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Trilobite and acritarch assemblages from the Lower–Middle Cambrian boundary interval in the Holy Cross Mountains (Poland)

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ABSTRACT:

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Integrated analysis of trilobite and acritarch assemblages across the traditional Lower–Middle Cambrian boundary in the Holy Cross Mountains (Poland) has documented the development of both groups in this interval. Trilobite assemblages, comprising 31 taxa (13 are revised herein) dominated by the Ellipsocephalidae, change from the protolenoid-dominated in the Lower Cambrian to the kingaspidoid–ornamentaspidoid-dominated in the Middle Cambrian, and correlate well with the Agdzian Stage of West Gondwana (Geyer and Landing 2004). Correspondence to West Gondwana and Avalonia is also evident from the presence of the associated trilobite genera, *Palaeolenus*, *Myopsolenites*, *Latikingaspis*, *Kingaspis*, *Latoucheia* and *Orodes*. The acritarch assemblages, comprising 77 taxa, indicate that their main taxonomic turnover was gradual and preceded the earliest occurrence of *Paradoxides* spp., as in the Spanish sections. The geological succession studied in the HCM represents part of the Cambrian strata that are generally missing in Baltica.

Keywords: Lower Cambrian; Middle Cambrian; Cambrian Series 2 and 3; Stratigraphy; Holy Cross Mountains; Trilobita; Acritarcha; Poland.

INTRODUCTION

The biostratigraphic definition of the traditional Lower–Middle Cambrian boundary, corresponding to the base of Cambrian Series 3 and Stage 5 as currently defined (Babcock *et al*. 2005; Babcock and Peng 2007) (Text-fig. 1), is still under debate. Finding a trilobite group with high stratigraphical potential and wide geographic distribution is hampered by the high endemicity of trilobites in this interval. The most favoured are the oryctocephalids, with the first appearance of *Oryctocephalus indicus* (Reed, 1910) (McCollum and Sundberg 2002; Fletcher 2003; Zhao *et al.* 2004, 2005; Geyer 2005; Sundberg and McCollum 2007). Unfortunately, most oryctocephalids are known from palaeo-equatorial areas and deeper settings (Sundberg and McCollum 1997), whereas their presence in shallow marine environments of temperate zones (West Gondwana, Baltica) is uncertain (Liñán and Gozalo 1999; Geyer 2006).

This paper is focused on the biostratigraphic analysis of the traditional Lower–Middle Cambrian boundary interval in the Kielce Region of the Holy Cross Mountains (HCM), Poland, based on trilobite and acritarch assemblages. The studied interval is developed in predominantly shallow-marine to open-shelf siliciclastic facies consisting of taxonomically rich but unevenly distributed trilobite faunas (Orłowski 1964, 1985a, b). The dominance of Ellipsocephalidae in the succession allows comparisons with the West Gondwanan scheme of Geyer and Landing (2004). The presence of palynomorph-yielding shales and siltstones in this part of the Cambrian succession allows parallel biostratigraphic analysis of acritarch assemblages. The research was based on over 1500 trilobite specimens, mostly from museum collections, with most of the specimens from the collection of Prof. Stanisław Orłowski (Appendix 1), and on 17 productive acritarch samples from seven localities (Appendix 2).

System	Age [Ma]	Series	Stage	GSSPs or potential correlation bioevents
O		LOWER	Tremadocian	
	488.3±1.7			FAD of *Iapetognathus fluctivagus* (**GSSP**)
CAMBRIAN		**FURONGIAN**	Stage 10	
	~492			FAD of *Lotagnostus americanus*
			Stage 9	
	~496			FAD of *Agnostotes orientalis*
			Paibian	
	~499			FAD of *Glyptagnostus reticulatus* (**GSSP**)
		SERIES 3	**Guzhangian**	
	~503			FAD of *Lejopyge laevigata* (**GSSP**)
			Drumian	
	~506.5			FAD of *Ptychagnostus atavus* (**GSSP**)
			Stage 5	
	~510			FAD of *Oryctocephalus indicus*
		SERIES 2	Stage 4	
	~515			?FAD of *Olenellus* or redlichiid species
			Stage 3	
	~521			FAD of trilobites
		TERRE-NEUVIAN	Stage 2	
	~528			?FAD of SSF or archaeocyathid species
			Fortunian	
	542.0±1.0			FAD of *Trichophycus pedum* (**GSSP**)
E				

Text-fig. 1. Chronostratigraphic standard for the Cambrian System with geochronological data and global bioevents. After Babcock *et al.* (2005), Zhu *et al.* (2006), Babcock and Peng (2007), and www.stratigraphy.org. E – Ediacaran, O – Ordovician. Arrow shows the position of the discussed boundary

STRATIGRAPHIC FRAMEWORK

The recent activities of the International Subcommission on Cambrian Stratigraphy have resulted in the subdivision of the period into four sub-even epochs (Geyer and Shergold 2000; Shergold and Geyer 2003; Babcock *et al*. 2005; Babcock and Peng 2007). Accordingly, the traditional Lower–Middle Cambrian boundary corresponds approximately to the Cambrian Series 2 and 3 boundary (Text-fig. 1; see also www.stratigraphy.org). A bioevent defining this boundary has not yet been selected, mainly due to high trilobite endemicity in this interval (see e.g., Geyer 2005; Sundberg and McCollum 2007).

The base of the traditional Middle Cambrian in Europe, northern Africa and Siberia was defined by the FAD of the trilobite *Paradoxides sensu lato* (Brøgger 1878; see e.g., Geyer 2005; Żylińska and Masiak 2007 for references). In North America, the Middle Cambrian constituted beds above the Lower Cambrian defined by the range of *Olenellus sensu lato* (Walcott 1891). It subsequently appeared that the ranges of *Paradoxides s.l.* and *Olenellus s.l.* overlap in some areas (Geyer and Palmer 1995; Fletcher 2003; Geyer and Landing 2004) and hence it became necessary to redefine the Lower–Middle Cambrian boundary (Geyer and Shergold 2000; Fletcher 2003; Geyer and Landing 2004; Geyer 2005), a task that has gained even greater importance with the latest modifications of the Cambrian chronostratigraphic scheme.

The recent candidate bioevent that could potentially define the base of global Cambrian Series 3 is the FAD of *Oryctocephalus indicus* (McCollum and Sundberg 2002; Zhao *et al.* 2004, 2005; Sundberg and McCollum 2007) (Text-fig. 1), a small trilobite characteristic of open-shelf facies of the tropical areas (Sundberg and McCollum 1997). This event is well recognized and located close to the traditional Lower–Middle Cambrian boundary in North America and Asia. Unfortunately, the level with *O. indicus* cannot be defined in Baltica and is poorly defined in West Gondwana (Geyer 2005, 2006), although representatives of the Oryctocephalidae occur in Spain and Morocco (Liñán and Gozalo 1999; Geyer 2006).

Alternative chronostratigraphic schemes were proposed for West Gondwana (Spain, Morocco, Sardinia) (Geyer and Landing 2004; Text-fig. 2). In Morocco, where the Cambrian is developed as a thick carbonate-dominated succession followed by siliciclastic-dominated deposits (see Geyer and Landing 2006 for details), the boundary interval is composed of fine-grained siliciclastics with minor nodular and bedded limestones (Banian Stage of the Issafen Formation), followed by higher-energy, shallow marine sandstone-dominated facies with minor fossil-hash limestone beds (Agdzian Stage of the Tatelt, Tazlaft and Jbel Wawrmast formations) (Geyer and Landing 2004, 2006). The Banian trilobite assemblages are composed predominantly of the Antatlasiinae, Strenuellinae and

WEST GONDWANA		MOROCCO			SPAIN		
Celtiberian (*part*)	Agdzian	**Middle Cambrian (*part*)**	'Tissafinian'	*Ornamentaspis frequens*	**Middle Cambrian (*part*)**	'Leonian'	*Eccaparadoxides sdzuy*
							Acadoparadoxides mureroensis
				Cephalopyge notabilis			
					Lower Cambrian (*part*)	'Bilbilian'	*Protolenus jilocanus*
				Hupeolenus			*Protolenus dimarginatus*
							Realaspis
Atlasian (*part*)	Banian (*part*)	**Lower Cambrian (*part*)**	Banian (*part*)	*Sectigena*		'Marianian'	*Serrodiscus*
							Andalusiana
				Antatlasia guttapluviae			*'Strenuaeva'*

Text-fig. 2. Chronostratigraphic standard for West Gondwana correlated with the schemes for Morocco and Spain. After Geyer and Landing (2004), with modifications of Dies Álvarez and Gozalo (2006)

Saukiandidae, whereas the Agdzian assemblages are characterized by the Protoleninae and Ellipsocephalinae (Geyer 1990a, b; Geyer and Palmer 1995; Geyer and Landing 2004, 2006).

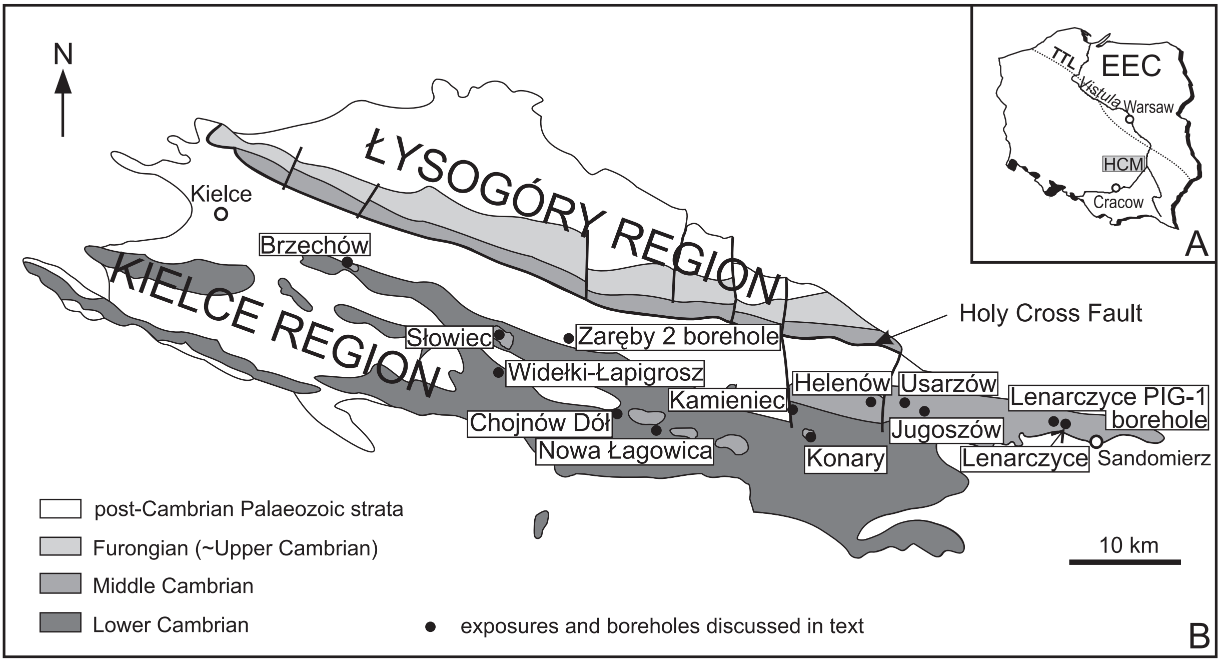
The studied interval is also characterized by evolutionary changes in palynomorph assemblages (e.g., Moczydłowska 1991, 1998; Text-fig. 3). In the traditional late Early Cambrian (~ Cambrian Epoch 2), the acritarchs became highly diverse and attained high frequency in the *Holmia kjerulfi* Zone of Baltica, which corresponds to the highstand tracts and relative sea-level maximum (see e.g., Moczydłowska 1998; Nielsen and Schovsbo 2006). This event is followed by a decrease in variability and frequency of palynomorphs, reflecting the transition from the *Heliosphaeridium dissimilare–Skiagia ciliosa* Zone to the *Volkovia dentifera–Liepaina plana* Zone (Moczydłowska 1991, 1998; Moczydłowska and Zang 2006; Text-fig. 3). The base of the *Eliasum llaniscum–Cristallinium cambriense* Zone reflects the disappearance of numerous and morphologically diverse representatives of *Skiagia* spp., and their replacement with a very characteristic association containing *C. cambriense* and *Eliasum* spp.; the event is of global significance and is recorded in successions of Baltica, Gondwana and Avalonia (Vanguestaine and Van Looy 1983; Volkova *et al*. 1983; Moczydłowska and Vidal 1986; Hagenfeldt 1989a, b; Moczydłowska 1989, 1991, 1999; Volkova 1990; Szczepanik 2000; Moczydłowska and Zang 2006).

series	EAST EUROPEAN CRATON		
	POLAND		Russia/Estonia
	trilobite zones	acritarch zones	acritarch 'horizons'
MC (part)	*A. oelandicus*	*Eliasum llaniscum – Cristallinium cambriense*	Kibartai
Lower Cambrian	*Protolenus*	*Volkovia dentifera – Liepaina plana*	Rausve
	Holmia kjerulfi assemblage	*Heliospaeridium dissimilare – Skiagia ciliosa*	Vergale
	Schmidtiellus mickwitzi equivalent	*Skiagia ornata – Fimbriaglomerella membranacea*	Talsy

Text-fig. 3. Correlation scheme of trilobite and acritarch zones for the Lower Cambrian and lowermost Middle Cambrian in the East European Craton. Modified after Moczydłowska (1991, 1999). MC – Middle Cambrian

GEOLOGICAL SETTING

The HCM are a small hilly area in south-central Poland, composed predominantly of Palaeozoic and Mesozoic successions. Palaeozoic strata crop out approximately between Kielce in the west and Sandomierz in the east, in a c. 70 km long and 50 km wide belt (Text-fig. 4B), often referred to as the Palaeozoic core or basement. The present-day geological and geomorphologic setting of this belt reflects the multi-stage evolution of the area, of which the Late Cretaceous–Early Paleogene tectonic inversion and uplift was one



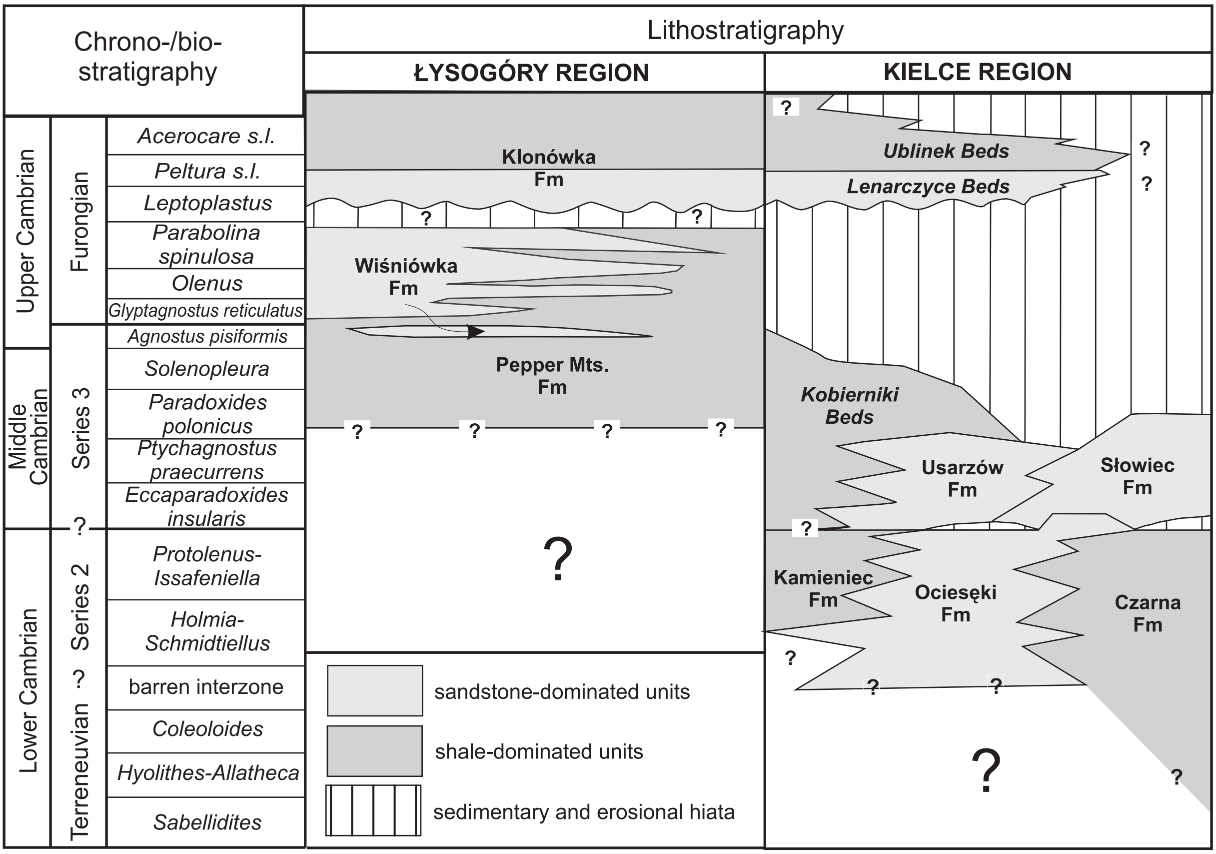
Text-fig. 4. (A) Sketch-map of Poland with location of the Holy Cross Mountains (HCM) in relation to the East European Craton (EEC) and Teisseyre–Tornquist Line (TTL). (B) Geological sketch-map of the HCM showing the distribution of Cambrian deposits (compiled from Samsonowicz 1962 and Orłowski 1975b, 1992, with modifications), with location of the studied exposures and boreholes

of the last major structural reorganizations (Kutek and Głazek 1972; Krzywiec *et al.* 2009). The inversion resulted in partial removal of Mesozoic strata and exposure of Palaeozoic rocks. Thus, the HCM represent one of the very few areas where Palaeozoic rocks are exposed in the direct vicinity of the Teisseyre–Tornquist Line (Text-fig. 4A), and their basement belongs to one of the main geotectonic domains in Europe – the Trans-European Suture Zone (TESZ; Berthelsen 1992).

Based on differences in facies development, stratigraphy, and tectonic evolution, the HCM are subdivided into two regions: the Kielce Region in the south and the Łysogóry Region in the north, separated by the WNW–ESE-oriented Holy Cross Fault (e.g., Czarnocki 1919; Text-fig. 4B). These regions are understood either as tectono-stratigraphic (e.g., Czarnocki 1919) or palaeogeographic units (e.g., Belka *et al*. 2000, 2002; Nawrocki and Poprawa 2006 and references therein) of proximal or exotic provenance. A crustal structure identical with that of the East European Craton (EEC) has been recently distinguished in the Małopolska Block (basement of the Kielce Region) by deep seismic sounding profiles, indicating that the unit is linked with the EEC (Malinowski *et al*. 2005). This structural block was probably a proximal terrane dextrally relocated along the TESZ margin of Baltica (Nawrocki *et al.* 2007), and in the Lower–Middle Cambrian boundary interval was located close to the margin of Gondwana (Belka *et al.* 2002; Nawrocki *et al.* 2007; Nawrocki and Poprawa 2006).

The Cambrian of the area is developed in siliciclastic facies with a total thickness estimated at 2500–3500 m (e.g., Orłowski 1988). The succession is dominated by sandstones in the west and by siltstones and shales in the east. So far, the Precambrian–Cambrian boundary has not been recognized, and the relationship to the basement remains unknown (Kowalczewski *et al.* 2006). Sandstone-dominated units represent shallow-marine facies, whereas the shale-dominated are referred to deeper, outer shelf environments (e.g., Studencki 1988; Jaworowski and Sikorska 2006). The most common fossils are trilobites, which form the basis of the applied biostratigraphic scheme (e.g., Orłowski 1988, 1992; Żylińska 2002).

The Lower–Middle Cambrian boundary interval is recorded only in the Kielce Region (Text-fig. 5). Traditionally, the Lower and Middle Cambrian trilobite fauna of the HCM was compared with that from Scandinavia (Orłowski 1959a, b, 1964, 1985a, b), with the base of the Middle Cambrian defined by the FAD of *Paradoxides s.l.* The representatives of Ellipsocephalidae allow comparisons with the trilobite succession of West Gondwana (Geyer and Landing 2004). The siltstone and shale successions can also be dated using palynomorphs, particularly acritarchs. The Cambrian acritarchs of the HCM have been studied for over 40



Text-fig. 5. Lithostratigraphic scheme of the Cambrian in the HCM. Based on Orłowski (1975b), Kowalczewski (1990), Szczepanik *et al.* (2004a, b) and Kowalczewski *et al.* (2006). Biostratigraphic scheme after Orłowski (1992), Żylińska (2002), and this paper; modified after Peng *et al.* (2004). Chronostratigraphy modified after Babcock *et al.* (2005), Zhu *et al.* (2006) and Babcock and Peng (2007)

years (e.g., Michniak 1959; Jagielska 1963, 1965, 1966; Lendzion *et al.* 1983; Kowalczewski *et al*. 1986, 1987; Szczepanik 1988, 1997, 2001), but a local biostratigraphic scheme based on acritarchs has not been presented.

DESCRIPTION OF LOCALITIES

Two lithostratigraphic units have been distinguished in the Lower Cambrian of the HCM (Orłowski 1975b; Text-figs 4–6): the Ociesęki Sandstones Formation in the west and the Kamieniec Shales Formation in the east. In the Middle Cambrian four lithostratigraphic units have been distinguished (Orłowski 1975b, 1985b; Orłowski and Mizerski 1995; Szczepanik *et al*. 2004b): from west to east, the Słowiec Sandstones Formation, the Ociesęki Sandstones Formation, the Usarzów Sandstones Formation, and the Kobierniki Beds (informal lithostratigraphic unit). The following exposures and boreholes with trilobites and acritarchs were studied (Text-fig. 4B) (from west to east): Brzechów (Słowiec Formation and undetermined lithostratigraphic unit); Widełki–Łapigrosz and Słowiec (Ociesęki and Słowiec formations); the Zaręby 2 borehole (Kamieniec Formation); Chojnów Dół (Ociesęki Formation); Nowa Łagowica, Wola Jastrzębska, and Kamieniec (Kamieniec Formation); Konary (Kamieniec and Słowiec formations); Helenów, Sternalice, Jugoszów, and Usarzów (Usarzów Formation); and the Lenarczyce PIG 1 borehole and Lenarczyce exposure (Kobierniki Beds).

The exposures and boreholes are briefly described below.

Brzechów

A small natural exposure of coarse- and medium-grained sandstones and siltstones of the Słowiec Formation and clayey, silty and sandy shales is located to the north of the village of Brzechów (Text-fig. 4B). The fauna comes exclusively from sandstone beds (Stasińska 1960; Bednarczyk 1970; Masiak and Żylińska 1994; Żylińska and Masiak 2007), assigned to the Słowiec Formation. A 16-m long ditch dug in 2006 close to the exposure yielded only silty and clayey shales with very thin sandstone intercalations. Seven samples for acritarchs were taken from the ditch and an additional two samples were collected from the debris; four of them yielded acritarchs. The contact of the shales with the coarse-grained sandstones remains unknown, which hampers recognition of their mutual relationships and their lithostratigraphic assignment. They may represent silty facies of the Ociesęki Formation (see Żylińska and Masiak 2007), the Kamieniec Formation, or the Kobierniki Beds.

Widełki–Łapigrosz and Słowiec

These are classic trilobite-yielding exposures of the Ociesęki and Słowiec formations (Czarnocki 1919, 1927; Samsonowicz 1959a, b; Orłowski 1965, 1975a, 1985a, b) (Text-fig. 4B). The Ociesęki Sandstones are exposed in small quarries on the north-western slopes of the Zamczysko Hill (Widełki–Łapigrosz exposure). The Słowiec Sandstones occur on the Słowiec Hill. From the Zamczysko Hill near the Zamczysko–Słowiec road come sandstone slabs with well-preserved and diverse trilobites of Middle Cambrian age (Orłowski 1985b; Orłowski and Mizerski 1995).

Zaręby 2 borehole

It is the only borehole that penetrated Cambrian strata in this part of the HCM (Bednarczyk *et al.* 1965; Jurkiewicz 1971; Text-fig. 4B). Cambrian deposits of the Kamieniec Formation occur between 1375.0 and 1218.2 m (Jurkiewicz 1971). Trilobite faunas occur between 1336.0 and 1336.5 m (Bednarczyk *et al.* 1965), and palynomorphs were noted by Jagielska (see Jurkiewicz 1971, pp. 7, 8) between 1373.0 and 1237.0 m. Four productive acritarch samples were collected from the existing core; the richest assemblage was noted in a sample from 1290.0 m.

Chojnów Dół, Nowa Łagowica, Wola Jastrzębska and Kamieniec

The Chojnów Dół ravine section (Text-fig. 4B), located c. 10 km to the south of Łagów, is famous for the Sandomirian angular unconformity between the Cambrian and the Ordovician (Czarnocki 1939; Bednarczyk *et al.* 1981). Cambrian rocks of the Ociesęki Formation yield rare trilobite faunas (Orłowski 1985a). The Nowa Łagowica and Wola Jastrzębska sections, c. 10 km to the east, are small, densely overgrown ravines on the left bank of the Łagowica River, near the villages of Nowa Łagowica and Wola Jastrzębska (Text-fig. 4B), that expose siltstones and shales of the Kamieniec Formation, which yield rare but important trilobite faunas (Orłowski 1985a). Exposures near Kamieniec (Text-fig. 4B) yield rare trilobites from the dam and mill along the Koprzywianka River (Samsonowicz 1920, 1956, 1960, 1962; Orłowski 1985a). The succession, considerably overgrown, is still visible along the river. Two productive acritarch samples from the Kamieniec dam were analysed.

Konary

A rare and poorly preserved trilobite fauna was described from coarse-grained sandstones (Słowiec Formation) from the quarry on Konarska Hill (Samsonowicz 1920; Orłowski 1971) (Text-fig. 4B). The sandstones are underlain by shales of the Kamieniec Formation, which crop out in the village of Konary; the shales were sampled for acritarchs.

Jugoszów and Usarzów

These classic Middle Cambrian occurrences in the HCM (Text-fig. 4B; Samsonowicz 1934; Orłowski 1959a, b, 1964) are the stratotype of the Usarzów Formation with its contact to the underlying Kamieniec Formation (Orłowski 1975b). Located on the eastern slope of a stream flowing through Usarzów, Osiny, and Jugoszów (Jugoszów–Usarzów section) and in small exposures in its vinicity (Helenów, Sternalice) (see Orłowski 1964, fig. 2), they are one of the most fossiliferous Cambrian units in the HCM (trilobites and echinoderms; Orłowski 1959a, 1964; Dzik and Orłowski 1995). Of the three acritarch samples collected, one, taken from the stream slope near the Jugoszów 20 section, was productive.

Lenarczyce PIG 1 borehole and Lenarczyce exposure

The Lenarczyce PIG 1 borehole (project PCZ-007-21 ‘Palaeozoic Accretion of Poland’) was drilled recently near the village of Lenarczyce (Text-fig. 4B). Structurally, the borehole is located in the Kielce Region, just a few kilometres south of the Holy Cross Fault. Below the Furongian occurs a 15-m thick complex of tectonically disturbed shales (Szczepanik *et al.* 2004a, b). Similar rocks are exposed in escarpments in the villages of Lenarczyce and Kobierniki. These deposits have been assigned to an informal lithostratigraphic unit termed the Kobierniki Beds (Szczepanik *et al.* 2004b) of Middle Cambrian age. Five productive acritarch samples were collected from the core and exposure.

BIOSTRATIGRAPHIC ANALYSIS OF THE TRILOBITE AND ACRITARCH ASSEMBLAGES

Trilobite assemblages

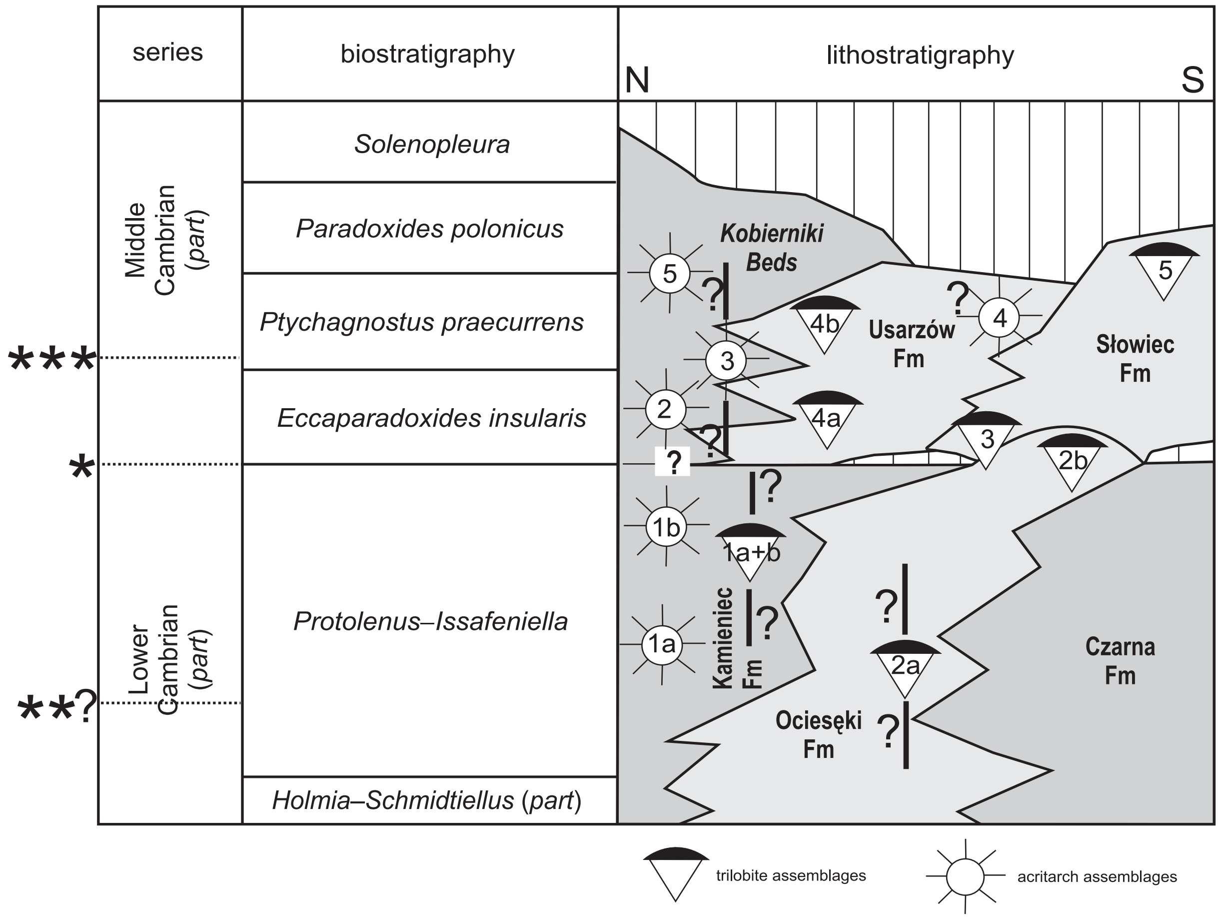
Assemblages 1a and 1b (Kamieniec Formation) (Text-figs 6–8; Pl. 1)

The material comprises c. 80 specimens from the Kamieniec, Nowa Łagowica and Wola Jastrzębska sections and the Zaręby 2 borehole core. The trilobite fauna displays relatively high taxonomic diversity (7 taxa; Text-figs 7 and 8).

The Protoleninae of both assemblages indicate the traditional '*Protolenus* Zone'. The '*Protolenus* Fauna' or 'Zone', typically composed of *Protolenus* Matthew, 1892 (*s.l.*), *Strettonia* Cobbold, 1931, *Calodiscus* Howell, 1935, *Serrodiscus* Richter and Richter, 1941, and *Cobboldites* Kobayashi, 1943, was recognized as a late Early Cambrian unit in Newfoundland (e.g., Matthew 1895; Landing 1992; Fletcher 2006) and England (e.g., Cobbold 1927; Rushton 1966, 1974). In a formal sense (i.e. *Protolenus–Strenuaeva* Assemblage Zone), the unit was recognized in the study area by Orłowski (1987). The interval corresponds to the '*Ornamentaspis*' *linnarssoni* Zone of Sweden (Bergström and Ahlberg 1981; Ahlberg and Bergström 1993) and can be correlated with the *Hupeolenus* and *Cephalopyge notabilis* zones of Morocco (Geyer and Landing 2004; Text-fig. 2). Typical Protoleninae in the study area are *Protolenus* (*P.*) *expectans* Orłowski, 1985a (Pl. 1, Fig. 5), similar to e.g., *Protolenus* (*P.*) *densigranulatus* Geyer, 1990b (Geyer 1990b; Geyer and Landing 2004) from the *Hupeolenus* and *C. notabilis* zones of Morocco, and *Protolenus* (*Hupeolenus*) *czarnockii* Orłowski and Bednarczyk, 1965 (Pl. 1, Figs 3, 4), which is mostly characteristic of the *Hupeolenus* Zone in Morocco (Geyer 1990b). *Hupeolenus* was also identified in Spain (Dies *et al.* 2001), from the uppermost 'Bilbilian' *Hamatolenus* (*H.*) *ibericus* Zone (= *Protolenus jilocanus* Zone – see Dies Álvarez and Gozalo 2006; Text-fig. 2). However, *Protolenus* (*Hupeolenus*) cf. *termierelloides* Geyer, 1990b of Dies *et al.* (2001) was shown to represent *Hamatolenus* (*Hamatolenus*) *vincentii* Geyer and Landing, 2004, a representative of the *C. notabilis* Zone fauna (see Geyer and Landing 2004 for discussion). The third Protoleninae species in the study area is *Hamatolenus* (*Hamatolenus*) *glabellosus* (Orłowski, 1985a) (Pl. 1, Fig. 2), which is similar to, if not synonymous with, *Hamatolenus* (*Hamatolenus*) *marocanus* (Neltner, 1938) from the *C. notabilis* and *Ornamentaspis frequens* zones of Morocco (Geyer 1990b).

The *C. notabilis* Zone age is also indicated by *Strettonia cobboldi* Orłowski and Bednarczyk, 1965 (Pl. 1, Figs 6, 7) and eodiscids. *Strettonia comleyensis* Cobbold, 1931 was described from the *Protolenus* Limestone of Shropshire, England (Cobbold 1931) and *Strettonia* sp. from the *C. notabilis* Zone in the Siskawn region of Morocco (Geyer 1994; Geyer and Palmer 1995). The eodiscid *Cobboldites comleyensis* (Cobbold, 1910) (Pl. 1, Fig. 8) was first described (as a *Microdiscus* species) by Cobbold (1910) from the *Protolenus* Limestone, Shropshire. A possible *Cobboldites* accompanied by other eodiscids was noted in the Purley Shales of Warwickshire, England (Rushton 1966; see Fletcher 2006, p. 53), in the *Orodes howleyi* Zone of Newfoundland, corresponding to the Moroccan *Hupeolenus* Zone (Fletcher 2006), and also in the *C. notabilis* Zone of Morocco (Geyer 1988; Geyer and Palmer 1995). According to Geyer and Landing (2004), the *C. notabilis* Zone is an interval with a maximum sea-level in the Early–Middle Cambrian boundary interval. The other eodiscid, *Serrodiscus primarius* Orłowski, 1985a (Pl. 1, Fig. 9), represents one of the genera characterizing the *Protolenus* Limestone of Comley (e.g., Rushton 1974; Geyer and Landing 2004) and the Purley Shales of Warwickshire (Rushton 1966). The genus was originally described from southern Spain (Richter and Richter 1941), and further from south-western Spain (Liñán and Perejón 1981). Other West Gondwanan occurrences are the Lower Cambrian *Sectigena* Zone of Morocco (Hupé 1953; Geyer 1988) and the Charlottenhof Formation (*Lusatiops* Member) in the Görlitz Synclinorium of eastern Germany (e.g., Geyer and Elicki 1995). The genus seems to have a worldwide distribution and a narrow stratigraphic range (see Jell in Kaesler 1997), although it is unknown from Baltica. Finally, the *C. notabilis* Zone age of the assemblage is indicated by a probable juvenile oryctocephalid in the Zaręby 2 borehole (Bednarczyk *et al.* 1965, fig. 11). Oryctocephalids are very rare in West Gondwana, known only from the *Protolenus jilocanus* Zone in Spain (Liñán and Gozalo 1999) and the *C. notabilis* Zone in Morocco (Geyer 2006).

Summing up, the trilobite fauna of Assemblages 1a and 1b, referred formerly to the *Protolenus* beds (Czarnocki 1927, 1933; Samsonowicz 1959a, b), *Protolenus* Zone (Orłowski 1985a), or the *Protolenus–Strenuaeva* Zone (Orłowski 1987) corresponds to the boundary interval of the *Hupeolenus* and *C. notabilis* zones. As the *Strenuaeva* species from this assemblage were shown to be *Issafeniella* (Żylińska and Masiak 2007 and this paper), the zone is referred herein to the *Protolenus–Issafeniella* Zone.



Text-fig. 6. Position of the recognized trilobite and acritarch assemblages and their position within the Cambrian litho- and biostratigraphic scheme for the HCM. Explanations as in Text-fig. 5. * marks the Lower–Middle Cambrian boundary after Orłowski (1988, 1992), ** marks the Atlasian–Celtiberian series boundary after Geyer and Landing (2004), and *** marks the FAD of *Oryctocephalus indicus*

Assemblages 2a and 2b (Ociesęki Formation) (Text-figs 6–8; Pl. 2)

Two characteristic trilobite assemblages dominated by ellipsocephalids occur in the Ociesęki Formation. Assemblage 2a is a low-diversity (only 2–3 taxa; see Text-figs 7 and 8) but high-frequency assemblage (hundreds of collectable specimens). Its most characteristic element is *Kingaspidoides sanctacrucensis* (Czarnocki, 1927) emend. Żylińska in Żylińska and Masiak, 2007 (Pl. 2, Figs 2, 4, 5), a taxon endemic to the HCM, which spans an interval from the *Protolenus-Issafeniella* to the *Paradoxides polonicus* zones (Orłowski 1964; Bednarczyk 1970; Żylińska and Masiak 2007). In Morocco, the highest diversity of *Kingaspidoides* spp. is noted in the *C. notabilis* Zone (Agdzian), where it is represented by at least seven species. *Kingaspidoides velata* (Sdzuy, 1961) and *K.* cf. *velata* from Spain indicate an older age, from the middle and upper Marianian up to the lower Bilbilian (Liñán *et al.* 2003), corresponding to the middle and upper part of the Banian (Geyer and Landing 2004; see Text-fig. 2). Another element of assemblage 2a is *Issafeniella* Geyer, 1990b (Text-fig. 7; Pl. 2, Figs 1, 3). The genus occurs in the middle and upper Banian Stage of West Gondwana (Geyer and Landing 2004; Text-fig. 2). *Issafeniella orlowinensis* (Samsonowicz, 1959a) emend. Żylińska in Żylińska and Masiak, 2007, together with *K. sanctacrucensis*, also appears in the *Eccaparadoxides insularis* Zone (Brzechów, Słowiec Formation; Bednarczyk 1970; Żylińska and Masiak 2007), thus in strata corresponding to the lowermost Agdzian Stage. The low taxonomic diversity of the assemblage and the co-occurrence of Antatlasiinae and Ellipsocephalinae do not allow unequivocal correlation with the Moroccan succession. The co-occurrence with two species of *Issafeniella* may indicate the Banian Stage (*Sectigena* Zone; see Text-fig. 2). However, the presence of a kingaspidoid species may point instead to the *Hupeolenus* or *C. notabilis* zones of the Agdzian. A similar case was noted in Avalonia by Fletcher (2003, 2006),

	1a	1b	2a	2b	3a	3b	4a	4b	5
Paradoxides (*Eccaparadoxides*) *pinus*								+	
Latikingaspis samsonowiczi							+	+	+
Ellipsocephalus hoffi							+	+	+
Kingaspidoides jugoszowi							+	+	
Paradoxides (*Eccaparadoxides*) *torelli*							+	+	
Paradoxides kozlowskii							+	+	
Protolenus (*Protolenus*) *polonicus*							+		
Paradoxides samsonowiczi							+		
Paradoxides (*Eccaparadoxides*) *insularis*							+		
Paradoxides (*Acadoparadoxides*) *czarnockii*							+		
Latoucheia (*Latoucheia*) *longa*						+	+	+	+
Paradoxides (*Acadoparadoxides*) *oelandicus*					+		+	+	
Paradoxides (*Acadoparadoxides*) cf *mureroensis*					+		+		
Palaeolenus medius					+				
Myopsolenites kielcensis					+				
Kingaspis guerichi				+			+	+	+
Kingaspidoides sandomiri				+			+	+	+
Orodes usarzowi				+			+	+	+
Ornamentaspis puschi				+			+	+	+
Ornamentaspis opatowi				+			+	+	+
Ornamentaspis henningsmoeni				+			+	+	+
Ornamentaspis hupei				+		+	+	+	+
Kingaspidoides sanctacrucensis			+		+				+
Issafeniella orlowinensis			+		+	+			
Strettonia cobboldi		+							
Protolenus (*Hupeolenus*) *czarnockii*		+							
Issafeniella trifida	+		+						
Protolenus (*Protolenus*) *expectans*	+								
Hamatolenus (*Hamatolenus*) *glabellosus*	+								
Serrodiscus primarius	+								
Cobboldites comleyensis	+								

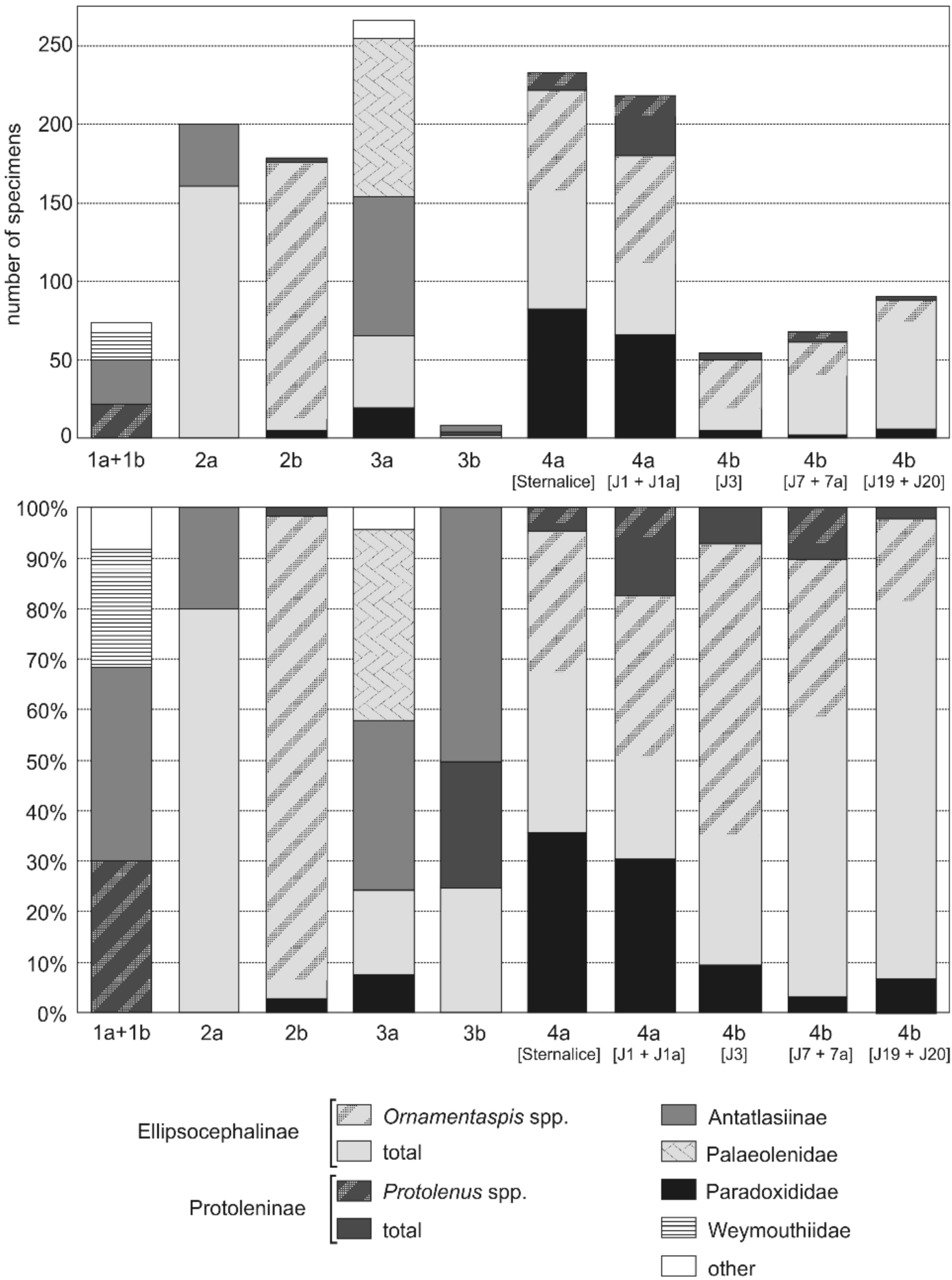
Text-fig. 7. Distribution of trilobite taxa in particular assemblages

who reported *Strenuaeva nefanda* Geyer, 1990b from the *Cephalopyge* Zone of south-western Newfoundland, a species which in Morocco is known from the lower *Sectigena* Zone (Geyer and Landing 2004). In the HCM zonation, the interval with the *Issafeniella–Kingaspidoides* association has been referred to the *Protolenus–Strenuaeva* Assemblage Zone (Orłowski 1987), the *Protolenus–Issafeniella* Zone herein.

Another constituent of Assemblage 2a is an obolid brachiopod, *Westonia bottnica* Wiman, 1902. Its presence in the Widełki-Łapigrosz section was widely noted (Czarnocki 1927, 1933; Jendryka-Fuglewicz 1992; Belka *et al.* 2000); however, its taxonomic assignment, stratigraphic potential and biogeographic significance is seriously doubted (Cocks 2002).

Assemblage 2b, recognized in sandstone blocks collected along the Zamczysko–Słowiec road, is much more diverse (8 taxa) and dominated by ellipsocephalines (Text-fig. 8). The dominant element of this assemblage, the genus *Ornamentaspis* Geyer, 1990b, is characterized by wide geographic distribution, noted in Scandinavia (Baltica), Germany, Bohemia, Spain and Morocco (West Gondwana) (Geyer 1990b). In Morocco it first appears in the *Hupeolenus* Zone, and has the highest taxonomic diversity in the *O. frequens* Zone (10 taxa) (Geyer 1990b). In the analysed assemblage the most abundant is *O. puschi* (Orłowski, 1959b) (Pl. 2, Figs 7, 8).

Ornamentaspis is accompanied by other ellipsocephalids, *Kingaspis guerichi* (Orłowski, 1959b), *Orodes usarzowi* (Orłowski, 1985b) (Pl. 2, Fig. 6), and *Kingaspidoides sandomiri* (Orłowski, 1959b). *Kingaspis* Kobayashi, 1935 emend. Geyer and Landing, 2001 is hitherto known only from West Gondwana, with its type species, *K. campbelli* (King, 1923) known from the lowest Mid-



Text-fig. 8. Composition of trilobite assemblages with regard to (A) number of specimens; (B) percentage dle Cambrian of Jordan (Rushton and Powell 1998), from a level probably equivalent to the *C. notabilis* Zone of Morocco (Geyer 1990b). Moroccan species generally occur in the *C. notabilis* and *O. frequens* zones (Geyer 1990b). Specimens referred to *K. campbelli* from the *Protolenus jilocanus* Zone of Spain (Liñán *et al.* 2003) were shown to be taxonomically distinct from the original material (Geyer and Landing 2004). The former Polish reports of *Kingaspis* (Orłowski 1964; Lendzion 1972) were assigned to other genera (see systematic descriptions). The genus *Orodes* Geyer, 1990b was originally described from the *Hupeolenus* and *C. notabilis* zones of Morocco (Geyer 1990b). It also probably occurs in the upper '*Ornamentaspis*' *linnarssoni* Zone in northern Sweden (Axheimer *et al.* 2007), and in the *Orodes howleyi* Zone of Newfoundland (Fletcher 2006). The genus *Kingaspidoides* Hupé, 1953 emend. Geyer, 1990b spans the entire Agdzian Stage in West Gondwana (Geyer and Landing 2004), and has a similar range in the HCM; *K. sanctacrucensis* ranges from the *Protolenus–Issafeniella* Zone up to the *Paradoxides polonicus* Zone, and *K. sandomiri* and *K. jugoszowi* (Orłowski, 1959b) span the *Eccaparadoxides insularis* through to the *Paradoxides polonicus* zones.

Assemblage 2b most probably represents the *E. insularis* Zone, although this stratigraphic position is equivocal. The assemblage is therefore referred to a wide interval corresponding to the Scandinavian *Acadoparadoxides oelandicus* Superzone.

Assemblages 3a, 3b and 5 (Słowiec Formation) (Text-figs 6–8; Pl. 3, Figs 1–5)

Assemblage 3a is known exclusively from Brzechów (Text-fig. 7; see Żylińska and Masiak 2007 for details). It is dated by *Paradoxides* (*Acadoparadoxides*) *oelandicus* Sjögren, 1872, the index species of the eponymous Superzone in Scandinavia (Sjögren 1872; Linnarsson 1877; Westergård 1928, 1936; Henningsmoen 1952). However, the presence of *Palaeolenus medius* (Bednarczyk, 1970) emend. Żylińska in Żylińska and Masiak, 2007 and *Myopsolenites** *kielcensis* (Bednarczyk, 1970) emend. Żylińska in Żylińska and Masiak, 2007, a member of the short-ranging *Onaraspis* clade (see Geyer and Landing 2004), allows the stratigraphical range of Assemblage 3a to be narrowed to an interval equivalent to the *C. notabilis* Zone of Morocco (Geyer and Landing 2004; Żylińska and Masiak 2007). A distinctly older position is suggested by members of the subfamily Antatlasiinae (represented herein by *I. orlowinensis*), which in Morocco occur in the *A. guttapluviae* and *Sectigena* zones (Geyer 1990b), although these were also reported in the *Cephalopyge* Zone of south-western Newfoundland (Fletcher 2003). Also, the co-occurrence of *P.* (*A.*) *oelandicus* with *P.* (*A.*) cf. *mureroensis* (Sdzuy, 1958), the second paradoxidid in Assemblage 3a, may indicate an earlier appearance of *P.* (*A.*) *oelandicus* in the HCM than in Scandinavia. If this is correct, it means that time-equivalent strata of beds containing Assemblage 3a are missing in the epicratonic seas of Baltica (see also Żylińska and Masiak 2007), where a stratigraphic gap is recorded at the Lower–Middle Cambrian boundary transition (e.g., Lendzion 1976; Bergström and Gee 1985; see also Nielsen and Schovsbo 2006). This gap most probably resulted from the late Early Cambrian circum-Iapetus 'Hawke Bay' regression (Palmer and Jones 1980).

Assemblage 3b, known from sandstones on Konarska Hill (Text-fig. 8), contains the antatlasiine *I.* cf. *orlowinensis* (Pl. 3, Fig. 4), the ellipsocephaline *Ornamentaspis hupei* (Orłowski, 1964) (Pl. 3, Figs 1, 2) and the protolenine *Latoucheia* (*Latoucheia*) *longa* (Orłowski, 1959b) (Pl. 3, Figs 3, 5). In Morocco, *Latoucheia* Hupé, 1953 emend. Geyer, 1990b occurs exclusively in the *C. notabilis* Zone (Geyer 1990b), and in Newfoundland it is known from the *Orodes howleyi* Zone (Fletcher 2006). Other taxa of the assemblage are known from the boundary interval of the *Hupeolenus* and *C. notabilis* zones of Morocco (see above).

Assemblage 5, known from the Słowiec Hill (Text-fig. 6; after Orłowski 1965, 1985b, 1988), is dominated by paradoxidids indicative of the upper Middle Cambrian *Paradoxides polonicus* Zone and, consequently, will not be discussed further herein. Interestingly, however, it shows the co-occurrence of Ellipsocephalidae, noted from the lower Middle Cambrian, e.g., *Ornamentaspis* spp. and *Latikingaspis samsonowiczi* (Orłowski, 1964), and of rare Solenopleuridae, e.g., *Parasolenopleura linnarssoni* (Brøgger, 1878), and of Dorypygidae (Orłowski 1985b), known from the middle and upper Middle Cambrian. In Sweden, *P. linnarssoni* is known from the middle Middle Cambrian *Paradoxides paradoxissimus* Superzone (Westergård 1946; Axheimer and Ahlberg 2003). The base of this interval (FAD of *Ptychagnostus atavus*) is now globally recognized as the base of the Middle Cambrian Drumian Stage (Babcock *et al.* 2007), and correlates with the West Gondwanan mid-Caesaraugustian Stage (Geyer and Shergold 2000; Geyer and Landing 2004).

* *Myopsolenites* was considered a junior subjective synonym of *Onaraspis* Öpik by Dies Álvarez *et al.* (2007). Following Geyer and Landing (2004) it is regarded herein an independent genus (see Żylińska and Masiak 2007).

Assemblages 4a and 4b (Usarzów Formation) (Text-figs 6–8; Pl. 3, Figs 6–10; Pls 4, 5)

These two assemblages, known from the Jugoszów–Usarzów section and other localities of the Usarzów Formation, are characterized by the co-occurrence of paradoxidids and numerous and diverse ellipsocephalids, dominated by *Ornamentaspis* (Text-figs 7, 8). The stratigraphic sub-division of the Jugoszów–Usarzów section, based on paradoxidid trilobites, was proposed by Orłowski (1959a, 1964). The Jugoszów 1a, Jugoszów 1 and Sternalice sections yielded (see Appendix 1) *Paradoxides* (*Eccaparadoxides*) *insularis* Westergård, 1936 (Pl. 4, Fig. 8) and *P.* (*A.*) *oelandicus* (Pl. 4, Fig. 7), indicating the lower *A. oelandicus* Superzone (*Eccaparadoxides insularis* Zone). *Paradoxides* (*Acadoparadoxides*) *czarnockii* (Orłowski, 1959a) (Pl. 4, Fig. 10), another paradoxidid present in this part of the succession (Sternalice), is endemic. It shows, however, a strong similarity to *P.* (*A.*) *harlani* Green, 1834 emend. Geyer and Landing, 2001, known from the *P.* (*A.*) *harlani* Zone of Massachusetts, USA (Avalonia), which can tentatively be correlated with the lower *O. frequens* Zone of Morocco and the *E. insularis* Zone in Baltica (Geyer and Landing 2001). The other exposures of the Usarzów Formation, based on the presence of *Paradoxides* (*Eccaparadoxides*) *pinus* Westergård, 1936 (Pl. 4, Fig. 9), were referred to the upper part of the *A. oelandicus* Superzone (*Eccaparadoxides pinus* Zone = *Ptychagnostus praecurrens* Zone) (Orłowski 1964), equivalent of the upper *O. frequens* and the *Kymataspis arenosa* zones of Morocco. The co-occurrence of *P.* (*A.*) cf. *mureroensis*, *P.* (*A.*) *oelandicus* and of *P.* (*E.*) *insularis* noted in the Jugoszów 1a section (see Appendix 1) may suggest (similarly as in the case of Assemblage 3a from Brzechów; see above and Żylińska and Masiak 2007) that the time-equivalent of this interval in Baltica is missing.

Other species of Assemblage 4a, *Protolenus* (*Protolenus*) *polonicus* Orłowski, 1964 (Pl. 5, Figs 9, 12), *L.* (*L.*) *longa*, and *O. usarzowi* (Pl. 5, Figs 6–8), allow its correlation with the *C. notabilis* Zone of Morocco (see above).

Assemblage 4b is dominated by ellipsocephalines (see Text-fig. 8), with *Ornamentaspis* as the most common genus (Pl. 3, Fig. 8; Pl. 4, Fig. 5).

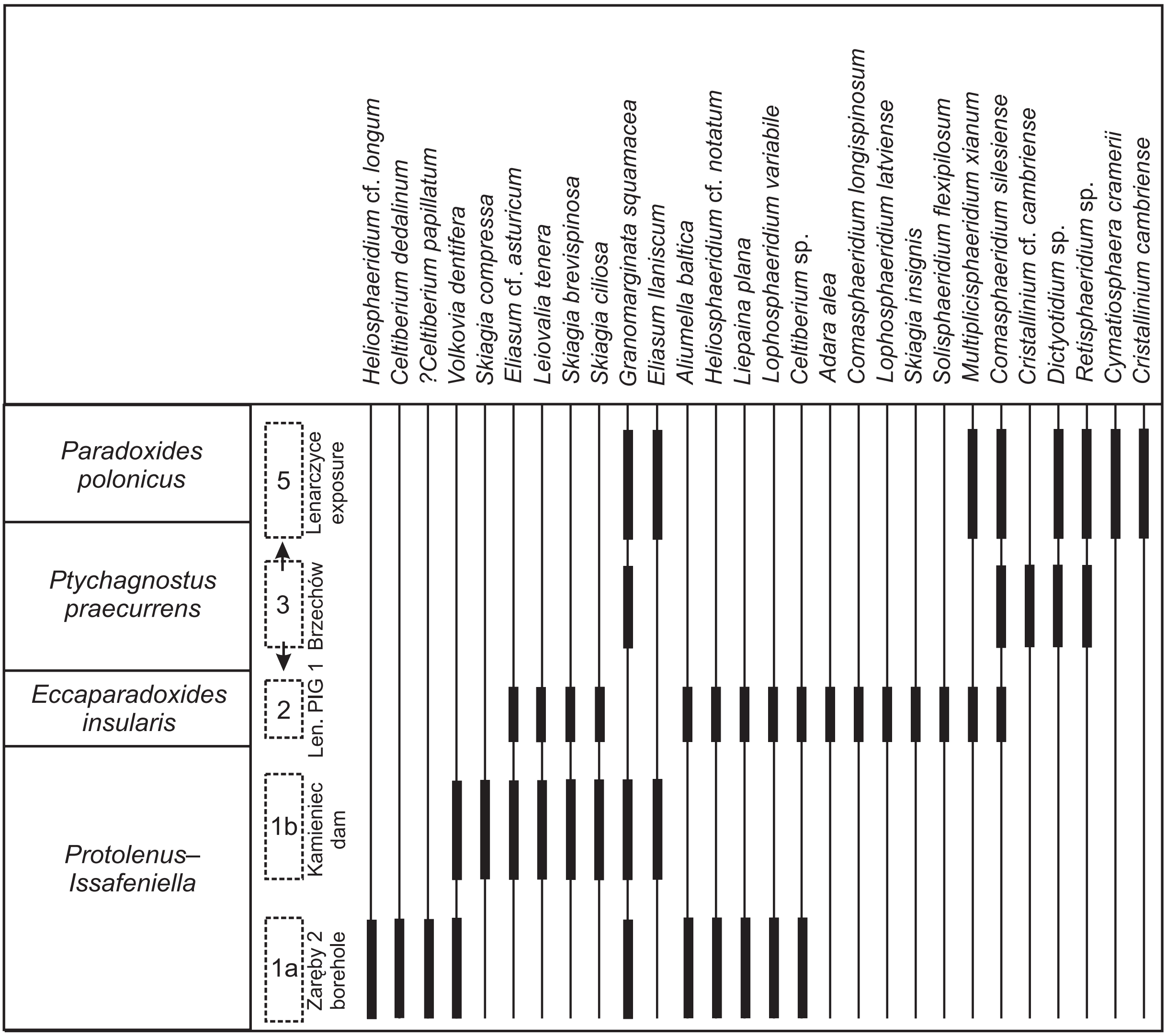
Both assemblages share a number of species, which occur in variable abundance. *Latikingaspis samsonowiczi* (Pl. 5, Figs 10, 11, 13) is the most abundant in Assemblage 4a. *Latikingaspis sulcatus* Geyer, 1990b is known from the *Hupeolenus* Zone (Geyer 1990b), and *L. alatus* (Hupé, 1953) emend. Geyer, 1990b was noted from the *C. notabilis* Zone (Hupé 1953; Geyer 1990b). Rare *Kingaspidoides jugoszowi* (Pl. 4, Fig. 3), *K. sandomiri* (Pl. 4, Figs 1, 2), *Kingaspis guerichi* (Pl. 3, Figs 9, 10) and *Ellipsocephalus hoffi* (Schlotheim, 1823) (Pl. 5, Figs 3–5) are also present in both assemblages. *Ellipsocephalus hoffi* spans the interval between the mid-Agdzian Stage and the basal Languedocian Stage in West Gondwana (Šnajdr 1958; Valíček and Szabad 2002; Geyer and Landing 2004; Geyer *et al.* 2008).

Acritarch assemblages

Biostratigraphic analysis of the acritarch assemblages has been based on 17 productive samples collected from seven exposures and borehole-sections. Samples were taken from siltstones and shales in the Kamieniec and Usarzów formations and in the Kobierniki Beds. Shales from the ditch made in Brzechów (undetermined lithostratigraphic unit) were also sampled. To supplement the observations, previously collected samples from the studied interval (Lenarczyce PIG 1 borehole, Zaręby 2 borehole, vicinity of Jugoszów and Kamieniec), housed in the Holy Cross Branch of the Polish Geological Institute in Kielce, were re-analysed. Ranges of selected acritarch taxa in the study area are presented in Text-fig. 9.

Assemblage 1a (Kamieniec Formation in the Zaręby 2 borehole, 1290.0 m) (Text-figs 6 and 9; Pl. 6)

This low-frequency and low-diversity assemblage contains abundant and morphologically diverse *Leiosphaeridia* sp. (Pl. 6, Fig. 15), accompanied by *Lophosphaeridium* spp. (Pl. 6, Figs 21, 28, 30), *Granomarginata* spp. (Pl. 6, Figs 8, 14, 17, 18), *Pterospermella solida* (Volkova) Volkova in Volkova *et al*., 1979 (Pl. 6, Fig. 16), frequent *Heliosphaeridium* spp. (Pl. 6, Figs 22–24) and *Asteridium* sp. (Pl. 6, Fig. 25). The most characteristic in the assemblage is, however, *Volkovia dentifera* (Volkova) Downie, 1982 (Pl. 6, Figs 31–48), the index taxon of the *Volkovia–Liepaina* Acritarch Zone (Moczydłowska 1991) (Text-fig. 3). This species is widely known in eastern Poland (Volkova 1969; Volkova *et al.* 1983; Moczydłowska 1991), Latvia, Ukraine (Volkova 1969; Volkova *et al.* 1983), Sweden (Eklund 1990) and Scotland (Downie 1982), where it occurs in the late Early Cambrian *Protolenus* Zone. Its occurrence in the Zaręby 2 borehole is, however, exceptional because of its high abundance; usually *V. dentifera* is an accessory element in the assemblages. The *Volkovia–Liepaina* Zone (corresponding to the *Protolenus–Issafeniella* Zone) age of Assemblage 1a is also confirmed by single finds of ?*Liepaina* sp. (Pl. 6, Fig. 11), *Heliosphaeridium* cf. *longum* (Moczydłowska) Moczydłowska, 1991 (Pl. 6,



Text-fig. 9. Range chart of selected acritarch taxa in the studied interval

Fig. 22), *H.* cf. *notatum* (Volkova) Moczydłowska, 1991 (Pl. 6, Fig. 23) and *Polygonium varium* (Volkova) Moczydłowska, 1998 (Pl. 6, Figs 4, 5).

Assemblage 1b (Kamieniec Formation at Kamieniec dam) (Text-figs 6 and 9; Pl. 7)

It is a typical Lower Cambrian palynofloral assemblage, with numerous *Skiagia* spp., *Lophosphaeridium* spp., *Pterospermella* spp. and *Heliosphaeridium* spp. The assemblage is widely known in the EEC (Volkova 1969; Yankauskas 1972, 1974, 1975; Yankauskas and Posti 1973, 1976; Moczydłowska 1980, 1981, 1989, 1991; Volkova *et al*. 1983; Moczydłowska and Vidal 1986, 1988), Scandinavia (Vidal 1981; Moczydłowska and Vidal 1986, 1992; Hagenfeldt 1989a; Eklund 1990), Scotland, Greenland, Canada (Downie 1982; Vidal and Peel 1993), Spain (Palacios and Vidal 1992; Palacios and Moczydłowska 1998; Palacios *et al.* 2006) and Siberia (Moczydłowska and Vidal 1988; Vidal *et al.* 1995).

The assemblage is composed of abundant *Leiosphaeridia* sp. (Pl. 7, Fig. 30), numerous *Leiovalia tenera* Kiryanov, 1974 (Pl. 7, Figs 31–33), taxonomically variable *Skiagia* spp. (Pl. 7, Figs 1–11), *Lophosphaeridium* spp. (Pl. 7, Figs 12–15), *Pterospermella* spp. (Pl. 7, Figs 17–19), *Granomarginata* spp. (Pl. 7, Figs 20, 22–24) and *Heliosphaeridium* spp.

The biostratigraphy of the assemblage is not straightforward. The presence of *Skiagia ciliosa* (Volkova) Downie, 1982 (Pl. 7, Figs 1, 2), *Pterospermella solida* (Volkova) Volkova, in Volkova *et al*., 1979 (Pl. 7, Fig. 19), *Leiovalia tenera* Kiryanov, 1974 (Pl. 7, Figs 31–33) and *Polygonium varium* (Volkova) Moczydłowska, 1998 (Pl. 7, Fig. 25) suggests the *Heliosphaeridium*–

Skiagia and *Volkovia–Liepaina* acritarch zones (Moczydłowska 1991), corresponding to the Vergale–Rausve acritarch horizons (Volkova *et al.* 1983; see Text-fig. 3). The critical taxon, however, is *Volkovia dentifera* (Pl. 7, Fig. 28), indicative of the *Volkovia–Liepaina* acritarch Zone (Moczydłowska 1991), correlated with the Rausve acritarch horizon (Volkova *et al.* 1983; see Text-fig. 3), and corresponding to the *Protolenus* Zone. The most surprising element of Assemblage 1b is *Eliasum llaniscum* Fombella, 1977 (Pl. 7, Fig. 35), the index taxon of the basal Middle Cambrian (Moczydłowska 1998, 1999; Palacios and Moczydłowska 1998), although the species is also reported from the uppermost Lower Cambrian (Volkova *et al.* 1979; Hagenfeldt 1989a; Young *et al.* 1994). Jankauskas and Lendzion (1992, 1994) suggested that *E. llaniscum* and other representatives of the Kibartai Acritarch Horizon appear already with Rausve acritarchs, but this appeared uncertain (Moczydłowska 1998, p. 68). In the HCM *E. llaniscum* first appears evidently in the *Volkovia–Liepaina* Zone, co-occurring with trilobites indicative of the *Protolenus–Issafeniella* Zone (Text-fig. 6)

Assemblage 2 (Kobierniki Beds in the Lenarczyce PIG 1 borehole; 132.5–138.7 m) (Text-figs 6 and 9; Pls 8 and 9, Figs 1–26)

The assemblage is dominated by *Leiosphaeridia* sp., accompanied by *Comasphaeridium* spp. (Pl. 8, Figs 17, 18, 20–23; Pl. 9, Figs 24, 25), *Lophosphaeridium* spp. (Pl. 9, Figs 19–23) and other taxa (Text-fig. 9). Also quite frequent is *Liepaina plana* Yankauskas and Volkova in Volkova *et al.*, 1979 (Pl. 8, Figs 1–7), the index taxon of the *Volkovia–Liepaina* Zone (Moczydłowska 1991), widely known in the EEC (Volkova *et al.* 1983; Moczydłowska 1991). Another characteristic taxon is *Skiagia insignis* (Fridrichsone) Downie, 1982 (Pl. 8, Figs 12–16), spanning the upper Lower through to basal Middle Cambrian (Volkova *et al.* 1983; Hagenfeldt 1989a, b). Another *Skiagia* species is *S. ciliosa* (Pl. 9, Fig. 1), which is common in the Lower Cambrian, but is also noted in the Middle Cambrian *A. oelandicus* Superzone (Volkova *et al.* 1983; Hagenfeldt 1989b; Eklund 1990; Moczydłowska 1998, 1999). Also stratigraphically significant is *Heliosphaeridium* cf. *notatum* (Pl. 9, Figs 8–10) noted widely in the *Protolenus* Zone and the lower *A. oelandicus* Superzone (Vanguestaine and Van Looy 1983; Volkova *et al*. 1983; Hagenfeldt 1989a, b; Vidal and Peel 1993; Moczydłowska 1998; Palacios *et al.* 2006). The same age is suggested by *Eliasum* spp. (Pl. 8, Figs 27–31, 33, 34), and particularly *E.* cf. *llaniscum* (Pl. 8, Figs 29, 30), indicative of the Middle Cambrian (see Moczydłowska 1999). In Assemblage 2, *Eliasum* co-occurs with *Volkovia dentifera*; this was also observed in Assemblage 1b. Also characteristic of the Middle Cambrian is *Comasphaeridium silesiense* Moczydłowska, 1998 (Pl. 8, Figs 17, 18) (see Moczydłowska 1999; Palacios *et al.* 2006); it was additionally noted from the Furongian in the Sosnowiec IG-1 borehole, Upper Silesia (Moczydłowska 1998), although a different interpretation was presented in Jachowicz and Buła (1996). In Spain (Palacios *et al.* 2006), *C. silesiense* has been considered the index taxon of the *C. silesiense* Zone, an equivalent of the *A. oelandicus* Superzone. Such a stratigraphic position is also suggested by *Comasphaeridium longispinosum* Hagenfeldt, 1989b (Pl. 9, Figs 24, 25), *Lophosphaeridium variabile* Volkova, 1974 (Pl. 9, Figs 19, 21), *L. latviense* (Volkova) Moczydłowska, 1998 (Pl. 9, Fig. 22), *Multiplicisphaeridium xianum* Fombella, 1977 (Pl. 9, Figs 11, 12) and *Celtiberium* sp. (Pl. 8, Figs 39, 41; Pl. 9, Fig. 26). The taxon which complicates the stratigraphic interpretation of the assemblage is *Adara alea* Martin in Martin and Dean, 1981 (Pl. 8, Figs 8–11), reported so far exclusively from the distinctly younger, late Middle Cambrian *P. paradoxissimus* Superzone (e.g., Moczydłowska 1998; Palacios *et al.* 2006). The presence of this taxon is interpreted herein as the recognition of its actual much earlier appearance. The suggestion that the Lenarczyce PIG 1 borehole sample may simply represent a condensed succession, spanning the *A. oelandicus* and *P. paradoxissimus* superzones, is highly improbable; in other HCM sections of the *P. paradoxissimus* Superzone, acritarch assemblages are dominated by *Cristallinium cambriense* (Slavíková) Vanguestaine, 1978 and *Cymatiosphaera cramerii* Slavíková, 1968, which are absent from the Lenarczyce PIG-1 borehole sample.

Assemblage 3 (ditch near Brzechów) (Text-figs 6 and 9; Pl. 9, Figs 27–41)

This is a low-diversity and low-frequency assemblage composed of *Leiosphaeridia* sp. (Pl. 9, Figs 31, 33, 34), long-ranging *Granomarginata squamacea* Volkova, 1968 (Pl. 9, Figs 35, 37) and *Cristallinium* cf. *cambriense* (Pl. 9, Figs 27, 28). The presence of the last taxon indicates a level not older than the Middle Cambrian (Moczydłowska 1998, 1999), and agrees well with the recognized stratigraphical position of other species, such as *Comasphaeridium silesiense* (Pl. 9, Fig. 38), *Lophosphaeridium* cf. *latviense* (Pl. 9, Fig. 41), *Retisphaeridium* sp. (Pl. 9, Figs 29, 30) and *Dictyotidium* sp. (Pl. 9, Fig. 39).

Assemblage 4 (Usarzów Formation, Jugoszów 20 section) (Text-fig. 6; Pl. 9, Figs 42–45)

This assemblage is composed of high-frequency but low-diversity palynomorphs represented almost entirely by large *Leiosphaeridia*. Other members are very rare *Eliasum* sp. A (Pl. 9, Figs 42–44), *Cymatiosphaera* cf. *postae* (Yankauskas) Yankauskas in Volkova *et al*., 1979 (Pl. 9, Fig. 45) and *Lophosphaeridium* sp. Although the recognized taxa do not give a precise age assignement, the sample can be dated by co-occurring trilobites as the low Middle Cambrian (Text-fig. 6)

Assemblage 5 (Kobierniki Beds at Lenarczyce) (Text-figs 6 and 9; Pl. 10)

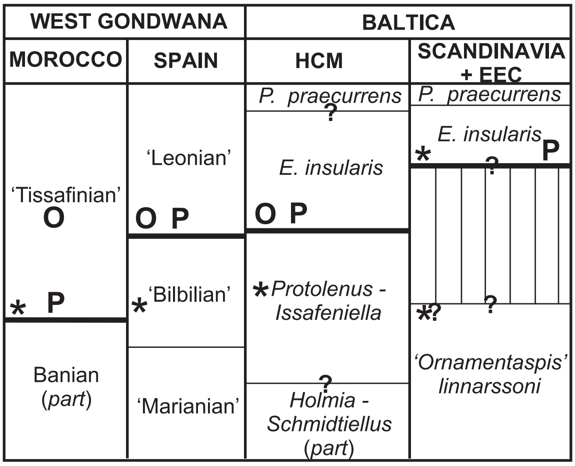
This assemblage is dominated by long-ranging *Leiosphaeridia* sp. (Pl. 10, Figs 14, 21, 29), relatively frequent *Cymatiosphaera cramerii* (Pl. 10, Fig. 17), morphologically diverse *Heliosphaeridium* spp. (Pl. 10, Fig. 25), *Comasphaeridium silesiense* (Pl. 10, Fig. 19), *Retisphaeridium* sp. (Pl. 10, Figs 9, 10, 13), *Multiplicisphaeridium xianum* (Pl. 10, Fig. 24) and rare *Lophosphaeridium* spp. (Pl. 10, Figs 26–28). *Granomarginata squamacea* (Pl. 10, Fig. 20) is very rare. The co-occurrence of stratigraphically important taxa such as *Cristallinium cambriense* (Pl. 10, Figs 1–7) and *Eliasum llaniscum* (Pl. 10, Figs 31, 33), unequivocally indicates its Middle Cambrian age (Moczydłowska 1998, 1999; Palacios *et al.* 2006). The taxa co-occur abundantly in the Middle Cambrian (upper *A. oelandicus* Superzone to *P. forchhammeri* Superzone) (Fombella 1977, 1978, 1979; Martin and Dean 1981, 1984, 1988; Welsch 1986; Erkmen and Bozdoğan 1988; Hagenfeldt 1989b; Volkova 1990; Jankauskas and Lendzion 1992, 1994; Moczydłowska 1998, 1999; Palacios and Moczydłowska 1998; Szczepanik 2000, 2001). The lack of *Timofeevia* spp., typical of the upper Middle Cambrian, and the absence of diverse populations of *Skiagia*, suggest the middle Middle Cambrian age of the assemblage.

DISCUSSION

With a single exception, all of the trilobite assemblages distinguished in the studied HCM sections correspond to the Agdzian Stage of the West Gondwanan scale (Geyer 1990b; Geyer and Landing 2004). The exception is Assemblage 2a, known from the Ocieseki Formation (see Text-fig. 6), which is correlated with the Banian Stage. If the latter assumption is correct it would mean an earlier appearance of the trilobite genus *Kingaspidoides*, similarly as in Spain (Liñán *et al.* 2003), in comparison to Morocco where it is claimed to appear first in the Agdzian Stage. For the HCM succession it would mean that the base of the Middle Cambrian, according to the West Gondwanan standard (Geyer and Landing 2004), should be placed above this assemblage (Text-fig. 6). Assemblage 2b from the Ocieseki Formation (Text-fig. 6) is questionably referred to the *E. insularis* Zone of the *A. oelandicus* Superzone, which corresponds to the middle Adgzian *C. notabilis* Zone of Morocco; the *Hupeolenus* Zone, representing the oldest Agdzian Stage was not recognized in the Ocieseki Formation.

The stratigraphical equivalent of the boundary interval of the *Hupeolenus–C. notabilis* zones of the Agdzian Stage in West Gondwana is the Kamieniec Formation yielding protolenines (trilobite assemblages 1a and 1b in Text-fig. 6) and acritarchs (acritarch assemblages 1a and 1b in Text-fig. 6), indicating the *Protolenus–Issafeniella* Zone and partially the *Volkovia dentifera–Liepaina plana* Zone as recognized in the EEC. However, acritarch assemblage 1b also yields acritarchs so-far considered typical of the Middle Cambrian; *Volkovia dentifera* and other species indicative of the Lower Cambrian co-occur with *Eliasum llaniscum*, a taxon characteristic of the basal Middle Cambrian (see above). The ranges of *V. dentifera* and *E. llaniscum* have never been shown to overlap either in Scandinavia or the EEC (Volkova *et al.* 1983; Hagenfeldt 1989a; Eklund 1990; Moczydłowska 1991; Pacześna 2008). The new observation shows that acritarch assemblage 1b is transitional between the Lower Cambrian *Volkovia dentifera–Liepaina plana* Zone associations and the Middle Cambrian associations of the Kibartai Acritarch Horizon as defined by e.g. Volkova *et al.* (1983). Thus, the exchange of acritarch assemblages across the Lower–Middle Cambrian boundary interval was more gradual than hitherto interpreted.

In Spain, the base of the Middle Cambrian *Eliasum llaniscum–Celtiberium dedalinum* Zone lies slightly below the FAD of *Paradoxides* (*A.*) *mureroensis* (Palacios and Moczydłowska 1998; Moczydłowska 1999; Text-fig. 10) within the upper part of the 'Bilbilian' Stage. This level corresponds to the *Hupeolenus* Zone of Morocco (Geyer and Landing 2004) (see Text-fig. 2). Similarly in the HCM, acritarch assemblages 1a and 1b (Text-fig. 6), with *E. llaniscum* and *Celtiberium*, predate strata with *Paradoxides* (trilobite assemblages 2b, 3a, and 4a in Text-fig. 6; see Text-fig. 10). In Morocco, representatives of *Paradoxides s.l.* appear already in the *Hupeolenus* Zone (lower part of the Agdzian Stage) (Geyer 1990a; Geyer and Palmer 1995; Text-fig. 10). In Spain, this event took place later, in strata correlated with the early *C. notabilis* Zone (Liñán *et al*. 1996; Geyer and Landing 2004). A similar later appearance of *Para-*



Text-fig. 10. Correlation of the Lower–Middle Cambrian interval of the HCM with West Gondwana and Baltica, showing the local Lower–Middle Cambrian boundary (thick black line), FAD of *Paradoxides* spp. (P), FAD of the *Eliasum–Cristallinium* assemblage (*), and position of the *Onaraspis* clade (O). Vertical lines indicate non-deposition and/or sedimentary gap. Compiled after: Geyer and Landing (2004) and Nielsen and Schovsbo (2006), with acritarch data from Jankauskas and Lendzion (1992), Palacios and Moczydłowska (1998) and Moczydłowska (1999)

doxides s.l. was also documented in Newfoundland (Fletcher 2003). In the HCM, the paradoxidids appear in the *E. insularis* Zone in assemblages 3a and 4a, the level corresponding to the *C. notabilis* Zone (Text-fig. 10). All these arguments support the view of Geyer and Palmer (1995) concerning the diachronous first appearances of *Paradoxides s.l.*; this event predates (Spain, NW Wales, HCM, Scandinavia) or is almost coeval (Morocco) with the first appearance of the *Eliasum–Cristallinium* acritarch association. In Scandinavia, *Paradoxides s.l.* appears with the *Eliasum–Cristallinium* assemblage directly within transgressive deposits that appeared on Baltica after the Hawke Bay events (Nielsen and Schovsbo 2006; Text-fig. 10).

Correlatable with the *C. notabilis* Zone of Morocco are intervals with trilobite assemblages 3a, 3b and 4a (Text-fig. 6), referred to the *E. insularis* Zone. In Scandinavia a part of this interval is missing (see also Żylińska and Masiak 2007; Text-fig. 10). Also time-equivalent of the *C. notabilis* Zone is the interval with acritarch assemblage 2 from the Kobierniki Beds (Text-fig. 6). Intervals with trilobite assemblage 4b from the Jugoszów–Usarzów section, most probably with the acritarch assemblage 4 from the Jugoszów 20 section, and with the acritarch assemblage 5 from the upper part of the Kobierniki Beds, correspond to the upper but not uppermost part of the Agdzian Stage, dominated by *Ornamentaspis* spp. The Słowiec Hill succession, with the trilobite assemblage 5 corresponds already to the Caesaraugustian Stage (Text-fig. 6).

The observed changes in the trilobite and acritarch assemblages in the Lower–Middle Cambrian boundary interval of the HCM are closely associated with a distinct facies change, expressed by the onset of shallow-marine sandstones of the Słowiec and Usarzów formations above the shale-dominated, open-shelf deposits of the Kamieniec Formation (Text-figs 5 and 6). This facies change most probably reflects the regressive events caused by the eustatic Hawke-Bay fall. On Baltica, this regression caused a regional stratigraphic gap (e.g., Lendzion 1976; Bergström and Gee 1985). A corresponding eustatic fall is marked in Morocco by the *Hupeolenus* Zone high-energy tidalites of the Tazlaft Formation, and in Spain by the appearance of lower Daroca sandstones in the Iberian Chains, replacing low-energy, shale-dominated deposition (Landing *et al.* 2006). The facies change in the HCM is stratigraphically younger, as evidenced by *E. insularis* Zone assemblages (*C. notabilis* Zone equivalent) in the Słowiec and Usarzów formations (trilobite assemblages 3a, 3b and 4a; Text-fig. 6).

CONCLUSIONS

1. Trilobite and acritarch analyses in the Lower–Middle Cambrian boundary interval in the HCM allowed trilobite and acritarch assemblages documenting the evolution of these groups to be distinguished. Some of the assemblages document the part of the Baltic succession that is largely missing due to the Hawke-Bay regressive events.
2. Based on trilobites, the studied interval can be directly compared to the West Gondwanan standard of Geyer and Landing (2004). The successions of both areas document similar evolution of the ellipsocephalids, and contain a number of trilobite taxa in common (e.g., *Kingaspidoides, Kingaspis*, *Latikingaspis*, *Latoucheia*, *Myopsolenites*, *Ornamentaspis*, *Orodes*, *Palaeolenus*, *Paradoxides* (*A.*) *mureroensis*).
3. The palynomorph associations of the studied interval are widely noted assemblages, common to Baltica, Gondwana or Avalonia. The gradual transition from the Early Cambrian *Skiagia*-dominated assemblages to the Middle Cambrian *Eliasum* and *Cristallinium*-dominated assemblages was evidenced. The transitional assemblages contain taxa regarded hitherto as Early or Middle Cambrian. The *Eliasum–Cristallinium* assemblage preceded the appearance of *Paradoxides* spp., which occurred approximately at the same time as in Spain and Newfoundland.

PALAEONTOLOGICAL NOTES

Trilobites (AŻ)

Material and methods

The specimens studied are preserved as moulds or casts in sandstones, siltstones or shales; in the fine-grained siliciclastics they are usually flattened. Due to flattening, the measured dimensions are often not reliable. Disarticulated remains, dominated by cranidia, prevail. Complete or almost complete specimens are very rare, and they are more common in the fine-grained sediments (Kamieniec or Ociesęki formations). In the coarse sandstones of the Słowiec Formation, complete specimens do not occur at all.

The terms applied to the trilobite exoskeleton follow the Trilobite Treatise (Kaesler 1997). Measurements were made with digital callipers (0.1 mm accuracy). Character lengths were measured either sagittally (sag) or exsagittally (exs), and widths were measured transversely (tr). For each specimen, the measurements were taken in one plane. Particular parameters were calculated with Microsoft Excel software. The term 'approximately' refers to cases when only one specimen is measured; a value range is given for two to four specimens, whereas for five specimens or more the mean value together with the standard deviation is given (after Sundberg and McCollum 1997, modified). The number of specimens for which the character lengths and widths have been measured is given in parentheses after the mean value (e.g., n=6). Before being photographed the specimens were coated with ammonium chloride.

Detailed systematic diagnoses and descriptions are supplied only for taxa whose taxonomic assignment is revised herein. The distribution of trilobite specimens in particular exposures and cores together with their repository numbers are given in Appendix 1.

Systematic descriptions

Superfamily Ellipsocephalacea Matthew, 1887
Family Ellipsocephalidae Matthew, 1887
Subfamily Antatlasiinae Hupé, 1953 emend. Geyer, 1990b
Genus *Issafeniella* Geyer, 1990b

TYPE SPECIES: *Issafeniella turgida* Geyer, 1990b, from the Issafen Formation of the Anti-Atlas, Morocco, OD.

Issafeniella trifida (Orłowski, 1985a)
(Pl. 1, Fig. 1)

1985a. *Strenuaeva trifida* sp. n.; S. Orłowski, p. 241, text-fig. 10; pl. 6, figs 8, 9.

HOLOTYPE: Cranidium MUZWG ZI/29/1188, illustrated in Orłowski (1985a, pl. 6, fig. 8), from the *Protolenus–Issafeniella* Zone at Nowa Łagowica, HCM.

EMENDED DIAGNOSIS: *Issafeniella* with glabella c. 75% of cranidial length and three pairs of lateral glabellar furrows, obsolete in adult specimens. Preglabellar field and anterior border typically confluent, distinctly inflated. Preglabellar field separated from glabella and eye-ridges by distinct, wide furrow. Occipital spine absent.

MATERIAL: 36 cranidia, 5 cranidia with thoraces, single pleura.

DESCRIPTION: Cranidium sub-quadrangular, overall convexity medium, glabella and fixigenae distinctly elevated above frontal area, length 76±10% of maximum width across centre of palpebral lobes (n=9). Glabella convex, only slightly elevated above fixigenae, 74±6% of cranidial length (n=9) and 48±4% of cranidial width across occipital ring (n=7); slightly narrowing forwards and truncated anteriorly. Frontal lobe sagittally short and sub-truncate. Three pairs of lateral glabellar furrows, wide but shallow, directed backward and decreasing in length towards the anterior; obsolete in large specimens. Occipital furrow wide but shallow, slightly more distinct than lateral glabellar furrows. Occipital ring 13±3% of cranidial length (n=8), flat and undifferentiated. Occipital spine absent. Axial furrows wide and shallow. Fixigenae inflated, reaching almost to the same level as the glabella, and sloping from centre towards the margins, 75±11% of transverse occipital ring width (n=6). Palpebral lobes 24–38% of cranidial length, flat. Palpebral furrow represented as a shallow and poorly defined depression. Anterior branch of facial suture only slightly divergent from palpebral lobes to frontal margin, then curving sharply adaxially. Posterior branch strongly divergent, short. Frontal area sloping downwards anteriorly, 26±6% of cranidial length (n=9), strongly inflated, entire, without border furrow. Preglabellar furrow very distinct, shallow and rather wide, becoming narrower and crescent-shaped in front of glabella; with a tendency to diverge forwards distally in large specimens. Posterior furrow deeper distally.

Thorax with at least 10 segments. Thoracic pleurae narrower than axial ring. Pleural furrows long, sharply delimited. Fulcral process located in external 1/3 of pleural flange. Pleural terminations slightly narrowing and curved posteriorly in the first four segments, in the posterior segments only with pointed tip and directed distally. Pleural spines absent. Librigenae and pygidium unknown.

MEASUREMENTS: Length of the largest, most complete specimen (cranidium with incomplete thorax; MUZWG ZI/29/2146; Pl. 1, Fig. 1) is 48 mm; the cranidium is 15 mm long and 18.6 mm wide across centre of palpebral lobes. Specimens preserved as cranidia with thoraces usually represent juveniles, from 7.1 to 9.1 mm total length. Cranidial length 3–17.3 mm; cranidial width across centre of palpebral lobes 4.6–23.2 mm (n=12). The holotype cranidium is 13.6 mm long and 16.5 mm wide across centre of palpebral lobes.

REMARKS: In addition to *Issafeniella orlowinensis* (Samsonowicz, 1959a) (see Żylińska and Masiak 2007 for emended diagnosis and description), *I. trifida* is another representative of *Issafeniella* in the HCM. It differs from *I. orlowinensis* in a slightly longer and wider glabella, wider and more inflated fixigenae, and the presence of a wide preglabellar furrow. With regard to the latter feature, *I. trifida* particularly recalls *I. turgida*, the type species of *Issafeniella* from the *Antatlasia guttapluviae* Zone in Morocco (Geyer 1990b, pl. 12, figs 1–5), but has a much wider glabella at the level of the palpebral lobes. Similarly as in *I. orlowinensis*, occipital spines were not observed in specimens of *I. trifida*, although this might be the result of poor preservation of internal moulds (see Żylińska and Masiak 2007, p. 675 for remarks).

OCCURRENCE: Lower Cambrian *Protolenus–Issafeniella* Zone, Kamieniec Formation at Chojnów Dół, Nowa Łagowica, and Wola Jastrzębska, HCM.

Subfamily Ellipsocephalinae Matthew, 1887 emend. Geyer, 1990b

Genus *Kingaspis* Kobayashi, 1935 emend. Geyer and Landing, 2001

TYPE SPECIES: *Anomocare campbelli* King, 1923, from the Burj Formation at Wadi Zarqa Ma'in in Jordan, OD.

REMARKS: Hupé (1953) erected two subgenera of *Kingaspis*, i.e. *K.* (*Kingaspis*) and *K.* (*Kingaspidoides*), based on the respective absence or presence of an occipital spine. Geyer (1990b) transferred the subgenera into genera and supplied a set of distinguishing characters. This view was supported by Rushton and Powell (1998) and Geyer and Landing (2001). On the other hand, Liñán *et al.* (2003) gave emended definitions of *Kingaspis* and *Kingaspidoides* as subgenera of *Kingaspis*. As pointed out by Geyer (e.g., 1990b and in Geyer and Landing 2004), correct generic and specific identification of the kingaspidoids (*Kingaspis*, *Kingaspidoides*, and *Ornamentaspis*) should be based on specimens with well-recognized internal and external morphology of the cranidia. The reported Spanish specimens of these genera show a considerable degree of tectonic deformation and are often flattened (e.g., Sdzuy 1961; Liñán *et al*. 1993, 2003), thus not allowing precise recognition of the external morphology. Characters presented by Geyer (1990b) and Geyer and Landing (2001) for distinguishing *Kingaspis* from *Kingaspidoides* and *Ornamentaspis* are possible to identify on the much less deformed specimens from the HCM, and their concept of these genera is applied herein. *Kingaspis* has been recorded previously from Poland (Orłowski 1964; Lendzion 1972), but the specimens in fact represent other genera. *Kingaspis* (*Kingaspis*) *henningsmoeni* Orłowski, 1964 is assigned to *Ornamentaspis* (see below), while *Kingaspis* (*Kingaspis*) *borealis* Lendzion, 1972, because of its strongly tapering glabella and wide frontal area, is completely distinct from the genus (see also Geyer 1990b, pp. 103, 104).

Kingaspis guerichi (Orłowski, 1959b)
(Pl. 3, Figs 9, 10)

1959b. *Ellipsocephalus gürichi* sp. n.; S. Orłowski, pp. 516, 517, text-fig. 1a; pl. 1, figs 6–10.
partim 1964. *Ellipsocephalus gürichi* Orłowski; S. Orłowski, p. 82, pl. 4, figs 4, 6, 7, 9; pl. 9, fig. 1 *non* pl. 4, figs 5, 8 (= *Ornamentaspis puschi*).
1965. *Ellipsocephalus gürichi* Orłowski; S. Orłowski, p. 137, pl. 1, fig. 6.
partim 1985b. *Ellipsocephalus guerichi* Orłowski; S. Orłowski, p. 24, pl. 2, figs 9–14 *non* pl. 2, fig. 15 (= *Ornamentaspis puschi*).
1990. *Ellipsocephalus guerichi* Orłowski; K. Lendzion and S. Orłowski in Pajchlowa, p. 52, pl. 14, fig. 1.

HOLOTYPE: Cranidium MUZWG ZI/29/2432, illustrated in Orłowski (1959b, pl. 1, fig. 6a–c; 1985b, pl. 2, fig. 9) and in Lendzion and Orłowski in Pajchlowa (1990, pl. 14, fig. 1), from the *Eccaparadoxides insularis* Zone at Sternalice, HCM.

EMENDED DIAGNOSIS: *Kingaspis* with cranidium wider than long, wide glabella c. 80% of cranidial length and c. 55% of cranidial width across centre of palpebral lobes; glabella with slightly concave axial furrows; lateral glabellar furrows typically effaced; fixigenae c. 75% of maximum glabellar width; exsagittal length of palpebral lobes c. 22% of cranidial length; anterior border slightly rounded, narrow, poorly separated from preglabellar field; occipital ring narrow, without occipital spine.

MATERIAL: 98 cranidia.

DESCRIPTION: Cranidium sub-rectangular, distinctly wider than long, length 68±6% of maximum width across centre of palpebral lobes (n=14); overall convexity rather uniform sagittally and transversely. Glabella slightly convex, 81±3% of cranidial length (n=15) and 56±6% of cranidial width across occipital ring (n=15), with sub-parallel to slightly concave sides, slightly tapering forward, frontal lobe rounded anteriorly. Lateral glabellar furrows generally effaced, although faint traces of furrows are present on some internal moulds; in those cases S1 is strongly curved backwards. Occipital furrow straight in central part, slightly curved forward distally, rather shallow and sagittally narrow, not reaching axial furrows. Occipital ring 13±2% of cranidial length (n=14), strongly sloping downwards posteriorly, of constant width, without spine or node. Axial furrows shallow but distinct, slightly shallower adjacent to frontal lobe of glabella. Fixigenae transversely convex, slightly elevated above axial furrows, 75±9% of transverse occipital ring width (n=17). Palpebral lobes crescent-shaped, 22±3% of cranidial length (n=12), passing into eye-ridges that curve obliquely forward and towards glabella. Parafrontal band well-developed. Palpebral furrows indistinct. Anterior branch of facial suture long, slightly divergent from palpebral lobes to anterior border, anterolateral wings extending exsagittally beyond palpebral lobes. Posterior branch short, strongly divergent, posterolateral wings extending exsagittally beyond palpebral lobes. Posterior ends of palpebral lobes not reaching posterior border furrow. Frontal area 19±3% of cranidial length (n=15), poorly separated into flat preglabellar field and slightly convex anterior border. Posterior border furrow shallow and wide.

MEASUREMENTS: The holotype cranidium is 10.6 mm long and 15.9 mm wide across centre of palpebral lobes. Cranidial length 5.3–13.9 mm; cranidial width across centre of palpebral lobes 7.9–20.3 mm (n=17).

REMARKS: Geyer (1990b) considered this species to represent *Ornamentaspis*; however, due to uniform convexity of the cranidium, effaced lateral glabellar furrows on external moulds and slightly concave sides of glabella, the species fits the concept of *Kingaspis sensu* Geyer and Landing (2001). From the type species, *K. campbelli* (see Geyer 1990b; Rushton and Powell 1998), it differs in a slightly longer glabella in relation to the total cranidial length, and a much wider glabella in relation to the transverse glabellar width. It also possesses a much longer occipital ring, but similarly to *K. campbelli*, it lacks a node or spine and is strongly bent downwards posteriorly. A long occipital ring is present e.g., in *K. sarhroensis* Geyer, 1990b from the *C. notabilis* Zone of Morocco (Geyer 1990b), but this species has a slightly narrower glabella and strongly concave glabellar sides in comparison with *K. guerichi*. The species discussed is closest in cranidial proportions to *K. glabrata* Geyer, 1990b, another species from the *C. notabilis* to *O. frequens* zones in Morocco, from which it differs in a wider glabella in relation to the transverse glabellar width and a shorter occipital ring (Geyer 1990b); moreover, *K. glabrata* has a very low relief, whereas the specimens studied display a more prominent cranidial morphology.

OCCURRENCE: Middle Cambrian *Eccaparadoxides insularis* to *Paradoxides polonicus* zones; Ociesęki Formation at Zamczysko, Usarzów Formation at Sternalice, Jugoszów 1a, 1, 3–5, 7a, 19, 20, and Helenów, and Słowiec Formation on Słowiec Hill, HCM.

Genus *Kingaspidoides* Hupé, 1953 emend. Geyer, 1990b

TYPE SPECIES: *Kingaspis* (*Kingaspidoides*) *armatus* [sic] Hupé, 1953, a subjective synonym of *Kingaspis* (*Kingaspis*) *brevifrons* Hupé, 1953 emend. Geyer, 1990b from the Bréche à *Micmacca* facies from Ourika Wawrmast, Anti Atlas, Morocco (*cf.* Geyer 1990b).

Kingaspidoides jugoszowi (Orłowski, 1959b)
(Pl. 4, Fig. 3)

1959b. *Ellipsocephalus jugoszovi* n. sp.; S. Orłowski, p. 518, text-fig. 1d; pl. 2, figs 5, 6.
1964. *Ellipsocephalus jugoszovi* Orłowski; S. Orłowski, p. 68, pl. 3, figs 9–12.
1985b. *Ellipsocephalus jugoszowi* Orłowski; S. Orłowski, p. 254, pl. 2, figs 1–4.
1990. *Ellipsocephalus jugoszowi* Orłowski; K. Lendzion and S. Orłowski in Pajchlowa, p. 53, pl. 14, fig. 3.

HOLOTYPE: Cranidium MUZWG ZI/29/2522, illustrated in Orłowski (1959b, pl. 2, fig. 6a–c; 1985b, pl. 2, fig. 2) and Lendzion and Orłowski in Pajchlowa (1990, pl. 14, fig. 3), from the *Eccaparadoxides insularis* Zone in the Jugoszów–Usarzów section (exposure Jugoszów 1a), HCM.

EMENDED DIAGNOSIS. *Kingaspidoides* with glabella slightly elevated above preglabellar field and fixigenae; glabella c. 80% of cranidial length and less than 45% of cranidial width across centre of palpebral lobes, sub-triangular anteriorly; occipital ring without spine; fixigenae of more than 75% of maximum glabellar width; exsagittal length of palpebral lobes c. 24% of cranidial length; anterior border barely defined.

MATERIAL: 42 cranidia.

DESCRIPTION: Cranidium sub-quadrangular, overall convexity modest, length 86±5% of maximum width across centre of palpebral lobes (n=8). Glabella convex, slightly elevated above fixigenae, in some specimens with faint median ridge, 81±2% of cranidial length (n=11) and 43±3% of cranidial width across occipital ring (n=11). Frontal lobe bluntly pointed. Lateral glabellar furrows effaced. Occipital furrow narrow, almost indistinct, curved forward distally. Occipital ring 15±2% of cranidial length (n=11), without spine. Axial furrows shallow but distinct, slightly shallower adjacent to frontal lobe of glabella. Fixigenae flat, gently sloping towards palpebral lobes, 76±7% of transverse occipital ring width (n=10). Palpebral lobes narrow, crescent-shaped, 24±4% of cranidial length (n=6). Palpebral furrow narrow and indistinct. Anterior branch of facial suture moderately short, slightly divergent, not extending exsagittally beyond palpebral lobes. Posterior branch short, not divergent. Frontal area 19±2% of cranidial length (n=11), poorly defined into preglabellar field and anterior border. Posterior border furrow shallow, almost indistinct.

MEASUREMENTS: The holotype cranidium is 11.4 mm long and 12.6 mm wide across centre of palpebral lobes. Cranidial length 8.4–11.6 mm; cranidial width across centre of palpebral lobes 10–12.8 mm (n=11).

REMARKS: The assignment to *Kingaspidoides* Hupé, 1953 emend. Geyer, 1990b is justified by such cranidial features as the bar-like elevation of the glabella above the fixigenae, overall convexity of the cranidium and the wide and convex frontal area. From *K. sanctacrucensis*, an abundant species in the HCM (see Żylińska and Masiak 2007 for emended diagnosis and discussion), *K. jugoszowi* differs in a transversely narrower glabella, longer occipital ring, distinctly wider fixigenae, and less pronounced bar-like elevation of the glabella above the fixigenae. It is very similar to *K. sandomiri* (see below), differing in a slightly longer glabella in relation to the total cranidial length, shorter palpebral lobes and wider fixigenae. Of the Moroccan representatives of the genus, *K. brevifrons* has a shorter glabella in relation to the total cranidial length and narrower fixigenae in relation to the maximum glabellar width; *K. laetus* Geyer, 1990b has a longer glabella, narrower fixigenae and a median occipital thorn; *K. larvalis* Geyer, 1990b has narrower fixigenae with stronger relief, while *K. obliquoculatus* Geyer, 1990b has a narrower glabella and slightly narrower fixigenae (see Geyer 1990b). The specimens at hand are quite close to *K. borjensis* Geyer, 1990b, differing in much wider fixigenae and shorter palpebral lobes.

OCCURRENCE: Middle Cambrian *Eccaparadoxides insularis* and *Ptychagnostus praecurrens* zones; Usarzów Formation at Jugoszów 1a, 3, 7a, HCM.

Kingaspidoides sandomiri (Orłowski, 1959b)
(Pl. 4, Figs 1, 2)

partim 1959b. *Ellipsocephalus polytomus* Linnarsson; S. Orłowski, p. 515, pl. 1, figs 1, 2a–c *non* pl. 1, figs 3–5 (= *Ellipsocephalus hoffi*).

partim 1959b. *Ellipsocephalus sandomiri* n. sp.; S. Orłowski, p. 518, text-fig. 1c; pl. 2, figs 2, 3 *non* pl. 2, fig. 4 (= *Ornamentaspis hupei*).

partim 1964. *Ellipsocephalus sandomiri* Orłowski; S. Orłowski, p. 83, pl. 3, figs 4–7 *non* pl. 3, fig. 8 (= *Ornamentaspis puschi*).

1965. *Ellipsocephalus sandomiri* Orłowski; S. Orłowski, p. 137, pl. 1, figs 7–9.

1985b. *Ellipsocephalus sandomiri* Orłowski; S. Orłowski, p. 253, pl. 1, figs 9–13.

1990. *Ellipsocephalus sandomiri* Orłowski; K. Lendzion and S. Orłowski in Pajchlowa, p. 54, pl. 14, fig. 8.

HOLOTYPE: Cranidium MUZWG ZI/29/2353, illustrated in Orłowski (1959b, pl. 2, fig. 2a–c; 1985b, pl. 1, fig. 9) and in Lendzion and Orłowski in Pajchlowa (1990, pl. 14, fig. 8), from the *Ptychagnostus praecurrens* Zone in the Jugoszów–Usarzów section (exposure Jugoszów 19), HCM.

EMENDED DIAGNOSIS: *Kingaspidoides* with parallel-sided glabella exceeding 80% of cranidial length and c. 45% of cranidial width across centre of palpebral lobes, with triangular anterior margin; lateral glabellar furrows effaced; glabella slightly elevated above level of short (sag) occipital ring without spine; fixigenae almost 80% of maximum glabellar width (tr); exsagittal length of palpebral lobes c. 20% of cranidial length; anterior border gently rounded anteriorly, almost fused with preglabellar field.

MATERIAL: Three cranidia with thoraces, single thorax, and 85 cranidia.

DESCRIPTION: Cranidium sub-quadrangular, overall convexity modest, length 83±8% of maximum width across centre of palpebral lobes (n=26). Glabella convex, slightly elevated above fixigenae and occipital ring, in some specimens with median ridge, 83±3% of cranidial length (n=30) and 45±5% of cranidial width across occipital ring (n=30). Frontal lobe bluntly pointed, extensions of anterolateral corners of glabella connected with poorly marked eye-ridges. Lateral glabellar furrows effaced. Occipital furrow distinct, curved forward distally, not reaching axial furrows. Occipital ring slightly longer (sag) at mid-line, 14±2% of cranidial length (n=30), without spine. Axial furrows shallow but distinct, slightly shallower adjacent to frontal lobe of glabella. Fixigenae nearly flat, gently sloping towards palpebral lobes, 79±9 % of transverse occipital ring width (n=27). Palpebral lobes narrow, crescent-shaped, 19±6% of cranidial length (n=30). Palpebral furrow narrow and indistinct. Anterior branch of facial suture moderately short, slightly divergent, anterolateral wings not extending exsagittally beyond palpebral lobes. Posterior branch short, divergent from posterior parts of palpebral lobes. Frontal area 17±3% of cranidial length (n=30), preglabellar field almost fused with anterior border. Posterior border furrow shallow, broadening distally.

Librigena small, without spine, with wide lateral border. Thorax with at least 11 segments, pleural tips directed slightly backwards. Axial part almost 50% of maximum thoracic width. Pygidium unknown.

MEASUREMENTS: The holotype cranidium is 10.4 mm long and 12.9 mm wide across centre of palpebral lobes. Cranidial length 5.8–17.9 mm; cranidial width across centre of palpebral lobes 12.9–21.3 mm (n=31).

REMARKS: The assignment of the studied specimens to *Kingaspidoides* is based on overall cranidial convexity, slightly bar-like elevation of the glabella above the fixigenae, and a moderately wide frontal area. The species greatly resembles *K. jugoszowi*, from which it differs in having a slightly shorter glabella in relation to the total cranidial length, longer palpebral lobes and narrower fixigenae (see description of *K. jugoszowi* for comparison with other species).

OCCURRENCE: Middle Cambrian *Eccaparadoxides insularis* to *Paradoxides polonicus* zones; Ociesęki Formation at Zamczysko, Usarzów Formation at Sternalice, Jugoszów 1, 7, 19 and 20, and Słowiec Formation on Słowiec Hill, HCM.

Genus *Latikingaspis* Geyer, 1990b

TYPE SPECIES: *Kingaspis* (*Kingaspis*) *alatus* Hupé, 1953 emend. Geyer, 1990b, from Ourika Wawrmast, Anti Atlas, Morocco, OD.

Latikingaspis samsonowiczi (Orłowski, 1964)
(Pl. 5, Figs 10, 11, 13; Text-fig. 11)

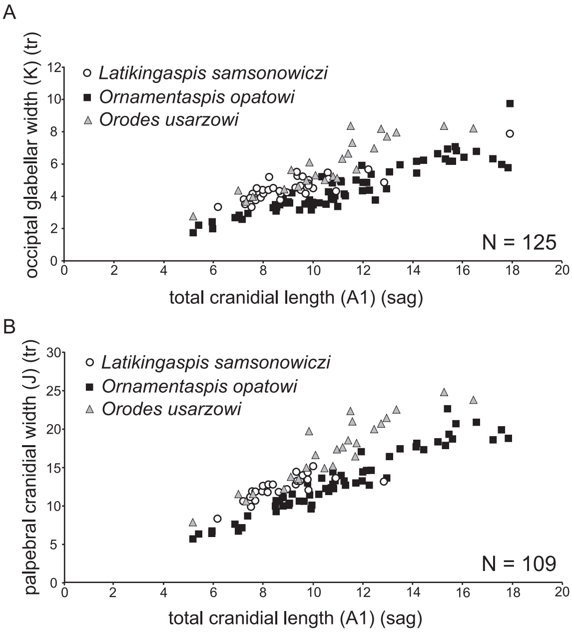
partim 1964. *Strenuella* (*Comluella*) *samsonowiczi* n. sp.; S. Orłowski, pp. 83–85, fig. 16; pl. 6, figs 1–4, 6 *non* pl. 6, fig. 5; pl. 7, figs 1–9; pl. 8, figs 1–3, 5–7 (= *Ornamentaspis opatowi*); *non* pl. 8, figs 4, 8, 9; pl. 9, figs 1–5 (= *Orodes usarzowi*).
partim 1964. *Protolenus* (*Protolenus*) *polonicus* n. sp.; S. Orłowski, pl. 11, fig. 3 (only).
1965. *Strenuella* (*Comluella*) *samsonowiczi* Orłowski; S. Orłowski, p. 137, pl. 1, figs 10–12.
non 1972. *Strenuella* (*Comluella*) *samsonowiczi* Orłowski; K. Lendzion, p. 133, pl. 4, figs 12–19 (= ?*Ellipsocephalus polytomus*).
1985b. *Comluella samsonowiczi* (Orłowski); S. Orłowski, pp. 254, 255, fig. 2; pl. 3, figs 7–13.
1990. *Strenuella* (*Comluella*) *samsonowiczi* Orłowski; K. Lendzion and S. Orłowski in Pajchlowa, p. 56, pl. 15, fig. 6.

HOLOTYPE: Cranidium MUZWG ZI/29/1615, illustrated in Orłowski (1964, pl. 6, fig. 1; 1985b, pl. 3, fig. 12a–b) and in Lendzion and Orłowski in Pajchlowa (1990, pl. 15, fig. 6), from the *Eccaparadoxides insularis* Zone in the Jugoszów–Usarzów section (exposure Jugoszów 1), HCM.

EMENDED DIAGNOSIS: *Latikingaspis* with narrow glabella c. 80% of cranidial length and 50% of glabellar width across centre of palpebral lobes, parallel sides and three pairs of lateral glabellar furrows directed backwards; fixigenae distinctly elevated above the preglabellar field, c. 70% of maximum glabellar width; exsagittal length of palpebral lobes less than 30% of cranidial length; anterior border poorly defined.

MATERIAL: Three carapaces without librigenae, 76 cranidia.

DESCRIPTION: Cranidium sub-rectangular, wider than long, length 71±7% of maximum width across centre of palpebral lobes (n=26); overall convexity minor. Glabella distinctly convex, tapering forwards and rounded anteriorly, 79±3% of cranidial length (n=36) and 50±5% of cranidial width across occipital ring (n=35). Three pairs of short lateral glabellar furrows directed obliquely backwards, S3 shortest. Occipital furrow wide and shallow, slightly curved forward



Text-fig. 11. Bivariate scatterplots showing relations between (A) total cranidial length (sag) and occipital glabellar width (tr), and (B) total cranidial length (sag) and palpebral cranidial width (tr) in *Latikingaspis samsonowiczi* (Orłowski, 1964), *Ornamentaspis opatowi* (Orłowski, 1985b) and *Orodes usarzowi* (Orłowski, 1985b). Measurements in millimetres

distally. Occipital ring 17±2% of cranidial length (n=32), sagittally longer medially, rounded posteriorly, posterior part of occipital ring more elevated than its anterior part and glabella. Slender median spine on posterior part of occipital ring is directed backwards; spine preserved only on external moulds. Axial furrows shallow but distinct, shallower adjacent to frontal lobe of glabella. Fixigenae elevated above the surrounding furrows, 70±12% of transverse occipital ring width (n=29); most elevated part of fixigenae is located closer to suture than to glabella. Palpebral lobes crescent-shaped, 28±4% of cranidial length (n=24). Eye-ridges faint. Palpebral furrows shallow and wide. Anterior branch of facial suture moderately long, slightly divergent from palpebral lobes to anterior border, anterolateral wings not extending exsagittally beyond palpebral lobes. Posterior branch shorter, divergent. Frontal area indistinctly separated into flat preglabellar field and slightly convex, shorter anterior border, 21±3% of cranidial length (n=36). Posterior furrow shallow and wide, straight.

Librigena unknown. Thorax composed of at least 14 segments, pleural tips directed backward. Axis distinctly elevated above the pleurae, transverse width of axis exceeds 1/3 total width of thorax. Pygidium small, triangular in outline.

MEASUREMENTS: The holotype is an almost complete carapace without librigenae of 23.9 mm total length; the cranidium is 9.3 mm long and 12.8 mm wide across centre of palpebral lobes. Cranidial length 6.2–17.9 mm; cranidial width across centre of palpebral lobes 8.4–18 mm (n=36).

REMARKS: The first description by Orłowski (1964) of *S.* (*C.*) *samsonowiczi* was based on a collection of morphologically distinct specimens (Text-fig. 11). These specimens were subsequently assigned (Orłowski 1985b) to three taxa, i.e. *Comluella samsonowiczi*, *C. opatowi* and *C. usarzowi*. Geyer (1990b, p. 127) suggested that the taxa represent species of *Ornamentaspis*, but as shown herein, they in fact should be assigned to three different genera, i.e. *Latikingaspis* (*L. samsonowiczi*), *Ornamentaspis* (*O. opatowi*) and *Orodes* (*O. usarzowi*). The overall convexity of the cranidium and the location of the most elevated point of the fixigenae closer to the suture than to the glabella in specimens of *Comluella samsonowiczi sensu* Orłowski (1985b) are features indicative of *Latikingaspis* Geyer, 1990b. From *L. sulcatus* Geyer, 1990b, the specimens studied differ in their tapering glabella, distinct lateral glabellar furrows and the presence of a median spine on the occipital ring, and from *L. alatus* (Hupé, 1953) emend. Geyer, 1990b in stronger relief of the glabella which is also tapering and not parallel-sided, deeper lateral glabellar furrows and a flat preglabellar field (Geyer 1990b). Specimens of *S.* (*C.*) *samsonowiczi* found in the *A. oelandicus* Superzone of the Tłuszcz IG-1 borehole (Lendzion 1972) are too poorly preserved to allow a confident taxonomic assignment. However, they seem to represent instead *Ellipsocephalus polytomus* Linnarsson, 1877 (see Geyer 1990b, pl. 14, fig. 4a–d).

OCCURRENCE: Middle Cambrian *Eccaparadoxides insularis* to *Paradoxides polonicus* zones; Usarzów Formation at Sternalice, Jugoszów 1a, 1, 3, 5, 7 and Helenów, and Słowiec Formation on Słowiec Hill, HCM.

Genus *Ornamentaspis* Geyer, 1990b

TYPE SPECIES: *Ornamentaspis frequens* Geyer, 1990b, from the Lemdad Syncline, High Atlas, Morocco, OD.

REMARKS: Although similar to many other representatives of the Ellipsocephalinae, *Ornamentaspis* can clearly be distinguished by a uniform sagittal convexity of the cranidium, fixigenae that are convex transversely and rise above the axial furrows, and a mixed kingaspidoid and protolenoid pattern of the lateral glabellar furrows (Geyer 1990b). As currently understood, the genus includes a wide variety of species from a rather long interval spanning the Lower–Middle Cambrian boundary in different palaeogeographic areas. Many Scandinavian species assigned to this genus (Geyer 1990b) are strongly distorted and poorly preserved (see e.g., Ahlberg and Bergström 1978; Ahlberg 1979, 1984; Bergström and Ahlberg 1981), hampering detailed comparison with species recognized in other areas. This is also the case with Spanish specimens of this genus (see remarks for *Kingaspidoides*).

Ornamentaspis henningsmoeni (Orłowski, 1964)
(Pl. 5, Figs 1, 2)

1964. *Kingaspis* (*Kingaspis*) *henningsmoeni* n. sp.; S. Orłowski, pp. 86–88, fig. 18; pl. 10, figs 1–9.
1971. *Kingaspis* (*Kingaspis*) *henningsmoeni* Orłowski; S. Orłowski, p. 353, pl. 1, fig. 8.
1990. *Kingaspis* (*Kingaspis*) *henningsmoeni* Orłowski; K. Lendzion and S. Orłowski in Pajchlowa, p. 56, pl. 15, fig. 7a–c.

HOLOTYPE: Complete carapace MUZWG ZI/29/1791, illustrated in Orłowski (1964, pl. 10, fig. 1a–c) and in Lendzion and Orłowski in Pajchlowa (1990, pl. 15, fig. 7a–c), from the *Ptychagnostus praecurrens* Zone in the Jugoszów–Usarzów section (exposure Jugoszów 3), HCM.

EMENDED DIAGNOSIS: *Ornamentaspis* with glabella c. 80% of cranidial length and c. 55% of glabellar width across centre of palpebral lobes, narrower at mid-length; occipital ring relatively narrow; fixigenae almost 80% of maximum glabellar width; exsagittal length of palpebral lobes c. 27% of cranidial length; anterior border barely distinguishable from preglabellar field.

MATERIAL: One complete carapace, 35 cranidia, and single thorax.

DESCRIPTION: Cranidium sub-rectangular, wider than long, length 68±4% of maximum width across centre of palpebral lobes (n=17). Cranidial convexity more pronounced sagittally than transversely. Glabella slightly convex, gently tapering forwards, 80±2% of cranidial length (n=19) and 55±4% of cranidial width across occipital ring (n=19); front triangular to gently rounded. Four pairs of lateral glabellar furrows, S1 and S2 deep, directed backwards, S3 of the same length and depth but directed forwards, S4 located at shorter distance to S3 than the remaining furrows from each other, shorter and directed forwards. Occipital furrow wide, wider at mid-length, slightly curved forward distally. Occipital ring 18±2% of cranidial length (n=16), slightly longer medially, posterior part of occipital ring more elevated than anterior part. Median node visible only on exterior. Axial furrows shallow but distinct, slightly deeper at mid-length of palpebral lobes. Anterolateral corners of glabella almost indistinct. Fixigenae slightly elevated above the surrounding furrows, 79±7% of transverse occipital ring width (n=20); most elevated part of the fixigenae is located closer to the glabella than to the suture. Palpebral lobes crescent-shaped, 27±3% of cranidial length (n=18). Eye-ridges faint, not reaching axial furrows. Palpebral furrows narrow, distinct. Anterior branch of facial suture moderately long, slightly diverging from palpebral lobes to anterior border, anterolateral wings not extending exsagittally beyond palpebral lobes. Posterior branch shorter, divergent. Frontal area 20±2% of cranidial length (n=19), sloping downwards distally, separated into flat preglabellar field and slightly convex and shorter anterior border. Posterior furrow shallow and wide, distally wider and slightly diverging forwards.

Librigena small, without lateral spine, with relatively narrow lateral border. Thorax of 12 segments, pleural tips pointed distally. Axis strongly elevated above pleurae, transverse width of axis exceeds 1/3 of total thorax width. Pygidium small, triangular in outline, approximately twice wider than long.

MEASUREMENTS: The holotype carapace is strongly curved, its cranidium is 12.2 mm long and 18 mm wide across centre of palpebral lobes and the thorax is c. 25 mm long. Cranidial length 9.3–14.5 mm; cranidial width across centre of palpebral lobes 11.3–22.9 mm (n=21).

REMARKS: Because of the different overall convexity and mixed kingaspidoid–protolenoid pattern of the lateral glabellar lobes, the studied specimens should not be assigned to *Kingaspis*. They were considered to belong to *Ellipsostrenua* Kautsky, 1945 (see Geyer 1990b). The concept of *Ellipsostrenua* was based on *Strenuella* (*Ellipsostrenua*) *gripi* Kautsky, 1945 from the uppermost Lower Cambrian of Sweden (Kautsky 1945). Ahlberg and Bergström (1978) showed that *Ellipsostrenua* is certainly not a subgenus of *Strenuella* Matthew, 1887 and, moreover, synonymized this genus with *Ellipsocephalus* Zenker, 1833. Geyer (1990b) pointed out the deep lateral glabellar furrows, triangular frontal area, lack of anterolateral corners of the glabella as well as the short preglabellar field of *K.* (*K.*) *henningsmoeni* as indicative of *Ellipsostrenua*. Detailed examination of the HCM specimens has shown the presence of a poorly preserved parafrontal band with anterolateral corners. The frontal area may be triangular, but in most specimens is rather rounded anteriorly. The lateral glabellar furrows may be equally deep in many members of *Ornamentaspis* from Morocco (see Geyer 1990b) and HCM (see below). The preglabellar field is also much shorter in most Moroccan *Ornamentaspis* (see Geyer 1990b). Thus, *K.* (*K.*) *henningsmoeni* fits the concept of *Ornamentaspis* in practically all aspects. Most important is the presence of a mixed kingaspidoid–protolenoid pattern of the lateral glabellar furrows, as well as the more pronounced sagittal than transverse convexity of the cranidium. The only character that does not fit into the concept of *Ornamentaspis* is the poorly marked parafrontal band generating anterolateral corners of the glabella, but this may be the result of preservation. The HCM specimens differ from Moroccan species (see Geyer 1990b) in their wider glabella across the occipital ring, lack of occipital spine (median node preserved only on the exterior) and shorter palpebral lobes.

OCCURRENCE: Middle Cambrian *Eccaparadoxides insularis* to *Paradoxides polonicus* zones; Ociesęki Formation at Zamczysko, Usarzów Formation at Sternalice, Jugoszów 1, 3 and 7, and Słowiec Formation on Słowiec Hill, HCM.

Ornamentaspis hupei (Orłowski, 1964)
(Pl. 3, Figs 1, 2; Pl. 4, Figs 4–6)

partim 1959b. *Ellipsocephalus sandomiri* n. sp.; S. Orłowski, p. 518, pl. 2, fig. 4 (only).
partim 1964. *Strenuella* (*Comluella*) *hupei* n. sp.; S. Orłowski, pp. 85, 86, fig. 17; pl. 9, figs 6–11 *non* pl. 9, fig. 12 (= *Ornamentaspis opatowi*).
1971. *Strenuella* (*Comluella*) *hupei* (Orłowski); S. Orłowski, p. 353, pl. 1, figs 1–3.
1990. *Strenuella* (*Comluella*) *hupei* Orłowski; K. Lendzion and S. Orłowski in Pajchlowa, p. 56, pl. 15, fig. 5.

HOLOTYPE: Cranidium with incomplete thorax, MUZWG ZI/29/2346, illustrated in Orłowski (1964, pl. 9, fig. 6) and in Lendzion and Orłowski in Pajchlowa (1990, pl. 15, fig. 5), from the *Ptychagnostus praecurrens* Zone in the Jugoszów–Usarzów section (exposure Jugoszów 19), HCM.

EMENDED DIAGNOSIS: *Ornamentaspis* with narrow glabella c. 82% of cranidial length and c. 50% of cranidial width across centre of palpebral lobes; glabella with three pairs of rather shallow lateral glabellar furrows; occipital ring narrow, without spine; fixigenae c. 70% of maximum glabellar width; palpebral lobes less than 30% of cranidial length; preglabellar field and anterior border poorly differentiated.

MATERIAL: Two cranidia with librigenae and incomplete thoraces, 32 cranidia.

DESCRIPTION: Cranidium sub-quadrangular, length 83±7% of maximum width across centre of palpebral lobes (n=9). Sagittal convexity of cranidium more pronounced than transverse convexity. Glabella convex, slightly elevated above fixigenae, 82±2% of cranidial length (n=13) and 49±5% of cranidial width across occipital ring (n=13). slightly tapering forwards, anterior lobe sub-triangular to gently rounded. Three pairs of short and shallow lateral glabellar furrows, S1 and S2 bent backwards, S3 bent forwards. Occipital furrow shallow, straight medially and slightly curved forward distally, not reaching axial furrows. Occipital ring 16±2% of cranidial length (n=12), wider medially, only slightly elevated above the occipital furrow, without spine or node. Axial furrows shallow, straight, slightly shallower adjacent to frontal lobe of glabella. Fixigenae slightly elevated above the surrounding furrows, 69±3% of transverse occipital ring width (n=10). Palpebral lobes crescent-shaped, 27±2% of cranidial length (n=10). Eye-ridges faint, passing into poorly developed anterolateral corners of the glabella. Palpebral furrows shallow, indistinct. Anterior branch of facial suture short, slightly divergent, not extending exsagittally beyond palpebral lobes. Posterior branch short, divergent. Frontal area poorly separated into preglabellar field and shorter, gently convex anterior border, 18±2% of cranidial length (n=13). Posterior furrow shallow, straight.

Librigena small, probably without spine, otherwise too poorly preserved to allow detailed description. Thorax comprising at least 8 segments. Pleural tips pointed distally. Axial part slightly elevated above the pleural parts.

MEASUREMENTS: Cranidial length 6.3–11.4 mm; cranidial width across centre of palpebral lobes 7–13.6 mm (n=13). The holotype cranidium is the largest specimen.

REMARKS: The studied specimens represent a species of *Ornamentaspis* due to the following features: the transverse convexity of the cranidium is less pronounced than the sagittal convexity, the fixigenae are slightly elevated above the axial furrows, the glabella has sub-parallel sides, and the lateral glabellar furrows have a mixed kingaspidoid–protolenoid pattern. The species resembles *O. crassilimbata* Geyer, 1990b, differing in a slightly wider glabella across the occipital ring, shorter palpebral lobes and the lack of an occipital spine or node (Geyer 1990b). Moroccan species of the genus are characterized by a more or less pronounced parafrontal band generating anterolateral corners of the glabella (Geyer 1990b), a feature that is barely developed in the specimens of *O. hupei*, although this might be the result of poor preservation.

OCCURRENCE: Middle Cambrian *Eccaparadoxides insularis* to *Paradoxides polonicus* zones; Ociesęki Formation at Zamczysko, Słowiec Formation on Konarska and Słowiec hills, and Usarzów Formation at Jugoszów 1a, 1, 3, 4, 7a, 19 and 20, HCM.

Ornamentaspis opatowi (Orłowski, 1985b)
(Pl. 3, Figs 6–8; Text-fig. 11)

partim 1964. *Strenuella* (*Comluella*) *samsonowiczi* n. sp.; S. Orłowski, pp. 83–85, pl. 6, fig. 5; pl. 7, figs 1–9; pl. 8, figs 1–3, 5–7 *non* text-fig. 16; pl. 6, figs 1–4, 6 (= *Latikingaspis samsonowiczi*); *non* pl. 8, figs 4, 8, 9; pl. 9, figs 1–5 (= *Orodes usarzowi*).

partim 1964. *Strenuella* (*Comluella*) *hupei* n. sp.; S. Orłowski, pp. 85, 86, pl. 9, fig. 12 (only).

1985b. *Comluella opatowi* sp. n.; S. Orłowski, pp. 255–257, fig. 3, pl. 4, figs 6–14.

HOLOTYPE: Cranidium MUZWG ZI/29/1707, illustrated in Orłowski (1964, pl. 7, fig. 2a–b; 1985b, pl. 4, fig. 12), from the Jugoszów–Usarzów section (exposure Jugoszów 1a), HCM.

EMENDED DIAGNOSIS: *Ornamentaspis* with parallel-sided glabella c. 80% of cranidial length and c. 40% of cranidial width across centre of palpebral lobes, rounded anteriorly, with three pairs of lateral glabellar furrows, of which the two posterior are directed backwards, and the anterior is directed forwards; fixigenae c. 87% of maximum glabellar width; exsagittal length of palpebral lobes c. 27% of cranidial length; preglabellar field not differentiated from anterior border; free cheek with tiny lateral spine.

MATERIAL: 155 cranidia, one cranidium with librigenae.

DESCRIPTION: Cranidium sub-quadrangular, slightly wider than long, length 85±7% of maximum width across centre of palpebral lobes (n=59). Overall convexity low. Glabella strongly convex, 79±4% of cranidial length (n=67) and 40±5% of cranidial width across occipital ring (n=67); with parallel sides and anterior lobe strongly elevated and rounded anteriorly. Three pairs of lateral glabellar furrows, shallow, short and in most cases indistinct, S1 and S2 directed backwards, S3 directed forwards. Occipital furrow deep, only slighly curved forward distally. Occipital ring 17±2% of cranidial length (n=56), slightly longer medially, rounded posteriorly, with trace of a median spine or node on exterior. Axial furrows deep, slightly shallower adjacent to frontal lobe of glabella. Fixigenae distinctly elevated above the surrounding furrows, particularly the palpebral furrow, evenly convex both exsagittally and transversely, 87±12% of transverse occipital ring width (n=58). Palpebral lobes crescent-shaped, narrow, 27±4% of cranidial length (n=53). Palpebral furrow shallow and narrow. Eye-ridges faint, anterolateral corners indistinct. Anterior branch of facial suture short, divergent, anterolateral wings not exceeding exsagittally beyond palpebral lobes. Posterior branch short, divergent. Frontal area indistinctly separated into flat preglabellar field and gently convex short anterior border, 21±4% of cranidial length (n=67). Posterior furrow deep, very wide, widening distally.

Librigena small, with wide, poorly defined lateral border and tiny lateral spine.

MEASUREMENTS: The holotype cranidium is 15.5 mm long and 19.3 wide across centre of palpebral lobes. Cranidial length 5.4–17.9 mm; cranidial width across centre of palpebral lobes 6.3–17.9 mm (n=67).

REMARKS: *Comluella opatowi* was distinguished by Orłowski (1985b) as one of the three species (besides *C. samsonowiczi* and *C. usarzowi*) from the diverse group of specimens assigned by him earlier (Orłowski 1964) to *Strenuella* (*Comluella*) *samsonowiczi* (see Text-fig. 11). Geyer (1990b) referred these three species to *Ornamentaspis*. This reference is retained herein only for specimens assigned earlier to *C. opatowi*, whereas *C. samsonowiczi* is a representative of *Latikingaspis* Geyer, 1990b (see above) and *C. usarzowi* of *Orodes* Geyer, 1990b (see below). *O. opatowi* is characterized by a distinctly convex glabella with elevated anterior lobe, a feature that it shares with *O. crassilimbata* Geyer, 1990b from the *O. frequens* Zone of Morocco (Geyer 1990b). Moroccan species of the genus (Geyer 1990b) generally have longer palpebral lobes except *O. usitata* Geyer, 1990b, which in turn has a slightly shorter and low-relief glabella. *O. opatowi* can be clearly distinguished from the Polish representatives of *Ornamentaspis* by its pronounced cranidial morphology (elevated glabella and fixigenae) and generally narrower glabella across the occipital ring, a feature that is also present in most Moroccan species (see Geyer 1990b).

OCCURRENCE: Middle Cambrian *Eccaparadoxides insularis* to *Paradoxides polonicus* zones; Ociesęki Formation at Zamczysko, Usarzów Formation at Sternalice, Jugoszów 1a, 1, 3, 4, 7, 7a and 20, and Słowiec Formation on Słowiec Hill, HCM.

Ornamentaspis puschi (Orłowski, 1959b)
(Pl. 2, Figs 7, 8)

1959b. *Ellipsocephalus puschi* n. sp.; S. Orłowski, p. 517, text-fig. 1b; pl. 2, fig. 1a–c.
1964. *Ellipsocephalus puschi* Orłowski; S. Orłowski, p. 82, pl. 4, figs 1–3.
partim 1964. *Ellipsocephalus sandomiri* Orłowski; S. Orłowski, p. 83, pl. 3, fig. 8 (only).
partim 1964. *Ellipsocephalus gürichi* Orłowski; S. Orłowski, pl. 4, figs 5, 8 (only).
1985b. *Ellipsocephalus puschi* Orłowski; S. Orłowski, p. 253, pl. 2, figs 5–8.
partim 1985b. *Ellipsocephalus guerichi* Orłowski; S. Orłowski, p. 24, pl. 2, fig. 15 (only).
1990. *Ellipsocephalus puschi* Orłowski; K. Lendzion and S. Orłowski in Pajchlowa, p. 54, pl. 14, fig. 7.

HOLOTYPE: Cranidium MUZWG ZI/29/2578, illustrated in Orłowski (1959b, pl. 2, fig. 1a–c; 1985b, pl. 2, fig. 6) and in Lendzion and Orłowski in Pajchlowa (1990, pl. 14, fig. 7), from the *Ptychagnostus praecurrens* Zone in the Jugoszów–Usarzów section (exposure Jugoszów 4), HCM.

EMENDED DIAGNOSIS: *Ornamentaspis* with glabella c. 80% of cranidial length and c. 47% of cranidial width across centre of palpebral lobes, slightly tapering forwards; occipital ring sagittally narrow, separated from glabella by narrow and deep occipital furrow; fixigenae c. 80% of maximum glabellar width; exsagittal length of palpebral lobes c. 23% of cranidial length; preglabellar field distinctly separated from narrow anterior border.

MATERIAL: Over 250 cranidia, one incomplete thorax, and one pygidium tentatively assigned to the species.

DESCRIPTION: Cranidium sub-quadrangular, slightly wider than long, length 80±7% of maximum width across centre of palpebral lobes (n=38). Overall convexity moderate, more pronounced sagittally than transversely. Glabella convex, distinctly elevated above fixigenae, 81±3% of cranidial length (n=48) and 47±5% of cranidial width across occipital ring (n=48), tapering forwards and rounded anteriorly. Lateral glabellar furrows effaced. Occipital furrow shallow to obsolescent, curved forward distally, not reaching axial furrows. Occipital ring 13±2% of cranidial length (n=47), strongly bent downwards posteriorly in lateral view. No trace of spine or node. Axial furrows shallow, shallower adjacent to frontal lobe of the glabella. Fixigenae slightly elevated above the surrounding furrows, 80±9% of transverse occipital ring width (n=43). Palpebral lobes crescent-shaped, 23±3% of cranidial length (n=39), palpebral furrows indistinct. Eye-ridges faint, passing into anterolateral corners of glabella. Parafrontal band clearly visible. Anterior branches of facial suture diverging, short, anterolateral wings slightly extending exsagittally beyond palpebral lobes. Posterior branches shorter, divergent. Posterior border furrow shallow, slightly curved forward distally. Frontal area 19±3% of cranidial length (n=48), rounded anteriorly, faintly differentiated into preglabellar field and gently convex, slightly shorter anterior border.

Thorax comprising at least 11 segments; pygidium small, triangular in outline.

MEASUREMENTS: The holotype cranidium is 16.9 mm long and 18.5 wide across centre of palpebral lobes. Cranidial length 7.7–19.3 mm; cranidial width across centre of palpebral lobes 10–22.3 mm (n=67).

REMARKS. Following Geyer (1990b), *Ellipsocephalus puschi sensu* Orłowski, 1959b is assigned herein to *Ornamentaspis*. This is justified by an overall convexity of the cranidium which is more pronounced sagittally than transversely, a distinct parafrontal band and fixigenae elevated above the surrounding furrows. In contrast to *Ornamentaspis*, *O. puschi* has effaced lateral glabellar furrows, and its occipital ring lacks an occipital spine or node. In these characters the species resembles *Kingaspis sensu* Geyer, 1990b. However, species of *Kingaspis* should have all furrows effaced on the exterior, whereas in *O. puschi* only the lateral glabellar furrows are effaced. The specimens studied might therefore represent a genus transitional between *Kingaspis* and *Ornamentaspis*. The lack of complete specimens does not allow a confident interpretation.

OCCURRENCE: Middle Cambrian *Eccaparadoxides insularis* to *Paradoxides polonicus* zones; Ociesęki Formation at Zamczysko, Usarzów Formation at Sternalice, Jugoszów 3, 4, 7, 7a, 19, and Helenów, and Słowiec Formation on Słowiec Hill, HCM.

Subfamily Protoleninae Richter and Richter, 1948
emend. Geyer, 1990b
Genus *Hamatolenus* Hupé, 1953 emend. Geyer, 1990b

TYPE SPECIES: *Hamatolenus continuus* Hupé, 1953 (= *Protolenus elegans* var. *marocana* Neltner, 1938 emend. Geyer, 1990b) from Wirgane, High Atlas, Morocco, OD.

Subgenus *Hamatolenus* Hupé, 1953 emend. Geyer, 1990b

TYPE SPECIES: As for genus.

Hamatolenus (*Hamatolenus*) *glabellosus* (Orłowski, 1985a)
(Pl. 1, Fig. 2)

1962. *Conocoryphe*? sp.; J. Samsonowicz, p. 20, pl. 3, fig. 10, 10a.
1985a. *Protolenus* (*Latoucheia*) *glabellosus* sp. n.; S. Orłowski, pp. 247, 248, fig. 18; pl. 6, fig. 10.
2007. *Hamatolenus* (*Hamatolenus*) *glabellosus* (Orłowski); J. Nawrocki *et al.*, fig. 8.1.

HOLOTYPE: Cranidium MUZWG ZI/42/148, illustrated in Samsonowicz (1962, pl. 3, fig. 10, 10a), Orłowski (1985a, pl. 6, fig. 10), and Nawrocki *et al.* (2007, fig. 8.1), from the *Protolenus–Issafeniella* Zone at Kamieniec dam, HCM (Pl. 1, Fig. 2).

EMENDED DIAGNOSIS: *Hamatolenus* with glabella c. 75% of cranidial length, parallel sides, and three pairs of lateral glabellar furrows. Eye ridges almost as broad as palpebral lobes which are c. one-third of cranidial length. Surface of test covered with distinct ornamentation in form of fine tubercles.

MATERIAL: One cranidium and two pleurae assigned to the species.

DESCRIPTION: Cranidium sub-rectangular, overall convexity modest, length approximately 70% of maximum width across centre of palpebral lobes. Glabella slightly convex, approximately 75% of cranidial length and approximately 40% of cranidial width across occipital ring; glabella parallel-sided, with rounded front anterior to eye-ridges. Three short lateral glabellar furrows slightly curved obliquely backwards. Occipital furrow very narrow, slightly curved forward distally. Occipital ring approximately 13% cranidial length, slightly wider medially, with median node. Axial furrows deep and narrow. Fixigenae almost flat, slightly elevated above axial furrows, maximum width approximately 65% of transverse occipital ring width. Palpebral lobes cord-like, exsagittally approximately 35% of cranidial length; transverse width of palpebral lobes slightly larger than width of eye-ridges which curve obliquely forwards and pass into distinct parafrontal band. Palpebral furrow shallow and indistinct. Anterior branches of facial suture moderately short, diverging from palpebral lobes to anterior margin, anterolateral wings not extending exsagittally beyond palpebral lobes. Posterior branches short, diverging; posterior ends of palpebral lobes not reaching posterior border furrow. Frontal area approximately 25% of cranidial length, separated into slightly convex preglabellar field and much wider and flat anterior border. Parafrontal band well-developed. Posterior border furrow deep, wider distally. Test evenly covered with fine tubercles.

MEASUREMENTS: The single known cranidium is a flattened specimen; it is approximately 11.5 mm long and 22 mm wide across centre of palpebral lobes.

REMARKS: Despite its poor preservation and strong flattening, the single specimen fits the definition of *Hamatolenus* (*Hamatolenus*). It best resembles the type species *H.* (*H.*) *marocanus* (see Geyer 1990b), differing in the absence of an occipital spine, which may be the result of poor preservation. In the absence of additional specimens, *H.* (*H.*) *glabellosus* cannot be included with confidence into the synonymy of *H.* (*H.*) *marocanus*. *H.* (*H.*) *draensis* (Hupé, 1953) emend. Geyer, 1990b has much longer palpebral lobes whose posterior ends reach the posterior border furrow, and eye-ridges that are slightly narrower than the palpebral lobes, while *H.* (*H.*) *meridionalis* Geyer, 1990b has much longer palpebral lobes (Geyer 1990b).

OCCURRENCE: Lower Cambrian *Protolenus–Issafeniella* Zone; Kamieniec Formation at Kamieniec dam, HCM.

Genus *Protolenus* Matthew, 1892 emend. Geyer, 1990b

TYPE SPECIES: *Protolenus elegans* Matthew, 1892, emend. Westrop and Landing, 2000, from Hanford Brook, New Brunswick, Canada, OD.

Subgenus *Hupeolenus* Geyer, 1990b

TYPE SPECIES: *Protolenus* (*Hupeolenus*) *hupei* Geyer, 1990b, from the Lemdad Syncline, High Atlas, Morocco, OD.

Protolenus (*Hupeolenus*) *czarnockii* Orłowski and Bednarczyk in Bednarczyk *et al.*, 1965
(Pl. 1, Figs 3, 4)

1965. *Protolenus* (*Protolenus*) *czarnockii* n. sp.; S. Orłowski and W. Bednarczyk in Bednarczyk *et al*., pp. 233, 234, pl. 1, figs 1–6.
1990. *Protolenus* (*Protolenus*) *czarnockii* Orłowski and Bednarczyk; W. Bednarczyk and S. Orłowski in Pajchlowa, pp. 57, 58, pl. 16, fig. 4.
2007. *Protolenus* (*Protolenus*) *czarnockii* Orłowski and Bednarczyk; J. Nawrocki *et al*., figs 8.3, 8.5.

HOLOTYPE: Cranidium OS-69/3, illustrated in Bednarczyk *et al.* (1965, pl. 1, fig. 1), Bednarczyk and Orłowski in Pajchlowa (1990, pl. 16, fig. 4), and Nawrocki *et al.* (2007, fig. 8.5), from the *Protolenus–Issafeniella* Zone in the Zaręby 2 borehole, HCM.

EMENDED DIAGNOSIS: Species of *Protolenus* (*Hupeolenus*) with narrow, gently tapered glabella with rounded anterior lobe, c. 70% of cranidial length and c. 25% of glabellar width across centre of palpebral lobes in undistorted specimens; three pairs of lateral glabellar furrows directed backwards; parafrontal band distinct; eye-ridges straight, normal to axis, passing into slightly wider palpebral lobes; preglabellar field of similar sagittal width as flat anterior border.

MATERIAL: One almost complete carapace without pygidium, 3 cranidia, one librigena.

DESCRIPTION: Cranidium sub-rectangular, overall convexity minor, length 83–88% of maximum width across centre of palpebral lobes. Glabella slightly convex, barely elevated above fixigenae, 75–80% of cranidial length and 34–39% of cranidial width across occipital ring; glabella parallel-sided in posterior part, slightly tapering forward in anterior part, with gently rounded frontal lobe. Three straight and short lateral glabellar furrows; S1 directed strongly backwards, S2 less inclined backwards, and S3 almost normal to axis. Occipital furrow moderately narrow, almost straight. Occipital ring 10–16% of cranidial length, sagittally wider than at axial furrows. Axial furrows narrow and deep. Fixigenae almost flat, each with faint diagonal furrow which is more distinct in distorted specimens; 96–110% of transverse occipital ring width. Palpebral lobes cord-like, exsagittally approximately 28% of cranidial length, extending into eye-ridges directed almost normal to axis. Furrow separating palpebral lobes and eye ridges narrow. Palpebral furrow distinct, narrow. Anterior branches of facial suture moderately short and slightly diverging from palpebral lobes to anterior margin, anterolateral wings not extending exsagittally beyond palpebral lobes in undistorted specimens. Posterior branches short, slightly diverging, posterolateral wings not extending exsagittally beyond palpebral lobes. Frontal area 19–25% of cranidial length, distinctly separated into preglabellar field and flat, anteriorly rounded anterior border. Parafrontal band well-developed. Corner furrows on preglabellar field barely visible. Posterior border widening distally, posterior border furrow shallow, deeper adjacent to axial furrows and shallowing distally, slightly curved forward adaxially.

Librigena with stout spine of moderate length, almost confluent with lateral margin. Border wide, flat, broadening posteriorly. Lateral and posterior border furrows well defined. Genal spine angle obtuse, inner spine angle close to a right angle.

Thorax composed of at least 11 segments. Segments transversely widest in anterior part of thorax, distinctly narrowing after 7th segment. Axis narrow, distinctly elevated above transversely wide pleurae. Anterior pleural tips pointed and directed backwards, with moderately stout pleural spines. Macropleural second segment, its distal portion modified with slender pleural spine, extending at least beyond 11th segment. Pygidium unknown.

MEASUREMENTS: The largest undeformed cranidium (OS 69/3a) is 4.6 mm long and 5.1 mm wide across centre of palpebral lobes. The holotype cranidium is deformed (tilted and transversely compressed); after retrodeformation it is c. 4.0 mm long and c. 5.0 mm wide across centre of palpebral lobes.

REMARKS: Apart from being flattened due to compaction, the specimens assigned to this species are mostly distorted, either transversely or sagittally. They have small dimensions and most probably represent juvenile forms. Nevertheless, in most aspects they fit the diagnosis for *Protolenus* (*Hupeolenus*) (see also Geyer 1990b), with the only difference that the corner furrows are barely developed, being visible only on some specimens. This may be caused either by the fact that the specimens are distorted and flattened, or that corner furrows are not well-developed in juveniles. From *P.* (*H.*) *hupei* Geyer, 1990b the species differs in barely pronounced corner furrows and a less tapering posterior part of the glabella, and from *P.* (*H.*) *termierelloides* Geyer, 1990b and *P*. (*H*.) *dimarginatus* Geyer, 1990b in a much narrower and sub-parallel glabella and a preglabellar field of almost the same width as the anterior border. All Moroccan species have tests covered with granules (see Geyer 1990b), whereas ornamentation is not visible on the HCM specimens.

OCCURRENCE: Lower Cambrian *Protolenus–Issafe-*

niella Zone; Kamieniec Formation in the Zaręby 2 borehole (1336.5–1337.0 m), HCM.

Genus *Latoucheia* Hupé, 1953 emend. Geyer, 1990b

TYPE SPECIES: *Protolenus latouchei* Cobbold, 1910, from Comley, Shropshire, UK; OD.

Subgenus *Latoucheia* Hupé, 1953 emend. Geyer, 1990b

TYPE SPECIES: As for genus.

Latoucheia (*Latoucheia*) *longa* (Orłowski, 1959b)
(Pl. 3, Figs 3, 5)

1959b. *Ellipsocephalus longus* n. sp.; S. Orłowski, p. 519, text-fig. 1e; pl. 2, figs 7–9.
1971. ?*Ellipsocephalus longus* Orłowski; S. Orłowski, p. 353, pl. 1, figs 4–6.
1985b. *Ellipsocephalus longus* Orłowski; S. Orłowski, p. 254, pl. 3, figs 1–3.
1990. *Ellipsocephalus longus* Orłowski; K. Lendzion and S. Orłowski in Pajchlowa, p. 53, pl. 14, fig. 4.

HOLOTYPE: Cranidium MUZWG ZI/29/2609, illustrated in Orłowski (1959b, pl. 2, fig. 8a–c; 1985b, pl. 3, fig. 3) and in Lendzion and Orłowski in Pajchlowa (1990, pl. 14, fig. 4), from the *Eccaparadoxides insularis* Zone in the Jugoszów–Usarzów section (exposure Jugoszów 1a), HCM.

EMENDED DIAGNOSIS: *Latoucheia* (*Latoucheia*) with narrow, parallel-sided glabella c. 83% of cranidial length and c. 43% of cranidial width across centre of palpebral lobes, slightly rounded anteriorly; occipital ring c. 17% of cranidial length, distinctly rounded posteriorly; fixigenae c. 73% of transverse glabellar width; exsagittal length of palpebral lobes c. 27% of cranidial length; preglabellar field narrow, anterior border poorly distinguishable from preglabellar field.

MATERIAL: 17 cranidia.

DESCRIPTION: Cranidium sub-quadrangular, overall convexity minor, length 87±5% of maximum width across centre of palpebral lobes (n=6). Glabella convex, only slightly elevated above fixigenae, 83±3% of cranidial length (n=9) and 43±3% of cranidial width across occipital ring (n=7); glabella almost parallel-sided, slightly narrowing forwards. Frontal lobe gently rounded anteriorly. Three poorly developed lateral glabellar furrows, short and very shallow, visible only on a few specimens. Occipital furrow broad sagittally, narrower distally, straight. Occipital ring 17±2% of cranidial length (n=5), sagittally longer than at axial furrows. Axial furrows shallow to almost obsolescent adjacent to frontal lobe of glabella. Fixigenae almost flat, exsagittally 73±12% of occipital ring width (n=6). Palpebral lobes crescent-shaped, 27±3% of cranidial length (n=5), only slightly elevated above faintly marked palpebral furrows. Eye-ridges developed as a distinct change of slope on fixigenae passing into frontal area. Anterior branches of facial suture short and slightly diverging from palpebral lobes to frontal margin, anterolateral wings only slightly extending exsagittally beyond palpebral lobes. Posterior branches short, slightly diverging, not extending exsagittally beyond palpebral lobes. Frontal area 17±3% of cranidial length (n=9), barely separated into preglabellar field and anterior border. Preglabellar field slightly wider than anterior border in front of glabella. Parafrontal band faint. Posterior border slightly broadening distally. Posterior border distally deeper and wider.

MEASUREMENTS: Cranidial length 5.9–10.4 mm; cranidial width across centre of palpebral lobes 7.2–11.6 mm (n=9). The holotype cranidium is the largest specimen.

REMARKS: The studied specimens are closest to *Latoucheia* (*Latoucheia*) due to the general cranidial proportions, modest cranidial convexity, narrow and parallel-sided glabella, faint parafrontal band and eye-ridges normal to the axis. They differ from *L.* (*L.*) *pusilla* Geyer, 1990b in a slightly longer glabella and slightly shorter occipital ring in relation to the cranidial length, and from *L.* (*L.*) *epichara* Geyer, 1990b in a slightly longer glabella. *L.* (*L.*) *longicervix* Geyer, 1990b is characterized by an extremely long occipital ring in larger specimens. The development of the eye-ridge as a distinct change of slope between the fixigenae and the frontal area in *L.* (*L.*) *longa* is similar to that in *L.* (*L.*) *epichara* (see Geyer 1990b, pl. 48). All species from Morocco are characterized by distinct external ornamentation of the cranidium (see Geyer 1990b).

OCCURRENCE: Middle Cambrian *Eccaparadoxides insularis* to *Paradoxides polonicus* zones; Słowiec Formation at Konarska and Słowiec hills, and Usarzów Formation at Jugoszów 1a, 1, 3, 4 and 7a, HCM.

Genus *Orodes* Geyer, 1990b

TYPE SPECIES: *Orodes schmitti* Geyer, 1990b, from Amouslek, Anti-Atlas, Morocco, OD.

Orodes usarzowi (Orłowski, 1985b)
(Pl. 2, Fig. 6; Pl. 5, Figs 6–8; Text-fig. 11)

partim 1964. *Strenuella* (*Comluella*) *samsonowiczi* sp. n.; S. Orłowski, pp. 83–85, pl. 8, figs 4, 8, 9; pl. 9, figs 1–5 *non* pl. 6, fig. 5; pl. 7, figs 1–9; pl. 8, figs 1–3, 5–7 (= *Ornamentaspis opatowi*); *non* pl. 6, figs 1–4, 6 (= *Latikingaspis samsonowiczi*).
1985b. *Comluella usarzowi* sp. n.; S. Orłowski, pp. 257, 258, fig. 4; pl. 3, figs 4–6; pl. 4, figs 1–5.

HOLOTYPE: Cranidium MUZWG ZI/29/1681, illustrated in Orłowski (1964, pl. 8, fig. 9a–b; 1985b, pl. 4, fig. 1a–b), from the *Eccaparadoxides insularis* Zone in the Jugoszów–Usarzów section (exposure Jugoszów 1a), HCM.

EMENDED DIAGNOSIS: *Orodes* with glabella c. 82% of cranidial length and 55% of cranidial width across centre of palpebral lobes; glabella prominently convex anteriorly, with three pairs of lateral glabellar furrows directed slightly backwards; fixigenae c. 84% of maximum glabellar width; exsagittal length of palpebral lobes c. 27% of cranidial length; anterior border poorly defined from preglabellar field, strongly bent ventrally; librigena with small lateral spine.

MATERIAL: 58 cranidia, one cranidium with single librigena.

DESCRIPTION: Cranidium distinctly wider than long, strongly convex anteriorly, length 64±6% of maximum width across centre of palpebral lobes (n=24). Glabella strongly convex, distinctly elevated above fixigenae, 82±3% of cranidial length (n=24) and 55±7% of cranidial width across occipital ring (n=23); frontal lobe rounded and prominent, bearing the most elevated point of glabella; three pairs of shallow and wide lateral glabellar furrows; S1 deeper than S2 and S3, directed slightly backwards. Occipital furrow distinct and broad, slightly deeper medially. Occipital ring 17±3% of cranidial length (n=23), medially wider than at axial furrows, flat, with posterior rim strongly curved inwards. Axial furrows shallow and wide, but distinct, obsolescent adjacent to frontal lobe of glabella. Fixigenae distinctly elevated above axial furrows and palpebral lobes, more-or-less flat, 84±13% of transverse occipital ring width (n=19), exsagittally 31±5% of cranidial length (n=21). Palpebral lobes crescent-shaped, with slightly narrower anterior and posterior ends, 27±5% of cranidial length (n=20). Palpebral furrow shallow and narrow. Eye-ridges indistinct, normal to axis. Anterior branches of facial suture short, diverging from palpebral lobes to frontal margin and anterolateral wings extending exsagittally beyond palpebral lobe. Posterior branches diverging, posterolateral wings extending exsagittally beyond palpebral lobes. Frontal area 18±3% of cranidial length (n=24), strongly sloping ventrally anteriorly, indistinctly separated into preglabellar field and anterior border. Posterior border distinct, convex, broadening distally. Posterior border furrow narrow and deep, slightly oblique to axis.

Librigena small, with short stout spine directed distally, with flat and distinct lateral border. Thorax and pygidium unknown.

MEASUREMENTS: The holotype cranidium is 12.5 mm long and 20 mm wide across centre of palpebral lobes. Cranidial length 5.2–16.5 mm; cranidial width across centre of palpebral lobes 7.9–23.8 mm (n=24).

REMARKS. Orłowski (1985b) distinguished specimens referred herein to *O. usarzowi* as separate species from the very diverse collection of specimens assigned by him earlier (Orłowski 1964) to *Strenuella* (*Comluella*) *samsonowiczi* (see Text-fig. 11). These specimens in fact represent a species of *Orodes* Geyer, 1990b due to the following features: proportion of cranidial width to cranidial length, proportion of glabellar length to cranidial length, most elevated point of glabella in its anterior half, and frontal area located much lower than the fixigenae. From the type species, *O. schmitti*, the specimens differ in a slightly shorter glabella in relation to cranidial length, greater width of the glabella across the occipital ring, a slightly less elevated anterior lobe of the glabella, less pronounced eye-ridges, and an anterior border that is poorly separated from the preglabellar field. The latter two differences may result from poor preservation. Other species falling into the definition of *Orodes* include *O. howleyi* (Walcott, 1889) from the *Orodes howleyi* Zone of Newfoundland (Fletcher 2003, 2006) and *O.*? *lapponica* (Ahlberg, 1980) from the upper '*Ornamentaspis*' *linnarssoni* Zone of northern Sweden (Axheimer *et al.* 2007). From these species, *O. usarzowi* differs in its parallel sided glabella and the absence of ornamentation on the test. The eye-ridges are also directed forwards exsagittally in both *O. howleyi* and *O.*? *lapponica*.

OCCURRENCE: Middle Cambrian *Eccaparadoxides insularis* to *Paradoxides polonicus* zones; Ociesęki Formation at Zamczysko, Usarzów Formation at Sternalice, Jugoszów 1a, 1, 3, 4, 7, 7a and 20, and Słowiec Formation on Słowiec Hill, HCM.

Acritarchs (ZS)

Material and methods

Samples, 150 to 200 g in weight were processed using standard palynological method by acid digestion (Vidal 1988). Glycerine-gelatine microscope slides were studied in bright-field microscopy (Leitz Laborlux S microscope) under magnifications between 200× and 1200×, and photographed with a Canon A620 camera attached to a computer. Detailed descriptions are supplied only for taxa important biostratigraphically.

Systematic descriptions

Genus *Adara* Fombella, 1977 emend. Martin in Martin and Dean, 1981

TYPE SPECIES: *Adara matutina* Fombella, 1977.

Adara alea Martin in Martin and Dean, 1981
(Pl. 8, Figs 8–11)

1981. *Adara alea* sp. nov.; F. Martin in Martin and Dean, p. 16, pl. 1, figs 20–22; pl. 4, fig. 7.
1988. *Adara denticulata* Tongiorgi sp. nov.; G. Bagnoli *et al*., pp. 183, 184, pl. 25, figs 1–5; pl. 26, figs 6, 7.
1998. *Adara alea* Martin, 1981; M. Moczydłowska, pp. 46–49, pl. 21a–c.
2001. *Adara* cf. *alea* Martin, 1981; Z. Szczepanik, pl. 3, fig. 13.

MATERIAL: 5 well-preserved specimens.

DESCRIPTION: Vesicle subcircular to oval with numerous short conical processes with very wide bases and rounded distal ends. Surface of central body smooth. Long, very thin (thread-like) 2nd range processes sometimes present on the surface of processes (remains of damaged membrane?). Processes hollow and freely connected with the inner cavity of the central body. Processes numerous with 11 to 20 processes visible on the vesicle outline.

MEASUREMENTS. Length of vesicle: 25–36 µm (average 31 µm); width of vesicle: 22–28 µm (average 25 µm); length of process: 2–4 µm (average 3 µm); width of process base: 3–6 µm (average 5 µm) (n=5).

OCCURRENCE: *Adara alea* is an index taxon of the Middle Cambrian *P. paradoxissimus* Superzone, and ranges most probably to a part of the *A. oelandicus* Superzone (co-occurrence with *Liepaina plana*). In the study area the species occurs in the Middle Cambrian Kobierniki Beds of the Lenarczyce PIG-1 borehole. It is also known from the Middle Cambrian of the Pepper Mts. Formation, HCM, Poland (Szczepanik 2001); Middle Cambrian *P. paradoxissimus* and *P. forchhammeri* superzones (Moczydłowska 1998) and lower part of the Furongian (but see discussion in Vanguestaine and Brück 2008, pp. 91, 92) in Upper Silesia, Poland; Middle Cambrian *P. paradoxissimus* Superzone of Newfoundland, Canada (Martin and Dean 1981, 1984, 1988); Middle Cambrian (*P. paradoxissimus* Superzone equivalent) of south-east Turkey (Erkmen and Bozdoğan 1981); Middle Cambrian *P. paradoxissimus* Superzone of the Furuhäll section, Sweden (Bagnoli *et al.* 1988); the *P. paradoxissimus* Superzone equivalent of Tunisia (Albani *et al*. 1991); Middle Cambrian of south-east Ireland (Vanguestaine and Brück 2008); the *P. paradoxissimus* Superzone equivalent of south-west Spain (Palacios *et al.* 2006); Middle Cambrian of north-west Algeria (Vecoli *et al.* 2008).

Genus *Comasphaeridium* Staplin, Jansonius and Pocock, 1965

TYPE SPECIES: *Comasphaeridium cometes* (Valensi, 1949) Staplin, Jansonius and Pocock, 1965.

Comasphaeridium silesiense Moczydłowska, 1998
(Pl. 8, Figs 17, 18; Pl. 10, Fig. 19)

1998. *Comasphaeridium silesiense* n. sp.; M. Moczydłowska, pp. 54, 55, pl. 22a–c, e (with full synonymy).
2001. *Comasphaeridium* sp.; Z. Szczepanik, pl. 2, fig. 24.
2008. *Comasphaeridium silesiense* Moczydłowska, 1998; M. Vanguestaine and P.M. Brück, p. 75, pl. 1, fig. 11.

MATERIAL: 12 well-preserved specimens.

DESCRIPTION: Vesicle subcircular to oval with very numerous, evenly distributed and densely arranged, solid, slender, flexible, hair-like processes. All processes of similar length, smaller than the vesicle radius.

MEASUREMENTS: Length of vesicle: 24–38 µm (average 30 µm); width of vesicle: 22–28 µm (average 25 µm); length of process: 5–10 µm (average 7 µm) (n=10).

OCCURRENCE: In the study area it occurs in the Middle Cambrian of the Lenarczyce exposure and Lenarczyce PIG-1 borehole section. It is also known from the Middle Cambrian of the Pepper Mts. Formation, HCM, Poland (Szczepanik 2001); Middle Cambrian *A. oe-*

landicus and *P. paradoxissimus* superzones and lower Furongian (but see discussion in Vanguestaine and Brück 2008, pp. 91, 92) of Upper Silesia, Poland (Moczydłowska 1998); Middle Cambrian *A. oelandicus* Superzone of Sweden (Hagenfeldt 1989a); lower Middle Cambrian of Libya (Albani *et al.* 1991); Furongian of Ireland (Moczydłowska and Crimes 1995); Middle Cambrian of Ireland (Vanguesteine and Brück 2008); Middle Cambrian of south-west Spain (Palacios *et al.* 2006).

Genus *Eliasum* Fombella, 1977

TYPE SPECIES: *Eliasum llaniscum* Fombella, 1977.

Eliasum sp. A
(Pl. 9, Figs 42–44)

MATERIAL: 4 well-preserved specimens.

DESCRIPTION: Large, elongated, ellipsoidal vesicle with asymmetrical poles. One is wide, with rounded edge, located opposite a narrower pole, smoothly passing into a bottleneck-shaped kind of process with round opening in the distal part. Few wide crests extending along the vesicle. Crests distorted probably due to deformation of vesicle.

MEASUREMENTS: Length of vesicle: 69–91 μm (average 80 μm); width of wider part of vesicle: 36–49 μm (average 44 μm) (n=4).

REMARKS: The specimens are characterized by a bottle-like shape and may be a new species of the genus *Eliasum*. However, due to the very few specimens available and their occurrence in only one exposure, they are left in open nomenclature.

OCCURRENCE: Middle Cambrian *Ptychagnostus praecurrens* Zone of the Jugoszów 20 exposure, Usarzów Formation, HCM, Poland.

Genus *Leiovalia* Eisenack, 1965 ex. Górka, 1969

TYPE SPECIES: *Leiofusa* (= *Leiovalia*) *ovalis* Eisenack, 1938.

Leiovalia tenera Kiryanov, 1974
(Pl. 7, Figs 31–33)

1974. *Leiovalia terena* sp. nov.; V.V. Kiryanov, pp. 124, 125, pl. 7, fig. 11a–b.
1974. *Leiovalia terena* Kiryanov, 1974; N.A. Volkova, pl. 28, fig. 6.
1979. *Leiovalia terena* Kiryanov, 1974; N.A. Volkova *et al*., p. 24, pl. 22, figs 1–6.
1982. *Leiovalia* sp.; R. Tynni, fig. 1e.

MATERIAL: 44 well-preserved specimens.

DESCRIPTION: Vesicle large, elongated-oval in outline, sometimes slightly flattened in the vicinity of poles. Vesicle wall very thin, with numerous tiny folds due to compression. Folds distributed irregularly. Compression folds not altering the outline of the vesicle but concentrating on its surface. Circular or polygonal imprints observed in many specimens, probably representing imprints of mineral crystals (pyrite). Surface of vesicle generally smooth, sometimes slightly rough. No opening structure present.

MEASUREMENTS: Length of vesicle: 95–190 μm (average 160 μm); width of vesicle: 49–85 μm (average 64 μm) (n=10).

OCCURRENCE: In the study area it is known from the Lower Cambrian *Protolenus–Issafeniella* Zone of the Kamieniec dam section. It is also known from the upper Lower Cambrian and lower Middle Cambrian of the EEC and in Scandinavia (for detailed localities and ranges see Volkova *et al.* 1983, p. 30 and Hagenfeldt 1989a, pp. 65, 66).

Genus *Liepaina* Yankauskas and Volkova in Volkova *et al*., 1979

TYPE SPECIES: *Liepaina plana* Yankauskas and Volkova in Volkova *et al.,* 1979.

Liepaina plana Yankauskas and Volkova in Volkova *et al*., 1979
(Pl. 8, Figs 1–7)

1979. *Liepaina plana* Yankauskas and Volkova sp. nov.; N.A. Volkova *et al*., pp. 28, 29, pl. 20, figs 1–6.
1989b. *Liepaina plana* Yankauskas and Volkova, 1979; S.E. Hagenfeldt, pp. 203, 204, pls 2, 3.
1991. *Liepaina plana* Yankauskas and Volkova, 1979; M. Moczydłowska, p. 61, pl. 10c–d.

MATERIAL: 10 variably preserved specimens.

DESCRIPTION: Vesicle oval to slightly irregular in outline. Few to over a dozen (6–19) wide, spoke-like processes that in most protrude from the central body into the equatorial plane. Outline of central body similar to the shape of the vesicle. Processes wide, rounded in distal part and supporting a web-like membrane. Membrane between neighbouring processes sometimes connected only in the proximal part of the processes. Central body of the vesicle clearly defined.

MEASUREMENTS: Length of vesicle: 37–63 µm (average 52 µm); width of vesicle: 31–45 µm (average 42 µm); length of process: 7–20 (average 12 µm); width of process: 3–5 (average 4); number of processes: 7–15 (average 12) (n=6).

REMARKS: Two morphotypes are observed in *Liepaina plana*. One, from the Middle Cambrian Kibartai Horizon (Volkova *et al.* 1983, pl. 20, figs 1–6; Hagenfeldt 1989b, pl. 3), is generally larger and has a higher number of processes and a wider membrane between the processes. The other morphotype is characterized by smaller dimensions and a significantly smaller number of processes, in which the membranes surrounding the processes are not in contact with each other (Moczydłowska 1991, pl. 10c–d). Both morphotypes differ significantly and probably should be assigned to separate species. In most cases (except the specimen illustrated in Pl. 8, Fig. 7) the population studied herein resembles the larger Middle Cambrian morphotype.

OCCURRENCE: In the study area it is known from the Middle Cambrian of the Lenarczyce PIG-1 borehole section. It is also known from the *V. dentifera–L. plana* Zone (= coeval with the *Protolenus* Zone) of eastern Poland (Moczydłowska and Vidal 1986; Moczydłowska 1991); Middle Cambrian Kibartai Horizon in Latvia, Lithuania and north-west Russia (Volkova *et al.* 1979, 1983); Lower Cambrian *Holmia* C Zone of Norway (Moczydłowska and Vidal 1986); *A. oelandicus* Beds in south-central Sweden and western Finland (Hagenfeldt 1989a, b).

Genus *Skiagia* Downie, 1982

TYPE SPECIES: *Skiagia scotica* Downie, 1982.

Skiagia insignis (Fridrichsone) Downie, 1982
(Pl. 8, Figs 12–16)

1971. *Hystrichosphaeridium*? *insigne*; A.I. Fridrichsone, pp. 14–16, pl. 2, figs 10–22.
1974. *Baltisphaeridium insigne* (Fridrichsone) comb. nov.; N.A. Volkova, p. 195, pl. 21, figs 5–7.
1982. *Skiagia insigne* (Fridrichsone) comb. nov.; C. Downie, pp. 263, 264, fig. 5.
1989a. *Skiagia insigne* (Fridrichsone) Downie, 1982; S.E. Hagenfeldt, pp. 116–118, pl. 5, figs 3, 4.
1990. *Skiagia insignis* (Fridrichsone) Downie, 1982; R.A. Fensome *et al.*, p. 453 (corrected spelling of species name).

MATERIAL: 6 variably preserved specimens.

DESCRIPTION: Vesicle sub-circular, wrinkled due to compression. Vesicle wall thick with slightly granulate surface, bearing 3–11 short processes each with wide base and widened tips and narrower in central part. A plug probably present in this narrow part. Communication between vesicle and internal part of process closed but processes open in their distal parts. Surface of process smooth, sometimes slightly rough. Opening structure not present.

MEASUREMENTS. Length of vesicle: 25–30 µm (average 27 µm); width of vesicle: 20–25 µm (average 22 µm); length of process: 3–7 µm (average 5 µm); width of process in external part: 4–9 µm (average 6 µm); number of processes: 3–11 (average 7 µm) (n=5).

REMARKS: Due to the characteristic shape of the processes, which is distinctly different from those in other species of *Skiagia*, and their much smaller number, this form might eventually be established as a separate genus. Among the specimens studied, two morphotypes can be distinguished; the first has rare but very wide processes (Pl. 8, Figs 12, 14, 15), whereas the second has a distinctly higher number of processes that are narrower and shorter (Pl. 8, Figs 13, 16). Such observations were already reported by Hagenfeldt (1989a). The two morphotypes may belong to two separate species.

OCCURRENCE: In the study area it is known from the Middle Cambrian of the Lenarczyce PIG-1 borehole section. It is also known from the Vergale, Rausve and Kibartai horizons in Latvia, Lithuania, Estonia and eastern Poland (Volkova *et al.* 1983), and the Lower and Middle Cambrian (*A. oelandicus* Superzone) of Scandinavia (Hagenfeldt 1989a).

Genus *Volkovia* Downie, 1982

TYPE SPECIES: *Volkovia dentifera* (Volkova, 1969) comb. nov. Downie, 1982 [= *Deunffia dentifera* Volkova, 1969].

Volkovia dentifera (Volkova) Downie, 1982
(Pl. 6, Figs 31–48; Pl. 7, Fig. 28)

1969. *Deunffia dentifera* sp. nov.; N.A. Volkova, p. 234, pl. 50, figs 29–31.

1979. *Deunffia dentifera* Volkova, 1969; N.A. Volkova *et al.*, p. 23, pl. 10, figs 1–3.

1982. *Volkovia dentifera* (Volkova, 1969) comb. nov.; C. Downie, pp. 265, 278, fig. 10o–p.

1989a. *Volkovia dentifera* (Volkova) Downie, 1982; S.E. Hagenfeldt, pp. 133, 134, pls 5–12.

1990. *Deunffia dentifera* Volkova, 1969; C. Eklund, fig. 8j.

1991. *Volkovia dentifera* (Volkova, 1969) Downie, 1982; M. Moczydłowska, pp. 71, 72, pl. 9k–k'.

MATERIAL: 83 well-preserved specimens.

DESCRIPTION: Oval to ellipsoidal vesicle with relatively long single process. Process wrinkled, widened in the proximal part (so that vesicle often continuing smoothly into the process), and sharply pointed at distal termination. Circular opening (pylome?) often present, located opposite the process; sometimes with few short spines around the opening. Vesicle thin, granular, with rare wrinkles. Granules present on surface of both vesicle and process, sometimes showing regular alignment. Spines arranged in brush-like structures, in some cases occurring near the end of the processes.

MEASUREMENTS: Length of vesicle: 8–18 µm (average 14.5 µm); width of vesicle: 7–11 µm (average 8.5 µm); length of process: 6–17.5 (average 12 µm) (n=40); width of opening in the optical plane: 1–6 (average 3.5 µm) (n=21).

REMARKS: *V. dentifera* is rare in palynological assemblages (e.g., Downie 1982; Hagenfeldt 1989a; Moczydłowska 1991). The form is also very rare in the HCM assemblages, with the exception of one sample from the Zaręby 2 borehole core. This rarity may be explained as artificial, being caused by maceration without a filter. The presence of openings at one end of the vesicles that was the reason to transfer the species to *Volkovia*, are clearly visible in the material studied. In the HCM material, the length of the processes in relation to the length of vesicle is shorter by comparison to other reported specimens with the exception of material from Scotland (Downie 1982). *V. dentifera* is an index species of the *Volkovia–Liepaina* Zone (Moczydłowska 1991).

OCCURRENCE: In the study area the species is known from the Lower Cambrian *Protolenus–Issafeniella* Zone of the Kamieniec dam section and the Zaręby 2 borehole section. It is also known from Scotland (Downie 1982); Lower Cambrian of Sweden (Hagenfeldt 1989a; Eklund 1990); Lower Cambrian *Protolenus* Zone of eastern Poland (Volkova 1969; Volkova *et al.* 1979, 1983; Moczydłowska 1991); Lower Cambrian Rausve Horizon in Latvia and Ukraine (Volkova 1969; Volkova *et al.* 1979, 1983; Yankauskas 1982).

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REFERENCES

Ahlberg, P. 1979. Early Cambrian trilobites from Mount Luopakte, northern Sweden. *Sveriges Geologiska Undersökning*, *ser. C*, **765**, 3–12.

Ahlberg, P. 1984. A Lower Cambrian trilobite fauna from Jämtland, central Scandinavian Caledonides. *Geologiska Föreningens i Stockholm Förhandlingar*, **105**, 349–361.

Ahlberg, P. and Bergström, J. 1978. Lower Cambrian ptychopariid trilobites from Scandinavia. *Sveriges Geologiska Undersökning*, *ser. Ca*, **49**, 5–41.

Ahlberg, P. and Bergström, J. 1993. The trilobite *Calodiscus lobatus* from the Lower Cambrian of Scania, Sweden. *Geologiska Föreningens i Stockholm Förhandlingar*, **115**, 331–334.

Albani, R., Massa, D. and Tongiorgi, M. 1991. Palynostratigraphy (Acritarchs) from some Cambrian Beds from the Rhadames (Ghadamis) Basin (Western Libya–Southern Tunisia). *Bolletino della Societá Paleontologica Italiana*, **30**, 255–280.

Axheimer, N. and Ahlberg, P. 2003. A core drilling through Cambrian strata at Almbacken, Scania, S. Sweden: trilobites and stratigraphical assessment. *GFF*, **125**, 139–156.

Axheimer, N., Ahlberg, P. and Cederström, P. 2007. A new lower Cambrian eodiscoid trilobite fauna from Swedish Lapland and its implications for intercontinental correlation. *Geological Magazine*, **144**, 953–961.

Babcock, L.E. and Peng, S.C. 2007. Cambrian chronostratigraphy: current state and future plans. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **254**, 62–66.

Babcock, L.E., Peng, S.C., Geyer, G. and Shergold, J.H. 2005.

Changing perspectives on Cambrian chronostratigraphy and progress toward subdivision of the Cambrian System. *Geosciences Journal*, **9**, 101–106.

Babcock, L.E., Robison, R.A., Rees, M.N., Peng, S.C. and Saltzman, M.R. 2007. The Global boundary Stratotype Section and Point (GSSP) of the Drumian Stage (Cambrian) in the Drum Mountains, Utah, USA. *Episodes*, **30**, 85–95.

Bagnoli, G., Stouge, S. and Tongiorgi, M. 1988. Acritarchs and conodonts from the Cambrian–Ordovician Furuhäll (Köpingsklint) section (Öland, Sweden). *Rivista Italiana di Paleontologia e Stratigrafia*, **94**, 163–248.

Bednarczyk, W. 1970. Trilobites Fauna [sic] of the Lower *Paradoxides oelandicus* Stage from the Brzechów Area in the Western Part of the Świętokrzyskie Mts. *Bulletin de l'Academie Polonaise des Sciences, Série des Sciences Géologiques et Géographiques*, **18**, 29–35.

Bednarczyk, W., Jurkiewicz, H. and Orłowski, S. 1965. Lower Cambrian and its fauna from the Boring of Zaręby near Łagów (Holy Cross Mts). *Bulletin de l'Academie Polonaise des Sciences, Série des Sciences Géologiques et Géographiques*, **13**, 231–236.

Bednarczyk, W., Kowalczewski, Z., Studencki, M. and Tomczyk, H. 1981. Stop 1. The Chojnów Dół Ravine in Kądziorka. In: H. Żakowa (Ed.), Przewodnik 53 Zjazdu Polskiego Towarzystwa Geologicznego, pp. 134–139. [In Polish]

Belka, Z., Ahrendt, H., Franke, W. and Wemmer, K. 2000. The Baltica–Gondwana suture in central Europe: evidence from K–Ar ages of detrital muscovites and biogeographical data. In: W. Franke, V. Haak, O. Oncken and D. Tanner (Eds), *Orogenic Processes: Quantification and Modelling in the Variscan Belt*. *Special Publications of the Geological Society of London*, **179**, 87–102.

Belka, Z., Valverde-Vaquero, P., Dörr, W., Ahrendt, H., Wemmer, K., Franke, W. and Schäfer, J. 2002. Accretion of first Gondwana-derived terranes at the margin of Baltica. In: J.A. Winchester, T.C. Pharaoh and J. Verniers (Eds), *Palaeozoic Amalgamation of Central Europe*. *Special Publications of the Geological Society of London*, **201**, 19–36.

Bergström, J. and Ahlberg, P. 1981. Uppermost Lower Cambrian biostratigraphy in Scania, Sweden. *Geologiska Föreningens i Stockholm Förhandlingar*, **103**, 193–214.

Bergström, J. and Gee, D.G. 1985. The Cambrian in Scandinavia. In: D.E. Gee and B.A. Sturt (Eds), The Caledonide Orogen – Scandinavia and Related Areas, John Wiley & Sons Ltd., London, 247–271.

Berthelsen, A. 1992. From Precambrian to Variscan Europe. In: D. Blundell, R. Freeman and S. Muller (Eds), A Continent Revealed: The European Geotraverse, Cambridge University Press, 153–164.

Brøgger, W.C. 1878. Om Paradoxidesskiferne ved Krekling. *Nyt Magazin Naturvidenskap*, **24**, 18–88.

Cobbold, E.S. 1910. On some small trilobites from the Cambrian rocks of Comley (Shropshire). *Quarterly Journal of the Geological Society of London*, **66**, 19–51.

Cobbold, E.S. 1927. The stratigraphy and geological structure of the Cambrian area of Comley (Shropshire). *Quarterly Journal of the Geological Society of London*, **83**, 551–573.

Cobbold, E.S. 1931. Additional fossils from the Cambrian rocks of Comley, Shropshire. *Quarterly Journal of the Geological Society of London*, **87**, 459–512.

Cocks, L.R.M. 2002. Key Lower Palaeozoic faunas from near the Trans-European Suture Zone. In: J.A. Winchester, T.C. Pharaoh and J. Verniers (Eds), *Palaeozoic Amalgamation of Central Europe*. *Special Publications of the Geological Society of London*, **201**, 37–46.

Czarnocki, J. 1919. Stratigraphy and tectonics of the Święty Krzyż Mountains. *Prace Towarzystwa Naukowego Warszawskiego*, **28**, 1–172. [In Polish]

Czarnocki, J. 1927. The Cambrian and its fauna in the central part of the Holy Cross Mountains. *Sprawozdania Polskiego Instytutu Geologicznego*, **4**, 189–207. [In Polish]

Czarnocki, J. 1933. The scientific significance of Cambrian exposures in the vicinity of Ociesęki and Orłowiny. *Zabytki Przyrody Nieożywionej*, **2**, 78–84. [In Polish]

Czarnocki, J. 1939. Report on field studies conducted in the Holy Cross Mountains in 1938. *Biuletyn Państwowego Instytutu Geologicznego*, **15**, 1–41. [In Polish]

Dies, M.E., Gozalo, R. and Liñán, E. 2001. *Protolenus* (*Hupeolenus*) Geyer, 1990 (Trilobita) en el Bilbiliense (Cámbrico Inferior) de Jarque (Zaragoza, Cadenas Ibéricas). In: G. Meléndez, Z. Herrera, G. Delvene and B. Azanza (Eds), *Los fósiles y la paleogeografía*. *Publicaciones del Seminario de Paleontología de Zaragoza*, **5.1**, 301–309.

Dies Álvarez, M.E. and Gozalo, R. 2006. El género *Hamatolenus* Hupé, 1953 (Cámbrico Inferior–Medio) en Murero y áreas adyacentes de las Cadenas Ibéricas (NE de España). *Revista Española de Paleontología*, **21**, 61–78.

Dies Álvarez, M.E., Liñán, E. and Gozalo, R. 2007. The Cambrian genus *Onaraspis* Öpik, 1968 (Trilobita), in Spain. *Memoirs of the Association of Australasian Palaeontologists*, **34**, 419–429.

Downie, C. 1982. Lower Cambrian acritarchs from Scotland, Norway, Greenland and Canada. *Transactions of the Royal Society of Edinburgh, Earth Sciences*, **72**, 257–282.

Dzik, J. and Orłowski, S. 1995. Primitive ctenocystoid echinoderm from the earliest Middle Cambrian of Poland. *Annales de Paléontologie*, **81**, 17–35.

Eisenack, A. 1938. Hystrichosphaerideen und verwandte Formen im baltischen Silur. *Zeitschrift für Geschiebeforschung und Flachlandsgeologie*, **14**, 1–30.

Eisenack, A. 1965. Die Mikrofauna der Ostseekalke. 1. Chitinozoen, Hystrichosphären. *Neues Jahrbuch für Geologie und Paläontologie*, *Abhandlungen*, **123**, 115–148.

Eklund, C. 1990. Lower Cambrian acritarch stratigraphy of the Barstad 2 core, Östergötland, Sweden. *Geologiska Föreningens i Stockholm Förhandlingar*, **112**, 19–44.

Erkmen, U. and Bozdoğan, N. 1981. Cambrian acritarchs from the Sosnik Formation in southeast Turkey. *Revista Española de Micropaleontología*, **13**, 47–60.

Fensome, R.A., Williams, G.L., Barss, M.S., Freeman, J.M. and Hill, J.M. 1990. Acritarchs and fossil prasinophytes: an index to genera, species and intraspecific taxa. *American Association of Stratigraphic Palynologists, Contributions Series*, **25**, pp. 1−771.

Fletcher, T.P. 2003. *Ovatoryctocara granulata*: the key to a global Cambrian stage boundary and the correlation of the olenellid, redlichiid and paradoxidid realms. *Special Papers in Palaeontology*, **70**, 73–102.

Fletcher, T.P. 2006. Bedrock geology of the Cape St. Mary's Peninsula, southwest Avalon Peninsula, Newfoundland. Government of Newfoundland and Labrador, Geological Survey, Department of Natural Resources, St. John's, Report, **06-02**, pp. 1–117.

Fombella, M. 1977. Acritarcos de edad Cámbrico Medio–Inferior de la provincia de Leon, España. *Revista Española de Micropaleontología*, **9**, 115–124.

Fombella, M. 1978. Acritarcos de la Formacion Oville, edad Cámbrico Medio–Tremadoc, Provincia de Leon, España. *Palinología, Num. extraord*., **1**, 245–261.

Fombella, M. 1979. Palinologia de la Formacion Oville al Norte y Sur de la Cordillera Cantábrica, España. *Palinología*, **1**, 1–15.

Fridrichsone, A.I. 1971. Acritarchs *Baltisphaeridium* and histrichosphaeres (?) from the Cambrian deposits in Latvia. In: *Paleontologiya i Stratigrafiya Pribaltiki i Belorusii*, **3**, 5–22. [In Russian]

Geyer, G. 1988. Agnostida aus dem höheren Unterkambrium und dem Mittelkambrium von Marokko. Teil 2: Eodiscina. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, **177**, 93–133.

Geyer, G. 1990a. Revised Lower to lower Middle Cambrian biostratigraphy of Morocco. *Newsletters on Stratigraphy*, **22**, 53–70.

Geyer, G. 1990b. Die marokkanischen Ellipsocephalidae (Trilobita: Redlichiida). *Beringeria*, **3**, 3–363.

Geyer, G. 1994. Cambrian corynexochid trilobites from Morocco. *Journal of Paleontology*, **68**, 1306–1320.

Geyer, G. 2005. The base of a revised Middle Cambrian: are suitable concepts for a series boundary in reach? *Geosciences Journal*, **9**, 81–99.

Geyer, G. 2006. First African oryctocephalid trilobites from the Lower–Middle Cambrian boundary interval. *Palaeoworld*, **15**, 348–359.

Geyer, G. and Elicki, O. 1995. The Lower Cambrian trilobites from the Görlitz Synclinorium (Germany) – review and new results. *Paläontologische Zeitschrift*, **69**, 87–119.

Geyer, G., Elicki, O., Fatka, O. and Żylińska, A. 2008. Cambrian. In: T. McCann (Ed.), The Geology of Central Europe, vol. 1. Precambrian and Palaeozoic, Geological Society of London, 155–202.

Geyer, G. and Landing, E. 2001. Middle Cambrian of Avalonian Massachusetts: stratigraphy and correlation of the Braintree trilobites. *Journal of Paleontology*, **75**, 116–135.

Geyer, G. and Landing, E. 2004. A unified Lower–Middle Cambrian chronostratigraphy for West Gondwana. *Acta Geologica Polonica*, **54**, 179–219.

Geyer, G. and Landing, E. 2006. Latest Ediacaran and Cambrian of the Moroccan Atlas regions. In: G. Geyer and E. Landing (Eds), *Morocco 2006, Ediacaran–Cambrian depositional environments and stratigraphy of the western Atlas regions. Explanatory description and field guide*. *Beringeria Special Issue*, **6**, 7–46.

Geyer, G. and Palmer, A.R. 1995. Neltneriidae and Holmiidae (Trilobita) from Morocco and the problem of Early Cambrian intercontinental correlation. *Journal of Paleontology*, **69**, 459–474.

Geyer, G. and Shergold, J. 2000. The quest for internationally recognized divisions of Cambrian time. *Episodes*, **23**, 188–195.

Górka, H. 1969. Microorganismes de l'ordovicien de Pologne. *Palaeontologia Polonica*, **22**, 1–102.

Hagenfeldt, S.E. 1989a. Lower Cambrian acritarchs from the Baltic Depression and south-central Sweden, taxonomy and biostratigraphy. *Stockholm Contributions in Geology*, **41**, 1–176.

Hagenfeldt, S.E. 1989b. Middle Cambrian acritarchs from the Baltic Depression and south-central Sweden, taxonomy and biostratigraphy. *Stockholm Contributions in Geology*, **41**, 177–250.

Henningsmoen, G. 1952. Early Middle Cambrian fauna from Rogaland, SW Norway. *Norsk Geologisk Tidsskrift*, **30**, 13–32.

Hupé, P. 1953. Contribution a l'étude du Cambrien inférieur et du Précambrien III de l'Anti-Atlas marocain. *Notes et Mémoirs de la Service géologique du Maroc*, **103**, 1–402. ['1952']

Jachowicz, M. and Buła, Z. 1996. The Lower Paleozoic sediments in the Upper Silesian Block. *Geological Quarterly*, **40**, 299–336.

Jagielska, L. 1963. Preliminary results of microspore studies in the Bazów borehole. *Geological Quarterly*, **7**, 736–737. [In Polish]

Jagielska, L. 1965. New data on the Eocambrian and lowermost Cambrian microflora in the Klimontów Anticlinorium. *Geological Quarterly*, **9**, 499–509. [In Polish]

Jagielska, L. 1966. Microflora in Eocambrian and Lower Cambrian strata of eastern Poland. *Geological Quarterly*, **10**, 251–261. [In Polish]

Jankauskas, T.V. and Lendzion, K. 1992. Lower and Middle Cambrian acritarch-based biozonation of the Baltic Syneclise and adjacent areas (East European Platform). *Przegląd Geologiczny*, **40**, 519–525.

Jankauskas, T.V. and Lendzion, K. 1994. Biostratigraphic correlation of Lower and Middle Cambrian sections in the Baltic Syneclise and adjacent areas. *Przegląd Geologiczny*, **42**, 365–370.

Jaworowski, K. and Sikorska, M. 2006. Łysogóry Unit (Central Poland) versus East European Craton – application of sedimentological data from Cambrian siliciclastic association. *Geological Quarterly*, **50**, 77–86.

Jendryka-Fuglewicz, B. 1992. Comparative analysis of brachiopods from the Cambrian deposits of the Holy Cross Mountains and the Precambrian Platform in Poland. *Przegląd Geologiczny*, **40**, 150–155. [In Polish]

Jurkiewicz, H. 1971. Deep geological structure of the Łagów area. *Biuletyn Instytutu Geologicznego*, **242**, 5–27. [In Polish]

Kaesler, R. L. (Ed.) 1997. Treatise on Invertebrate Paleontology, Part O, Arthropoda 1, Trilobita, Revised, pp. i–xxiv, 1–530. Geological Society of America, Boulder, and University of Kansas Press, Lawrence.

Kautsky, F. 1945. Die unterkambrische Fauna vom Aistjakk. *Geologiska Föreningens i Stockholm Förhandlingar*, **67**, 129–211.

King, W.B.R. 1923. Cambrian fossils from the Dead Sea. *Geological Magazine*, **60**, 507–514.

Kiryanov, V.V. 1974. Acritrachs from the Cambrian deposits of Volhynia. *Paleontologicheskij Zhurnal'*, **8/2**, 117–129. [In Russian]

Kobayashi, T. 1935. The Cambro–Ordovician Formations and Faunas of South Chosen. Palaeontology. Part III. Cambrian Fauna of South Chosen with a special study of the Cambrian Trilobite Genera and Families. *Journal of the Faculty of Science, Imperial University of Tokyo, section 2*, **4**, 49–344.

Kowalczewski, Z. 1990. Coarse-grained Cambrian rocks in central south Poland (lithostratigraphy, tectonics, paleogeography). *Prace Państwowego Instytutu Geologicznego*, **131**, 5–82. [In Polish with English summary]

Kowalczewski, Z., Kuleta, M. and Moczydłowska, M. 1987. New data on the Lower Cambrian near Kotuszów and Korytnica in the Holy Cross Mountains. *Geological Quarterly*, **31**, 225–226. [In Polish]

Kowalczewski, Z., Kuleta, M., Lisik, R. and Moczydłowska, M. 1986. New data on the Cambrian and Lower Ordovician rocks in the Wiśniówka area in the Holy Cross Mountains. *Geological Quarterly*, **30**, 201–228. [In Polish with English summary]

Kowalczewski, Z., Żylińska, A. and Szczepanik, Z. 2006. Cambrian in the Holy Cross Mountains. In: S. Skompski and A. Żylińska (Eds), Procesy i zdarzenia w historii geologicznej Gór Świętokrzyskich. 77 Zjazd Naukowy Polskiego Towarzystwa Geologicznego, pp. 14–27. Warszawa. [In Polish]

Krzywiec, P., Gutowski, J., Walaszczyk, I., Wróbel, G. and Wybraniec, S. 2009. Tectonostratigraphic model of the Late Cretaceous inversion along the Nowe Miasto–Zawichost Fault Zone, SE Mid-Polish Trough. *Geological Quarterly*, **53**, 27–48.

Kutek, J. and Głazek, J. 1972. The Holy Cross area, Central Poland, in the Alpine cycle. *Acta Geologica Polonica*, **22**, 603–652.

Landing, E. 1992. Lower Cambrian of Southeastern Newfoundland. Epeirogeny and Lazarus Faunas, Lithofacies–Biofacies Linkages, and the Myth of a Global Chronostratigraphy. In: J.H. Lipps and P.W. Signor (Eds), Origin and Early Evolution of the Metazoa, Plenum Press, New York, pp. 283–309.

Landing, E., Geyer, G. and Heldmaier, W. 2006. Distinguishing eustatic and epeirogenic controls on Lower–Middle Cambrian boundary successions in West Gondwana (Morocco and Spain). *Sedimentology*, **53**, 899–918.

Lendzion, K. 1972. Lower Cambrian stratigraphy in the Podlasie area. *Biuletyn Instytutu Geologicznego*, **233**, 69–147. [In Polish]

Lendzion, K. 1976. Stratigraphy of the Cambrian in the western part of the Peri-Baltic Syneclise. *Biuletyn Instytutu Geologicznego*, **270**, 59–76. [In Polish with English summary]

Lendzion, K., Moczydłowska, M. and Żakowa, H. 1983. A new look at the Bazów Cambrian sequence (southern Holy Cross Mts.). *Bulletin of the Polish Academy of Sciences, Earth Sciences*, **30**, 67–75.

Liñán, E., Dies, M.E. and Gozalo, R. 2003. A review of the genus *Kingaspis* (Trilobita, Lower Cambrian) from Spain and its biostratigraphical consequences in the Mediterranean subprovince. *Revista Española de Paleontología*, **18**, 3–14.

Liñán, E., Fernández-Nieto, C., Gámez, J.A., Gozalo, R., Mayoral, E., Moreno-Eiris, E., Palacios, T. and Perejón, A. 1993. Problemática del límite Cámbrico Inferior–Medio en Murero (Cadenas Ibéricas, España). *Revista Española de Paleontología*, **no. extr.**, 26–39.

Liñán, E. and Gozalo, R. 1999. Nuevos trilobites del Cámbrico inferior de Aragón. In: J.A. Gámez-Vintaned and E. Liñán (Eds), 25 Años de Paleontología aragonesa. Homenaje al Profesor Leandro Sequeiros. Institución Fernando El Católico, Zaragoza, pp. 255–261.

Liñán, E. and Perejón, A. 1981. El Cámbrico inferior de la «Unidad de Alconera», Badajoz (SW de España). *Boletín de la Real Sociedad Española de Historia Natural* (*Geología*), **79**, 125–148.

Liñán, E., Sdzuy, K., Álvaro, J.J., Gámez-Vintaned, J.A. and Gozalo, R. 1996. The Jarque section: Lower and Middle

Cambrian (West Asturian–Leonese Zone, Eastern Iberian Chain). In: E. Liñán, J.A. Gámez-Vintaned and R. Gozalo (Eds), II Field Conference of the Cambrian Stage Subdivision Working Group, International Subcommission on Cambrian Stratigraphy, Spain, 13-21 September 1996. Field Trip Guide and Abstracts, 57–72.

Linnarsson, J.G.O. 1877. Om faunan i lagren med *Paradoxides ölandicus*. *Geologiska Föreningens i Stockholm Förhandlingar*, **3**, 352–375.

Malinowski, M., Żelaźniewicz, A., Grad, M., Guterch, A. and Janik, T. 2005. Seismic and geological structure of the crust in the transition from Baltica to Palaeozoic Europe in SE Poland – CELEBRATION 2000 experiment, profile CEL02. *Tectonophysics*, **401**, 55–77.

Martin, F. and Dean, W.T. 1981. Middle and Upper Cambrian and Lower Ordovician acritarchs from Random Island, eastern Newfoundland. *Bulletin of the Geological Survey of Canada*, **343**, 1–43.

Martin, F. and Dean, W.T. 1984. Middle Cambrian acritarchs from the Chamberlains Brook and Manuels River formations at Random Island, eastern Newfoundland. *Geological Survey of* Canada, **84-1A**, 429–440.

Martin, F. and Dean, W.T. 1988. Middle and Upper Cambrian acritarch and trilobite zonation at Manuels River and Random Island, eastern Newfoundland. *Bulletin of the Geological Survey of Canada*, **381**, 1–91.

Masiak, M. and Żylińska, A. 1994. Burgess Shale-type fossils in Cambrian sandstones of the Holy Cross Mountains. *Acta Palaeontologica Polonica*, **39**, 329–340.

Matthew, G.F. 1892. *Protolenus* – a new genus of Cambrian trilobites. *Bulletin of the Natural Historical Society of New Brunswick*, **10**, 34–37.

Matthew, G.F. 1895. The Protolenus fauna. *Transactions of the New York Academy of Sciences*, **14**, 101–153.

McCollum, L.B. and Sundberg, F.A. 2002. Correlation of the Lower–Middle Cambrian boundary interval in the Circum-Pacific region based on oryctocephalid trilobites. *First International Palaeontological Congress (Abstracts), Geological Society of Australia*, **68**, 242–243.

Michniak, R. 1959. Notes on the petrography and micropaleophytology in the oldest strata of the Holy Cross Mts. *Bulletin de l'Academie Polonaise des Sciences, Série des Sciences Chimiques, Géologiques et Géographiques*, **7**, 457–462.

Moczydłowska, M. 1980. Results of acritarch studies in the Cambrian deposits of the Okuniew IG-1 borehole. *Kwartalnik Geologiczny*, **24**, 397–398. [In Polish]

Moczydłowska, M. 1981. Lower and Middle Cambrian acritarchs from northeastern Poland. *Precambrian Research*, **15**, 63–74.

Moczydłowska, M. 1989. Upper Proterozoic and Lower Cambrian acritarchs from Poland – micropaleontology, biostratigraphy and thermal study. *Lund Publications in Geology*, **75**, 1–30.

Moczydłowska, M. 1991. Acritarch biostratigraphy of the Lower Cambrian and the Precambrian–Cambrian boundary in southeastern Poland. *Fossils and Strata*, **29**, 1–127.

Moczydłowska, M. 1998. Cambrian acritarchs from Upper Silesia, Poland – biochronology and tectonic implications. *Fossils and Strata*, **48**, 1–121.

Moczydłowska, M. 1999. The Lower–Middle Cambrian boundary recognized by acritarchs in Baltica and at the margin of Gondwana. *Bolletino della Società Paleontologica Italiana*, **38**, 207–225.

Moczydłowska, M. and Crimes, T.P. 1995. Late Cambrian acritarchs and their age constraints on an Ediacaran-type fauna from the Booley Bay Formation, Co. Wexford (Eire). *Geological Journal*, **30**, 111–128.

Moczydłowska, M. and Vidal, G. 1986. Lower Cambrian acritarch zonation in southern Scandinavia and southeastern Poland. *Geologiska Föreningens i Stockholm Förhandlingar*, **108**, 201–223.

Moczydłowska, M. and Vidal, G. 1988. Early Cambrian acritarchs from Scandinavia and Poland. *Palynology*, **12**, 1–10.

Moczydłowska, M. and Vidal, G. 1992. Phytoplankton from the Lower Cambrian Læsa Formation on Bornholm, Denmark; biostratigraphy and palaeoenvironmental constraints. *Geological Magazine*, **129**, 17–40.

Moczydłowska, M. and Zang, W.L. 2006. The Early Cambrian acritarch *Skiagia* and its significance for global correlation. *Palaeoworld*, **15**, 328–337.

Nawrocki, J., Dunlap, J., Pecskay, Z., Krzemiński, L., Żylińska, A., Fanning, M., Kozłowski, K., Salwa, S., Szczepanik, Z. and Trela, W. 2007. Late Neoproterozoic to Early Palaeozoic palaeogeography of the Holy Cross Mountains (Central Europe): an integrated approach. *Journal of the Geological Society*, **164**, 405–423.

Nawrocki, J. and Poprawa, P. 2006. Development of Trans-European Suture Zone in Poland: from Ediacaran rifting to Early Palaeozoic accretion. *Geological Quarterly*, **50**, 59–76.

Neltner, L. 1938. Etudes géologiques dans le Sud marocain (Haut Atlas et Anti-Atlas). *Notes et Mémoirs de la Service des Mines et Carte géologique du Maroc*, **42**, 1–298.

Nielsen, A.T. and Schovsbo, N.H. 2006. Cambrian to basal Ordovician lithostratigraphy in southern Scandinavia. *Bulletin of the Geological Society of Denmark*, **53**, 47–92.

Orłowski, S. 1959a. Paradoxidae from lower Middle Cambrian strata in the vicinity of Sandomierz (Central Poland). *Bulletin de l'Académie Polonaise des Sciences, Série des Sciences Chimiques, Géologiques et Géographiques*, **7**, 441–446.

Orłowski, S. 1959b. Ellipsocephalidae from the lower beds of the Middle Cambrian in the vicinity of Sandomierz

(Central Poland). *Bulletin de l'Académie Polonaise des Sciences, Série des Sciences Chimiques, Géologiques et Géographiques*, **7**, 515–520.

Orłowski, S. 1964. Middle Cambrian and its fauna in the eastern part of the Holy Cross Mountains. *Studia Geologica Polonica*, **16**, 7–94. [In Polish with English summary]

Orłowski, S. 1965. A revision of the Middle Cambrian fauna from the Słowiec Hill (Holy Cross Mountains). *Biuletyn Geologiczny Uniwersytetu Warszawskiego*, **6**, 134–146.

Orłowski, S. 1971. The Middle Cambrian of the Klimontów anticlinorium, Holy Cross Mts. *Acta Geologica Polonica*, **21**, 349–358.

Orłowski, S. 1975a. The systematic position and ontogeny of the Lower Cambrian trilobite species *Ellipsocephalus sanctacrucensis* (Samsonowicz, 1959). *Acta Geologica Polonica*, **25**, 369–375.

Orłowski, S. 1975b. Cambrian and Upper Precambrian lithostratigraphic units in the Holy Cross Mts. *Acta Geologica Polonica*, **25**, 431–448. [In Polish with English summary]

Orłowski, S. 1985a. Lower Cambrian and its trilobites in the Holy Cross Mts. *Acta Geologica Polonica*, **35**, 231–250.

Orłowski, S. 1985b. New data on the Middle Cambrian trilobites and stratigraphy in the Holy Cross Mts. *Acta Geologica Polonica*, **35**, 251–263.

Orłowski, S. 1987. Stratigraphy of the Lower Cambrian in the Holy Cross Mountains, Central Poland. *Bulletin of the Polish Academy of Sciences, Earth Sciences*, **35**, 91–96.

Orłowski, S. 1988. Stratigraphy of the Cambrian System in the Holy Cross Mts. *Geological Quarterly*, **32**, 525–532.

Orłowski, S. 1992. Cambrian stratigraphy and stage subdivision in the Holy Cross Mountains, Poland. *Geological Magazine*, **129**, 471–474.

Orłowski, S. and Mizerski, W. 1995. New data on geology of the Middle Cambrian rocks in the Klimontów Anticlinorium (Holy Cross Mts.). *Geological Quarterly*, **39**, 293–306.

Paczeŝna, J. (Ed.) 2008. Łopiennik IG 1. *Profile Głębokich Otworów Wiertniczych Państwowego Instytutu Geologicznego*, **123**, pp. 1–265. [In Polish]

Pajchlowa, M. (Ed.) 1990. Atlas of guide and characteristic fossils, Geology of Poland, III, 1a, Older Palaeozoic (with Upper Proterozoic), pp. 1–493. [In Polish, English version published in 1991]

Palacios, T., Jensen, S. and Apalategui, O. 2006. Acritarch biostratigraphy from the Upper Lower Cambrian–Middle Cambrian of the Northern Margin of Gondwana (Ossa–Morena Zone, Southwest Iberia). In: J. Bek, R. Brocke, J. Dašková and O. Fatka (Eds), CIMP General Meeting in Prague 2006. Palaeozoic palynology in space and time, 40–42.

Palacios, T. and Moczydłowska, M. 1998. Acritarch biostratigraphy of the Lower–Middle Cambrian boundary in the Iberian chains, province of Soria, northeastern Spain. *Revista Española de Paleontología*, ***no. extr.***, *Homenaje al Prof. Gonzalo Vidal*, 65–82.

Palacios, T. and Vidal, G. 1992. Lower Cambrian acritarchs from northern Spain; the Precambrian–Cambrian boundary and its biostratigraphic implications. *Geological Magazine*, **129**, 421–436.

Palmer, A.R. and James, N.P. 1980. The Hawke Bay event: a circum-Iapetus regression near the Lower Middle Cambrian boundary. In: D.R. Wones (Ed.), The Caledonides in the USA. Proceedings, 1979 Meeting, Blacksburg, Virginia, Virginia Polytechnic Institute and State University, pp. 15–18.

Peng, S., Babcock, L.E., Robison, R.A., Lin, H., Rees, M.N. and Saltzman, M.R. 2004. Global Standard Stratotype-Section and Point (GSSP) of the Furongian Series and Paibian Stage (Cambrian). *Lethaia*, **37**, 351–474.

Richter, R. and Richter, E. 1941. Die Fauna des Unter-Kambriums von Cala in Andalusien. *Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft*, **455**, 1–81.

Rushton, A.W.A. 1966. The Cambrian trilobites from the Purley Shales of Warwickshire. *Palaeontological Society Monographs*, **120**, 1–55.

Rushton, A.W.A. 1974. The Cambrian of Wales and England. In: C.H. Holland (Ed.), Cambrian of the British Isles, Norden and Spitsbergen, John Wiley, pp. 43–120.

Rushton, A.W.A. and Powell, J.H. 1998. A review of the stratigraphy and trilobite faunas from the Cambrian Burj Formation in Jordan. *Bulletin of the Natural History Museum of London* (*Geology*), **54**, 131–146.

Samsonowicz, J. 1920. Stratigraphy of the Cambrian and Ordovician in the eastern part of the Holy Cross Mountains. *Sprawozdania Polskiego Instytutu Geologicznego*, **1**, 53–67. [In Polish]

Samsonowicz, J. 1934. Explication de la feuille Opatów. Service Géologique de Pologne. Carte Géologique Générale de la Pologne au 100.000–e, pp. 1–97.

Samsonowicz, J. 1956. Cambrian paleogeography and the base of the Cambrian system in Poland. In: XX Congreso Geológico International. El sistema Cámbrico, su paleogeografía y el problema de su base. Part I, pp. 127–160.

Samsonowicz, J. 1959a. On *Strenuaeva* from Lower Cambrian in Klimontów Anticlinorium. *Bulletin de l'Académie Polonaise des Sciences, Série des Sciences Chimiques, Géologiques et Géographiques*, **7**, 521–524.

Samsonowicz, J. 1959b. On *Strenuella* and *Germaropyge* from the Lower Cambrian in the Klimontów Anticlinorium. *Bulletin de l'Académie Polonaise des Sciences, Série des Sciences Chimiques, Géologiques et Géographiques*, **7**, 525–529.

Samsonowicz, J. 1960. The Lower Cambrian of the Klimontów Anticlinorium. In: B. Asklund and C. Poulsen (Eds), Report of the Twenty-First Session, Norden, International

Congress, Part VIII. Late Pre-Cambrian and Cambrian stratigraphy, pp. 86–92.

Samsonowicz, J. 1962. Lower Cambrian fossils from the Klimontów anticlinorium of the Holy Cross Mts., Poland. Prepared for print from the deceased author's MS notes by K. Korejwo and L. Teller. In: E. Passendorfer (Ed.), Księga Pamiątkowa ku czci Profesora Jana Samsonowicza, pp. 9–29.

Sdzuy, K. 1961. Teil II: Trilobiten. In: F. Lotze and K. Sdzuy (Eds), *Das Kambrium Spaniens. Akademie der Wissenschaften und der Literatur, Abhandlungen der matematisch-naturwissenschaftlichen Klasse* **7**, pp. 217–408.

Shergold, J.H. and Geyer, G. 2003. The Subcommission on Cambrian Stratigraphy: the status quo. *Geologica Acta*, **1**, 5–9.

Sjögren, A. 1872. Om några försteningar i Ölands kambriska lager. *Geologiska Föreningens i Stockholm Förhandlingar*, **1**, 67–80.

Šnajdr, M. 1958. Trilobiti českého středního kambria. *Rozpravy Ústředního Ústavu Geologického*, **24**, 1–280.

Staplin, F.L., Jansonius, J. and Pocock, S.A.J. 1965. Evaluation of some acritarchous hystrichosphere genera. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, **123**, 165–201.

Stasińska, A. 1960. *Velumbrella czarnockii* n. gen., n. sp. – Méduse du Cambrien inférieur des Monts de Sainte-Croix. *Acta Palaeontologica Polonica,* **5**, 337–344.

Studencki, M. 1988. Sedimentary conditions of the Ociesęki Sandstone and Kamieniec Shale Formations (Lower Cambrian) in the Holy Cross Mountains. *Kwartalnik Geologiczny*, **32**, 533–540. [In Polish with English summary]

Sundberg, F.A. and McCollum, L.B. 1997. Oryctocephalids (Corynexochida: Trilobita) of the Lower-Middle Cambrian boundary interval from California and Nevada. *Journal of Paleontology*, **71**, 1065–1090.

Sundberg, F.A. and McCollum, L.B. 2007. Assessment of the potential GSSP sections for Cambrian series 3 using the FAD of *Oryctocephalus indicus*. In: E. Landing (Ed.) *Ediacaran–Ordovician of East Laurentia – S.W. Ford Memorial Volume, 12th International Conference of the Cambrian Chronostratigraphy Working Group*. *New York State Museum Bulletin*, **510**, 89–90.

Szczepanik, Z. 1988. Acritarcha from Cambrian deposits of the Wszachów 2 borehole. *Geological Quarterly*, **32**, 541–554. [In Polish]

Szczepanik, Z. 1997. Preliminary results of thermal alteration investigations of the Cambrian acritarchs in the Holy Cross Mts. *Geological Quarterly*, **41**, 257–264.

Szczepanik, Z. 2000. The Cambrian of the western part of the Pomeranian Caledonides foreland, Peribaltic Syneclise: microfloral evidence. *Geological Quarterly*, **44**, 261–273.

Szczepanik, Z. 2001. Acritarchs from Cambrian deposits of the southern part of the Łysogóry unit in the Holy Cross Mountains, Poland. *Geological Quarterly*, **45**, 117–130.

Szczepanik, Z., Trela, W. and Salwa, S. 2004a. Upper Cambrian in the eastern part of the Kielce Region in the Holy Cross Mountains – preliminary report. *Przegląd Geologiczny*, **52**, 895–898. [In Polish]

Szczepanik, Z., Trela, W., Żylińska, A. and Salwa, S. 2004b. New Cambrian and Ordovician lithostratigraphic units in the Kielce region of the Holy Cross Mountains. *Posiedzenia Naukowe Państwowego Instytutu Geologicznego*, **61**, 57–58. [In Polish]

Tynni, R. 1982. On Paleozoic microfossils in clastic dykes in the Åland Islands and in the core samples of Lumparn. In: L. Bergman, R. Tynni and B. Winterhalter (Eds), Palaeozoic sediments in the Rapakivi area of the Åland Islands. *Bulletin of the Geological Survey of Finland*, **317**, 36–132.

Valensi, L. 1949. Sur quelques microorganismes planctoniques de silex du Jurassique moyen du Poitou et de Normandie. *Bulletin de la Société Géologique de France, 5e série*, **18**, 537–550.

Valíček, J. and Szabad, M. 2002. Revision early Middle Cambrian trilobite fauna from central Bohemia [sic]. *Palaeontologia Bohemiae*, **8**, 75–98.

Vanguestaine, M. and Brück, P.M. 2008. A Middle and Late Cambrian age for the Booley Bay Formation, County Wexford, Ireland: New acritarch data and its implications. *Revue de Micropaléontologie*, **51**, 67–95.

Vanguestaine, M. and Van Looy, J. 1983. Acritarches du Cambrien moyen de la vallée de Tacheddirt (Haut-Atlas, Maroc) dans le cadre d'une nouvelle zonation du Cambrien. *Annales de la Société geologique de Belgique*, **106**, 69–85.

Vecoli, M., Videt, B. and Paris, F. 2008. First biostratigraphic (palynological) dating of Middle and Late Cambrian strata in the subsurface of northwestern Algeria, North Africa: Implications for regional stratigraphy. *Review of Palaeobotany and Palynology*, **149**, 57–62.

Vidal, G. 1981. Lower Cambrian acritarch stratigraphy in Scandinavia. *Geologiska Föreningen i Stockholm Förhandlingar*, **103**, 183–192.

Vidal, G. 1988. A palynological preparation method. *Palynology*, **12**, 215–220.

Vidal, G., Moczydłowska, M. and Rudavskaya, V.A. 1995. Constraints on the Early Cambrian radiation and correlation of the Tommotian and Nemakit–Daldynian regional stages of eastern Siberia. *Journal of the Geological Society*, **152**, 499–510.

Vidal, G. and Peel, J.S. 1993. Acritarchs from the Lower Cambrian Buen Formation in North Greenland. *Grønlands Geologiske Undersøgelse Bulletin*, **164**, 1–35.

Volkova, N.A. 1969. Acritarchs of the northwestern Russian Platform. In: A.Yu. Rozanov *et al.* (Eds), *Tommotskii Yarus i Problema Nizhnei Granitsy Kembriya. Akademiya Nauk SSSR, Trudy Geologicheskogo Instituta*, **206**, 224–236. [In Russian]

Volkova, N.A. 1974. Acritarchs from the Lower–Middle Cambrian boundary beds of western Latvia. In: I.T. Zhuravleva and A.Yu. Rozanov (Eds), Biostratjgrafiya i paleontologiya nizhnego kembriya Evropy i severnoy Azii, pp. 194–198. Nauka, Moskva. [In Russian]

Volkova, N.A. 1990. The Middle and Upper Cambrian acritarchs in the East European Platform. *Trudy Akademii Nauk SSSR*, **454**, 1–113. [In Russian]

Volkova, N.A., Kiryanov, V.V., Piskun, L.V., Paskeviciene, L.T. and Yankauskas, T.V. 1979. Plant microfossils. In: B.M. Keller and A.Yu. Rozanov (Eds), Paleontologiya verkhnedokembrijskikh i kembriyskikh otlozeniy Vostochno-Evropejskoj platformy, pp. 4–38. Nauka, Moskva. [In Russian]

Volkova, N.A., Kiryanov, V.V., Piskun, L.V., Paskeviciene, L.T. and Yankauskas, T.V. 1983. Plant microfossils. In: A. Urbanek and A.Yu. Rozanov (Eds), Upper Precambian and Cambrian Palaeontology of the East European Platform, pp. 7–46. Wydawnictwa Geologiczne, Warszawa.

Walcott, C.D. 1891. The fauna of Lower Cambrian or *Olenellus* Zone. *Tenth Annual Report of the U.S. Geological Survey*, **1**, 509–774.

Welsch, M. 1986. Die Acritarchen der höheren Digermul-Gruppe, Mittelkambrium bis Tremadoc, Ost-Finnmark, Nord-Norwegen. *Palaeontographica*, *Abteilung B*, **201**, 1–109.

Westergård, A.H. 1928. A deep boring through Middle and Lower Cambrian strata at Borgholm, Isle of Öland. *Sveriges Geologiska Undersökning Ser. C*, **355**, 3–19.

Westergård, A.H. 1936. *Paradoxides œlandicus* beds of Öland with the account of a diamond boring through the Cambrian at Mossberga. *Sveriges Geologiska Undersökning Ser. C*, **394**, 5–66.

Westergård, A.H. 1946. Agnostidea of the Middle Cambrian of Sweden. *Sveriges Geologiska Undersökning*, **40**, 1–141.

Yankauskas, T.V. 1972. Biostratigraphy of the Lower Cambrian of Lithuania based on acritarchs. *Doklady Akademii Nauk SSSR*, **205**, 1186–1189. [In Russian]

Yankauskas, T.V. 1974. Correlation of Cambrian strata in the Lithuanian SSR based on acritarchs. In: I.T. Zhuravleva and A.Yu. Rozanov (Eds), Biostratjgrafiya i paleontologiya nizhnego kembriya Evropy i severnoj Azii, Nauka Moskva, 22–29. [In Russian]

Yankauskas, T.V. 1975. New Lower Cambrian acritarchs in the Baltic area. *Paleontologicheskiy Zhurnal'*, **1975(1)**, 94–104. [In Russian]

Yankauskas, T.V. 1982. Plant microfossils from the Upper Precambrian and Cambrian of the European part of the USSR, and their stratigraphic significance. Thesis – Akademiya Nauk SSSR. pp. 1–52. [In Russian]

Yankauskas, T.V. and Posti, E.A. 1973. Micropalaeontological characteristics of the Lower Cambrian stratotype sections in Estonia. *Eesti NSV Teaduste Akadeemia Toimetised, Keemia–Geoloogia*, **22**, 143–148. [In Russian]

Yankauskas, T.V. and Posti, E.A. 1976. New acritarch species in the Cambrian of the Baltic area. *Eesti NSV Teaduste Akadeemia Toimetised, Keemia–Geoloogia*, **25**, 145–151. [In Russian]

Young, T.P., Martin, F., Dean, W.T. and Rushton, A.W.A. 1994. Cambrian stratigraphy of St. Tudwal's Peninsula, Gwynedd, Northwest Wales. *Geological Magazine*, **131**, 335–360.

Zhao, Y., Yuan, J., Peng, S., Peng, J., Wang, P. and Wang, Y. 2004. *Oryctocephalus indicus* is the best trilobite of FAD of the Middle Cambrian [sic]. In: D. Choi (Ed.), IX International Conference of the Cambrian Stage Subdivision Working Group (Abstracts with Program), Taebaek, Korea, September 16-21, 32.

Zhao, Y.L., Yuan, J.L., Zhu, M.Y., Babcock, L.E., Peng, J., Wang, Y., Yang, X.L., Guo, Q.J., Yang, R.D. and Tai, T.S. 2005. Balang Section, Guizhou, China: stratotype section for the Taijiangian Stage and candidate for GSSP of an unnamed Cambrian series. In: S.C. Peng, L.E. Babcock and M.Y. Zhu (Eds), Cambrian System of China and Korea, Guide to Field Excursions, IV International Symposium on the Cambrian System and X Field Conference of the Cambrian Stage Subdivision Working Group, 62–83.

Zhu, M.Y., Babcock, L.E. and Peng, S.C. 2006. Advances in Cambrian stratigraphy and paleontology: Integrating correlation techniques, paleobiology, taphonomy and paleoenvironmental reconstruction. *Palaeoworld*, **15**, 217–222.

Żylińska, A. 2002. Stratigraphic and biogeographic significance of Late Cambrian trilobites from Łysogóry (Holy Cross Mountains, central Poland). *Acta Geologica Polonica*, **52**, 217–238.

Żylińska, A. and Masiak, M. 2007. Cambrian trilobites from Brzechów, Holy Cross Mountains (Poland) and their significance in stratigraphic correlation and biogeographic reconstructions. *Geological Magazine*, **144**, 661–686.

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Appendix 1

Distribution of trilobites (in alphabetical order) in particular exposures with their repository numbers [MUZWG Museum of the Faculty of Geology, University of Warsaw (ZI/29/ collection of Stanisław Orłowski; ZI/42/ collection of Jan Samsonowicz); INGPAN Institute of Geological Sciences, Polish Academy of Sciences (WB collection of Wiesław Bednarczyk; MP collection of Marian Piwocki; JS collection of Jan Samsonowicz); OS 69 collection of trilobites from the Zaręby 2 borehole, Holy Cross Branch of the Polish Geological Institute in Kielce; AK collection of Adrian Kin, Museum of the Geoscience Friends Association "Phacops", Łódź; IGPUW B/II collection of AŻ, Institute of Geology, Faculty of Geology, University of Warsaw]. Abbreviations: ce – cephala; cr – cranidia, pl – pleurae, th – thoraces, pyg – pygidia; lib – librigenae; com – complete specimens; J – Jugoszów. Type specimens are in **bold**..

Cobboldites comleyensis (Cobbold, 1931) – Kamieniec mill: ce [MUZWG ZI/42/098]; Kamieniec dam: ce [MUZWG ZI/42/093, 128]; Nowa Łagowica: pyg [MUZWG ZI/29/1188].

Ellipsocephalus hoffi (Schlotheim, 1823) – Sternalice: pyg [MUZWG ZI/29/3465]; J 1a: com [MUZWG ZI/29/2324]; cr [MUZWG ZI/29/2307, 2322, 2323, 2325–2327, 2339]; J 7a: cr [MUZWG ZI/29/2338]; Jugoszów–Usarzów section: cr [MUZWG ZI/29/2300, 2301, 2304–2306, 2308–2321, 2328–2337, 2340, 2341]; Słowiec Hill: cr [MUZWG ZI/29/2296–2299, 2302, 2303, 2342–2344].

Hamatolenus (*Hamatolenus*) *glabellosus* (Orłowski, 1985a) – Kamieniec dam: cr [MUZWG ZI/42/**148**], pl [MUZWG ZI/42/129].

Issafeniella orlowinensis (Samsonowicz, 1959a) – Widełki–Łapigrosz: cr [MUZWG ZI/29/1274–84; MUZWG ZI/42/044, 052, 063, 150, **152**; INGPAN WB 107, 122, 138, 152, 154, 168; INGPAN MP 4, 7, 8, 19, 22, 23]; Brzechów: cr [INGPAN WB 84, 176; for additional specimens see Żylińska and Masiak 2007]; Konarska Hill: cr [IGPUW B/II/68; INGPAN JS 17, 18].

Issafeniella trifida (Orłowski, 1985a) – Nowa Łagowica: cr [MUZWG ZI/29/**1188**, 1189, 1192, 1194–1198; 1200, 1204, 1207–1209, 2144, 2145, 2148; MUZWG ZI/42/018], pl [MUZWG ZI/29/1902]; Chojnów Dół: cr [MUZWG ZI/29/1191, 1193, 1199, 1205; AK 200/BC 30], cr + th [MUZWG ZI/29/1190, 1201, 1203, 1206]; Wola Jastrzębska: cr + th [MUZWG ZI/29/2146].

Kingaspidoides jugoszowi (Orłowski, 1959b) – J 1a: cr [MUZWG ZI/29/2501, 2502, 2505, 2517, 2518, **2522**]; J 3: cr [MUZWG ZI/29/3488]; J 7a: cr [MUZWG ZI/29/2500, 2503, 2504, 2506–2516, 3506]; Jugoszów–Usarzów section: cr [MUZWG ZI/29/2227, 2519–2521, 2523–2536].

Kingaspidoides sanctacrucensis (Czarnocki, 1927) – Chojnów Dół: cr [MUZWG ZI/29/1212–1214]; Widełki–Łapigrosz: com [MUZWG ZI/29/1213, 1242, 1243, 1257]; cr [MUZWG ZI/29/1215–1219, 1222, 1223, 1225, 1227–1236, 1238–1241, 1244–1256, 1262, 1265–1273, 1282, 3702; MUZWG ZI/42/**020**; INGPAN WB 103, 104, 106, 109–112, 114–116, 118, 125–137, 139, 140, 143–151, 153, 155, 156, 198; INGPAN MP 6, 9, 13, 15–18, 20, 22; c. 50 specimens in unnumbered collection, Institute of Geology, University of Warsaw]; lib [MUZWG ZI/29/1220, 1224, 1258, 1259, 1261; MUZWG ZI/42/130, 149]; pyg [MUZWG ZI/29/1226; MUZWG ZI/42/058]; th [MUZWG ZI/1237, 1264]; pl [MUZWG ZI/29/1221; MUZWG ZI/42/019]; Brzechów: cr [INGPAN WB 77, 80, 85–87, 91–93, 95, 99; for additional specimens see Żylińska and Masiak 2007]; Słowiec Hill: cr [MUZWG ZI/29/3712].

Kingaspidoides sandomiri (Orłowski, 1959b) – Zamczysko: cr [MUZWG ZI/29/2422]; Sternalice: cr [MUZWG ZI/29/2364, 3466]; J 1: cr [MUZWG ZI/29/2358, 3493, 3501]; J 7: cr [MUZWG ZI/29/3502]; J 19: cr + th [MUZWG ZI/29/2347, 2378], cr [MUZWG ZI/29/2345, 2347, **2353**, 2379–2387, 2391–2396, 2406, 2407, 2411–2419, 3515], th [MUZWG ZI/29/2377]; J 20: cr [MUZWG ZI/29/2354, 2355, 2363, 2365–2371, 2388–2390, 2404, 2405, 2408, 2410]; Jugoszów–Usarzów section: cr + th [MUZWG ZI/29/2351], cr [MUZWG ZI/29/2348–2350, 2352, 2356, 2357, 2359–2362, 2372–2376]; Słowiec Hill: cr [MUZWG ZI/29/2397–2403, 2421, 2424–2427].

Kingaspis guerichi (Orłowski, 1959b) – Zamczysko: cr [MUZWG ZI/29/1823, 1824, 2005, 2088, 2091, 2096]; Sternalice: cr [MUZWG ZI/29/2428–**2432**, 2443, 2463, 2464, 2466–2469, 2474–2479, 2493–2497, 3224–3226, 3231, 3233–3235, 3243]; J 1a: cr [MUZWG ZI/29/2452, 2458, 2460, 2462, 2499]; J 1: cr [MUZWG ZI/29/2441, 2465, 2471, 2472, 2491]; J 3: cr [MUZWG ZI/29/2433–2435, 2438, 2447, 2473, 2492, 3480, 3522]; J 4: cr

[MUZWG ZI/29/2437]; J 5: cr [MUZWG ZI/29/2440]; J 7a: cr [MUZWG ZI/29/1735, 2436, 2439, 2442, 2444–2446, 2448–2450, 2456, 2457, 2459, 2461, 3509]; J 19: cr [MUZWG ZI/29/2409, 2417, 2420, 2480, 2481, 2488, 2490, 2498, 3499, 3520, 3525]; J 20: cr [MUZWG ZI/29/2482, 2484–2486]; Helenów: cr [MUZWG ZI/29/3473]; Słowiec Hill: cr [MUZWG ZI/29/2453, 2454].

Latikingaspis samsonowiczi (Orłowski, 1964) – Sternalice: com (without lib) [MUZWG ZI/2240], cr [MUZWG ZI/29/1624, 1625, 1627, 1634, 1639, 1644, 2241–2245, 2250, 2252, 2253, 2256–2259, 2261–2265, 2267–2269, 2271–2273, 2276–2284, 3446, 3451]; J 1a: com (without lib) [MUZWG ZI/29/**1615**, 1616]; cr [MUZWG ZI/29/3453]; J 1: cr [MUZWG ZI/29/1617, 1619, 1620, 1626, 1629, 1630, 1636, 1641, 1643, 3444; MUZWG ZI/42/092]; J 3: cr [MUZWG ZI/29/3356]; J 5: cr [MUZWG ZI/29/3384]; J 7: cr [MUZWG ZI/29/1633]; Jugoszów–Usarzów section: cr [MUZWG ZI/29/2248, 2341, 2387, 3450, 3454]; Helenów: cr [MUZWG ZI/29/1618, 1622, 3433–3442]; Słowiec: cr [MUZWG ZI/29/1648, 2288].

Latoucheia (*Latoucheia*) *longa* (Orłowski, 1959b) – Konarska Hill: cr [MUZWG ZI/29/3214, 3215]; J 1a: cr [MUZWG ZI/29/2602, 2604, 2605, **2609**–2611]; J 1: cr [MUZWG ZI/29/2606]; J 3: cr [MUZWG ZI/29/2607, 2608, 3500]; J 4: cr [MUZWG ZI/29/3524]; J 7a: cr [MUZWG ZI/29/2603]; Jugoszów–Usarzów section: cr [MUZWG ZI/29/2556]; Słowiec Hill: cr [MUZWG ZI/29/2612, 2613].

Myopsolenites kielcensis (Bednarczyk, 1970) – Brzechów: cr and pyg [see Żylińska and Masiak 2007].

Ornamentaspis henningsmoeni (Orłowski, 1964) – Zamczysko: cr [MUZWG ZI/29/1798, 1820–1826]; Sternalice: cr [MUZWG ZI/1797, 1799, 1808–1817]; J 1: cr [MUZWG ZI/29/1792–1796, 1800–1803, 1805–1807]; J 3: com [MUZWG ZI/29/**1791**]; th [MUZWG ZI/29/1804]; J 7: cr [MUZWG ZI/29/3529]; Słowiec Hill: cr [MUZWG ZI/29/1818, 1819].

Ornamentaspis hupei (Orłowski, 1964) – Zamczysko: cr [MUZWG ZI/29/1680]; Konarska Hill: cr [MUZWG ZI/29/3213, 3216]; J 1a: cr [MUZWG ZI/29/1650, 1653, 1658, 1660, 1667, 1669, 1672, 1675, 1676]; J 1: cr [MUZWG ZI/29/1678]; J 3: cr [MUZWG ZI/29/1652, 1655, 1656, 1679]; J 4: cr [MUZWG ZI/29/1668]; J 7a: cr [MUZWG ZI/29/1664, 1666, 1671, 1677]; J 19: cr + lib + th [MUZWG ZI/29/1663, **2346**]; cr [MUZWG ZI/29/1662, 1665, 1670, 3460]; J 20: cr [MUZWG ZI/29/1651, 1657, 1673, 1674]; Słowiec Hill: cr [MUZWG ZI/29/2235].

Ornamentaspis opatowi (Orłowski, 1985b) – Zamczysko: cr [MUZWG ZI/29/1789, 2006, 2042, 2045]; Sternalice: cr [MUZWG ZI/29/1645, 1647, 1718, 1770, 1771, 1774–1780, 2217, 2246, 2251, 2254, 2255, 2260, 2266, 2270, 2274, 2275, 3240, 3447, 3449, 3452, 3457]; J 1a: cr [MUZWG ZI/29/1623, 1646, 1694, **1707**, 1710, 1712, 1719, 1721–1723, 1725, 1728, 1730, 1733, 1745, 1748, 1750, 1751, 1756, 1757], cr + lib [MUZWG ZI/29/1727]; J 1: cr [MUZWG ZI/29/1621, 1628, 1631, 1632, 1635, 1637, 1638, 1640–1642, 1709, 1711, 1713–1715, 1717, 1720, 1729, 1732, 1734, 1787, 3445, 3455, 3456; MUZWG ZI/42/099]; J 3: cr [MUZWG ZI/29/1724, 1731, 1747, 1752, 1755, 1758, 1760, 1769, 1772, 1773, 1785, 1786, 1788]; J 4: cr [MUZWG ZI/29/1726, 1746, 1759, 1761, 1762, 1764, 1765, 1781–1784, 3458, 3459]; J 7: cr [MUZWG ZI/29/1742]; J 7a: cr [MUZWG ZI/29/1659, 1736–1741, 1743, 1744, 1749, 1753, 1754]; J 20: cr [MUZWG ZI/29/1661, 1654]; Jugoszów–Usarzów section: cr [MUZWG ZI/29/1708, 1763, 2201, 2206–2216, 2247, 2249, 2285, 2286, 3448]; Słowiec Hill: cr [MUZWG ZI/29/1649, 1766–1768, 1790, 2199, 2200, 2202–2205, 2218, 2223].

Ornamentaspis puschi (Orłowski, 1959b) – Zamczysko: cr [MUZWG ZI/29/2001–2054, 2057–2060, 2062–2090, 2092–2095, 2097]; Sternalice: cr [MUZWG ZI/29/2231, 2470, 2543–2549, 2593–2601, 3219, 3221, 3228, 3230, 3242, 3461, 3463]; J 3: cr [MUZWG ZI/29/2555, 3344, 3356, 3469, 3474, 3476, 3489, 3494]; th [MUZWG ZI/29/2537]; J 4: cr [MUZWG ZI/29/**2578**, 3495]; J 7: cr [MUZWG ZI/29/2451]; J 7a: cr [MUZWG ZI/29/3513]; J 19: cr [MUZWG ZI/2489, 2570, 3498]; Jugoszów–Usarzów section: cr [MUZWG ZI/29/2538–2542, 2550–2554, 2556–2569, 2571–2577, 2579–2592]; Helenów: cr [MUZWG ZI/29/3467, 3468]; Słowiec Hill: cr [MUZWG ZI/29/2204, 2289–2292, 2294, 2295, 2423], py [MUZWG ZI/29/2293].

Orodes usarzowi (Orłowski, 1985b) – Zamczysko: cr [MUZWG ZI/29/2041, 2042, 2044]; Sternalice: cr [MUZWG ZI/29/2231, 3227]; J 1a: cr [MUZWG ZI/29/**1681**–1683, 1685–1689, 1694, 1695, 1697–1699, 1701–1703, 1705, 1716]; J 1: cr [MUZWG ZI/42/091]; J 3: cr + lib [MUZWG ZI/29/1684]; J 4: cr [MUZWG ZI/29/1691, 1704, 2455]; J 7: cr [MUZWG ZI/29/1692]; J 7a: cr [MUZWG ZI/29/1690, 1693, 1700, 1735]; J 20: cr [MUZWG ZI/29/2483, 2487]; Jugoszów–Usarzów section: cr [MUZWG ZI/29/1696, 1706, 2224–2226, 2228–2230, 2238, 2239]; Słowiec Hill: cr [MUZWG ZI/29/2219–2222, 2232–2237].

Palaeolenus medius (Bednarczyk, 1970) – Brzechów: cr [INGPAN WB 82, 83; for additional specimens see Żylińska and Masiak 2007].

Paradoxides (*Acadoparadoxides*) *czarnockii* (Orłowski, 1959a) – Sternalice: cr [MUZWG ZI/29/**3212**, 3310].

Paradoxides (*Acadoparadoxides*) cf. *mureroensis* (Sdzuy, 1958) – Brzechów: cr [see Żylińska and Masiak 2007]; Sternalice: cr [MUZWG ZI/29/3254, 3311]; J 1a: cr [MUZWG ZI/29/3387]; J 1: cr [MUZWG ZI/29/3428].

Paradoxides (*Acadoparadoxides*) *oelandicus* Sjögren, 1872 – Brzechów: cr [INGPAN WB100; for additional specimens see Żylińska and Masiak 2007]; Sternalice: cr [MUZWG ZI/29/3220, 3244, 3248–3250, 3252, 3253, 3255–3258, 3260–3262, 3280, 3285, 3287–3289, 3292–3294, 3297, 3298, 3301, 3303, 3305, 3307, 3308, 3316–3318, 3323, 3325, 3326, 3328, 3334, 3338, 3340], lib [MUZWG ZI/29/3251, 3290, 3329], hyp [MUZWG ZI/29/3321]; J 1a: cr [MUZWG ZI/29/3372, 3375, 3397, 3406, 3416], lib [MUZWG ZI/29/3363, 3367, 3408], hyp [MUZWG ZI/29/3376], th [MUZWG ZI/29/3411], pl [MUZWG ZI/29/3377, 3388, 3389, 3398, 3399, 3405, 3422, 3426]; J 1: cr [MUZWG ZI/29/3346, 3357, 3359, 3360, 3419, 3423, 3425; MUZWG ZI/42/131, 139, 142, 146], hyp [MUZWG ZI/29/3354, 3355, 3410; MUZWG ZI/42/143]; J 3: cr [MUZWG ZI/29/3343]; J 4: pl [MUZWG ZI/29/3390]; J 5: lib [MUZWG ZI/29/3384]; J 7: lib [MUZWG ZI/29/3373]; J 7a: cr [MUZWG ZI/29/3370]; J 10: lib [MUZWG ZI/29/3401]; Helenów: cr [MUZWG ZI/42/133].

Paradoxides (*Eccaparadoxides*) *insularis* Westergård, 1936 – Sternalice: cr [MUZWG ZI/29/3259, 3263, 3299, 3300, 3309, 3312, 3315, 3320, 3324, 3331, 3333]; hy [MUZWG ZI/29/3302, 3306, 3332, 3336, 3337, 3339]; J 1a: cr [MUZWG ZI/29/3211, 3369, 3421]; J 1: cr [MUZWG ZI/29/3349, 3353, 3415; MUZWG ZI/42/138].

Paradoxides (*Eccaparadoxides*) *pinus* Westergård, 1936 – J 3: cr [MUZWG ZI/29/3210, 3222, 3348, 3350]; J 4: cr [MUZWG ZI/29/3378], hyp [MUZWG ZI/29/3378]; J 14: hyp [MUZWG ZI/29/3374]; J 18: cr [MUZWG ZI/29/3392]; J 19: cr [MUZWG ZI/29/3273]; J 20: hyp [MUZWG ZI/29/3269, 3271]; pl [MUZWG ZI/29/3270].

Paradoxides (*Eccaparadoxides*) *torelli* Westergård, 1936 – J 1a: lib [MUZWG ZI/29/3385], pl [MUZWG ZI/29/3409]; J 1: cr [MUZWG ZI/29/3414]; lib [MUZWG ZI/29/3412, 3424]; J 3: cr [MUZWG ZI/29/3341], pl [MUZWG ZI/29/3351].

Paradoxides kozlowskii Orłowski, 1959a – Sternalice: pyg [MUZWG ZI/29/3286, 3304, 3319, 3322, 3335]; J 1a: pyg [MUZWG ZI/29/3395]; J 1: pyg [MUZWG ZI/29/**3217**]; J 4: pyg [MUZWG ZI/29/3383]; J 17: pyg [MUZWG ZI/29/3379]; J 19: pyg [MUZWG ZI/29/3266]; J 20: pyg [MUZWG ZI/29/3272]; Helenów: pyg [MUZWG ZI/29/3413].

Paradoxides samsonowiczi Orłowski, 1959a – Sternalice: pyg [MUZWG ZI/29/3245–3247, 3281, 3313]; J 1: pyg [MUZWG ZI/29/**3218**].

Protolenus (*Hupeolenus*) *czarnockii* Orłowski and Bednarczyk *in* Bednarczyk *et al*., 1965 – Zaręby 2 borehole (1336.5–1337.0 m): com [OS 69/6, 69/7], cr [OS 69/2, **69/3**, 69/9], lib [OS 69/2, 69/3].

Protolenus (*Protolenus*) *expectans* Orłowski, 1985a – Nowa Łagowica: com [MUZWG ZI/29/2131]; cr [MUZWG ZI/29/1204, 2133, 2135, **2136**, 2137–2141, 2143]; Wola Jastrzębska: com [MUZWG ZI/29/2132]; lib [MUZWG ZI/29/2134].

Protolenus (*Protolenus*) *polonicus* Orłowski, 1964 – Sternalice: cr [MUZWG ZI/29/**3209**, 3534–3537, 3541, 3549; MUZWG ZI/42/132]; J 1: cr [MUZWG ZI/29/3530–3533, 3540, 3542–3547; MUZWG ZI/42/140, 144]; Jugoszów–Usarzów section: cr [MUZWG ZI/29/3538, 3539, 3548, 3550].

Serrodiscus primarius Orłowski, 1985a – Kamieniec dam: com [MUZWG ZI/42/**151**]; ce [MUZWG ZI/29/2147–2150, 2153; MUZWG ZI/42/097, 104], pyg [MUZWG ZI/29/2151, 2152, 2154, 2155; MUZWG ZI/42/105].

Strettonia cobboldi Orłowski and Bednarczyk *in* Bednarczyk *et al*., 1965 – Zaręby 2 borehole (1336.5–1337.0 m): cr [OS 69/1–69/5; **69/10**].

Appendix 2

Distribution of acritarch taxa (in alphabetical order) in particular boreholes and exposures

	Zaręby 2	Kamieniec dam	Lenarczyce PIG 1	Brzechów	Jugoszów 20	Konary	Lenarczyce exposure
Adara alea Martin in Martin and Dean, 1981			+				
Adara cf. *matutina* Fombella, 1979			+				
Adara sp.			+				
?*Adara* sp.			+				
Aliumella baltica Vanderflit in Umnova and Vanderflit, 1971	+		+				
Aranidium sp.	+	+					
?*Archaeodiscina* sp.	+						
Asteridium sp.	+						
Celtiberium dedalinum Fombella, 1978	+						
Celtiberium cf. *dedalinum* Fombella, 1978	+						
?*Celtiberium papillatum* Moczydłowska, 1998	+						
Celtiberium sp.	+		+				
Comasphaeridium longispinosum Hagenfeldt, 1989b			+				
Comasphaeridium silesiense Moczydłowska, 1998			+	+			+
Comasphaeridium cf. *strigosum* (Yankauskas) Downie, 1982			+				
Comasphaeridium sp.	+	+	+	+			+
?*Comasphaeridium* sp.	+			+			
Cristallinium cambriense (Slavíková) Vanguestaine, 1978							+
Cristallinium cf. *cambriense* (Slavíková) Vanguestaine, 1978				+			+
Cristallinium cf. *cambriense* (Slavíková) Vanguestaine, 1978				+			
Cristallinium sp.			+				+
?*Cristallinium* sp.							+
Cymatiosphaera cramerii Slavíková, 1968							+
Cymatiosphaera gotlandica Hagenfeldt, 1989a		+					
Cymatiosphaera cf. *gotlandica* Hagenfeldt, 1989a		+					
Cymatiosphaera cf. *postae* (Yankauskas) Yankauskas in Volkova *et al*., 1979					+		+
Cymatiosphaera sp.	+	+	+	+	+		+
?*Deunffia* sp.			+				
Dictyotidium sp.				+			+
Eliasum cf. *asturicum* Fombella, 1977		+	+				
Eliasum llaniscum Fombella, 1977		+					+
Eliasum cf. *llaniscum* Fombella, 1977		+	+				+
Eliasum cf. *pisciforme* Fombella, 1977			+				
Eliasum sp. A					+		
Eliasum sp.	+		+				+
?*Eliasum* sp.		+	+				
Granomarginata squamacea Volkova, 1968	+	+		+			+
Granomarginata cf. *squamacea* Volkova, 1968	+	+	+	+			
Heliosphaeridium cf. *coniferum* (Downie) Moczydłowska, 1991	+						
Heliosphaeridium cf. *longum* (Moczydłowska) Moczydłowska, 1991	+						
Heliosphaeridium cf. *notatum* (Volkova) Moczydłowska, 1991	+		+				
Heliosphaeridium div. sp.	+	+	+				+
Leiosphaeridia sp.	+	+	+	+	+	+	+
Leiovalia tenera Kiryanov, 1974		+	+				

Liepaina plana Yankauskas and Volkova in Volkova *et al*., 1979			+				
Liepaina sp.			+				
?*Liepaina* sp.	+						
Lophosphaeridium latviense (Volkova) Moczydłowska, 1998			+				
Lophosphaeridium cf. *latviense* (Volkova) Moczydłowska, 1998				+			
Lophosphaeridium tentativum Volkova, 1968	+	+	+	+			+
Lophosphaeridium truncatum Volkova, 1969	+	+					+
Lophosphaeridium variabile Volkova, 1974	+		+				
Lophosphaeridium sp.	+	+	+	+	+		+
?*Lophosphaeridium* sp.			+				
Multiplicisphaeridium xianum Fombella, 1977			+				+
Polygonium sp.			+				
Polygonium varium (Volkova) Moczydłowska, 1998	+	+	+				
Pterospermella solida (Volkova) Volkova in Volkova *et al*., 1979	+	+					
Pterospermella cf. *velata* Moczydłowska, 1988		+					
Pterospermella vitalis Yankauskas in Volkova *et al*., 1979			+				
Pterospermella cf. *vitalis* Yankauskas in Volkova *et al*., 1979		+	+				
Pterospermella sp.							+
Retisphaeridium sp.				+			+
Skiagia brevispinosa Downie, 1982		+	+				
Skiagia cf. *brevispinosa* Downie, 1982		+	+				
Skiagia ciliosa (Volkova) Downie, 1982		+	+				
Skiagia cf. *ciliosa* (Volkova) Downie, 1982		+	+				
Skiagia compressa (Volkova) Downie, 1982		+					
Skiagia cf. *compressa* (Volkova) Downie, 1982		+					
transition between *S. ciliosa* and *S. brevispinosa*		+					
Skiagia insignis (Fridrichsone) Downie, 1982			+				
Solisphaeridium flexipilosum Slavíková, 1968			+				
Solisphaeridium sp.			+				
Tasmanites sp.							+
Volkovia dentifera (Volkova) Downie, 1982	+	+					
Volkovia cf. *dentifera* (Volkova) Downie, 1982		+					
gen. et sp. indet.	+	+					

PLATES 1-10

PLATE 1

Trilobite assemblage 1a, Lower Cambrian *Protolenus–Issafeniella* Zone, Kamieniec Formation

1 – *Issafeniella trifida* (Orłowski, 1985a), cranidium with thorax, MUZWG ZI/29/2146, from Wola Jastrzębska

2 – *Hamatolenus* (*Hamatolenus*) *glabellosus* (Orłowski, 1985a), holotype cranidium, MUZWG ZI/42/148, from Kamieniec dam, original of Samsonowicz (1962, pl. 3, fig. 10, 10a)

5 – *Protolenus* (*Protolenus*) *expectans* Orłowski, 1985a, cranidum with thorax, MUZWG ZI/29/2131, from Nowa Łagowica

8 – *Cobboldites comleyensis* (Cobbold, 1910), cephalon, MUZWG ZI/42/128, from Kamieniec dam, original of Samsonowicz (1962, fig. 8)

9 – *Serrodiscus primarius* Orłowski, 1985a, holotype, MUZWG ZI/42/151, from Kamieniec dam, original of Samsonowicz (1962, fig. 6) and Orłowski (1985a, pl. 3, fig. 1)

Trilobite assemblage 1b, Lower Cambrian *Protolenus–Issafeniella* Zone, Kamieniec Formation (Zaręby 2 borehole, 1336.5–1337.0 m)

3-4 – *Protolenus* (*Hupeolenus*) *czarnockii* Orłowski and Bednarczyk, 1965, 3 – holotype cranidium, OS-69/3, original of Bednarczyk *et al.* (1965, figs 1, 2); 4 – cranidium, OS-69/2

6-7 – *Strettonia cobboldi* Orłowski and Bednarczyk, 1965, 6 – cranidium, OS 69/3, original of Bednarczyk *et al.* (1965, fig. 9); 7 – cranidium, OS 69/5

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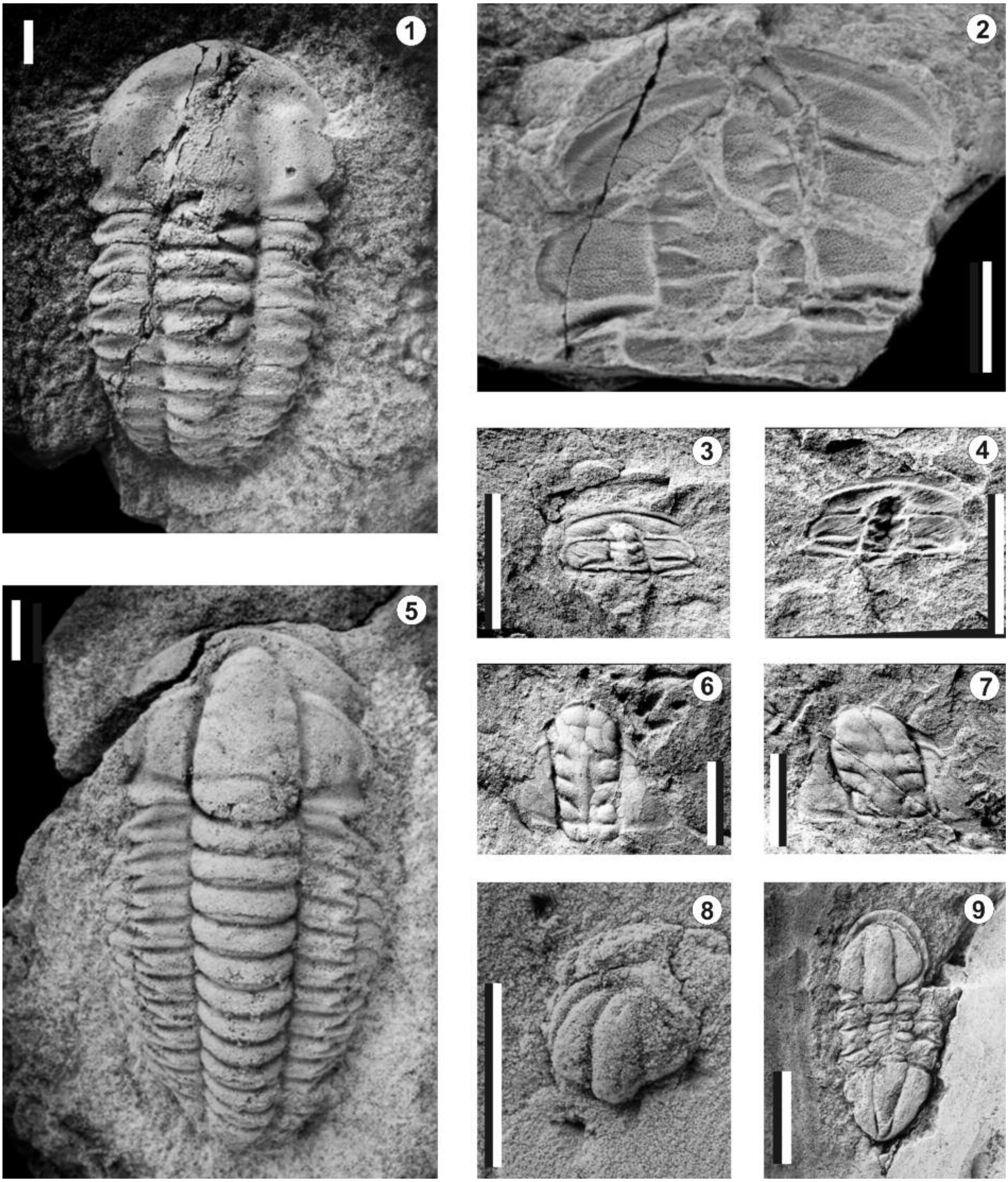
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PLATE 2

Trilobite assemblage 2a, Lower Cambrian *Protolenus–Issafeniella* Zone, Ociesęki Formation

1, **3** – *Issafeniella orlowinensis* (Samsonowicz, 1959a) from Widełki–Łapigrosz, 1 – cranidium, MUZWG ZI/29/1279; 3 – neotype cranidium, MUZWG ZI/42/150, original of Samsonowicz (1959b, pl. 1, fig. 14)

2, **4-5** – *Kingaspidoides sanctacrucensis* (Czarnocki, 1927), 2 – cranidium, MUZWG ZI/29/1213, from Widełki–Łapigrosz; 4 – cranidium, MUZWG ZI/29/1217, from Widełki–Łapigrosz; 5 – cranidium, MUZWG ZI/29/1212, from Chojnów Dół

Trilobite assemblage 2b, Middle Cambrian *Acadoparadoxides oelandicus* Superzone, Ociesęki Formation (Zamczysko)

6 – *Orodes usarzowi* (Orłowski, 1985b), cranidium, MUZWG ZI/29/2044

7-8 – *Ornamentaspis puschi* (Orłowski, 1959b), 7 – cranidium, MUZWG ZI/29/2062; 8 – cranidium, MUZWG ZI/29/2050

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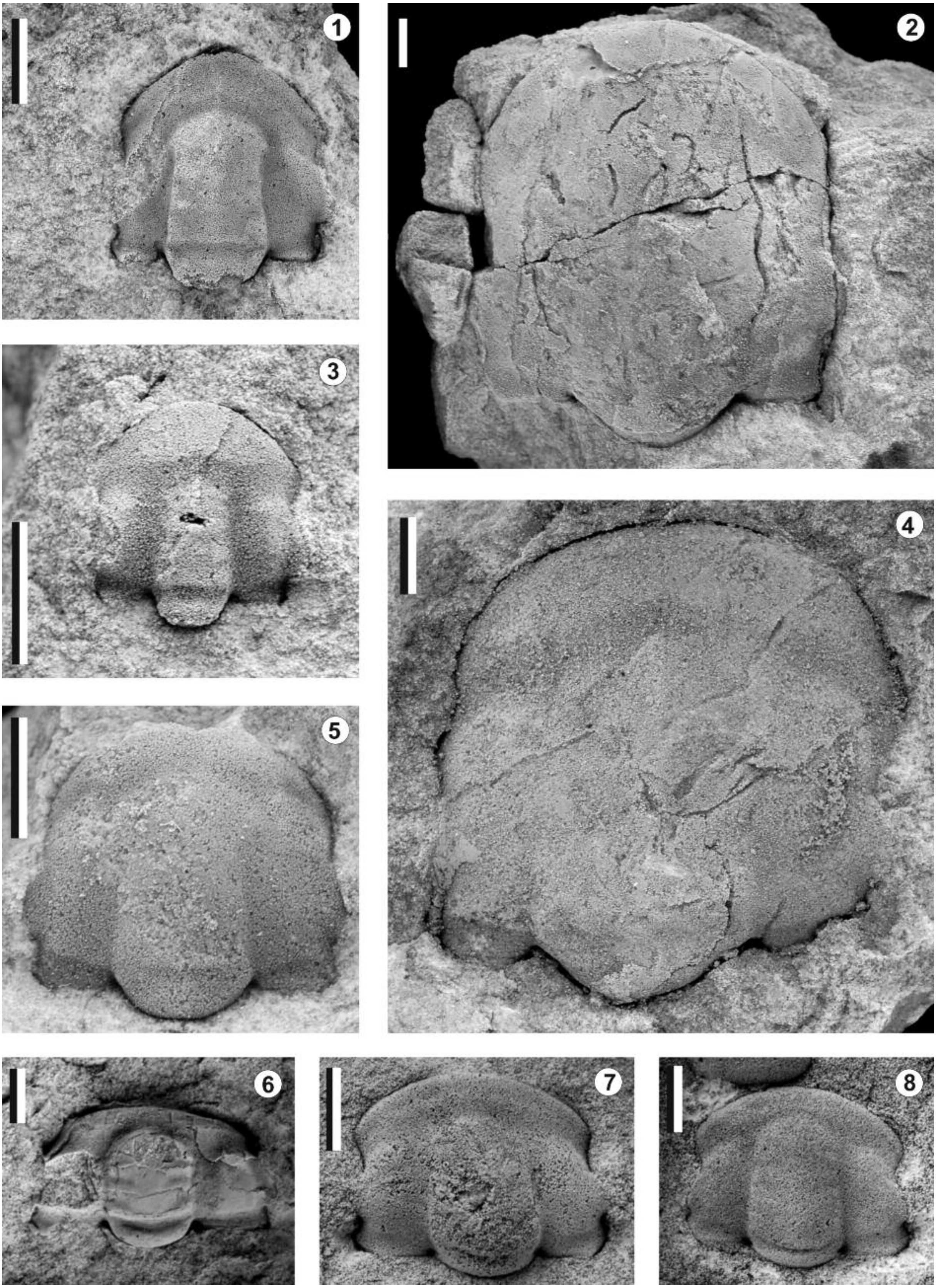
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PLATE 3

Trilobite assemblage 3b, Middle Cambrian *Eccaparadoxides insularis* Zone, Słowiec Formation from Konarska Hill

1-2 – *Ornamentaspis hupei* (Orłowski, 1964), 1 – cranidium, MUZWG ZI/29/3213; original of Orłowski (1971, pl. 1, fig. 1); 2 – two cranidia, MUZWG ZI/29/3216; original of Orłowski (1971, pl. 1, fig. 2)

3, **5** – *Latoucheia* (*Latoucheia*) *longa* (Orłowski, 1959b), 3 – cranidium, MUZWG ZI/29/3214; original of Orłowski (1971, pl. 1, fig. 6); 5 – cranidium, MUZWG ZI/29/3215; original of Orłowski (1971, pl. 1, fig. 5)

4 – *Issafeniella* cf. *orlowinensis* (Samsonowicz, 1959a), cranidium, IGPUW B/II/68

Trilobite assemblage 4a, from the *Eccaparadoxides insularis* Zone, and assemblage 4b, from the *Ptychagnostus praecurrens* Zone; Usarzów Formation

6-8 – *Ornamentaspis opatowi* (Orłowski, 1985b), 6 – holotype cranidium, MUZWG ZI/29/1707, from Jugoszów 1a, *E. insularis* Zone; original of Orłowski (1964, pl. 7, fig. 2a–b) and Orłowski (1985b, pl. 4, fig. 12); 7 – cranidium, MUZWG ZI/29/1750, from Jugoszów 1a, *E. insularis* Zone; 8 – cranidium, MUZWG ZI/29/1754, from Jugoszów 7a, *P. praecurrens* Zone

9-10 – *Kingaspis guerichi* (Orłowski, 1959b), 9 – cranidium, MUZWG ZI/29/2451, from Jugoszów 7, *P. praecurrens* Zone; original of Orłowski (1964, pl. 4, fig. 8); 10 – holotype cranidium, MUZWG ZI/29/2432, from Sternalice, *E. insularis* Zone; original of Orłowski (1959b, pl. 1, fig. 6)

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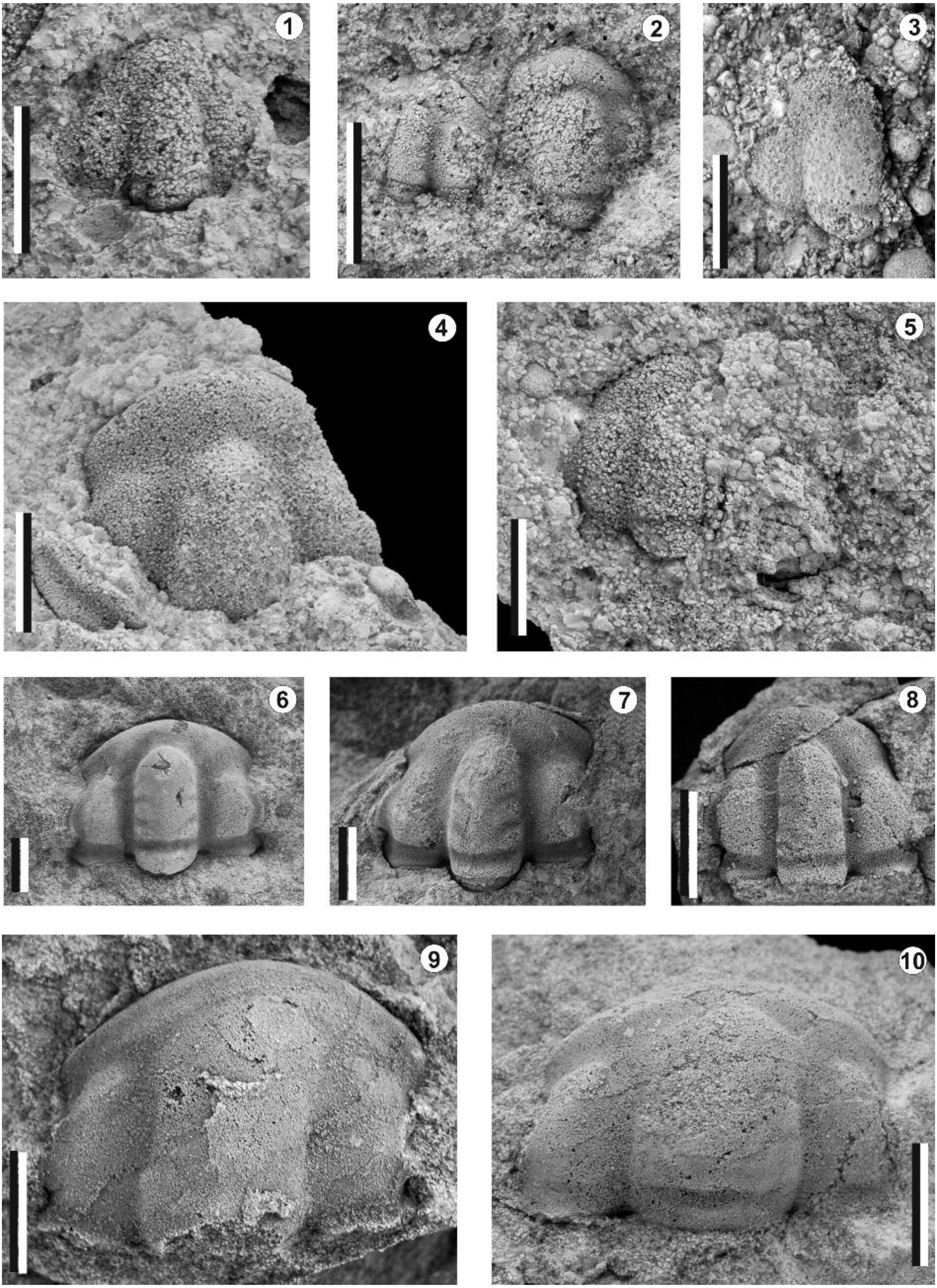
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PLATE 4

Trilobite assemblages from the Usarzów Formation, assemblage 4a from the *Eccaparadoxides insularis* Zone and assemblage 4b from the *Ptychagnostus praecurrens* Zone

1-2 – *Kingaspidoides sandomiri* (Orłowski, 1959b), *P. praecurrens* Zone, 1 – holotype cranidium, MUZWG ZI/29/2353, from Jugoszów 19; original of Orłowski (1959b, pl. 2, fig. 2a–c); 2 – cranidium, MUZWG ZI/29/2407, from Jugoszów 19

3 – *Kingaspidoides jugoszowi* (Orłowski, 1959b), holotype cranidium, MUZWG ZI/29/2522, from Jugoszów 1a, *E. insularis* Zone; original of Orłowski (1959b, pl. 2, fig. 6a–c)

4-6 – *Ornamentaspis hupei* (Orłowski, 1964), 4 – cranidium, MUZWG ZI/29/1669, from Jugoszów 1a, *E. insularis* Zone; 5 – cranidium, MUZWG ZI/29/1673, from Jugoszów 20, *P. praecurrens* Zone; original of Orłowski (1964, pl. 9, fig. 11); 6 – cranidium, MUZWG ZI/29/1650, from Jugoszów 1a, *E. insularis* Zone

7 – *Paradoxides* (*Acadoparadoxides*) *oelandicus* (Sjögren, 1872), cranidium, MUZWG ZI/42/133, from Sternalice, *E. insularis* Zone

8 – *Paradoxides* (*Eccaparadoxides*) *insularis* Westergård, 1936, cranidium, MUZWG ZI/29/3211, from Jugoszów 1a, *E. insularis* Zone; original of Orłowski (1959a, pl. 2, fig. 2)

9 – *Paradoxides* (*Eccaparadoxides*) *pinus* Westergård, 1936, cranidium, MUZWG ZI/29/3210, from Jugoszów 3, *P. praecurrens* Zone; original of Orłowski (1964, pl. 2, fig. 2)

10 – *Paradoxides* (*Acadoparadoxides*) *czarnockii* Orłowski, 1959a, holotype cranidium, MUZWG ZI/29/3212, from Sternalice, *E. insularis* Zone; original of Orłowski (1959a, pl. 2, fig. 4a–b)

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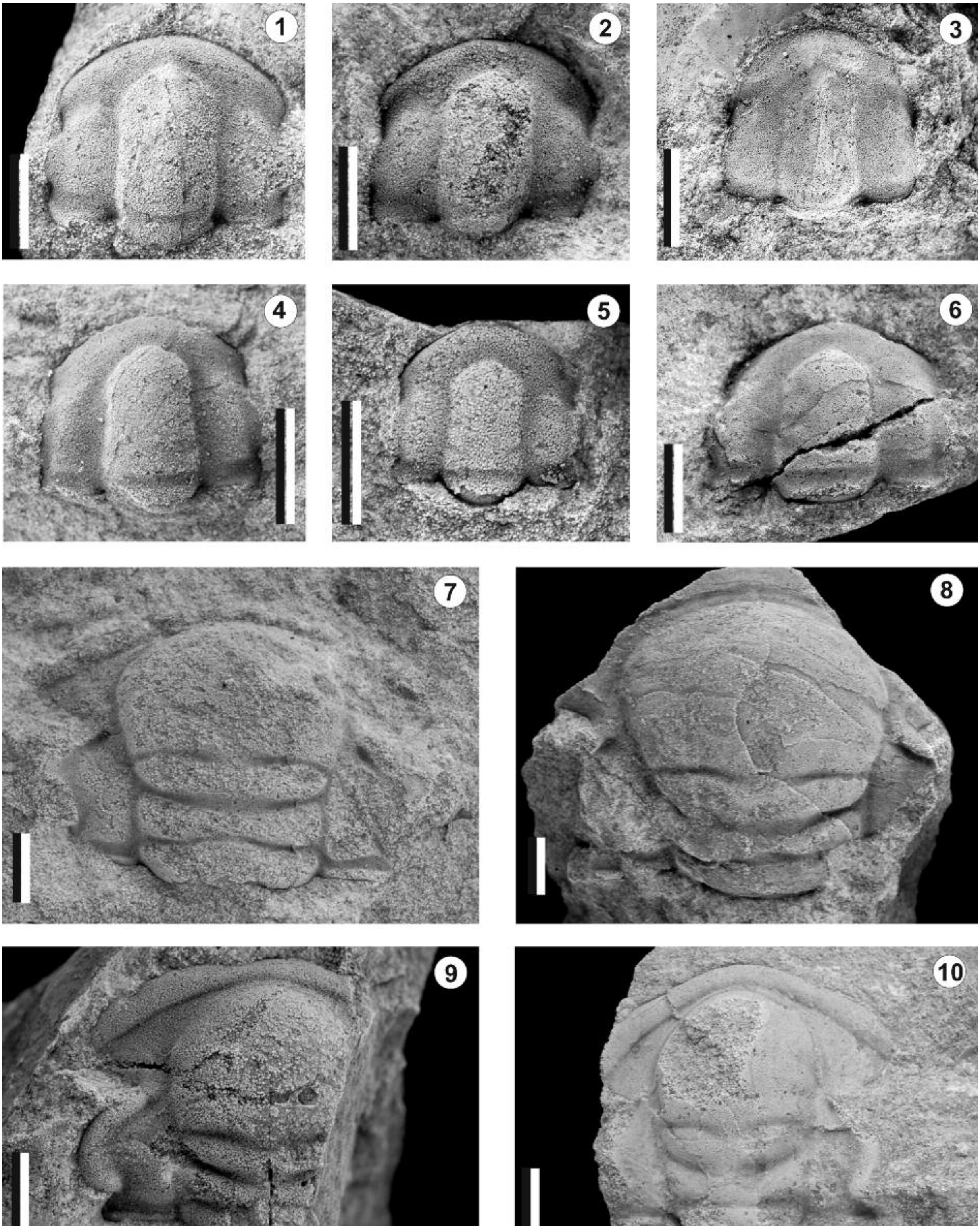
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PLATE 5

Trilobite assemblages from the Usarzów Formation, assemblage 4a from the *Eccaparadoxides insularis* Zone and assemblage 4b from the *Ptychagnostus praecurrens* Zone

1-2 – *Ornamentaspis henningsmoeni* (Orłowski, 1964), from Jugoszów 1, *E. insularis* Zone, 1 – cranidium, MUZWG ZI/29/1792; original of Orłowski (1964, pl. 10, fig. 5); 2 – cranidium, MUZWG ZI/29/1803; original of Orłowski (1964, pl. 10, fig. 8)

3-5 – *Ellipsocephalus hoffi* (Schlotheim, 1823), 3 – cranidium with thorax, MUZWG ZI/29/2324, from Jugoszów 1a, *E. insularis* Zone; original of Orłowski (1959b, pl. 1, fig. 1a–b); 4 – cranidium, MUZWG ZI/29/2306, from Jugoszów 7a, *P. praecurrens* Zone; 5 – cranidium, MUZWG ZI/29/2307, from Jugoszów 1a, *E. insularis* Zone; original of Orłowski (1985b, pl. 1, fig. 4)

6-8 – *Orodes usarzowi* (Orłowski, 1985b), 6 – holotype cranidium, MUZWG ZI/29/1681, from Jugoszów 1a, *E. insularis* Zone; original of Orłowski (1964, pl. 8, fig. 9a–b) and Orłowski (1985b, pl. 4, fig. 1a–b); 7 – incomplete cranidium with librigena, MUZWG ZI/29/1684, from Jugoszów 3, *P. praecurrens* Zone; original of Orłowski (1964, pl. 9, fig. 5) and Orłowski (1985b, pl. 4, fig. 2); 8 – cranidium, MUZWG ZI/29/1691, from Jugoszów 4, *P. praecurrens* Zone; original of Orłowski (1964, pl. 9, fig. 3) and Orłowski (1985b, pl. 3, fig. 5)

9, **12** – *Protolenus* (*Protolenus*) *polonicus* Orłowski, 1964, from Sternalice, *E. insularis* Zone, 9 – holotype cranidium, MUZWG ZI/29/3209; original of Orłowski (1964, pl. 11, fig. 1); 12 – crandium, MUZWG ZI/42/132

10-11, **13** – *Latikingaspis samsonowiczi* (Orłowski, 1964), from the *E. insularis* Zone, 10 – cranidium, MUZWG ZI/29/2281, from Sternalice; original of Orłowski (1964, pl. 11, fig. 3); 11 – holotype cranidium with thorax, MUZWG ZI/29/1615, from Jugoszów 1; original of Orłowski (1964, pl. 6, fig. 1); 13 – cranidium, MUZWG ZI/29/1627, from Sternalice; original of Orłowski (1985b, pl. 3, fig. 7)

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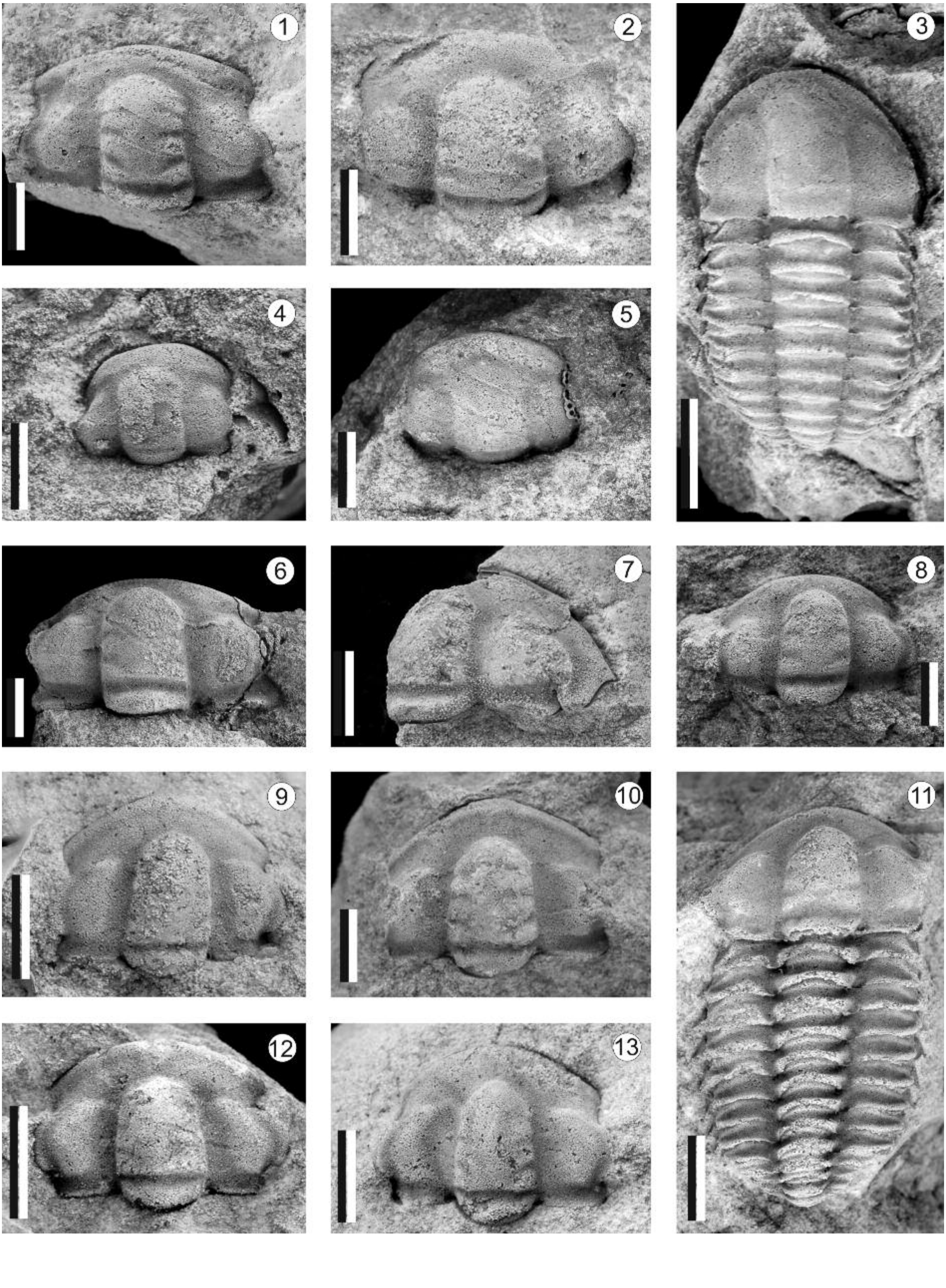
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PLATE 6

Acritarch assemblage 1a, Kamieniec Formation, from the Zaręby 2 borehole
(depth 1290.0 m unless otherwise stated)

1 – ?*Celtiberium papillatum* Moczydłowska, 1998, 1278 A54-1 (1256.5 m)
2 – *Celtiberium* cf. *dedalinum* Fombella, 1978, 1279A M28-1
3 – *Celtiberium dedalinum* Fombella, 1978, 1279A F26-2
4-5 – *Polygonium varium* (Volkova) Moczydłowska, 1998, D – 1279A B27-2; E – 1279A F48-3
6-7 – ?*Archaeodiscina* sp., F – 1279A C37-2; G – 1279A H33-3
8, **14**, **17** – *Granomarginata* cf. *squamacea* Volkova, 1968, H – 1279A F44-3; N – 1279A S34-1; Q – 1279A P48-2
9-10 – *Cymatiosphaera* sp., 9 – 1279A H34-3; 10 – 4921 N47-3 (1367.5 m)
11 – ?*Liepaina* sp., 1279A P27-4
12 – ?*Comasphaeridium* sp., 1279A P26-2
13 – *Aranidium* sp., 1279A Z44-1
15 – *Leiosphaeridia* sp., 1279A Z50-4
16 – *Pterospermella solida* (Volkova) Volkova in Volkova *et al*., 1979, 1279A P40
18 – *Granomarginata squamacea* Volkova, 1968, 1279A W30-1
19-20 – *Eliasum* sp., 19 – 1278 C24 (1256.5 m); 20 – 1279A N43
21 – *Lophosphaeridium truncatum* Volkova, 1969, 1279A T32-2
22 – *Heliosphaeridium* cf. *longum* (Moczydłowska) Moczydłowska, 1991, 1279A K54
23 – *Heliosphaeridium* cf. *notatum* (Volkova) Moczydłowska, 1991, 1279A H35
24 – *Heliosphaeridium* cf. *coniferum* (Downie) Moczydłowska, 1991, 1279A H49
25 – *Asteridium* sp., 1279A J53-2
26 – *Comasphaeridium* sp., 1279A J29-2
27 – *Aliumella baltica* Vanderflit in Umnova and Vanderflit, 1971, 1279A H49-2
28 – *Lophosphaeridium variabile* Volkova, 1974, 4921 L31 (1367.0 m)
29 – gen. et sp. indet., 1279 O36
30 – *Lophosphaeridium tentativum* Volkova, 1968, 1279A A28
31-48 – *Volkovia dentifera* (Volkova) Downie, 1982, 31 – 1279A B29; 32 – 1279A B27-1; 33 – 1279A C28-4; 34 – 1279A C41-4; 35 – 1279A D28-4; 36 – 1279A D32; 37 – 1279A D32-2; 38 – 1279A E33-2; 39 – 1279A K52-4; 40 – 1279A D38-1; 41 – 1279A D57-1; 42 – 1279A C43-4; 43 – 1279A E30-3; 44 – 1279A E58-1; 45 – 1279A F28-2; 46 – 1279A F29-1; 47 – 1279A K52; 48 – 1279A L38-2

Symbols refer to number of slide and location of specimen according to England Finder.
Scale bar equals 10 μm

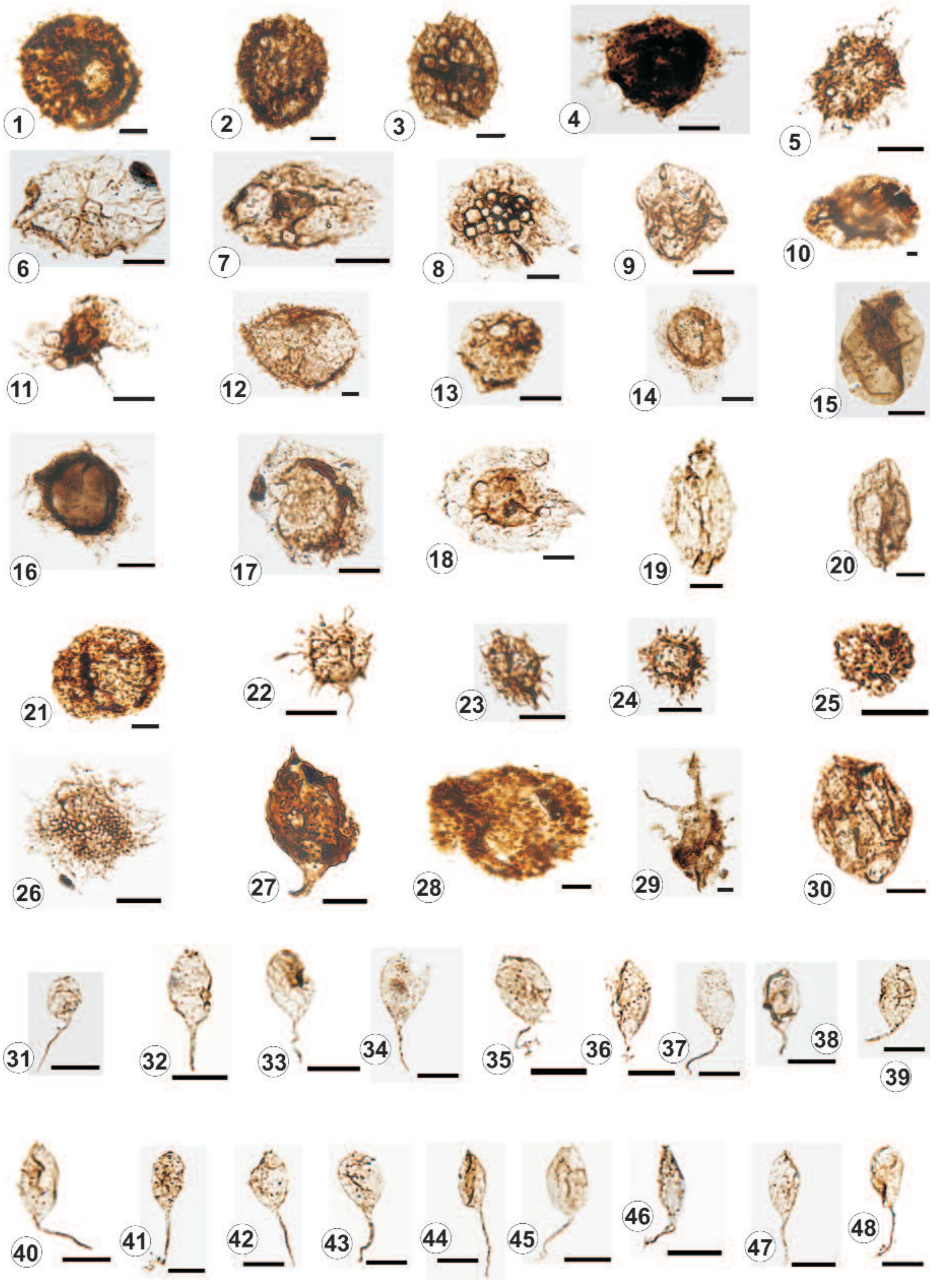
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PLATE 7

Acritarch assemblage 1b, Kamieniec Formation, from Kamieniec dam

1-2 – *Skiagia ciliosa* (Volkova) Downie, 1982, 1 – 4984 A40-1; 2 – 4984 Q45-4
3-4 – *Skiagia* cf. *ciliosa* (Volkova) Downie, 1982, 3 – 4984 X45-2; 4 – 4984 N28-2
5-6 – transition between *S. ciliosa* and *S. brevispinosa*,. 5 – 4984 O49-3; 6 – 4984 B31-2
7-9 – *Skiagia brevispinosa* Downie, 1982, 7 – 4984 F38-3; 8 – 4984 B49-3; 9 – 4984 M27-2
10 – *Skiagia* cf. *compressa* (Volkova) Downie, 1982, 5072 L50-2
11 – *Skiagia compressa* (Volkova) Downie, 1982, 5072 J35
12-13 – *Lophosphaeridium truncatum* Volkova, 1969, 12 – 5072 O35-3; 13 – 5072 T41
14-15 – *Lophosphaeridium tentativum* Volkova, 1968, 14 – 5072 U40; 15 – 4984 N45
16 – *Aranidium* sp., 4984 X46
17 – *Pterospermella* cf. *vitalis* Yankauskas in Volkova *et al*., 1979, 4984 M43-1
18 – *Pterospermella* cf. *velata* Moczydłowska, 1988, 4984 P41-2
19 – *Pterospermella solida* (Volkova) Volkova in Volkova *et al*., 1979, 4984 O51
20, **22-23** – *Granomarginata squamacea* Volkova, 1968, T – 4984 V47-2; V – 4984 J32; W – 4984 P31
21 – gen. et sp. indet., 5072 Q41-3
24 – *Granomarginata* cf. *squamacea* Volkova, 1968, 5072 V41
25 – *Polygonium varium* (Volkova) Moczydłowska, 1998, 4984 N40-4
26 – *Cymatiosphaera gotlandica* Hagenfeldt, 1989a, 4984 N31-4
27 – *Cymatiosphaera* cf. *gotlandica* Hagenfeldt, 1989a, 4984 J38-1
28 – *Volkovia dentifera* (Volkova) Downie, 1982, 4984 J43
29 – *Volkovia* cf. *dentifera* (Volkova) Downie, 1982, 4984 Y35-2
30 – *Leiosphaeridia* sp., 4984 Z38-4
31-33 – *Leiovalia tenera* Kiryanov, 1974, 31 – 5072 H43-3; 32 – 4984 A35-2; 33 – 4984 O38-2
34 – *Eliasum* cf. *asturicum* Fombella, 1977, 4984 J28-2
35 – *Eliasum llaniscum* Fombella, 1977, 4984 M29-2
36 – *Eliasum* cf. *llaniscum* Fombella, 1977, 4984 A46-2
37 – ?*Eliasum* sp., 4984 J39-1

Symbols refer to number of slide and location of specimen according to England Finder.
Scale bar equals 10 μm

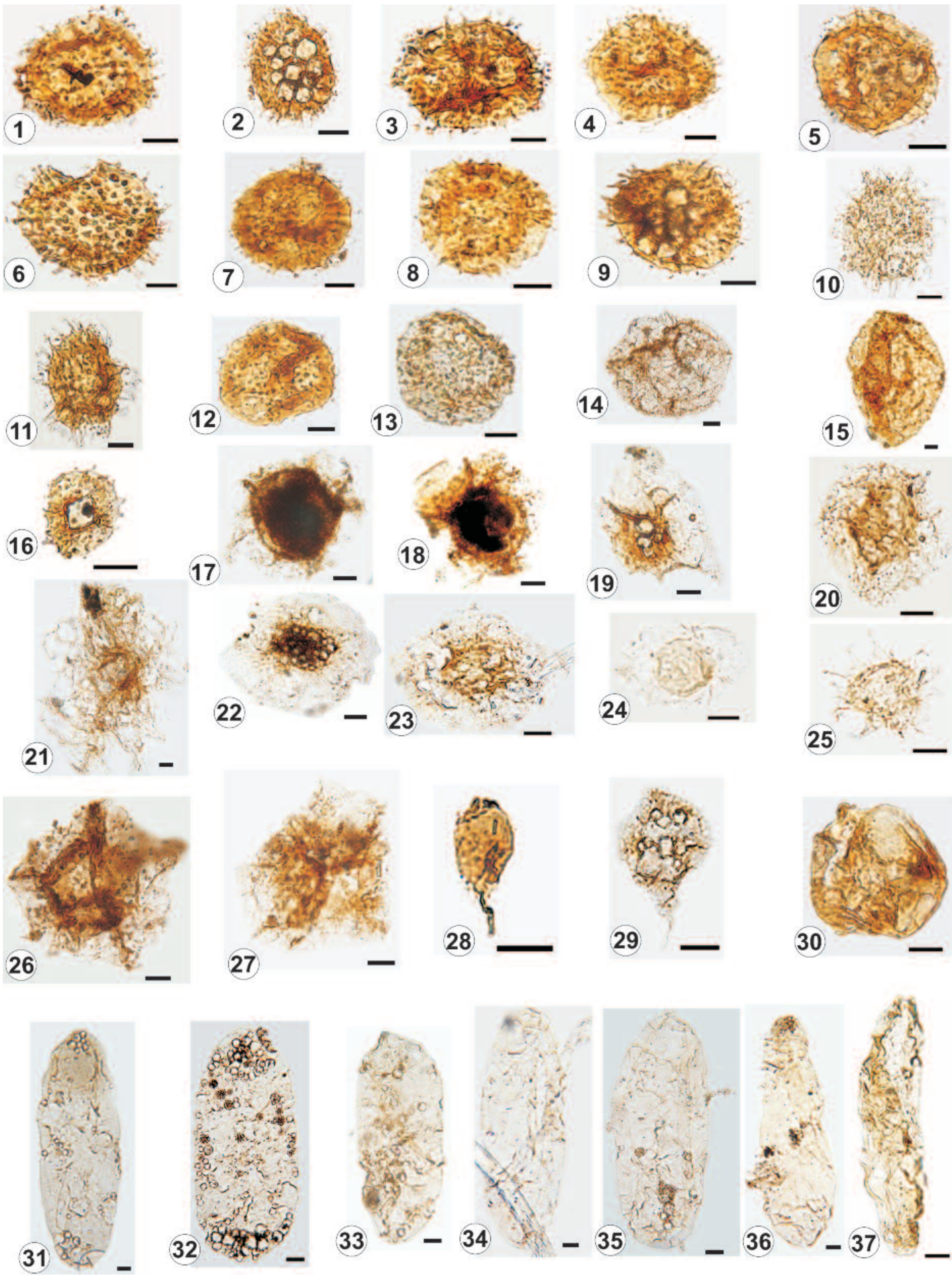
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PLATE 8

Acritarch assemblage 2, Kobierniki Beds, from the Lenarczyce PIG 1 borehole (depth 138.4 m unless otherwise stated)

1-7 – *Liepaina plana* Yankauskas and Volkova in Volkova *et al*., 1979, 1 – 5287 X27; 2 – 5285 A39 (136.2 m); 3 – 5284 M41-2 (132.5 m); 4 – 5285 C27-3 (136.2 m); 5 – 5287A M43-4; 6 – 5287A G35; 7 – 5287B P45-2

8-11 – *Adara alea* Martin in Martin and Dean, 1981, 8 – 5287C J44; 9 – 5287B Q31-2; 10 – 5287B D27-4; 11 – 5287B M43

12-16 – *Skiagia insignis* (Fridrichsone) Downie, 1982, 12 – 5285 P45-4 (136.2 m); 13 – 5285 U39 (136.2 m); 14 – 5285 O37-3 (136.2 m); 15 – 5287C A43-1; 16 – 5287A E48-4

17-18 – *Comasphaeridium silesiense* Moczydłowska, 1998, 17 – 5284 K35-3 (132.5 m); 18 – 5287B O42-3

19 – *Pterospermella vitalis* Yankauskas in Volkova *et al*., 1979, 5287 W32-3

20 – *Comasphaeridium* cf. *strigosum* (Yankauskas) Downie, 1982, 5287A L37-3

21-23 – *Comasphaeridium* sp., 21 – 5285 Q33-4 (136.2 m); 22 – 5284 W42-1 (132.5 m); 23 – 5285 Q45-3 (136.2 m)

24-25 – *Granomarginata* cf. *squamacea* Volkova, 1968, 24 – 5287C J39-2; 25 – 5287C U46

26 – *Aliumella baltica* Vanderflit in Umnova and Vanderflit, 1971, 5287DD U41-2

27, 31 – *Eliasum* sp., 27 – 5287A F33-2; 31 – 5285 D24-3 (136.2 m)

28, **33** – *Eliasum* cf. *pisciforme* Fombella, 1977, 28 – 5285 G41 (136.2 m); 33 – 5284 W44-4 (132.5 m)

29-30 – *Eliasum* cf. *llaniscum* Fombella, 1977, 29 – 5285 C36-3 (136.2 m); 30 – 5285 Q36-3 (136.2 m)

31 – *Eliasum* sp., 5285 D24-3 (136.2 m)

32 – *Leiovalia tenera* Kiryanov, 1974, 5284 X40 (132.5 m)

34 – *Eliasum* cf. *asturicum* Fombella, 1977, 5287A O42-3

35 – *Polygonium* sp., 5287DD S37

36 – *Polygonium varium* (Volkova) Moczydłowska, 1998, 5285 U47-2 (136.2 m)

37-38 – *Solisphaeridium* sp., 37 – 5287C D46; 38 – 5287DD M44-2

39, 41 – *Celtiberium* sp., 39 – 5284 W42-2 (132.5 m); 41 – 5287B Y39-1

40 – *Adara* cf. *matutina* Fombella, 1979, 5284 J32-1 (132.5 m)

42 – ?*Adara* sp., 5287DD N36-4

Symbols refer to number of slide and location of specimen according to England Finder.
Scale bar equals 10 μm

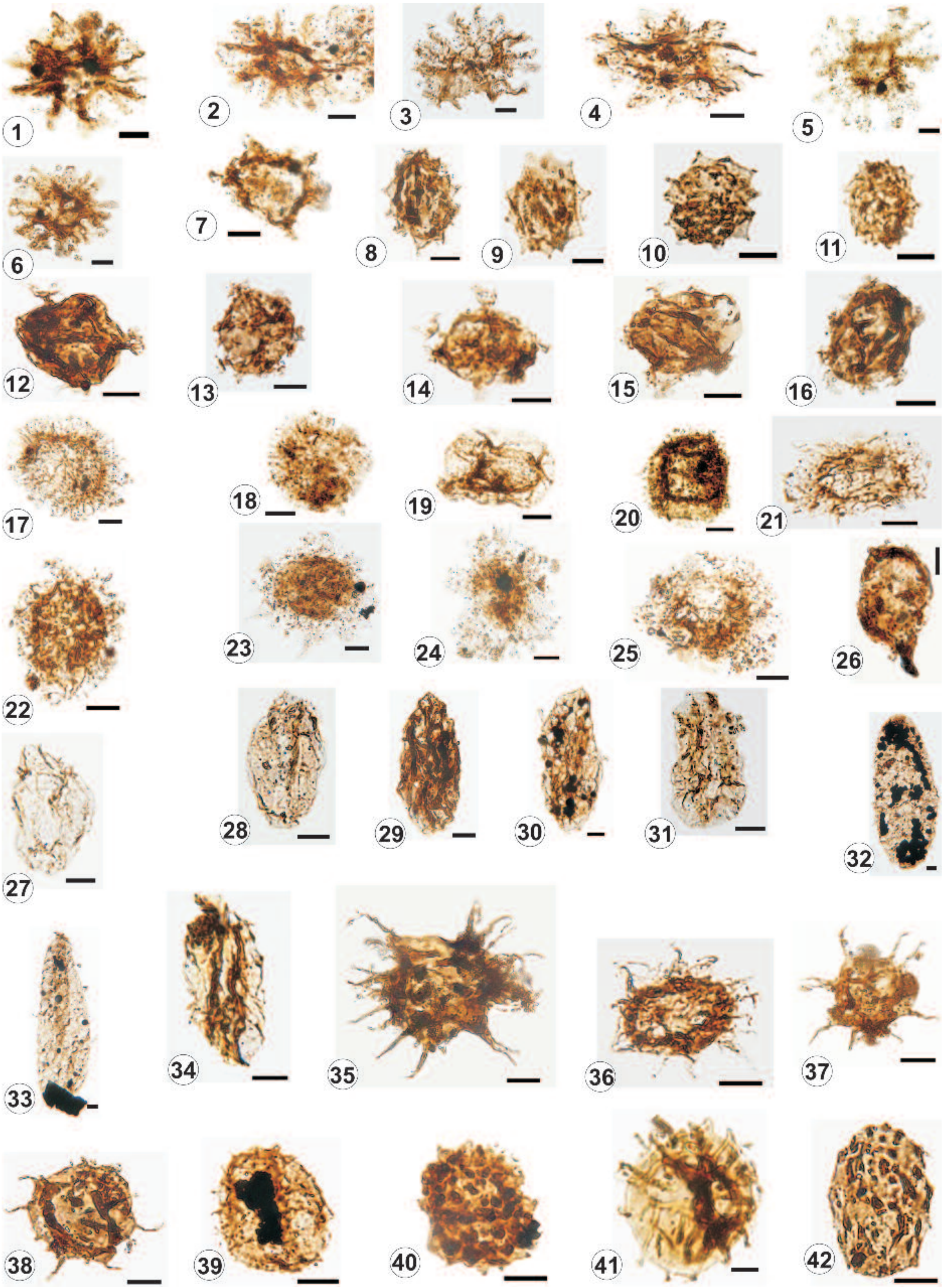
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PLATE 9

Acritarch assemblage 2, Kobierniki Beds, from the Lenarczyce PIG 1 borehole (depth 138.4 unless otherwise stated)

1 – *Skiagia ciliosa* (Volkova) Downie, 1982, 5284 C44-4 (132.5 m)
2-4 – *Skiagia* cf. *ciliosa* (Volkova) Downie, 1982, 2 – 5284 C48-3 (132.5 m); 3 – 5284 Y48 (132.5 m); 4 – 5284 Q38-3 (132.5 m)
5-6 – *Skiagia* cf. *brevispinosa* Downie, 1982, 5 – 5287C E36; 6 – 5284 H26 (132.5 m)
7 – *Skiagia brevispinosa* Downie, 1982, 5284 W47 (132.5 m)
8-10 – *Heliosphaeridium* cf. *notatum* (Volkova) Moczydłowska, 1991, 8 – 5287A C35; 9 – 5287A J46-2; 10 – 5285 S37-2 (136.2 m)
11-12 – *Multiplicisphaeridium xianum* Fombella, 1977, 11 – 5287C N41-4; 12 – 5287B H43.
13 – *Cristallinium* sp., 5287A W36-4
14-15 – ?*Deunffia* sp., 14 – 5285 X45 (136.2 m); 15 – 5287A W34-2
16 – *Cymatiosphaera* sp., 5284 Y41-3 (132.5 m)
17 – *Solisphaeridium flexipilosum* Slavíková, 1968, 5284 V42-3 (132.5 m)
18 – *Polygonium varium* (Volkova) Moczydłowska, 1998, 5284 P40 (132.5 m)
19, **21** – *Lophosphaeridium variabile* Volkova, 1974, 19 – 5285 H33 (136.2 m); 21 – 5287C M33-3
20 – *Lophosphaeridium tentativum* Volkova, 1968, 5287C L30-2
22 – *Lophosphaeridium latviense* (Volkova) Moczydłowska, 1998, 5287C X39-2
23 – ?*Lophosphaeridium* sp., 5287A L40-2
24-25 – *Comasphaeridium longispinosum* Hagenfeldt, 1989b, 24 – 5285 D45-1 (136.2 m); 25 – 5285 C45-4 (136.2 m)
26 – *Celtiberium* sp., 5284 F36-3 (132.5 m)

Acritarch assemblage 3, from Brzechów

27-28 – *Cristallinium* cf. *cambriense* (Slavíková) Vanguestaine, 1978, 27 – 5374 R39-4; 28 – 5374 R34-3
29-30 – *Retisphaeridium* sp., 29 – 5375 B31-4; 30 – 5381 L30-3
31, **33-34** – *Leiosphaeridia* sp., 31 – 5374 J41-4; 33 – 5374 L42-1; 34 – 5374 G39-4
32 – *Cymatiosphaera* sp., 5374 O37-4
35, 37 – *Granomarginata squamacea* Volkova, 1968, 35 – 5374 L39-1; 36 – 5382 M40-4
36 – ?*Comasphaeridium* sp., 5375 V42
38 – *Comasphaeridium silesiense* Moczydłowska, 1998. 5375 T44-2
39 – *Dictyotidium* sp., 5382 M34-2
40 – *Lophosphaeridium tentativum* Volkova, 1968, 5382 N43-3
41 – *Lophosphaeridium* cf. *latviense* Volkova (Moczydłowska, 1998), 5382 J42-3

Acritarch assemblage 4, from Jugoszów 20

42-44 – *Eliasum* sp. A, 42 – 5000 B35-2; 43 – 5000 C40-2; 44 – 5000 P31-1
45 – *Cymatiosphaera* cf. *postae* (Yankauskas) Yankauskas in Volkova *et al*., 1979, 5000 L31-3

Symbols refer to number of slide and location of specimen according to England Finder.
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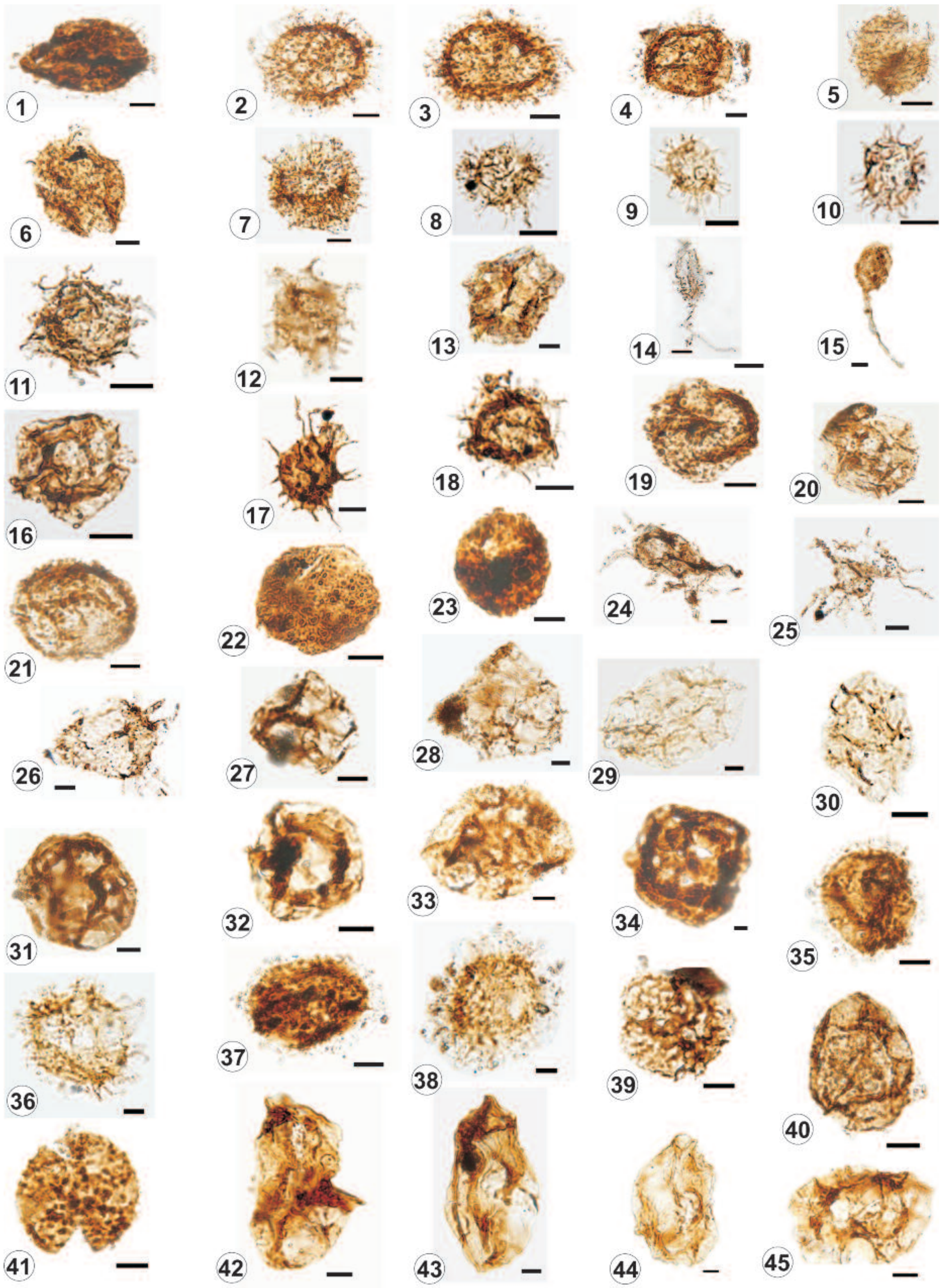
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PLATE 10

Acritarch assemblage 5, Kobierniki Beds, from the Lenarczyce exposure

1-7 – *Cristallinium cambriense* (Slavíková) Vanguestaine, 1978, 1 – 5325 M30-3; 2 – 5325 T31; 3 – 5325 H28-1; 4 – 5325 E35-1; 5 – 5325 U40-4; 6 – 5091 O34-2; 7 – 5091 G30-4

8 – ?*Cristallinium* sp., 5324 F41-4

9-10, **13** – *Retisphaeridium* sp., 9 – 5325 N39-3; 10 – 5325 R32-3; 13 – 5324 G29-4

11 – *Cristallinium* sp., 5091 W34-3

12 – *Dictyotidium* sp., 5325 V42-3

14, **21**, **29** – *Leiosphaeridia* sp., 14 – 5325 S37; 21 – 5325 M30-3; 28 – 5325 C42-3

15-16 – *Cymatiosphaera* cf. *postae* (Yankauskas) Yankauskas in Volkova *et al*., 1979, 15 – 5091 E50; 16 – 5091 J33

17 – *Cymatiosphaera cramerii* Slavíková, 1968, 5325 V41-2

18 – *Pterospermella* sp., 5325 X34

19 – *Comasphaeridium silesiense* Moczydłowska, 1998, 5325 T40-3

20 – *Granomarginata squamacea* Volkova, 1968, 5325 U37-4

22 – *Cristallinium* cf. *cambriense* (Slavíková) Vanguestaine, 1978, 5325 M39-1

23, **35** – *Eliasum* sp., 23 – 5325 L49; 35 – 5091 O27-4

24 – *Multiplicisphaeridium xianum* Fombella, 1977, 5091 X37

25 – *Heliosphaeridium* sp., 5091 N38-4

26-27 – *Lophosphaeridium truncatum* Volkova, 1969, 26 – 5325 O44-2; 27 – 5325 L35-2

28 – *Lophosphaeridium tentativum* Volkova, 1968, 5325 J44

30 – *Tasmanites* sp., 5325 N35-4

31, **33** – *Eliasum llaniscum* Fombella, 1977, 31 – 5325 V33; 33 – 5091 M46-2

32, **34** – *Eliasum* cf. *llaniscum* Fombella, 1977, 32 – 5091 A29-2; 34 – 5091 A29-2

Symbols refer to number of slide and location of specimen according to England Finder.
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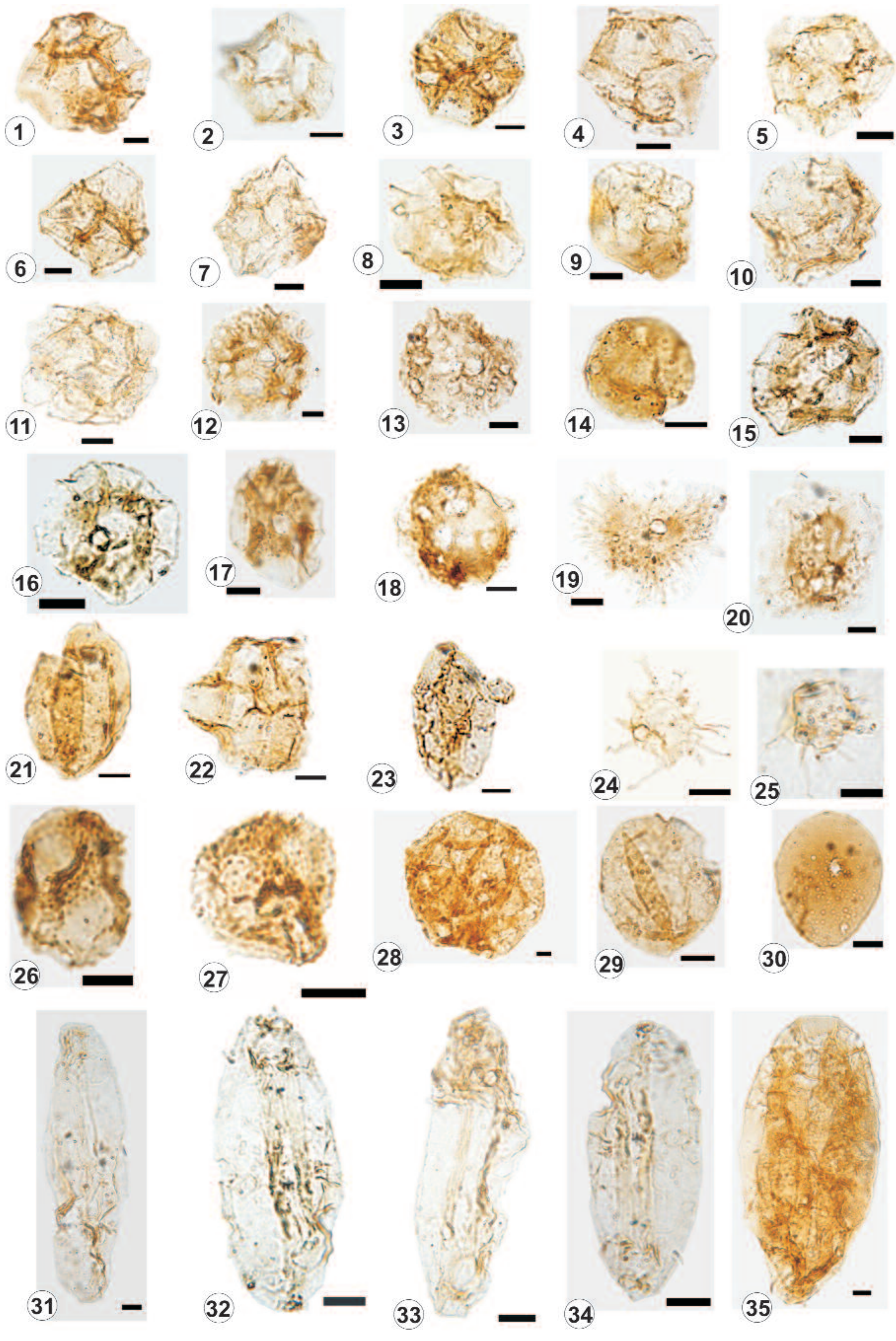
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