

a week was occupied in travelling to and from Mangonui and reporting upon the occurrence of an oil-shale deposit in that area. The shales are of poor quality, and yield only 5 to 10 gallons of oil to the ton.

By comparing the cost per square mile of the survey last year with the cost this year it becomes evident that the work is accelerated and that economies are effected by having two geologists with one field party.

The chief object of the present survey is to determine the stratigraphical succession in order to make it possible to define (a) the known coal-bearing areas, and (b) the possible coal-bearing areas. Other objects of the survey are (c) to study the occurrences of minerals of economic value, and (d) to gather material relative to the productivity of the soils, and thus construct a soil-map of the district.

SUMMARY OF THE GEOLOGY.

The stratigraphical succession of the late Mesozoic and of the Tertiary formations in the Whangarei and Bay of Islands Subdivision, and the relative positions of the coal-bearing horizons, were matters of some uncertainty until large areas of the country had been systematically mapped. The work of the past two field seasons has yielded a definite interpretation of the stratigraphy, has established the limits of the known coal-bearing areas, and has imposed certain limits upon the distribution of possible coal-bearing areas.

The geological history of the subdivision includes three complete cycles of depression, deposition, elevation, and erosion.

(1.) *The Waipapa Cycle.*—In Trias-Jura times a vast series of clays and sands of unknown thickness was laid down on the sinking edge of land of continental dimensions, which supplied the material so deposited. The continent finally disappeared; and following this the clays and sands were folded, crumpled, and indurated, and subsequently altered to quartzites, argillites, and greywackes. The folding was intense, and was accompanied by orogenic movements which uplifted these sediments until a new land-surface appeared. This land-surface was deeply dissected and maturely eroded before being depressed in Cretaceous times to such an extent that the greater part, or perhaps the whole, of what is now North Auckland sank beneath the sea.

(2.) *The Onerahi Cycle.*—During the Cretaceous depression claystones and impure limestones accumulated on the sea-floor in the present North Auckland area. Next in early Tertiary times the folding of the first-described cycle gave place to faulting accompanied by elevation and by the eruption of igneous rocks of intermediate composition. In places the soft Cretaceous strata were wholly removed by the denudation consequent on the uplift. After peneplanation the land once more began to sink.

(3.) *The Whangarei Cycle.*—On the edge of the sinking land, gravels, grits, and sands were deposited, and vegetable matter accumulated to a great thickness in some of the coastal lagoons and swamps. As the depression of this, the third or Whangarei cycle, continued the sea transgressed far over the land, but probably less extensively than during the Cretaceous. This further sinking allowed the accumulation of a series of calcareous sandstones and arenaceous limestones (shallow-water deposits). Renewed uplift subjected these sediments to erosion, which has continued to the present day. Those portions of the accumulated vegetable matter mentioned above, which survived the marine erosion during depression, were transformed to coal; the present coalfields of North Auckland represent those portions which have managed to survive the subaerial erosion of the final uplift.

Block-faulting, as well as the eruption of acidic tuffs and the extrusion of basic lavas, accompanied this final uplift, which gave the district its present topographical form. Since then, except for minor oscillations of level, this part of New Zealand appears to have been continuously above sea-level.

AGE AND CORRELATION OF THE SEDIMENTARY ROCKS.

The sediments accumulated in North Auckland at the beginning of the Waipapa cycle have yielded no internal evidence as to their age. This series is called the Waipapa Formation, and for several reasons, too lengthy to be detailed here, it is correlated with the Hokonuiian (Trias-Jura) of other parts of New Zealand.

The Onerahi Formation, including the hydraulic limestone of Limestone Island, is often found resting unconformably upon the pre-Cretaceous land-surface. It has yielded a few imperfect fossils not sufficient to determine its age, but from the results of other workers it would seem that this formation accumulated during the Waiparan (Cretaceous) period.

The Whangarei Formation, including the crystalline or Whangarei limestone, rests upon the eroded surfaces of the Waipapa or the Onerahi Formation with marked unconformity. The assemblage of fossils—containing among others *Cucullæa alta*, *Dentalium solidum*, *Ostrea wuellerstorfi*, *Pecten williamsoni*, and *Turritella ambulacrum*—obtained from this formation places it in the Oamaruian (Miocene) system. Such forms as *Amphistegina* sp., *Pecten huttoni*, and *Pecten beethami*, found in the Whangarei limestone, prove that this rock belongs to the Ototaran stage.

Scattered outcrops of fresh-water leaf-beds containing fossilized leaves of living species of New Zealand trees, of gravels, and of carbonaceous sandstones, in part covered and preserved by sheets of basalt, give evidence of the existence of a Pliocene and Pleistocene land-surface.

ECONOMIC GEOLOGY.

As indicated in the report of last year, minerals of high commercial value are not abundant in North Auckland, but there are many accumulations of minerals of low value which could be utilized and thus be made commercially valuable. Deposits of coal, cinnabar, manganese, antimony, limestones, pottery clays, brick-earths, and glass-sands have been surveyed during the progress of the work; these are potential sources of wealth to the district.