pin, 2001). Protoliths of the metavolcanic rocks were dated using various geochronological methods as late Cambrian–Early Ordovician (Bendl & Patočka, 1995; Oliver, Corfu & Krogh, 1993; Kozdrój *et al*. 2005).

The metasedimentary and metavolcanic sequences of the Krkonoše–Jizera Massif have been divided by Chaloupský (1989) into four lithostratigraphic groups of Mesoproterozoic to early Carboniferous age. This interpretation, however, has been revised by the detailed work of Kachlík (1996) and Winchester *et al*. (2003), who disproved most of the lithostratigraphic arguments for this subdivision and combined most of the central and eastern Krkonoše–Jizera Massif metasedimentary rocks into a single unit of Cambrian–Ordovician to Silurian–Devonian age. Moreover, an apparent lack of pre-Palaeozoic metasedimentary rocks in the structurally lowermost part of the Krkonoše–Jizera Massif was suggested by Oberc-Dziedzic *et al*. (2010), who presented late Cambrian (∼ 500 Ma) zircon age spectra from a quartzo-feldspathic rock of the unit Chaloupský (1989) assumed to be Mesoproterozoic.

In its central part, the Krkonoše–Jizera Massif is intruded by the Variscan Krkonoše–Jizera granite pluton (Fig. 1), which was dated at 304 ± 14 Ma by Pb–Pb zircon evaporation dating (Kröner *et al*. 1994) and at ∼ 314–319 Ma by U–Pb zircon SHRIMP dating (Machowiak & Armstrong, 2007; Awdankiewicz *et al*. 2010).

3. Description of samples and their tectonometamorphic position

Detrital zircons were separated from quartzite samples collected at four localities within the southern outcrop of the Krkonoše–Jizera Massif (Fig. 2). Samples VU371 and EL111 come from the lower thrust sheet of the complex, which was recognized by Žáčková *et al*. (2010) as a high-pressure nappe metamorphosed and exhumed during early Carboniferous times (Fig. 2). Metapelites of this unit show the highest metamorphic conditions within the metamorphic complex. Samples of micaschists often contain relics of a garnet-bearing high-pressure mineral assemblage, and the peak metamorphic conditions were estimated at 18–19 kbar at 460–520 °C (Žáčková *et al*. 2010). The pressure peak was followed by decompression and cooling to temperatures lower than 480 °C and pressures lower than 8.5 kbar (Žáčková *et al*. 2010). The other two samples, EL189 and EL190, were collected from localities within the middle thrust sheet that consists mostly of garnet-free micaschists, phyllites, quartzites and numerous bodies of marbles. Metabasites with

https://doi.org/10.1017/S0016756811000744 Published online by Cambridge University Press

relics of blueschist-facies metamorphism appear along the outer flank of this unit (Fig. 2). Some metapelitic samples bear garnet-free mineral assemblages with chloritoid and paragonite, and estimated *P–T* conditions suggest blueschist-facies metamorphism at $\sim$ 11.5 kbar and 420 °C (Žáčková *et al.* 2007). However, the major proportion of rocks from this unit show a late blastesis of albite, suggesting re-equilibration during decompression. Ar–Ar dating of phengite from blueschist-facies metabasites in the easternmost part of this unit provided a Devonian age of 360 Ma, which was interpreted as the age of the high-pressure blueschist-facies metamorphism (Maluski & Patočka, 1997).

All the analysed zircons were separated from medium- to fine-grained quartzite samples with thin layers of muscovite within a recrystallized quartz matrix. Apart from zircon, other accessory minerals observed were ilmenite, pyrite, apatite, chlorite and tourmaline. Sample VU371 was collected from the Kozí hřbety locality in the northeastern part of the Krkonoše Mountains (Fig. 2), where a quartzite body occurs in the lowermost part of the micaschist-dominated lower thrust sheet. Sample EL111 comes from the Hnědá skála locality, situated northeast of Vrchlabí, in the central Krkonoše Mountains (Fig. 2), where a quartzite body is situated within the micaschists of the lower thrust sheet. Sample EL189 comes from the Modré kameny locality in the vicinity of Jánské Lázně in the southeastern Krkonoše Mountains (Fig. 2). There, a quartzite body is in direct contact with the underlying large orthogneiss slab and apparently forms the lowermost part of the phyllite-dominated middle thrust sheet with associated mafic blueschists in its hanging wall. Quartzite sample EL190 was collected in the vicinity of Machlov, northeast of the Železný Brod (Fig. 2), where a quartzite body forms the footwall of the mafic Železný Brod Volcanic Complex. The sampled quartzite, together with surrounding phyllites, is regarded as part of the middle thrust sheet.

The zircon grains from all samples differ in morphology and size, and many of them show a high degree of abrasion with moderately to strongly rounded edges and numerous scratches on the surface. Cathodoluminescence images obtained from the studied zircon crystals revealed the presence of (1) euhedral elongate to stubby grains with igneous oscillatory zoning, (2) euhedral oscillatory-zoned zircons with older, often high-U cores and (3) round equant grains with sector fir-tree zoning typical of granulite-facies rocks.

4. Laser ablation ICP-MS dating of zircons and the results

Zircons were extracted from *c.* 10 kg samples using conventional crushing, the Wilfley shaking table and heavy liquids. Handpicked zircon grains were mounted in epoxy-filled mount blocks and polished to reveal the internal structures of the grains and to obtain smooth surfaces suitable for analysis by laser ablation inductively coupled plasma source mass spectrometry (LA-ICP-MS). Isotopic analysis followed the technique described by Košler *et al.* (2002). A Thermo-Finnigan Element 2 sector field ICP-MS system coupled to a 213 Nd–YAG laser (New Wave UP-213) at Bergen University was used to measure Pb/U and Pb isotopic ratios in zircons. Raw data were corrected for dead time of the electron multiplier, processed offline in a spreadsheet-based program Lamdate (Košler *et al.* 2002) and plotted on concordia diagrams using Isoplot (Ludwig, 1999). Data processing included corrections for blank, laser-induced Pb/U fractionation and ICP-MS mass discrimination. Zircon reference materials Plešovice (337 Ma; Sláma *et al.* 2008) and GJ-1 (*c.* 609 Ma; Jackson *et al.* 2004) were periodically analysed during this study and they yielded concordia ages (Ludwig, 1998) of 340 ± 3 Ma and 616 ± 6 Ma, respectively. Only data that were less than 20 % discordant (calculated as $(100 * Age_{207Pb/206Pb}/Age_{206Pb/238U}) - 100$) were used in this study.

The U–Pb ages of zircons from sample VU371 (Kozí hřbety locality), where 60 zircon grains were analysed, show the youngest cluster of data between 450 and 500 Ma and most of the data fall between 500 and 530 Ma (Fig. 3; Table 1). Older ages are represented by individual Palaeoproterozoic data between 1.6 and 2.3 Ga. Similar data were obtained from sample EL111 from the Hnědá skála locality (56 zircons analysed). The youngest data from this locality cluster between 450 and 500 Ma (Fig. 3; Table 2). The majority of data from this sample concentrate at 500 Ma and between 590 and 660 Ma. A cluster of Palaeoproterozoic ages between 1.6 and 2.2 Ga and individual Mesoproterozoic and Archaean ages of 2.5, 3.0 and 3.1 Ga are also present. Zircon ages from sample EL189 (Jánské Lázně locality) were interpreted from 44 analyses and the youngest data cluster between 500 and 550 Ma, with the early Cambrian peak at 526 Ma (Fig. 3; Table 3). Older data are Neoproterozoic and lie in the range 590–650 Ma. Individual Palaeoproterozoic to Archaean data occur between 1.8 and 3.0 Ga. In sample EL190 from the Machlov locality, 70 zircon grains were used for interpretation. The youngest data cluster between 450 and 500 Ma and the Neoproterozoic ages appear in the range 600–670 Ma (Fig. 3; Table 4). The oldest data are represented by a cluster of Palaeoproterozoic and individual Archaean ages in the range 1.8–3.0 Ga.

5. Discussion

5.a. Sedimentation age of the quartzite protoliths

Apart from the presence of palaeontologically proven very low-grade Silurian to lower Carboniferous (meta)sedimentary rocks (see summary in Chlupáč, 1993) on the western flank of the Krkonoše–Jizera Massif (the Ještěd Mts), the only robust information about the stratigraphic age of more easterly exposed metasediments comes from the discovery of Silurian graptolites in the phosphatic concretions of the middle

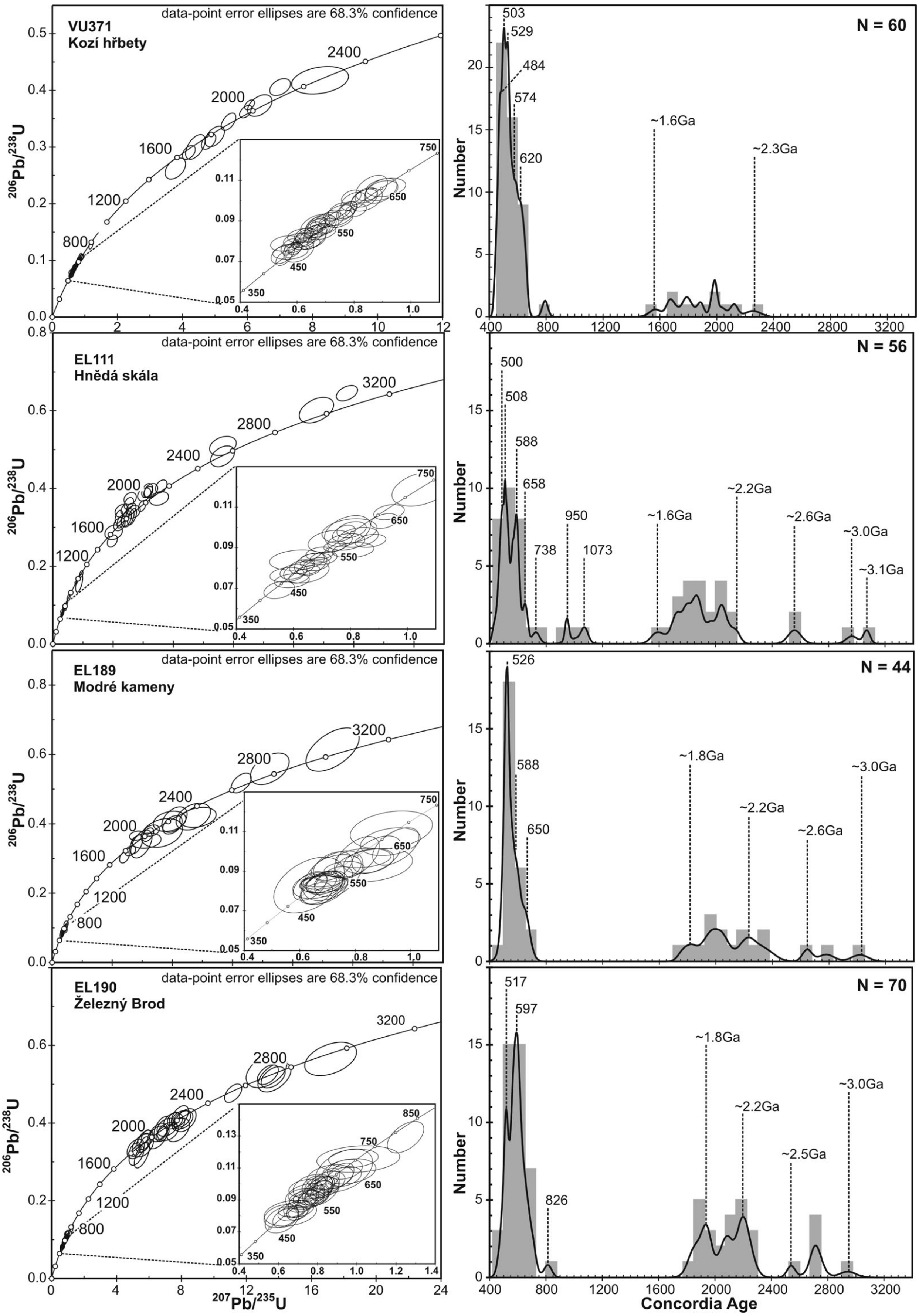

Figure 3. Concordia diagrams of detrital zircons from analysed samples (left column) with details of Neoproterozoic to early Palaeozoic data, and corresponding binned frequency and probability density distribution plots (right column, N = number of analyses).

https://doi.org/10.1017/S0016756811000744 Published online by Cambridge University Press

Table 1. Laser ablation ICP-MS U–Pb isotopic data of detrital zircons from sample VU371

	ISOTOPIC RATIOS						CALCULATED AGES Ma						
Analysis	^{207}Pb/^{235}U	± 1 sigma	^{206}Pb/^{238}U	± 1 sigma	^{207}Pb/^{206}Pb	± 1 sigma	^{207}Pb/^{235}U	± 1 sigma	^{206}Pb/^{238}U	± 1 sigma	^{207}Pb/^{206}Pb	± 1 sigma	Discord. (%)
							Sample VU371						
# 1	0.7780	0.0220	0.0953	0.0028	0.0592	0.0008	584	13	587	16	575	30	−2
# 2	4.9952	0.1963	0.3186	0.0120	0.1137	0.0013	1819	33	1783	59	1860	20	4
# 3	0.6555	0.0215	0.0829	0.0024	0.0573	0.0011	512	13	513	15	505	44	−2
# 4	0.8937	0.0378	0.1048	0.0041	0.0618	0.0012	648	20	643	24	668	40	4
# 5	0.5937	0.0161	0.0762	0.0019	0.0565	0.0009	473	10	473	11	473	36	0
# 6	6.3780	0.2487	0.3732	0.0126	0.1239	0.0020	2029	34	2045	59	2014	29	−2
# 7	0.6230	0.0240	0.0786	0.0018	0.0575	0.0017	492	15	488	11	511	71	5
# 8	0.7977	0.0285	0.0996	0.0030	0.0581	0.0012	596	16	612	17	532	41	−13
# 9	3.7849	0.2082	0.2621	0.0123	0.1047	0.0020	1590	44	1501	63	1709	33	14
# 10	0.9126	0.0455	0.1065	0.0030	0.0621	0.0024	658	24	653	18	679	82	4
# 11	0.8429	0.0259	0.1027	0.0025	0.0596	0.0012	621	14	630	15	587	44	−7
# 12	0.7229	0.0200	0.0927	0.0018	0.0566	0.0011	552	12	571	10	474	41	−17
# 13	0.7489	0.0316	0.0911	0.0028	0.0596	0.0020	568	18	562	17	591	76	5
# 14	0.6012	0.0324	0.0803	0.0024	0.0543	0.0015	478	21	498	14	382	53	−19
# 15	0.8371	0.0302	0.1012	0.0029	0.0600	0.0017	618	17	622	17	603	62	−3
# 16	0.6811	0.0366	0.0847	0.0026	0.0583	0.0029	527	22	524	15	542	116	3
# 17	0.8438	0.0368	0.1004	0.0037	0.0609	0.0019	621	20	617	22	637	73	3
# 18	0.7500	0.0266	0.0949	0.0027	0.0573	0.0010	568	15	584	16	504	39	−14
# 19	0.5830	0.0212	0.0756	0.0023	0.0559	0.0011	466	14	470	14	449	43	−4
# 20	0.5529	0.0180	0.0716	0.0024	0.0560	0.0009	447	12	446	14	452	33	1
# 21	0.5765	0.0408	0.0747	0.0024	0.0560	0.0039	462	26	464	14	451	147	−3
# 22	0.6556	0.0191	0.0859	0.0024	0.0554	0.0013	512	12	531	14	427	57	−20
# 23	8.2346	0.5789	0.4179	0.0160	0.1429	0.0043	2257	64	2251	73	2263	52	1
# 24	0.7906	0.0230	0.1018	0.0023	0.0564	0.0013	592	13	625	13	466	46	−19
# 25	0.6688	0.0213	0.0808	0.0025	0.0600	0.0011	520	13	501	15	604	40	19
# 26	0.7143	0.0324	0.0906	0.0025	0.0572	0.0018	547	19	559	15	497	72	−11
# 27	0.7053	0.0191	0.0896	0.0019	0.0571	0.0012	542	11	553	11	494	42	−11
# 28	1.1918	0.0435	0.1273	0.0049	0.0679	0.0007	797	20	773	28	865	23	12
# 29	0.8974	0.0376	0.1050	0.0033	0.0620	0.0017	650	20	643	19	675	61	5
# 30	0.5872	0.0208	0.0769	0.0017	0.0554	0.0017	469	13	477	10	429	68	−10
# 31	0.5499	0.0270	0.0737	0.0031	0.0542	0.0016	445	18	458	19	377	67	−18
# 32	0.7739	0.0233	0.0950	0.0031	0.0591	0.0013	582	13	585	18	570	45	−3
# 33	0.6748	0.0412	0.0876	0.0039	0.0559	0.0019	524	25	541	23	448	75	−17
# 34	0.6237	0.0221	0.0829	0.0024	0.0545	0.0013	492	14	514	14	393	52	−19
# 35	0.6780	0.0206	0.0854	0.0023	0.0576	0.0010	526	12	528	14	513	35	−3
# 36	4.1980	0.1321	0.2904	0.0081	0.1048	0.0016	1674	26	1644	41	1712	27	4
# 37	0.6630	0.0237	0.0869	0.0028	0.0554	0.0013	516	14	537	16	427	49	−19
# 38	5.4189	0.1486	0.3447	0.0101	0.1140	0.0014	1888	24	1909	49	1865	22	−2
# 39	6.0680	0.1022	0.3745	0.0057	0.1175	0.0010	1986	15	2051	27	1919	15	−6
# 40	0.7487	0.0340	0.0928	0.0034	0.0585	0.0021	567	20	572	20	550	79	−4
# 41	0.5729	0.0193	0.0775	0.0025	0.0536	0.0015	460	12	481	15	356	50	−20
# 42	0.8061	0.0249	0.0952	0.0021	0.0614	0.0019	600	14	586	12	653	66	11
# 43	0.6302	0.0334	0.0789	0.0020	0.0579	0.0016	496	21	490	12	527	63	8
# 44	0.6682	0.0224	0.0884	0.0024	0.0548	0.0010	520	14	546	14	404	36	−20
# 45	0.6238	0.0192	0.0824	0.0021	0.0549	0.0010	492	12	511	12	408	36	−18

Table 1. Continued.

Analysis	ISOTOPIC RATIOS $^{207}Pb/^{235}U$	±1 sigma	$^{206}Pb/^{238}U$	±1 sigma	$^{207}Pb/^{206}Pb$	±1 sigma	CALCULATED AGES Ma $^{207}Pb/^{235}U$	±1 sigma	$^{206}Pb/^{238}U$	±1 sigma	$^{207}Pb/^{206}Pb$	±1 sigma	Discord. (%)
							Sample VU371						
#46	0.6225	0.0174	0.0821	0.0016	0.0550	0.0010	491	11	509	9	411	40	−19
#47	0.7084	0.0253	0.0876	0.0025	0.0587	0.0018	544	15	541	15	554	57	2
#48	5.9504	0.1265	0.3625	0.0073	0.1190	0.0016	1969	18	1994	34	1942	24	−3
#49	4.8062	0.1470	0.3099	0.0093	0.1125	0.0021	1786	26	1740	46	1840	34	6
#50	0.6771	0.0256	0.0885	0.0030	0.0555	0.0010	525	15	547	18	432	37	−20
#51	0.6200	0.0354	0.0827	0.0024	0.0544	0.0027	490	22	512	14	386	101	−20
#52	0.6782	0.0205	0.0885	0.0019	0.0556	0.0011	526	12	547	12	435	38	−19
#53	0.6548	0.0328	0.0820	0.0039	0.0579	0.0016	511	20	508	23	526	58	4
#54	4.3993	0.1984	0.3002	0.0145	0.1063	0.0021	1712	37	1692	72	1737	35	3
#55	0.6879	0.0191	0.0857	0.0018	0.0582	0.0010	532	12	530	10	537	34	1
#56	7.2612	0.2426	0.4354	0.0160	0.1209	0.0019	2144	30	2330	72	1970	27	−15
#57	0.6075	0.0340	0.0751	0.0036	0.0587	0.0031	482	21	467	21	555	102	19
#58	7.0045	0.2118	0.4058	0.0099	0.1252	0.0021	2112	27	2196	45	2031	29	−7
#59	0.8619	0.0366	0.1062	0.0041	0.0588	0.0019	631	20	651	24	561	70	−14
#60	0.6256	0.0257	0.0805	0.0023	0.0563	0.0020	493	16	499	14	466	72	−7

thrust sheet (Horný, 1964). This information became critical in any further attempts at tectonostratigraphic subdivision of the Krkonoše–Jizera Massif.

Chaloupský (1989) suggested that the metasedimentary rocks of the lower thrust sheet are Mesoproterozoic rocks intruded by the granitoid protolith of orthogneisses exposed in the core of the complex. The metasedimentary sequences with subordinate metavolcanic rocks of the middle thrust sheet were considered by the same author as Upper Ordovician to Silurian. Based on the presence of ichnofossils, Chlupáč (1997) suggested an Ordovician age for phyllites in the eastern part of the Krkonoše–Jizera Massif, which were interpreted by Chaloupský (1989) as metamorphosed Proterozoic–lower Cambrian sediments.

Further biostratigraphic data come from marbles of the southern and eastern part of the Krkonoše–Jizera Massif. Carbonates in the easternmost part of the area provided a fragment of archaeocyath and several trilobite fragments attributed to the early Cambrian, whereas faunal microfragments in metacarbonates from the southern and central part of the complex were interpreted as Silurian–Early Devonian (Hladil *et al.* 2003).

Age spectra presented in this work show that the dominant proportion of detrital zircons from the analysed samples of both upper and lower units is Cambrian–Ordovician and Neoproterozoic in age, which is in agreement with the SHRIMP detrital zircon data by Oberc-Dziedzic *et al.* (2010). Three of the samples, EL111, EL190 and VU371, show the youngest data in the interval between *c.* 460 and 490 Ma. If these ages represent true formation ages of the youngest detrital zircons, then the sedimentary protolith cannot be older than Ordovician. Only sample EL189 from the quartzite directly overlying the Cambrian orthogneiss did not provide zircon grains younger than *c.* 500 Ma. This difference with respect to the other three analysed samples probably means that the youngest, *c.* 490–460 Ma source existed, but was not available at the time of sedimentation, or that the protolith age of the sample is somewhere between the observed 526 Ma peak and the youngest ages encountered in the other studied samples.

All the samples show a marked peak at *c.* 525–500 Ma, which is strong evidence for the early Palaeozoic age of the sedimentary protolith. As already recognized by Oberc-Dziedzic *et al.* (2010), such a finding rules out the Mesoproterozoic age suggested by Chaloupský (1989) for the lower allochthonous unit represented by samples EL111 and VU371. Thus, given the Late Devonian–early Carboniferous metamorphism of the Krkonoše–Jizera Massif (Maluski & Patočka, 1997; Marheine *et al.* 2002; Žáčková *et al.* 2010), our data, together with the earlier published zircon age data and the above-discussed palaeontological evidence, all suggest that the protolith age of metasedimentary rocks in the Krkonoše–Jizera Massif spans the interval between late Cambrian and Late Devonian time.

Occurrences of thick early Palaeozoic quartzite bodies in western Europe have been documented

Table 2. Laser ablation ICP-MS U–Pb isotopic data of detrital zircons from sample EL111

	ISOTOPIC RATIOS						CALCULATED AGES Ma						
Analysis	$^{207}Pb/^{235}U$	± 1 sigma	$^{206}Pb/^{238}U$	± 1 sigma	$^{207}Pb/^{206}Pb$	± 1 sigma	$^{207}Pb/^{235}U$	± 1 sigma	$^{206}Pb/^{238}U$	± 1 sigma	$^{207}Pb/^{206}Pb$	± 1 sigma	Discord. (%)
							Sample EL111						
# 1	0.8095	0.0484	0.0888	0.0025	0.0661	0.0044	602	27	548	15	810	134	19
# 2	0.6530	0.0263	0.0788	0.0016	0.0601	0.0023	510	16	489	10	607	87	19
# 3	0.6214	0.0242	0.0758	0.0022	0.0594	0.0018	491	15	471	13	583	77	6
# 4	0.8272	0.0472	0.0952	0.0032	0.0630	0.0023	612	26	586	19	710	84	15
# 5	5.9347	0.1681	0.3552	0.0095	0.1212	0.0014	1966	25	1959	45	1974	21	1
# 6	17.5160	0.7559	0.6015	0.0217	0.2112	0.0038	2964	41	3036	87	2915	29	−4
# 7	0.5501	0.0355	0.0692	0.0028	0.0576	0.0022	445	23	431	17	516	81	19
# 8	19.5441	0.4703	0.6451	0.0131	0.2197	0.0031	3069	23	3209	51	2979	22	−7
# 9	0.6936	0.0329	0.0872	0.0021	0.0577	0.0018	535	20	539	12	517	67	−4
# 10	0.8041	0.0342	0.0989	0.0026	0.0590	0.0017	599	19	608	15	566	66	−11
# 11	0.7972	0.0638	0.0982	0.0040	0.0589	0.0026	595	36	604	24	562	92	−4
# 12	3.9495	0.2199	0.2650	0.0103	0.1081	0.0025	1624	45	1515	52	1768	42	20
# 13	0.7772	0.0263	0.0972	0.0026	0.0580	0.0016	584	15	598	15	530	62	−12
# 14	0.6607	0.0374	0.0821	0.0035	0.0583	0.0023	515	23	509	21	543	102	−10
# 15	7.0582	0.4186	0.3744	0.0116	0.1367	0.0043	2119	53	2050	54	2186	54	7
# 16	0.7857	0.0432	0.0929	0.0027	0.0613	0.0026	589	25	573	16	651	92	14
# 17	6.5138	0.2954	0.3946	0.0121	0.1197	0.0031	2048	40	2144	56	1952	47	−9
# 18	11.2785	0.5264	0.4829	0.0177	0.1694	0.0032	2546	44	2540	77	2552	31	1
# 19	0.9199	0.0319	0.1032	0.0024	0.0647	0.0015	662	17	633	14	763	48	20
# 20	0.6814	0.0298	0.0820	0.0021	0.0603	0.0020	528	18	508	13	614	77	16
# 21	6.3377	0.2041	0.3911	0.0094	0.1175	0.0021	2024	28	2128	44	1919	31	−7
# 22	5.3446	0.3041	0.3400	0.0107	0.1140	0.0036	1876	49	1887	52	1864	57	0
# 23	0.7455	0.0258	0.0907	0.0017	0.0596	0.0018	566	15	560	10	589	67	6
# 24	0.8706	0.0360	0.0934	0.0021	0.0676	0.0023	636	20	576	12	856	74	17
# 25	1.5449	0.0522	0.1582	0.0027	0.0708	0.0019	948	21	947	15	953	54	1
# 26	1.8867	0.0769	0.1801	0.0055	0.0760	0.0017	1076	27	1068	30	1094	45	1
# 27	5.2619	0.1964	0.3275	0.0140	0.1165	0.0028	1863	32	1826	68	1903	41	8
# 28	4.8849	0.2317	0.3226	0.0132	0.1098	0.0040	1800	40	1803	64	1796	64	3
# 29	4.5817	0.2945	0.3425	0.0108	0.0970	0.0031	1746	54	1899	52	1568	56	−12
# 30	0.6455	0.0528	0.0782	0.0037	0.0599	0.0033	506	33	485	22	599	127	17
# 31	1.0489	0.0680	0.1190	0.0056	0.0639	0.0027	728	34	725	32	739	91	−1
# 32	0.7899	0.0531	0.0983	0.0050	0.0583	0.0033	591	30	604	29	541	128	−14
# 33	6.0727	0.2930	0.3848	0.0111	0.1144	0.0022	1986	42	2099	51	1871	34	−10
# 34	0.6005	0.0314	0.0782	0.0024	0.0557	0.0018	478	20	485	14	440	69	−4
# 35	7.2016	0.2546	0.4054	0.0111	0.1288	0.0027	2137	32	2194	51	2082	36	−4
# 36	11.3005	0.5889	0.5095	0.0162	0.1609	0.0035	2548	49	2655	69	2465	36	−5
# 37	1.7447	0.1537	0.1565	0.0154	0.0808	0.0044	1025	57	937	86	1218	129	10
# 38	0.7292	0.0513	0.0931	0.0036	0.0568	0.0024	556	30	574	21	484	87	−10
# 39	4.4181	0.2527	0.3082	0.0112	0.1040	0.0026	1716	47	1732	55	1696	45	0
# 40	0.6300	0.0289	0.0807	0.0023	0.0566	0.0019	496	18	500	14	477	71	−1
# 41	0.6131	0.0641	0.0839	0.0033	0.0530	0.0028	486	40	520	20	328	94	−20
# 42	4.0383	0.3855	0.2875	0.0125	0.1019	0.0052	1642	78	1629	63	1658	93	3
# 43	0.5944	0.0407	0.0738	0.0023	0.0584	0.0023	474	26	459	14	546	77	19
# 44	5.1998	0.2127	0.3478	0.0097	0.1084	0.0029	1853	35	1924	46	1773	48	−7
# 45	4.5107	0.1684	0.3147	0.0108	0.1040	0.0024	1733	31	1764	53	1696	42	−3

Table 2. Continued.

Analysis	ISOTOPIC RATIOS						CALCULATED AGES Ma						
	$^{207}Pb/^{235}U$	±1 sigma	$^{206}Pb/^{238}U$	±1 sigma	$^{207}Pb/^{206}Pb$	±1 sigma	$^{207}Pb/^{235}U$	±1 sigma	$^{206}Pb/^{238}U$	±1 sigma	$^{207}Pb/^{206}Pb$	±1 sigma	Discord. (%)
Sample EL111													
#46	0.5776	0.0395	0.0767	0.0024	0.0546	0.0021	463	25	477	14	395	77	−7
#47	5.0520	0.2066	0.3616	0.0101	0.1013	0.0027	1828	35	1990	48	1648	48	−17
#48	4.3825	0.1636	0.3272	0.0112	0.0971	0.0022	1709	31	1825	55	1570	42	−13
#49	0.7054	0.0315	0.0848	0.0021	0.0603	0.0025	542	19	525	13	615	84	17
#50	5.1348	0.2732	0.3744	0.0102	0.0995	0.0031	1842	45	2050	48	1614	57	−20
#51	0.6794	0.0353	0.0848	0.0016	0.0581	0.0022	526	21	525	10	533	78	7
#52	0.9356	0.0357	0.1076	0.0025	0.0631	0.0021	671	19	659	14	711	59	18
#53	4.7344	0.1398	0.3461	0.0083	0.0992	0.0013	1773	25	1916	40	1610	25	−16
#54	0.6497	0.0172	0.0824	0.0011	0.0572	0.0015	508	11	511	7	498	59	−1
#55	4.9801	0.2769	0.3244	0.0155	0.1113	0.0021	1816	47	1811	75	1821	35	−1

in the Lower Ordovician strata. These quartzites belonging to the Armorican Quartzite Formation are believed to document the opening of the Rheic Ocean (Linnemann *et al.* 2008), and their protoliths are often sedimented after the so-called Cadomian unconformity. According to Linnemann *et al.* (2008), a quartzite from Central Iberia–Ossa Morena transition zone contains the youngest detrital zircon of 522 ± 7 Ma within the lower Cambrian cluster following the most abundant Neoproterozoic zircons and small amount of zircons of Archaean and Palaeoproterozoic age. Similar zircon populations were found also in quartzites of the Saxothuringian Domain (Linnemann *et al.* 2007), which are attributed to widely distributed Lower Ordovician shallow marine sedimentation of the Gondwanan realm.

5.b. Source rocks and the Saxothuringian passive margin dynamics

The presented data indicate that the detritus most probably came from eroded Cambrian–Ordovician granitoids and from their Neoproterozoic (meta)sedimentary or magmatic country rocks. This is also consistent with the presence of igneous oscillatory zoning in most of the studied euhedral zircon grains and fir-tree sector zoning, typical of high-grade metamorphic zircons, in most of the oval detrital grains. The apparent absence of metasedimentary rocks with Neoproterozoic protoliths in the central and eastern part of the Krkonoše–Jizera Massif and the direct contact of the early Palaeozoic metasedimentary rocks with the Cambrian metagranitoids suggest complete erosion of the Neoproterozoic sedimentary country rocks during the development of the early Palaeozoic rift basin in this part of the Saxothuringian passive margin. Our data from detrital zircons suggest that the thrust sheets overlying the Cambrian–Ordovician granitoid intrusions of the Krkonoše–Jizera Massif represent metamorphosed equivalents of the uppermost Cambrian–Devonian passive margin sediments (cf. Mazur & Aleksandrowski, 2001; Winchester *et al.* 2003).

In the Saxothuringian Domain, there is no evidence for basement rocks older than Neoproterozoic. Thus, sporadic Mesoproterozoic–Archaean zircon grains in the studied samples were presumably recycled from Neoproterozoic basement sediments or they represent former xenocrysts in the Cambrian–Ordovician granitoids.

5.c. 'Grenvillian' ages in the West Sudetes and the palaeogeographic affinity of the Saxothuringian Domain

The current opinion on the palaeogeographic affinity of the Saxothuringian Domain can be divided into two contrasting theories. Hegner & Kröner (2000), Kröner *et al.* (2001) and Mingram *et al.* (2004) suggested that the early Palaeozoic granitoids of the Saxothuringian Domain were largely generated

https://doi.org/10.1017/S0016756811000744 Published online by Cambridge University Press

Table 3. Laser ablation ICP-MS U–Pb isotopic data of detrital zircons from sample EL189

	ISOTOPIC RATIOS						CALCULATED AGES Ma						
Analysis	$^{207}Pb/^{235}U$	± 1 sigma	$^{206}Pb/^{238}U$	± 1 sigma	$^{207}Pb/^{206}Pb$	± 1 sigma	$^{207}Pb/^{235}U$	± 1 sigma	$^{206}Pb/^{238}U$	± 1 sigma	$^{207}Pb/^{206}Pb$	± 1 sigma	Discord. (%)
							Sample EL189						
# 1	7.2980	0.9094	0.3738	0.0275	0.1416	0.0107	2149	111	2047	129	2247	121	17
# 2	0.6857	0.0572	0.0834	0.0028	0.0596	0.0045	530	34	516	16	590	155	20
# 3	0.7599	0.0477	0.0909	0.0027	0.0607	0.0040	574	28	561	16	627	151	6
# 4	0.6754	0.0459	0.0844	0.0023	0.0580	0.0039	524	28	522	14	531	115	17
# 5	6.3834	0.2454	0.3689	0.0129	0.1255	0.0036	2030	34	2024	61	2036	50	2
# 6	0.8286	0.0659	0.0967	0.0032	0.0622	0.0049	613	37	595	19	680	158	19
# 7	7.8123	0.7189	0.4074	0.0193	0.1391	0.0102	2210	83	2203	88	2216	122	4
# 8	0.6653	0.0595	0.0829	0.0045	0.0582	0.0057	518	36	513	27	537	204	10
# 9	9.7023	0.8013	0.4187	0.0191	0.1681	0.0094	2407	76	2255	87	2538	97	10
# 10	0.9299	0.0978	0.1108	0.0064	0.0608	0.0049	668	51	678	37	634	180	−9
# 11	6.2679	0.6502	0.3514	0.0145	0.1294	0.0127	2014	91	1941	69	2089	169	10
# 12	5.1996	0.2379	0.3220	0.0093	0.1171	0.0052	1853	39	1799	45	1913	79	6
# 13	0.6788	0.0494	0.0849	0.0018	0.0580	0.0041	526	30	525	11	530	148	6
# 14	5.6467	0.3296	0.3660	0.0086	0.1119	0.0062	1923	50	2011	41	1830	98	−7
# 15	0.8677	0.0915	0.0931	0.0056	0.0676	0.0071	634	50	574	33	857	275	19
# 16	6.6288	0.3368	0.3806	0.0107	0.1263	0.0051	2063	45	2079	50	2047	70	1
# 17	0.6830	0.0534	0.0837	0.0030	0.0592	0.0044	529	32	518	18	575	143	11
# 18	5.5909	0.2843	0.3407	0.0181	0.1190	0.0037	1915	44	1890	87	1942	57	0
# 19	0.8482	0.0596	0.0951	0.0042	0.0647	0.0032	624	33	585	24	765	127	8
# 20	8.1393	0.5541	0.4124	0.0242	0.1432	0.0055	2247	62	2226	111	2266	67	1
# 21	0.8766	0.0585	0.0984	0.0062	0.0646	0.0023	639	32	605	36	761	99	−2
# 22	0.6590	0.0389	0.0788	0.0036	0.0606	0.0033	514	24	489	21	627	134	13
# 23	0.7040	0.0340	0.0848	0.0032	0.0602	0.0023	541	20	525	19	610	85	12
# 24	0.6903	0.0451	0.0842	0.0039	0.0595	0.0029	533	27	521	23	584	98	12
# 25	0.6526	0.0315	0.0842	0.0029	0.0562	0.0018	510	19	521	17	461	81	−12
# 26	4.8074	0.2155	0.3044	0.0114	0.1145	0.0024	1786	38	1713	57	1873	38	9
# 27	12.5678	0.4455	0.5178	0.0189	0.1760	0.0028	2648	33	2690	80	2616	27	−4
# 28	14.4769	0.8536	0.5585	0.0301	0.1880	0.0036	2781	56	2861	124	2725	32	−6
# 29	9.3893	0.7575	0.4209	0.0255	0.1618	0.0103	2377	74	2265	116	2474	113	5
# 30	0.7194	0.0713	0.0877	0.0083	0.0595	0.0050	550	42	542	49	586	151	19
# 31	0.6340	0.0841	0.0830	0.0093	0.0554	0.0061	499	52	514	55	429	208	−2
# 32	0.8054	0.0536	0.0970	0.0070	0.0602	0.0032	600	30	597	41	612	108	7
# 33	5.9378	0.4662	0.3417	0.0265	0.1260	0.0113	1967	68	1895	127	2043	163	5
# 34	0.6780	0.0356	0.0839	0.0033	0.0586	0.0025	526	22	519	20	553	112	−10
# 35	0.7219	0.0450	0.0848	0.0050	0.0617	0.0032	552	27	525	30	665	129	11
# 36	0.7187	0.0459	0.0926	0.0048	0.0563	0.0032	550	27	571	28	464	92	9
# 37	0.6363	0.0397	0.0825	0.0048	0.0559	0.0028	500	25	511	29	450	89	8
# 38	0.9458	0.0552	0.1025	0.0063	0.0669	0.0027	676	29	629	37	835	92	20
# 39	8.0019	0.4296	0.3970	0.0176	0.1462	0.0046	2231	48	2155	81	2302	53	7
# 40	5.5987	0.2543	0.3299	0.0176	0.1231	0.0028	1916	39	1838	85	2001	42	5
# 41	0.9262	0.0712	0.1049	0.0046	0.0640	0.0042	666	38	643	27	742	155	4
# 42	18.6519	1.1677	0.6139	0.0413	0.2203	0.0088	3024	60	3086	165	2983	65	−3
# 43	0.6885	0.0566	0.0817	0.0056	0.0611	0.0036	532	34	506	33	643	139	18
# 44	0.6837	0.0512	0.0815	0.0056	0.0608	0.0034	529	31	505	33	633	141	8

Table 4. Laser ablation ICP-MS U–Pb isotopic data of detrital zircons from sample EL190

	ISOTOPIC RATIOS						CALCULATED AGES Ma						
Analysis	$^{207}Pb/^{235}U$	± 1 sigma	$^{206}Pb/^{238}U$	± 1 sigma	$^{207}Pb/^{206}Pb$	± 1 sigma	$^{207}Pb/^{235}U$	± 1 sigma	$^{206}Pb/^{238}U$	± 1 sigma	$^{207}Pb/^{206}Pb$	± 1 sigma	Discord. (%)
							Sample EL190						
# 1	0.6930	0.0273	0.0822	0.0021	0.0611	0.0020	535	16	509	12	644	77	15
# 2	7.1530	0.4303	0.3782	0.0153	0.1372	0.0063	2131	54	2068	72	2192	82	4
# 3	7.9857	0.3832	0.4107	0.0142	0.1410	0.0051	2229	43	2218	65	2240	61	3
# 4	1.0074	0.1399	0.1156	0.0055	0.0632	0.0070	708	71	705	32	716	264	−8
# 5	0.8381	0.0466	0.0964	0.0023	0.0630	0.0030	618	26	593	14	709	96	20
# 6	0.9832	0.0836	0.1160	0.0038	0.0615	0.0043	695	43	707	22	656	140	0
# 7	7.5075	0.2473	0.4103	0.0118	0.1327	0.0038	2174	30	2216	54	2134	49	−2
# 8	0.6735	0.0473	0.0838	0.0030	0.0583	0.0029	523	29	519	18	540	96	17
# 9	13.6497	0.4900	0.5178	0.0180	0.1912	0.0037	2726	34	2690	77	2753	31	3
# 10	0.7020	0.0399	0.0837	0.0041	0.0609	0.0023	540	24	518	24	634	87	16
# 11	0.7288	0.0520	0.0928	0.0028	0.0569	0.0036	556	31	572	17	489	135	−12
# 12	17.1951	1.0549	0.5651	0.0284	0.2207	0.0088	2946	59	2888	117	2986	64	4
# 13	0.7446	0.0590	0.0906	0.0036	0.0596	0.0036	565	34	559	21	589	122	13
# 14	0.6354	0.0421	0.0787	0.0040	0.0586	0.0028	499	26	488	24	551	104	14
# 15	0.9395	0.0589	0.1091	0.0041	0.0625	0.0040	673	31	668	24	690	133	5
# 16	0.6848	0.0288	0.0827	0.0026	0.0601	0.0018	530	17	512	16	606	62	18
# 17	15.5111	0.5478	0.5816	0.0206	0.1934	0.0045	2847	34	2955	84	2772	38	−6
# 18	0.7767	0.0668	0.0983	0.0051	0.0573	0.0041	584	38	605	30	503	146	−10
# 19	5.8078	0.1888	0.3651	0.0116	0.1154	0.0023	1948	28	2007	55	1885	35	−5
# 20	0.7383	0.0559	0.0972	0.0036	0.0551	0.0026	561	33	598	21	415	86	−17
# 21	0.7822	0.0403	0.0992	0.0040	0.0572	0.0031	587	23	610	23	500	125	−18
# 22	0.7463	0.0726	0.0922	0.0054	0.0587	0.0044	566	42	569	32	556	161	−1
# 23	13.2374	0.8281	0.5344	0.0286	0.1797	0.0068	2697	59	2760	120	2650	63	−4
# 24	0.9142	0.0473	0.1050	0.0053	0.0631	0.0032	659	25	644	31	713	112	6
# 25	0.6615	0.0881	0.0817	0.0053	0.0587	0.0058	516	54	506	32	556	241	−1
# 26	5.2217	0.2965	0.3177	0.0174	0.1192	0.0036	1856	48	1778	85	1944	54	8
# 27	0.7668	0.0599	0.0916	0.0040	0.0607	0.0037	578	34	565	24	628	128	15
# 28	5.6960	0.2092	0.3450	0.0132	0.1197	0.0026	1931	32	1911	63	1952	40	1
# 29	13.3211	0.4291	0.5244	0.0169	0.1842	0.0036	2703	30	2718	71	2691	32	0
# 30	0.7536	0.0347	0.0909	0.0033	0.0601	0.0028	570	20	561	20	607	104	4
# 31	5.1816	0.3511	0.3332	0.0165	0.1128	0.0055	1850	58	1854	80	1845	85	2
# 32	0.9366	0.0576	0.1047	0.0041	0.0649	0.0034	671	30	642	24	771	114	17
# 33	6.8351	0.2639	0.3716	0.0125	0.1334	0.0039	2090	34	2037	59	2143	50	6
# 34	0.6190	0.0568	0.0776	0.0055	0.0579	0.0034	489	36	482	33	524	135	6
# 35	0.7679	0.0443	0.0919	0.0033	0.0606	0.0026	579	25	567	20	625	95	9
# 36	8.2348	0.4417	0.4073	0.0196	0.1466	0.0062	2257	49	2203	90	2307	74	3
# 37	0.9615	0.0896	0.1079	0.0052	0.0646	0.0051	684	46	660	30	763	176	10
# 38	6.5789	0.3338	0.3723	0.0134	0.1282	0.0046	2057	45	2040	63	2073	64	0
# 39	7.1071	0.4095	0.3892	0.0154	0.1324	0.0065	2125	51	2119	71	2131	87	0
# 40	7.4903	0.3853	0.4055	0.0136	0.1340	0.0049	2172	46	2195	62	2150	63	−1
# 41	0.8127	0.0412	0.0966	0.0036	0.0610	0.0028	604	23	595	21	639	81	16
# 42	7.8225	0.2515	0.3976	0.0107	0.1427	0.0033	2211	29	2158	50	2260	40	4
# 43	0.7222	0.0475	0.0882	0.0039	0.0594	0.0034	552	28	545	23	582	152	−12
# 44	0.7837	0.0345	0.0931	0.0041	0.0611	0.0022	588	20	574	24	642	91	−3
# 45	5.1541	0.2336	0.3317	0.0115	0.1127	0.0023	1845	39	1846	56	1844	36	1

https://doi.org/10.1017/S0016756811000744 Published online by Cambridge University Press

Table 4. Continued.

	ISOTOPIC RATIOS						CALCULATED AGES Ma						
Analysis	$^{207}Pb/^{235}U$	± 1 sigma	$^{206}Pb/^{238}U$	± 1 sigma	$^{207}Pb/^{206}Pb$	± 1 sigma	$^{207}Pb/^{235}U$	± 1 sigma	$^{206}Pb/^{238}U$	± 1 sigma	$^{207}Pb/^{206}Pb$	± 1 sigma	Discord. (%)
							Sample EL190						
# 46	0.8448	0.0449	0.0982	0.0046	0.0624	0.0024	622	25	604	27	689	78	20
# 47	0.8558	0.0378	0.1031	0.0045	0.0602	0.0021	628	21	632	26	612	81	−12
# 48	0.6154	0.0582	0.0799	0.0047	0.0559	0.0041	487	37	495	28	447	167	−11
# 49	0.8075	0.0453	0.0947	0.0048	0.0619	0.0025	601	25	583	28	670	85	17
# 50	0.8634	0.0780	0.1043	0.0051	0.0600	0.0046	632	43	640	30	605	188	−15
# 51	6.5202	0.4188	0.3667	0.0216	0.1290	0.0033	2049	57	2014	102	2084	45	3
# 52	1.2484	0.0616	0.1293	0.0065	0.0700	0.0029	823	28	784	37	930	83	19
# 53	0.8049	0.0463	0.0988	0.0041	0.0591	0.0027	600	26	608	24	569	84	8
# 54	5.6514	0.3035	0.3489	0.0163	0.1175	0.0048	1924	46	1929	78	1918	72	0
# 55	11.1858	0.3507	0.4768	0.0157	0.1701	0.0025	2539	29	2513	68	2559	24	2
# 56	0.8159	0.0468	0.0977	0.0047	0.0606	0.0035	606	26	601	28	624	110	16
# 57	0.8520	0.0580	0.1011	0.0044	0.0611	0.0036	626	32	621	26	643	110	17
# 58	13.7335	0.6721	0.5178	0.0250	0.1924	0.0066	2732	46	2690	106	2762	56	4
# 59	0.8151	0.0609	0.0955	0.0059	0.0619	0.0039	605	34	588	35	672	138	13
# 60	6.7905	0.3236	0.3869	0.0198	0.1273	0.0029	2084	42	2109	92	2061	39	−1
# 61	0.8252	0.0402	0.0970	0.0049	0.0617	0.0026	611	22	597	29	664	100	3
# 62	0.7447	0.0340	0.0894	0.0046	0.0604	0.0024	565	20	552	27	618	81	18
# 63	7.9034	0.3491	0.4177	0.0180	0.1372	0.0040	2220	40	2250	82	2193	49	1
# 64	8.0950	0.4043	0.4083	0.0154	0.1438	0.0050	2242	45	2207	71	2273	61	2
# 65	5.6172	0.4322	0.3424	0.0194	0.1190	0.0054	1919	66	1898	93	1941	84	−1
# 66	7.7933	0.4575	0.3822	0.0200	0.1479	0.0047	2207	53	2086	93	2322	56	10
# 67	5.7661	0.3134	0.3566	0.0165	0.1173	0.0048	1941	47	1966	78	1915	69	2
# 68	9.4022	0.5310	0.3952	0.0200	0.1726	0.0067	2378	52	2147	92	2583	66	20
# 69	5.5562	0.3087	0.3174	0.0218	0.1270	0.0055	1909	48	1777	106	2056	77	14
# 70	0.9344	0.0964	0.1084	0.0088	0.0625	0.0050	670	51	663	51	692	153	14

by melting of basement spanning *c.* 1.0–1.4 Ga, which is known as the Grenvillian event in the Amazonian Craton and the Sveconorwegian event in the southwestern Baltic Shield. This interpretation is based on the ages of xenocrystic zircons and their apparent correspondence with Nd model ages of these granitoids. In accordance with these data, the authors mentioned above interpreted the West Sudetes and Erzgebirge as a part of eastern Avalonia, which was probably rifted off the northern Amazonian Craton. In contrast, Tichomirowa *et al.* (2001) did not find any Grenvillian-age zircon xenocrysts in late Neoproterozoic rocks of the Erzgebirge and suggested their affinity to the West African Craton. The West African provenance of Saxothuringian Neoproterozoic and lower Palaeozoic sediments was also proposed by Linnemann *et al.* (2004) based on the absence of Grenvillian ages in age spectra obtained by the SHRIMP U–Pb geochronology of detrital and inherited zircon grains.

Only a few data from our analysed samples fall into the time interval 0.9–1.4 Ga typical of the Grenvillian event, and the pre-Palaeozoic age frequency histograms are nearly identical (differing only in the frequency of particular age groups) to the data published by Linnemann *et al.* (2004, 2007) for the Lugian and Saxothuringian sedimentary rocks and also with the data for the Neoproterozoic–Palaeozoic sediments in the Teplá–Barrandian Domain (Drost *et al.* 2004, 2010). The pattern obtained by dating of detrital zircons from the Krkonoše–Jizera Massif quartzites (Fig. 3) shows good correlation with a summary of the protolith and xenocryst zircon ages from magmatic rocks, and of the detrital zircon ages from the Neoproterozoic sediments of the Saxothuringian Domain (Fig. 4). On the other hand, this pattern is very different from xenocrystic and detrital zircon populations presented by Hegner & Kröner (2000) and Mingram *et al.* (2004) characterized by a large number of Grenvillian ages. Separation of the Pb–Pb evaporation ages from the set of pooled protolith and detrital data from the Saxothuringian Domain rocks (Fig. 4) clearly shows that the Mesoproterozoic ages between 1.0 and 1.4 Ga were mostly obtained by zircon evaporation that does not allow the recognition of discordant data and represents only the minimum age of the dated grain. A very good fit of our data with the pooled results of U–Pb dating of pre-Variscan granitoids and detrital zircon populations in Neoproterozoic sediments of the Saxothuringian Domain is in accord with the interpretation of, for example, Kachlík & Patočka (1998), Winchester *et al.* (2003) and Oberc-Dziedzic *et al.* (2010) that the Krkonoše–Jizera Massif metasedimentary rocks represent metamorphosed lower Palaeozoic deposits of the Saxothuringian passive margin. Finally, the lack of Grenvillian ages in dated detrital zircons supports the conclusion of Linnemann *et al.* (2004) that the Saxothuringian Neoproterozoic basement (as a source region for the early Palaeozoic detritus of our samples)

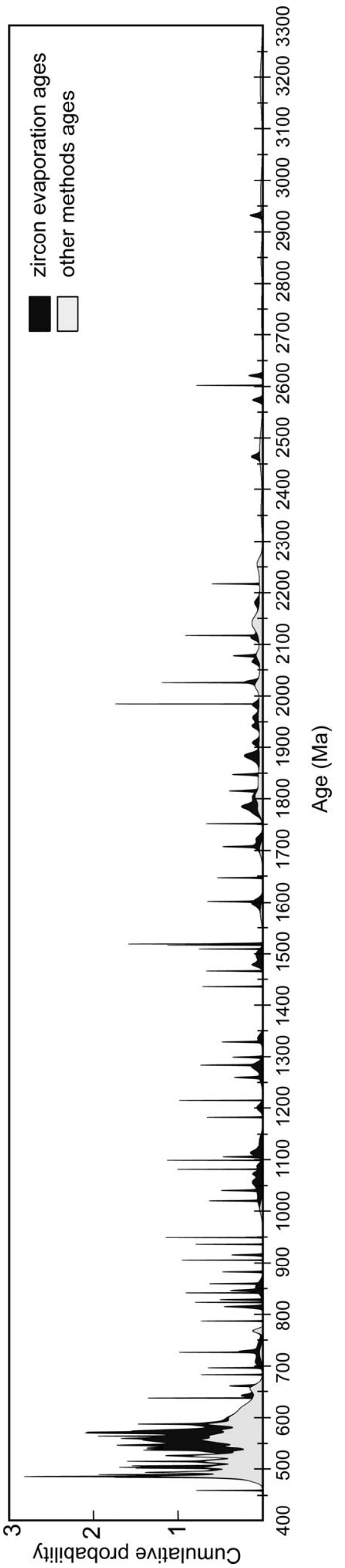

Figure 4. Distribution of the protolith and xenocryst zircon ages from magmatic rocks, and of the detrital zircon ages from the Neoproterozoic sediments of the Saxothuringian Domain presented as a cumulative probability plot (see text for references). The black area represents the results of Pb–Pb zircon evaporation dating, whereas the grey area corresponds to the results obtained by U–Pb zircon dating methods.

https://doi.org/10.1017/S0016756811000744 Published online by Cambridge University Press

has an affinity to the northern margin of Gondwana occupied by the West African Craton.

Acknowledgements. The authors very much appreciate the constructive reviews provided by R. Kryza and S. Mazur. This work was supported by internal projects No. 390001 and 325900 of the Czech Geological Survey. EZ and JK also appreciate financial support from the Ministry of Education, Youth and Sports of the Czech Republic through the Research Centre 'Advanced Remedial Technologies and Processes' (identification code 1M0554). PJ acknowledges the Research Plan No. MSM0021620855 by the Ministry of Education, Youth and Sports of the Czech Republic.

References

ALEKSANDROWSKI, P., KRYZA, R., MAZUR, S. & ŻABA, J. 1997. Kinematic data on major Variscan strike-slip faults and shear zones in the Polish Sudetes, northeast Bohemian Massif. *Geological Magazine* **134**, 727–39.

AWDANKIEWICZ, M., AWDANKIEWICZ, H., KRYZA, R. & RODIONOV, R. 2010. SHRIMP zircon study of a micromonzodiorite dyke in the Karkonosze Granite, Sudetes (SW Poland): age constraints for late Variscan magmatism in Central Europe. *Geological Magazine* **147**, 77–85.

BENDL, J. & PATOČKA, F. 1995. The $^{87}Rb/^{86}Sr$ isotope geochemistry of the metamorphosed bimodal volcanic association of the Rýchory Mts. Crystalline Complex, West Sudetes, Bohemian Massif. *Geologica Sudetica* **29**, 3–18.

CHÁB, J. & VRÁNA, S. 1979. Crossite-actinolite amphiboles of the Krkonoše–Jizera crystalline complex and their geological significance. *Věštník Ústředního ústavu geologického* **54**, 143–50.

CHALOUPSKÝ, J. (ed.) 1989. *Geology of the Krkonoše and Jizerské Hory Mountains*. Praha: Ústřední ústav geologický (in Czech with English summary).

CHLUPÁČ, I. 1993. Stratigraphic evaluation of some metamorphic units in the N part of the Bohemian Massif. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen* **188**, 363–88.

CHLUPÁČ, I. 1997. Paleozoic ichnofossils in phyllites near Železný Brod, northerm Bohemia. *Journal of the Czech Geological Society* **42**, 75–94.

DOSTÁL, J., PATOČKA, F. & PIN, C. 2001. Middle/Late Cambrian intracontinental rifting in the central West Sudetes, NE Bohemian Massif (Czech Republic): geochemistry and petrogenesis of the bimodal metavolcanic rocks. *Geological Journal* **36**, 1–17.

DROST, K., GERDES, A., JEFFRIES, T., LINNEMANN, U. & STOREY, C. 2010. Provenance of Neoproterozoic and early Paleozoic siliciclastic rocks of the Teplá-Barrandian unit (Bohemian Massif): evidence from U–Pb detrital zircon ages. *Gondwana Research*, doi:10.1016/j.gr.2010.05.003.

DROST, K., LINNEMANN, U., MCNAUGHTON, N., FATKA, O., KRAFT, P., GEHMLICH, M., TONK, C. & MAREK, J. 2004. New data on the Neoproterozoic – Cambrian geotectonic setting of the Tepla-Barrandian volcano-sedimentary successions: geochemistry, U–Pb zircon ages, and provenance (Bohemian Massif, Czech Republic). *International Journal of Earth Sciences* **93**, 742–57.

FALK, F., FRANKE, W. & KURZE, M. 1995. Stratigraphy. In *Pre-Permian Geology of Central and Eastern Europe* (eds R.D. Dallmeyer, W. Franke & K. Weber), pp. 221–34. Berlin-Heidelberg: Springer-Verlag.

FRANKE, W. 1989. Tectonostratigraphic units in the Variscan belt of central Europe. *Geological Society of America Special Papers* **230**, 67–90.

FRANKE, W. 2000. The mid-European segment of the Variscides: tectonostratigraphic units, terrane boundaries and plate tectonic evolution. In *Orogenic Processes: Quantification and Modelling in the Variscan Belt of Central Europe* (eds W. Franke, V. Haak, O. Oncken & D. Tanner), pp. 35–56. Geological Society of London, Special Publication no. 179.

FURNES, H., KRYZA, R., MUSZYNSKI, A., PIN, C. & GARMANN, L. B. 1994. Geochemical evidence for progressive rift-related early Paleozoic volcanism in the western Sudetes. *Journal of the Geological Society, London* **151**, 91–109.

GUIRAUD, M. & BURG, J. P. 1984. Mineralogical and petrological study of a blueschist metatuff from the Zelezny Brod Crystalline Complex, Czechoslovakia. *Neues Jahrbuch für Mineralogie – Abhandlungen* **149**, 1–12.

HEGNER, E. & KRÖNER, A. 2000. Review of Nd isotopic data and xenocrystic and detrital zircon ages from the pre-Variscan basement in the eastern Bohemian Massif: speculations on palinspastic reconstructions. In *Orogenic Processes: Quantification and Modelling in the Variscan Belt of Central Europe* (eds W. Franke, V. Haak, O. Oncken & D. Tanner), pp. 113–30. Geological Society of London, Special Publication no. 179.

HLADIL, J., PATOČKA, F., KACHLÍK, V., MELICHAR, R. & HUBAČÍK, M. 2003. Metamorphosed carbonates of Krkonoše Mountains and Paleozoic evolution of Sudetic terranes (NE Bohemia, Czech Republic). *Geologica Carpatica* **54**, 281–97.

HORNÝ, J. R. 1964. The Middle Cambrian Pelagiellacea of Bohemia (Mollusca). *Sborník Národního Muzea v Praze* **20**, 133–40.

JACKSON, S. E., PEARSON, N. J., GRIFFIN, W. L. & BELOUSOVA, E. A. 2004. The application of laser ablation-inductively coupled plasma-mass spectrometry to in situ U-Pb zircon geochronology. *Chemical Geology* **211**, 47–69.

KACHLÍK, V. 1996. Lithostratigraphy and architecture of the Zelezny Brod Crystaline Unit: result of Variscan tectonodeformation (in Czech). *Zprávy o geologických výzkumech vroce 1996*, 30–1.

KACHLÍK, V. & KOZDROJ, W. 2001. Ještěd Range Unit. In *Comments on the Geological map Lauzitz-Jizera-Karkonozse (without Cenozoic sediments)* (eds W. Kozdroj, O. Krentz & M. Opletal), pp. 27–31. Freiberg: Sächsisches Landesamt für Umwelt und Geologie/Bereich Boden und Geologie; Warzsawa: Panstvowy Institut Geologiczny; Praha: Český geologický ústav.

KACHLÍK, V. & PATOČKA, F. 1998. Cambrian/Ordovician intracontinental rifting and Devonian closure of the rifting generated basins in the Bohemian Massif realms. *Acta Universitatis Carolinae Geologica* **42**, 433–41.

KONOPÁSEK, J. & SCHULMANN, K. 2005. Contrasting Early Carboniferous field geotherms: evidence for accretion of a thickened orogenic root and subducted Saxothuringian crust (Central European Variscides). *Journal of the Geological Society, London* **162**, 463–70.

KOŠLER, J., BOWES, D. R., KONOPÁSEK, J. & MÍKOVÁ, J. 2004. Laser ablation ICPMS dating of zircons in Erzgebirge orthogneisses: evidence for Early Cambrian and Early Ordovician granitic plutonism in the western Bohemian Massif. *European Journal of Mineralogy* **16**, 15–22.

KOŠLER, J., FONNELAND, H., SYLVESTER, P., TUBRETT, M. & PEDERSEN, R. B. 2002. U–Pb dating of detrital zircons for sediment provenance studies-a comparison of laser ablation ICPMS and SIMS techniques. *Chemical Geology* **182**, 605–18.

KOSSMAT, F. 1927. Gliederung des varistischen Gebirgsbaues. *Abhandlungen des Sächsischen Geologischen Landesamtes* **1**, 1–39.

KOZDRÓJ, W., TURNIAK, K., TICHOMIROVA, M., BOMBACH, K., KACHLÍK, V. & ZIÓŁKOWSKA-KOZDRÓJ, M. 2005. New $^{207}Pb/^{206}Pb$ zircon ages from the East Karkonosze Metamorphic Complex, West Sudetes – evidence of the Late Cambrian–Early Ordovician magmatism. *Geolines* **19**, 69–70.

KRÖNER, A., HEGNER, E., HAMMER, J., HAASE, G., BIELICKI, K.-H., KRAUSS, M. & EIDAM, J. 1994. Geochronology and Nd-Sr systematics of Lusatian granitoids: significance for the evolution of the Variscan orogen in east-central Europe. *Geologische Rundschau* **83** 357–76.

KRÖNER, A., JAECKEL, P., HEGNER, E. & OPLETAL, M. 2001. Single zircon ages and whole-rock Nd isotopic systematics of early Palaeozoic granitoid gneisses from the Czech and Polish Sudetes (Jizerské hory, Krkonoše and Orlice-Sněnik Complex). *International Journal of Earth Sciences* **90**, 304–24.

KRYZA, R. & MAZUR, S. 1995. Contrasting metamorphic paths in the SE part of the Karkonosze-Izera block (Western Sudetes, SW Poland). *Neues Jahrbuch für Mineralogie – Abhandlungen* **169**, 157–92.

KRYZA, R., MAZUR, S. & PIN, C. 1995. Leszczyniec meta-igneous complex in the eastern part of the Karkonosze-Izera Block, Western Sudetes: trace element and Nd isotope study. *Neues Jahrbuch für Mineralogie – Abhandlungen* **170**, 59–74.

KRYZA, R., MUSZYNSKI, A. & VIELZEUF, D. 1990. Glaucophane-bearing assemblage overprinted by greenschist-facies metamorphism in the Variscan Kaczawa complex, Sudetes, Poland. *Journal of Metamorphic Geology* **8**, 344–55.

KRYZA, R. & PIN, C. 2010. The Central-Sudetic ophiolites (SW Poland): petrogenetic issues, geochronology and palaeotectonic implications. *Gondwana Research* **17**, 292–305.

KRYZA, R. & ZALASIEWICZ, J. 2008. Records of Precambrian–Early Palaeozoic volcanic and sedimentary processes in the Central European Variscides: a review of SHRIMP zircon data from the Kaczawa succession (Sudetes, SW Poland). *Tectonophysics* **461**, 60–71.

KRYZA, R., ZALASIEWICZ, J., MAZUR, S., ALEKSANDROWSKI, P., SERGEEV, S. & LARIONOV, A. 2007. Precambrian crustal contribution to the Variscan accretionary prism of the Kaczawa Mountains (Sudetes, SW Poland): evidence from SHRIMP dating of detrital zircons. *International Journal of Earth Sciences* **96**, 1153–62.

LINNEMANN, U., GEHMLICH, M., TICHOMIROWA, M., BUSCHMANN, B., NASDALA, L., JONAS, P., LÜTZNER, H. & BOMBACH, K. 2000. From Cadomian subduction to Early Palaeozoic rifting: the evolution of Saxo-Thuringia at the margin of Gondwana in the light of single zircon geochronology and basin development (central European Variscides, Germany). In *Orogenic Processes: Quantification and Modelling in the Variscan Belt*. (eds W. Franke, V. Haak, O. Oncken & D. Tanner), pp. 131–53. Geological Society of London, Special Publication no. 179.

LINNEMANN, U., GERDES, A., DROST, K. & BUSCHMANN, B. 2007. Cadomian orogenic processes – the ultimate cause for the opening of the Rheic Ocean: constraints by Laser Ablation-ICP-MS U–Pb zircon dating and analysis of the geotectonic setting (Saxo-Thuringian zone, Bohemian massif, Germany). In *The Geology of Peri-Gondwana: The Avalonian–Cadomian Belt, Adjoining Cratons and the Rheic Ocean* (eds U. Linnemann, P. Kraft, R. D. Nance & G. Zulauf), pp. 61–96. Geological Society of America, Special Papers 423.

LINNEMANN, U., MCNAUGHTON, N. J., ROMER, R. L., GEHMLICH, M., DROST, K. & TONK, C. 2004. West African provenance for Saxo-Thuringia (Bohemian Massif): did Armorica ever leave pre-Pangean Gondwana? – U–Pb-SHRIMP zircon evidence and the Nd-isotopic record. *International Journal of Earth Sciences* **93**, 683–705.

LINNEMANN, U., PEREIRA, F., JEFFRIES, T. E., DROST, K. & GERDES, A. 2008. The Cadomian Orogeny and the opening of the Rheic Ocean: the diacrony of the geotectonic processes constrained by LA-ICP-MS U–Pb zircon dating (Ossa-Morena and Saxo-Thuringian Zones, Iberian and Bohemian Massifs). *Tectonophysics* **461**, 21–43.

LUDWIG, K. R. 1998. On the treatment of concordant uranium-lead ages. *Geochimica et Cosmochimica Acta* **62**, 665–76.

LUDWIG, K. R. 1999. *IsoplotEx v. 2.6*. Berkeley Geochronological Center Special Publications, 1a.

MACHOWIAK, K. & ARMSTRONG, R. 2007. SHRIMP U-Pb zircon age from the Karkonosze granite. *Mineralogia Polonica, Special Papers* **31**, 193–6.

MALUSKI, H. & PATOČKA, F. 1997. Geochemistry and ^{40}Ar-^{39}Ar geochronology of the mafic metavolcanic rocks from the Rychory Mountains complex (west Sudetes, Bohemian Massif): palaeotectonic significance. *Geological Magazine* **134**, 703–16.

MARHEINE, D., KACHLÍK, V., MALUSKI, H., PATOČKA, F. & ŻELAZNIEWICZ, A. 2002. The $^{40}Ar/^{39}Ar$ ages from the West Sudetes (NE Bohemian Massif): constraints on the Variscan polyphase tectonothemal development. In *Palaeozoic Amalgamation of Central Europe* (eds J. Winchester, T. Pharaoh & J. Verniers), pp. 133–55. Geological Society of London, Special Publication no. 201.

MATTE, P., MALUSKI, H., RAJLICH, P. & FRANKE, W. 1990. Terrane boundaries in the Bohemian Massif: result of large-scale Variscan shearing. *Tectonophysics* **177**, 151–70.

MAZUR, S. 1995. Structural and metamorphic evolution of the country rocks at the eastern contact of the Karkonosze granite in the southern Rudawy Janowickie Mts and Lasocki Range (in Polish with English summary). *Geologica Sudetica* **29**, 31–98.

MAZUR, S. & ALEKSANDROWSKI, P. 2001. The Teplá(?)/Saxothuringian suture in the Karkonosze-Izera massif, Western Sudetes, Central European Variscides. *International Journal of Earth Sciences* **90**, 341–60.

MAZUR, S., ALEKSANDROWSKI, P., KRYZA, R. & OBERC-DZIEDZIC, T. 2006. The Variscan Orogen in Poland. *Geological Quarterly* **50**, 89–118.

MAZUR, S. & KRYZA, R. 1996. Superimposed compressional and extensional tectonics in the Karkonosze-Izera Block, NE Bohemian Massif. In *Basement Tectonics 11, Europe and Other Regions* (eds O. Oncken & C. Jansen), pp. 51–66. Potsdam: Kluwer, Dordrecht.

MINGRAM, B., KRÖNER, A., HEGNER, E. & KRETZ, O. 2004. Zircon ages, geochemistry, and Nd isotopic systematics of pre-Variscan orthogneisses from the Erzgebirge, Saxony (Germany), and geodynamic interpretation. *International Journal of Earth Sciences* **93**, 706–27.

MLČOCH, B. & KONOPÁSEK, J. 2010. Pre-Late Carboniferous geology along the contact of the Saxothuringian and Teplá–Barrandian zones in the area covered by younger sediments and volcanics (western Bohemian Massif, Czech Republic). *Journal of Geosciences* **55**, 137–50.

NARĘBSKI, W. 1994. Lower to Upper Paleozoic tectonomagmatic evolution of NE part of the Bohemian Massif. *Zentralblatt für Geologie und Paläontologie* **I**, 961–72.

OBERC-DZIEDZIC, T., KRYZA, R., MOCHNACKA, K. & LARIONOV, A. 2010. Ordovician passive continental margin magmatism in the Central-European Variscides: U-Pb zircon data from the SE part of the Karkonosze-Izera Massif, Sudetes, SW Poland. *International Journal of Earth Sciences* **99**, 27–46.

OLIVER, G. J. H., CORFU, F. & KROGH, T. E. 1993. U-Pb ages from SW Poland: evidence for a Caledonian suture zone between Baltica and Gondwana. *Journal of the Geological Society, London* **150**, 355–69.

PATOČKA, F., FAJST, M. & KACHLÍK, V. 2000. Mafic-felsic to mafic-ultramafic Early Palaeozoic magmatism of the West Sudetes (NE Bohemian Massif); the South Krkonoše Complex. *Zeitschrift für Geologische Wissenschaften* **28**, 177–210.

PATOČKA, F. & PIN, C. 2005. Sm-Nd isotope and trace element evidence for heterogeneous igneous protoliths of Variscan mafic blueschists in the East Krkonoše Complex (West Sudetes, NE Bohemian Massif, Czech Republic). *Geodinamica Acta* **18**, 363–74.

PATOČKA, F., PIVEC, E. & OLIVERIOVÁ, D. 1996. Mineralogy and petrology of mafic blueschists from the Rychory Mts crystalline complex (West Sudetes, Bohemian Massif). *Neues Jahrbuch für Mineralogie – Abhandlungen* **170**, 313–30.

PIN, C., KRYZA, R., OBERC-DZIEDZIC, T., MAZUR, S., TURNIAK, K. & WALDHAUSROVA, J. 2007. The diversity and geodynamic significance of Late Cambrian (ca. 500 Ma) felsic anarogenic magmatism in the northern part of the Bohemian Massif: a review based on Sm-Nd isotope and geochemical data. In *The Evolution of the Rheic Ocean: From Avalonian-Cadomian Active Margin to Alleghenian-Variscan Collision* (eds U. Linnemann, D. Nance, P. Kraft & G. Zulauf), pp. 209–29. Geological Society of America Special Paper 423.

SCHULMANN, K., KONOPÁSEK, J., JANOUŠEK, V., LEXA, O., LARDEAUX, J.-M., EDEL, J.-B., ŠTÍPSKÁ, P. & ULRICH, S. 2009. An Andean type Palaeozoic convergence in the Bohemian Massif. *Comptes Rendus Geoscience* **341**, 266–86.

SESTON, R., WINCHESTER, J. A., PIASECKI, M. A. A., CROWLEY, Q. G. & FLOYD, P. A. 2000. A structural model for the western-central Sudetes: a deformed stack of Variscan thrust sheets. *Journal of the Geological Society, London* **157**, 1155–67.

SLÁMA, J., KOŠLER, J., CONDON, D. J., CROWLEY, J. L., GERDES, A., HANCHAR, J. M., HORSTWOOD, M., MORRIS, G. A., NASDALA, L., NORBERT, N., SCHALTEGER, U., SCHOENE, B., TUBRETT, M. N. & WHITEHOUSE, M. J. 2008. Plešovice zircon – a new natural reference material for U-Pb and Hf isotopic microanalysis. *Chemical Geology* **249**, 1–35.

SMULIKOWSKI, W. 1995. Evidence of glaucophane-schist facies metamorphism in the East Karkonosze complex, West Sudetes, Poland. *Geologische Rundschau* **84**, 720–37.

TICHOMIROWA, M., BERGER, H.-J., KOCH, E. A., BELYATSKI, B. V., GOTZE, J., KEMPE, U., NASDALA, L. & SCHALTEGGER, U. 2001. Zircon ages of high-grade gneisses in the Eastern Erzgebirge (Central European Variscides) – constraints on origin of the rocks and Precambrian to Ordovician magmatic events in the Variscan foldbelt. *Lithos* **56**, 303–32.

WINCHESTER, J. A., FLOYD, P. A., CHOCYK, M., HORBOWY, K. & KOZDRÓJ, W. 1995. Geochemistry and tectonic environment of Ordovician meta-igneous rocks in the Rudawy Janowickie Complex, SW Poland. *Journal of the Geological Society, London* **152**, 105–15.

WINCHESTER, J. A., PATOČKA, F., KACHLÍK, V., MELZER, M., NAWAKOWSKI, C., CROWLEY, Q. G. & FLOYD, P. A. 2003. Geochemical discrimination of metasedimentary sequences in the Krkonose-Jizera Terrane (West Sudetes, Bohemian Massif): paleotectonic and stratigraphic constraints. *Geologica Carpathica* **54**, 267–80.

ŽÁČKOVÁ, E., KONOPÁSEK, J., JEŘÁBEK, P. & FARYAD, S. W. 2007. Blueschist-facies metamorphism in metasediments of the Krkonoše–Jizera Complex (Western Sudetes, northern Bohemian Massif). In *Proceedings and Excursion Guide of the 5th Meeting of the Central European Tectonic Studied Group in Teplá*, p. 99.

ŽÁČKOVÁ, E., KONOPÁSEK, J., JEŘÁBEK, P., FINGER, F. & KOŠLER, J. 2010. Early Carboniferous blueschist-facies metamorphism in metapelites of the West Sudetes (Northern Saxothuringian Domain, Bohemian Massif). *Journal of Metamorphic Geology* **28**, 361–79.