*The "Hydraulic Limestones" of North Auckland.**

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A CONSIDERABLE amount of discussion has taken place in regard to the age of this formation. It is not intended in this paper to review the opinions that have been expressed in regard to this question, and it will merely be stated that the officers of the Geological Survey regard it as of Cretaceous age, whilst in various papers the present author has ascribed to it a Lower Tertiary age. At the present time it is merely intended to mention some facts not previously adduced which favour the author's contention.

The "hydraulic limestone" is, generally speaking, a foraminiferal limestone which covers large areas of the North Auckland Peninsula between Hokianga and Waipu, thence extending south-westward to the Kaipara Harbour. Although usually composed largely of the tests of Foraminifera, it frequently contains also a great many remains of organisms that had siliceous skeletons—sponges, diatoms, and Radiolaria are included amongst these. The limestone often contains a good deal of glauconite, and sometimes a number of grains of silica. Although relatively hard, it is traversed by a great number of crevices and joints, and slides readily, even on country with gently sloping relief. It has been subject to considerable earth-pressure, and is usually intensely folded, and sometimes also faulted. Up to the present time no fossils that indicate a definite age have been recorded from it. In the Auckland Exhibition of 1912 a *Cucullaea* and a *Dentalium* were shown in a case by the Wilson's Cement Company. These specimens, however, have never been described, and appear now to be lost. Some stratigraphical relations have lately been noted and require a definite statement.

(1.) At Pahi the hydraulic limestone is clearly seen to overlie a greensand. This is very clear on the shore-line of the eastern side of the Pahi arm of the Kaipara Harbour, between Whakapirau and Jackman's, where the rocks dip about 30° to the south-west and strike to the north-west.

(2.) On the hill between Pahi Township and the Arapaoa arm of the Kaipara Harbour it is found that all the eastern and higher parts of the hill are formed of limestone, while greensands crop out at the bottom of the western and southern sides. On the west side and on the south the greensands have a generally easterly dip. The obvious conclusion is that the greensands dip under the hydraulic limestone. Although the slope of the hill near the base is covered with detritus, the dip of the rocks shows that their relation is properly represented by the diagram fig. 1—the same relation as at Jackman's, mentioned previously, which is about one mile distant.

If the shore-line of the Arapaoa arm is followed to the north-west for about one mile, a syncline is found exposed on the foreshore of the harbour

* For a map of the locality see MARSHALL, *Trans. N.Z. Inst.*, vol. 49, p. 435, 1916.

and cliff that bounds it, as shown in fig. 2. At the south-east side of this syncline there has been a small amount of differential rock-movement, and the limestone has moved slightly over the greensand. There has been no movement of this kind at the north-west side, and there the limestone shows gradations to the greensand.

At a third point, between Mr. Blackwell's house and Tokatapu, opposite Colbeck's Landing, on the west side of the Pahi arm, the hydraulic limestone is again seen to rest on a highly arenaceous greensand, which is probably a local equivalent of the Pahi greensand. Again at Portland, near Whangarei, about fifty miles distant, on the downthrow side of a fault which shows clearly in a cutting on the railway-line, the greensand has been lowered so as to be brought into contact with the limestone. In these four localities it is clear that the hydraulic limestone is a higher horizon than the greensand.

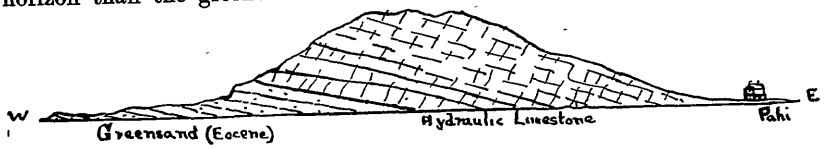

FIG. 1.—Hydraulic limestone between Pahi and Arapaoa arm.

Palaeontological evidence of the age of the limestone is very scanty. The greensand which lies below it at Pahi contains a considerable variety of fossil Mollusca, including an *Aturia,* and is probably the equivalent of the European Eocene—certainly not Cretaceous. It follows that the hydraulic limestone in this locality at least is not older than the Upper Eocene.

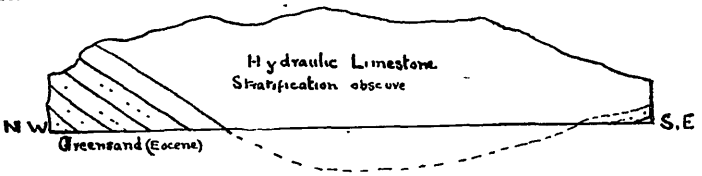

FIG. 2.—Syncline on foreshore north-west of Arapaoa arm.

Mr. W. Linton, of Batley, recently presented to the Auckland Museum a shark's tooth obtained from the hydraulic limestone near Batley, about six miles from Pahi. Dr. Smith Woodward, of the Natural History Branch of the British Museum, kindly examined it for me, and wrote as follows: "The green tooth of *Carcharodon* from Batley has the irregular serrations which characterize our Eocene and perhaps Danian species. To me it suggests Eocene age. The base being absent, it cannot be determined specifically." Miss Rhoda Linton also found a large vertebra near the same locality. Dr. Smith Woodward wrote of this: "The vertebra belongs to a large Lamnid shark, perhaps *Carcharodon.*

There is also in the Auckland Museum a string of six similar vertebrae from the hydraulic limestone at Portland, and, like the previous one, these probably represent *Carcharodon.*

This palaeontological and stratigraphical evidence seems to me to prove that the hydraulic limestone at Portland, Pahi, and Batley is certainly of Tertiary age, and not older than the Upper Eocene.