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Stratigraphy and palaeogeography of the Ordovician in the Holy Cross Mts

ABSTRACT: The biostratigraphic division of the Holy Cross Ordovician is based for both facial regions, that of Kielce and of Łysogóry, on brachiopods, trilobites, graptolites and conodonts. The Holy Cross conodonts had not previously been worked out. The writer's investigations of that faunal group have led to the discovery within the Kielce region of the Llandeilo and Caradoc stages. The palaeogeographic and facial relations in the above regions are discussed, too. In the Łysogóry region the sedimentation took place in a sea that had persisted since the Cambrian and was characterized by considerable depths. The Kielce region was not overflooded until the Upper Tremadoc after a break due to the old Caledonian (Sandomirian) phase. In this area, the deposits formed under shallow-sea conditions, with local emersions at the close of the Tremadoc and of the Ashgill.

INTRODUCTION

The present paper sums up the writer's studies on the Ordovician in the Holy Cross Mts (Central Poland). Most of the field and laboratory investigations have been carried out in the Department of the Historical Geology of the Warsaw University. The final stage of the work has been completed in the Stratigraphic Laboratory of the Institute of Geological Sciences of the Polish Academy of Sciences.

Acknowledgements. The paper is based on materials collected from 18 boreholes drilled by the Polish Geological Survey (Fig. 1). The writer has obtained these materials due to courtesy of Docent J. Znosko, also of Messrs. R. Cieśla, Z. Deczkowski and Z. Kowalczewski to whom words of thanks are here tendered. He also feels indebted to Professor E. Passendorfer and Docent A. Radwański for critical reading of the paper and for their help in its preparation. Messrs. S. Tyborowski and R. Adamik have kindly done the drawings and photographs.

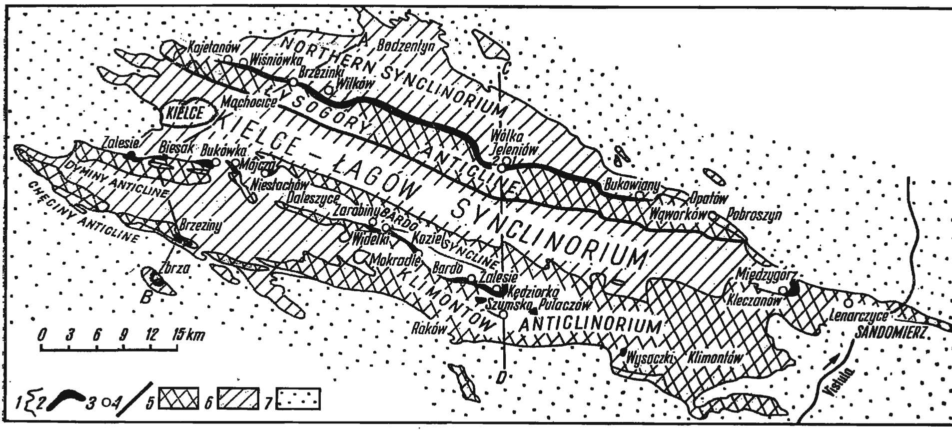


Fig. 1

Geological sketch map of the Palaeozoic core of the Holy Cross Mts (according to Czarnocki, 1953, and Tomczykowa, 1968)

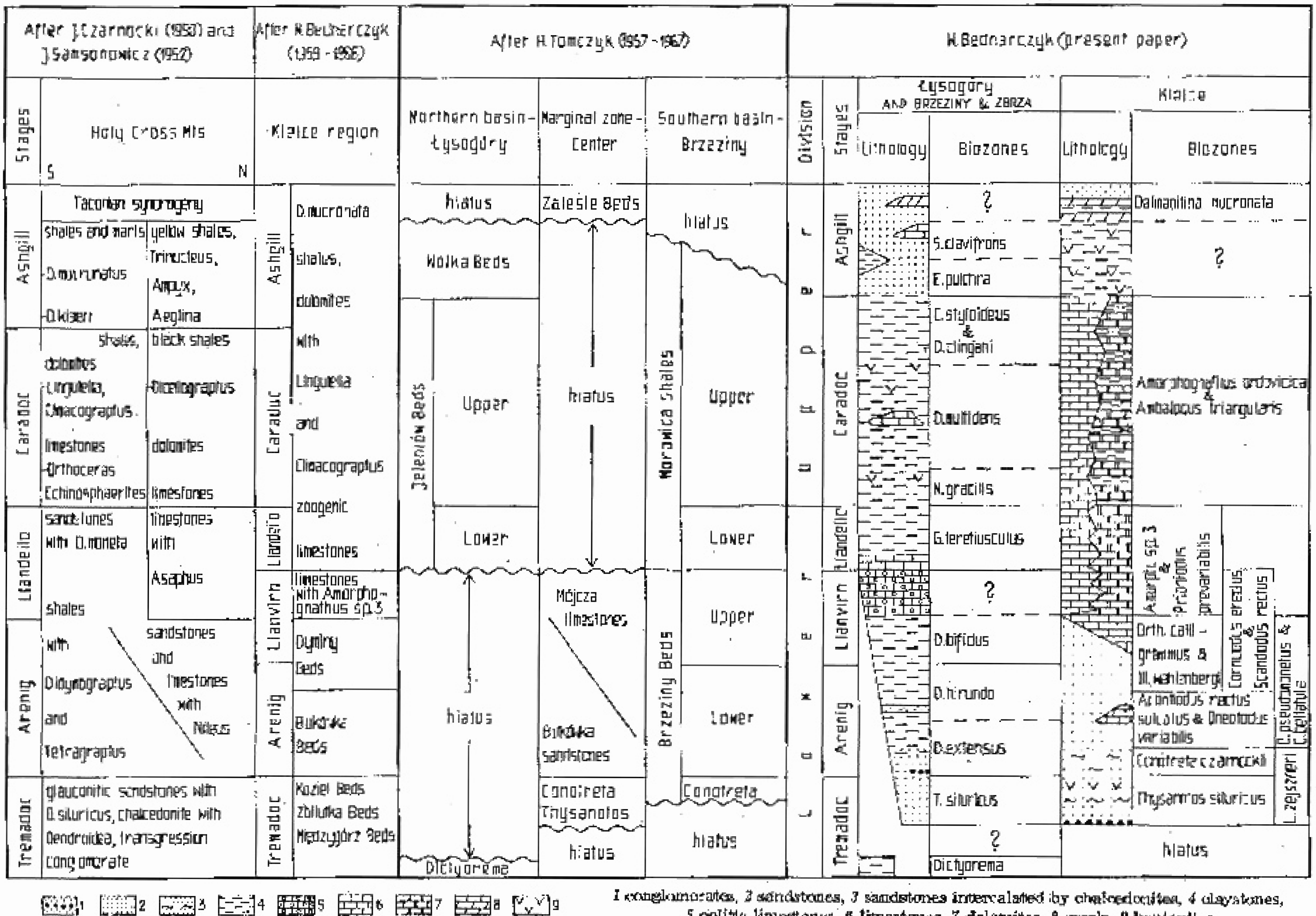
1 boundary of the Palaeozoic core, 2 Ordovician, 3 boreholes, 4 main fault of the Łysogóry anticline, 5 Cambrian, 6 Palaeozoic younger than Ordovician, 7 Meso- and Caenozoic
A—B and *C—D* lines of sections presented in Fig. 2

REVIEW OF PREVIOUS INVESTIGATIONS

Two investigation periods may be distinguished for the Holy Cross Ordovician. The first one is marked by the investigations of Michalski (1883) whose assignment of the sandstones from Bukówka near Kielce to the Ordovician was based on a brachiopod fauna. Additional data on the Ordovician are reported by Gürich (1896, 1901), later on by Czarnocki (1913, 1919, 1928a, b, 1939, 1950, 1957) and Samsonowicz (1916, 1920, 1934). Among the most important results of the two last mentioned authors are the discovery of the oldest Ordovician members (the so called sandstones with *Obolus siluricus*) at Międzygórz near Sandomierz (Samsonowicz 1916) and of the Lower Ordovician of the graptolite facies at Brzeziny (Czarnocki 1950; the Lower Ordovician graptolites being up to that time known only from the chalcedonites at Wysoczki, Kozłowski 1948), of the Ashgilian deposits in the northern slopes of the Łysogóry Mts (Czarnocki 1939), finally the synthetic description of the Ordovician stratigraphy of the Holy Cross Mts (Samsonowicz 1952).

The second period is characterized by increasing intensity of drillings. This has helped to gain a better knowledge of the Ordovician stratigraphy in the Holy Cross Mts and to determine the graptolite zones (Tomczyk 1957, 1962) known from the British Isles. The trilobite studies (Kielan 1956, 1959) helped to determine the Ashgillian stratigraphy, while descriptions of the brachiopod fauna (Bednarczyk 1959, 1964) and that

Stratigraphic subdivision of the Ordovician in the Holy Cross Mts



1 conglomerates, 2 sandstones, 3 sandstones intercalated by chalcedonites, 4 claystones, 5 oolitic limestones, 6 limestones, 7 dolomites, 8 marls, 9 bentonites

of trilobites (Bednarczyk 1966a) from the Lower Ordovician in the Kielce region stressed its importance for the local stratigraphy.

Petrographic studies (Turnau-Morawska 1958, 1960) led to the discovery in the same region of bentonites (Ryka & Tomczyk 1959; Chlebowski 1964, 1971; Bednarczyk & al. 1970).

Attempts have been made by the writer to analyse the range of the particular faunistic assemblages, *i.a.* of the conodonts recorded here for the first time. They allowed to establish a biostratigraphic subdivision based on the four major groups of fossils, *i.e.* the brachiopods, trilobites, graptolites and conodonts (Tables 1 and 2). The subdivision here presented suggests closer correlation of the Ordovician profiles from the Holy Cross Mts and comparison with the Ordovician of the classical European profiles (Table 4).

STRATIGRAPHY AND CORRELATION OF PROFILES

Tremadoc

The Lower Tremadoc has been observed in isolated sites in the Łysogóry region [1] (Table 3). It is represented by dark greyish claystones, here and there laminated and slated, containing lenses and concretions of calcareous claystones or grey limestones with a meagre and monotonous fauna of *Lingulella* sp., *Acrotreta* sp. and *Dictyonema* sp. (cf. Tomczykowa 1968).

Outside of the Łysogóry region, younger possibly still Lower Tremadocian members occur in the Kielce region. At the quarry in the Chełm ravine at Międzygórz (Fig. 1, Table 3) they are represented by conglomerates, *c.* 12 m thick, separated by a 3.5 m thick bed of conglomeratic sandstones containing sporadic thin-shelled obolids of the subgenus *Schmidtites* (cf. Bednarczyk 1964). In the profile of Zalesie Nowe (Czarnocki 1928a, b) their age-equivalents are quartzitic shales intercalated by silty-sandy shales resting on a thin bed of glauconitic sand with pebbles of Cambrian quartzites (*c.* 2.9 m in thickness). Similarly as the deposits from Międzygórz here discussed, they are a part of the Lingulella (Leptembolon) zejszneri Zone (Table 2) distinguished by the present writer. In this zone they occur (Bednarczyk 1966c) below deposits with *Thysanotos siluricus* (Eichw.) already belonging to the Upper Tremadoc.

Outside the vicinity of Pobroszyn in the Łysogóry region (Samsonowicz 1934), the Upper Tremadocian deposits represented by the Thy-

[1] The subdivision into the regions of Łysogóry and Kielce, used in this paper, is that accepted by Czarnocki (1957).

Stratigraphic range of the Ordovician fossils in the Holy Cross Mts

System	Divisions	Stages	Substages	GRAPTOLITES	TRILOBITES	BRACHIOPODS	CONODONTS	OTHER FAUNA
ORDOVICIAN	UPPER	Ashgill	Upper		Dalmanitina mucronata	Eustropheodonta, Dalmanella		ostracods Bolia & Primitia
			Lower		Staurocephalus clavifrons; Eodindymene pulchra			
		Caradoc	Upper	Climacograptus styloideus & Dicranograptus clingani	Cyclopyge,	Hisingerella, Paterula,	Amorphognathus ordovicica & Ambalodus triangularis	pelecypod Modiolopsis plana; paracrinoid Camarocystites
			Middle	Diplograptus multidens	Pharostoma, Tretaspis, Raphiophorus	Obolus ?, Lingulella, Onniella, Sericoidea,		
			Lower	Nemagraptus gracilis		Chonetoidea, Scaphelasma		
	LOWER	Llandeilo		Glyptograptus teretiusculus			Amorphognathus sp. 3 & Prioniodus prevariabilis; Cornuodus erectus & Scandodus rectus	
		Llanvirn	Upper	?				
			Lower	Didymograptus bifidus	Cybele bellatula; Illaenus wahlenbergi	Orthambonites pseudomonetus; Orthambonites calligramma		
		Arenig	Upper	Didymograptus hirundo			Acontiodus rectus sulcatus & Oneotodus variabilis	bryozoan Diplotrypa petropolitana; gastropod Modospira polonica; nautiloids Endoceras, Orthoceras; cystoid Echinosphaerites
			Lower	Didymograptus extensus		Lingulella zejszneri; Conotreta czarnockii		
		Tremadoc	Upper	?		Thysanotos siluricus		
			Lower	Dictyonema				

sanotos siluricus Subzone (Tables 1 and 2) are known only from the Kielce region (Table 3). In the western part of that region they occur in the vicinity of Zalesie near Słowik, in the Biesak quarry at Białogon, and on Mt. Telegraf near Kielce. The best Upper Tremadocian exposure occurs at the Biesak quarry where it is represented by moderately or thick bedded quartz sandstones with pale-green glauconite occasionally having a secondary greyish-red colouration. The sandstones contain *Thysantos siluricus* (Eichw.) and *Acrothele ceratopygarum* (Brögg.) and are intercalated by bentonite ranging from 5 to 15 cm in thickness. The thickness of the sandstones within the Thysanotos siluricus Subzone at the localities here discussed does not exceed 30 metres.

Throughout the Kielce region, the Upper Tremadoc rests on a bed of conglomerates, up to 60 cm thick, *e.g.* at the Biesak quary. In the bottom parts of the Upper Tremadocian there are intercalations and streaks of glauconite sand (*e.g.* at Zbrza, Table 3). The Upper Tremadoc of the eastern part of that region, in the vicinity of Międzygórz (the Chełm ravine, Mt. Zamkowa) and of Lenarczyce (Fig. 1, Table 3) is similarly developed. It consists of dark-green quartzitic sandstones with glauconite,

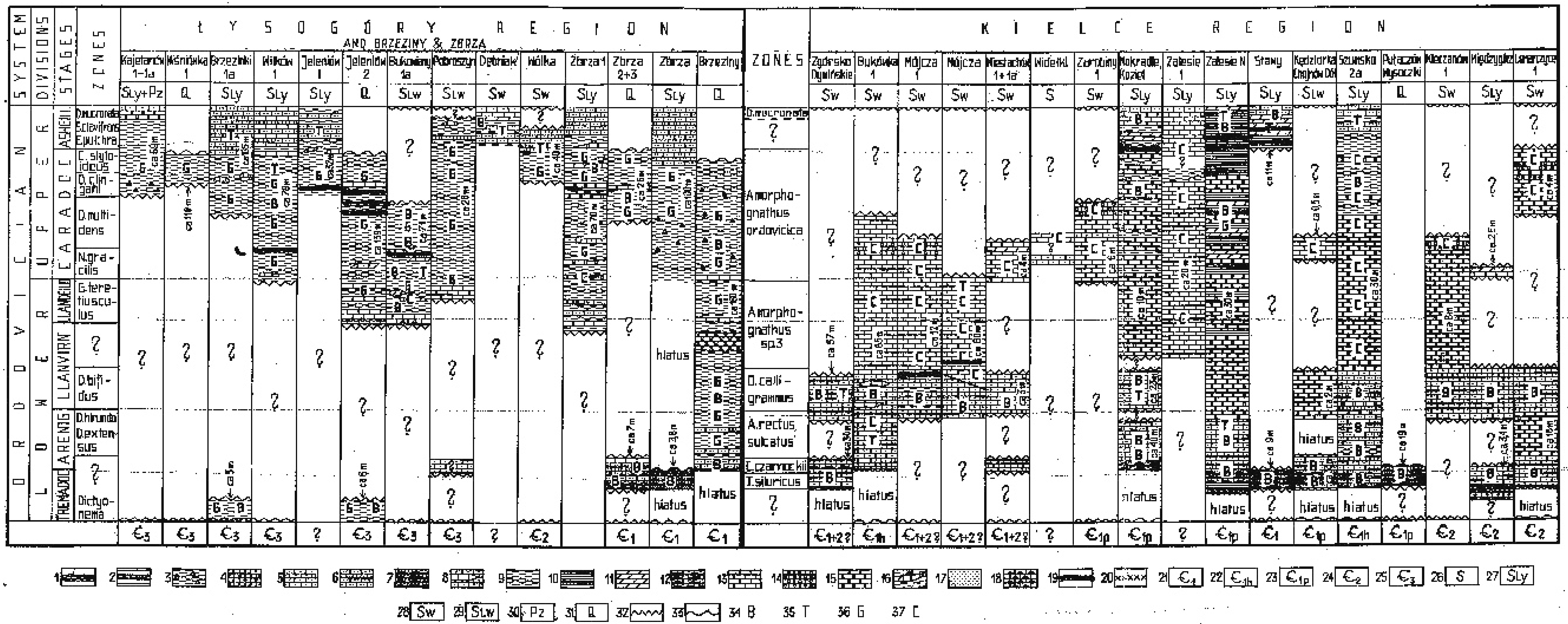
Chart 1

Tremadocian fauna in the Holy Cross Mts

(based on the data by Kozłowski 1948; Bednarczyk 1959, 1962, 1964; Bednarczyk & al. 1966, 1970; Tomczykowa 1968; completed by the author)

Fossils \ Localities	Brzezinki 1	Jeleniów 2	Zbrza	Zalesie	Biesak	Mt. Telegraf & Bukówka	Koziel	Powalisko	Mokradle 1	Stawy	Zalesie Nowe	Wilcza Góra	Choinów Dół	Szumsko 2a	Pułaczów	Wysoczki	Międzygórz	Mt. Zamkowa	Lenarczyce 1
BRACHIOPODA																			
Obolus /Schmidtites/ complexus Barrande			+				+	+		+	+		+	+			+	+	
Thysanotos siluricus /Eichwald/			+	+	+	+	+	+		+	+	+	+		+	+	+	+	+
Aulonotreta cf. antiquissimus /Eichwald/												+				+			
Lingulobus feistmanteli minor /Koliha/			+				+				+	+	+	+	+	+	+		+
Lingulella lepis /Salter/											+	+							
Lingulella sp.	+	+																	
Lingulella /Leptembolon/ insons insons /Barrande/			+				+				+	+			+	+			
Lingulella /Leptembolon/ insons lata Koliha							+	+	+		+	+	+		+				
Lingulella /Leptembolon/ zejszneri Bednarczyk			+			+	+	+			+	+	+		+	+			
Lingulella /Leptembolon/ sanctacrucensis Bednarczyk							+				+					+			
Lingulella /Leptembolon/ sp.div.			+			+	+	+	+		+	+	+		+	+			
Acrothele cf. borgholmensis Walcott											+								
Acrothele ceratopygarum /Brögger/					+	+											+		
Orbithele contraria /Barrande/							+				+								
Acrotreta cf. circularis Moberg & Segerberg											+								
Acrotreta cf. inchoans Barrande															+	+			
Acrotreta cf. subconica Kutorga												+							
Acrotreta sp.div.	+					+		+					+			+			
Conotreta samsonowiczi Bednarczyk											+	+				+			
Siphonotreta acrotretomorpha Gorjansky											+	+	+			+			
Siphonotreta sp.div.			+					+											
Schizambon cf. typicalis Walcott												+							
Apheoorthina cf. dauna /Walcott/																		+	
BRYOZOA																			
Diplotrypa petropolitana /Pander/											+	+			+	+			
GRAPTOLITA																			
Dictyonema sp.	+	+																	
and: 64 species monographed by Kozłowski /1948/																+			

Correlation of the Ordovician profiles in the Holy Cross Mts



1 conglomerates, *2* intraformational conglomerates in limestones, *3* claystones with siliceous concretions (or marly at Zbrza and Brzeziny), *4* gravelous sandstones, *5* sandstones, *6* siltstones, *7* siltstones intercalated by chalcedonites, *8* sandstones intercalated by limestones, *9* claystones, *10* shales, *11* marls, *12* sandstones intercalated by chalcedonites, *13* limestones, *14* oolitic limestones, *15* dolomites (in places with ooids), *16* claystones with limestone lenses and/or intercalations, *17* glauconitic sandstones, *18* limestones with siliceous concretions, *19* bentonites, *20* chamosite-siderite band, *21* undivided Lower Cambrian, *22* Lower Cambrian, Holmia Beds, *23* Lower Cambrian, Protolenus Beds, *24* Middle Cambrian, *25* Upper Cambrian, *26* undivided Silurian, *27* Silurian, Llandovery, *28* Silurian, Wenlock, *29* Silurian, Ludlow, *30* Zechstein, *31* Quaternary, *32* faults, *33* erosion surfaces, *34* occurrence sites of brachiopods, *35* occurrence of trilobites, *36* occurrence of graptolites, *37* occurrence of conodonts up to 34 m thick. Besides species known from the western part of the region (Chart 1) the fauna here also contains *Obolus (Schmidtites) complexus* Barr. and *Lingulobolus feistmanteli minor* (Kol.).

Stronger lithological and faunal differences are observable in the Upper Tremadocian within the Bardo syncline (Koziel, Powalisko, Zalesie Nowe, Zbilutka — Fig. 1, Table 3 and Chart 1), also in the vicinity of Szumsko, Pułaczów and Wysoczki. The occurrence is there noted of pale--green or green tuffite siltstones with glauconite, intercalated by chalcedonite and resting almost throughout on thin beds of conglomerate or of glauconitic sand with pebbles of Cambrian quartzites. The above deposits vary in thickness, ranging from 6 m at Zalesie Nowe to c. 20 m at Pułaczów.

In addition to the faunal remains already mentioned, there also occur here large numbers of: *Lingulella (Leptembolon) insons insons* (Barr.), *L. (L.) insons lata* Kol., *L. (L.) sanctacrucensis* Bedn., *L. (L.) zejszneri* Bedn., *Orbithele contraria* (Barr.), *Conotreta samsonowiczi* Bedn., *Acrotreta subconica* Kut. and others (Chart 1).

In the vicinity of Zbrza (Fig. 1, Table 3), the Upper Tremadoc displays a similar development. It is represented by quartz siltstones with glauconite, interbedded by chalcedonites. Towards the top the siltstones end with conglomerates (Bednarczyk 1966c) or pass into quartz sands and sandy limestones with *Conotreta* sp. (boreholes Zbrza *2* and *3*, Table 3); the thickness of these deposits is rather small and does not exceed 4 metres. The faunal remains observed in the Tremadocian of the Holy Cross Mts (Chart 1) permits its correlation with contemporaneous sediments of NE Poland, Scandinavia, NW Soviet Union and Czechoslovakia.

The claystones with *Dictyonema* sp. correspond to an inaccurately defined part of the Dictyonema Beds (Tjernvik 1958) in Sweden, or of the Pakerort stage in Estonia (Männil 1966). The age-equivalents of the *Dictyonema*-bearing claystones in Poland may be looked for in the *Dictyonema* shales described from boreholes in the eastern part of the Podlasie depression (Szymański 1968).

The deposits of the Thysanotos siluricus Subzone have their age--equivalents in sediments of the B_I Zone (Lamansky 1905, Balašova 1966) from the vicinity of Leningrad and Estonia (Männil 1966, Gorjansky 1969). Their Scandinavian age-equivalents are the Ceratopyge Beds (Tjernvik 1956, Jaanusson 1960a), and in Bohemia the Milina formation (Havliček & Vaněk 1966; Table 4).

In NE Poland the Thysanotos siluricus Subzone has its equivalents in the *Bryograptus* shales (Szymański 1968), in some cases also in the glauconitites containing *Lingulella* and *Acrotreta* as well as numerous conodonts from the genera *Drepanodus, Oistodus, Scandodus* and others (Bednarczyk 1968a).

Correlation of the Ordovician in the Holy Cross Mts and other regions

Scotland and Wales (Bulman 1958, Williams 1969)				Baltoscandia (Männil 1966)				Poland (Bednarczyk, present paper) — Holy Cross Mts				Bohemia (Havlíček & Vaněk 1966)		
Systems	Subsystems	Series	Graptolite zones	Series	Subseries	Stages	Graptolite zones	Division	Stages	Łysogóry region AND BRZEZINY & ZBRZA — Biozones	Kielce region — Biozones	Stages	Substages	Formations
Ordovician	Upper	Ashgill	Dicellograptus anceps	Harju	Ashgill	F_I	D.anceps	Upper	Ashgill	?	Dalmanitina mucronata	Ashgill	Bohdalec	Kosov
			Dicellograptus complanatus			F_{Ic}	D.complanatus			Staurocephalus clavifrons; Eodindymene pulchra	?			Králův Dvůr
		?	Pleurograptus linearis		Caradoc	F_{Ib} F_{Ia}	P.linearis		Caradoc	D.styloideus & D.clingani	Amorphognathus ordovicica & Ambalodus triangularis	Caradoc	Lodenice	Bohdalec
		? Caradoc	Dicranograptus clingani			E D_{III}	D.clingani							
			Climacograptus wilsoni	Viru		D_{II}	Diplograptus multidens			D.multidens			Chrustenice	Zahořany
			Climacograptus peltifer			D_I C_{III}								Vinice; Letná
			Nemagraptus gracilis			C_{II}	N.gracilis			N.gracilis				Libeň
	Lower	Llandeilo	Glyptograptus teretiusculus		Tallinn	C_{Ic}	G.teretiusculus	Lower	Llandeilo	G.teretiusculus	Amorphognathus sp.3 & Prioniodus prevariabilis	Llandeilo		Dobrotivá
		Llanvirn	Didymograptus murchisoni			C_{Ib} C_{Ia}	D.murchisoni		Llanvirn	?	Cornuodus erectus	Llanvirn		Šárka
			Didymograptus bifidus	Oeland	Ontikan	B_{III}	D.bifidus			D.bifidus	?.calligrammus			
		Arenig	Didymograptus hirundo			B_{II}	D.hirundo		Arenig	D.hirundo	Acontiodus rectus sulcatus	Arenig		Klabava
			Didymograptus extensus			B_I	D.extensus			D.extensus	Conotreta czarnockii			
Cambrian		Tremadoc	Bryograptus		Tremadoc	A_{III}	?		Tremadoc	T.siluricus	Thysanotos siluricus	Tremadoc		Mílina
			Dictyonema flabelliforme			A_{II}	D.flabelliforme			?; Dictyonema sp.	Hiatus			Třenice

Arenig

Lower Arenig

This substage consists of sediments of the local Conotreta czarnockii Subzone representing the upper part of the Lingulella (Leptembolon) zejszneri Zone (Table 2). Its most complete development occurs in the western part of the Bardo syncline at Koziel (Bednarczyk 1964, Bednarczyk & al. 1966). Its other occurrence sites are at Zbrza, Brzeziny, Mt. Bukówka, the Biesak quarry near Białogon, Niestachów, Zalesie Nowe and the vicinity of Szumsko (Fig. 1, Table 3).

Chart 2

Arenigian fauna in the Holy Cross Mts

(based on the data by Tomczyk 1962; Bednarczyk 1962, 1964; Tomczyk & Turnau-Morawska 1964; Bednarczyk & al. 1966; completed by the author)

Fossils \ Localities	Zbrza 3	Brzeziny	Bukówka 1	Koziel	Mokradle 1	Zalesie Nowe	Szumsko 2a	Lenarczyce 1
BRACHIOPODA								
Obolus /Schmidtites/ complexus Barrande				+		+		+
Obolus? ornatus Hadding							+	
Lingulobolus feistmanteli minor /Koliha/						+		
Broeggeria salteri /Holl/		+						
Lingulella /Leptembolon/ insons insons /Barrande/				+		+	+	
Lingulella /Leptembolon/ insons lata Koliha				+				
Lingulella /Leptembolon/ sanctacrucensis Bednarczyk				+		+		
Lingulella /Leptembolon/ zejszneri Bednarczyk						+		
Lingulella lepis /Salter/		+		+		+		
Lingulella sp.div.		+		+				
Orbithele contraria /Barrande/				+				
Acrothele cf. borgholmensis Walcott							+	
Conotreta calvamontana Bednarczyk				+				
Conotreta czarnockii Bednarczyk				+				
Conotreta kozielensis Bednarczyk				+				
Conotreta kozlowskii Bednarczyk				+				
Conotreta polonica Bednarczyk				+				
Conotreta samsonowiczi Bednarczyk				+				
Conotreta sp.div.	+	+		+		+	+	
Siphonotreta acrotretomorpha Gorjansky				+		+		
Apheoorthina cf. christianiae /Kjerulf/			+					
Apheoorthina cf. daunus /Walcott/				+				
Orthambonites pseudomonetus Bednarczyk				+		+		
Orthambonites semicircularis Pander				+				
Antigonambonites planus /Pander/						+		
GASTROPODA								
Moderospira polonica /Gürich/				+	+	+		
TRILOBITA								
Agnostus glabratus Angelin			+					
Telephus cf. granulatus Angelin		+						
Asaphus sp.		+						
Megistaspis sp.						+		
Nileus armadillo /Dalman/			+			+		
Illaenus sp.						+		
Cyrtometopus clavifrons /Dalman/			o	+				
Cybele bellatula /Dalman/			+	+		+		
GRAPTOLITA								
listed by Tomczyk /1962/		+						
CONODONTA								
presented in Table 5 of this paper			+					

On the whole the above subzone is characterized by the subordinate presence of chalcedonite which occurs as thin intercalations or concretions in the sandstones and tuffite siltstone. Side by side with *Obolus (Schmidtites) complexus* Barr., *Lingulella (Leptembolon) insons insons* (Barr.), *L. (L.) insons lata* (Kol.), already present in the Upper Tremadocian, there also appear new species of the genus *Conotreta*, i.a. *Conotreta czarnockii* Bedn., *C. calvamontana* Bedn., *C. kozlowskii* Bedn. (Chart 2).

The presence in the deposits of this subzone of such Bohemian forms as *Obolus (Schmidtites) complexus* Barr., *Lingulobolus feistmanteli minor* (Kol.), *Lingulella (Leptembolon) insons insons* (Barr.), *L. (L.) insons lata* Kol. and *Orbithele contraria* (Barr.) allows a correlation with the lower members of the Klabava formation of Bohemia (cf. Prantl & Ružička 1941, Havliček & Vaněk 1966).

Upper Arenig

Deposits of this substage are known only from the Kielce region (Table 3). In borehole Bukówka *IG-1* (Fig. 1) they are represented by a local Acontiodus rectus sulcatus Zone (Tables 2—3). This begins with dolo-calcareous sandstones of a dirty-cherry colour, with irregular intercalations of dolomitic limestones. Towards the top the sandstones pass into organodetrital greyish-brown limestones intercalated by thin, reddish claystones. The fauna observed here contains: *Nileus* sp., *Cybele* sp., *Acontiodus rectus sulcatus* Lindstr. (Pl. 1, Fig. 6), *Drepanodus arcuatus* Pand. (Pl. 1, Fig. 11), *D. proteus* Lindstr. (Pl. 1, Fig. 12), *D. subarcuatus* Furnish, *D. suberectus* (Branson & Mehl) (Pl. 1, Fig. 8), *D.* cf. *homocurvatus* Lindstr., *Falodus* cf. *parvidentatus* Serg. (Pl. 1, Fig. 10), *Oistodus* cf. *triangularis* Lindstr. (Pl. 1, Fig. 9) and *Oneotodus variabilis* Lindstr. (Pl. 1, Fig. 5). From this type of limestones, Samsonowicz (1916) and Czarnocki (1928a) reported *Nanorthis* cf. *christaniae* (Kjer.), *Agnostus glabratus* Ang., *Cybele bellatula* (Dalm.), *Cyrtometopus clavifrons* (Dalm.) and others.

The conodont assemblage mentioned above allows a correlation with the Arenig of Scandinavia and of the Leningrad area (cf. Lindström 1954, Sergeeva 1963).

The Bukówka area excepted, no evidence is available to prove the occurrence of the Upper Arenig in the western part of the Kielce region. This probably results from faulting along contacts of the Tremadocian and the Lower Llanvirnian deposits (Bednarczyk 1966c).

In the central part of the Kielce region, the Upper Arenig occurs in the southern limb of the Bardo syncline and in the adjacent area. Its best and most complete outcrop occurs in the northern part of the village Koziel (Bednarczyk 1964, 1966c). Test pits show thick-bedded quartz sandstones of a light-grey or yellowish colour, c. 9 m thick, with: *Orthambonites pseudomonetus* Bedn., *O. semicircularis* Pand., *Cybele bellatula*

(Dalm.), *Nileus armadillo* (Dalm.), *Cyrtometopus clavifrons* (Dalm.) and *Moderospira polonica* (Gür.). This fauna indicates the lower part of a local Orthambonites pseudomonetus & Cybele bellatula Zone which, within the Kielce region, comprises the Upper Arenig and the Lower Llanvirn (Table 2 and Chart 2).

In borehole Mokradle *IG-1* (Fig. 1, Table 3), lying east of Koziel, the Upper Arenig is developed as quartzitic light-grey sandstones with *Moderospira polonica* (Gür.). Towards the top, the sandstones pass into siltstones interbedded by ostracod-bearing dolomites (Bednarczyk & al. 1966).

At Zalesie Nowe (Fig. 1, Table 3) the member under consideration is represented by thick-bedded sandstones with *Antigonambonites planus* (Pand.), *Nileus armadillo* (Dalm.) and *Cyrtometopus clavifrons* (Dalm.). Its development in borehole Szumsko *IG-2a* (Fig. 1, Table 3) is different: the Upper Arenig comprises claystones, cherry-brown or variegated, also applegreen siltstones with a meagre fauna of: *Acrothele* cf. *borgholmensis* Walc., *Obolus? ornatus* Hadding and *Drepanodus* sp.

Within the three last mentioned profiles the thickness of the Upper Arenig is rather small and does not exceed 2 metres.

In Baltoscandia, the equivalents of the stratigraphic members of the Holy Cross Arenig are represented by the Lattorpian (B_I) stage (without the lowermost parts) and also by the Volkhov (B_{II}) stage (without the uppermost parts, cf. Männil 1966, Table 4).

The claystone facies of the Arenig has been observed only at Brzeziny (Czarnocki 1950). More detailed investigations of the borehole materials have recently been done by Tomczyk & Turnau-Morawska (1964).

PL. 1

Upper Arenigian — Lower Llanvirnian conodonts

1 — *Oistodus forceps* Lindström; Lower Llanvirn, Mt. Skała near Mójcza.
2 — *Oistodus basiovalis* Sergeeva; the same age and locality.
3 — *Drepanodus planus* Lindström; the same age and locality.
4 — *Oistodus linguatus* Lindström; the same age and locality.
5 — *Oneotodus variabilis* Lindström; Upper Arenig, borehole Bukówka *IG-1* (depth 84.0—95.6 m).
6 — *Acontiodus rectus sulcatus* Lindström; ibidem.
7 — *Scandodus rectus* Lindström; Lower Llanvirn, the same borehole (83.5—84.0 m).
8 — *Drepandous suberectus* (Branson & Mehl); Upper Arenig, the same borehole (84.0—95.6 m).
9 — *Oistodus* cf. *triangularis* Lindström; ibidem.
10 — *Falodus* cf. *parvidentatus* Sergeeva; ibidem.
11 — *Drepanodus arcuatus* Pander; ibidem.
12 — *Drepanodus proteus* Lindström; ibidem.

All photographs are *c.* × 70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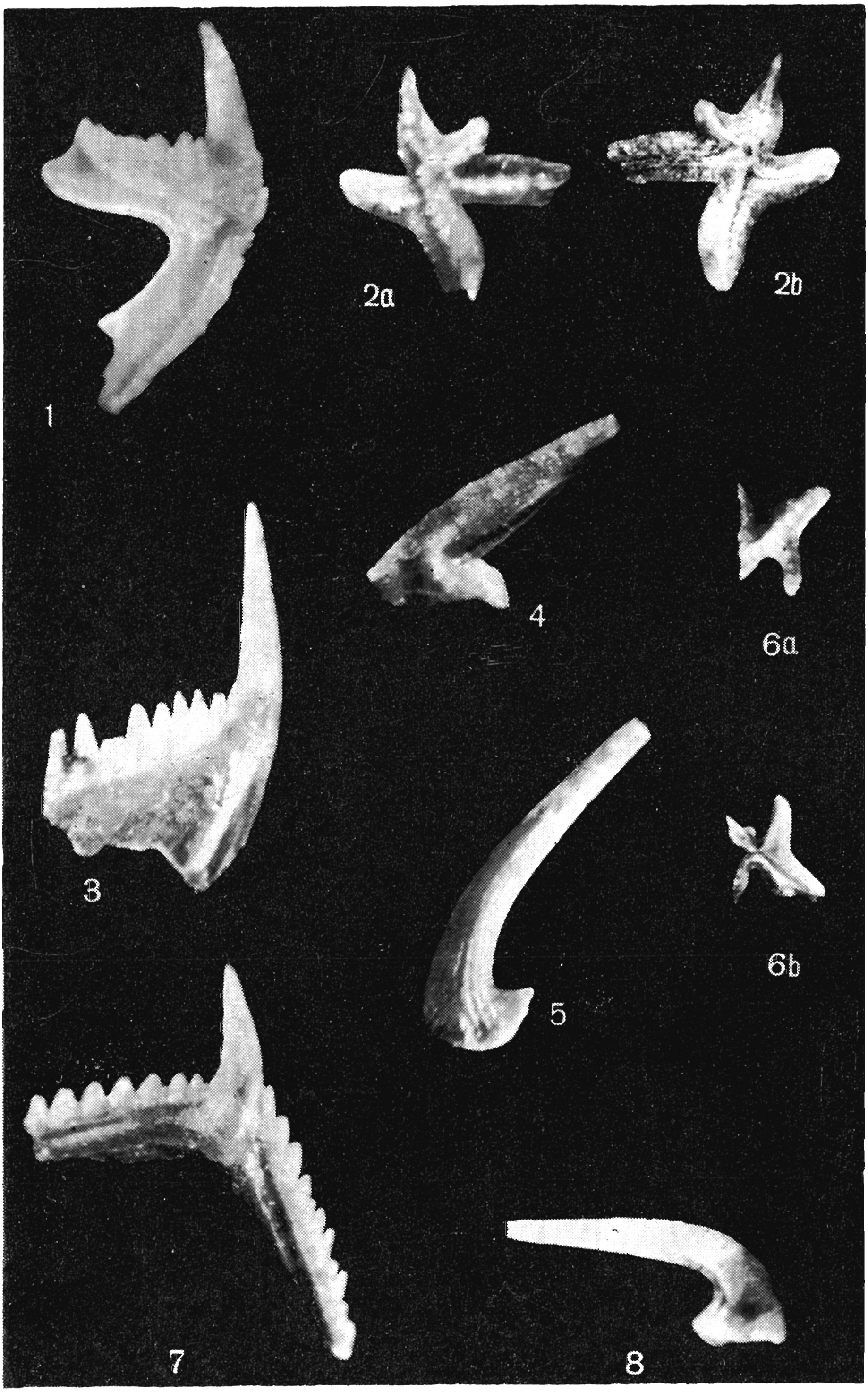
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According to H. Tomczyk, irregularly laminated, clayey or silty-clayey intercalations, with *Clonograptus* sp. and *Loganograptus logani* Hall, occur in the top of the 15 m thick sandstones and glauconitic siltstones. In the present paper these are regarded as an equivalent of the Conotreta czarnockii Subzone. It is overlain by claystones, 25—35 m in thickness, representing the Didymograptus deflexus, D. extensus and D. hirundo zones.

In the Didymograptus deflexus and D. extensus zones, developed as claystones with siltstone, partly sandy intercalations, there is a rich graptolite fauna, i.a. *Isograptus gibberulus* (Nich.), *Tetragraptus tardifurcatus* Elles, *Schizograptus reclinatus* Nich., *Didymograptus extensus* Hall and *D. deflexus* Elles & Wood. The above faunal remains allow the correlation of these zones, as well as the Loganograptus logani Zone distinguished by Tomczyk (*in* Tomczyk & Turnau-Morawska 1964) with the Didymograptus extensus Zone of England (cf. Whittington & Williams 1964, Williams 1969, Skevington 1963).

The uppermost zone of the Arenig is represented by clayey deposits with *Didymograptus hirundo* Salt., *D. nanus* Lapw., *Isograptus gibberulus* (Nich.) and *Phyllograptus typus* Hall. It corresponds to the Didymograptus hirundo Zone (Table 4) of the British profiles.

Llanvirn

This stage has been observed only in the Kielce region (Table 3).

Lower Llanvirn

According to Tomczyk (*in* Tomczyk & Turnau-Morawska 1964), the Lower Llanvirn is represented at Brzeziny by grey-greenish siltstones with claystone interbeddings; its most complete development occurs in borehole Brzeziny *45* where it is based on an abundant graptolite fauna,

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PL. 2

Llanvirnian conodonts from Mt. Skała near Mójcza

1 — *Prioniodus prevariabilis* Fåhraeus; Upper Llanvirn.
2 — *Amorphognathus* sp. *3* Lindström — *a* oral view, *b* aboral view; the same age.
3 — *Gothodus* cf. *costulatus* Lindström; Lower Llanvirn.
4 — *Oistodus brevibasis* Sergeeva; the same age.
5 — *Scandodus rectus* Lindström; Upper Llanvirn.
6 — *Amorphognathus complicata* Rhodes — *a* oral view, *b* aboral view; the same age.
7 — *Prioniodus alatus* Hadding; the same age.
8 — *Acodus viruensis* Fåhraeus; the same age.

All photographs are c. × 70

i.a. *Azygograptus robustus* Elles & Wood, *Didymograptus arctus* Elles & Wood, *D. bifidus* Hall, *D.* cf. *indentus* Hall, *D. nanus* Lapw., *Phyllograptus* cf. *typus* Hall and *Tetragraptus* sp.

Llanvirnian deposits are, moreover, known from the numerous exposures and quarries in the northern slope of the Zgórsko-Posłowice and Dyminy range, on Mt. Bukówka and Mt. Skała near Mójczą. This substage is represented by the Orthambonites calligrammus Subzone which corresponds to the upper part of the Orthambonites pseudomonetus Zone (Tables 2 and 3) distinguished in the Ordovician profiles of the Kielce region. These are quartz sandstones with: *Orthambonites calligrammus* (Dalm.), *Productorthis obtusa* (Pand.), *Lycophoria nucella* (Dalm.), *L. nucella transversa* Bedn., *Progonambonites inflexus* (Pand.) and *Illaenus wahlenbergi* Eichw. (Chart 3; Bednarczyk 1964, 1966c). Their thickness here is on the whole considerable and ranges from 50 to 84 metres.

In borehole Bukówka *IG-1* (Fig. 1, Table 3), the Lower Llanvirn also comprises grey quartz sandstones, about 40 m thick, with a calcareous matrix. They are characterized by the presence of thin dark-grey clay intercalations and of irregular intercalations of grey limestones. The age of this series is based both on *Conotreta* aff. *mica* Gorj., *Myotreta* cf. *crassa* Gorj., *Acantambonia minutissima* Cooper, *Scaphelasma septatum* Cooper, *Philhedra baltica* Koken, *Orthambonites calligrammus* (Dalm.), *Lycophoria nucella* (Dalm.) and on the conodonts *Acodus* sp., *Acontiodus rectus* Lindstr., *Cornuodus erectus* Fähr., *Prioniodus alatus* Hdg. and *Scandodus rectus* Lindstr. (Pl. 1, Fig. 7). East of Kielce the sandstones of the Orthambonites calligrammus Subzone interfinger with the limestones representing the local Illaenus wahlenbergi Subzone or the lower part of the Cornuodus erectus Zone (Tables 2 and 3). This is reliably suggested by exposures in the area of Mójcza and of Niestachów, as well as by boreholes in their vicinity. The Lower Llanvirnian limestones from the neighbourhood of Mójcza have provided a very rich fauna of trilobites and conodonts (Bednarczyk 1966a) containing such species as *Illaenus? polonicus* Gür., *I. wahlenbergi* (Eichw.), *Pterygometopus sclerops* (Dalm.), *Cyrtometopus* cf. *affinis* Ang., *Pseudoptychopyge* sp. *1* and *2* Bedn., *Gothodus* cf. *costulatus* (Pl. 2, Fig. 3), *Oistodus basiovalis* Serg. (Pl. 1, Fig. 2), *O. brevibasis* Serg. (Pl. 2, Fig. 4), *O. forceps* Lindstr. (Pl. 1, Fig. 1), *O. linguatus* Lindstr. (Pl. 1, Fig. 4), *Prioniodus* cf. *elegans* Pander and *Drepanodus planus* Lindstr. (Pl. 1, Fig. 3).

Within the Bardo syncline, tle Lower Llanvirn (the Orthambonites calligrammus Subzone), is developed either as sandstones or quartz siltstones with *Orthambonites calligrammus* (Dalm.), *Productorthis obtusa* (Pand.), *Lycophoria nucella* (Dalm.), *Cybele bellatula* (Dalm.), *Cyrtometopus clavifrons* (Dalm.) and *Illaenus wahlenbergi* (Eichw.) at Koziel, the Maliniak hill near Orłowiny, at Widełki, borehole Ocięsęki *IG-1*, the

Stawy ravine (Bednarczyk 1964, 1966c; Bednarczyk & al. 1966), or, in the dolomite facies in the lower part of the Cornuodus erectus Zone (Table 2) with conodonts *Prioniodus prevariabilis* Fähr. (borehole Zalesie *IG-1*, Zalesie Nowe, Szumsko borehole *IG-2a*; cf. Fig. 1, Table 3). As compared with the Kielce region, the deposits of the Lower Llanvirn within the Bardo syncline are thinner and vary in thickness. In many cases this is, however, due to faulting. The maximum thicknesses are reported from the northern part of the village Koziel (26.6 m), while in the remaining areas the thickness of the Lower Llanvirn ranges from 2 to 8 metres.

In the eastern part of the Kielce region, the Lower Llanvirn is represented by the quartz sandstones of the Orthambonites calligrammus Subzone bearing a typical brachiopod fauna with *Orthambonites calligrammus* (Dalm.), *Lycophoria nucella* (Dalm.) and *Progonambonites inflexus* (Pand.). These sandstones crop out in the Chełm quarry and on Mt. Zamkowa near Międzygórz. They are also known from boreholes in the vicinity of Kleczanów and Lenarczyce near Sandomierz (Fig. 1, Table 3). The thicknesses are small, not exceeding 10 m, whereas at Międzygórz they range between 9 m in the Chełm ravine and 14 m on Mt. Zamkowa.

Upper Llanvirn

To the Upper Llanvirn at Brzeziny belong clayey-sandy siltstones with subordinate claystone interbeddings and with unfossiliferous intercalations of sideritic, locally sideritic-chamositic limestones. These deposits, which are the equivalents of the Didymograptus murchisoni Zone, do not exceed a thickness of 6—8 metres.

In the remaining parts of the Kielce region, the Upper Llanvirn is developed in the carbonate facies.

In the vicinity of Kielce, in profiles on Mt. Skała near Mójcza and in boreholes Bukówka *IG-1* and Mójcza *IG-1*, this substage is represented by the upper part of the Cornuodus erectus Zone (Table 3) consisting of limestones and dolomites with a rich conodont fauna. In addition to species known only from the above mentioned zone, this fauna also contains species occurring in the next zone distinguished in the Ordovician of the Kielce region. Such a conodont assemblage endows the upper part of the Cornuodus erectus Zone with the character of a concurrent-range zone, or mixed-range-zone (Størmer 1966). These species are as follows: *Acodus similaris* Rhodes, *A. viruensis* Fähr. (Pl. 2, Fig. 8), *Acontiodus arcuatus* Lindstr., *A. rectus* Lindstr. (Pl. 3, Fig. 2), *A. robustus* (Hdg) (Pl. 3, Fig. 3), *Ambalodus reclinatus* Fähr. (Pl. 3, Figs 4*a* and 4*b*), *Amorphognathus* sp. *3* Lindstr. (Pl. 2, Figs 2*a*—*b*), *Cornuodus erectus* Fähr. (Pl. 3, Fig. 5), *Drepanodus* cf. *subarcuatus* Furnish, *D. sculponea* Lindstr., *D. suberectus* Furnish, *Falodus simplex* Serg., *Gothodus* sp., *G.* cf. *costulatus* Lindstr., *Oistodus longiramis* Lindstr., *O. robustus* Bergstr., *Paracordy-*

lodus sp., *Prioniodus alatus* (Hdg) (Pl. 2, Fig. 7), *P. navis* Lindstr. (Pl. 3, Fig. 11), *P. prevariabilis* Fähr. (Pl. 2, Fig. 1), *Panderodus panderi* (Stauffer), *Paracordylodus lindstroemi* Bergstr., *Scandodus formosus* Fähr. (Pl. 3, Fig. 1), *S. rectus* Lindstr. (Pl. 2, Fig. 5), *Strachanognathus parva* Rhodes (Pl. 3, Fig. 6), *Tetraprioniodus asymmetricus* Bergstr., *Trichonodella* sp., and *Amorphognathus complicata* Rhodes (Pl. 2, Fig. 6*a*—*b*).

The dolomite facies, known from boreholes Mokradle *IG-1* and Szumsko *IG-2a* and from vicinity of Zalesie Nowe (Table 3), dominates in the Upper Llanvirnian deposits within the Bardo syncline. Deposits of that age from borehole Szumsko *IG-2a* are those most thoroughly investigated. They occur here as greyish dolomites, *c.* 2 m in thickness. The assemblage of the conodont fauna is made up of *Acontiodus rectus* Lindstr., *Drepanodus* cf. *arcuatus* Pand., *D.* cf. *subarcuatus* Furnish, *Oistodus inaequalis* Pand., *Ozarkodina* sp., *Scandodus* cf. *pipa* Lindstr., *Trichonodella* cf. *erecta* (Branson & Mehl) (Pl. 3, Fig. 10) and *Tetraprioniodus* sp.

In the vicinity of Zalesie Nowe (borehole Zalesie *IG-1*, Table 3), pelitic limestones with a chamosite intercalation, and sparry limestones, also belong to the Upper Llanvirn. Hence comes the abundant conodont fauna with *Ambalodus* sp., *Amorphognathus* sp., *Cornuodus erectus* Fähr., *Drepanodus* cf. *arcuatus* Pand., *D. homocurvatus* Lindstr. (Pl. 3, Fig. 9), *D.* sp. *14* Lindstr., *Oistodus* sp., *Ozarkodina* sp., *Paracordylodus lindstroemi* Bergstr. (Pl. 3, Fig. 7), *Prioniodus prevariabilis* Fähr. (Pl. 3, Fig. 8), and the brachiopods *Ephippelasma minutum* Cooper.

In the eastern part of the Kielce region, the Upper Llanvirn occurs in the dolomite facies, too. It has been identified in borehole Kleczanów *IG-1* (Table 3) as greyish dolomites containing a more closely unidentifiable trilobite fauna.

The correlation of the deposits from the Orthambonites calligram-

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PL. 3

Upper Llanvirnian conodonts

1 — *Scandodus formosus* Fähraeus; borehole Bukówka *IG-1* (depth 37.0—38.7 m).
2 — *Acontiodus rectus* Lindström; ibidem.
3 — *Acontiodus robustus* (Hadding); ibidem.
4 — *Ambalodus reclinatus* Fähraeus — *a* oral view, *b* aboral view; ibidem.
5 — *Cornuodus erectus* Fähraeus; ibidem.
6 — *Strachanognathus parva* Rhodes; ibidem.
7 — *Paracordylodus lindstroemi* Bergström; borehole Zalesie *IG-1* (217.6—218.9 m).
8 — *Prioniodus prevariabilis* Fähraeus; ibidem.
9 — *Drepanodus homocurvatus* Lindström; ibidem.
10 — *Trichonodella* cf. *erecta* (Branson & Mehl); borehole Szumsko *IG-2a* (41.5—42.7 m).
11 — *Prioniodus navis* Lindström; Mt. Skała near Mójcza.

All photographs are *c.* × 70

mus Subzone or from other corresponding zones (cf. Table 2) with the contemporaneous deposits in Baltoscandia does not offer particular difficulties. This is so thanks to the nearly identical fauna showing a predominance of Lower Llanvirnian species. In the areas thus correlated (Männil 1966) those to be foremost mentioned are: brachiopods *Orthambonites calligrammus* (Dalm.), *Productorthis obtusa* (Pand.), *P. obtusa parallela* (Pand.), *Iru concava* (Pahl.), *Progonambonites inflexus* (Pand.), *Lycophoria nucella* (Dalm.) and the trilobites *Nileus armadillo* (Dalm.), *Cyrtometopus clavifrons* (Dalm.), *Pterygometopus sclerops* (Dalm.), *Cybele bellatula* (Dalm.) and *Illaenus wahlenbergi* (Eichw.). The above species show a mass occurrence in the Kunda-B_{III} stage in Latvia, Estonia, the Leningrad area and Sweden (cf. Alikhova 1960; Männil 1963, 1966; Jaanusson 1957). The Llanvirnian age of this stage is also confirmed by conodonts (Table 5); *Cornuodus erectus* Fähr. and *Oistodus basiovalis* Serg. are among the index forms there.

It may be noted that, similarly as in the lower part of the Orthambonites pseudomonetus & C. bellatula Zone, representatives of the Bohemian fauna, the genus *Zeliszkella* Delo (cf. Bednarczyk 1966a) excepted, are almost wholly absent from the upper part of that Zone, too (defined as the Orthambonites calligrammus Subzone).

The Upper Llanvirn, developed mostly as carbonate deposits (Table 3), is based exclusively on a conodont fauna (Chart 3). Its composition fits in with that worked out by Fähraeus (1966) for the limestones from Vikarby and Skövde, representing the Upper Llanvirnian deposits at the Gullhögen quarry in southern Sweden. Out of the 18 identified species, 12 occur in the Upper Llanvirn of the above area, while the remaining 6 are Scandinavian species known from various Lower Ordovician members of Baltoscandia (Table 5). Similar faunistic assemblages have been

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PL. 4

Caradocian conodonts

1 — *Keislognathus gracilis* Rhodes — *a* rear view, *b* side view; borehole Zaróbiny *IG-1* (depth 136.2—137.1 m).
2 — *Roundya inclinata* Rhodes; borehole Lenarczyce *IG-1* (48.0—49.1 m).
3 — *Holodontus superbus* Rhodes; borehole Niestachów *IG-1* (46.2 m).
4 — *Ligonodina delicata* (Branson & Mehl); ibidem.
5 — *Scandodus inflexus* Hamar; borehole Zalesie *IG-1* (212.2—213.4 m).
6 — *Ambalodus pulcher* Rhodes; borehole Niestachów *IG-1* (46.2 m).
7 — *Tetraprioniodus delicatus* (Branson & Mehl); ibidem.
8 — *Amorphognathus ordovicica* (Branson & Mehl) — *a* side view, *b* oral view, *c* aboral view; borehole Bukówka *IG-1* (29.8—31.0 m).
9 — *Ambalodus frognoeyensis* Hamar; borehole Niestachów *IG-1* (46.2 m).
10 — *Ambalodus triangularis* Branson & Mehl; borehole Kleczanów *IG-1* (269.2 m).

All photographs are c. × 70

Chart 3

Llanvirnian fauna in the Holy Cross Mts

(based on the data by Samsonowicz 1920; Tomczyk 1962; Tomczyk & Turnau-Morawska 1964; Bednarczyk 1962, 1964, 1966a; completed by the autor)

Fossils \ Localities	Brzeziny	Zalesie	Mt.Telegraf	Mt.Bukówka	Bukówka 1	Mt.Skała	Mójcza 1	Mt.Otrocz	Kozieł	Powalisko	Maliniak	Zalesie 1	Szumsko 2a	Kleczanów 1	Międzygórz	Mt.Zamkowa	Lenarczyce 1
BRACHIOPODA																	
Obolus sp.div.	+					+											+
Lingulella sp.div.	+					+											+
Acantambonia minutissima Cooper					+												
Philhedra baltica Koken					+												
Conotreta aff. mica Gorjansky					+												
Myotreta cf. crassa Gorjansky					+												
Scaphelasma septatum Cooper					+												
Ephippelasma minutum Cooper												+					
Apheoorthina cf. daunus /Walcott/		+	+			+			+		+						
Orthambonites pseudomonetus Bednarczyk		+	+	+		+		+			+				+	+	
Orthambonites semicircularis Pander		+		+		+			+						+		
Orthambonites calligrammus /Dalman/		+		+	+	+		+			+				+	+	
Orthambonites? sp.div.							+							+			
Productorthis obtusa obtusa /Pander/		+									+						
Productorthis obtusa paralella /Pander/		+				+					+						
Iru concava /Pahlen/											+						
Ladogiella? sp.		+									+						
Rauna cf. janischewskyi /Lessnikov/		+				+					+						
Antigonambonites planus planus /Pander/		+		+		+					+				+	+	
Antigonambonites planus anna Öpik				+				+			+				+	+	
Antigonambonites maekulaensis Öpik						+					+						
Progonambonites inflexus /Pander/				+		+					+				+	+	
Clitambonites sp.																	+
Porambonites? sp.						+											
Lycophoria nucella nucella /Dalman/		+	+	+	+	+			+		+				+	+	
Lycophoria nucella elongata Bednarczyk						+		+			+				+	+	
Lycophoria nucella transversa Bednarczyk		+	+	+		+					+						
Lycophoria? sp.							+							+			
Ingria cf. nefedyewi /Eichwald/		+				+					+						
Sowerbyella sp.						+											
BRYOZOA																	
Diplotrypa petropolitana /Pander/		+		+		+					+				+	+	
GASTROPODA																	
Moderospira polonica /Gürich/		+		+		+		+	+	+							
NAUTILOIDEA																	
Endoceras sp.						+											
Orthoceras sp.						+											
TRILOBITA																	
Asaphus sp.	+								+								
Asaphus /Neoasaphus/ cf. nieszkowskii /Schmidt/										+							
Pseudoptychopyge sp.1 Bednarczyk						+				+							
Pseudoptychopyge sp.2 Bednarczyk						+											
Pseudoptychopyge cf. schmidti Balašova										+							
Niobe /Niobella/ aff. innotata /Barrande/										+							
Nileus armadillo /Dalman/						+				+							
Nileus cf. limbatus /Brögger/									+	+							
Bronteopsis? sp.		+															
Illaenus? polonicus Gürich						+											
Illaenus wahlenbergi /Eichwald/		+		+		+			+								
Ampyx sp.									+								
Cyrtometopus cf. affinis Angelin						+											
Cyrtometopus clavifrons /Dalman/									+								
Cybele bellatula /Dalman/		+		+		+			+		+						
Zeliszkella sp.						+											
Pterygometopus sclerops /Dalman/						+											
CYSTOIDEA																	
Echinosphaerites sp.						+											
GRAPTOLITA																	
listed by Tomczyk /1962/	+																
CONODONTA																	
presented in Table 5 of this paper					+	+	+					+	+				+


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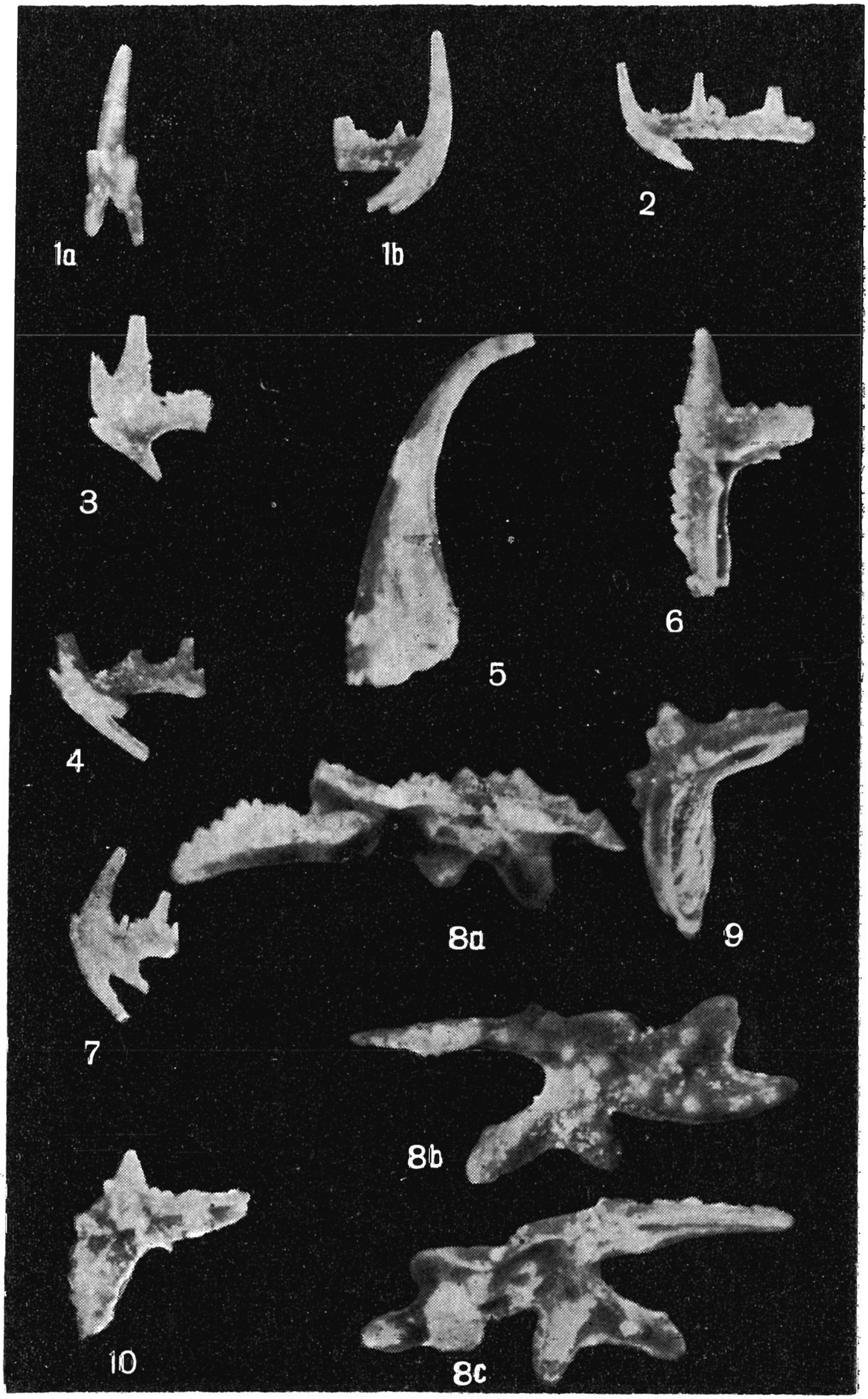
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observed in Upper Llanvirnian limestones reached in boreholes in the eastern part of the Peribaltic syneclise and in the Podlasie depression (Bednarczyk 1966b, 1968a, b).

Llandeilo

In the Llandeilo of the Holy Cross Mts the claystone facies occurs within the Łysogóry region and in the SW part of the Kielce region (Brzeziny and Zbrza, Table 3), while the carbonate facies occupies the remaining part of the Kielce region. In the Łysogóry region the Llandeilo begins with light-grey limestones impregnated by pyrite and intercalated by greyish claystones. At the base there are also clayey-siliceous concretions (borehole Bukowiany *IG-1a,* Table 3) or sideritic organodetrital limestones, here and there containing oolites and sideritic intercalations (borehole Jeleniów *IG-2,* Tomczyk & Turnau-Morawska 1967). Towards the top the calcareous rocks pass into greyish claystones with irregular intercalations of grey limestone (borehole Bukowiany *IG-1a*) containing *Paterula* sp., *Conotreta* aff. *plana* Cooper, *Scaphelasma septatum* Cooper, *Lingulella* sp., *Glyptograptus* cf. *teretiusculus* (His.), *Pseudoclimacograptus scharenbergi* (Lapw.), and *Gymnograptus linnarssoni* (Tullb.). In borehole Jeleniów *IG-2* (Tomczyk & Turnau-Morawska 1967), the presence has also been observed of *Glyptograptus teretiusculus* (His.), *Pseudoclimacograptus* cf. *scharenbergi* (Lapw.), *Dicellograptus* cf. *sextans* Hall, *D. sextans* Hall and *Nemagraptus* sp.

The thickness of the Llandeilo ranges from 4 m in borehole Bukowiany *IG-1a* to c. 8 m in borehole Jeleniów *IG-2.*

Within the Kielce region, the Llandeilo has been observed in the lithologically analogous deposits in the vicinity of Zbrza and Brzeziny.

At Zbrza (borehole Zbrza *IG-1,* Table 3), the Llandeilo comprises dark-grey dolomitic claystones with dolomite concretions, alternating with sideritic, calcareous-dolomitic siltstones with *Climacograptus* sp. The thickness of this series is *c.* 30 metres. In the vicinity of Brzeziny the Llandeilo is developed as greyish-greenish claystones and siltstones, some 15 m thick, with sideritic and dolomitic-calcareous intercalations bearing a graptolite fauna (after Tomczyk & Turnau-Morawska 1964) of *Glyptograptus teretiusculus* (His.), *Nemagraptus* sp., *Pseudoclimacograptus scharenbergi* (Lapw.), *Dicellograptus* sp. and *Dicranograptus* sp.

An analysis of the graptolites from the Holy Cross Llandeilo shows that they contain species known from contemporaneous deposits in boreholes in Western Pomerania or mentioned from the Llandeilo of Scandinavia (Berry 1964) and Estonia (Männil 1966). Besides *Glyptograptus teretiusculus* (His.), which is an index species of that stage, other species have been encountered having a wide geographical distribution and a great vertical range, e.g. *Pseudoclimacograptus scharenbergi* (Lapw.) and

Dicellograptus sextans Hall. Unfortunately, however, neither the brachiopod fauna found in the limestone concretions, e.g. *Conotreta plana* Cooper and *Scaphelasma septatum* Cooper (cf. Chart 4), nor the observed graptolite fauna reasonably suggests a more detailed division of the Holy Cross Llandeilo. The only reliable conclusion is the occurrence here of a member corresponding to the Lower Llandeilo. The presence of this members is confirmed by the species *Gymnograptus linnarssoni* (Tullb.) which is the index species of the Lower Llandeilo in Sweden (Jaanusson 1960b, Hede 1951) and in Estonia (Männil 1966). In view of the above evidence it may be reasonably suggested that the above graptolite fauna permits to correlate the deposits under consideration with the Uhaku stage of Baltoscandia. On the whole, this fits in with the British classification of the Llandeilo (Table 4, Männil 1966).

In the remaining parts of the Kielce region, the Llandeilo is represented by limestones and dolomites. The limestones have been observed in boreholes Bukówka *IG-1* and Mójcza *IG-1*, in outcrops on Mt. Skała near Mójcza, also in borehole Zalesie *IG-1* (Table 3).

The thickness there is rather small, being *c.* 2 m at Bukówka, *c.* 0.6 m at Mójcza and *c.* 1.2 m at Zalesie. The limestones yield abundant conodonts resembling the Caradocian assemblage (Table 5). As compared with the latter, however, it contains more Lower Ordovician species. It

Chart 4

Llandeilian fauna in the Holy Cross Mts

(based on the data by Tomczyk & Turnau-Morawska 1964, 1967; Tomczykowa 1968; completed by the autor)

Fossils \ Localities	Jeleniów 2	Bukowiany 1a	Pobroszyn	Zbrza 1	Brzeziny	Bukówka 1	Mójcza 1	Mt. Skała	Zalesie 1	Szumsko 2a
BRACHIOPODA										
Lingulella sp.		+								
Paterula sp.		+								
Conotreta plana Cooper		+								
Conotreta aff. plana Cooper		+								
Scaphelasma septatum Cooper		+								
TRILOBITA										
Lichas sp.								+		
GRAPTOLITA										
Didymograptus sp.		+								
Nemagraptus sp.		+			+					
Dicellograptus sextans Hall		+								
Dicellograptus sp.					+					
Dicranograptus sp.					+					
Climacograptus sp.				+						
Pseudoclimacograptus scharenbergi /Lapworth/		+	+		+					
Glyptograptus teretiusculus /Hisinger/	+	+			+					
Diplograptus sp.			+							
Gymnograptus linnarssoni /Tullberg/		+								
CONODONTA										
presented in Table 5 of this paper		+				+	+	+	+	+

is represented by: *Acodus mutatus* (Branson & Mehl), *A. similaris* Rhodes, *Acontiodus arcuatus* Lindstr., *A. robustus* (Hdg), *A. rectus* Lindstr., *Armorphognathus* sp. *3* Lindstr., *Amorphognathus variabilis* Serg., *Ambalodus* sp., *Cordylodus* cf. *spinatus* Hdg, *Dichograptus* sp., *Distacodus falcatus* Stauffer, *Drepanodus arcuatus* Pand., *D.* cf. *arcuatus* Pand., *D. homocurvatus* Lindstr., *Haddingodus serrus* (Hdg), *Keislognathus gracilis* Rhodes, *Oistodus excelsus* Stauffer, *O. robustus* Bergstr., *O. venustus* Stauffer, *Panderodus panderi* (Stauffer), *P. similaris* (Rhodes), *Paracordylodus lindstroemi* Bergstr., *Prioniodina* cf. *densa* Lindstr., *Prioniodus alatus* (Hdg), *P. navis* Lindstr., *P. prevariabilis* Fähr., *Scandodus* sp. *2* Lindstr., *Scolopodus cordis* Hamar, *S. tuatus* Hamar, *S. varicostatus* Branson & Mehl, *Strachanognathus parva* Rhodes, *Tetraprioniodus asymmetricus* Bergstr., *T.* cf. *superbus* (Rhodes), *T. superbus* (Rhodes), *T. robustus* Lindstr., *Trichonodella* cf. *tenuis* (Branson & Mehl) and *Trucherognathus bidentatus* Rhodes.

In the dolomite facies, the Llandeilo is known from an exposure at Zalesie Nowe and from borehole Kleczanów *IG-1* (Fig. 1, Table 3).

At Zalesie Nowe this stage is represented by light-yellow platy dolomites, c. 3 m thick, towards the top passing into thin-bedded dolomites, c. 2 m thick. In borehole Kleczanów *IG-1,* the Llandeilo comprises greyish dolomites of undetermined thickness, bearing few conodonts.

In the neritic facies, the Llandeilo has been differentiated on the distribution of conodonts within the particular Ordovician profiles from the Kielce region. It has been observed that, in the biostratigraphic division, the upper part of the Amorphognathus sp. *3* Zone (Table 2) fits in with the Llandeilo. Though the conodont fauna of the Holy Cross Llandeilo is lacking in index species, yet it differs from the conodont fauna of the Llanvirn in the presence of new species not encountered in the older Ordovician, e.g. *Haddingodus serrus* (Hdg), *Keislognathus gracilis* Rhodes, *Strachanognathus parva* Rhodes and *Tetraprioniodus superbus* (Rhodes). These species, occurring side by side with representatives of such Upper Llanvirnian species as *Amorphognathus* sp. *3* Lindstr., *Paracordylodus lindstroemi* Bergstr. and *Prioniodus prevariabilis* Fähr. constitute a characteristic assemblage passing into the Caradoc and differentiated as an equivalent of the Llandeilo. In spite of the presence of Scandinavian fauna, the Llandeilo from the Kielce region differs from that of the Baltoscandian areas in the characters mentioned above.

Caradoc

The Holy Cross Caradoc is a stage present in nearly all the investigated profiles. It is represented by two facial types characteristic of the Kielce and the Łysogóry regions: the claystone graptolite-bearing facies and the carbonate facies with a predominant conodont fauna.

In the Łysogóry region, the Caradoc is subdivided into three graptolite zones: Nemagraptus gracilis, Diplograptus multidens and Dicranograptus clingani & Climacograptus styloideus. No such classification of the Caradoc is possible in the Kielce region because of the lack there of graptolites. Although the conodont assemblage contains species providing reliable evidence for the determination of this stage, yet it has not yielded forms permitting a more detailed stratigraphic classification. On the northern side of the Łysogóry Range, the Caradocian claystone facies has been observed in boreholes Kajetanów *IG-1,* Brzezinki *IG-1,* Wilków *IG-1,* Bukowiany *IG-1a,* Jeleniów *IG-1* and *2* (Table 3, Deczkowski 1964, Tomczyk & Turnau-Morawska 1967, Deczkowski & Tomczyk 1969a). It occurs in the same facies in the SW part of the Kielce region, in the vicinity of Brzeziny and Zbrza (Fig. 1, Table 3; Deczkowski 1964, Deczkowski & Tomczyk 1969b, Tomczyk & Turnau-Morawska 1964).

Throughout the remaining part of the Holy Cross area the claystone facies is subordinate in relation to the carbonate facies.

The most complete development of the Caradoc has been observed in the vicinity of Wilków (Borehole Wilków *IG-1*) and of Jeleniów (borehole Jeleniów *IG-2*). In borehole Wilków *IG-1,* the lowermost Caradoc (the Nemagraptus gracilis Zone) is represented by *c.* 40 m of dark-grey claystones, strongly slated and compressed. Towards the top they pass into similar claystones containing clayey-siliceous concretions. The fauna here is rare and consists of *Paterula bohemica* Barr., *P.* cf. *portlocki* (Gein.), *Sericoidea restricta* (Hdg), *Climacograptus* sp. and *Amplexograptus perexcavatus* (Lapw.). This zone is analogously developed in borehole Jeleniów *IG-2,* differing only in the presence of thin lenses of clayey limestones. The thickness of the zone here is, however, five times smaller, being *c.* 8 metres. The fauna contains an abundance of graptolites. According to Tomczyk (in Tomczyk & Turnau-Morawska 1967) they belong to the species *Nemagraptus gracilis* Hall, *Pseudoclimacograptus scharenbergi* (Lapw.), *Glyptograptus* sp., *Dicranograptus* sp. and *Diplograptus* sp.

In the profile of borehole Bukowiany *IG-1a,* the thickness of the Nemagraptus gracilis Zone does not exceed 8 metres. It is made up of grey claystones with limestone intercalations and lenses. Towards the top they pass into grey dolomitic limestones intercalated by dark-grey claystones with clayey-siliceous concretions. The claystones bear a meagre fauna of *Glyptograptus* sp., *Pseudoclimacograptus scharenbergi* (Lapw.) and *Cyclopyge* cf. *rediviva* Barr. The following conodonts are frequent in the limestones: *Acodus* cf. *similaris* Rhodes, *Acontiodus robustus* (Hdg), *A. cooperi* Sweet & Bergstr., *Drepanodus homocurvatus* Lindstr., *Haddingodus serrus* (Hdg), *Oistodus robustus* Bergstr., *O. venustus* Stauffer, *Paracordylodus lindstroemi* Bergstr., *Prioniodus alatus* Hdg and *Scolopodus varicostatus* Branson & Mehl.

The Diplograptus multidens Zone has been found in three borehole on the northern side of the Łysogóry Range. It is most completely represented in borehole Wilków *IG-1* by dark-grey dolomitic claystones, c. 25 m thick, with an abundant brachiopod fauna: *Paterula* cf. *bohemica* Barr., *P.* cf. *portlocki* (Gein.), *Obolus?* cf. *ornatus* Hdg, *Lingulella dicellograptorum* (Hdg), *L.* cf. *fostermontensis* (Butts), *Hisingerella nitens* (His.) and *Chonetoidea* sp. The graptolites there are sporadical and have been referred to *Orthograptus* cf. *notabilis* (Hdg) and *Glyptograptus* sp. H. Tomczyk (*in* Deczkowski & Tomczyk 1969b) report from there *i.a.* also: *Diplograptus* cf. *multidens* Elles & Wood and *Orthograptus truncatus pauperatus* Elles & Wood. The fragmentary remains of *Camarocystites* sp. have also been yielded by the above deposits.

The natural boundary of the Nemagraptus gracilis and Diplograptus multidens zones in borehole Wilków *IG-1* is indicated by a 20 cm thick layer of grey-greenish bentonitic claystone. The same role is played by a bentonite layer in the Bukowiany *IG-1a* borehole (Table 3). The Diplograptus multidens Zone here is *c.* 40 cm thick. It consists of calcareous claystones with limestone intercalations and lenses. A rich fauna has been observed: *Paterula bohemica* Barr., *Lingulella* cf. *fostermontensis* (Butts), *Onniella bancrofti* Lindstr., *Modiolopsis? plana* Hdg, *Cyclopyge rediviva* Barr., *Pseudoclimacograptus scharenbergi* (Lapw.), *Glyptograptus* sp. and *Orthograptus* sp.

In borehole Jeleniów *IG-2,* the zone under consideration is represented by dark-grey calcareous claystones with thin intercalations of limestones and thin bentonite interbeddings in the upper part. According to Tomczyk (*in* Tomczyk & Turnau-Morawska 1967) the graptolite fauna belongs to the species: *Diplograptus multidens* Elles & Wood, *Climacograptus brevis* Elles & Wood, *Pseudoclimacograptus scharenbergi* (Lapw.) and *Amplexograptus* sp. The brachiopod *Paterula* cf. *bohemica* Barr. has also been cited. The upper part of the above zone has also been identified in borehole Brzezinki *IG-1* (Table 3).

The Dicranograptus clingani & Climacograptus styloideus Zone has been identified in practically all of the boreholes on the northern slope of the Łysogóry Range. It is made up of a monotonous series of dark-grey calcareous claystones with concentrations and impregnations of pyrite, also with clayey-siliceous concretions. Bentonite intercalations occur in the lower part of the above zone in borehole Jeleniów *IG-1* and *IG-2*. The maximum thickness of this zone has been observed in borehole Jeleniów *IG-2* where it is *c.* 60 m (Tomczyk & Turnau-Morawska 1967). A none too numerous graptolite fauna consists there of: *Pleurograptus* sp., *Climacograptus* cf. *styloideus* Lapw., *Dicranograptus* sp. *Dicellograptus* cf. *pumilus* Lapw., *D.* cf. *caduceus* Lapw., *Climacograptus minimus* Carr., *C. tubuliferus* Lapw., *Orthograptus* cf. *calcaratus* Lapw., *O. truncatus* Lapw.

and *Leptograptus* sp. A sporadical occurrence is also noted of the brachiopods *Paterula* sp. and *Lingulella* sp.

The above zone is fairly thick in borehole Jeleniów *IG-1,* too, where it is represented by claystones of a thickness of 60 metres.

In borehole Kajetanów *IG-1* (Tomczykowa 1968) there are claystones, *c.* 50 m thick, with *Climacograptus* cf. *minimus* Carr., *C. tubuliferus* Lapw., *Orthograptus* cf. *truncatus* Lapw. and *O. calcaratus* Lapw. Claystones in borehole Wiśniówka *IG-1* (Tomczykowa 1968), bearing a fauna almost identical as that just mentioned (with the addition of *Climacograptus scalaris miserabilis* Elles & Wood), are rather thick, too, while their equivalents in borehole Brzezinki *IG-1* are considerably less thick, hardly reaching 20 metres. Faulting, responsible for a decrease in the thickness, should here be taken into account.

In borehole Wilków *IG-1,* the thickness of the Dicranograptus clingani & Climacograptus styloideus Zone is *c.* 30 m made up of greyish strongly calcareous claystones with a rare and poorly preserved fauna of: *Climacograptus?* sp., *Lingulella fostermontensis* (Butts) and *Bilobia?* sp. The forms reported from here by Tomczykowa (1968) are *Tretaspis* sp. and *Diplograptus* sp., that mentioned by Tomczyk (*in* Deczkowski & Tomczyk 1969a) is *Tretaspis* cf. *seticornis* (His.).

In the SW part of the Kielce region, in the vicinity of Brzeziny and Zbrza, the Caradoc is developed in the clay facies, too (Table 3). It differs from the Caradoc of the Łysogóry region in the presence of numerous dolomite and siltstone intercalations, and in a lighter colouring of the deposits.

In the Zbrza area, the Nemagraptus gracilis Zone has been found in test pits and in borehole Zbrza *IG-1* (Table 3). It consists there of dark--grey claystones, here and there irregularly intercalated by dolomites. The graptolite fauna is rather poor and belongs to the species *Amplexograptus perexcavatus* Lapw. and *Glyptograptus euglyphus* (Lapw.). The zone is *c.* 13 m thick.

The Diplograptus multidens Zone has hitherto been reported only from test-pits (Tomczyk 1957). In borehole Zbrza *IG-1* it is represented by 17 m of greyish claystones, and dolomitic sandstones with a dolomite intercalation occurring in the upper part of the zone. The fauna is scarce and consists of *Paterula bohemica* Barr., *Lingulella* sp., *Ambalodus frognoeyensis* Hamar and *Ozarkodina* sp. The equivalents of this zone in borehole Zbrza *IG-2* are hardly one half of its thickness (8 m) in borehole Zbrza *IG-1*. In borehole Zbrza *IG-3* the grey or light-grey claystones may belong to the Diplograptus multidens Zone. They are intercalated by grey marly limestones with a bentonite streak in the top (Table 3) underlying the *Climacograptus styloideus* Lapw. series. The fauna here is made up of *Craniops?* sp., *Paterula bohemica* Barr., *Climacograptus* *minimus* (Carr.), *Pseudoclimacograptus scharenbergi* (Lapw.). The thickness is 11 metres.

The Dicranograptus clingani & Climacograptus styloideus Zone has been observed only in boreholes Zbrza *IG-1* and *IG-3*. In the borehole Zbrza *IG-1* it consists of greyish claystones intercalated by light-grey dolomites, passing, as above, into dolomites intercalated by greyish claystones with *Climacograptus bicornis* (Carr.). The thickness here is *c.* 3 metres. In borehole Zbrza *IG-3*, the thickness of the zone is *c.* 5 metres. It is made up of dark-grey shales or clays with intercalations of grey clay at the top. The fauna is abundant and represented by: *Paterula bohemica* Barr., *P.* cf. *perfecta* Cooper, *Onniella bancrofti* Lindstr., *Cyclopyge rediviva* (Barr.), *Pharostoma pulchrum pulchrum* (Barr.), *Raphiophorus setirostris* Ang., *Climacograptus bicornis* (Hall), *C. styloideus* Lapw., *Amplexograptus* sp. and *Diplograptus* sp.

In the vicinity of Brzeziny (Fig. 1) the Caradoc has been identified by Tomczyk in numerous boreholes (Tomczyk & Turnau-Morawska 1964); it consists of claystones up to 100—120 m thick.

The Nemagraptus gracilis Zone is 10 m thick. In association with the nominal species there occur: *Dicranograptus* sp., *Dicellograptus sextans* Hall, *Pseudoclimacograptus scharenbergi* (Lapw.), *Glyptograptus* sp., and the brachiopod *Paterula* sp.

In the area here considered the Diplograptus multidens Zone is characterized by rather great thicknesses. It is developed as greyish calcareous-dolomitic claystones bearing: *Dicranograptus* sp., *Dicellograptus* sp., *Climacograptus* sp., *Orthograptus* sp., *Diplograptus multidens* Elles & Wood and *Amplexograptus* sp.

The Dicranograptus clingani & Climacograptus styloideus Zone, likewise some tens of metres in thickness, in its upper part contains a graptolite assemblage. According to Tomczyk (*in* Tomczyk & Turnau-Morawska 1964) these graptolites possibly suggest the close correlation of this zone with its age-equivalent in the northern part of the Łysogóry region. It is indicated by the species: *Dicranograptus clingani* Carr., *Climacograptus minimus* (Carr.), *C.* cf. *bicornis* (Hall), *Orthograptus calcaratus* Lapw. and *O. truncatus* Lapw. Lithologically, in the Brzeziny region the zone is developed as claystones and calcareous dark-grey shales, partly also as dolomites.

In the remaining area of the Kielce region, the Caradoc is represented mainly by carbonate rocks belonging to the Amorphognathus ordovicica Zone (Tables 2 and 3).

In the areas of Bukówka, Mójcza and Niestachów (Fig. 1, Table 3) the carbonate facies of the Caradoc has been observed mostly in boreholes Bukówka *IG-1*, Mójcza *IG-1* and Niestachów *IG-1a*. This stage is represented by sparry light-grey limestones, here and there (borehole Niestachów *IG-1a*) containing dolomites in the top, also intercalations of grey clay and streaks of oolites. The Caradocian assemblages of conodonts hardly differ one from the other, not only in the three above boreholes, but elsewhere, too. Hence, the conodonts listed below may be regarded as the index forms for the whole Caradocian stage in the Kielce region (cf. Table 5): *Acodus similaris* Rhodes, *A. mutatus* (Branson & Mehl), *Acontiodus rectus* Lindstr., *A. robustus* (Hdg), *Ambalodus elegans* Rhodes, *A. frognoeyensis* Hamar (Pl. 4, Fig. 9), *A. pulcher* Rhodes (Pl. 4, Fig. 6), *A. triangularis* Branson & Mehl (Pl. 4, Fig. 10), *Amorphognathus ordovicica* Branson & Mehl (Pl. 4, Fig. 8a, b, c). *Dichognathus typica* Branson & Mehl, *Drepanodus arcuatus* Pand., *D. homocurvatus* Lindstr., *Haddingodus serrus* (Hdg), *Holodontus superbus* Rhodes (Pl. 4, Fig. 3), *Keislognathus gracilis* Rhodes (Pl. 4, Fig. 1*a*, *b*), *Ligonodina delicata* (Branson & Mehl) (Pl. 4, Fig. 4), *Oistodus excelsus* Stauffer, *O. robustus* Bergstr., *Ozarkodina* cf. *tenuis* Branson & Mehl, *O. polita* (Hinde), *O. robusta* (Stauffer), *Panderodus compressus* (Branson & Mehl), *P. gracilis* (Pand.) *P. nakholmensis* Hamar, *P. panderi* (Stauffer), *P. unicostatus* (Branson & Mehl), *Paracordylodus lindstroemi* Bergstr., *Prioniodus alatus* Hdg, *Rhipidognathus* cf. *discreta* (Branson & Mehl), *Scandodus inflexus* Hamar (Pl. 4, Fig. 5), *S. osloensis* Hamar, *Scandodus* sp. *2* Lindstr., *Scolopodus cordis* Hamar, *Strachanognathus parva* Rhodes, *Tetraprioniodus delicatus* (Branson & Mehl) (Pl. 4, Fig. 7), *T. superbus* Rhodes, *T.* cf. *superbus* Rhodes, *Trichonodella* aff. *erecta* (Branson & Mehl).

Within the Bardo syncline, the Caradoc has been identified in boreholes Zarobiny *IG-1*, Widełki *IG-1*, Mokradle *IG-1*, Zalesie *IG-1*, Kędziorka *IG-1* and borehole Szumsko *IG-2a* (Fig. 1, Table 3).

In borehole Zarobiny *IG-1* the Caradoc is represented by greyish dolomitic limestones, 6 m thick, intercalated by greyish clay, here and there, towards the top, by oolites. In the middle part of the Zarobiny Caradoc, the limestones are interbedded by greyish calcareous sandstones, *c.* 0.5 m in thickness. Disturbed sedimentation is indicated both by the above sandy interbedding, traces of erosion and a zone of conglomeratic limestones. Throughout the Caradocian profile in this borehole there occurs a conodont assemblage very much the same as that reported from the Caradoc of the Kielce region. The following species have been identified in addition to those already mentioned: *Acodus inornatus* Ethington, *Drepanodus subarcuatus* Furnish, *Panderodus gracilis* (Branson & Mehl) and *Plectodina?* sp.

The presence of the Caradoc in borehole Widełki *IG-1* is reliably indicated by sparry limestones with conodont species known from Zarobiny.

In borehole Mokradle *IG-1* (Table 3), the Caradoc is represented by dolomites with *Paterula* cf. *portlocki* (Gein.) and ostracods. Owing to faulting it is hardly possible to determine the thickness of these dolomites.

Caradocian deposits in the dolomitic facies are also known from Zalesie Nowe (Czarnocki 1928a, b). The dolomites here probably represent the lower part of this stage. Its upper members consist of thin-bedded dolomitic marls passing into light- or dark-green shales containing *Orbiculoidea* sp., *Paterula bohemica* Barr., *P.* cf. *portlocki* (Gein.), *Lingulella* sp., *Hisingerella nitens* (His.) and *Pseudoclimacograptus* cf. *scharenbergi* (Lapw.). The clayey-marly series is 3.2 m thick. The thickness of the Caradocian dolomites occurring at the base cannot be definitely determined, because their assignment to the Caradoc is arbitrary owing to the absence of fauna.

In borehole Zalesie *IG-1* (Fig. 1, Table 3), the Caradocian deposits differ slightly. They are developed as dark-grey limestones with streaks of claystones being separated from the over-lying sparry limestones by 5 m of claystones. The thickness of the limestone series is c. 10 metres. Besides the conodont species reported from other boreholes, the following have also been found: *Oneotodus* aff. *galatini* Hamar, *Oulodus oregonia* (Branson & Mehl) and *Panderodus panderi* (Stauffer).

The Caradoc developed as starry or oolitic limestones, has also been observed in borehole Kędziorka *IG-1* (Table 3) near Zbilutka in the eastern part of the Bardo syncline. *Plectodina dilata* Stauffer and the brachiopods *Conodiscus?* sp. and *Schizotreta* cf. *corrugata* Cooper have been identified here in addition to the conodont forms typical of this stage.

In borehole Szumsko *IG-2a* (Fig. 1, Table 3), near the southern limb of the Bardo syncline, the Caradocian deposits resemble those from Zalesie Nowe (Table 3). They begin with light-grey dolomites, upwards passing into claystones and silty claystones interbedded by dolomites. The rather meagre fauna contains *Paterula* cf. *bohemica* Barr., *Scaphelasma septatum* Cooper as well as a conodont assemblage known from the vicinity of Kielce. Other forms are: *Cordylodus* cf. *spinatus* (Hdg), *Histiodella* cf. *sinuosa* Graves & Ellison, *Panderodus* cf. *compressus* (Branson & Mehl) and *Scolopodus varicostatus* Sweet & Bergstr. The thickness of the Caradocian profile in the above borehole is c. 4.5 metres.

In the eastern part of the Kielce region, Caradocian deposits have been identified in boreholes Kleczanów *IG-1* and Lenarczyce *IG-1* (Fig. 1, Table 3).

In borehole Kleczanów *IG-1,* this stage is represented by sparry dolomites with manganese oolites at the bottom. The fairly abundant conodont fauna contains *Acodus* sp., *Ambalodus triangularis* Branson & Mehl (Pl. 4, Fig. 10), *Amorphognathus?* sp., *Drepanodus* cf. *altipes* Hennings. and *Ozarkodina polita* (Hinde). The dolomites are c. 0.5 m thick.

In borehole Lenarczyce *IG-1* (Fig. 1) the Caradoc comprises dolomites with scattered glauconite, containing: *Eurytreta?* sp. and *Ambalodus* cf. *frognoeyensis* Hamar, *Drepanodus altipes* Hennings., *Keislogna-*

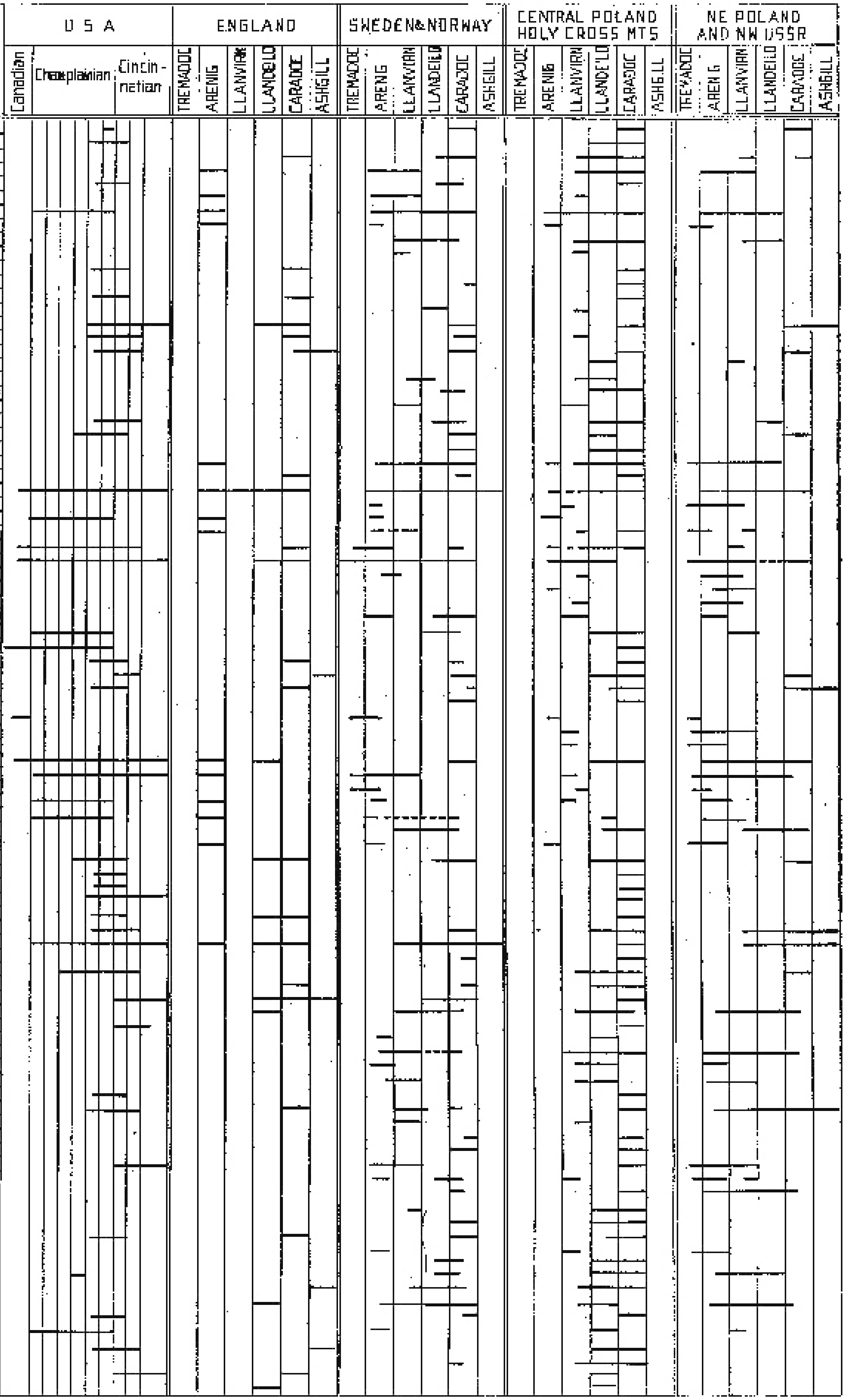
thus gracilis Rhodes, *Prioniodus alatus* Hadding, *Roundya inclinata* (Rhodes) (Pl. 4, Fig. 2), *Scandodus inflexus* Hamar, *Strachanognathus parva* Rhodes. The thickness of the dolomites is c. 4 metres.

The correlation given below is based on an analysis of the collected fauna (Chart 5). Beginning with the graptolite facies of the Caradoc, it is clearly seen that the graptolite assemblage of the Nemagraptus gracilis Zone containing — besides its nominal species — also representatives of *Amplexograptus perexcavatus* (Lapw.), *Dicellograptus sextans* Hall, *Glyptograptus euglyphus* (Lapw.) and *Pseudoclimacograptus scharenbergi* (Lapw.), permits a conclusive correlation with the Nemagraptus gracilis Zone of England (cf. Elles & Wood 1904, 1906; Costonian, Whittington & Williams 1964). Moreover, it reliably indicates the direction of faunal migration and the connections with the Caradocian sea then covering Northern Europe. The graptolites, brachiopods, trilobites and conodonts, encountered in the Caradoc of Bohemia and Scandinavia (Hadding 1913, Jaanusson 1960b, Hávliček & Vaněk 1966), reasonably suggest faunal migration between these two areas. Their influence was, however, much weaker than that exercised by the British fauna. At the beginning of the Caradoc, a direct route was established with the Bohemian sea. This is reasonably suggested by the presence in the Nemagraptus gracilis Zone of such species as *Cyclopyge* cf. *rediviva* Barr. and *Paterula bohemica* Barr. These species are known from the Caradoc of Bohemia; that mentioned first occurs in deposits corresponding to the Climacograptus peltifer Zone (the so called Lodenice Subzone of Havliček & Vaněk, 1966).

Another zone distinguished in the claystone facies of the Holy Cross Caradoc, namely the Diplograptus multidens Zone, corresponds to the same zone of Baltoscandia (Table 4, Männil 1966). The graptolite assemblage in the above zone comprises species common in the Caradoc of Scotland and Wales. The species *Climacograptus minimus* (Carr.) and *C. brevis* Elles & Wood, occurring together with the nominal species, have been found in the Dicranograptus shales of Scotland and Wales (Elles & Wood 1906). The two other species, *Orthograptus notabilis* (Hdg) and *Pseudoclimacograptus scharenbergi* (Lapw.), are present in older members, too: the former in the Nemagraptus gracilis Zone of Scania (Hadding 1913), the latter not higher up than in the Climacograptus wilsoni Zone of Scotland and Wales, but also in the Llandeilo and Caradoc of Sweden and Bohemia (Elles & Wood 1906, Berry 1964, Havliček & Vaněk 1966). The predominance of the British graptolite species is thus clearly seen, while brachiopod species suggest stronger connections with Scandinavia. Such species as *Paterula bohemica* Barr., *P.* cf. *portlocki* (Gein.), *Hisingerella nitens* (His.), *Obolus? ornatus* Hdg, *Lingulella dicellograptorum* Hdg and *Onniella bancorfti* Lindstr. are found throughout the Caradocian faunal assemblages of Sweden (Hadding 1913, Henningsmoen 1948, Lindström 1953, Männil 1966). It is interesting that in Swe-

Stratigraphic range and geographic distribution of the conodonts recognized in the Holy Cross Ordovician

	SPECIES	
1	Acodus inornatus Ethington	
2	A. mutatus (Branson & Mehl)	
3	A. similaris Rhodes	
4	Acontiodus arcuatus Lindström	
5	A. cooperi Sweet & Bergström	
6	A. reclinatus Lindström	
7	A. rectus Lindström	
8	A. rectus sulcatus Lindström	
9	A. robustus (Hadding)	
10	Acodus viruensis Fåhraeus	
11	Ambalodus elegans Rhodes	
12	A. frognoeyensis Hamar	
13	A. pulcher Rhodes	
14	A. rectiratus Fåhraeus	
15	A. triangularis Branson & Mehl	
16	Amorphognathus complicata Rhodes	
17	A. ordovicica (Branson & Mehl)	
18	A. variabilis Sergeeva	
19	A. sp. 3 Lindström 1960	
20	Cordylodus cf. spinatus Hadding	*
21	Cornuodus erectus Fåhraeus	
22	Dichognathus typica Branson & Mehl	
23	Distacodus falcatus Stauffer	
24	D. stpgoeyensis Hamar	
25	Drepanodus arcuatus Pander	
26	D. altipes Henningsmoen	
27	D. homocurvatus Lindström	
28	D. planus Lindström	
29	D. proteus Lindström	
30	D. sculponea Lindström	
31	D. suberectus Furnish	
32	D. suberectus (Branson & Mehl)	
33	D. sp. 14 Lindström 1960	
34	Falodus cf. parvidentatus Sergeeva	*
35	F. simplex Sergeeva	
36	Gothodus cf. costulatus Lindström	*
37	Haddingodus serrus (Hadding)	
38	Histiodella cf. sinuosa (Graves & Ellison)	*
39	Holodontus superbus Rhodes	
40	Keislognathus gracilis Rhodes	
41	Ligonodina delicata (Branson & Mehl)	
42	Oneotodus aff. gallatini Hamar	
43	O. variabilis Lindström	
44	Oistodus basiovalis Sergeeva	
45	O. brevibasis Sergeeva	
46	O. excelsus Stauffer	
47	O. forceps Lindström	
48	O. inaequalis Pander	
49	O. linguatus Lindström	
50	O. longiramis Lindström	
51	O. robustus Bergström	
52	O. cf. triangularis Lindström	*
53	O. venustus Stauffer	
54	Oulodus oregonia Branson & Mehl	
55	Ozarkodina pollita (Hinde)	
56	O. robusta (Stauffer)	
57	O. tenuis Branson & Mehl	
58	Panderodus compressus (Branson & Mehl)	
59	P. gracilis (Branson & Mehl)	
60	P. rhabdodognosa Hamar	
61	P. panderi (Stauffer)	
62	P. similaris (Rhodes)	
63	P. unicostatus (Branson & Mehl)	
64	Paracordylodus lindstroemi Bergström	
65	Plectodina dilata Stauffer	
66	Prioniodina cf. densa Lindström	*
67	Prioniodus alatus Hadding	
68	P. navis Lindström	
69	P. prevariabilis Fåhraeus	
70	Rhipidognathus discreta Bergström & Sweet	
71	Roundya inclinata Rhodes	
72	Scandodus formosus Fåhraeus	
73	S. inflexus Hamar	
74	S. osloensis Hamar	
75	S. pipa Lindström	
76	S. rectus Lindström	
77	S. sp. 1 Lindström 1960	
78	S. sp. 2 Lindström 1960	
79	Scolopodus cornis Hamar	
80	S. insculptus Branson & Mehl	
81	S. rex Lindström	
82	S. tuatus Hamar	
83	S. varicostatus Branson & Mehl	
84	Strachanognathus parva Rhodes	
85	Tetraprioniodus asymmetricus Bergström	
86	T. delicatus (Branson & Mehl)	
87	T. robustus Lindström	
88	T. superbus (Rhodes)	
89	Trichonodella exacta (Branson & Mehl)	
90	T. cf. tenue (Branson & Mehl)	*
91	Trucherognathus bidentatus Rhodes	



Asterisked are the species determined for the Holy Cross Mts as conformis

Chart 5

Caradocian fauna in the Holy Cross Mts

(based on the data by Tomczyk 1957, 1962; Tomczyk & Turnau-Morawska 1964, 1967; Tomczykowa 1968; Deczkowski & Tomczyk 1969a, b; completed by the author)

Fossils \ Localities	Kajetanów 1	Wiśniówka 1	Brzezinki 1	Brzezinki	Wilków 1	Jeleniów	Jeleniów 2	Bukowiany 1a	Pobroszyn	Wólka	Zbrza 1	Zbrza 2	Zbrza 3	Zbrza	Brzeziny	Bukówka 1	Mójcza 1	Niestachów 1	Zarobiny 1	Widełki 1	Zalesie 1	Zalesie Nowe	Kędziorka 1	Szumsko 2a	Kleczanów 1	Lenarczyce 1
BRACHIOPODA																										
Obolus? ornatus Hadding					+																					
Lingulella dicellograptorum /Hadding/					+																	+				
Lingulella fostermontensis /Butts/					+			+																		
Lingulella sp.div.							+	+			+	+										+				
Paterula bohemica Barrande					+		+	+			+	+	+									+		+		
Paterula cf. perfecta Cooper													+													
Paterula cf. portlocki /Geinitz/					+			+														+				
Paterula sp.div.			+		+		+	+				+	+		+											
Craniops? sp.													+													
Conodiscus? sp.																							+			
Eurytreta? sp.																										+
Hisingerella nitens /Hisinger/					+																	+				
Scaphelasma septatum Cooper																								+		
Schizotreta cf. corrugata Cooper																							+			
Schizotreta? sp.								+																		
Orbiculoidea sp.																						+				
Onniella bancrofti Lindström								+					c													
Bilobia? sp.					+																					
Chonetoidea sp.					+																					
LAMELLIBRANCHIATA																										
Modiolopsis? plana Hadding								+																		
TRILOBITA																										
Cyclopyge rediviva /Barrande/								+					+													
Tretaspis? sp.					+								+													
Raphiophorus setirostris Angelin													+													
Pharostoma pulchrum pulchrum /Barrande/													+													
GRAPTOLITA																										
Leptograptus sp.						+	+																			
Nemagraptus gracilis Hall							+	+																		
Nemagraptus sp.							+																			
Pleurograptus sp.div.		+					+																			
Dicellograptus cf. caduceus Lapworth						+	+																			
Dicellograptus cf. forchammeri Geinitz						+																				
Dicellograptus cf. pumilus Lapworth						+	+	+		+																
Dicellograptus cf. sextans Hall								+							+											
Dicellograptus sp.div.			+							+				+	+											
Dicranograptus clingani Carruthers						+								+	+											
Dicranograptus cf. ramosus Hall						+																				
Dicranograptus sp.div.							+							+	+											
Climacograptus bicornis /Carruthers/					+	c					+		+		c											
Climacograptus brevis Elles & Wood							+																			
Climacograptus cf. caduceus Lapworth						+																				
Climacograptus minimus Carruthers	c	c	+		+		+			+				+	+											
Climacograptus scalaris miserabilis Elles & Wood		+								c																
Climacograptus styloideus Lapworth		c	+			+	c			+			+													
Climacograptus tubuliferus Lapworth	+					c	+																			
Climacograptus sp.div.	+	+	+	+	+			+				+	+	+	+							+				
Pseudoclimacograptus scharenbergi /Lapworth/							+	+					+		+							+				
Orthograptus calcaratus Lapworth	+			+	+		c								+											
Orthograptus cf. notabilis /Hadding/					+																					
Orthograptus truncatus truncatus Lapworth	c	c		c		+	+			+					+											
Orthograptus truncatus intermedius Elles & Wood														+												
Orthograptus truncatus pauperatus Elles & Wood					+																					
Orthograptus sp.div.	+	+		+	+			+	+					+												
Glyptograptus euglyphus /Lapworth/											+															
Glyptograptus sp.div.					+		+	+					+	+	+											
Diplograptus multidens multidens Elles & Wood					c	+	+		c					+	+											
Diplograptus multidens compactus Elles & Wood						+	c							+												
Diplograptus sp.div.			+		+			+		+			+													
Amplexograptus perexcavatus /Lapworth/					+						+			+												
Amplexograptus sp.div.							+						+		+											
Neurograptus fibratus cf. margaritatus Lapworth							+																			
Lasiograptus cf. harknessi /Nicholson/							+																			
CONODONTA																										
presented in Table 5 of this paper								+			+					+	+	+	+	+	+	+	+	+	+	

c = cf.

den the species *Hisingerella nitens* (His.) occurs in the Black Tretaspis Shales, an equivalent of the Pleurograptus linearis Zone of the uppermost Caradoc. In the Peribaltic area, *Hisingerella nitens* (His.) is known throughout the Caradoc (Bednarczyk 1968b).

Besides connections with the seas of Great Britain and Scandinavia it will be interesting to note similar connections with the Caradocian sea of Bohemia. This is reliably indicated by the presence of *Cyclopyge rediviva* Barr. which occurs in the Lodenice Substage (formation of Zahořany and Bohdalec, Havliček & Vaněk 1966) corresponding to the British Climacograptus wilsoni Zone (Williams 1969).

As already has been mentioned, the Dicranograptus clingani & Climacograptus styloideus Zone of the Holy Cross Mts corresponds to the British Dicranograptus clingani and Pleurograptus linearis zones (Table 4). The species *Climacograptus styloideus* Lapw. is known from boreholes Jeleniów *IG-2* (Tomczyk & Turnau-Morawska 1967) and Zbrza *IG-3*. In Scotland it occurs in the Dicranograptus clingani and Pleurograptus linearis zones (Elles & Wood 1906, Toghill 1970). Its occurrence is very much the same in Scandinavia where it has been encountered in the Black Tretaspis Shales (Henningsmoen 1948). In Scotland, similarly as in the Holy Cross Mts, *Climacograptus styloideus* Lapw. occurs together with *Climacograptus minimus* (Carr.). In the remaining boreholes the graptolite fauna is represented by species known from both uppermost Caradocian zones. Hence, the division of the uppermost Holy Cross Caradoc cannot, naturally, follow the British division. The differentiation of a member corresponding to the British zones and, at the same time, typical of the Holy Cross Mts, would, however seem reasonably correct. In the above assemblage there is a striking increase of the Bohemian forms such as: *Paterula bohemica* Barr., *Cyclopyge rediviva* (Barr.) and *Pharostoma pulchrum pulchrum* (Barr.).

The Caradoc of the neritic zone in the Kielce region is developed mainly in the carbonate facies. Clayey deposits are subordinate. The age assignment of the deposits is reliably suggested by the abundant conodonts which (Chart 5, Table 5), moreover, permit the differentiation of a Caradocian biostratigraphic zone, viz. the Amorphognathus ordovicica Zone (Table 3). Such conodont fauna is known from the United States of America (Sweet & Bergström 1966), Great Britain (Rhodes 1955), Scandinavia (Hamar 1966), the Soviet Union (Viira 1968), also from the Podlasie and the Peribaltic areas (Table 5). Its importance for the stratigraphy of the Holy Cross Ordovician is stressed by the fact that, out of the 55 conodont species identified here, 30 are confined to the Caradoc. Other faunal elements, *e.g.* the brachiopods *Paterula bohemica* Barr., *P.* cf. *portlocki* (Gein.), *Schizotreta corrugata* Cooper, *Scaphelasma septatum*

Cooper, merely indicate connections with the seas of North America (cf. Cooper 1956), Scandinavia (cf. Henningsmoen 1948), Estonia and Latvia (cf. Männil 1966).

Ashgill

Ashgillian deposits are known from both facial regions, but, as compared with the Caradocian deposits, their occurrence sites are fewer.

Data on the Ashgillian stratigraphy in the northern side of the Łysogóry Range are given by Czarnocki (1928a, 1939, 1957), Kielan (1956, 1959) and Tomczyk (*in* Tomczyk & Turnau-Morawska 1967). Kielan's (1959) subdivision of the Ashgill into three zones but slightly amended is that accepted in the present paper.

Of these three zones, the Eodindymene pulchra Zone is observed at Brzezinki. The upper members of this zone may possibly also occur at Wólka, as siltstones 25 m in thickness. Besides the index species, the occurrence is noted there *i.a.* of *Pseudosphaeroxochus laticeps* Linnrs., *Tretaspis granulata* (Wahl.), *Trinodus tardus* (Barr.), *Lonchodomas portlocki* (Barr.) and *Cyclopyge quadrangularis* Kielan. All these forms, the first one excepted, are present in the next zone, too.

The Staurocephalus clavifrons Zone is proved at Brzezinki and Wólka; it consists of 32 metres of siltstones (Brzezinki) with i.a.: *Staurocephalus clavifrons* Ang., *Phillipsinella parabola* (Barr.), *Ceraurinella intermedia* (Kielan), *Panderia megalophtalma* (Linnrs.), *Diacanthaspis decantha* (Ang.), *Oedicybele kingi* Whitt., *Hammatocnemis tetrasulcatus* Kielan and *Opsimasaphus jaanussoni* Kielan.

At Wólka, in addition to others (cf. Kielan 1959), there also occur *Carmon mutilus* (Barr.), *Panderia megalophtalma* (Linnrs.), *Phillipsinella parabola* (Barr.) and *Staurocephalus clavifrons* Ang.

As reported by Kielan, the Staurocephalus clavifrons Zone at Brzezinki is overlaid by an unfosiliferous, 23 m thick, siltstone series with black shales containing *Orthograptus vesiculosus* Nich. in their top. These shales generally represent the lowest Silurian.

At Jeleniów and Dębniak, the occurrence is noted of yellow siltstones, referred to the Ashgill (Czarnocki 1939, Tomczyk 1957). According to Kielan (1959) they have yielded trilobites indicating the Staurocephalus clavifrons Zone. The Dębniak material from 5 shallow boreholes (cf. Czarnocki 1957) reliably indicates that, below the Valentian, there are Ordovician shales, some metres thick. At the Silurian/Ordovician boundary, the presence has been noted of grey unbedded sandstone, varying in thickness, with a clayey matrix. The sandstone rests on shales and siltstones containing the ostracods *Primitia conica* Troeds., trilobites *Dalmanitina* sp. and *Trinucleus bucklandi* Barr., also brachiopods *Orthis* cf.

honorata Barr., *Foliomena folium* (Barr.), *Strophomena radiata* Barr. and *Orbiculoidea* cf. *radiata* (Troeds.).

The presence, below the grey sandstones in the Dębniak profile, of representatives of the genus *Dalmanitina,* may indicate the occurrence of the equivalents of the Dalmanitina mucronata Zone in the northern slope of the Łysogóry Range, too. This supposition is likewise supported by similarities in borehole Szumsko *IG-2a* (Table 3). In this profile, the marly claystones, bearing *Dalmanitina mucronata* (Brongn.) and *D.* cf. *olini* Temple, are overlaid by sandy siltstones interbedded by grey claystones with brachiopod and trilobite remains, and higher up by unfossiliferous greenish siltstones or sandstones. The latter may be an equivalent of the grey sandstones from Dębniak, possibly also of the siltstones from the top of the Staurocephalus Zone at Brzezinki.

On the above evidence it may be reliably supposed that the Ashgill of the Łysogóry region is represented by three zones (from top): *1.* the Eodindymene pulchra Zone at Brzezinki and Wólka, *2.* the Staurocephalus clavifrons Zone at Brzezinki and *3.* the Dalmanitina Zone at Brzezinki and Dębniak. Elsewhere on the northern slope of the Łysogóry Range, the Ashgill has been identified only by the lithological analysis. This applies to borehole Jeleniów *IG-1,* where, after Tomczykowa (1968), the Ashgill is represented by a 30 m thick series of claystones and calcareous or dolomitic siltstones intercalated by marly and sandy limestones. In borehole Wilków *IG-1,* the same author suggests the assignment to the Ashgill of a 30 m thick, clayey-calcareous series.

In the Kielce region, the Ashgill is known in the Bardo syncline from boreholes Mokradle *IG-1,* Zalesie *IG-1,* Szumsko *IG-2a* and from the outcrops in the Stawy ravine near Bardo, and Zalesie Nowe (Table 3). These latter profiles have been discovered by Czarnocki (1919, 1928a), the trilobite fauna was investigated in detail by Kielan (1959), while Temple (1965) has worked out the brachiopods from the Stawy ravine. The Lower Ashgill from the Bardo syncline is characterized by the dark-red as well as grey and greenish colouration of the deposits. These are clay-marly rocks, here and there interbedded by dolomites with bentonite intercalations.

In borehole Mokradle *IG-1* (Table 3), in the western part of the Bardo syncline, the Lower Ashgill is represented by greenish nodular marls, towards the top passing into dark-red claystones. These deposits are *c.* 1.8 m in thickness. In the eastern part of the Bardo syncline, the Lower Ashgill has its equivalents in dark-red or variegated shales (the Stawy ravine near Bardo, Zalesie Nowe; Table 3), here and there with a sporadical fauna of *Hisingerella nitens* (His.). In this part of the syncline the thickness of the Lower Ashgill ranges from 0.6 m at Zalesie Nowe to 1.5 m in the Stawy ravine.

At a distance of *c.* 1.5 km from the southern margin of the syncline, deposits of that age have been observed in borehole Szumsko *IG-2a* (Table 3). These are, likewise, dark-red claystones, towards the top having a greenish colour, *c.* 2 m thick, with dolomite intercalations and a meagre fauna of *Paterula* cf. *bohemica* Barr. and *Scaphelasma septatum* Cooper.

The Upper Ashgill in the western part of the Bardo syncline (borehole Mokradle *IG-1,* Table 3), is represented by limestones with *Eostropheodonta hirnantensis* (M'Coy), 3 m thick, and by the overlying grey siltstones, *c.* 0.6 m thick, with brachiopod and trilobite remains. On the other hand, in the eastern part of the syncline (Zalesie Nowe and the Stawy ravine, Table 3), the Upper Ashgill consists of yellowish marls interbedded by pale-yellow sandstones or siltstones intercalated by bentonites and containing abundant trilobites and brachiopods, i.a.: *Dalmanitina olini* Temple, *D. mucronata* (Brongn.), *Raphiophorus acus* (Troeds.), *Lingulella* sp., *Orbiculoidea radiata* (Troeds.), *Philhedra? stawyensis* Temple, *Bancroftina bouceki* (Havliček), *Dalmanella testudinaria* (Dalm.), *Hirnantia sagittifera* (M'Coy), *H. kielanae* Temple, *Bracteoleptaena polonica* (Temple), *Eostropheodonta hirnantensis* (M'Coy) and *Plectothyrella platystrophoides* Temple. The thickness of the Upper Ashgill in the Stawy ravine is 9.2 metres. The other deposits that here make up the Upper Ashgill are dolomitic marls and dolomites intercalated by bentonites, 2.4 m in thickness, with sporadical faunal remains, and, higher up, marls and greenish-greyish marly shales bearing i.a.: *Trinodus tardus* (Barr.), *Phillipsinella parabola* (Barr.), *Leonaspis olini* Troeds., *Brongniartella platynota* (Dalm.), *Dalmanitina olini* Temple, *D. mucronata* (Brongn.), *Staurocephalus clavifrons* Ang., *Oedicybele kingi* (Whitt.), *Dalmanella testudinaria* (Dalm.), *Bancroftina* cf. *bouceki* (Havl.), *Bracteoleptaena polonica* (Temple). Ostracods are numerous, i.a. *Primitia tenera* Troeds., *P. conica* Troeds. and *Bolia harparum* Troeds. (comp. Chart 6). This uppermost part of the Ashgill is *c.* 3.2 m in thickness.

In the Szumsko syncline (borehole Szumsko *IG-2a,* Table 3) the Upper Ashgill comprises dark-grey marly claystones, 0.7 m thick, with *Dalmanitina mucronata* (Brongn.), *D.* cf. *olini* Temple, Strophomenidae and ostracods. Towards the top they pass into greenish siltstones interbedded by claystones and bearing trilobites and inarticulate brachiopods, still higher up into green unfossiliferous siltstones. The total thickness of the Upper Ashgill in the above profile is 1.8 metres.

In describing the Ashgill in the Kielce region of the Holy Cross Mts, the problematic occurrence of this stage in the vicinity of Zbrza may be mentioned. It is represented by yellow siltstones with concretions of unfossiliferous nodular limestones, lying in the top of the palaeontologically proved Caradoc. The lithological analogies with the Ashgillian deposits observed in the other areas of the Holy Cross Mts reasonably suggest this assignment (Tomczyk 1957).

Chart 6

Ashgillian fauna in the Holy Cross Mts

(based on the data by Czarnocki 1928a, 1939; Samsonowicz 1934; Tomczyk 1957; Kielan 1959; Temple 1965; Tomczykowa 1968; completed by the author)

Fossils \ Localities	Brzezinki	Jeleniów	Pobroszyn	Dębniak	Wólka	Mokradle 1	Stawy	Zalesie Nowe	Szumsko 2a
BRACHIOPODA									
Orbiculoidea radiata /Troedsson/				c		c	+		
Orbiculoidea sp.			+						
Lingulella sp.							+		
Paterula cf. bohemica Barrande									+
Philhedra? stawyensis Temple							+		
Hisingerella nitens /Hisinger/								+	
Acrotreta sp.									+
Scaphelasma septatum Cooper									+
Orthis cf. honorata Barrande				+					
Boreadorthis cf. crassa Öpik						+			
Dalmanella testudinaria /Dalman/			+				+	+	
Bancroftina? boucoki /Havlíček/							+	+	
Hirnantia kielanae Temple							+		
Hirnantia sagittifera /M'Coy/							+		
Strophomena radiata Barrande				+					
Bracteoleptaena polonica /Temple/							+	+	
Foliomena folium /Barrande/				+					
Stropheodonta sp.									+
Eostropheodonta hirnantensis /M'Coy/						+	+		
Plectothyrella platystrophoides Temple							+		
TRILOBITA									
Phillipsinella parabola /Barrande/		+							
Dalmanitina mucronata /Brongniart/									+
Dalmanitina olini Temple									+
Dalmanitina sp.				+					
Staurocephalus clavifrons Angelin		+							
and: 75 species monographed by Kielan /1959/	+				+		+	+	
OSTRACODA									
Primitia bursascanensis Troedsson			+				+	+	
Primitia conica Troedsson			+	+			+	+	
Primitia sexpapillosa Troedsson								+	
Primitia tenera Linnarsson			+					+	
Bolia biplicata Troedsson								+	
Bolia harparum Troedsson								+	
GRAPTOLITA									
Dicellograptus sp.					+				
Climacograptus cf. scalaris miserabilis Elles & Wood					+				
Climacograptus sp.				+					
Orthograptus truncatus Lapworth					+				
Plegmatograptus nebula Elles & Wood					+				

c = cf.

On the above data it may be reliably accepted that the complete development of the Ashgill occurs both in the Kielce and the Łysogóry region. This contradicts the views of Kielan (1959) according to which on the northern side of the Łysogóry Range there are only two Lower Ashgillian zones, viz. the Eodindymene pulchra and Staurocephalus clavifrons zones, while the third zone representing the Upper Ashgill is missing. In the present writer's opinion the equivalent of the third zone is probably represented by the unfossiliferous sandstones and siltstones from Brzezinki as well as by the sediments which Czarnocki (1939) described from Dębniak (Table 3). The latter supposition seems reasonably supported by the fact that Kielan did not observe tectonic or erosional discontinuity between the unfossiliferous siltstones and the Silurian shales with *Orthograptus vesiculosus* (Nich.). According to Kielan (1956) the deposits just mentioned are separated by a layer of grey clay several centimetres in thickness.

Hence, it is concluded that, at the close of the Ordovician, only a shallowing of the sea basin had occurred. Within the eastern part of the Bardo syncline, however, the sea basin was not subjected to any important changes until the end of the Ashgill. This is indicated by the abundant and diversified fauna in the top parts of the Ashgill in the Stawy ravine near Bardo. The fauna there is nearly identical with that of the Hirnantia Beds in Wales (Temple 1965), representing the latest Ashgillian members of Great Britain (Williams 1969).

Controversial opinions have also been advanced with regard to the Zalesie Nowe profile. Namely, Kielan (1959) postulated the presence, above the glauconitic Lower Ordovician sandstones in this profile, of only the Upper Ashgill, *i.e.* the so called Dalmanitina Beds. The writer's analysis of this profile, and the list of fauna, recently supplemented, show the correctness of Czarnocki's opinion postulating that this profile represents the complete Ordovician stage. Below the Dalmanitina Beds, the Lower Ashgill is represented by a red clayey-marly series, bearing *Hisingerella nitens* (His.). This series may be correlated with the Red Tretaspis Mudstone of Scandinavia (cf. Henningsmoen 1948) or with the Jonstorp series (cf. Jaanusson 1964) and their equivalents in Estonia and Latvia (cf. Männil 1963, 1966).

STRATIGRAPHICAL REMARKS

In what concerns the faunal composition, litological development and occurrence range of the zones previously distinguished, the above data clearly suggest that relatively unimportant amendments have been introduced into the stratigraphic division of the Ordovician from all the Łysogóry region and the western part of the Kielce region. The situation is, however, quite different in the central and eastern parts of the Kielce region. A summary of the new stratigraphic division used there is as follows.

The Lingulella (Leptembolon) zejszneri Zone is the oldest one in the Kielce region. It comprises deposits corresponding to the Upper Tremadoc and the Lower Arenig and is separated into two subzones: the Thysanotos siluricus and the Conotreta czarnockii.

The Thysanotos siluricus Subzone begins with transgressive conglomerate. It contains frequent inarticulate brachiopods (Bednarczyk

1964) on which this subzone is based. Its thickness varies, ranging from a few to some 40 metres.

The Conotreta czarnockii Subzone has been identified in the central part of the Kielce region (Koziel, Zalesie Nowe and Szumsko), also at Zbrza and Brzeziny (Table 3) in the SW part of that region. The brachiopod assemblage typical of this subzone is characterized by the absence of *Thysanotos siluricus* (Eichw.) and by the mass occurrence of representatives of the genus *Conotreta*. The thickness of this subzone ranges from a few to c. 40 metres. At Brzeziny (Table 3), its equivalent is represented by the lower part of the Didymograptus extensus Zone. The total thickness of the Lingulella (Leptembolon) zejszneri Zone is up to 60 metres.

The next Lower Ordovician zone which has been distinguished is the Orthambonites pseudomonetus & Cybele bellatula Zone. This includes deposits which are contemporaneous with the Upper Arenig and the Lower Llanvirn (Table 2). The thickness of the deposits of the lower part of this zone does not exceed 10 metres. In the vicinity of Kielce, this part of the zone has its equivalent in the local Acontiodus rectus sulcatus & Oneotodus variabilis Zone (Table 2). At Brzeziny (Table 3), the upper part of the Didymograptus extensus Zone corresponds to the lower part of the Orthambonites pseudomonetus & Cybele bellatula Zone.

The upper part of the zone has been identified as the Orthambonites calligrammus & Illaenus wahlenbergi Subzone (cf. Bednarczyk 1964). This is up to 60 m in thickness. The deposits of the Didymograptus bifidus Zone (Table 2) are the equivalents of the Orthambonites calligrammus & Illaenus wahlenbergi Subzone. The total thickness of the Orthambonites pseudomonetus & Cybele bellatula Zone does not exceed 70 metres.

The third Lower Ordovician Zone, to be distinguished in the Kielce region has been defined as the Amorphognathus sp. 3 & Prioniodus prevariabilis Zone. It comprises deposits contemporaneous with the Upper Llanvirn and the Llandeilo. The abundant conodont fauna there includes, besides the index species, also: *Acontiodus reclinatus* Fähraeus, *Prioniodus navis* Lindström and *Tetraprioniodus asymmetricus* Bergström (Table 5, Charts 3 and 4). At Brzeziny, Jeleniów and Bukowiany (Table 3) this zone has its equivalent in deposits belonging to the Didymograptus murchisoni and Glyptograptus teretiusculus zones (Table 2). The thickness of the Amorphognathus sp. 3 & Prioniodus prevariabilis Zone does not exceed 4 metres.

A conodont assemblage, documenting the Cornuodus erectus & Scandodus rectus Zone, is of additional help in determining the Lower Llanvirn/Upper Llanvirn and the Llanvirn/Landeilo boundary. The above assemblage is made up of 11 conodont species characteristic only of the Llanvirn. Beside the index species there occur: *Acodus viruensis* Fähraeus, *Acontiodus reclinatus* Lindström, *Drepanodus* sp. *14* Lindström, 1960, *Falodus simplex* Sergeeva, *Oistodus basiovalis* Sergeeva, *O. inaequalis* Pander, *Scandodus formosus* Fähraeus and *Scolopodus rex* Lindström.

The last conodont zone to be distinguished is the Amorphognathus ordovicica & Ambalodus triangularis Zone indicating the Caradoc. It is based on the most abundant conodont assemblage containing as many as 25 species. In addition to the index species the others (cf. Table 5) are: *Acodus inornatus* Ethington, *Ambalodus frognoeyensis* Hamar, *A. pulcher* Rhodes, *Drepandus altipes* Henningsmoen, *Holodontus superbus* Rhodes, *Ligonodina delicata* (Branson & Mehl), *Scandodus inflexus* Hamar and *Tetraprioniodus delicatus* (Branson & Mehl). The thickness of the zone is up to 10 metres.

The uppermost Ordovician in the Kielce region is represented by the Dalmanitina mucronata Zone. The fauna of trilobites, which justified the differentiation of this zone, was worked out by Kielan (1959), that of brachiopods by Temple (1965). The thickness of this zone ranges from 1.8 m to 9.2 metres.

The Dalmanitina mucronata Zone is separated from the Amorphognathus ordovicica & Ambalodus triangularis Zone by a series of shaly claystones or clayey shales. Here and there they contain thin-shelled brachiopods of the genera *Hisingerella* and *Paterula* known from the Caradoc of the peribaltic areas (cf. Bednarczyk 1968b). The age of this series has been determined as Lower Ashgillian. Its equivalents in the Łysogóry region are the Eodindymene pulchra and the Staurocephalus clavifrons zones. The thickness of the Lower Ashgill in the Kielce region ranges from 0.6 m to 2.0 metres.

The total thickness of the Ordovician deposits in the Łysogóry region, also at Brzeziny and Zbrza, is *c.* 380 metres. Within the remaining part of the Kielce region the thickness of Ordovician deposits hardly reaches half of that figure, never exceeding *c.* 170 metres.

FACIAL DEVELOPMENT

The distribution and differentiation of the Ordovician facies in the Holy Cross Mts depended closely on the orogenic movements prior to the Upper Tremadocian transgression. These processes are indicated by the old Caledonian (Sandomirian) phase which uplifted areas lying south of the Łysogóry region. This is reliably suggested by the transgressive position of Upper Tremadocian deposits on various Cambrian members of the Kielce region as well as on the Precambrian in the western part of the Carpathian Foredeep (Tomczyk 1962) and in the Miechów depression (Jaworowski, Jurkiewicz & Kowalczewski 1967).

The problem of the Sandomirian movements in the Łysogóry Range has not yet been conclusively cleared up. In numerous boreholes there it has been observed (Tomczykowa 1968) that claystones with *Parabolina acanthura* (Angelin) are directly overlaid by claystones with *Dictyonema* sp. This indicates the continuation of the Cambrian sea until the Lower Tremadoc. Nothing conclusive can, however, be said concerning later sedimentation or its absence since various members of the Upper Cambrian and the Lower Tremadoc have a faulted contact with various Llandeilo and Caradocian members (Table 3).

The presence of the Sandomirian phase, is however, quite admissible if the observations made by Samsonowicz (1934) be taken into consideration, as they reliably show the presence at Pobroszyn (cf. Fig. 1) of a sandstone contemporaneous with the sandstone containing *Thysanotos siluricus* (Eichwald) that belongs to the Lingulella (Leptembolon) zejszneri Zone (Table 2). This would indicate that, after the deposition of the claystones with *Dictyonema* sp., the orogenic movements covered the entire Holy Cross area, but that the southern region, more strongly uplifted and faulted, had been to a greater extent subjected to erosion which prevented the persistance of the Lower Tremadocian and uppermost Cambrian deposits.

At the turn of the Lower Tremadoc into the Upper, the movements of the Sandomirian phase were followed by the penetration of the sea through bays into the land that had been aggraded but still retained its morphological differentiation. In the vicinity of Międzygórz the first to be laid down were the conglomerates of considerable thickness, separated by a conglomeratic sandstone. In the Upper Tremadoc, the transgression covered the area of the later (Caledonian/Hercynian) Bardo syncline, also the Dyminy anticline and Zbrza. This resulted in the deposition of sandstones and quartz siltstones containing glauconite and chalcedonite, also Cambrian isolated pebbles occurring at the bottom. Locally the presence has also been noted of bentonites (Bednarczyk & al. 1970).

In the lowermost Arenig there is a further development of the transgression which covers the areas of Brzeziny, Bukówka and Niestachów and is indicated by the siltstone-sandstone facies with glauconite and thin chalcedonite intercalations.

Disturbances in the Holy Cross basin are indicated by facial differentiation expressed by both the eastern and the western margin being invaded by the sandstone facies, while the siltstone facies with chalcedonite occupy the area of the Bardo syncline and the vicinity of Zbrza. Additional evidence of disturbances in the Holy Cross basin is the variable thickness of the deposits and local emersions occurring at the close of the Tremadoc (Zbrza) and the lowermost Arenig (Chojnów Dół near Zbilutka-Kędziorka).

The fauna observed in deposits of the Upper Tremadoc and the lowermost Arenig (Charts 1 and 2) contains, besides endemic species, also numerous Bohemian (cf. Havlíček & Vaněk 1966) and Peribaltic forms (cf. Gorjanskij 1969). Their presence in the Holy Cross basin indicates convenient communication routes with the epicontinental sea of NE Poland, also with the Peribaltic areas of the USSR on the one hand and the Barrandian Basin on the other. As is suggested by boreholes in southern Poland (Tomczyk 1962, Jaworowski & al. 1967) connections with the Barrandian Basin may have existed across the eastern part of the present Carpathian Foredeep or the present Miechów depression. Neither should connections across the Sudetes be excluded.

At the beginning of the Upper Arenig, the facies of the southern part of the Holy Cross basin are subject to further differentiation. Together with the silty-sandy sedimentation in the vicinity of Bukówka, Mokradle, Zalesie and Szumsko, calcareous facies set in at Bukówka, and dolomitic ones at Lenarczyce.

At that time the sea basin at Brzeziny deepens, and the sandy-silty facies is replaced by a clayey one with graptolites, thin-shelled inarticulate brachiopods, sporadically also small trilobites of the genus *Telephus* (cf. Tomczyk 1962). In contradistinction to the fauna found in the sandy-carbonate deposits abounding in thick-shelled, richly ornamented articulate brachiopods, gastropods and nautiloids provided with large massive shells, bryozoans and large-sized trilobites, the fossils mentioned above suggest a deeper basin as compared with the remaining southern part.

An analysis of the Llandeilian and Caradocian profiles does not cancel the possibility of a facial development resembling that at Brzeziny in the Łysogóry region, too.

During the Lower Llanvirnian, within the shallow-neritic zone of the Kielce region, carbonate facies also make their appearance at Mójcza (locally with bentonites), Zalesie and Kędziorka. They acquire an importance similar to that of the sandy deposits which reach considerable thickness, *e.g.* at Bukówka and the Dyminy anticline. On the other hand, conditions of deep-neritic sedimentation still continue in the vicinity of Brzeziny.

Two faunal zones may be distinguished at that time in the Holy Cross basin; their areas fit in with the bathymetric zones. One of them comprises the region of Brzeziny, most probably also that of the Łysogóry Range in whose fauna there is a predominance of the British-Scandinavian species; the other one covers the remaining southern part showing the predominance of the Estonian-Scandinavian species (cf. Charts 2 and 3).

No Bohemian species, so common in the lowest Arenig and Upper Tremadoc, have been encountered in deposits of the Upper Arenig and

Lower Llanvirn, or in their age-equivalents at Brzeziny. This suggests palaeogeographic changes in the S and SW parts of Poland, responsible for the destruction of communication routes between the Holy Cross area and the Barrandian Basin.

At the beginning of the Upper Llanvirn, the sedimentary conditions in the southern part of the Holy Cross basin experienced further stabilization. The sandy facies disappear and are replaced by carbonate ones. Calcareous oolite-bearing deposits develop in the vicinity of Kielce (Bukówka, Mójcza), while dolomites, locally intercalated by limestones and clays, predominate within the Bardo syncline.

At that time changes in the character of sedimentation occur at Brzeziny, too. The clayey deposits are replaced by unfossiliferous chamosite-siderite rocks with oolites (Tomczyk & Turnau-Morawska 1964), suggesting a shallowing of this part of the basin as well as a setting in of conditions unfavourable to the development of organic life. Tomczyk's suggestions that these changes were connected with orogenic movements responsible for a break in sedimentation within the southern part of the Holy Cross basin do not seem probable. Indeed, numerous borehole profiles (Table 3) show the continuation here of marine sedimentation also during the Llandeilo. It is namely this age that has been assigned to the calcareous-oolitic deposits from the vicinity of Kielce (Bukówka, Mójcza) and to the dolomitic rocks with clayey intercalations from the Bardo syncline and the vicinity of Kleczanów.

The shallowing of the basin at Brzeziny was probably of short duration since it was confined to the Upper Llanvirn. Clayey facies re-appear in the Llandeilo, while south of Brzeziny transgression covers even the Zbrza area which has been emersed since the close of the Tremadoc. In the last named area the facies resemble those at Brzeziny and the Łysogóry region. Among the carbonate facies there is a local occurrence of fine-grained conglomeratic intercalations at Jeleniów (Tomczyk & Turnau-Morawska 1967) or of siliceous pebbles (Bukowiany *IG-1a*, Table 3). This will merely indicate disturbed sedimentation in some parts of the basin but does not suggest an orogenic phase.

During the Lower Caradoc, dark-grey facies, intercalated by bentonites and limestones, persist in the Łysogóry zone, also at Brzeziny and Zbrza; locally (at Pobroszyn) there is a predominance of the carbonate facies. In the southern part of the basin there is a continuation of carbonate sedimentation. Calcareous, here and there oolitic, facies develop in the vicinity of Bukówka and Mójcza, while farther east they are associated with dolomites.

During the Middle Caradoc, in the Łysogóry region as well as in the vicinity of Brzeziny and Zbrza, no important changes affected the development of the clayey facies; sandy intercalations occur but locally (Zbrza, Table 3). To the south, the limestones spread out from Kielce to

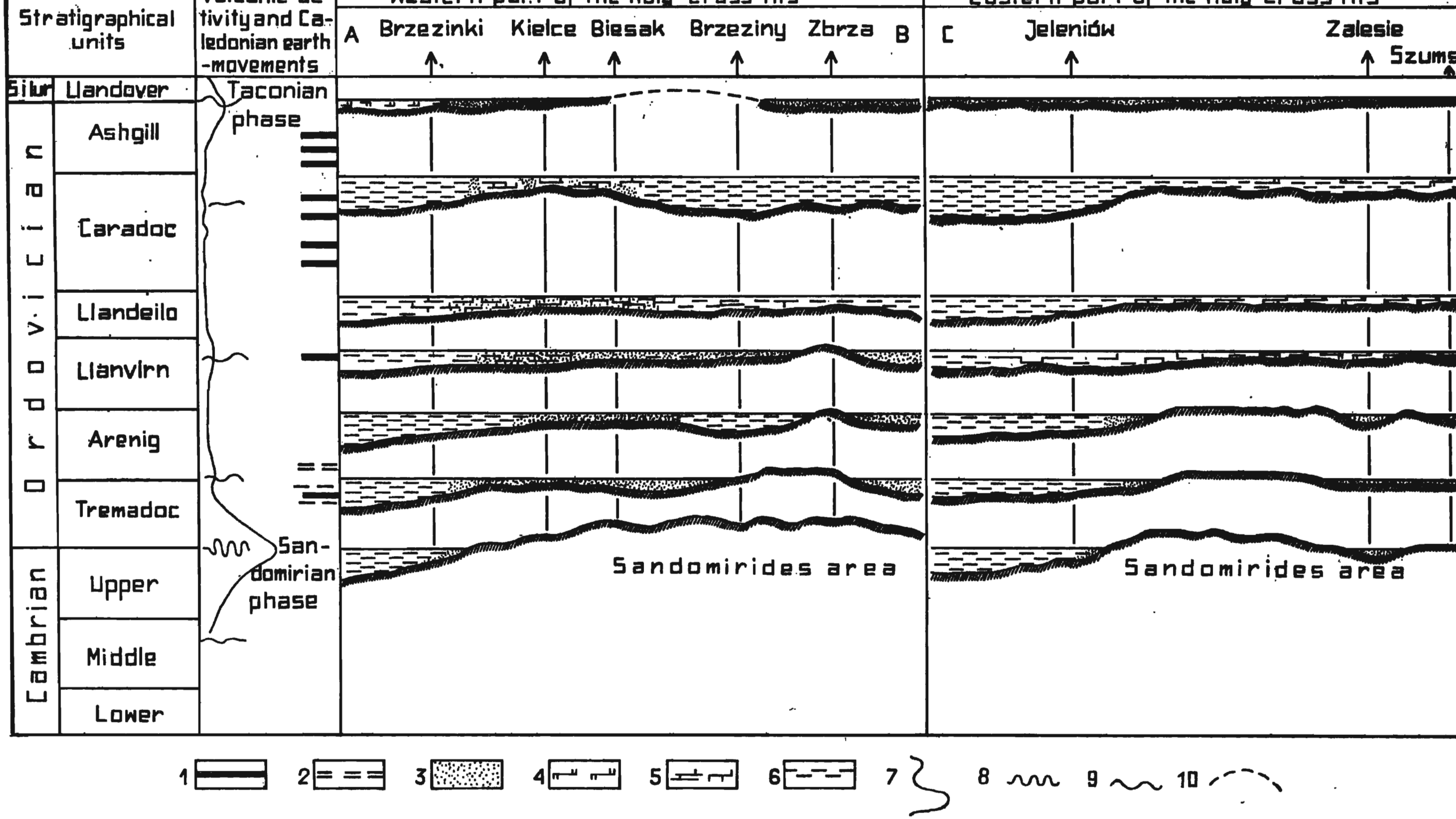


Fig. 2

Approximate thickness pattern of the Ordovician deposits in the Holy Cross Mts (for section lines see Fig. 1)

1 bentonites, *2* tuffites, *3* sandstones, *4* dolomites, *5* limestones, *6* claystones, *7* curve of the activity of Caledonian movements, *8* orogenic movem
9 epeirogenic movements, *10* supposed land

Zarobiny. Farther east, in the vicinity of Zalesie and Szumsko, claystones are encountered among them. In the direction of Kleczanów and Lenarczyce, these are replaced by dolomites, sometimes containing glauconite and oolites.

At the close of the Caradoc, the Holy Cross basin attains its maximum depth. In the Łysogóry region, as well as at Brzeziny and Zbrza, there are concentrations of fairly thick claystones intercalated by bentonite and bearing a locally rich fauna of graptolites, inarticulate brachiopods, sporadically of small trilobites (Chart 5). The same type of deposits, but containing isolated graptolites and brachiopods, also occurs within the Bardo syncline. The dolomitic facies persists only in the vicinity of Lenarczyce in the eastern margin of the southern area (Fig. 1).

The Caradocian deepening of the Holy Cross basin and the increased range of the graptolite-bearing clayey facies, which advances into the area of carbonate sedimentation, is associated with similar events in NE Poland and Baltoscandia. This is indicated by the replacement in these areas of the Llandeilian calcareous-oolitic facies by the marly and clayey facies (Tomczykowa 1964, Bednarczyk 1968b), as well as, *e.g.* in Scandinavia and the Baltic provinces of the USSR, by the increased range of the graptolite-bearing black claystones (Størmer 1953; Thorslund 1960; C. Poulsen 1922, 1960; V. Poulsen 1966; Männil 1966).

In the Lower Ashgill, the palaeogeographic and facial pattern undergoes changes. In the Łysogóry region and at Zbrza, the clay facies are replaced by the sandy and carbonate ones, while a local emersion takes place in the vicinity of Brzeziny. Graptolites disappear and trilobites and brachiopods develop (Brzezinki, Wólka). In the southern area, a facies of red clays with bentonite intercalations makes its appearance side by side with the marly facies. A similar type of deposits is also known from Baltoscandia (Männil 1966) and north-eastern Poland (Tomczykowa 1964, Bednarczyk 1968a) where a more abundant fauna has been observed.

In the Upper Ashgill, there is a shallowing of the basin in the Łysogóry region, indicated by an increase in the clastic material. The carbonate facies persists only locally in the vicinity of Kajetanów and Wilków, but the fauna disappears almost completely.

In the Bardo syncline, a development re-occurs of the brachiopod and trilobite fauna. Clayey, red-coloured deposits are replaced by grey-greenish ones, clays with bentonite intercalations, sandstones, less often by limestones. At the close of the Ashgill, the fauna disappears again and the deposits acquire a silty-sandy character. Fairly large-sized quartz grains and pebbles of clay rocks are rather frequent among the siltstones.

The shallowing of the basin and the facial changes there also took place in areas adjacent to the Holy Cross basin. In NE Poland the clayey-marly deposits passed into the calcareous and calcareous-sandy ones.

Farther north, in Baltoscandia, notwithstanding the local persistance (Scania and Bornholm) of the graptolite-bearing clayey facies, sandy deposits grow predominant. These changes are connected with the Horg phase (Kautsky 1949) of the Caledonian cycle which, towards the end of the Ashgill, resulted in marine regression from several Scandinavian areas (Spjeldnaes 1957) and from the Peribaltic syneclise (Männil 1966, Bednarczyk 1968b).

The faunal affinities of the Ordovician Holy Cross basin with the seas of northern and southern Europe are also reflected in the Ashgillian faunal assemblages. Namely, out of the 32 trilobite species, described by Kielan (1959) from the Ashgill of the Holy Cross Mts, 30 occur in Baltoscandia, 11 in Great Britain and 16 in the Barrandian. Among the eight brachiopods described by Temple (1965) as many as seven occur in deposits of the same age in Great Britain, and four in the Barrandian. Hence, it is reliably supposed that the fauna of the British sea migrated to the Holy Cross area and farther on to Bohemia across Baltoscandia and NE Poland.

FINAL REMARKS

During the Ordovician, the faunal pattern in the Holy Cross basin clearly shows the development there — from the Arenig to the Caradoc — of two distinct facial zones.

One comprised the regions of Łysogóry and Brzeziny, beginning with the Llandeilo also that of Zbrza. Clayey facies, typical of the deep-neritic (Brzeziny, Zbrza) or even of the bathyal zones (Łysogóry Range) were in the predominance.

To the other zone belonged the remaining part of the Holy Cross basin and the calcareous-dolomitic facies formed in the shallow-neritic sea.

The bentonite intercalations (Table 3, Fig. 2) — occurring in the Ordovician profiles of the Holy Cross Mts, also the Upper Tremadoc and lowermost Arenig siltstones containing pyroclastic material (Chlebowski 1971), reliably indicate volcanic activity in the adjacent areas. The greater frequency of the bentonites in profiles of the southern part of the Holy Cross Mts reasonably suggests that the alimentary area lay south of the Holy Cross basin.

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W. BEDNARCZYK

STRATYGRAFIA I PALEOGEOGRAFIA ORDOWIKU GÓR ŚWIĘTOKRZYSKICH

(Streszczenie)

W pracy przedstawiono podział biostratygraficzny ordowiku Gór Świętokrzyskich w oparciu o brachiopody (*por.* Bednarczyk 1959, 1964; Temple 1965), trylobity (*por.* Kielan 1959, Bednarczyk 1966a), graptolity (*por.* Tomczyk 1962; Tomczyk & Turnau-Morawska 1964, 1967) oraz konodonty. Dzięki tej ostatniej grupie skamieniałości zidentyfikowanej po raz pierwszy w licznych profilach wierceń i odsłonięć (fig. 1 oraz tab. 3 i 5), udowodniono obecność w regionie kieleckim pięter landeil i karadok (tab. 1 i 2). Przedstawiono także korelację badanych osadów z równowiekowymi utworami pozostałych obszarów Polski oraz Bałtoskandii, Wielkiej Brytanii i Czech (tab. 4).

W dalszej części pracy rozpatrzono stosunki facjalno-paleogeograficzne ordowiku Gór Świętokrzyskich. W regionie łysogórskim sedymentacja odbywała się w morzu przetrwałym od kambru, a charakteryzującym się znacznymi głębokościami. W regionie kieleckim morze wkroczyło po przerwie wywołanej ruchami starokaledońskiej fazy sandomierskiej (*por.* Samsonowicz 1934) dopiero w górnym tremadoku, sedymentacja zaś odbywała się w warunkach płytkomorskich, przy lokalnych i chwilowych wynurzeniach pod koniec tremadoku i w aszgilu (fig. 2).

Pracownia Stratygrafii
Zakładu Nauk Geologicznych PAN
Warszawa 22, Al. Żwirki i Wigury 93
Warszawa, w październiku 1970 r.