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Upper Viséan conodonts from Orlej in the Cracow Upland: stratigraphical and paleothermal implications

ABSTRACT: The conodont fauna from the Upper Viséan deposits of the Cracow Upland, contacted by the subvolcanic porphyry intrusion, and exposed at the Orlej Quarry includes stratigraphically important forms, indicative of the *Gnathodus girtyi collinsoni* Zone. The conodont-bearing algal-foraminiferal boundstones in their postdepositional history underwent the thermal influence of the porphyric intrusion of Zalas. The employment of conodont alteration index (*CAI*) indicates that the layer of algal-foraminiferal boundstones occurring 80 m off the contact with intrusion was heated over a temperature of 210° C during the period not shorter than 800 years.

INTRODUCTION

The Viséan conodont faunas have been reported only from a few places in Poland (*see* Skompski & Soboń-Podgórska 1980). These fragmentary investigations do not allow to propose the conodont zonal scheme for the Viséan sequences of Polond. The majority of biostratigraphic data of the Viséan based on conodonts come from the Cracow Upland, southern Poland (Gromczakiewicz-Łomnicka 1974, 1979; Matyja & Narkiewicz 1979), precisely from several outcrops of the Carboniferous limestones in the area north of Krzeszowice and of the investigated area of Orlej (*cf.* Text-fig. 1).

This study describes the conodont fauna from the Upper Viséan sequence contacted by a subvolcanic intrusion of the Zalas porphyry, and exposed at the Orlej Quarry in the southern Cracow Upland (Text--figs 1—2), being famous for a well preserved and very rich macrofauna (*cf.* Czarniecki 1955). The conodonts from this very sequence were taken for the biostratigraphical and paleothermal studies.

Since many years, the conodonts are used for the biostratigraphy of Paleozoic and Triassic rocks. Recently, the conodonts have also been used for determination of the degree of heating of the rocks (Epstein

& *al.* 1977, Bergström 1980). This method is founded upon the temperature-induced color alteration of conodonts, recognized by Epstein & *al.* (1977), who leading the laboratory experiments and field observations demonstrated that the color alteration of conodonts is time and temperature dependent (*cf.* Text-fig. 4), and thus it is directly related to the depth and duration of burial, and to the geothermal gradient. The color intervals distinguished by these authors were termed as color alter-

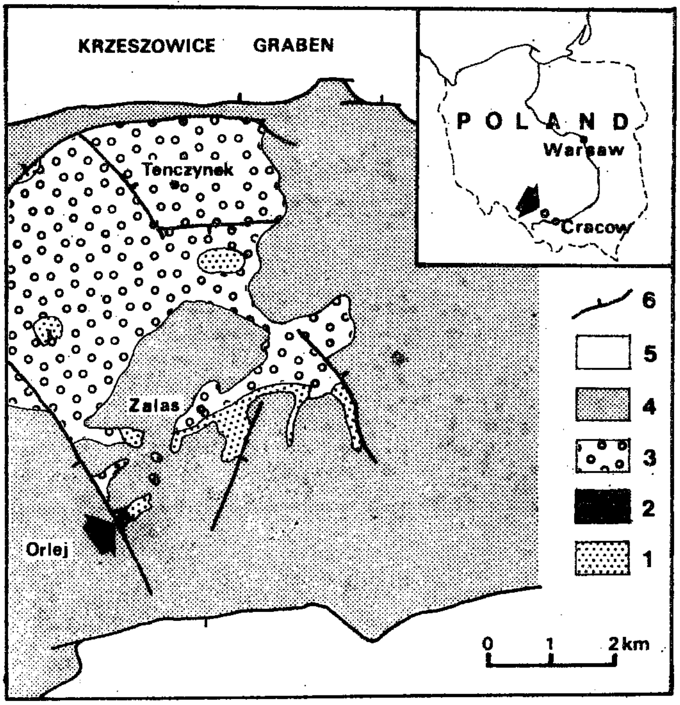

Fig. 1. Geological map of the area south of Krzeszowice in the Cracow Upland, with location of the Upper Viséan sequence exposed at the Orlej Quarry

1 Permian (volcanic rocks, the Zalas porphyry including), *2* Upper Viséan, *3* Namurian and Westphalian, *4* Jurassic, *5* Miocene, *6* faults

ation indexes (*CAI*). The index values correspond to progressive and irreversible color changes from pale yellow (*CAI* = 1) through black (*CAI* = 5) to crystal clear (*CAI* = 8). This method is particular useful for assessing organic metamorphism, because it is more rapid and inexpensive than other organic maturity indexes. Moreover, the color alteration of conodonts provide thermal cutoffs for oil and gas and it allows to recognize the thermal history in areas of ancient igneous activity (Epstein & *al.* 1977).

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GEOLOGICAL SETTING

Near the village Zalas, in the southern Cracow Upland, there appears the porphyric intrusion covered by transgressive Jurassic deposits (Text-fig. 1). According to Dżułyński (1955), the porphyries, about 100 m in thickness, sticking amid the Carboniferous rocks are subvolcanic intrusion of a laccolithic type. The age of the intrusion has hitherto not been precisely determined. Siedlecki (1954) supposed that the origin of the Zalas intrusion was connected with the Asturian phase (Stephanian) or with the Saalian phase (Permian), similary to what is the Variscan age of the majority of intrusive rocks in the Cracow Upland.

In the Orlej Quarry, the Zalas porphyries contacted with a sequence of black shales, over 100 m in thickness (Text-figs 1—2); the outcrop was described in detail by Dżułyński (1955) and Piłat (1957). In the contact aureole, which is about 40 m thick, there occur shales showing thermal changes indicated by intensive silification. Among the black unmetamorphosed shales, to continue the section, there occur two limestone layers (5 in Text-fig. 2). The shales which under- and overlie the limestones are richly fossilliferous. Thousands specimens of more than hundred species of macrofauna have been collected, mainly gastropods, pelecypods, trilobites, corals, bryozoans, blastoids, nautiloids, and brachiopods indicative of the uppermost Viséan (Czarniecki 1955, 1956; Gromczakiewicz-Łomnicka 1972). In the majority of cases the macrofossils were very well preserved. Unfortunately, the fossilliferous shales are not accessible at the present time. The limestones, to the contrary, are very poor in macrofaunal remains, being representative of a plant-dominated community. These are strongly bituminous algal-foraminiferal boundstones. The most important rock constituents are a few centimeters high mounds built by the red alga *Archaeolithophy-*

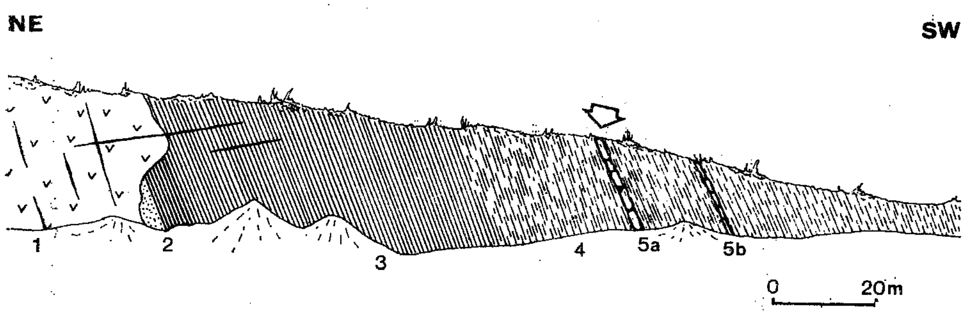


Fig. 2. Geological section showing the Upper Viséan deposits contacted by the porphyric intrusion in the Orlej Quarry (*after:* Dżułyński, 1955; *simplified*)

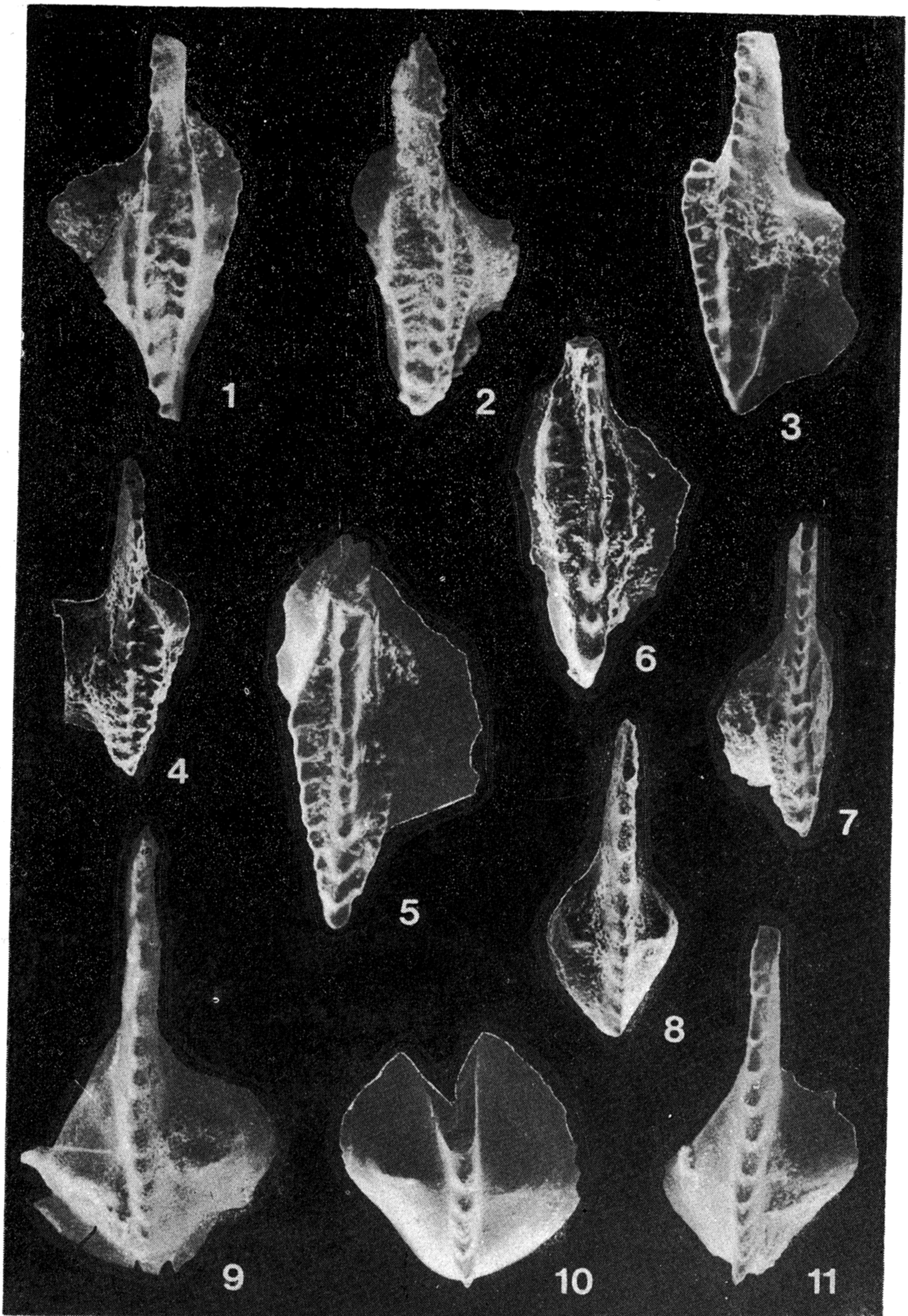
1 Zalas porhyry, *2* sandstones, *3* silicified shales (thermally metamorphosed), *4* argillaceous shales (unmetamorphosed), *5a, b* algal-foraminiferal boundstones (the conodont-bearing layer is arrowed) *llum*, encrusting foraminifer *Aphralysia*, and tubiform bluegreen algae referred to as *Girvanella* by Bełka (1981). Formerly, these structures were interpreted incorectly as stromatoporoids (Czarniecki 1955, 1956; Dżułżyński 1955). The Orlej sequence represents the only outcrop of the Culm facies to be supported by paleontological evidence on the east fringe of the Upper Silesian Coal Basin.

Analogical facies to that occurring in the Orlej Quarry is widely extended in the Upper Pennsylvanian of North America, where the sets ("mounds") of phylloid algal limestones are developed in much bigger proportion (Heckel & Cocke 1969). These carbonate bodies dominated by such leaflike or phylloid algae as *Archaeolithophyllum* indicate shallow-water marine conditions (Wray 1964; Heckel & Cocke 1969; Toomey 1976, 1979), featured probably by limited water circulation and relativly high rate of deposition. The sediments surrounding the phylloid algal mounds, mainly shales or calcilutitic limestones, are more open-marine. According to Heckel & Cocke (1969), these sediments were deposited more slowly in slightly deeper water, where greater water circulation provided nutrients for more diverse and widespread biota. Phylloid algal-mound complexes of the Upper Pennsylvanian occur between the open-marine limestone facies and the terrigenous clastic facies. Their location in the upper part of limestone units is interpreted by Fischer (1961) as a regresive feature of carbonate sedimentation.

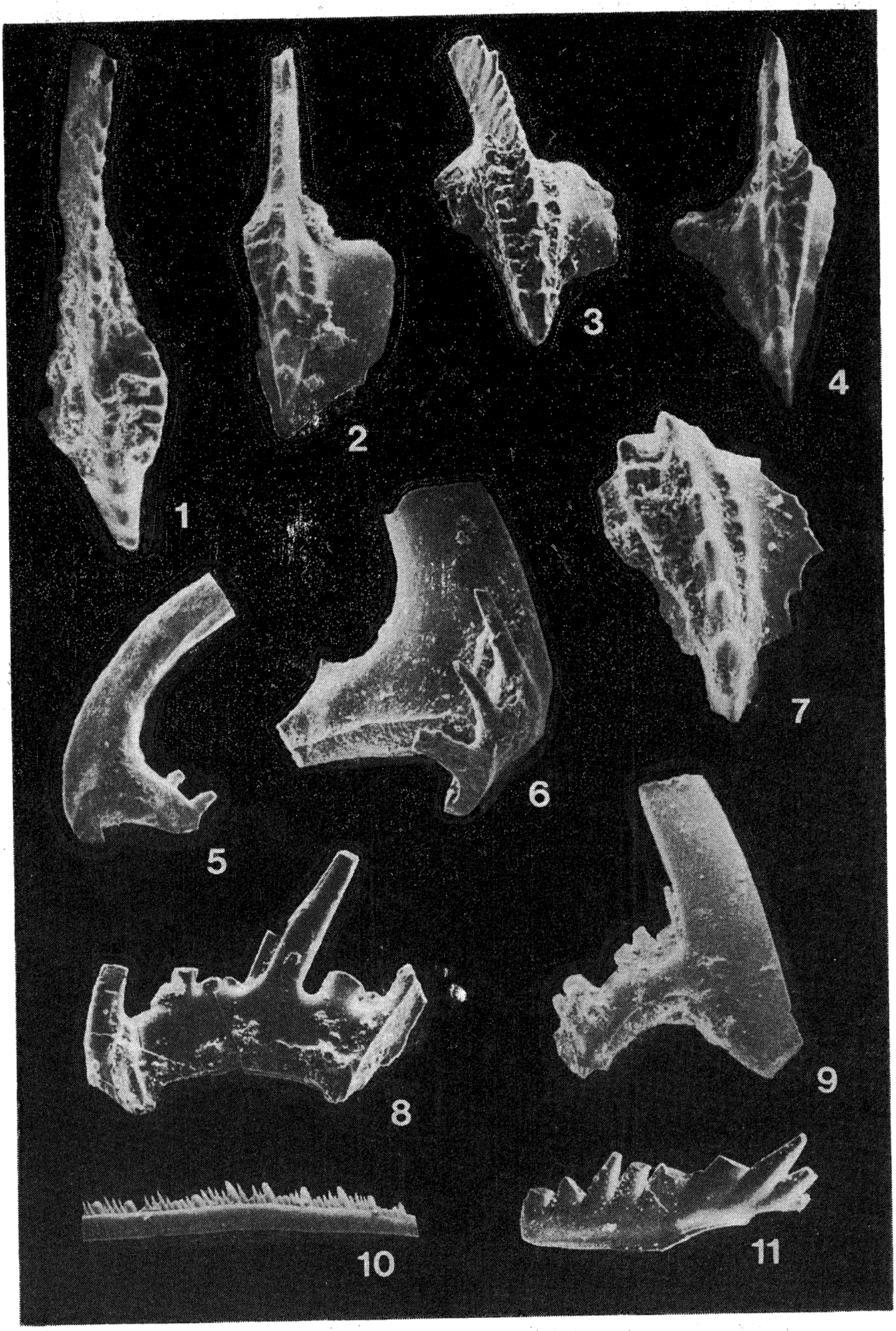
CONODONT FAUNA AND STRATIGRAPHY

The conodont were collected from the algal-foraminiferal boundstones occurring 80 m off the porphyric intrusion in the Orlej Quarry (layer *5a* in Text-fig. 2). A four-kilogram sample was procesed for conodonts, and the following forms were recovered:

	Number of specimens
Gnathodus girtyi girtyi Hass	7
Gn. girtyi collinsoni Rhodes, Austin & Druce	1
Gn. girtyi meischneri Austin & Husri	1
Gn. girtyi rhodesi Higgins	1
Hindeodella ibergensis Bischoff	3
Hindeodella sp.	6
Ligonodina levis Branson & Mehl	1
Ligonodina sp.	2
Neoprioniodus peracutus (Hinde)	1
Ozarkodina cf. plana (Huddle)	1
Paragnathodus commutatus (Branson & Mehl)	2
P. mononodosus (Rhodes, Austin & Druce)	1
P. nodosus (Bischoff)	2



1 — *Gnathodus girtyi meischneri* Austin & Husri; × 115
2—7 — *Gnathodus girtyi girtyi* Hass; 2 — × 80, 3 — × 80, 4 — × 40, 5 — × 115, 6 — × 90, 7 — × 65
8—9 — *Paragnathodus nodosus* (Bischoff); 8 — × 85, 9 — × 90
10 — *Paragnathodus mononodosus* (Rhodes, Austin & Druce); × 100
11 — *Paragnathodus commutatus* (Branson & Mehl); × 100



1 — *Gnathodus girtyi collinsoni* Rhodes, Austin & Druce; × 95; **2** — *Gnathodus girtyi rhodesi* Higgins; × 90; **3** — *Gnathodus girtyi girtyi* Hass; × 60; **4** — *Gnathodus girtyi meischneri* Austin & Husri; × 105; **5** — *Ligonodina* ? sp.; × 40; **6** — *Ligonodina levis* Branson & Mehl; × 80; **7** — *Gnathodus girtyi girtyi* Hass; × 120; **8** — *Hindeodella ibergensis* Bischoff; × 75; **9** — *Neoprioniodus peracutus* (Hinde); × 70; **10** — *Hindeodella* sp.; × 70; **11** — *Ozarkodina* cf. *plana* (Huddle); × 80

The majority of the obtained forms are characteristic of the Upper Viséan/Early Namurian time. However, only two of the subspecies are sufficiently restricted in their ranges to be important for precise correlation. These are *Gnathodus girtyi collinsoni* and *Gnathodus girtyi rhodesi* which indicate that Orlej fauna represents the *Gnathodus girtyi collinsoni* Zone (*sensu* Higgins 1975). This zone was proposed by Rhodes, Austin & Druce (1969) to include the upper part of the D_3 Zone in the Lower Carboniferous of England (*cf.* Text-fig. 3), and its lower limit was taken at the first appearance of *Gn. girtyi collinsoni*. The upper limit of the zone has not been defined at that time. The subspecies *Gnathodus girtyi collinsoni* Rhodes, Austin & Druce occurs primarily in the uppermost Viséan (*cf.* Gromczakiewicz-Łomnicka 1974, Higgins 1975, Skompski & Soboń-Podgórska 1980, Tynan 1980), but in Ireland it has been recorded from the Pendleian (E_1) stage (Aldridge, Austin & Husri 1968; Austin & Husri 1974). Therefore, Higgins (1975) restricted the stratigraphic range of *Gn. girtyi collinsoni* Zone to have its upper limit marked by the first appearance of *Gnathodus girtyi simplex;* this limit being simultaneously coincident with the Viséan/Namurian boundary (*cf.* Text-fig. 3).

The second subspecies, *Gnathodus girtyi rhodesi* Higgins has hitherto been noted only from the uppermost Viséan deposits (Higgins & Bouckaert 1968, Higgins 1975; Ramsbottom, Higgins & Owens 1969), so

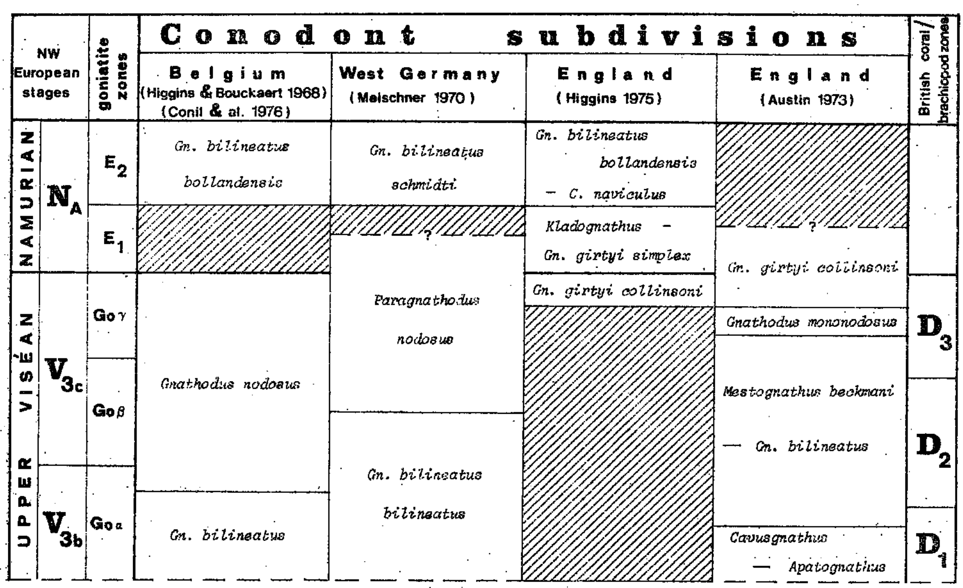


Fig. 3. Correlation of conodont subdivisions and macrofaunal zones of late Viséan/early Namurian age in western Europe

it co-occurs with *Gn. girtyi collinsoni* within the *Gnathodus girtyi collinsoni* Zone (*sensu* Higgins 1975).

In other regions of Europe, the uppermost conodont zone of the Viséan is based on the occurrence of *Paragnathodus nodusus* (= *Gnathodus nodosus*, = *Gnathodus commutatus nodosus*) which commonly occurs with *Gn. girtyi collinsoni*. This zone in Spain and Portugal embraces the range of index species (Higgins 1974), but in Belgium (Higgins & Bouckaert 1968), West Germany (Meischner 1970), Austria (Ebner 1977), and in the Pyrénées (Buchroithner 1979) it is a partial range zone, the upper limit of which is placed by authors differently, at the first appearance of the index species diagnostic for the locally accepted conodont zone. Similary to that, the position of the lower limit of *Paragnathodus nodosus* Zone in particular countries is diachronous (*cf.* Text-fig. 3). The *Paragnathodus nodosus* Zone in West Germany has its lower limit in the middle of Goβ (Meischner 1970) for instance, but in Belgium it already starts in Goα (*cf.* Conil & *al.* 1976). Nevertheless it seems, that differences in location of the lower limit of *P. nodosus* Zone result rather from the errors in correlation of particular conodont subdivisions with standard goniatite zonation than they are conditioned by natural facies or evolutionary factors. Different location of the lower and upper limits of the *Paragnathodus nodosus* Zone cause that *Gnathodus girtyi collinsoni* Zone (*sensu* Higgins 1975) established in the Pennines, corresponds either to the upper part of the *P. nodosus* Zone or, in other cases, to another part of that zone (*cf.* Text-fig. 3).

The fauna with *Gn. girtyi collinsoni* has also been described from North America; it occurs in the lower part of the Upper Zone *A* (Tynan 1980) correlated to the uppermost Viséan, that is identicly as in England.

Czarniecki (1955, 1956), basing mostly on the brachiopod fauna, determined the sequence of Orlej as the uppermost Viséan, corresponding to the D_2—D_3 Zones of coral/brachiopod zonation in England. The recovered conodont fauna allows to precise the age solely to the upper part of the D_3 Zone, being an equivalent to the *Gnathodus girtyi collinsoni* Zone (*cf.* Text-fig. 3).

Consequently, it is concluded that the Orlej sequence displays the same age as the Carboniferous Limestone deposits cropping out to the SE of the quarry „Nad Młynówką", north of the Krzeszowice graben (Gromczakiewicz-Łomnicka 1974). It represents the transitional shallow--water facies which was located between the terrigenous clastic facies and the open marine carbonates. The other outcrops of the Lower Carboniferous deposits in the Cracow Upland yield the conodont faunas indicative of the Tournaisian and the Lower to Middle Viséan, i. a. they are evidently older (Gromczakiewicz-Łomnicka 1974, 1979).

PALEOTHERMAL ANALYSIS

The conodonts from Orlej are generally black in color. With reference to the color alteration index, the conodonts have the *CAI* value between 4.5 and 5. Their color is due to thermal influence of the Zalas intrusion to the uppermost Viséan rocks, and not due to their burial because the Carboniferous and Devonian conodonts known from several outcrops north of the Krzeszowice graben, have the *CAI* indexes not higher than 2. Nothing is indicated as well that at any time the thickness of the post-Viséan deposits in the Zalas area was distinctly greater than that of the deposits north of the Krzeszowice graben.

The extreme temperature and time values of thermal influence of the subvolcanic intrusion to the conodont-bearing layer were determi-

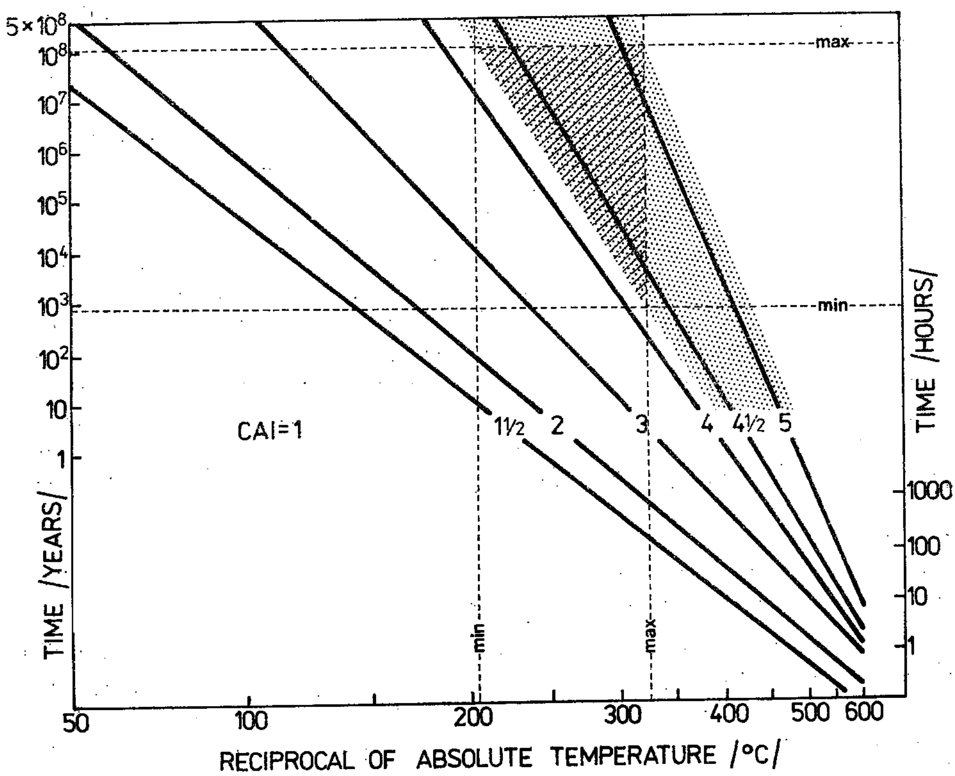


Fig. 4. Ahrrenius plot of conodont color alteration prepared by Epstein & *al.* (1977) on the laboratory experiments of conodont heating in open-air; diagonal lines indicate the color alteration index (*CAI*); color intervals based on Munsell soil color chips; at *CAI* = 4 to *CAI* = 5 conodont color is black

The field of color alteration for the Orlej conodonts, is stippled; the usage of this plot for determination of minimum and maximum temperatures and time ranges (*shaded triangle*) for the Upper Viséan conodonts from Orlej is explained in the text ned, based on the plot of color alteration indexes (Text-fig. 4) prepared by Epstein & *al.* (1977). It is possible to enumerate the maximum possible time of the thermal activity of the intrusion basing on the geological data. The intrusion sticks amid the Upper Viséan and Namurian rocks. Its Carboniferous cover at the roof was removed before the Jurassic, so the maximum possible time of thermal influence of the intrusion was not longer than about 110 m. y., the period between the Namurian and the Jurassic. The line of 110 m. y. yields to the x_1 axis the maximum temperature value of 325° C. It is true, that for the field of CAI = 4.5—5 much higher temperatures are possible, for all it seems that the algal-foraminiferal boundstones have never heated over the temperature of about 300° C. The following facts advocate that:

(*i*) There is no evidence of the epigenetic changes evoked by contact metamorphism in this layer. Sedimentary features, microfauna and calcareous algae are exceptionally well preserved, and therefore the colonies of *Aphralysia* have retained original wall microstructure, which allowed to recognize their foraminiferal nature (Bełka 1981).

(*ii*) In the conodont-bearing layer calcite is the most frequent mineral (about 85%). Moreover, these rocks contain dolomite, and X-ray analysis of insoluble parts in the < 2 μm fraction has displayed the presence of illite, chlorite, pyrite, quartz and apatite. Among these minerals there are no associations specific of the facies of the weakest metamorphism forming over the temperature of 300° C (*cf.* Turner & Verhoogen 1960).

(*iii*) Similar temperature data is shown by illite occurring in the algal-foraminiferal boundstones. It is frequently used to determine the degree of weak metamorphism. The "illite crystallinity" has commonly been used as an evidence of metamorphic recrystallization (*cf.* Dunoyer de Segonzac 1970). This parameter can be studied from the shape of illite 001 peak at 10 Å. The illite determination in this study was made according to method of Gill & *al.* (1977). The illite crystallinity in the layer of algal-foraminiferal boundstones shows the value of 3.8 indicative of the anchizone, which is the transition zone between the late diagenesis and the epizone of regional metamorphism. The anchizone is placed about temperature of 200° C. The above values correspond to the processes of the regional metamorphism, but we indirectly can use them because the illite crystallinity is temperature depedent first of all (Dunoyer de Segonzac 1970).

The temperature of 325°C is very probable as the maximum possible temperature of heating of the conodont-bearing layer. Both lines of temperature and time maximum bound the triangle (Text-fig. 4), the corners of which mark the minimum values of temperature (210°C) and of the time (800 years). The real parameters of the thermal activity of the intrusion to the limestone layer correspond to the points lying within this triangle.

If the plot of Epstein & *al.* (1977) is correct for the longtime intervals, one may conclude that the conodont-bearing layer of algal-foraminiferal boundstones was heated over the temperature of 210°C, but not higher than 300°C in the period between 800 years and 110 m. y. The real time of the thermal activity of the intrusion to the limestone layer is certainly related to minimum time value.

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REFERENCES

ALDRIDGE R. J., AUSTIN R. L. & HUSRI S. 1968. Viséan conodonts from North Wales and Ireland. *Nature,* **219,** 255—258. London.

AUSTIN R. L. 1973. Modification of the British Avonian conodont zonation and a reappraisal of European Dinantian conodont zonation and correlation. *Ann. Soc. Géol. Belgique,* **96** (3), 523—532. Brussels.

— & HUSRI S. 1974. Dinantian conodont faunas of Country Clare, Country Limerick and Country Leitrim. An appendix. *Int. Symp. Belg. Micropal. Lim. "Namur 1974",* **3,** 18—64. Brussels.

BEŁKA Z. 1981. The alleged algal genus *Aphralysia* is a foraminifer. *N. Jb. Geol. Paläont. Mh.,* 1981 (5), 257—266. Stuttgart.

BERGSTRÖM S. M. 1980. Conodont color alteration as indicator of incipient metamorphism in Ordovician rocks in Scandinavia and the British Isles. *Abh. Geol. Bundesanst.,* **35,** 185—186. Vienna.

BUCHROITHNER M. F. 1979. Die Conodontenchronologie im Karbon der Pyrenäen. *Mitt. Österr. Geol. Ges.,* **70,** 75—118. Vienna.

CONIL R., GROESSENS E. & PIRLET H. 1976. Nouvelle charte stratigraphique du Dinantien type de la Belgique. *Ann. Soc. Géol. Nord,* **96,** 363—373. Lille.

CZARNIECKI S. 1955. Lower Carboniferous fauna in the Culm facies of the eastern Upper Silesian Coal Basin. *Bull. Acad. Pol. Sci.,* **3** (8), 461—464. Warszawa.

— 1956. Lower Carboniferous fauna from the Culm deposits of the eastern part of the Upper Silesian Coal Basin [*in Polish*]. *Przegl. Geol.,* **1956** (4), 177—178. Warszawa.

DUNOYER de SEGONZAC G. 1970. The transformation of clay minerals during diagenesis and low-grade metamorphism: A review. *Sedimentology,* **15** (3—4), 281—346. Amsterdam.

DŻUŁYŃSKI S. 1955. On the geological form of the porphyry in the vicinity of Zalas (Cracow region) [*in Polish*]. *Biul. I. G.,* **97,** 9—38. Warszawa.

EBNER F. 1977. Die Gliederung des Karbons von Graz mit Conodonten. *Jahrb. Geol. B.-A.,* **120** (2), 449—493. Vienna.

EPSTEIN A. G., EPSTEIN J. B. & HARRIS L. D. 1977. Conodont color alteration — an index to organic metamorphism. *Geol. Surv. Prof. Paper,* **995,** 1—27. Washington.

FISCHER A. G. 1961. Stratigraphic record of transgressing seas in light of sedimentation on Atlantic coast of New Jersey. *Amer. Ass. Petrol. Geol. Bull.,* **45** (10), 1656—1666. Tulsa.

GILL W. D., KHALAF F. I. & MASSOUD M. S. 1977. Clay minerals as an index of the degree of metamorphism of the carbonate and terrigenous rocks in the South Wales coalfield. *Sedimentology,* **24** (4), 675—691. Amsterdam.

GROMCZAKIEWICZ-ŁOMNICKA A. 1972. Viséan gastropods from Orlej near Cracow. *Prace Muz. Ziemi,* **20,** 3—44. Warszawa.

— 1974. Upper Viséan conodont fauna from the Carboniferous Limestone north of Krzeszowice (environs of Cracow, Poland). *Ann. Soc. Géol. Pologne,* **44** (4), 475—482. Kraków.

— 1979. Conodont stratigraphy of the Uppermost Devonian and Lower Carboniferous rocks in the Racławka and Szklarka valleys west of Cracow. *Acta Geol. Polon.,* **29** (4), 489—487. Warszawa.

HECKEL P. H. & COCKE J. M. 1969. Phylloid algal-mound complexes in outcropping Upper Pennsylvanian rocks of Mid-Continent. *Amer. Ass. Petrol. Geol. Bull.,* **53** (5), 1058—1074. Tulsa.

HIGGINS A. 1974. Conodont zonation of the Lower Carboniferous of Spain and Portugal. *Int. Symp. Belg. Micropal. Lim. "Namur 1974",* **4,** 1—17. Brussels.

— 1975. Conodont zonation of the late Viséan — early Westphalian strata of the south and central Pennines of northern England. *Bull. Geol. Surv. Gr. Brit.,* **53,** 1—90. London.

— & BOUCKAERT J. 1968. Conodont stratigraphy and palaeontology of the Namurian of Belgium. *Mem. Expl. Cartes Géol. Min. Belgique,* **10,** 1—64. Brussels.

MATYJA H. & NARKIEWICZ M. 1979. Lithofacies and conodonts in Viséan profile, Olkusz area, southern Poland. *Acta. Geol. Polon.,* **29** (4), 475—488. Warszawa.

MEISCHNER D. 1970. Conodonten-Chronologie des deutschen Karbons. *C.-R. 6e Congr. Inter. Strat. Géol. Carbon., Sheffield 1967,* **3,** 1169—1180. Sheffield.

PIŁAT T. 1957. Porphyric pebbles from the shales of the Upper Viséan of the region of Zalas (Cracow region) [*in Polish*]. *Biul. I. G.,* **115,** 167—194. Warszawa.

RAMSBOTTOM W. H. C., HIGGINS A. C. & OWENS B. 1979. Palaeontological characterisation of the Namurian of the stratotype area (a report of the Namurian Working Group). *C.-R. 8e Congr. Inter. Strat. Géol. Carbon., Moscow 1975,* **3,** 85—99. Moscow.

RHODES F. H. T., AUSTIN R. L. & DRUCE E. C. 1969. British Avonian (Carboniferous) conodonts faunas and their value in local and intercontinental correlation. *Bull. British Museum (Nat. Hist.), Geology,* Suppl. 5, 1—313. London.

SIEDLECKI S. 1954. Paleozoic formations of the Cracow region [*in Polish*]. *Biul. I. G.,* **73,** 1—415. Warszawa.

SKOMPSKI S. & SOBOŃ-PODGÓRSKA J. 1980. Foraminifers and conodonts in the Viséan deposits of the Lublin Upland. *Acta Geol. Polon.,* **30** (1), 87—96. Warszawa.

TOOMEY D. F. 1976. Paleosynecology of a Permian plant dominated marine community. *N. Jb. Geol. Paläont. Abh.,* **152** (1), 1—18. Stuttgart.

— 1979. Role of archaeolithophyllid algae within a late Carboniferous algal-sponge community, southwestern United States. *Bull. Cent. Rech. Explor.-Prod. Elf-Aquitaine,* **3** (2), 843—853. Pau.

TURNER J. T. & VERHOOGEN J. 1960. Igneous and metamorphic petrology; *2nd ed.* New York.

TYNAN M. C. 1980. Conodont biostratigraphy of the Mississippian Chainman Formation, western Millard Country, Utah. *J. Paleont.,* **54** (6), 1282—1309. Tulsa.

WRAY J. L. 1964. *Archaeolithophyllum,* an abundant calcareous alga in limestones of the Lansing Group Pennsylvanian, southeastern Kansas. *Kansas Geol. Surv. Bull.,* **170** (1). 1—13. Lawrence.

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GÓRNOWIZEŃSKIE KONODONTY Z ORLEJA NA WYŻYNIE KRAKOWSKIEJ JAKO WSKAŹNIK STRATYGRAFICZNY I PALEOTERMICZNY

(Streszczenie)

W osadach górnego wizenu kontaktujących z intruzją porfirów zalaskich w kamieniołomie Orlej (fig. 1—2) stwierdzono obecność konodontów (*por.* pl. 1—2). Pozwalają one precyzyjniej określić wiek tych osadów odpowiadający zonie *Gnathodus girtyi collinsoni* w podziale Higginsa (1975), która stanowi najwyższą konodontową zonę wizenu (*por.* fig. 3).

Ławica wapieni algowych zawierających konodonty została poddana termicznemu oddziaływaniu intruzji zalaskiej, co wywołało zmianę barwy konodontów na czarną. Dzięki zastosowaniu wykresu skonstruowanego przez Epsteina & *al.* (1977), który pokazuje zmiany barw konodontów w zależności od czasu i temperatury (*por.* fig. 4), wykazano, że ławica wapieni algowych z Orleja była podgrzana powyżej 210°C (lecz nie ponad 325°C) przez okres nie krótszy niż 800 lat.