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REVISION OF AGE OF THE RADZIMOWICE SLATES FROM GÓRY KACZAWSKIE MTS (WESTERN SUDETES, POLAND) BASED ON CONODONTS

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Abstract: Conodont (euconodont) elements were found in a sericite-quartz-albite phyllite of the Góry Kaczawskie metamorphics, near Wojcieszów. The phyllite belongs to the Radzimowice slates hitherto assigned to the Upper Proterozoic (Eocambrian). These fossils indicate that the Radzimowice slates represent an undetermined part of the Palaeozoic, at least in part not older than early Ordovician.

Key words: Palaeozoic stratigraphy, conodonts, Góry Kaczawskie metamorphics.

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INTRODUCTION

The Radzimowice slates (Altenberger Schiefer of German geologists) or Radzimowice beds represent a formation consisting predominantly of dark sericite-quartz--albite phyllites. Lenses or irregular bodies of greenstones, sericite-quartz-chlorite--albite phyllites, crystalline limestones, and interbeds of siliceous slates occur subordinately. The present paper discusses, on the basis of conodont studies, the age of the Radzimowice slates, or, more precisely, the age of the sericite-quartz-albite phyllites.

The geologists studying the Radzimowice slates disagree about the mappable extent of the formation. However, the conodont sample localities (Figs. 1, 2) on all the maps (Zimmermann & Berg, 1932; Block, 1938; Teisseyre, 1963; Baranowski, in preparation) always occur within areas hachured as the Radzimowice slates (Fig. 2).

Conodonts were found in the course of geological investigations of the discussed formation carried out in the last few years by Z. Baranowski. The work on conodonts has been done and stratigraphic conclusions have been formulated by Z. Urbanek.

All the illustrated specimens belong to the collection ZGS (U. 81) housed in the Institute of Geological Sciences of the University of Wrocław.

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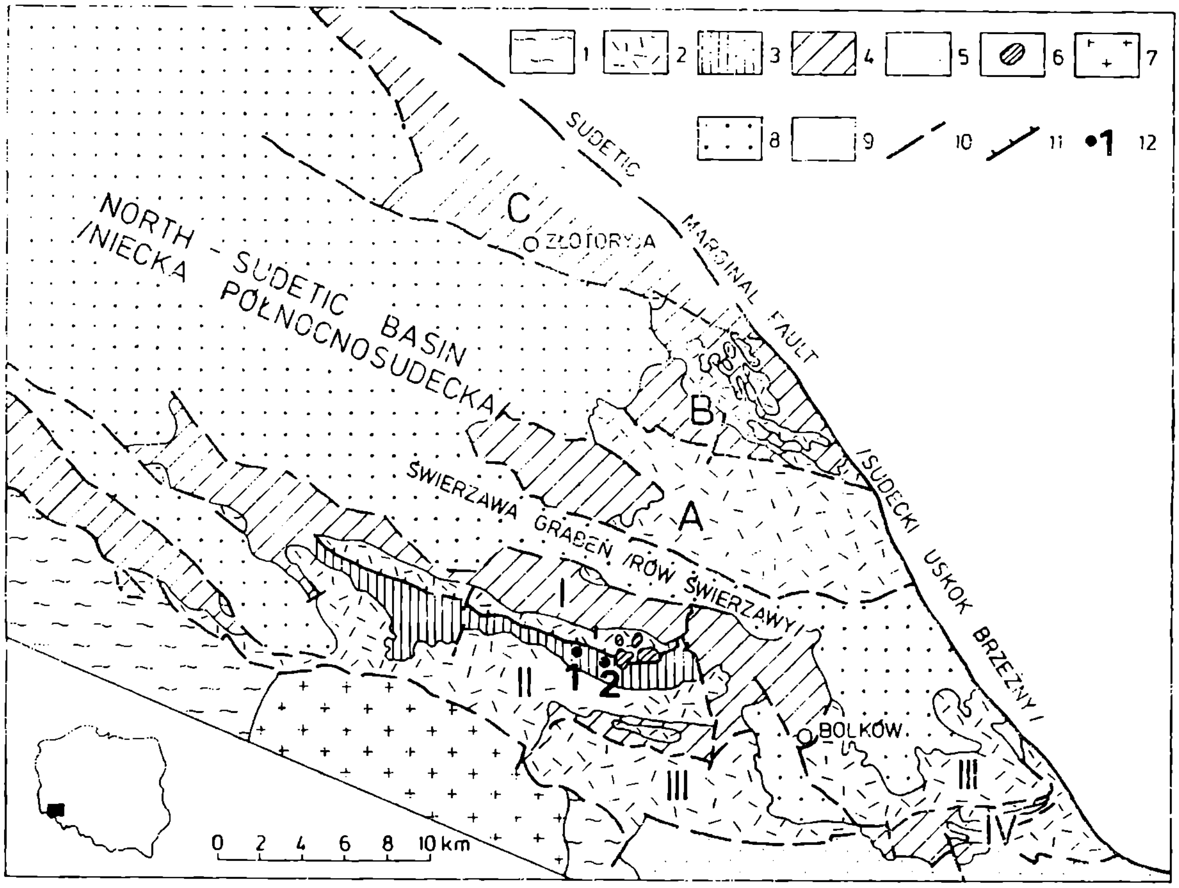

Fig. 1. Tectonic sketch-map of the Góry Kaczawskie Mts (after Geological Map of the Lower Silesia edited by L. Sawicki, 1966). *1* — mica schists and gneisses of the Karkonosze Granite envelope (Precambrian?); *2* — metavolcanic rocks and crystalline limestones of the lower structural stage of the Góry Kaczawskie Mts (Cambrian); *3* — Radzimowice slates (undefined Paleozoic); *4* — metasedimentary rocks (without Radzimowice slates) of the lower structural stage of the Góry Kaczawskie (Ordovician—Upper Devonian); *5* — sedimentary rocks of the Świebodzice depression and Intra-Sudetic depression (Upper Devonian—Carboniferous); *6* — Variscan porphyries; *7* — Karkonosze Granite; *8* — sedimentary rocks of the upper structural stage of the Góry Kaczawskie Mts (Upper Carboniferous, Permian, Triassic, Upper Cretaceous); *9* — sedimentary rocks (Tertiary, Quaternary); *10* — faults; *11* — overthrust; *12* — conodont sample sites; *I* — Świerzawa unit; *II* — Bolków unit; *III* — Dobromierz unit; *IV* — Cieszów unit; *A* — Rzeszówek —Jakuszowa unit; *B* — Chełmiec unit; *C* — Złotoryja—Luboradz unit

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GEOLOGICAL POSITION

The Radzimowice slates represent a part of the lower, epimetamorphic structural stage of the Góry Kaczawskie Mts. They occur in the southern part of the region, south of the Świerzawa graben. The southern part of the Góry Kaczawskie lower structural stage is composed of nappes (Schwarzbach, 1939, Teisseyre, 1956). Teisseyre (1956) distinguished in the eastern part of this area four geological units of

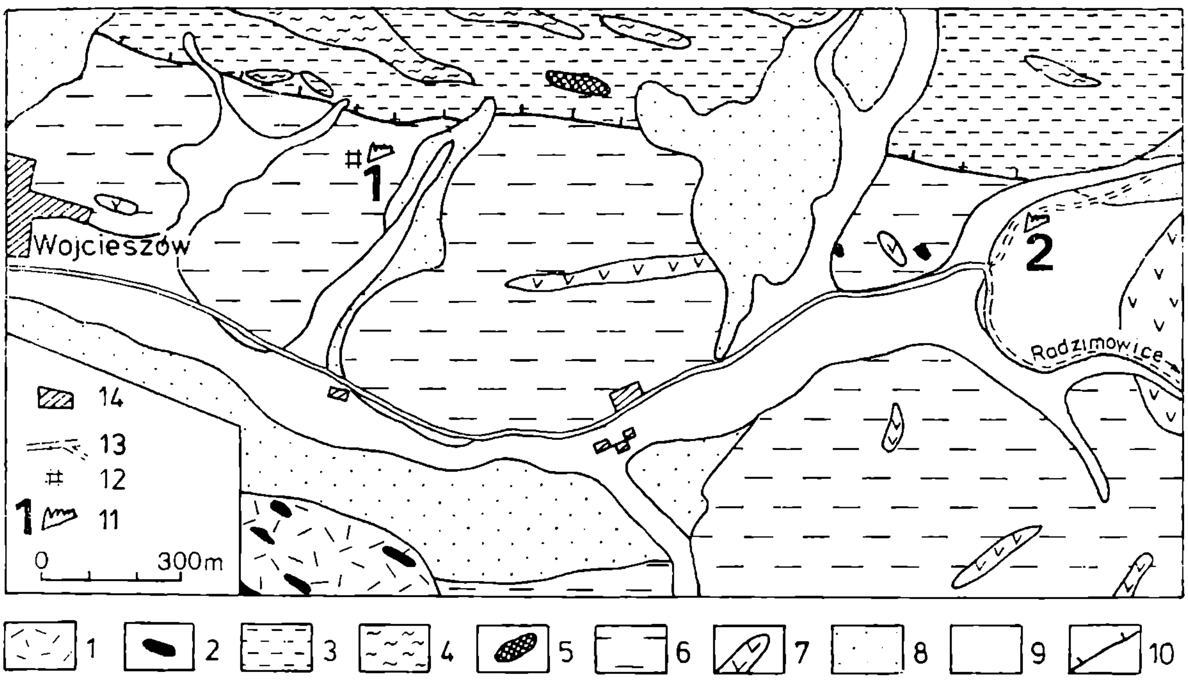

Fig. 2. Geological sketch-map of Wojcieszów region. *1* — greenstones; *2* — crystalline limestones; *3* — sericite-quartz-albite phyllites; *4* — sericite-quartz-albite-chlorite phyllites; *5* — porphyroids; *6* — Radzimowice slates; *7* — Variscan porphyries; *8* — fluvio-glacial deposits and loam; *9* — alluvium; *10* — over-thrust; *11* — conodont sample sites; *12* — pits; *13* — roads; *14* — buildings

the nappe type. According to him, the Radzimowice slates belong to the Bolków unit which was thrust southward over the lovermost Świerzawa unit. The Bolków unit was in turn overthrust by the Dobromierz unit and the Cieszów unit (Fig. 1).

PREVIOUS VIEWS ON AGE OF THE RADZIMOWICE SLATES

The Radzimowice slates have been commonly considered to be of Precambrian age. Zimmermann (1918) who introduced the term "Radzimowice slates" and mapped in detail their occurrences (Zimmermann & Haack, 1929; Zimmermann, 1932; Zimmermann & Berg, 1932) described them jointly with other metamorphic rocks as "Early Paleozoic deposits of unspecified age". Other authors (Bederke, 1933; Dahlgrün, 1934; Schwarzbach, 1935; Block, 1938; Schwarzbach, 1939) ascribed the Radzimowice slates to the Algonkian on the basis of their supposed tectonic position (saddle core), relatively stronger tectonization and metamorphism, and lithologic correlations with the Thuringian region. Although Zimmermann (1941) criticized these criteria, he eventually accepted the notion that the Radzimowice slates were of Algonkian age.

Teisseyre (1956) observed that there was no disconformity between the Radzimowice slates and the overlying so-called Lindenweg series, which was envisaged by Block (1938). This is why Teisseyre (1956) assigned the Radzimowice slates, which he referred to as Radzimowice beds, to the Eocambrian. Taking into account that the slates contained lenses of different rocks which in other parts of the Góry Kaczawskie Mts were ascribed to various systems of the Palaeozoic, he came out with an idea that the entire complex under question represented a tectonic formation composed of Eocambrian, Cambrian and Silurian rocks. The view that the Radzimowice slates were of the Eocambrian age was maintained in the later papers by this author (Teiysseyre, 1963, 1967, 1968, 1975, 1980). Oberc (1968) emphasized lithological similarities of a significant portion of the Radzimowice slates to rocks which in the Sudetes were commonly assigned to the Ordovician. But later he abandoned this view and suggested that the Radzimowice slates were of Proterozoic age and belonged to the Early Assyntian (Early Baikalian, Early Cadomian) tectogene forming the pre-Variscan basement of the Sudetes (Oberc-Dziedzic & Oberc, 1972; Oberc, 1973, 1980).

LITHOLOGY

The rocks named Radzimowice slates are sericite-quartz-albite phyllites. They are dark gray to gray black, with lighter laminae 1—5 mm thick, foliated, folded, and cleaved. Dark laminae consist of white mica (sericite, occasionally muscovite), scarce chlorite, variable amount of blasts of secondary albite, single grains and concentrations of quartz, and streaks of graphite. Light laminae are composed of quartz grains of silt size, with interwoven sericite and chlorite shreds as well as albite blasts. The light laminae make up 10 to 40% of the rock. The Radzimowice slates contain also carbonates, and sporadic pleochroic mineral occurring in fine scales — biotite or stilpnomelane, with varying amount of opaque minerals.

The rock is strongly disturbed and the laminae are commonly disrupted and squeezed into lenses. Secondary recrystallizational lamination parallel to the cleavage planes is frequently developed. Intense tectonization, both megascopic and microscopic, appears as very characteristic feature of the Radzimowice slates in all their outcrops.

There are many varieties of the Radzimowice slates differing from these described above by more intense albite blastesis, variable amount of graphite, and different silt/clay ratio in the primary sediment. Conodont fragments were extracted from the variety characterized by scarce presence of blastic albite and insignificant amount of the light laminae.

The mineral composition of the Radzimowice slates indicates a low-grade greenschist metamorphism, but no detailed account of their metamorphic transformations has been given. The recognized paragenesis quartz-muscovite-chlorite-albite-(stilpnomelane? biotite?) is also reported from the neighbouring areas. Thus the notion that the Radzimowice slates show a higher metamorphic grade seems unfounded. This problem should be investigated separately, the more so that contact metamorphic phenomena can be observed close to large porphyry bodies of the Mount Żeleźniak (Fig. 1).

METHOD OF PREPARATION

Twenty-five rock samples, 0.5 to 1.5 kg in weight, from different lithological varieties of the Radzimowice slates were processed, but only four of them yielded conodont fragments. All the productive samples were the sericite-quartz-albite phyllites described above. The samples were subjected to manifold etching in 10–20% hydrofluoric acid for 10–45 minutes. The rock dissolved very slowly because of its mineral composition, providing merely 10–25% of its bulk in sufficiently desintegrated form. Repeated and relatively long etching produced very fragile fragments of conodonts breaking into pieces when touched with a needle.

DESCRIPTION OF THE MATERIAL

All obtained specimens (ca. 200 pieces) are severely injured. Only a few of them display easily recognizable shapes of conodont elements 0.2–0.4 mm long (Pl. I: 1a, 2a, 3; Pl. III: 3). Most specimens are represented by small fragments of cusps or denticles with transversal and more rarely longitudinal fracturing. These fragments are 0.07–0.2 mm in diameter and 0.1–0.25 mm high. The remarkable comminution of the conodonts is caused by numerous transversal fractures which are well visible in both thin sections (Pl. III: 1, 4; Pl. IV; 2, 3) and in some specimens (Pl. I: 2a, 3; Pl. II: 3a). The origin of these fractures is not clear. Only to some extent, their occurrence may be explained by intense tectonization of the rocks involved as so closely spaced cleavage is not in evidence. Comminuted conodonts occur also in other collections derived from the Góry Kaczawskie metamorphics. Urbanek (1978) described conodonts cut by transversal or oblique fractures, but never the proportion of fairly complete specimens to undeterminable fragments was so unfavourable as in the present case. The poor quality of the paleontological material imposes severe limitations on stratigraphic conclusions.

The conodont specimens show distinctly pitted and grainy surface. Such irregularities are only in part produced by the action of hydrofluoric acid. It is visible at high magnification that the grainy surface results from the presence of large apatite crystals (10–20 μm), which obscure the primary micromorphological features of the surface. These crystals are usually prismatic and more rarely tabular, and their edges and corners are frequently rounded (Pl. I: 1b, 2b; Pl. II: 1b, 3b). Their *z* axis is commonly parallel to the longer axis of the cusps. Fragments of smooth surface of specimens may be seen occasionally, where the outer grainy layer has been removed (Pl. I: 2a).

Similar features of surface of the conodonts extracted from metamorphic rocks were described by Schönlaub *et al.* (1976) and Schönlaub (1979), who considered them to be due to action of metamorphic factors, mainly dissolution and recrystallization. The change from a smooth vitrous surface of conodonts to a pitted and grainy one was also achieved during experiments in response to the rising temperature (Epstein *et al.*, 1977).

The surfaces of the discussed conodont elements are white, thus displaying Colour Alteration Index (CAI) over 5*. Under the white outer cover, however,

* Epstein *et al.* (1977) introduced a standard series of colour-defined Colour Alteration Index (CAI) values ranging from 1 to 8. The sequence of colour change from pale yellow through brown to black corresponds to CAI 1–5. The higher CAI values (6–8) correspond to gray, opaque white and crystal clear conodonts.

the larger and more massive specimens become gray or black, particularly at their basal part. Nevertheless, the tops of the denticles always remain uniformly white. This is distinctly visible in thin sections (Pl. III: 2, 4; Pl. IV: 1, 2), on the injured surface of one of the studied conodont elements (Pl. I: 2a) and in many specimens which have longitudinal and transversal fractures. Similar distribution of colour was earlier observed in cusps and denticles of Devonian conodonts from the Góry Kaczawskie Mts. Their outer cover and fine denticles were white, whereas thicker basal part hidden beneath such a cover was gray or black. Thus the colouration of some Devonian conodonts and those studied presently shows striking analogies.

The characteristic bilayering of more massive fragments of the investigated conodonts is also matched by their internal structure. Comparing the cross-sections of denticles of the Devonian specimens and those of the presently discussed collection (Pl. I: 4; Pl. II: 2), one can notice that in both cases they have white (seen with light microscope) and porous (seen under scanning electron microscope) outer layer and darker, more compact inner layer consisting of finer crystals.

To complete the undertaken investigations, several selective chemical analyses were performed by means of Kevex-ray Subsystem 6000 attached to a Cambridge--Stereoscan S4-10 SEM (the apparatus does not detect elements of the atomic number below 11). Fragments of conodonts from the Radzimowice slates, and, for comparison, Devonian ones from the Góry Kaczawskie Mts were analysed (six and four analyses respectively). The analyses proved that conodonts of both collections have almost the same chemical composition. Ca and P are the main elements (intense peaks) and Al, K, Si and Fe appear only in traces. Such results are compatible with those reported by other authors (e.g. Klapper & Bergström, 1984; Schönlaub, 1979).

As it was mentioned above, most specimens of the collection discussed have a distinct two-layered structure, marked, among others, by different colours. Since the chemical analyses showed no compositional difference between the lighter outer layer and the darker inner layer of the conodonts, the observed colour variations may be explained by the presence of organic matter in the inner layer and its absence from the more strongly altered outer one. Changing colour of conodonts from black (CAI 5) toward white (CAI > 5) is interpreted by Epstein *et al.* (1977) as being effected by volatilization of carbon at the temperature exceeding 300° C.

AGE OF RADZIMOWICE SLATES

The fossils found in the sericite-quartz-albite phyllites near Wojcieszów undoubtedly represent conodonts. These are euconodonts *sensu* Bengtson (1976), which in taxonomic categories corresponds to the suborder *Conodontiformes* (*sensu* Müller & Nogami, 1971, *fide* Müller & Nogami, 1972), or to the order *Conodontophorida* Eichenberg, 1930 in the more recent systematics (Clark *et al.*, 1981). First specimens of this group of conodonts appeared in the Late Cambrian. Therefore, at least this portion of the Radzimowice slates from which the studied conodonts have been collected could not have been deposited before the Late Cambrian. The poor preservation of the material precludes identification of the taxa of lower categories and hampers precise concluding on the age of these rocks. Nevertheless, the occurrence of a platformlike element found in the locality 1 (Pl. I: 1a) sets the most probable lower age limit. This limit is defined by the first appearance of platformlike elements in the Early Ordovician (*cf.* Bergström, 1983; Lindström, 1977).

Accordingly, it is suggested that the Radzimowice slates represent an unspecified part of the Palaeozoic, at least partly not older than the Early Ordovician, contrary to the former belief that they belong to the Proterozoic (Eocambrian).

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Streszczenie

REWIZJA WIEKU ŁUPKÓW RADZIMOWICKICH W GÓRACH KACZAWSKICH (SUDETY ZACHODNIE) NA PODSTAWIE KONODONTÓW

Zdzisława Urbanek & Zdzisław Baranowski

Abstrakt: Elementy konodontowe (eukonodontów) zostały znalezione w metamorfiku kaczawskim, w fyllitach serycytowo-kwarcowo-albitowych, w rejonie Wojcieszowa. Skały te stanowią część łupków radzimowickich zaliczanych dotąd do górnego proterozoiku (eokambru). Obecność tych skamieniałości wskazuje, że łupki radzimowickie reprezentują nieokreśloną bliżej część paleozoiku, przynajmniej częściowo nie starszą niż wczesny ordowik.

Łupkami radzimowickimi (lub warstwami radzimowickimi) nazywa się zespół fyllitów kwarcowo-serycytowo-albitowych wraz z towarzyszącymi im łupkami krzemionkowymi i grafitowymi oraz soczewami lub nieregularnymi ciałami wapieni krystalicznych i zieleńców. Skały te występują w południowej części Gór Kaczawskich w jednostce Bolkowa (Fig. 1). Ich wiek określa się powszechnie na późny proterozoik (eokambr) na podstawie pozycji względem skał otaczających i porównań litologicznych z Turyngią. Istnieje ponadto zarzucony pogląd, że warstwy radzimowickie mogą stanowić kompleks mylonityczny, złożony z różnych ogniw stratygraficznych.

Obecne badania dają po raz pierwszy bezpośrednią, paleontologiczną podstawę datowania łupków radzimowickich.

W rejonie Wojcieszowa w fyllitach serycytowo-kwarcowych, objętych słabą blastezą albitową, znaleziono szczątki konodontów (Fig. 2). Kolekcja składa się z około 200 fragmentów konodontów (Pl. I, II) oraz kilkunastu przekrojów w płytkach cienkich (Pl. III, IV). Wszystkie wyseparowane okazy są znacznie uszkodzone na skutek przeobrażenia i silnego stektonizowania skał oraz trawienia w kwasie fluorowodorowym. Większość okazów stanowią drobne fragmenty zębów lub ząbków (Pl. II: 3a), a tylko nieliczne wykazują łatwo rozpoznawalne kształty elementów konodontowych (Pl. I: 1a, 2a, 3). Ich powierzchnię tworzą duże (wielkości kilkunastu μm) kryształy apatytu nadając jej ziarnisty charakter (Pl. I: 1b, 2b; Pl. II: 1b, 3b). Barwa okazów nie jest jednolita. Zewnętrzna, grubokrystaliczna powłoka masywniejszych elementów konodontowych oraz drobne ząbki są białe (CAI powyżej 5). Wewnętrzna część jest ciemna, prawie czarna i wykazuje bardziej zbitą, drobnokrystaliczną strukturę (Pl. II: 2; Pl. III: 2, 4; Pl. IV: 1, 2). Identyczny rozkład barwy oraz zróżnicowanie struktury obserwowano w niektórych dewońskich elementach konodontowych z metamorfiku kaczawskiego. Zmiana gładkiej, szklistej powierzchni konodontów na nierówną, ziarnistą oraz zróżnicowanie barwy są zapewne efektem oddziaływania czynników metamorficznych, zwłaszcza temperatury (por. Epstein *et al.*, 1977; Schönlaub *et al.*, 1976). Niepełne analizy chemiczne (wykonane za pomocą urządzenia Kevex-ray Subsystem 6000 połączonego ze skanningowym mikroskopem typu Cambridge-Stereoscan S4-10) okazów z opisywanej kolekcji i, dla porównania, z kolekcji dewońskiej wykazały obecność Ca i P (intensywne piki) oraz Al, K, Si i Fe (ślady).

Opisane skamieniałości niewątpliwie reprezentują eukonodonty *sensu* Bengtson (1976), co w kategoriach taksonomicznych odpowiada podrzędowi *Conodontiformes* (*sensu* Müller & Nogami, 1971, *fide* Müller & Nogami, 1972), a według nowszej systematyki stanowi rząd *Conodontophorida* Eichengerg, 1930. Źle zachowany materiał nie daje podstaw do identyfikacji taksonów niższej kategorii, a więc i do precyzyjnego wnioskowania o wieku skał. Niemniej obecność tych skamieniałości wskazuje, że opisywane fyllity serycytowo-kwarcowe nie mogły powstać przed późnym kambrem, a nawet przed wczesnym ordowikiem (stanowisko 1).

Zatem, łupki radzimowickie reprezentują bliżej nieokreśloną część paleozoiku, przynajmniej częściowo nie starszą niż wczesny ordowik, a nie, jak dotąd powszechnie uważano, górny proterozoik (eokambr).

EXPLANATION OF PLATES

All specimens illustrated in Plates I–IV derived from outcrop no. 1.

Plate I

1a — Fragment of platformlike conodont element, probably with three processes; visible two denticulate processes with developed ledges; cusp injured. ×150. Specimen ZGS/U. 81/1
1b — Details of basal part of the specimen of fig. 1a. Mag. ca ×1200
2a — Fragment of coniform element with injured cusp. Outer white layer composed of large apatite crystals partly removed during etching with hydrofluoric acid. The opposite side of specimen totally damaged. ×180. Specimen ZGS/U. 81/2
2b — Details of posterobasal part of specimen of fig. 2a. ×1000
3 — Fragment of cusp or denticle without basal and apical parts, specimen fractured transversally. Mag. ca ×290. Specimen ZGS/U. 81/3
4 — Cross-section of denticle of Devonian ramiform element from Góry Kaczawskie Mts. ×550. Specimen ZGS/U. 81/9

Plate II

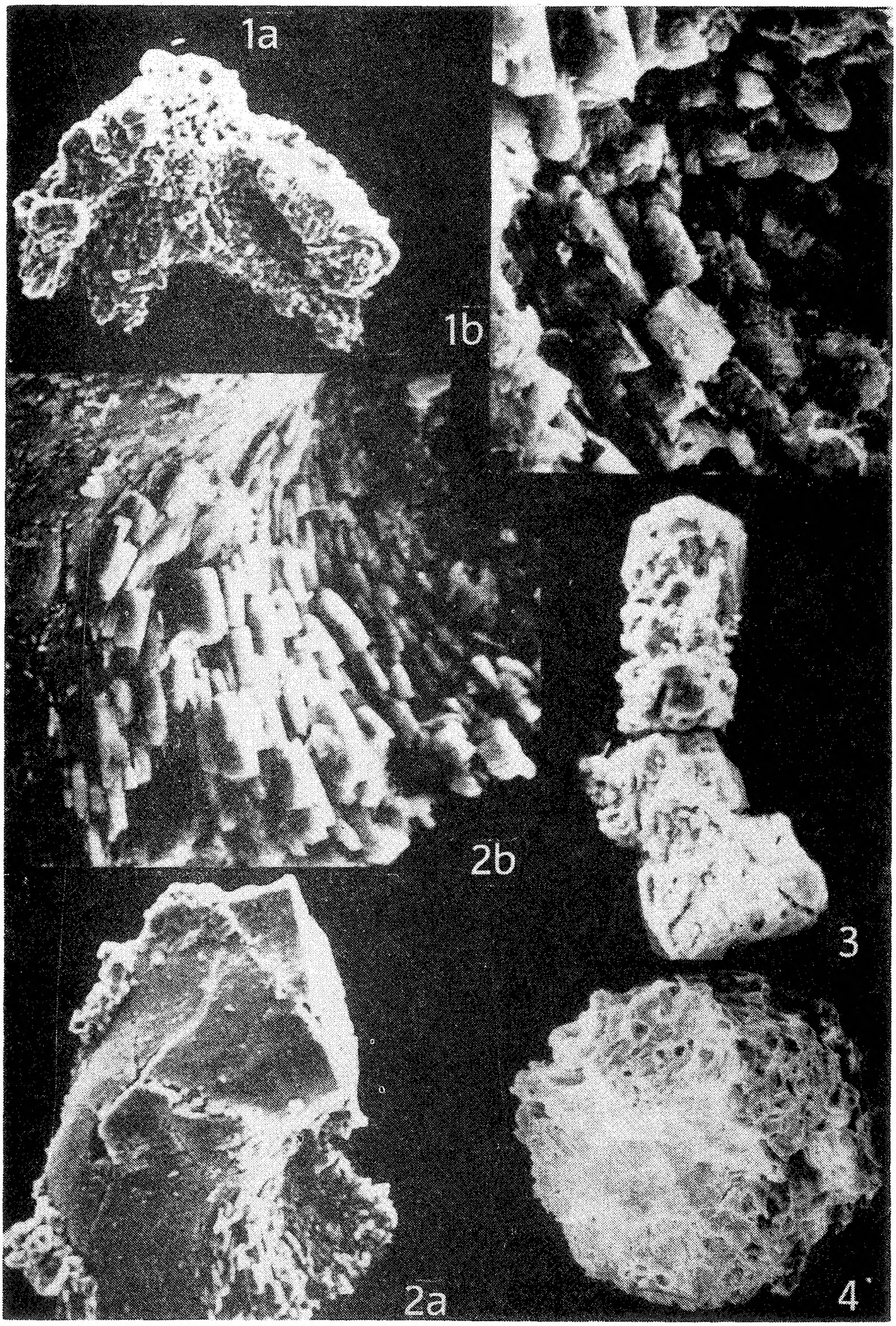
1a — Fragment of cusp, likely of ramiform element. Posterobasal part injured during picking. ×160. Specimen ZGS/U. 81/5
1b — Details of surface of specimen of fig. 1a. ×1200
2 — Cross-section of cusp or denticle of conodont element from Radzimowice slates. ×550. Specimen ZGS/U. 81/13
3a — Fragment of cusp or denticle with cross-cutting fractures. ×200. Specimen ZGS/U. 81/8
3b — Details of bottom part of surface of the specimen illustrated in fig. 3a. ×2700

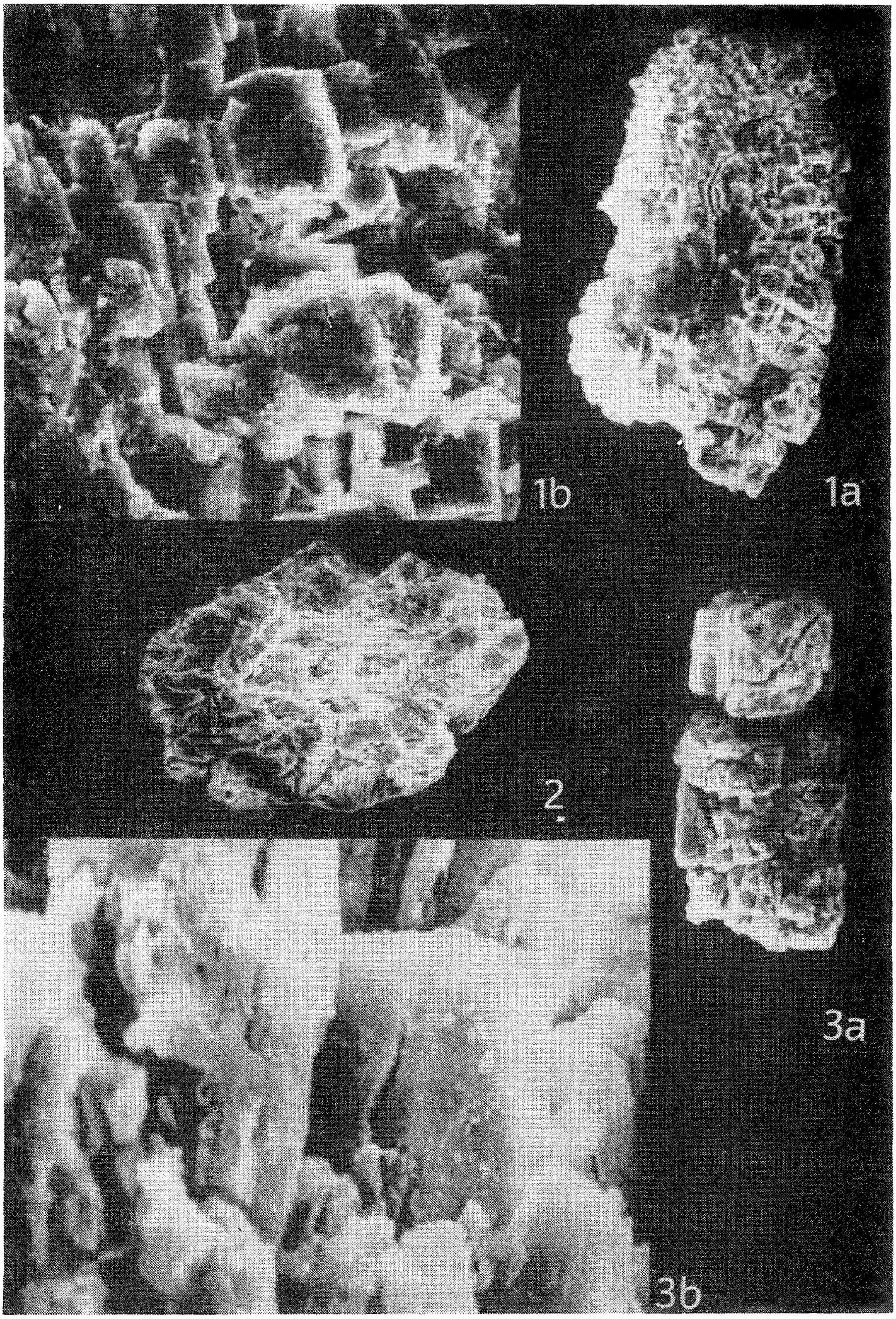
Plate III

1–4 — Cross-sections (longitudinal or approximately so) of conodont elements in thin sections. Nicols parallel. Scale bar = 0.1 mm. Specimen ZGS/U. 81/15, ZGS/U. 81/16, ZGS/U. 81/17 and ZGS/U. 81/18 respectively

Plate IV

1–3 — Cross-sections (transversal or approximately so) of conodont elements in thin sections. Nicols parallel. Scale bar = 0.1 mm. Specimen ZGS/U. 81/19


1a
1b
2b
3
2a
4


1b
1a
2
3a
3b