Introduction and Acknowledgements

The Akiyoshi Limestone is the classical field of the Upper Paleozoic stratigraphy and paleontology in Japan and has been repeatedly studied by many workers. Recently YANAGIDA (1962) has reported an interesting brachiopod fauna from the Uzura quarry, Yobara. The stratigraphic position of this quarry is thought to be lower part of the Akiyoshi Limestone Group and to be equivalent to the Millerella sp. a Zone (Toriyama, 1958). Also YAMAGIWA and OTA (1963) have described several corals from the same locality. We have succeeded to separate well-preserved rich conodonts from the limestone collected from the mentioned fossil locality. This paper is dealt with these conodonts and discussion of their geologic age.

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Conodont Fauna and its Geologic Age

The material was collected from the abandoned quarry named Uzura at Yobara, Ofuku, Yamaguchi Prefecture, southwestern Japan (Text-fig. 1). Limestone cropped out in this quarry is highly fossiliferous, pale gray and massive to bedded. It abundantly yields brachiopods, corals, smaller foraminifera and many other fossils. We have found the following conodonts, namely: — Hindeodella sakagamii Igo and Koike, Synpria- nodina sp., Ligonodina hanaii Igo and Koike, Lonchodus sp., Lonchodina aki- yoshiensis Igo and Koike, n. sp., Lon-
Hisayoshi IGO and Toshio KOIKE

Text-fig. 1. Maps showing the locality.

Hindeodella sakagamii, Lonchodina hanaii and Ozarkodina orientale are common species in both faunas. Gnathodus opinus and Gnathodus commutatus nagatoensis are very abundant and characteristic species in the Akiyoshi fauna, but they are rare in the Omi. Lonchodus sp., Lonchodina ? sp. A, Lonchodina sp., Lonchodina akiyoshiensis and Spathognathodus minutus are not so common in this fauna, but they have never been found in the Omi fauna. The genera Streptognathodus and Idiognathodus are characteristic in the Omi fauna, particularly the former, but both genera have never been obtained from the Akiyoshi fauna. The species of Hindeodella and Synprioniodina are rather common in the Omi fauna, but they are rare in Akiyoshi.

The geologic age of the representing fauna is an important problem. YANAGIDA (op. cit.) described many brachiopods from the same locality, although the brachiopod-bearing horizon is slightly below the conodont rich horizon. According to his extensive paleontological work, these brachiopods are similar to those of European and Asian upper Lower Carboniferous (Viséan), such as, Phricodothyris insolita GEROGL, Brachythyrus akiyoshiensis YANAGIDA, Spirifer aff. lianghehuanensis CHAO, Spirifer sp., Cleiothyridina expansa (PHILLIPS), Cleiothyridina royssii (L’EVEILLE), Actinoconchus planosulcata (PHILLIPS), Composita aff. argentea (SHEPARD), Dielasma cfr. kingi DE KONINCK, Dielasma sp., Yanishewskiella japonica YANAGIDA, Pugnax aff. sulcatus (SOWERBY) and Schizophoria aff. resupinata (MARTIN).

YAMAGIWA and OTA (1964) described the following corals, namely:—Styliophyllum ozawai YAMAGIWA and OTA, Clisiophyllum awa (MINATO), Clisiophyllum sp., Lonsdaleoides toriyamai MINATO and Lophophyllidium uzurensis YAMAGIWA and OTA. Although they did not
discuss the geologic age of the coral fauna, it has close similarities to those from the lower part of the Middle Carboniferous (the Millerella to Profusulinella Zones) in southwestern Japan.

As already discussed by the writers, the Omi conodont fauna was thought to be Early Pennsylvanian or Late Namurian in age, and not younger than Middle Pennsylvanian. The Omi conodont fauna are lacking the typical Mississippian genera and species. The Akiyoshi fauna is also avoided the characteristic Mississippian conodont genera, but some of the species are related to the highest Mississippian (Chesterian) species of North America. *Hindeodus imperfectus* is not so many in this fauna but it has been repeatedly described from the Chesterian of the upper Mississippi Valley region. According to COLLINSON, SCOTT and REXROAD (1962) this species ranges up to the top of the Kinkaid Limestone. *Spathognathodus minutus* is a long ranging species in the Pennsylvanian (ELLISON, 1941, STURGEN and YOUNGQUIST, 1949 etc.). *Ozarkodina orientale* is similar to the Chesterian species of *O. compressa* REXROAD. *Lonchodina akiyoshiensis* resembles *L. furnishi* REXROAD which was described from the Glen Dean Formation of the type Chesterian in the upper Mississippi Valley region. *Gnathodus opimus* is related to *G. roundyi* which has been known from the various localities of the Desmoinesian in North America. It also has some similarities to *Gnathodus girtyi* which was described from the Mississippian Llarnet Formation in Texas (HASS, 1953). The Mississippian species of *Gnathodus texanus* ROUNDY and the cosmopolitan species of *G. mosquensis* PANDER are also allied species to our specimens. *Gnathodus commutatus naga-toensis* resembles the several subspecies of *G. commutatus* described from the Mississippian and Namurian in North America and Europe.

As mentioned above the present fauna is consisting of both Upper Mississippian (Chesterian) and Pennsylvanian species or allied ones. On the other hand, entire lacking of *Spathognathodus* and *Idionathodus* is never overlooked to consider the geologic age of this fauna. The mentioned genera are very characteristic and prominent in the Omi Limestone. From these faunal characters we became to conclude that the Akiyoshi conodont fauna is slightly older than the Omi fauna and considered to be the earliest Pennsylvanian or latest Mississippian in age. There is, however, stronger possibility of the earliest Pennsylvanian age of this fauna rather than of the Mississippian.

**Description of Species**

**Genus *Hindeodella* BASSLER, 1925**

*Hindeodella sakagamii* IGO and KOIKE

Pl. 8, figs. 1, 2


**Comparison:**—All specimens at hand are quite identical to the Omi specimens and we could not find any remarkable difference. Further description seems to be unnecessary.

Reg. nos. 23090, 23091.

**Genus *Synprioniodina* ULRICH and BASSLER, 1926**

*Synprioniodina* sp.

Pl. 8, fig. 9
Two bars meet forming an angle of about 40 degrees in common plane. Posterior bar thin, laterally compressed, rather high and having sharply edged aboral side. Denticles subequal in size throughout, sharply pointed, almost erect or slightly angled anteriorly, fused at base and deeply penetrated into bar. Anticusp short, having coalesced and anteriorly inclined denticles. Main cusp thin, sharply pointed, directed anteriorly. Aboral side of bar distinctly grooved. Pulp cavity beneath main cusp deep, conical and with moderately elevated flare.

Comparison:—This indeterminable species resembles Synprioniodina microdena ELLISON, but the former has higher posterior bar and subequal posterior denticles. Synprioniodina collinsoni IGO and KOIKE is also allied species, but the denticles of the posterior bar and anticusp are dissimilar in shape. The American Chesterian species of Synprioniodina denticamur REXROAD and LIEBE is very similar to our S. sp., but owing to the incomplete Akiyoshi material detailed comparison is difficult.

Reg. no. 23093.

Genus Ligonodina BASSLER, 1925

*Ligonodina hanaii* IGO and KOIKE

Pl. 8. fig. 13


Comparison:—The Akiyoshi specimens are quite identical to the Omi specimens and no further description is necessary. As already pointed out by IGO and KOIKE this species resembles *Ligonodina typa* (GUNNELL). It also resembles *Ligonodina abbrevia* YOUNGQUIST and LIEZEEN described from the Early Pennsylvanian shale, Knoxville, Iowa.

Reg. no. 23093.

Genus Lonchodus PANDEL, 1856

*Lonchodus* sp.

Pl. 8, fig. 11

Imperfect bar straight, laterally compressed, slightly curved inward and having very thin posterior end. Aboral side distinctly grooved. Denticles long, discrete, laterally compressed, almost erect or slightly directed posteriorly, having sharp edges antero-posteriorly and sharply pointed tip.

Comparison:—Many similar fragmentary bars have been described and illustrated from the various Lower Pennsylvanian and Upper Mississippian rocks. *Lonchodus* ? sp. came from Knoxville, Iowa (YOUNGQUIST and LIEZEEN, 1948) and ELLISON'S (1941) indeterminable specimen (Pl. 20, fig. 28) are similar to our specimens.

Reg. no. 23094.

Genus Lonchodina BASSLER, 1925

*Lonchodina* sp. A

Pl. 8, fig. 15

Unit consisting of two bars forming about right angle. Anterior bar rather long, thin, and with five denticles. Anterior denticles discrete, sharply pointed, rounded in cross section, almost erect or curved posteriorly and inward. Main cusp not so large, circular in transverse section. Posterior denticles large, slightly curved posteriorly, flattened and with sharp edges antero-posteriorly. Number of posterior denticles may be one or two. Pulp cavity large, located beneath main.
cusp, conical and rather sharrow, surrounded by slightly expanded flare. Aboral side of bar distinctly grooved.

Comparison:—Lonchodina ? sp. A is similar to Lonchodina ? nipponica IGO and KOIKE described from the Omi Limestone, but the present indeterminable species has different main cusp and posterior denticles. It also closely resembles Lonchodina ? panderosa ELLISON, but our specimens have different shape of the denticles. This species seems to be new to science but denomination is reserved until more numerous materials are accumulated.

Reg. no. 23095.

Lonchodina akiyoshiensis IGO and KOIKE, n. sp.

Pl. 8. figs. 8, 10, 12, 14

Bar thin, blade-like, consisting of anterior and posterior bars meeting at an angle of 120 degrees. Anterior bar long and rather high and with sharp anterior end. Anterior denticles six to seven in number, laterally compressed, somewhat curved posteriorly and most of them equal in size, with sharp edges fore and aft and coalesced at base. Main cusp parallel to anterior denticles and having elevated median ridge continuing to expanded triangular flare. Posterior bar shorter than anterior bar. Posterior denticles variable in size and shape, three or four in number, thin, sharply pointed and almost erect to base of bar. Pulp cavity large and sharrow. Aboral side of bars with deep groove extended from pulp cavity.

Comparison:—Lonchodina akiyoshiensis resembles Lonchodina furnishi REXROAD described from the Glen Dean Formation (Chesterian) of Illinois and others, but the American species has larger main cusp than our form.

Reg. nos. 23096 (holotype), 23097-23099.

Genus Hindeodus REXROAD and FURNISH, 1964

Hindeodus imperfectus REXROAD

Pl. 8. figs. 3-5, 7


Lateral bars in one plane or very slightly twisted, thin and blade-like, meet at approximately 120 degrees beneath main cusp. Aboral side of bars slightly concave downward, sharply edged and not grooved. Denticles in both bars eight to nine in number and more or less variable in size and number, and generally smaller adjacent to main cusp and distal end, circular in cross section and sharply pointed, whose anterior surface flat and posterior surface convex posteriorly. Pulp cavity small, conical and shallow with faint elevation of flare on posterior side of main cusp but depressed on opposite side.

Comparison:—The Akiyoshi specimens are quite similar to the American Chesterian specimens and no remarkable difference can be recognized.

Reg. nos. 23100-23103.

Genus Ozarkodina BRANSON and MEHL, 1933

Ozarkodina orientale IGO and KOIKE
Comparison:—The Akiyoshi material is similar to the Omi specimens which were illustrated in Text-fig. 3 on plate 2 (Igo and Koike, 1964), but it differs from the latter in weaker elevation of flaring lip and larger main cusp. The mentioned biocharacter is closely related to Ozarkodina compressa Rexroad described from the Kinkaid Limestone, uppermost Chesterian in Illinois. Reg. nos. 23105, 23106.

Genus Spathognathodus Branson and Mehl, 1941

Spathognathodus minutus (Ellison) Pl. 9, figs. 16-18

Spathodus minutus Ellison, 1941. Jour. Pal. vol. 15. p. 120. pl. 20, figs. 50-52.

Explanation of Plate 8

(All figures x 75 except for fig. 6)

Figs. 1, 2. Hindeodella sakagamii Igo and Koike
1. inner lateral view; 2. outer lateral view.

Figs. 3-5, 7. Hindeodus imperfectus (Rexroad)
3, 4. outer lateral views; 5. inner lateral view; 7. outer lateral view.

Fig. 6. Lonchodina sp.
6. inner lateral view. x37.

Figs. 8, 10, 12, 14. Lonchodina akiyoshiensis Igo and Koike, n. sp.
8,10. outer lateral views; 12, inner lateral view; 14. inner lateral view of the holotype.

Fig. 9. Synprioniodina sp.
inner lateral view.

Fig. 11. Lonchodus sp.
outer lateral view.

Fig. 13. Ligonodina honai Igo and Koike
inner lateral view.

Fig. 15. Lonchodina ? sp. A
outer lateral view.
490. Carboniferous Conodonts from Akiyoshi

tical to the ELLISON's specimens and also to other American specimens. Compared with the ELLISON's holotype, the Japanese specimens have slightly fewer number of the posterior denticles.

Reg. nos. 23107-23109.

**Genus Gnathodus PANDER, 1856**

*Gnathodus opimus* IGO and KOIKE

Pl. 9, figs. 1-8


**Comparison:**—The Akiyoshi specimens slightly differ from the holotype of *Gnathodus opimus*. Species of *Gnathodus* are very variable in the ornamentation and shape of cup. Some of the Akiyoshi specimens have three parallel node-like ridges including carina continued from blade. The development of these ridges along carina are very variable as illustrated in the plate. Therefore we treated these biocharacters as an intraspecific variability. *Gnathodus girlyi* HASS has three parallel ridges but our species is lacking transversely developed nodes. *Gnathodus roundyi* GUNNELL is also similar to our species.

Reg. nos. 23110-23117.

*Gnathodus commutatus* (BRANSON and MEHL) *nagatoensis* IGO and KOIKE, n. subsp.

Pl. 9, figs. 9-13

Axis straight to slightly curved inward. Denticles of carina fused, node-like with obtuse tip or subtriangular shape in lateral view. Cup widest in almost middle, asymmetrical its and outer side slightly wider than inner side. Height of cup gradually decrease posteriorly. Oral surface of cup smooth in some specimens or ornamented by two low nodes adjacent to carina anteriorly in other specimens. Blade thin, laterally compressed, slightly longer than carina. Denticles of blade fused, increase in size to near anterior end. Each denticles has sharp-edged tip. Aboral side of blade sharply edged with fine groove merged into expanded pulp cavity. Apex of pulp cavity located at same point of widest part of cup.

**Comparison:**—This new subspecies of *Gnathodus commutatus* differs from other subspecies of *commutatus* in the lateral view of the cup. Summit line of *Gnathodus commutatus* (s.l.) in lateral view is usually straight or substraight, but our subspecies has arched summit line and shows narrow node-like carina on cup.

Reg. nos. 23120 (holotype) 23118, 23119.

**References Cited**


Cooper, C.L. (1935): Conodonts from the upper and middle Arkansas novaculite, Mississippian, at Caddo Gap, Arkansas. Jour. Pal., v. 9, no. 4, p. 307-315, pl. 27.

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(1933): Conodonts and fish remains from the Cheroke. Kansas City, and Wabaunsee groups of Missouri and Kansas. Ibid., v. 7, no. 3, p. 361-297, pls. 31-33.


and Clark, C.E. (1960): Conodonts from the Glen Dean Formation of Kentucky and equivalent formations of Virginia and West Virginia. Ibid., v. 34, p. 1201-1206.


and Jarrell, M.K. (1961): Correlation by conodonts of Golconda Group (Ches-

Explanation of Plate 9

(All figures x75)

Figs. 1-8. Gnathodus opimus IGO and KOIKE
1-8, oral views.

Figs. 9-13. Gnathodus commutatus (BRANSON and MEHL) nagatoensis IGO and KOIKE, n. subsp.
Figs. 14. 15. Ozarkodina orientale IGO and KOIKE
14, outer lateral view; 15, inner lateral view.

Figs. 16-18. Spathognathodus minutus (ELLISON)
16-18, outer lateral views.


