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Observations on the ornamentation and ultra-structure of some well preserved specimens of *Idiognathoides noduliferus inaequalis* Higgins (Pennsylvanian conodont)

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Abstract: Examination of specimens of *Idiognathoides noduliferus inaequalis* from the Panching limestone (Pennsylvanian) of Pahang, Peninsular Malaysia with a scanning electron microscope reveals well developed striations on the denticles of the blade. One of the specimens, broken to reveal the internal structure, shows that in the posterior part of the platform apatite crystallites are aligned with their c axes perpendicular to the lamellae whereas crystallites in lamellae of the blade denticles are oriented irregularly. The upper surface of the unit is seen to have a thick outer single layer of approximately 10μm thickness enveloping alternating thin lamellae (1μm) and interlamellae spaces. The interlamellae spaces are best developed in regions of active growth (ie. along axes of blade denticles).

INTRODUCTION

Hass (1941) demonstrated that conodonts had an internal lamellae structure and recognised that conodonts could be regenerated after breakage. More recently, Muller and Nogami (1971) studied the detailed histology of conodonts in thin section and also illustrated the surface sculpture of a number of conodont species using the scanning electron microscope. They recognised two types of regeneration in conodonts and also observed the healing of conodonts.

The ultrastructure of Lower Palaeozoic conodonts has been studied by Barnes, Sass and Monroe (1970, 1973), Barnes, Sass and Poplawski (1973), Lindstrom and Ziegler (1971) and Lindstrom McTavish and Ziegler (1972). Pierce and Langenheim (1969) described the ultrastructure of *Palmatolepis* and *Polygnathus* and concluded that the ultrastructure of compound conodonts may provide a basis for a more refined classification.

During a study of Pennsylvanian conodonts from the Panching limestone of Pahang, West Malaysia (Metcalfe, 1980) a specimen of *Idiognathoides noduliferus inaequalis* was found broken along its long axis so as to reveal the internal structure. The two halfs of the specimen were examined using a scanning electron microscope and other specimens of the same subspecies (from the same sample) were examined for surface ornamentation. The instrument used was a Cambridge S4-10 scanning electron microscope working at 20kV, the specimens being coated with gold/palladium. Figured specimens are deposited in the Department of Geology, University of Malaya, Kuala Lumpur.

SYSTEMATIC PALAEONTOLOGY

The form classification is here used.

Family Idiognathodontidae Harris and Hollingsworth 1933
Genus *Idiognathoides* Harris and Hollingsworth 1933

Type species: *Idiognathoides sinuatus* (Harris and Hollingsworth)

Idiognathoides noduliferus inaequalis Higgins
Plate 1, figs. 1–6, Plate 2, figs. 1–5.

1975 *Idiognathoides noduliferus inaequalis* Higgins; p. 53, pl. 12, figs. 1–7 pl. 14, 11–13, pl. 15, figs. 10, 14.

1980 *Idiognathoides noduliferus inaequalis* Higgins; Metcalfe, p. 306, pl. 38, figs. 10, 11, 12, 15.

Description: The blade is about the same length as the platform or slightly longer and is straight or slightly curved. It is composed of seven to ten denticles, fused at their bases but free at their apices. The blade is continued posteriorly as a central carina. There is often a slight lateral deflection of the blade/carina at the junction of the blade and platform. In lateral view the blade is as high as and often slightly higher than the platform.

The inner lateral platform is well developed and widest at about mid-length although in many specimens the width is consistent apart from the anterior and posterior ends. Anteriorly the inner lateral platform is transversely ridged but posteriorly the ridges may be replaced by nodes which extend to the posterior termination of the unit.

The outer lateral platform is less well developed. It extends almost as far anteriorly as the inner lateral platform but does not extend as far as the posterior end of the unit. The anterior part may be transversely ridged or may consist of a row of nodes which number four or more.

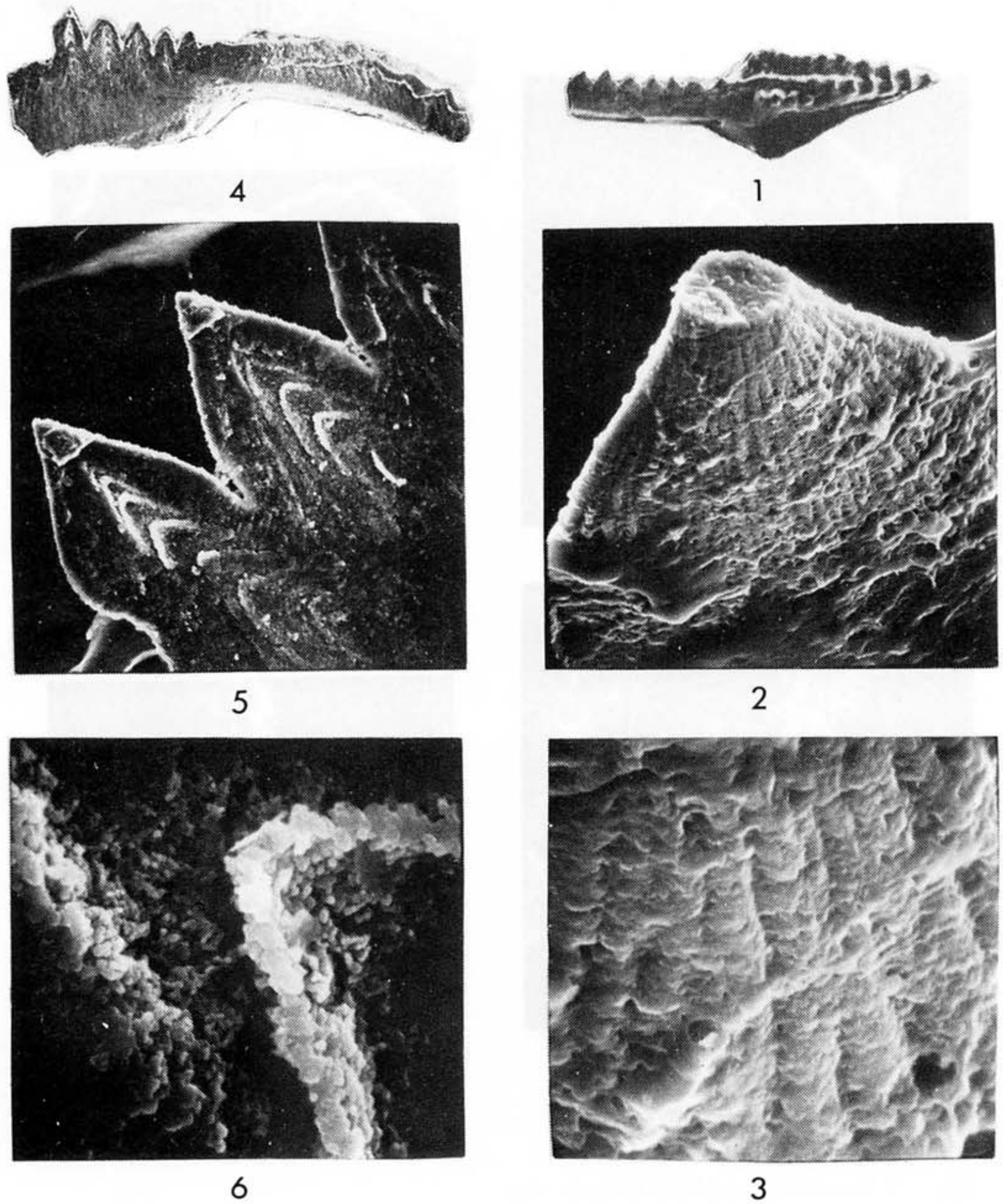
The basal cavity is widest near its anterior end and tapers to the pointed posterior. It is shallowly excavated.

Remarks: Specimens of this subspecies recovered from the Panching limestone of Pahang, West Malaysia are identical to those described by Higgins (1975) and form part of the transition series *Gnathodus girtyi simplex–Idiognathoides noduliferus inaequalis-Idiognathoides noduliferus noduliferus–Idiognathoides noduliferus japonicus* (Dunn 1970, Higgins 1975).

Material: Over two hundred specimens.

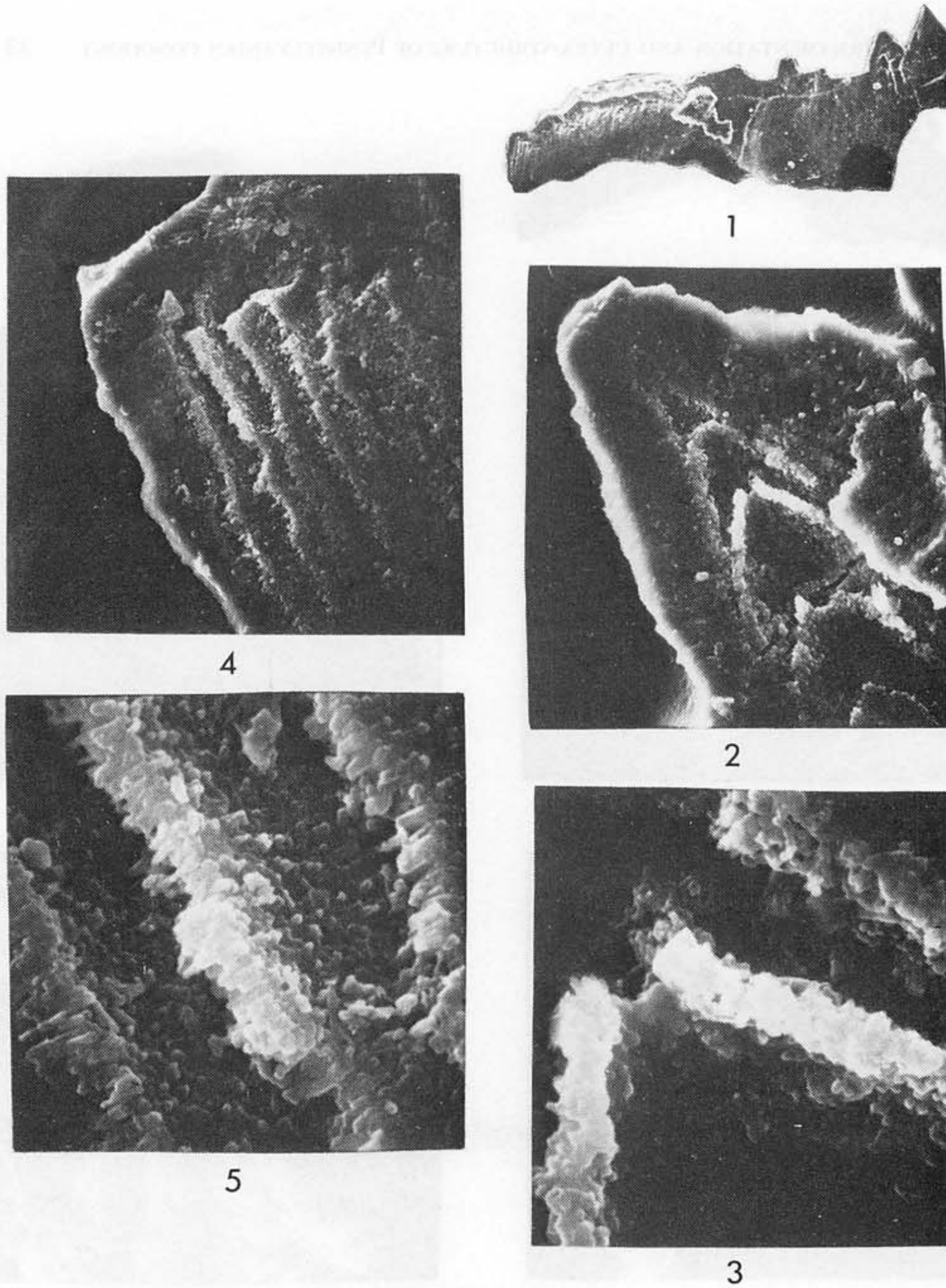
SURFACE ORNAMENTATION

The specimens of *Idiognathoides noduliferus inaequalis* examined by the author exhibit micro-surface ornamentation only on the blade denticles. Striations are formed



Figs. 1–6. *Idiognathoides noduliferus inaequalis* Higgins.

1. Oral view of specimen A358, X50.
2. Detail of blade of A358 showing striations, X1000.
3. Detail of ridges and grooves forming striations on the denticles of A358, x5000.
4. Outer lateral view of specimen A385 broken to reveal the internal structure, x100.
5. 'Cone in cone' structure in the denticles of A385. Note the interlamellae spaces are well developed along the denticles axes.
6. Detail showing irregularly oriented crystallites in the blade denticle lamellae.



Figs. 1–5. *Idiognathoides noduliferus inaequalis* Higgins.

1. Inner lateral view of specimen A385, broken to reveal the internal structure.
2. Detail of blade denticle showing thick outer layer enveloping thin lamellae and interlamellae spaces, X1000.
3. Detail of the thin lamellae of a blade denticle showing rather irregular crystallite orientation, X5000.
4. Detail of the posterior platform showing the lamellae.
5. Detail of the lamellae of the posterior platform showing well oriented crystallites with their c axes perpendicular to the lamellae surfaces, X5000.

by sub-parallel low ridges and fine grooves which extend from the base of the denticles to the apex (pl. 1, fig. 2). The ridges in this subspecies are approximately 2μm in width at the base of the denticle and taper to 1μm or less at the apices (pl. 1, figs. 2, 3). Bifurcation of the ridges occurs in the adapical direction. The grooves which separate the ridges are only 0.2 to 0.4μm in width.

ULTRASTRUCTURE

The specimen of *Idiognathoides noduliferus inaequalis* used to examine the ultrastructure had fractured along its long axis with the plane of section passing through the middle of the blade and carina.

Blade: The individual lamellae which compose the blade are of 1–2μm thickness and extend from the aboral edge up to the free apices of the denticles where they form the typical 'cone in cone' structure (pl. 1, figs. 4, 5). Interlamellae spaces are only well developed in the free apical denticle regions of the blade, presumably because this was an active area of growth. Each denticle is composed of a series of lamellae cones with intervening interlamellae spaces which are covered by an outer single layer of approximately 10μm thickness (pl. 2, figs. 1, 2). The individual apatite crystallites in the blade lamellae (pl. 1, fig. 6) appear to be rather irregular in orientation. This again may be a reflection of rapid growth.

Platform: The lamellae of the posterior part of the platform show a definite orientation of apatite crystallites. The major part of the platform is composed of lamellae of approximately 1μm thickness but there is an outer single layer (which may consist of several fused lamellae) of approximately 10μm thickness (pl. 2, fig. 4). The thin lamellae of the platform show that crystallites are arranged with their c axes perpendicular to the lamellae (pl. 2, fig. 5). The thickness of individual crystallites is approximately 0.2μm and they do not extend across lamellae boundaries. Orientation of crystallites was not observed in the thick outer layer.

DISCUSSION

Observations made by Lindstrom and Ziegler (1971) have shown that in the Superfamily Panderodontacea crystallites forming the conodont were approximately 0.1–0.2μm in width which compares well with the size observed in *Idiognathoides noduliferus inaequalis* (0.2μm). However, the crystallites of the Panderodontacea are aligned with their c axes parallel to the axis of the conodont and no interlamellae spaces are observed in that superfamily. Similar observations were made by Barnes and Slack (1975) on the subfamily Acanthodontidae which forms part of the Panderodontacea. Lindstrom, McTavish and Ziegler (1972) studied the ultrastructure of the family Prioniodontidae. Again they observed that the crystallites of this family are oriented with their c axes parallel to the axis of the conodont. Pierce and Langenheim (1969) described the ultrastructure of the genera *Palmatolepis* and *Polygnathus* which belong to the family Polygnathidae (Lindstrom 1970). They observed that the bulk of the conodonts was composed of crystallites orientated parallel to the long axis of the conodont.

The specimens described here belong to the family Idiognathodontidae which would appear to have more complex orientations of crystallites than the Polygnathidae or the Panderodontacea. Further work is planned on other members of the Idiognathodontidae which may reveal some general family characteristics of ultrastructure. It is evident from the limited work already done that real differences exist between the ultrastructure of the various families and superfamilies of conodont and with further study differences between genera and species may become a useful tool in classification.

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