UPPER CARBONIFEROUS CONODONT FAUNAS OF THE PANCHING LIMESTONE, PAHANG, WEST MALAYSIA

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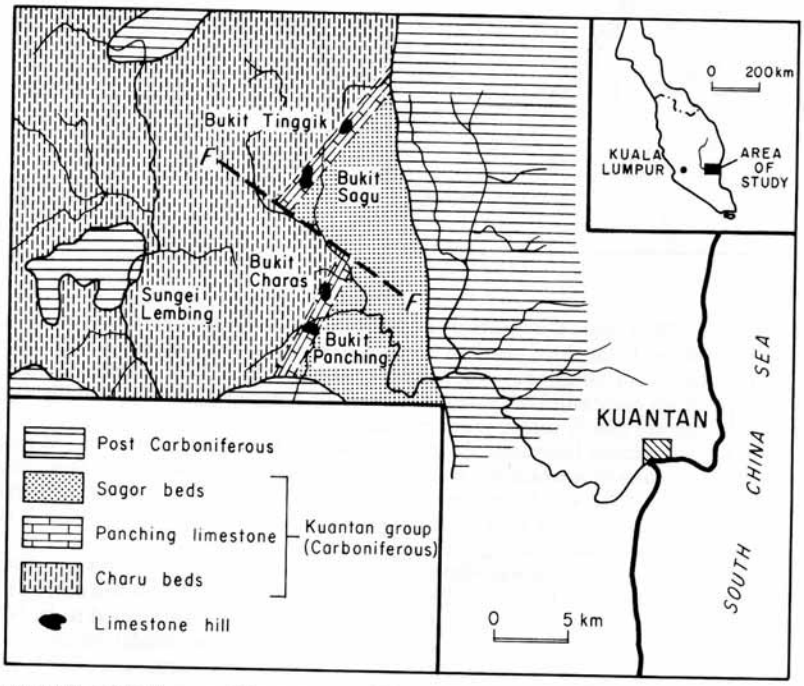
ABSTRACT. The Panching limestone, from Pahang, West Malaysia, has yielded a rich conodont fauna which represents the *Idiognathoides noduliferus–Streptognathodus lateralis* conodont Zone. Two subzones are recognized for the Panching limestone, a lower *Idiognathoides noduliferus inaequalis–Gnathodus commutatus* Subzone and an upper *Idiognathoides noduliferus japonicus–Rhachistognathus* Subzone. The age of the faunas in terms of European Stages is Chokierian (H_1) and possibly Alportian (H_2). It is considered that the Mississippian–Pennsylvanian boundary may be correlated with a level in the Panching limestone.

THE Panching limestone (a term here used informally pending formal designation; Metcalfe, Idris, and Tan, in prep.) crops out as a narrow band running SSW.–NNE. in the Panching area approximately twenty miles north-west of Kuantan, Pahang, West Malaysia (text-fig. 1). The



TEXT-FIG. 1. Sketch-map of the area west of Kuantan, Pahang, West Malaysia, showing the location of the Panching limestone.

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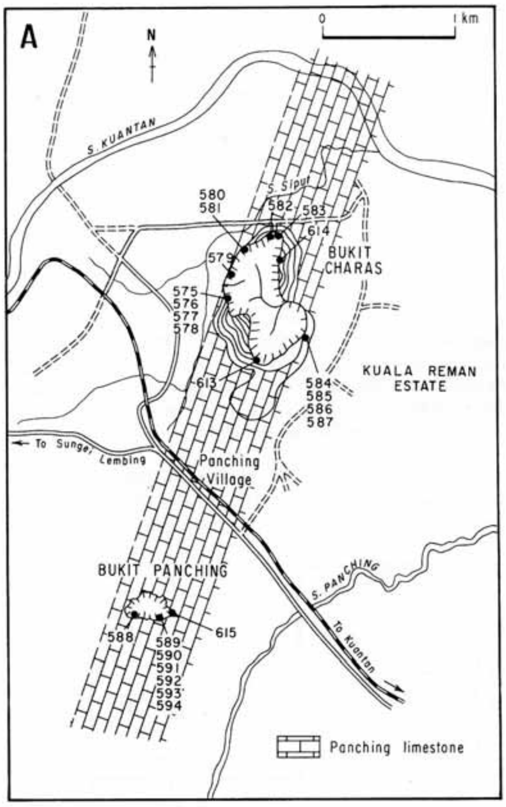


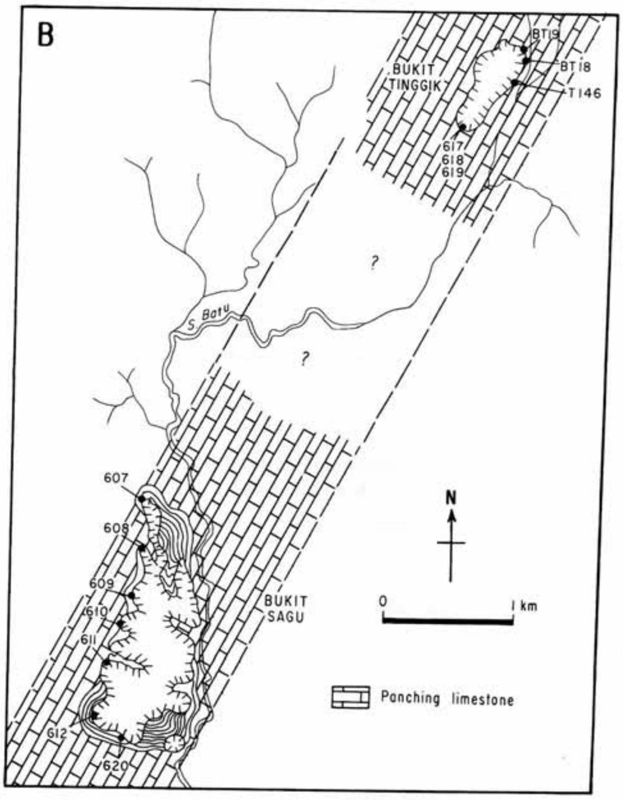
TEXT-FIG. 2A. Sketch-map showing sample localities at Bukit Panching and Bukit Charas.

limestone, which is 600 m thick, conformably overlies a series of alternating shales and sandstones approximately 1500 m thick, here referred to as Charu beds, and is overlain by alternating conglomerates, shales, and sandstones approximately 1600 m thick, here termed the Sagor beds. These sediments, which constitute the 'Kuantan Group' of Alexander (1959), generally dip steeply south-eastwards, but are tightly folded in many places.

Exposures of the Panching limestone, which is massive, fossiliferous, and partly recrystallized, occur as isolated limestone hills, which rise steeply out of relatively flat land to approximately 250 m. There are four limestone hills, which are from south to north, Bukit Panching, Bukit Charas, Bukit Sagu, and Bukit Tinggik. Samples were collected from each of the hills, and text-fig. 2 gives the locations of samples, which were all collected at ground level.

The age of the Panching limestone was originally regarded as Viséan (Muir-Wood *et al.* 1948; Fitch 1951; Sakagami 1972; Ozawa 1975). Igo and Koike (1968) and Mamet and Saurin (1970), however, described conodonts and foraminifera from Bukit Charas which they considered to be Namurian in age. Igo and Koike (1968) recorded *Idiognathoides noduliferus*, *Gnathodus bilineatus*, *Spathognathodus campbelli*, *Ozarkodina* sp., and *Hindeodella* sp. from Bukit Charas. The present study was undertaken to extract a more varied conodont fauna and to date the limestone more precisely in terms of conodont biostratigraphy.

TEXT-FIG. 2B. Sketch-map showing sample localities at Bukit Sagu and Bukit Tinggik.



SYSTEMATIC PALAEONTOLOGY

All figured specimens are deposited in the Department of Geology, University of Malaya.

Genus *Apatognathus* Branson and Mehl, 1934

Type species: *Apatognathus varians* Branson and Mehl, 1934

Apatognathus cuspidatus Varker

Plate 37, fig. 1

1967 *Apatognathus*? *cuspidata* Varker, p. 131, pl. 17, figs. 4, 6–10.
1970 *Apatognathus*? *cuspidatus* Varker; Reynolds, p. 7, pl. iii, fig. 4.

Remarks. The specimen is unfortunately broken but possesses the characteristic apical denticle of *A. cuspidatus*.

Material. 1 specimen, figured A339.

Apatognathus libratus Varker

Plate 37, fig. 4

1967 *Apatognathus*? *librata* Varker, p. 134, pl. 18, figs. 3, 6, 8, 9, 12, 13.
1969 *Apatognathus* cf. *libratus* Varker; Rhodes, Austin and Druce, p. 75, pl. 20, fig. 8*a*, *b*.
1970 *Apatognathus*? *libratus* Varker; Reynolds, p. 7, pl. iii, fig. 2.
1974 *Apatognathus libratus* Varker; Austin and Husri, pl. 10, fig. 6*a*, *b*.

Material. 1 specimen, figured A340.

Apatognathus scalenus Varker

Plate 37, fig. 2

1967 *Apatognathus*? *scalena* Varker, p. 136, pl. 18, figs. 1, 2, 4, 5.
1969 *Apatognathus scalenus* Varker; Rhodes, Austin and Druce, p. 74, pl. 20, figs. 9*a*–11*b* (with synonomy).
1970 *Apatognathus*? *scalenus* Varker; Reynolds, p. 7, pl. iii, fig. 6.
1974 *Apatognathus scalenus* Varker; Austin and Husri, pl. 10, fig. 12*a*, *b*.

Remarks. The present specimen has a more pronounced inward curvature of the apical denticle than is normal in *A. scalenus*, but this is not considered of specific significance.

Material. 1 specimen, figured A341.

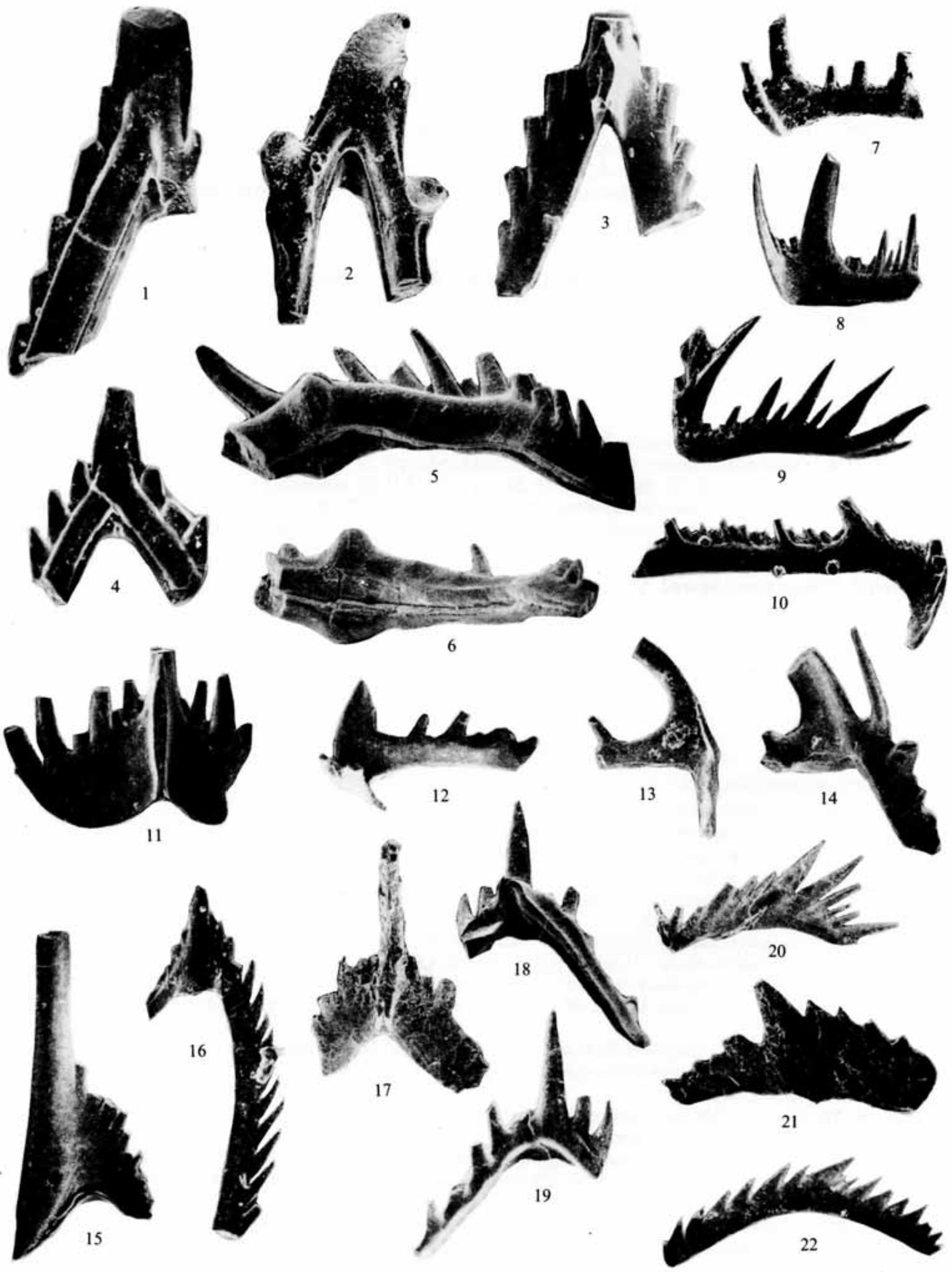
Genus *Geniculatus* Hass, 1953

Type species: *Polygnathus*? *claviger* Roundy, 1926

EXPLANATION OF PLATE 37

All figures are scanning electron micrographs.

Fig. 1. *Apatognathus cuspidatus* Varker, inner lateral view of A339, sample 579, ×120.
Fig. 2. *Apatognathus scalenus* Varker, inner lateral view of A341, sample 614, ×100.
Fig. 3. *Hibbardella acuta* Murray and Chronic, posterior view of A352, sample 588, ×100.
Fig. 4. *Apatognathus libratus* Varker, inner lateral view of A340, sample 579, ×120.
Figs. 5, 6. *Geniculatus claviger* (Roundy). 5. inner lateral view of A342, sample 588, ×100. 6. aboral view of A342, ×100.
Fig. 7. *Hindeodella undata* Branson and Mehl, lateral view of A355, sample 588, ×60.
Fig. 8. *Hindeodella mehli* Elias, lateral view of A356, sample 588, ×60.
Fig. 9. *Hindeodella uncata* Hass, oral view of A357, sample 610, ×100.
Fig. 10. *Hindeodella ibergensis* Bischoff, lateral view of A384, sample 585, ×100.
Fig. 11. *Hibbardella pennata* Higgins, posterior view of A353, sample 588, ×120.
Fig. 12. *Ligonodina roundyi* Hass, lateral view of A366, sample 588, ×60.
Figs. 13, 14. *Lonchodina bischoffi* Higgins and Bouckaert. 13. inner lateral view of A367, sample 588, ×60. 14. inner lateral view of A368, sample 588, ×50.
Fig. 15. *Neoprioniodus singularis* (Hass), inner lateral view of A370, sample 588, ×60.
Fig. 16. *Synprioniodina microdenta* Ellison, lateral view of A381, sample 585, ×100.
Fig. 17. *Hibbardella geniculata* Higgins, posterior view of A354, sample 578, ×100.
Figs. 18, 19. *Lonchodina ponderosa* Ellison. 18. aboral view of A369, sample 580, ×50. 19. oral view of A369.
Fig. 20. *Subbryantodus subaequalis* Higgins, lateral view of A380, sample 588, ×60.
Fig. 21. *Ozarkodina* sp., lateral view of A373, sample 578, ×100.
Fig. 22. *Ozarkodina delicatula* (Stauffer and Plummer), lateral view of A371, sample 579, ×50.



METCALFE, Carboniferous conodonts

Geniculatus claviger (Roundy)

Plate 37, figs. 5, 6

1926 *Polygnathus*? *claviger* Roundy, p. 14, pl. 4, figs. 1*a–c*, 2*a–b*.
1926 *Prioniodus* sp. D Roundy (partim), p. 11, pl. 4, fig. 13*a–b*.
1926 *Prioniodus healdi* Roundy, p. 10, pl. 4, fig. 5*a–b*.
1975 *Geniculatus claviger* (Roundy) Higgins, p. 27, pl. 2, fig. 5 (with synonomy).

Material. 4 specimens, figured A342.

Genus *Gnathodus* Pander, 1856

Type species: *Gnathodus mosquensis* Pander, 1856

Gnathodus bilineatus (Roundy)

Plate 38, figs. 5, 8, 9

1926 *Polygnathus bilineatus* Roundy, p. 13, pl. 3, fig. 10*a–c*.
1974 *Gnathodus bilineatus* (Roundy) Lane and Straka, pp. 72–77, fig. 32: 1–5, 7, 9, 11–13; fig. 33: 11–13, 19–23, 25, 28–32; fig. 34: 10, 13–26; fig. 40: 27 (with synonomy).
1975 *Gnathodus bilineatus bilineatus* (Roundy) Higgins, p. 28, pl. 11, figs. 1–4, 6, 7 (with synonomy).
1975 *Gnathodus bilineatus bollandensis* Higgins and Bouckaert; Higgins, p. 29, pl. 11, figs. 5, 8–13 (with synonomy).

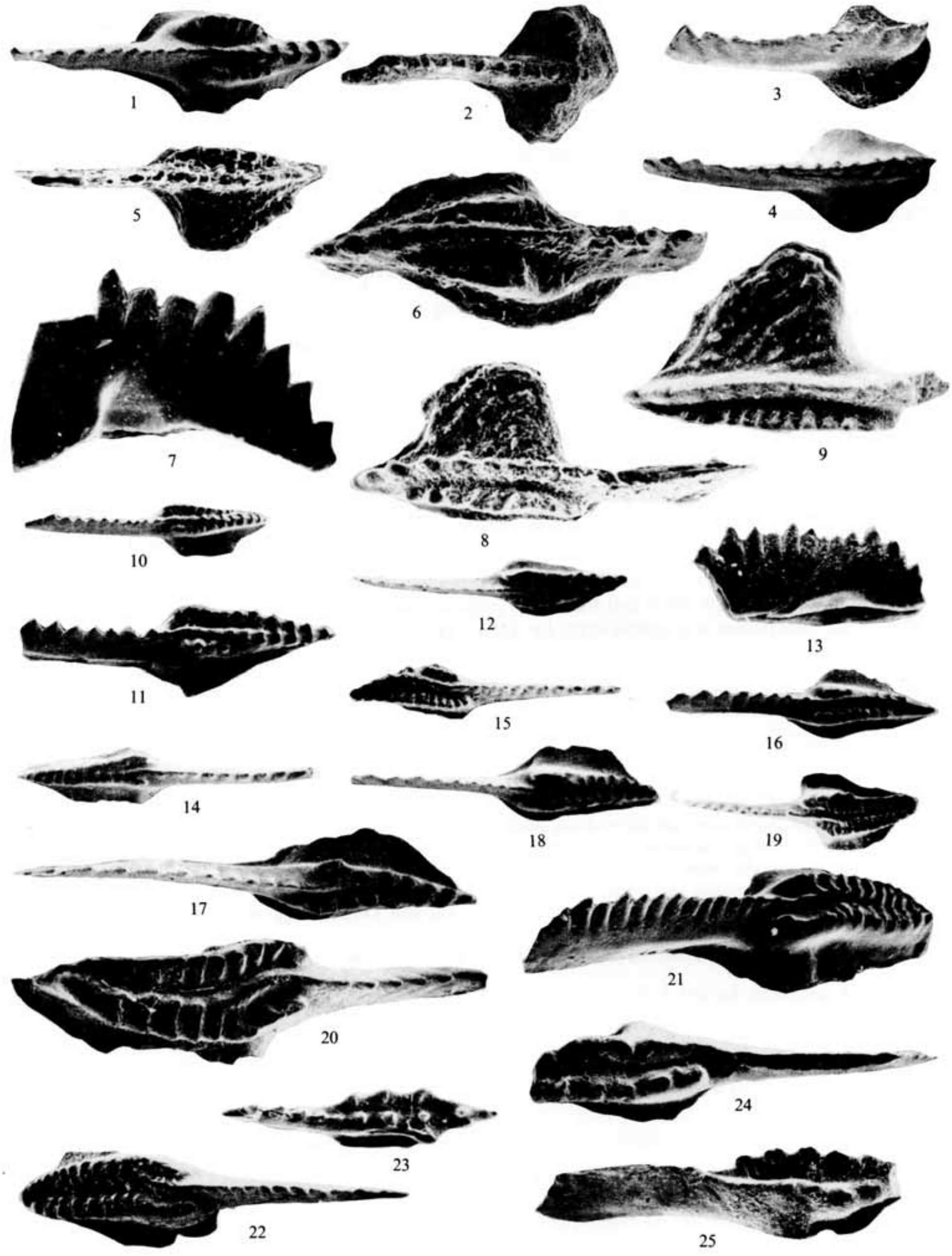
Material. 18 specimens, figured A343, A344, A345.

EXPLANATION OF PLATE 38

All figures are scanning electron micrographs.

Fig. 1. *Gnathodus girtyi simplex* Dunn, oral view of A350, sample 610, ×50.
Fig. 2. *Gnathodus nodosus* (Bischoff), oral view of A351, sample 577, ×50.
Figs. 3, 4. *Gnathodus commutatus* (Branson and Mehl). 3. oral view of A347, sample 588, ×60. 4. oral view of A346, sample 588, ×50.
Figs. 5, 8, 9. *Gnathodus bilineatus* (Roundy). 5. oral view of A344, sample 575, ×100. 8. oral view of A343, sample 575, ×100. 9. oral view of A345, sample 580, ×120.
Fig. 6. *Gnathodus girtyi rhodesi* Higgins, oral view of A349, sample 578, ×160.
Fig. 7. *Spathognathodus scitulus* (Hinde), lateral view of A375, sample 579, ×100.
Figs. 10, 11, 12, 15. *Idiognathoides noduliferus inaequalis* Higgins. 10. oral view of A360, sample 610, ×50. 11. oral view of A358, sample 618, ×100. 12. oral view of A361, sample 585, ×50. 15. oral view of A359, sample 620, ×50.
Fig. 13. *Spathognathodus campbelli* Rexroad, lateral view of A374, sample 579, ×100.
Figs. 14, 17. *Idiognathoides noduliferus japonicus*. 14, oral view of A363, sample 586, ×50. 17. oral view of A362, sample 586, ×100.
Figs. 16, 18. *Idiognathoides noduliferus noduliferus* (Ellison and Graves). 16. oral view of A364, sample 585, ×50. 18. oral view of A365, sample 585, ×50.
Figs. 19–22. *Streptognathodus lateralis* Higgins and Bouckaert. 19. oral view of A379, sample 617, ×25. 20. oral view of A377, sample 620, ×50. 21. oblique oral view of A378, sample 618, ×50. 22. oral view of A376, sample 620, ×50.
Fig. 23. *Rhachistognathus primus* Dunn, oral view of A383, sample 585, ×100.
Figs. 24, 25. *Rhachistognathus muricatus* (Dunn). 24. oral view of A382, sample 620, ×50. 25. outer lateral view of A382.

PLATE 38



METCALFE, Carboniferous conodonts

Gnathodus commutatus (Branson and Mehl)

Plate 38, figs. 3, 4

1941 *Spathognathodus commutatus* Branson and Mehl, p. 98, pl. 19, figs. 1–4.
1975 *Paragnathodus commutatus* (Branson and Mehl) Higgins, p. 70, pl. 7, figs. 7–9, 11, 13, 16, 20, 21 (with synonomy).

Material. 21 specimens, figured A346, A347.

Gnathodus girtyi rhodesi Higgins

Plate 38, fig. 6

1975 *Gnathodus girtyi rhodesi* Higgins, p. 32, pl. 10, figs. 3, 4 (with synonomy).

Material. 3 specimens, figured A349.

Gnathodus girtyi simplex Dunn

Plate 38, fig. 1

1965 *Gnathodus girtyi simplex* Dunn, p. 1158, pl. 140, figs. 2, 3, 12.
1975 *Gnathodus girtyi simplex* Dunn; Higgins, p. 33, pl. 10, figs. 3, 4 (with synonomy).

Remarks. *G. girtyi simplex* has been recorded from the Mississippian and basal Pennsylvanian of the U.S.A. (Lane and Straka 1974) and from the Pendleian and Arnsbergian Stages of Britain (Higgins 1975). This subspecies was considered by Dunn (1970*a*) to be the ancestor of *Idiognathoides noduliferus*.

Material. 2 specimens, figured A350.

Gnathodus nodosus (Bischoff)

Plate 38, fig. 2

1957 *Gnathodus commutatus nodosus* Bischoff, p. 23, pl. 4, figs. 12, 13.
1960 *Gnathodus cruciformis* Clarke, p. 25, pl. iv, figs. 10–12.
1969 *Gnathodus mononodosus* Rhodes, Austin and Druce, p. 103, pl. 19, figs. 13*a*–15*d*.
1975 *Paragnathodus cruciformis* (Clarke) Higgins, p. 71, pl. 7, fig. 10.
1975 *Paragnathodus mononodosus* (Rhodes, Austin and Druce) Higgins, p. 71, pl. 7, fig. 14 (with synonomy).
1975 *Paragnathodus nodosus* (Bischoff) Higgins, p. 72, pl. 7, figs. 12, 15, 17–19, 22, 23 (with synonomy).

Material. 3 specimens, figured A351.

Genus *Hibbardella* Ulrich and Bassler

Type species: *Prioniodus angulatus* Hinde, 1879

Hibbardella acuta Murray and Chronic

Plate 37, fig. 3

For synonomy and description see Higgins (1975, p. 34).

Material. 4 specimens, figured A352.

Hibbardella geniculata Higgins

Plate 37, fig. 17

1975 *Hibbardella geniculata* Higgins, p. 35, pl. 6, figs. 11, 12, 14.

Material. 1 specimen, figured A354.

Hibbardella pennata Higgins

Plate 37, fig. 11

For synonomy see Higgins (1975, p. 36) and description Higgins (1961, p. 213).

Material. 6 specimens, figured A353.

Genus *Hindeodella* Ulrich and Bassler, 1926

Type species: *Hindeodella subtilis* Ulrich and Bassler, 1926

Hindeodella ibergensis Bischoff

Plate 37, fig. 10

For synonomy see Higgins (1975, p. 38).

Material. 18 specimens, figured A384.

Hindeodella mehli Elias

Plate 37, fig. 8

1942 *Lochreia montanaensis* Scott (partim), pl. 39, fig. 7; pl. 40, fig. 18.
1956 *Hindeodella bigeniculata* Elias (partim), p. 106, pl. 1, figs. 20, 21.
1956 *Hindeodella mehli* Elias, p. 108, pl. 1, figs. 22–24.
1957 *Hindeodella germana* Holmes; Bischoff (partim), p. 27, pl. 6, fig. 32.
1958 *Hindeodella montanaensis* (Scott) Stanley (partim), p. 465, pl. 64, figs. 1–5.
1961 *Hindeodella germana* Holmes; Higgins (partim), pl. 10, fig. 12.
1968 *Hindeodella germana* Holmes; Higgins and Bouckaert, p. 36, pl. 1, fig. 12.
1969 *Hindeodella montanaensis* (Scott) Rhodes, Austin and Druce, p. 123, pl. 28, figs. 21, 26.
1974 *Hindeodella montanaensis* (Scott) Austin and Husri, pl. 15, fig. 16.
1975 *Hindeodella germana* Holmes; Higgins, p. 38, pl. 5, fig. 6.

Remarks. Scott (1942) described this form species as part of the multi-element species *Lochrea montanaensis*. It is considered inappropriate to use the multi-element specific name for the form species, and therefore the next unambiguous name available (i.e. *H. mehli* Elias, 1956) is used.

Material. 3 specimens, figured A356.

Hindeodella uncata Hass

Plate 37, fig. 9

For synonomy see Higgins (1975, p. 44).

Material. 1 specimen, figured A357.

Hindeodella undata Branson and Mehl

Plate 37, fig. 7

For synonomy see Higgins (1975, p. 44).

Material. 1 specimen, figured A355.

Genus *Idiognathoides* Harris and Hollingsworth, 1933

Type species: *Idiognathoides sinuatus* Harris and Hollingsworth, 1933

Idiognathoides noduliferus Group

In this paper, the subdivision of *I. noduliferus* into three subspecies, *I. noduliferus inaequalis*, *I. noduliferus noduliferus*, and *I. noduliferus japonicus* made by Higgins (1975) is followed. Higgins (1975, p. 52) showed that these three subspecies form a transition series by reduction of the outer lateral platform.

Idiognathoides noduliferus inaequalis Higgins

Plate 38, figs. 10, 11, 12, 15

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

Remarks. This subspecies is recognized by having four or more nodes developed on the outer platform.

Material. 211 specimens, figured A358–A361.

Idiognathoides noduliferus japonicus (Igo and Koike)

Plate 38, figs. 14, 17

1964 *Streptognathodus japonicus* Igo and Koike, p. 188, pl. 28, figs. 5–10.
1975 *Idiognathoides noduliferus japonicus* (Igo and Koike) Higgins, p. 54, pl. 14, figs. 7–10 (with synonomy).

Remarks. This subspecies is characterized by having only a single node on its outer platform.

Material. 13 specimens, figured A362, A363.

Idiognathoides noduliferus noduliferus (Ellison and Graves)

Plate 38, figs. 16, 18

1941 *Cavusgnathus noduliferus* Ellison and Graves, p. 4, pl. 3, fig. 4.
1974 *Idiognathoides noduliferus* (Ellison and Graves) Lane and Straka, p. 85, fig. 35: 1–15, fig. 41: 15–17.
1975 *Idiognathoides noduliferus noduliferus* (Ellison and Graves) Higgins, p. 54, pl. 14, figs. 15, 16 (with synonomy).

Remarks. This subspecies is characterized by having two or three nodes developed on its outer platform.

Material. 75 specimens, figured A364, A365.

Genus *Ligonodina* Ulrich and Bassler, 1926

Type species: *Ligonodina pectinata* Ulrich and Bassler 1926

Ligonodina roundyi Hass

Plate 37, fig. 12

For synonomy see Higgins (1975, p. 58).

Material. 1 specimen, figured A366.

Genus *Lonchodina* Ulrich and Bassler, 1926

Type species: *Lonchodina typicalis* Ulrich and Bassler, 1926

Lonchodina bischoffi Higgins and Bouckaert

Plate 37, figs. 13, 14

1968 *Lonchodina bischoffi* Higgins and Bouckaert, p. 43.
1975 *Lonchodina bischoffi* Higgins and Bouckaert; Higgins, p. 59, pl. 2, figs. 1–4, 8 (with synonomy).

Material. 3 specimens, figured A367, A368.

Lonchodina ponderosa Ellison

Plate 38, figs. 18, 19

1941 *Lonchodina*? *ponderosa* Ellison, p. 116, pl. 20, figs. 37–39.
1975 *Lonchodina ponderosa* Ellison; Higgins, p. 60, pl. 2, fig. 11 (with description).

Material. 1 specimen, figured A369.

Genus *Neoprioniodus* Rhodes and Muller, 1956

Type species: *Prioniodus conjunctus* Gunnell, 1931

Neoprioniodus scitulus? (Branson and Mehl)

For synonomy see Rhodes, Austin and Druce (1969, p. 162).

Material. 2 fragmentary specimens.

Neoprioniodus singularis (Hass)

Plate 37, fig. 15

For synonomy see Thompson (1972, p. 37).

Material. 10 specimens, figured A370.

Genus *Ozarkodina* Branson and Mehl, 1933

Type species: *Ozarkodina typica* Branson and Mehl, 1933

Ozarkodina delicatula (Stauffer and Plummer)

Plate 37, fig. 22

For synonomy see Webster (1969) and Higgins (1975).

Material. 33 specimens, figured A371.

Ozarkodina sp.

Plate 37, fig. 21

Remarks. The specimen illustrated resembles young forms of *O. delicatula* but is considered to be too large for a juvenile of that species.

Material. 1 specimen, figured A373.

Genus *Rhachistognathus* Dunn, 1966

Type species: *Rhachistognathus primus* Dunn, 1966

Rhachistognathus muricatus (Dunn)

Plate 38, figs. 24, 25

1965 *Cavusgnathus muricatus* Dunn, p. 1147, pl. 140, figs. 1, 4.
1974 *Rhachistognathus muricatus* (Dunn) Lane and Straka, p. 97, fig. 35: 16, 17, 24, 30, 31 (with synonomy).

Remarks. This species is similar to *Idiognathoides minutus* Higgins and Bouckaert, but Higgins (1975, p. 50) has pointed out that *I. minutus* is normally half the size of *R. muricatus*, and does not possess the medial row of nodes developed posteriorly in many specimens of *R. muricatus*.

Material. 3 specimens, figured A382.

Rhachistognathus primus Dunn

Plate 38, fig. 23

1966 *Rhachistognathus prima* Dunn, p. 1301, pl. 157, figs. 1, 2.
1974 *Rhachistognathus primus* Dunn; Lane and Straka, p. 98, fig. 35: 18–23, 25–29, 32–40, fig. 44: 6 (with synonomy).

Remarks. Lane and Straka (1974) have shown that *R. muricatus* and *R. primus* are intergradational via a transitional morphotype *R. transitorius*.

Material. 1 specimen, figured A383.

Genus *Spathognathodus* Branson and Mehl, 1941

Type species: *Ctenognathus murchisoni* Pander, 1856.

Spathognathodus campbelli Rexroad

Plate 38, fig. 13

1957 *Spathognathodus campbelli* Rexroad, p. 37, pl. 3, figs. 13–15.
1975 *Spathognathodus campbelli* Rexroad; Higgins, p. 73, pl. 10, fig. 11 (with synonomy).

Remarks. This is a somewhat variable species. The denticles of the unit may be sub-equal or may be larger in the anterior half. The lateral oral outline may be straight, or in some specimens considerably convex. In oral view the unit varies from straight to bowed.

Material. 7 specimens, figured A374.

Genus *Streptognathodus* Stauffer and Plummer, 1932

Type species: *Streptognathodus exelsus* Stauffer and Plummer, 1932.

Streptognathodus lateralis Higgins and Bouckaert

Plate 38, figs. 19–22

1968 *Streptognathodus lateralis* Higgins and Bouckaert, p. 45, pl. 5, figs. 1–4, 7.
1975 *Streptognathodus lateralis* Higgins and Bouckaert; Higgins, p. 73, pl. 12, fig. 9; pl. 17, figs. 10, 11, 13, 14 (with synonomy).

Material. 25 specimens, figured A376–A379.

Genus *Subbryantodus* Branson and Mehl, 1934

Type species: *Subbryantodus arcuatus* Branson and Mehl, 1934.

Subbryantodus subaequalis Higgins

Plate 37, fig. 20

For synonomy see Higgins (1975, p. 74) and description Higgins (1961, p. 218).

Material. 4 specimens, figured A380.

Genus *Synprioniodina* Ulrich and Bassler, 1926

Type species: *Synprioniodina alternata* Ulrich and Bassler, 1926

Synprioniodina microdenta Ellison

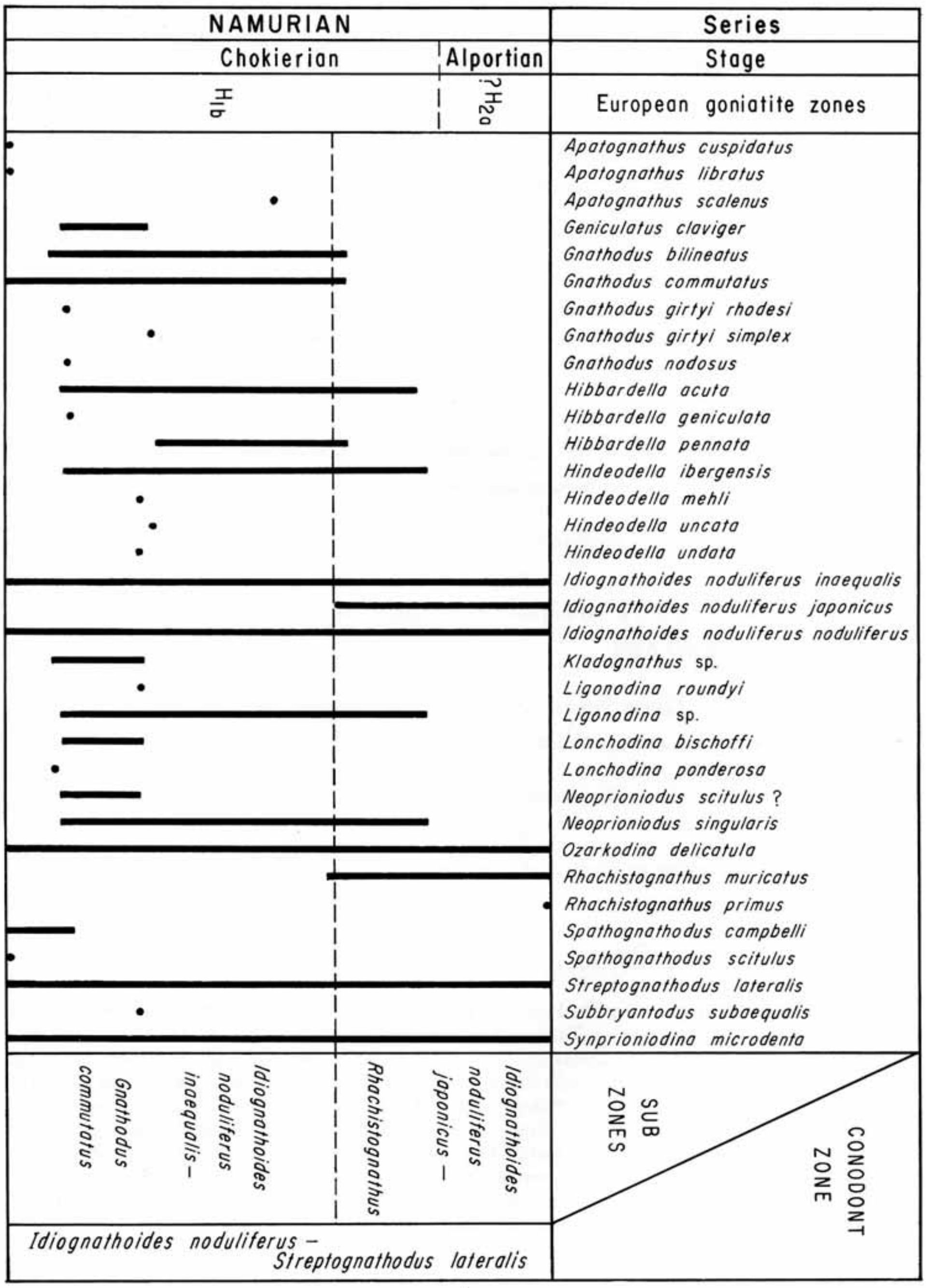
Plate 37, fig. 16

For synonomy and description see Higgins (1975, p. 75).

Material. 8 specimens, figured A381.

CONODONT ZONATION

The ranges of conodont species in the Panching limestone are given in text-fig. 3 and the numerical distribution in individual samples in Table 1. The Panching limestone fauna contains an assemblage characteristic of Higgins's (1975) *Idiognathoides noduliferous* Subzone and is therefore referred to the *I. noduliferus–Streptognathodus lateralis* Zone. In the Panching limestone, a lower and an upper fauna are recognized and these are here designated subzones. The lower subzone, the *I. noduliferus inaequalis–Gnathodus commutatus* Subzone, is taken to have its lower limit defined by the first appearance of *I. noduliferus inaequalis* and or *I. noduliferus noduliferus* and its upper limit defined as the first appearance of *I. noduliferus japonicus*. This subzone is characterized by an association of gnathodids and idiognathoidids, and in particular an association of *G. bilineatus*, *I. noduliferus inaequalis*, *I. noduliferus noduliferus*, and *G. commutatus*. The upper subzone, the *I. noduliferus*



TEXT-FIG. 3. Ranges of conodont species in the Panching limestone.

TABLE 1. Numerical distribution of conodont species in individual samples from the Panching limestone. Samples are only in stratigraphic order for each individual hill.

LIMESTONE HILL	SAMPLE NUMBER	*Apatognathus cuspidatus*	*Apatognathus libratus*	*Apatognathus scalenus*	*Apatognathus* sp.	*Geniculatus claviger*	*Gnathodus bilineatus*	*Gnathodus commutatus*	*Gnathodus girtyi rhodesi*	*Gnathodus girtyi simplex*	*Gnathodus nodosus*	*Hibbardella acuta*	*Hibbardella geniculata*	*Hibbardella pennata*	*Hibbardella* sp.	*Hindeodella ibergensis*	*Hindeodella mehli*	*Hindeodella uncata*	*Hindeodella undata*	*Hindeodella* sp.	*Idiognathoides noduliferus inaequalis*	*Idiognathoides noduliferus japonicus*	*Idiognathoides noduliferus noduliferus*	*Idiognathoides ?* sp.	*Kladognathus* sp.	*Ligonodina roundyi*	*Ligonodina* sp.	*Lonchodina bischoffi*	*Lonchodina ponderosa*	*Lonchodina* sp.	*Neoprioniodus scitulus*	*Neoprioniodus singularis*	*Neoprioniodus* sp.	*Ozarkodina delicatula*	*Ozarkodina* sp.	*Rhachistognathus muricatus*	*Rhachistognathus primus*	*Spathognathodus campbelli*	*Spathognathodus scitulus*	*Spathognathodus* sp.	*Streptognathodus lateralis*	*Streptognathodus ?* sp.	*Subbryantodus subaequalis*	*Synprioniodina microdenta*	*Synprioniodina* sp.	Gen. indet.	Total	Sample weight in kilograms	Concentration of conodonts in spec/kg.
BUKIT TINGGIK	T146															2				6	11						1					1		1	2					1	1					11	37	2.0	18
	BT18											1								1	3																				1					2	8	2.0	4
	BT19														1					1	3		4											1							2					11	23	2.5	9
	619																			2	4		1												1											3	11	2.0	5
	618							1												11	12		5											1	3						3			1		19	56	2.0	28
	617						1							1		2				14	34	3	6											8	1						2					30	102	3.0	34
BUKIT SAGU	620															3				4	29		11											1	1	1					2					21	73	2.0	37
	612																			1																										2	3	2.0	1.5
	611														1					8	2																			1						3	15	2.0	8
	610							4		2				1		1		1		24	6									1		1		1										2		13	59	2.0	30
	609						1	1												17	6		3											1	2											7	38	2.0	19
	608																			2															1											1	4	2.0	2
	607																																														0	2.0	0
BUKIT CHARAS	587																			2		1		2																						5	10	2.0	5
	586																			8		6	7	1										2		1										5	30	4.0	7
	585															1				6	14	3	28	5										6	1	1	1				1			1		23	91	3.5	25
	584																																														0	2.0	0
	613																																													3	3	2.0	1.5
	614			1																																											1	2.0	0.5
	583																																														0	2.0	0
	582																			2																					1					6	9	2.0	4
	578				1			3	1		1		1			2				42	4		1				1	1			1	3		4	5			1			1			2		24	99	4.0	25
	577						1	3			2									1							1											1								8	18	3.5	5
	576																																														0	3.0	0
	575					2	14		2			2								29	31			6									2		10			4			4	2		1	2	56	167	7.0	24
	581																			1	3																									4	8	1.0	8
	580						2								1					7	17			1	1				1					1								1				17	50	6.0	8
	579	1	1					1												11	22		9	1										4				1	1		2			1		65	120	9.0	13
BUKIT PANCHING	615																																														0	2.0	0
	594																																													2	2	2.0	1
	593																																								1						1	2.0	0.5
	592																																														0	2.0	0
	591																																													4	4	2.0	2
	590																				1																									3	4	2.0	2
	589																																														0	2.0	0
	588					2		8				1		3		7	3		1	67	9				1	1	1	2			1	5		2	2						4		4			24	148	5.5	27

japonicus–Rhachistognathus Subzone, has its base at the first appearance of *I. noduliferus japonicus* and its upper limit taken at the first appearance of *I. corrugatus* and is characterized by an association of *I. noduliferus inaequalis*, *I. noduliferus noduliferus*, *I. noduliferus japonicus*, *R. muricatus* and *R. primus*.

Correlation with other areas

Namurian conodonts are known from Europe, Japan, North America, and Australia. The best-described successions of faunas are from Britain, Belgium, Japan, Nevada, Utah, Arkansas, and Oklahoma. The correlation of these faunas with the assemblages from the Panching limestone is shown in text-fig. 4 and discussed below.

Correlation with Europe. The sequence of Namurian conodont faunas in Europe is poorly known except in northern England, where Higgins (1975) has recognized seven zones and four subzones

Series	European goniatite Zones	West Malaysia (This paper)		Britain (Higgins 1975)		Japan (Koike 1967, Igo *et al.* 1978)	Nevada, Utah (Dunn 1970)	Arkansas, Oklahoma (Lane and Straka 1974)
		Zone	Subzones	Zone	Subzones	Zones	Zones	Zones
NAMURIAN	? H_{2a}	*Idiognathoides noduliferus –*	*Idiognathoides noduliferus japonicus – Rhachistognathus*	*Idiognathoides noduliferus –*	*Idiognathoides noduliferus*	*Gnathodus bassleri bassleri*	*Rhachistognathus*	*Rhachistognathus primus*
	H_{1b}							*Rhachistognathus muricatus*
		Streptognathodus lateralis	*Idiognathoides noduliferus inaequalis – Gnathodus commutatus*	*Streptognathodus lateralis*		*Gnathodus bilineatus – Idiognathoides noduliferus*	*Gnathodus girtyi simplex*	*Adetognathus unicornis*
	H_{1a}				*Idiognathoides minutus*			

TEXT-FIG. 4. Comparisons of early Namurian conodont zonations.

spanning the interval from late Dinantian to early Westphalian, and in Belgium (Higgins and Bouckaert 1968). The faunas of the Panching limestone are similar to those assigned by Higgins to the *I. noduliferus–S. lateralis* Zone, which is equivalent to the E_{2c} to H_{2c} goniatite zones. The upper fauna lacks any of the typical Kinderscoutian forms recorded by Higgins and is characterized by *I. noduliferus japonicus* which first occurs in Higgins and Bouckaert's (1968, p. 21) 'upper' fauna of H_{1b} in Belgium, and in H_{2a} in northern England: it is therefore likely to be of Alportian and possibly late Chokierian age. The lower fauna lacks *I. minutus*, characteristic of the late Arnsbergian and early Chokierian of northern England, and is therefore likely to be of late Chokierian age (H_{1b}).

The lower fauna from the Panching limestone contains *Gnathodus* spp., which was not recorded by Higgins (1975) from levels above E_{2c} in northern England. *Gnathodus* spp., however, do occur in H_{1b} in Belgium (Higgins and Bouckaert 1968, p. 21), and Higgins (pers. comm. 1978) has reported *G. bilineatus bollandensis* from the Alportian (H_2) of north Staffordshire, England.

Correlation with Japan. Watanabe (in Igo *et al.* 1978, fig. 14) recognized four conodont zones for the Omi Limestone in central Japan, from oldest to youngest, the *G. bilineatus* Zone, *S. noduliferus* Zone, *S. expansus–S. suberectus* Zone, and *G. roundyi–I. delicatus* Zone. The middle and upper part of Watanabe's *S. noduliferus* Zone corresponds to the lower part of the *Profusulinella* fusuline zone and is therefore younger than the Panching limestone which contains an *Eostaffella–Millerella* Zone fauna (Ozawa 1975). The conodont faunas of the Panching limestone must therefore correlate with the lower part of Watanabe's *S. noduliferus* Zone which corresponds to the limestone conglomerate horizon of the Omi Limestone.

Koike (1967) proposed seven conodont zones for the late Mississippian to early Pennsylvanian Atetsu Limestone of south-west Japan. These zones are being modified by Koike (pers. comm.). In his revised zonation, Koike will recognize a *G. bilineatus–I. noduliferus* Zone (= *G. bilineatus–G. nodulifera* Zone of Koike 1967) at the top of the Nagoe Formation and an *I. noduliferus* Zone (= lower part of the *G. wapanuckensis* Zone of Koike 1967) at the base of the succeeding Kodani Formation. The *G. bilineatus–I. noduliferus* Zone of the Atetsu Limestone is correlated with the *I. noduliferus inaequalis–G. commutatus* Subzone of the present work since they both have an association of *I. noduliferus*, *G. bilineatus*, and *G. commutatus*. The overlying *I. noduliferus* Zone of Koike (1978 pers. comm.) is equivalent to the lower part of the *G. bassleri bassleri* Zone of Igo *et al.* (1978, tables 2, 3) and is here tentatively correlated with the *I. noduliferus japonicus–R.* Subzone of the present work.

Correlation with North America. Dunn (1970*b*) described the conodont zonation near the Mississippian–Pennsylvanian boundary in Nevada and Utah. He recognized a *R.* Zone which contained the Mississippian–Pennsylvanian boundary and correlated this with the upper part of the Chokierian Stage (H_1) of Europe. Lane and Straka (1974) working in Arkansas and Oklahoma recognized a lower *R. muricatus* Zone and an upper *R. primus* Zone and the boundary between these zones was shown to coincide with the Mississippian–Pennsylvanian boundary. Lane and Straka agreed with Dunn (1970*b*) in placing the boundary in H_1 and suggested it correlated with the upper part of the *Homoceras beyrichianum* goniatite zone (H_{1b}) of Europe. Both *R. muricatus* and *R. primus* are recorded from the upper part of the Panching limestone. This suggests that the *Rhachistognathus* zones of Dunn (1970*b*) and Lane and Straka (1974) correlate with the *I. noduliferus japonicus–R.* Subzone of the present work.

Correlation with European sections (see above) indicates that the H_1/H_2 boundary probably occurs in the uppermost part of the Panching limestone. The Mississippian–Pennsylvanian boundary would therefore fall in H_{1b} which agrees with correlations proposed by Dunn (1970*b*) and Lane and Straka (1974).

CONCLUSIONS

The Panching limestone conodont faunas represent the *I. noduliferus–S. lateralis* conodont zone of Britain and are of H_{1b} and possibly H_{2a} age. Two subzones are recognized in the Panching limestone, a lower *I. noduliferus inaequalis–G. commutatus* Subzone and an upper *I. noduliferus japonicus–R.* Subzone. The Mississippian–Pennsylvanian boundary may be correlated with a level in the upper part of the Panching limestone of Pahang, West Malaysia.

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