A Lingulid from the Tertiary Rocks of the Waikato District.

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PLATE 68.

INTRODUCTION.

THE fossils described in this paper were obtained from two of the coal mines in the Lower Waikato Basin where, owing to the occurrence of faults, it was found necessary to construct inclined drives through rock from one portion of the coal seam to the displaced portion. Fossils were found in part of the strata passed through, and it is unfortunate that at the time no collection was made apart from one or two specimens kept as "curios." The rock removed in mining was either thrown on the waste dump and subsequently covered over or used in filling old workings, and so is now inaccessible. The rock forming the sides and roof in these drives is badly weathered by the mine air, and for this reason and owing to the timbering required, the number of specimens that can be obtained from their place of origin is small. Outcrops, on account of weathering, afford no opportunity for the collection of fossils.

The collection described and now lodged with the palaeontological collections of the N.Z. Geological Survey, Wellington, consists of a few specimens obtained from the sides and roof of the inclined drives together with a small number which had been kept as "interesting curios." Although the total number is small, and the specimens imperfect, it is felt that they should be described and their occurrence recorded because brachiopods of this family have not up till now been recorded in New Zealand.

The writer's best thanks are due to Messrs. A. Burt, P. Hunter and C. Hunter, managers of Pukemiro, Glen Afton and Renown Collieries respectively, for their kindness in placing much information at his disposal and in affording him all facilities for making investigations.

GENERAL GEOLOGY.

The rock containing the fossils to be described is a light grey claystone forming a bed about 40 feet thick resting conformably on the claystones of the Coal Measure Series of the Lower Waikato Basin. In appearance, these two claystones are similar but may be distinguished, e.g., in borehole records, by the fact that the coal measure claystones (locally known as "fireclays") are usually of a brownish colour and contain frequent dark coloured bands, carbonaceous layers, and nodules of spathic iron ore, whereas the over-

lying claystone with the fossil fauna is practically uniform. In the process of mining, as in stone drives or cross-measure drifts, the claystones of the coal measures are seen to contain bedded leaf remains and irregularly distributed coalified vegetal matter (see Penseler, 1930) which are absent (except in rare instances and in small amount) from the overlying claystone. The difference is therefore that the one rock contains a fossil flora and the other a fossil fauna, the former being a fresh water deposit and the latter a brackish water to marine deposit. The name "Lingula Claystone" is proposed for the latter bed.

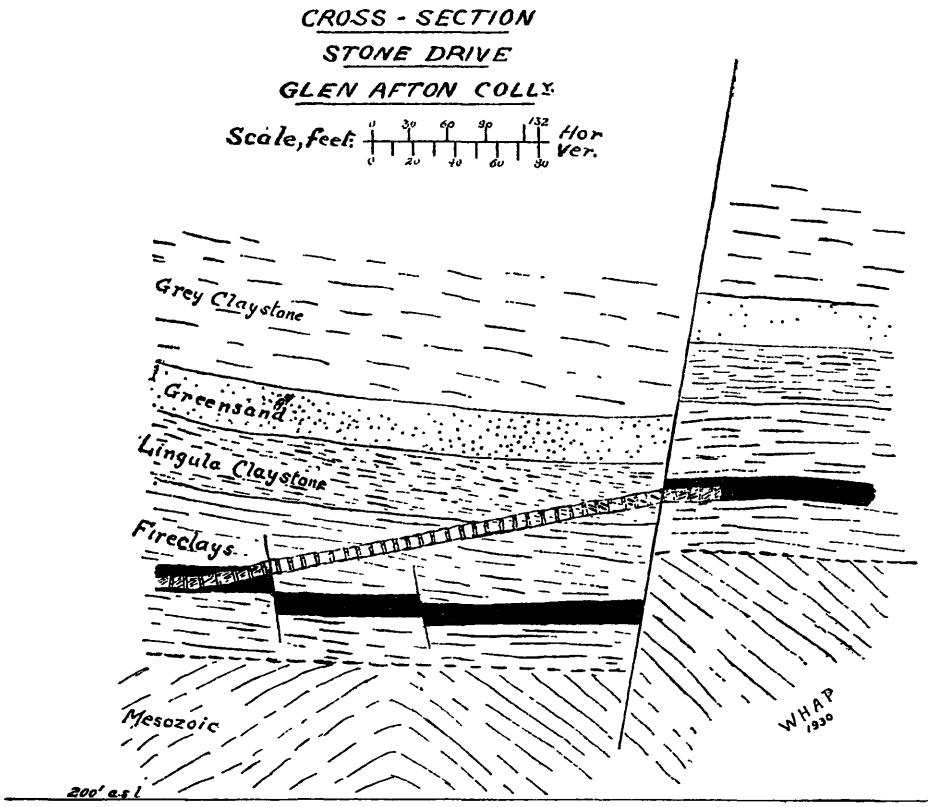


FIG. 1.

Overlying the Lingula Claystone is a bed, about 25 to 30 ft. thick, of bluish green glauconitic sandstone, more or less argillaceous and calcareous in places, which is followed by a thick bed of dark grey claystone. These three beds together are classed as equivalent to the Whaingaroa Series of Henderson and Grange (1926), and with the underlying Coal Measure Series and the overlying Te Kuiti limestones have been placed by Henderson (1929) in the Ototaran Stage of Oligocene Age. The Te Kuiti beds may possibly be of lower Miocene Age, but the Lingula Claystone may definitely be regarded as of Oligocene age.

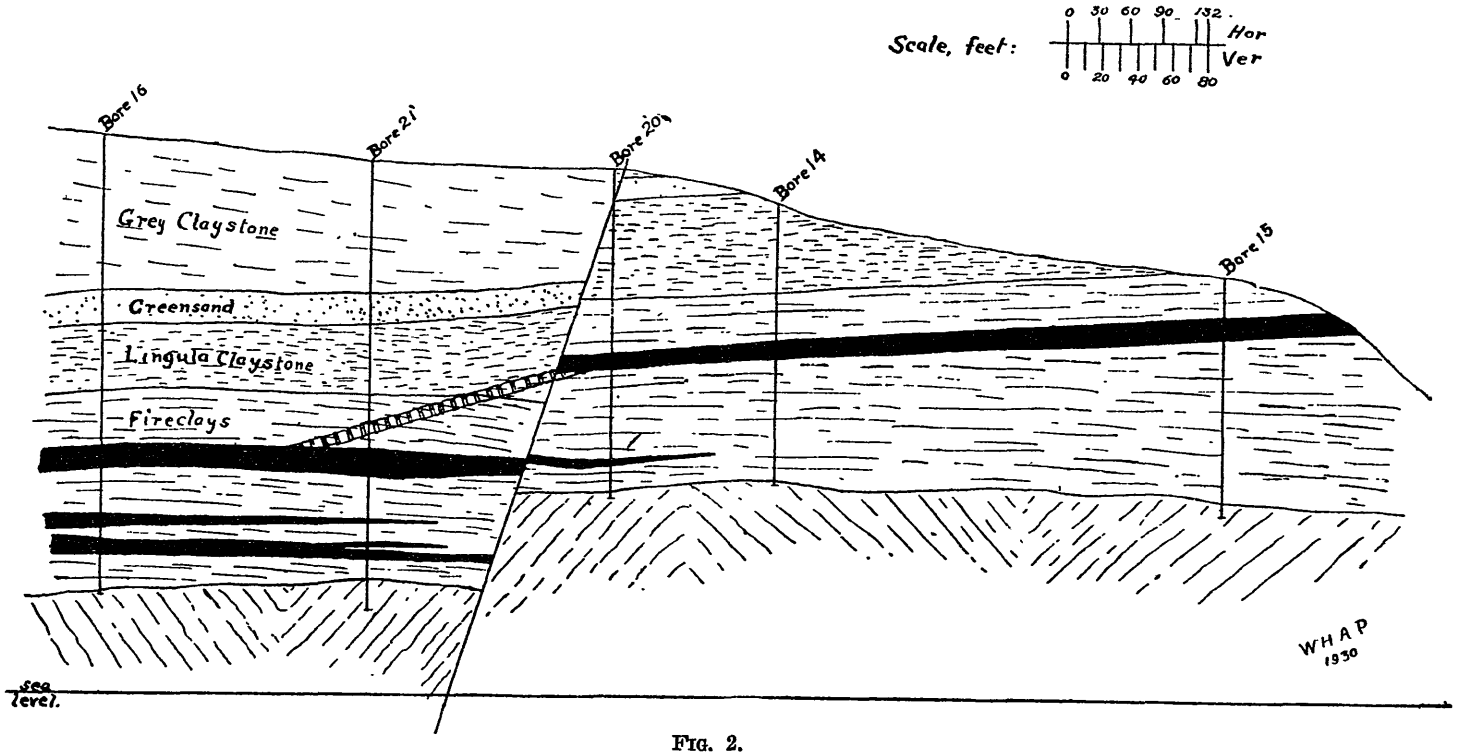

CROSS-SECTION ALONG MAIN DRIVE
RENOWN COLLIERY
Scale, feet:
0 30 60 90 132
Hor
Ver
0 20 40 60 80
Bore 16
Bore 21
Bore 20
Bore 14
Bore 15
Grey Claystone
Greensand
Lingula Claystone
Fireclays
WHAP 1930
sea level.

FIG. 2.

The Whaingaroa Series represents the first deposits of a marine facies which were laid down on the fresh water (estuarine) coal measure muds as the land was submerged, and the first stage of this submergence, necessarily a shallow water stage, resulted in the deposition of fine grained muds which show no evidence of bedding. Fossils occur scattered irregularly in these clays and may sometimes be missing. The position of this bed with respect to the enclosing rocks is shown in Figs. 1 and 2.

In Fig. 1, a stone drive in the Glen Afton Colliery, the claystones appear uniform to the eye from the base of the drive to the top and no break is noticeable between the coal measure claystone and the Lingula Claystone. Fossils were collected from near the top of the drive, about 50 feet above the top of the coal seam.

In driving the dip shown in Fig. 2 at the Renown Colliery, Waikokowai, lingulids were obtained in the upper part of the drive but were absent in the lower part which passed into the coal measure fireclays where leaf remains were common. Here again no break between the two claystones was seen.

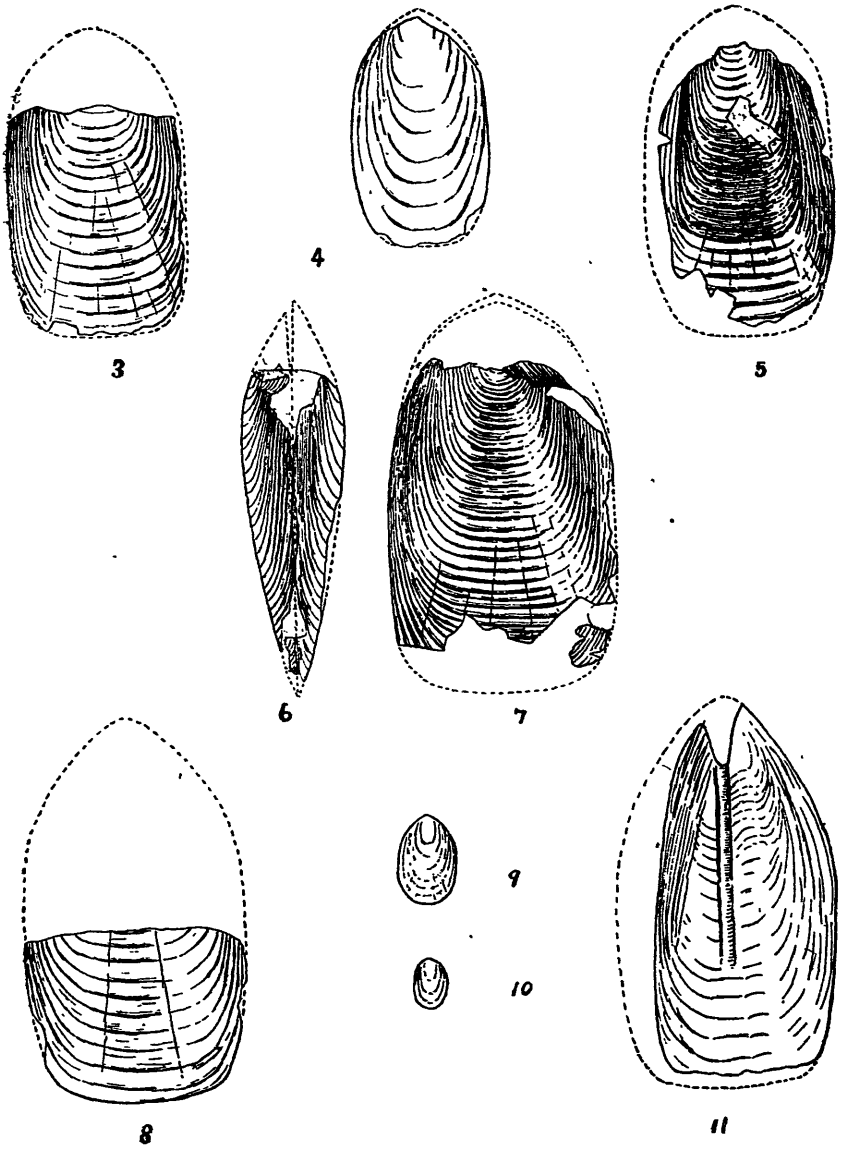
In the Pukemiro Colliery a similar stone drive connects one portion of the seam with the faulted portion about 90 feet higher, and here the stone drive must have passed through the Lingula Claystone. This drive was constructed about 12 years or more ago and there is no record of any fossil having been found, nor can any be seen now in the sides of the drive. Possibly the fossils are missing from this locality or may occur higher in the bed because the drive passed through the lower part only. Again no break can be seen in the succession.

It is evident therefore that the two series are conformable and that a transgression of the sea occurred over the slowly subsiding land surface. There is a gradual transition from fresh-water to marine conditions. There was apparently no difference in the kind of sediment brought down by the river, but, whereas previous deposition had been under fresh-water conditions in a large estuary with accompanying characteristic irregularity, the muds were now laid down under brackish to marine conditions. With increase of salinity of the water it was possible for a shallow water marine fauna to exist.

Description of Fossils.

Phylum: Brachiopoda.
Order: Atremata.
Genus: *Lingula* Bruguière.
Lingula waikatoensis n. sp. (Figs. 3-14).
Holotype: See Figs. 6, 7 and 14.
Dimensions: Approximate length 26 mm.; breadth 14 mm.; ratio 1.85.
Locality: Stone drive, Main Rope Road, Renown Colliery, Waikokowai.

Shell oblong oval, the length not quite twice the breadth. From the point of maximum breadth the shell tapers slightly to the anterior margin which is formed on a slight curve of large radius, and has rounded corners. No median projection, such as often occurs in



Lingula waikatoensis n. sp. All ×2.

FIGS. 3, 5, 8.—Portions of shells.
FIG. 4. —External cast of partly grown shell.
FIGS. 6 & 7.—Holotype. (See Fig. 14).
FIGS. 9 & 10.—External casts of young ferns.
FIG. 11. —Internal cast of distorted shell, showing medial depression. (See Fig. 13).

[*W.H.A P. del.*

Lingula, is present. Posteriorly the shell narrows more rapidly and is produced into an umbo which is probably blunt though no shell was found with the beak intact.

The exterior of the shell has usually a rounded median ridge or carination, high and narrow near the beak but diverging and flattening towards the anterior margin. According to Morse (1902, p. 321), from a study of living forms, this marked ridge especially in the small lingulids and *Glottidia* is due to warping and shrinkage of the soft tests on drying and "has no existence in nature." He stated that even in the larger and heavier shells, e.g., *L. anatina,* where a heavy deposit of lime renders the shell more rigid, "a region of the shell extending in a median line from the peduncular end is generally represented a little more arched than in nature." Johnston and Hirschfeld (1920, p. 56) state in regard to *L. hians,* a recent species, that "dried specimens became more or less distorted especially towards the umbonal end, where the valves contracted laterally in such a way that this portion of each became higher, narrower and more pointed than under natural conditions." Their proper shape was restored on immersion in warm water. It appears therefore that this ridge is a secondary feature and is more marked with the smaller and softer forms of lingulids.

The colour in the specimens collected varies from light brownish yellow or buff through dark amber to dark brown or nearly black. In the darker shells a distinct greenish tinge may be seen towards the centre of the valve. The largest shells are the thickest and the darkest; the young and small forms shown in Figs. 9 and 10, being a light buff to cream colour. Often two shades are present on the one shell marking lines of growth (see Fig. 13).

The shells are brittle, thin, smooth, glistening, and occasionally perforate. They appear to be composed mainly of chitinous material, but the number of specimens is insufficient to warrant the work of sectioning to determine the amount of calcium phosphate present.

Ridges due to increments of growth are well marked and were of assistance in reconstructing the original shape of each shell. As mentioned before, increase of the shell is sometimes accompanied by a change of colour. Radial striations are present near the anterior border.

Muscle impressions are not observable, but on one internal cast (Figs. 11 and 13) there is a well marked median depression which may represent the median septum in the dorsal valve of *Glottidia* (see Thomson 1927, Fig. 36b, p. 128).

Only single valves were found, with the exception of the specimen constituting the holotype. The shells are incomplete and more or less fragmental, and owing to shrinkage and movement of the enclosing muds they are often to some extent flattened and crushed. The shells of young lingulids are found with those of the mature forms, and are in general more complete. Examples of young shells are given in Figs. 4, 9 and 10. Small fragments of shells also occur scattered throughout the rock.

Comparison of this lingulid with other fossil lingulids has been difficult because no material and scanty literature are available here for such purposes.

Reference has been made to descriptions of fossil lingulids by Davidson (1874), Zittel (1900), Grabau and Shimer (1909), Hall (1847), Reeve (1841), Bittner (1890), and to descriptions of recent species by Blochmann (1892), Morse (1902), and Johnston and Hirschfeld (1920).

No specific affinities were found with any of the fossil lingulids described. With respect to the recent species Johnston and Hirschfeld (1920, p. 79) regard the ratio of length to breadth as constant for each species, and give the following ratios:—

L. hians Swains., 2.3 to 2.47.
L. murphiana King, 2.2 to 2.3.
L. anatina Lam., 2.2.
L. bancrofti Johns. and Hirsch., 2.0 to 2.1.
L. exusta Reeve, 2.2 to 2.5.
L. tumidula Reeve, 1.5 to 1.6.

From illustrations given by Morse (1902, Plate 40), the ratio for *Glottidia pyramidata* Dall is 2.7 to 3.

As far as it has been possible to determine from the fragmentary shells described in this paper their ratio varies from 1.85 to 1.87, which does not resemble that of any of the recent species quoted above. Schuchert (1911, p. 262) stated that "a survey of the geographic distribution of the inarticulate brachiopoda also shows that all the litoral and shallow water species are bound to warm waters, and that hardly any are common to two zoological provinces." During middle Tertiary times New Zealand must have been a separate zoological province, as it is at present, and therefore there were probably specific differences between the lingulids here and elsewhere. No recent lingulid is known in New Zealand waters and no other fossil lingulid is known either from New Zealand or from Australia. Comparison of types in this and neighbouring zoological provinces is thus impossible. The description of this newly discovered fossil form given above is sufficient to enable recognition of the species if found elsewhere. For the above reasons the creation of a new species is justified.

Associated Fossils.

Occurring with the lingulid were found *Cardium* (small), *Tellina, Dosinia,* and a small gastropod resembling *Cylichna* or *Bullinella.* In addition, one large fish scale was obtained from the Renown Colliery locality together with what appears to be portion of a fish bone.

The occurrence of *Cardium* is in keeping with the brackish and shallow water nature of the deposit, for according to Fischer (1887, p. 1035) it is an "animal marin, saumatre ou lacustre."

Some recent species of *Tellina* in New Zealand are found in mud flats at the mouths of rivers.

Tokunaga (1906, p. 69) recorded the occurrence of *Lingula hians* Swains., in a fossiliferous bed at Oji north of Tokyo, Japan. Associated with this *Lingula,* which was very scarce, were *inter alia* two species of *Cylichna,* six of *Tellina,* three of *Cardium* and a *Dosinia.* Indeterminable fragments of fish bones also occurred; a large number

of fossils was listed from Oji, deep water and shallow water types, and apparently further separation is needed. The age of the beds is probably Pleistocene. This occurrence, though not a parallel to the Lingula Claystone of the Waikato, is interesting as showing a similar association of genera.

Environmental Conditions.

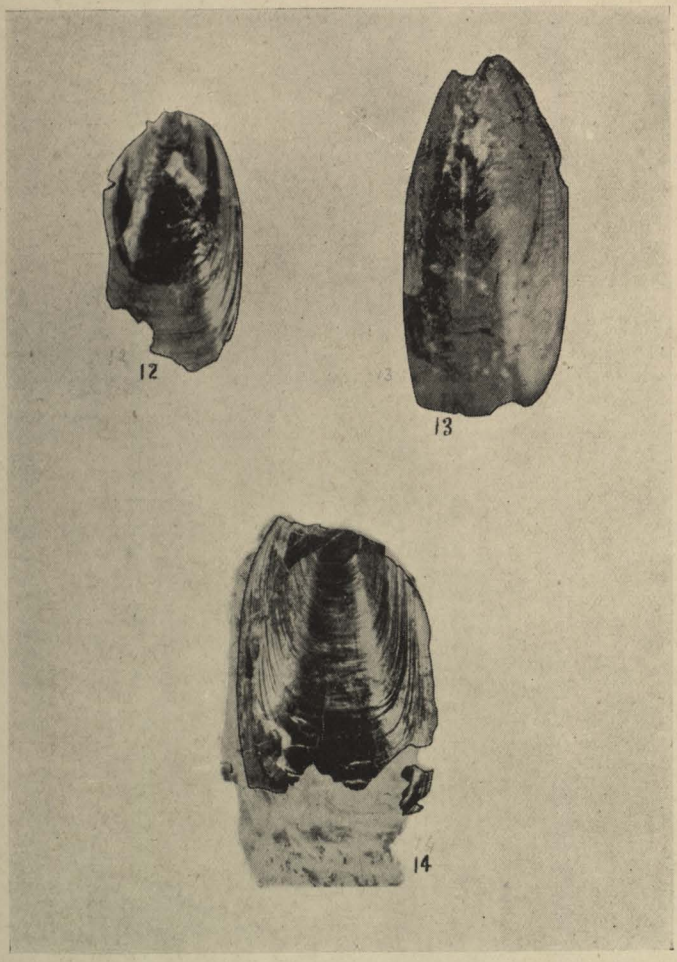
The environmental conditions of this fauna may be deduced from their known habits.

Morse (1902) stated that lingulids in general live in very shallow waters on a muddy or sandy bottom, and owing to their remarkable vitality, gradual elevation or subsidence of the coast line would in no way affect their condition. *Glottidia pyramidata* Dall was found living in great numbers at Beaufort Harbour, North Carolina, on shoals which are exposed at low tides (Morse 1902). *Lingula lepidula* lives in a few fathoms of water on a sandy bottom at Yenoshima, Japan (Morse, 1902). *L. anatina* is found at the mouth of the Takahashi River, which empties into the Shimabara Gulf, Japan, in a gravelly and muddy deposit just beyond low tide (Morse, 1902). *L. murphiana* is not uncommon in the sandy muds between tide marks in certain localities in Moreton Bay, South Queensland, and at the Philippines (Johnston and Hirschfeld, 1920, p. 59). *L. tumidula* is found in sandy mud at low water (Johnston and Hirschfeld, 1920, p. 51); *L. smaragdina* Adams from mud at 10 fathoms from Japan and the China Seas (*op. cit.*, p. 53); *L. hians* is common in mud flats at Noumea, and in the China Sea lives in mud or sandy clay at low water mark, its presence being indicated by the occurrence of oval orifices in the mud (*op. cit.*, p. 59). "The wide distribution of the species suggests that the larva has a fairly extended life and is able to adapt itself to rather wide limits of temperature, since the adult occurs in tropical, sub-tropical and warm temperate waters in the Eastern Pacific." A species, probably *L. hians*, was found "buried in a close unctuous mud two or three inches deep" from a muddy bay to the east of Evans Bay, near Cape York, North Queensland. "The fleshy or gelatinous pedicle which passed from between the beaks was five or six times as long as the shell and passed down into the mud, ending in a thickened knob. These pedicles did not appear to be attached to anything. On pulling at the shell a slight resistance was felt but not more than would be caused by the knob being drawn through the narrower hole in which the pedicle lies." (Jukes, fide Johnston and Hirschfeld 1920, p. 58).

L. exusta occurs in mud close to the edge of the beach sand at Dunk Island north of Rockingham Bay, North Queensland (Johnston and Hirschfeld, 1920, p. 65).

L. bancrofti (*op. cit.*, p. 67) is found in sheltered mud flats on the shores of Hervey Bay, Burnett Head, which are exposed at low tides.

Hayasaka (1922, p. 1) gives the depths of water in which recent species of *Lingula* occur as follows:—



Lingula waikatoensis n. sp.

All about twice natural size.

FIG. 12.—Portion of shell showing change in colour during growth. (See Fig. 5).

FIG. 13.—Internal cast showing median depression. (See Fig. 11).

FIG. 14.— Holotype. (See Fig. 7).

[*Royal Studios, photo.*

Face p. 448.

L. adamsi Dall, 7 fathoms.
L. affinis Hancock, 0-1 fathoms.
L. anatina Brug., 0-1 fathoms widely distributed.
L. jaspida Adams, 7 fathoms.
L. lepidula Adams, 10 fathoms.
L. smaragdina, Adams 10 fathoms.

Schuchert (1911) noted the great vitality of lingulids which he found growing on the tidal flats of Japan, where they are exposed for hours without injury. At high tide they are covered with three or four feet of water. He found further that lingulids lived in brackish water or water so foul with decomposing organic matter that all other shell fish were killed. He quoted Yatsu (1902) stating that the lingulids on little estuaries in certain bays in South Japan may be covered by sand and mud brought down by stream freshets, in which event the lingulids would continue to live by burrowing to the surface by means of their contractile and regenerative peduncle.

Schuchert observed that many species of *Lingula* occur in bays and estuaries indicating thereby that they prefer a habitat more or less freshened by fresh water.

"The immediate shore line, and often the estuarine bays and deltas, will be indicated especially by the large lingulids embedded in muds and sands with an otherwise sparse fauna." (Schuchert, 1911, p. 264).

Among recent species of inarticulate brachiopods he found that 24 live between high tide and a depth of 90 feet, and concluded that from the strand line to about 60 feet depth was characteristic of the litoral habits of *Lingula.*

During life the lingulids were able to crawl about slowly on the surface of the sediments or lie half buried in them (Morse, 1902). By means of their long peduncle, which with the Atremata is a burrowing and prehensile organ and not for permanent attachment to a given place as with all other brachiopods, they were able to draw themselves into the muds or force their way out when necessary. A secretion of mucous by the peduncle agglutinated particles of sand about the posterior end and by this means they are able temporarily to anchor themselves.

" On dying, the body (of *Glottidia*) protrudes from its burrow and rests at full length on the sand; it gradually turns black as a result of decomposition and the slightest jar causes the body to separate from the buried peduncle and float away." Morse (1902, p. 318). After death, therefore, the delicate and light shells are liable to be carried away by even the slightest current if sediment is being deposited too slowly to bury them in place.

As regards the fossil lingulids, Thomson (1927, p. 128) stated, "As the animal lives by preference on quite shallow sandy or muddy bottoms it is only exceptionally to be found fossil in rocks deposited at greater depths." According to Stevenson (1912, p. 518) "the inarticulate brachiopods have changed comparatively little in charac-

ter since their first appearance, and in all probability as little in their habits." On this fact he based his deductions as to the shallow water origin of the beds overlying coalfields in the Appalachian region where he found *Lingula* and *Orbiculoidea* (*Discina*) in the dark roof shale of the Middle Kittanning Coal Bed of Ohio, and in several of the roof shales in Kentucky.

Schuchert also (*op. cit.*) found that *Lingula* has endured since Ordovician times without change other than the superficial ones of form size and ornamentation.

Twenhofel (1926, p. 135) followed Schuchert in regarding *Lingula* and *Discina* as characteristic of shallow water from the strand line to about 60 feet. He stated that these two inarticulate forms were known to have lived on a muddy bottom as do some of the lingulids of to-day.

Summarising the significance of the habits of lingulids, Schuchert (*op. cit.*, p. 262) stated, "They are excellent guides as indicators of shore lines, and as such give clear guidance to the palaeogeography of any given time."

Conclusions.

The conclusions that may be drawn from the occurrence of *Lingula waikatoensis* in the claystone overlying the coal measure series in the Waikato are as follows:—

1. There is clear evidence of the inception of marine or brackish water conditions following the fresh water coal measure claystones. This is confirmed by the stratigraphical succession.

2. The climate was warm-temperate to sub-tropical.

The geological history of this region subsequent to the accumulation of the vegetable debris now forming the coal seams is therefore one of a slowly subsiding land surface, in a large estuary of which fluviatile muds were deposited over the vegetal matter by the inflowing rivers. These muds are characteristically variable both in colour and in consistency and contain leaf remains and irregularly distribtued masses of coalfield vegetable matter. Continued subsidence permitted a transgression of the sea and in the shallow brackish and saline waters which now covered the original fresh water muds the fine sediment carried in by the rivers was more uniform, especially in colour. In this shallow water area, protected from wave action either by a long barrier beach characteristic of subsiding coastal plains or by its situation in a large bay or sheltered gulf, conditions were suitable for the existence of a fauna characterised particularly by lingulids. This fauna is the first evidence of marine conditions in the coal basin of the Lower Waikato district, and if its extent and distribution could be determined the palaeogeography of the land in Middle Tertiary times would be definitely fixed. Continued subsidence resulted in the deposition of the deeper water marine beds of the Whaingaroa and Te Kuiti series.

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